FINAL TECHNICAL REPORT

Material characterisation and source term development for the Ensham Coal Mine Final Void Plan

Ensham Coal Mine

Prepared for Ensham Resources Pty Ltd

LEADERS IN MINING GEOCHEMISTRY

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Executive Summary

RGS Environmental Pty Ltd (RGS) was engaged by Idemitsu Australia Resources (IAR) to (i) sample, analyse, characterise and classify 92 fresh samples of overburden from two drill holes and six bulk samples of overburden from in-pit spoil dumps (ii) undertake vadose modelling to evaluate possible percolation rates through the rehabilitated spoil (iii) evaluate data from the 2008 flood event (iv) use the data from the material characterisation studies along with site measured data to derive source terms to be used by Hecon Pty Ltd (HEC) in a GoldSim model to provide long term water quantity and quality simulations, and (v) provide recommendations on how the hydrogeochemical characteristics of the spoils and wall rocks may affect the project closure options evaluated by IAR.

Material Characterisation

The three major overburden units at Ensham include Quaternary, Tertiary and Permian rock units dominated by siltstone and sandstone. The coal tailings and mine waste materials generated at Ensham can generally be described as having very low sulfur content and containing excess acid buffering capacity. Most materials are classified as Non-Acid Forming (NAF) and have a high factor of safety with respect to potential for acid generation and a low potential to produce drainage with elevated metal/metalloid concentrations.

The main issue at Ensham is related to salinity due to saline groundwater in the project area and in naturally occurring quaternary alluvium upgradient of the mine. The static and kinetic geochemical test work on drill core and in pit spoil samples showed that the salinity in the Quaternary sediments was generally elevated and quite variable whereas the salinity in the Tertiary and Permian materials was lower and more consistent.

The pit voids within the mine are open systems and have received surface runoff from the as-placed and as-mined low and high wall spoil, rehabilitated landforms, direct precipitation and water from other pits and groundwater from underground mining sources. The existing water quality in the pits does not therefore provide a clear reference point to predict how the water quality in the pits may evolve over time. The pit void water is known to have developed chemoclines and thermoclines, and this may occur again in the future. Whilst these phenomena can potentially work in favour of water management, future studies may be required to confirm this outcome.

In-pit spoil hydrology and hydrogeochemistry

The available information from the Ensham site was used to quantify the water balance within as-placed spoil and rehabilitated spoil, the latter of which has sustainable pasture cover. Vadose/W unsaturated soil modelling using estimated numerical inputs was used to determine how much of the rain at the site is likely to report as surface runoff, be lost as evapotranspiration, or pass through the soil cover and root zone into the spoil dumps. The Vadose/W modelling predicted that, on average, approximately 1% of rainfall reports into deeper spoil below the zone of effective evaporation and zone of transpiration at the root zone. Observations at site indicate that the spoil dumps do not lose much water as seepage and this is consistent with predicted Vadose zone hydrological processes in other spoil dumps in Queensland.

At the commencement of the study there were no measured in-pit toe seepage water quality or quantity data. To derive water quality source terms for toe seepage, which represent the major source of solutes that may enter the pit water bodies, kinetic testing was undertaken on Quaternary and Tertiary spoil samples and Tertiary and Permian drill core.

Three toe seepage samples were collected by site personnel in C Pit in March 2018 and this water quality data validates the kinetic test results (i.e. that the salinity of the seepage from in-pit spoil was 1,440 to 2,800 µS/cm and the salinity of the initial KLC test leachate for Tertiary and Permian material was 1,670 to 2,700 µS/cm. The kinetic test program then provided additional longer-term data to quantify the changes in salinity over time.

2008 flood events at Ensham Mine

On 28th January 2008 the Nogoa River flooded the A pit, B Pit, and C-D Pit within three days. The water was subsequently pumped from the pits back to the Nogoa River over a period of about four months. The water quality data that was released from the pits was used to provide a better understanding of the hydrological and geochemical processes that occurred at that time. The information from the flood data was then applied to develop spoil seepage source terms as an input to ongoing numerical simulations of pit water by HEC.

Source terms and their application in the water quality model

The source terms (numerical values) used in the water quality model developed by HEC, were derived by RGS from measured surface water data collected by Ensham and static and kinetic geochemical analyses undertaken on Quaternary, Tertiary and Permian sedimentary units. The application of the source terms and the results of the mass balance numerical modelling is described in the HEC report.

Option 1 involves the development of permanent landforms along the existing levee alignment. Option 2 involves the utilisation of post-mining voids to form water storages to capture a proportion of high flow flood water and store this water for potential beneficial use. Option 3 comprises backfilling residual mining voids within the pre-mining floodplain up to the elevation of the original floodplain within the lateral extent of the pre-mining Probable Maximum Flood level.

Limitations and disclaimer

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1 Introduction

1.1 Project context

Ensham Mine, an open cut and underground bord and pillar coal mine located approximately 35km east of Emerald, is operated by Ensham Resources Pty Ltd (Ensham), a wholly owned subsidiary of Idemitsu Australia Resources Pty Ltd (Idemitsu), on behalf of the Ensham Mine joint venture (JV) partners. The JV partners, and holders of the Environmental Authority, are Bligh Coal Limited, Idemitsu and Bowen Investment (Australia) Pty Ltd. EA EPML00732813 (the EA), dated 9 August 2018, is the relevant environmental authority under which Ensham operates the mine.

Condition G16 of the EA states that a Residual Void Project (RVP) must be completed and submitted to the administering authority for review and comment by 31 March 2019. The minimum content of the RVP is specified within Condition G16 of the EA as:

a) Terms of Reference;
b) Residual Void Study;
c) Progress Reports; and
d) Rehabilitation success criteria for voids.

In compliance with Condition G19 of the EA, "*the Residual Void Project must be carried out in accordance with the approved Terms of Reference"*. Terms of Reference (ToR) (Ensham Resources, 2017a) were approved by Queensland's Department of Environment and Science (DES, formerly the Department of Environment and Heritage Protection, DEHP) on 21 July 2017.

Condition G20 of the EA identifies the minimum content of the RVP identified in Condition G16.

In accordance with the ToR, the project has been divided into five stages:

Stage 1 - Project definition and options identification
Stage 2 - Preferred options technical studies
Stage 3 - Preferred options detail design
Stage 4 - Most preferred option identification
Stage 5 - Regulatory documentation.

Stage 1 - Project definition and options identification for the RVP have been completed. The Stage 1 Options Assessment report has been finalised and issued to the Department of Environment and Science (DES), the Department of Natural Resources Mines and Energy (DNRME) and the Community Reference Group (CRG). The report was independently peer reviewed and revised to address peer review comments. The final report has been delivered to DES, DNRME and the CRG.

The Options Analysis workshop held in Stage 1 of the RVP identified two options:

- Option 1: Landform Levee
- Option 2: Flood Mitigation and Beneficial Use.

DES required a third option, Backfill to Probable Maximum Flood level, be included in the study.

All three options have been advanced through Stage 2 and into Stage 3 of the RVP and are referred to as the 'preferred options'. The preferred options are discussed in Section 1.3 to Section 1.6 of this report.

Stage 2 identified the Environmental Values (EVs) in the immediate and surrounding area of Ensham Coal Mine and determined which EVs are likely to be affected by each preferred option. Similar to Stage 1, the

Stage 2 EV report and technical studies have been Independently Peer Reviewed and issued in final to DES, DNRME and the CRG.

Stage 3 builds on the technical studies completed in Stage 2 to develop feasibility level designs required to prevent or minimise the potential impacts to EVs for each preferred option. Detailed designs for each of the preferred options will inform a risk assessment of each option and includes as a minimum:

- the long-term stability of the final landform;
- safety of access to the site; and
- the short, medium and long-term risks associated with each preferred option.

The output of Stage 3, in addition to the associated technical reports, will be an Environmental Assessment report for each preferred option which identifies the design and management practices which will be implemented to minimise impacts on the identified EVs.

On completion, each preferred option report will be peer reviewed by an independent suitably qualified third party before submission to the administering authority for review and comment.

1.2 Purpose of this report

The purpose of this document is to present the geochemical material characterisation and source terms to be used by Hydro Engineering & Consulting Pty Ltd (HEC) to evaluate water quality associated with each of the Options.

The Options Appraisal workshop of Stage 1 of the RVP identified two options:

- Option 1: Landform Levee
- Option 2: Flood Mitigation and Beneficial Use.

DES required a third option to be included in the study:

- Option 3: Backfill to PMF.

All three options have been advanced through Stage 2 and into Stage 3 of the RVP and are referred to as the 'Preferred Options'. The Preferred Options are discussed in Section 1.3 to Section 1.6 of this report.

Stage 3 will build on the technical studies completed in Stage 2 to develop feasibility level designs required to prevent or minimise the potential impacts to EVs from each Preferred Option. Detailed designs for each of the Preferred Option will inform a risk assessment on each Option and include, as a minimum:

- the long-term stability of the final landform;
- safety of access to the site; and
- the short, medium and long-term risks associated with each Preferred Option

The output of Stage 3 will be a report for each Preferred Option that evidences how designed management practices will be effectively implemented for each impacted EV.

On completion, each Preferred Option report will be peer reviewed by an independent suitably qualified third party before submission to administering authority for review and comment.

1.3 Closure Options

The following sections briefly capture the closure options that have been identified and developed by Ensham.

1.3.1 Preferred Option 1: Landform Levee

Having conceptually evolved since Stage 1, proposed Option 1 will develop permanent landforms along the existing levee alignment to provide flood immunity for the 0.1% (1 in 1,000) Annual Exceedance Probability (AEP) flood event having had consideration of the risk of a PMF level event (as proposed in the Stage 2 assessment). **Figure 1-1** illustrates the current placement of the landform.

When compared to the landform levee designed at a PMF level (as considered in Stage 2) the proposed 0.1% AEP landform along the existing levee alignment:

- Eliminates afflux impacts for upstream landholders in a greater than 0.1% AEP event
- Eliminates any potential increased impacts on downstream landholders associated with widening the river floodplain
- Eliminates the need to realign the Nogoa anabranch

It is proposed to incorporate the existing levees into the landform design with overburden emplacement areas behind the levee being reshaped in a manner that achieves the minimum stable landform slope requirements.

In addition to any impacts associated with the existing farm levees and mining pit levees, flood levels in the vicinity of Ensham Mine are significantly affected by the confluence of flood flows from the Comet River and Nogoa River, which occurs immediately downstream of the mine. Pits would be subject to rehabilitation in accordance with the approved Ensham site Rehabilitation Management Plan and the landform design criteria.

A biodiversity corridor will be developed along the western (highwall) side of the rehabilitated A and B pits to provide connectivity between Corkscrew Creek and the Nogoa River flood plain as seen in **Figure 1-1**.

Figure 1-1: Option 1 – Landform Levee

1.3.2 Preferred Option 2: Flood Mitigation and Beneficial Use

Option 2 proposes to utilise the post-mining voids to form water storages to capture a proportion of high flow flood water and store this water for potential beneficial use as shown in **Figure 1- 2**. Flood water harvesting is able to quickly fill the post-mining voids with minimal downstream impact, achieving improved water quality to support a range of reuse options, and/or environmental, and social values.

This option is founded on the concept of capturing a small fraction of larger magnitude flood event flows in the Nogoa River, storing this water in residual voids and releasing it back to irrigation and industrial users via a series of pipes to the Weemah Channel and Yamala Inland Port. There will be no discharge to the Nogoa River by this option.

The design of rehabilitation should comply with the current site Rehabilitation Management Plan and landform design criteria to optimise water capacity? Overburden emplacement areas located adjacent to the water storage voids are to be reshaped in a manner that achieves stable landform slopes without resulting in significant void backfilling. Low wall areas are to be reshaped in-pit to achieve minimum stable slope requirements to ensure safe access and stability of exposed slope surfaces.

Option 2 would utilise storage afforded by residual voids remaining in A Pit and B Pit south of the Nogoa River, and C Pit and D Pit north of the river. The quantity of water likely to be required to operate the system – or put another way, the freeboard storage in the pits – is likely to be negligible when compared to overall discharges during flood events from the Nogoa River catchment into the Mackenzie River located downstream of the Ensham Coal Mine. However, in the context of irrigation usage, the freeboard storage represents a significant volume and a potential economic asset.

Future assessment and optimisation of Option 2 will consider the potential for interactive operation of the voids with Fairbairn Dam to improve water use efficiency across the water supply system.

Currently Fairbairn Dam's southern irrigation channel, known as the Weemah Channel, extends eastward to within approximately 10 km of Ensham Coal Mine. Water captured from the upper Nogoa River catchment and retained in Queensland's second largest but relatively shallow Fairbairn Dam, is subject to significant evaporative losses. Furthermore, allocated water releases from the dam into the Weemah Channel (and the corresponding northern Channel, the Selma Channel) experience significant seepage and seasonal evaporative losses before reaching their intended customers, particularly where these customers are close to the end of the Weemah Channel. This option includes linking the residual voids located to the south of the Nogoa River to the existing Weemah Channel with large diameter pipes and pumps to transfer water to and from the voids.

Water captured in Fairbairn Dam would be released into the Weemah channel when hydrologic conditions are likely to result in minimal evaporative and seepage losses (i.e. at times when the catchment is receiving rainfall, the ground is saturated and evaporation is minimal). Whilst the water may not be required by customers at these times, the water would be transferred to the residual voids via the proposed Weemah channel(s) (refer red line on **Figure 1-3**) and stored in the more evaporatively-efficient residual voids at Ensham. In times of irrigation water demand at the lower reaches of the Weemah Channel (i.e. where the evaporative and seepage distribution losses are likely to be greatest), water would be returned to the Weemah Channel from the residual voids via the Weemah channel.

Because the Weemah Channel and proposed channel(s) lie on the southern side of the Nogoa River floodplain, it would be necessary to maintain a hydraulic connection between the residual voids on the northern flanks of the floodplain and those on the southern flanks. It is proposed that an upgrade of the existing water distribution main, that runs parallel with the main haulage route between B Pit and C Pit, be undertaken early in the project to provide the required hydraulic connection (refer blue line on **Figure 1-3**).

Option 2 proposes that pontoon-based pumping stations would be sited at each pit to transfer water as required. The Weemah channel coming into the mining lease would be configured to deliver water initially to A pit. Similarly, pumping from the mine to the Weemah Channel would be done from A Pit.

An offtake from the pipe to Weemah channel would be used to meet water demand for the prospective Yamala Inland Port located to the south west of Ensham Mine.

Figure 1-2: Option 2 – Flood Mitigation and Beneficial Use

Figure 1-3: Conceptual drawing of the Weemah Virtual Channel to irrigation and Yamala Inland Port (red) and the mine internal pump system (blue)

1.3.3 Preferred Option 3: Backfill to PMF

Preferred Option 3 comprises backfilling residual mining voids located within the pre-mining floodplain up to the elevation of the original floodplain within the lateral extent of the pre-mining Probable Maximum Flood (PMF) level.

Conceptually, the residual voids lying within this PMF extent would be backfilled up to the approximate original (pre-mining) topography with an additional surcharging to accommodate settlement of the backfill. In practice, it may be necessary to extend the backfilling beyond the modelled extent of the PMF to ensure stability of the backfilled areas within the PMF extent and protect against collapse into the adjacent residual voids. Excess mining spoil that is currently present in the floodplain and that is not required for backfilling of residual mining voids, would be retained as seen in **Figure 1-4.**

The existing levees constructed to protect the voids from flooding would be removed, with the material re-used for backfilling voids. Material required to backfill residual voids would be drawn from the nearest cost-effective source e.g. low wall spoil. Any negative material balance will need to be met from adjacent low wall and high wall spoils.

Virgin rock (unmined rock) typically exhibits an increase in volume when excavated - this is referred to as 'bulking'. The degree of bulking will vary with the geo-mechanical properties and size distribution of the excavated rocks and the methods used in excavation and transport. Furthermore, it is likely to vary both along the linear extent of the open cut mine and within different parts of spoil tips created through the extraction of rock dominated by lithologies characterising the local stratigraphy. Re-excavation of spoil and re-emplacement within voids within the modelled PMF will again exhibit bulking. Whether subjected to dynamic compaction or allowed to settle with subsequent loading by overlying backfill, the spoil within the voids will inevitably exhibit uncontrolled settlement. This will lead to the development of low areas within the PMF extent which, though shallow, lie below the original level of the floodplain. These low areas will not necessarily be connected and are likely to collect surface water runoff but be subject to intense evaporation and surface accumulation of evaporative salts which would be flushed clean by fluvial flood events.

Static surcharging of the replaced spoil material may reduce the risk of long-term settlement below original floodplain. However, this will require material to be placed above the original floodplain elevation in direct contradiction of the intent of this option.

Beyond the modelled extent of the PMF, residual voids would be rehabilitated in accordance with a combination of Option 1 and option 2 landform criteria requirements.

Replaced spoil, however comprehensively compacted, is unlikely to provide durability equal to the original virgin rock and hence during times of fluvial flood, of magnitudes such that the current floodplain pinch point between B Pit and C Pit begins to develop afflux, it is likely that the Nogoa River would scour spoil within the adjacent backfilled pits. This has the potential over time to result in sink holes and ultimately a repeat of the 2008/2010 inundation events with the Nogoa River cutting a channel into one or more backfilled pits and flooding the remaining un-backfilled parts of each pit. Additionally, impacts on turbidity downstream of the backfilled areas would need to be considered.

As part of the rehabilitation process, the establishment of a biodiversity corridor along the western (highwall) side of the rehabilitated A and B pits is proposed to link Corkscrew Creek and the Nogoa River flood plain as seen in **Figure 1-4**.

Figure 1-4: Option 3 - Backfill to PMF

1.4 Pit extents

The extents of pits are illustrated on the plan provided in **Appendix A.6**.

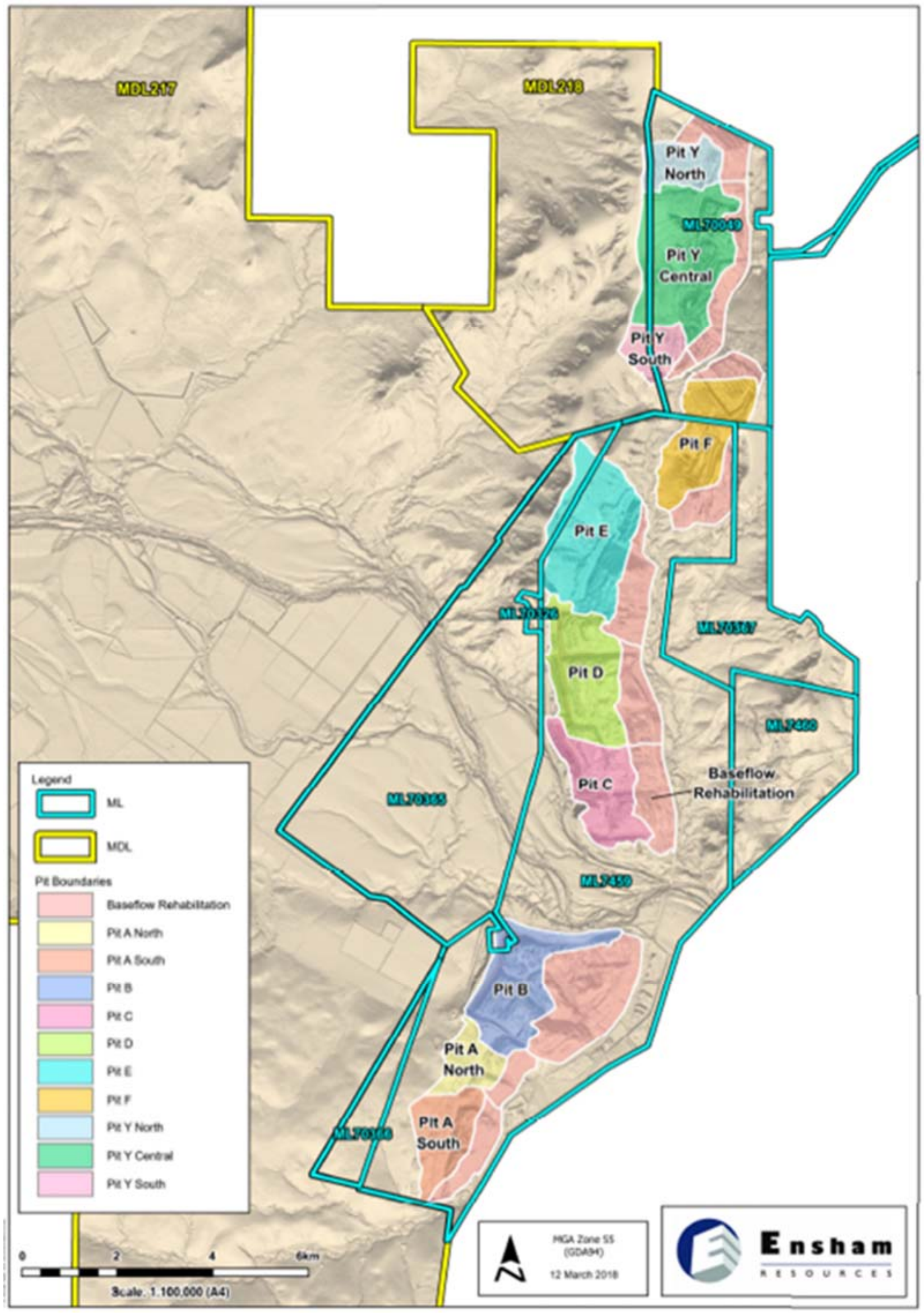

Figure 1-5: Location of open cuts

1.5 Background to the RGS scope of work

The current Environmental Authority (for the Ensham Central Project) is based on an Environmental Impact Statement (EIS) completed in 2006 and a subsequent Supplementary report completed in 2009. A geochemical characterisation study was completed in 2006 (URS, 2006) to inform the EIS for the Ensham Central Project.

1.6 Scope of Work

RGS Environmental Pty Ltd (RGS) was engaged by Ensham Resources Pty Ltd on behalf of Idemitsu Australia Resources Group (IAR) to:

- review previous technical reports and geological data;
- provide a geochemical sampling and analytical program; and,
- complete static and kinetic geochemical and physical material characterisation of the overburden above the primary coal seam that was mined by dragline and truck and shovel methods.

The data from the analytical programs was used to:

- verify that there is:
  - very little lateral or vertical variation in the geological strata associated with depositional processing or faulting;
  - a low potential for acid formation in the coal, coal roof and coal floor by evaluating the range and distribution of the sulfur data from the resource database;
  - limited potential for the overburden to produce acid and metalliferous drainage (AMD); and,
  - low to moderate potential for the development of saline drainage.
- develop hydrogeochemical source terms that were utilised by HEC to develop water quality model predictions for the northern, central and southern open cut pits at Ensham Coal Mine.

The GoldSim® water quality models were used (by HEC) to evaluate the rate of water flow into the voids, probable steady state water levels in the voids and associated water quality.

To address this requirement, RGS collected samples of fresh and aged materials which were analysed under the broad conditions that may be encountered during rehabilitation of the site. There are three general options that need to be addressed from a geochemical, hydrological and landform perspective and these are provided in **Figure 1-6, Figure 1-7 and Figure 1-8.**

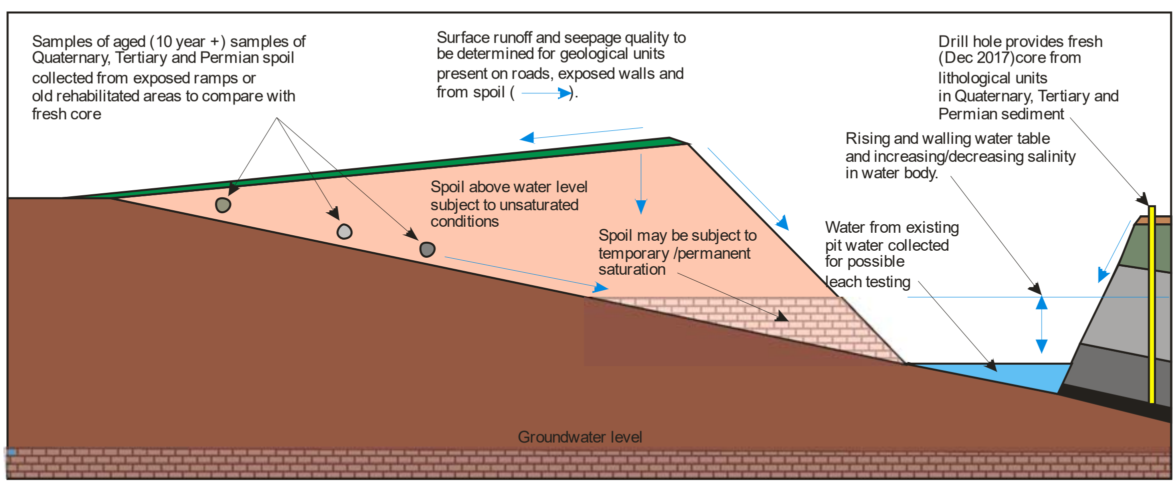

Figure 1-6: Option 1 – Landform Levee: Evolution of a rising and falling pond in the final pit shell

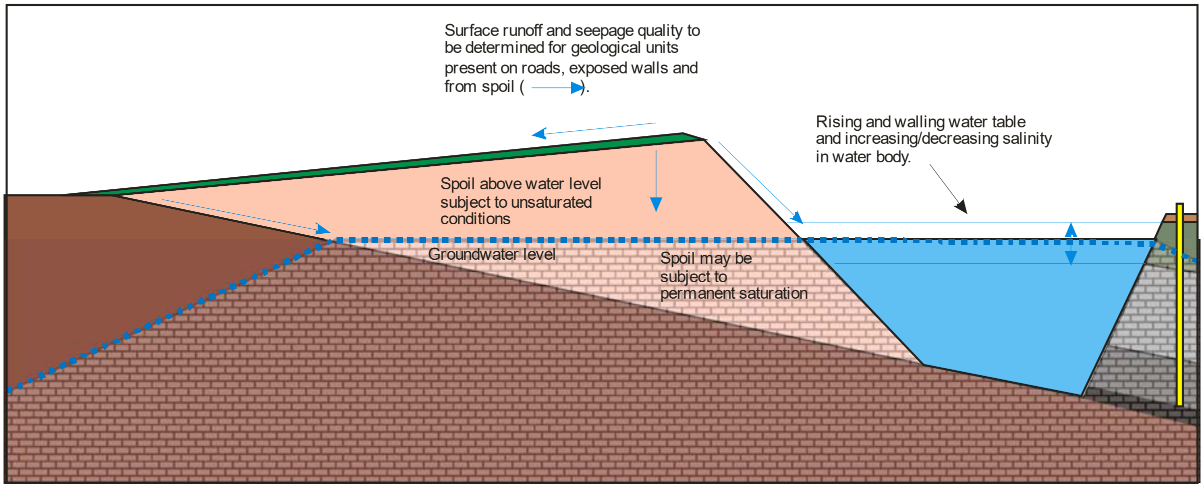

Figure 1-7: Option 2 - Flood Mitigation and Beneficial Use: Intentional flooding of the final pit shell/or development of flow through systems

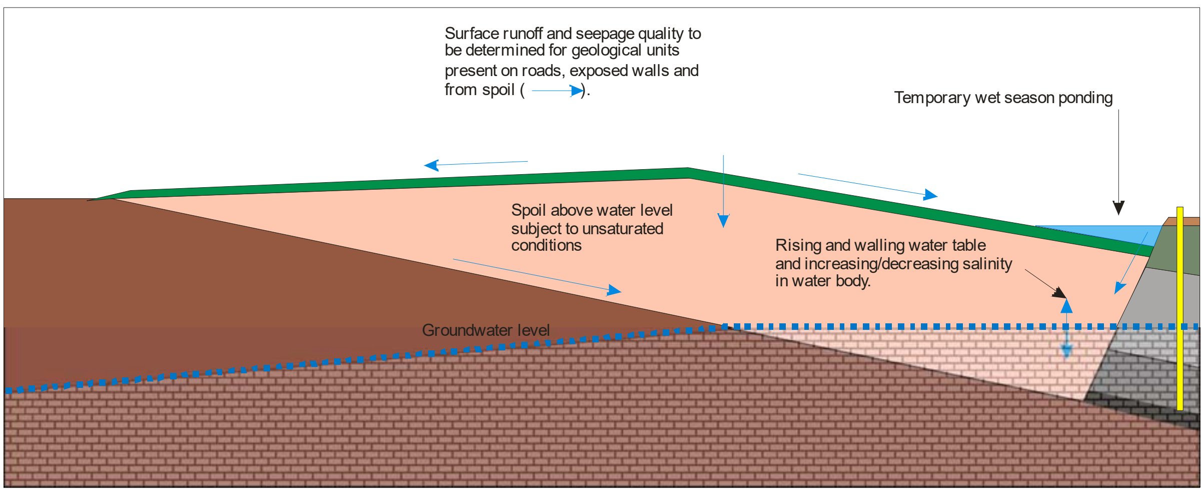

Figure 1-8: Option 3 – Backfill to PMF: Re-profiling the final pit shell

For the landform configurations the spoil will be present under free draining conditions or become inundated with water due to an increase in water level in the pit shell. Drill core samples were used to evaluate the chemical behaviour of “freshly exposed” materials and ‘aged’ spoil samples collected from old areas of the mine, approximately 20 years, to evaluate how the old materials differ from fresh materials. The fresh and aged materials have been evaluated using static and ongoing kinetic testing. The kinetic testing was implemented under both free draining and saturated conditions. The saturated testing included saturating the spoil samples with distilled water and mildly alkaline, saline water from B Pit in the southern extent of the mine.

2 Geology and Material Balances

2.1 Topography

The topography of the ECM A, B, C, D, E, F and Y pits and surrounding topography was generated from data supplied by Ensham (**Figure 2-1**).

The topography was modelled on a 10 m x 10 m grid and decimated (smoothed) where possible to reduce processing time. Smoothing was undertaken with points being moved no more than 0.1 m and faces with a difference in dip of greater than 20° were excluded. Decimation was repeated until there was a less than 10% change in the number of faces making up the model. The modelled topography is approximately 10.0 x 23.5 km, with the highest modelled point 293 m ASL and the lowest 47 m ASL. The northern pits, F and Y, are elevated compared to the central and southern pits (A, B, C, D and E).

Coal seam floor survey data supplied by Ensham was used to create deepest mined surfaces within the pits (**Figure 2-2**). Solids were created between the current modelled topography and the deepest mined surfaces.

The deepest mined surfaces generated for F Pit did not underlie the full extent of dumped waste. In this case the deepest mined surface was inferred to extend from the edge of the provided data to ground level, encompassing dumped material.

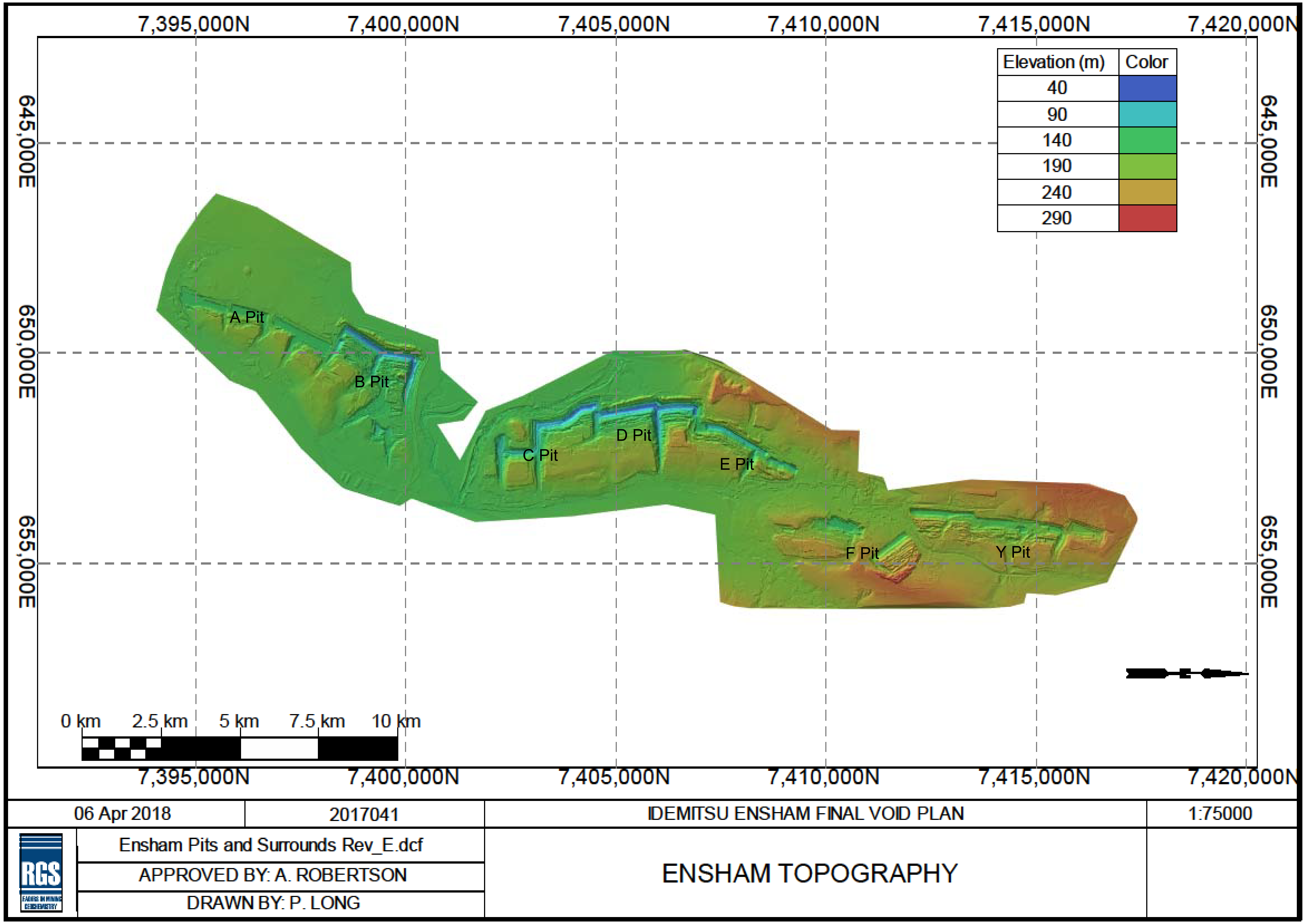

Figure 2-1: Model of current Ensham Coal Mine topography

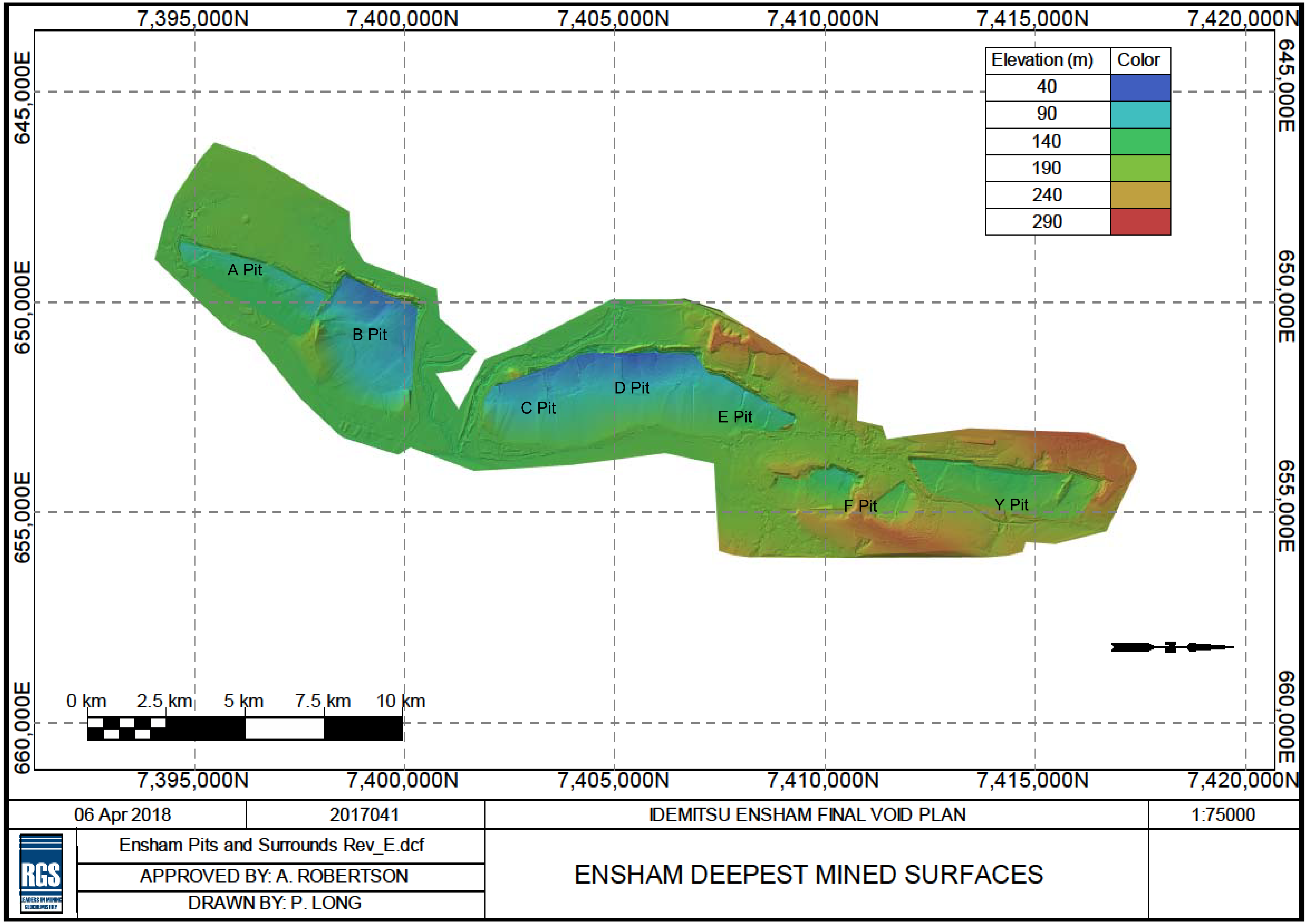

Figure 2-2: Ensham Coal Mine deepest mined surfaces model

2.2 Overburden

Ensham removed Quaternary, Tertiary and Permian stratigraphic units and then mined the upper coal seam within the A, B, C, D, E, F and Y open pits. The geology of the area modelled comprises of Cenozoic sediments (alluvium, gravel, sand silt, and clay), and sedimentary rock units including sandstone, siltstone and claystone, and Triassic/Permian sedimentary units, including sandstone, siltstone, carbonaceous mudstone and siltstone and coal. The Cenozoic sediments and sedimentary units have been subdivided into Quaternary sediments and Tertiary sedimentary units when modelled. The major sedimentary rock units are primarily interbedded siltstone and sandstone with laterally continuous coal seams and some non-coal carbonaceous material, mostly mudstone. Modelled lithology comprises approximately 88.4% Permian, 1.4% Tertiary and 10.2% Quaternary units. This distribution of ages was modelled using units logged as the Rangal Coal Measures or Rewan Group as the upper boundary of Permian stratigraphy. Sedimentary units shallower than this were designated as Tertiary units and sediments and silcrete overlying Permian or Tertiary stratigraphy were logged as Quaternary sediments.

A and B Pits were combined and are modelled as comprising 79 M m^3 of Permian over/interburden, 0.7M m^3 of Tertiary overburden and 19M m^3 of Quaternary sediments. B Pit is modelled as containing 171 Mm^3 of Permian material, 9,395 m^3 of Tertiary material and 18 Mm^3 of Quaternary material. Cenozoic sediments are approximately 50 m deep in the south of A Pit, becoming shallower to the north. The model of A and B Pit extends to the bottom of the Aries 1 seam, approximately 90 – 100 m below ground level (bgl). The Aries seam dips westward at approximately 3° – 4° and this dip and dip direction is roughly consistent through the rest of the A and B Pit model.

C, D and E Pits combined are modelled to contain 564 M m^3 of Permian material, 137,522 m^3 of Tertiary material and 135 M m^3 of Quaternary material. Cenozoic sediments are approximately 20 m deep and logged as primarily soil in C and southern D Pits and clay in the north of D Pit and E Pit. The model of the C, D and E lithology extends to the base of the Castor seam roughly 125 m bgl. Generally, strata are westward dipping at approximately 2°.

F Pit is modelled to comprise 28 M m^3 of Permian material, 5,448 m^3 of Tertiary material and 6 M m^3 of Quaternary material. Cenozoic sediments in F Pit are very shallow in the south (approximately 2 m bgl), deepening in the north (approximately 16 m bgl). These sediments are primarily clay with a thin soil covering. Marker beds in the model are dipping westward approximately 5 – 6° in the south of F Pit and 2 – 4° in the north. The model is approximately 55 m deep and extends to the base of the Pollux seam.

The Y Pit model contains 137M m^3 of Permian material, 32,824 m^3 of Tertiary material and 33 M m^3 of Quaternary material. The Cenozoic sediments in Y Pit are mostly clay with minor soil in the south and clay in the north. The sediments deepen from approximately 5 m in the south to 20 m in the north. The model extends to the base of the Pollux seam, 60 – 70 m below ground level for most of the model, thickening to 80 – 100 m in the north. There is a vertical offset of 11 m between coal beds logged in drill holes in the central east of the model. Drill hole X5057 is the only hole that shows an offset of this magnitude and coal beds logged in drill holes to the north and south become marginally deeper. This feature is interpreted to be an anticline, shallowly plunging southwest. Marker beds tend towards a western dip, bedding in the northern and southern ends of the model are near-flat (0 - 1°), with steeper angles modelled in the centre around the anticline (up to 12°).

2.3 Coal and sulfur

Sulfur in coal and in mine waste materials is important as it can be present in a reactive sulfide form (such as pyrite or marcasite) and is typically the main contributor to the generation of AMD at mining operations. In general, sulfur concentrations can be elevated in coal and coal reject materials due to the genesis of these materials but can also be present in other stratigraphic units (typically close to coal seams, e.g. coal seam roof and floor materials).

Sulfur in coal is derived from two sources that include the original plant materials and ambient fluids in the coal forming environment. Abundance of sulfur in coal is controlled by depositional environments and the genesis of the coal seams and overlying strata. Typically, low-sulfur coal seams are formed by deposition in an alluvial environment not influenced by seawater. The sulfur in these low-sulfur coals is derived mostly from its parent plant materials. In contrast, high sulfur coal seams are generally associated with marine strata where sulfate in the seawater diffuses into the initial peat and is reduced by microorganisms to form hydrogen sulfide, elemental sulfur and polysulfides. During early genesis in a reducing environment, ferric iron is reduced to ferrous iron, which reacts with hydrogen sulfide to form iron monosulfide. Iron monosulfide is later transformed by reaction with elemental sulfur into minerals such as pyrite or marcasite, which upon exposure to oxidising conditions are typically reactive and generate AMD.

Organic sulfur is formed by reaction of reduced sulfur species with the humic substances formed by bacterial decomposition of the initial peat. Organic sulfur species in coals are mainly thiols, sulfides, di-sulfides, and thiophene and its derivatives. The thiophenic fraction of organic sulfur increases with the carbon content of coals. Organic sulfur compounds formed in peat are mostly thiols and sulfides, which gradually convert to thiophenes with increasing coal maturation. Thus, the organic sulfur species in coal evolve during the history of coal formation and, upon exposure to oxidising conditions, are typically not a source of AMD.

The depositional environment of the coal in the Ensham stratigraphic sequence is understood to have been an alluvial environment with negligible marine influences at a regional level, therefore the magnitude of any potential for AMD generation is expected to be limited, compared to coal formed in marine influenced strata, and this was verified in this study through plotting sulfur data. The location of total sulfur assay results from coal within the pits are provided in **Figure 2-3**.

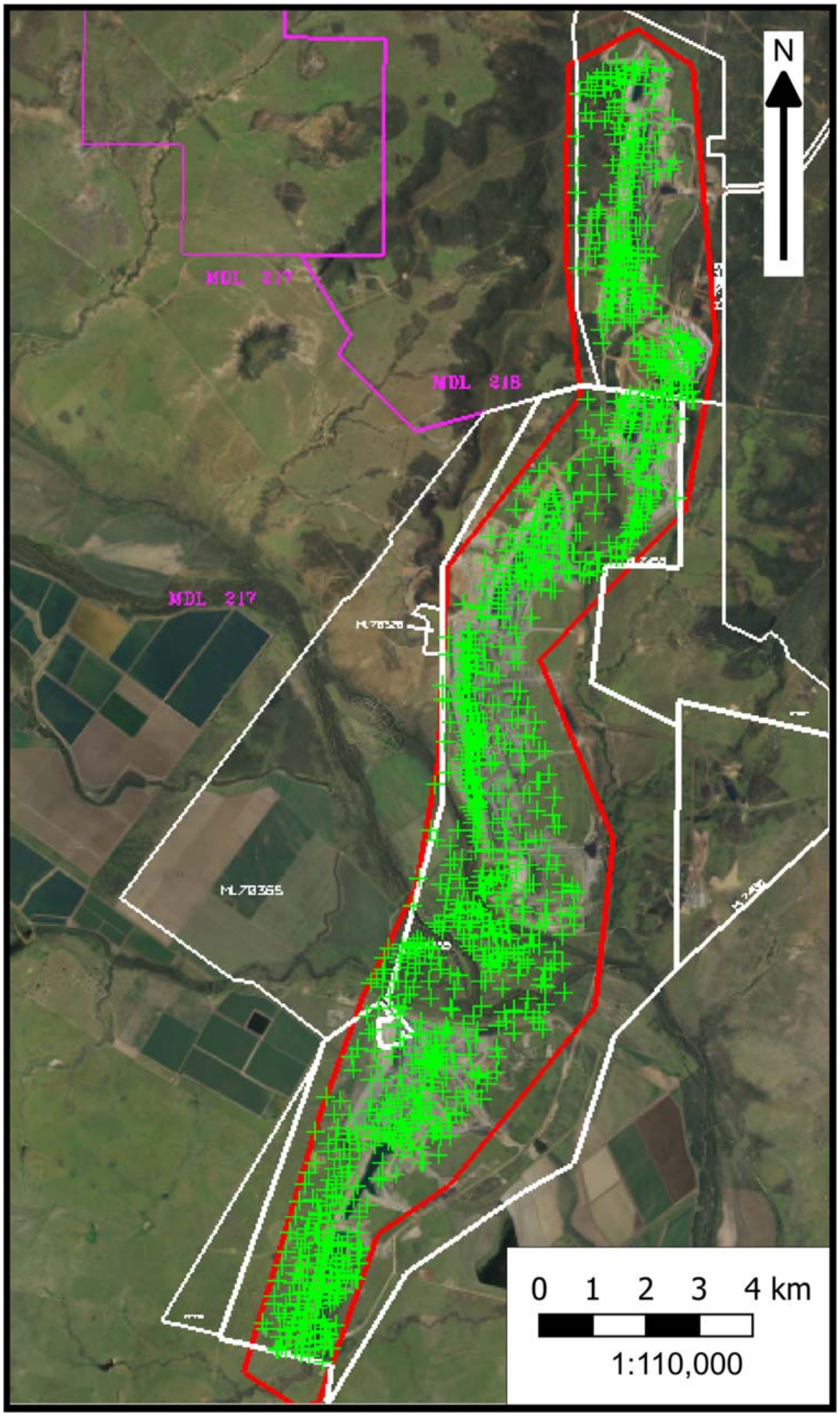

Figure 2-3: Coal assay locations

The coal sulfur data (n = 5,625) were used to produce a sulfur histogram to quantify the range and distribution of the sulfur in the coal (**Figure 2-4**): 50 % of the coal total sulfur assay results are less than 0.5 % total sulfur, and 91% are less than 1% total sulfur. The results verify the coal is a low sulfur coal. Additionally, as a good proportion of sulfur is known to be organic sulfur, the maximum potential acidity (MPA) is also inferred to be low. The range and distribution of sulfur in roof and floor samples indicates over/interburden is low in sulfur as 84 % of assay results are less than 0.5 % total sulfur and 95 % are less than 1 % total sulfur.

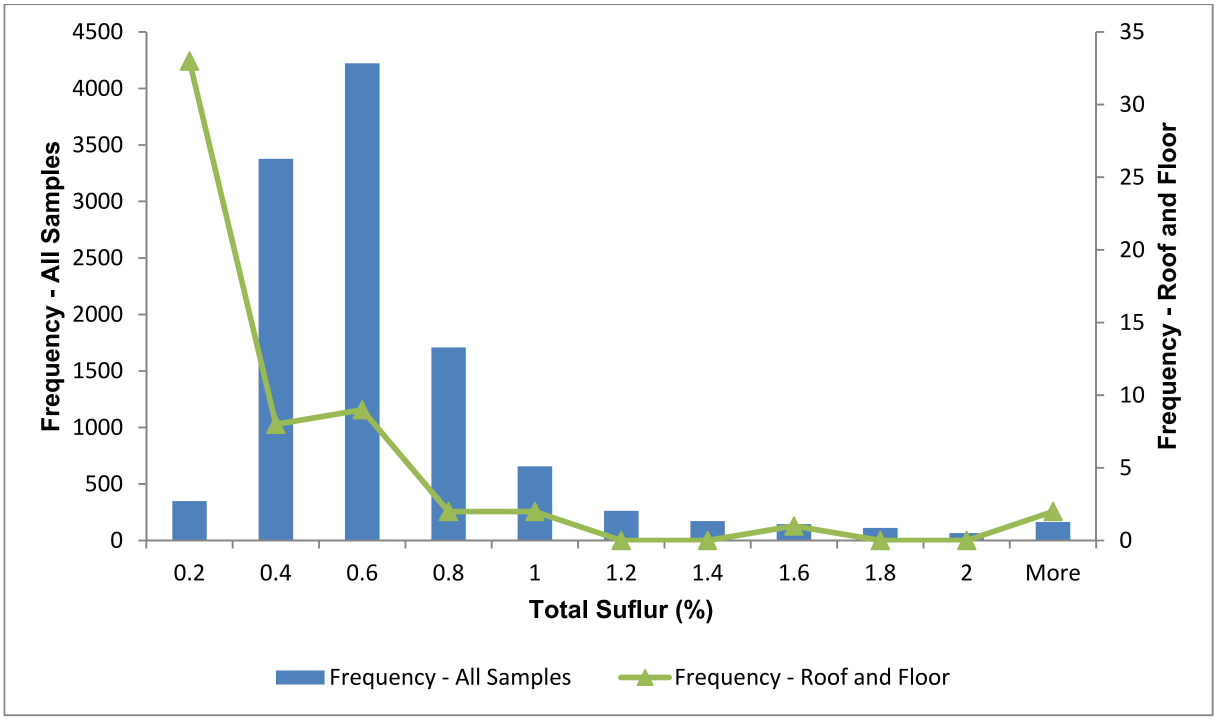

Figure 2-4: Coal total sulfur histogram

2.4 Overburden model

RGS developed a conceptual level material balance for the pre-mined pit shells to provide mass balance volumes of Quaternary (alluvium and clay), Tertiary and Permian strata. This was achieved through the following process in Deswik.CAD computer software:

- Adding the existing pit shells and deepest mined surface **Figure 2-1** and **Figure 2-2**;
- Identifying and adding drill holes (n = 82) along the length of the pits within the mining lease (**Table 2-1**);
- Determining from the drill hole logs that the lithological units and major strata are (relatively) laterally continuous across the pits within the mining lease (**Section 2.2**); and,
- Joining the lithological units between the drill holes across the pits to create a 3D “face model” (**Figure 2-5**).

Table 2-1: Drill holes used to construct geology models

A and B Pits	C, D and E Pits	F Pit	Y Pit
C4823	C4842	C5225	C4780
C4820	C4843	C5226	C5114
C4827	C4959R	C5120	C5235
C4828	C4960	X5124	C5236
C5200	C4845	C5070	X5113
C5205	C4846	X5100	C5075
C4826	C5232	C5102	C5111
C5204	C4905	C5069	C5074
C5199	C5191	C5101	C5076
C5203	C4779	C5067	X5107
C4813	C4856	C5066	C5110
C5201	C4849	C5103	C5237
C5198	C4957	C5068	C5119
C5172	C4848	C5065	C5055
C4781	C4958	C5064	C5077
C5227	C4913	C5104	C5106
C5194		C5105	C5058
C5195		C5063	C5062
C4985R			X5056
C5196			X5057
C4986			X5109
C5197			
C5224			
C4812			
C5228			
C5211			
C4805			

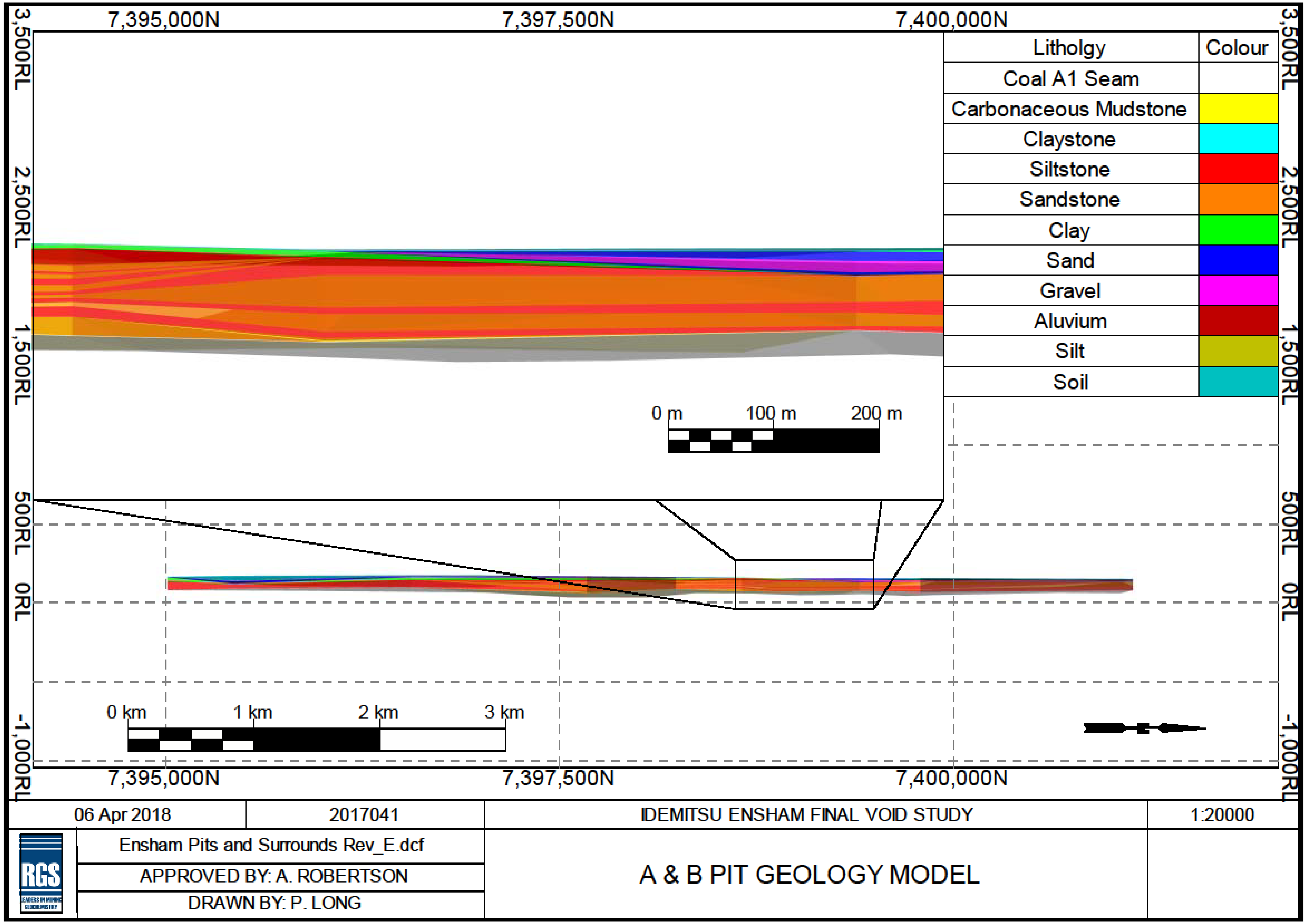

Figure 2-5: Geology model of A and B pits as viewed from the East

2.5 Material balance

2.5.1 Lithological units

The 3D face model in **Figure 2-5** was used to estimate the proportion of the major lithological units present on the high wall in each of the pit domains (**Table 2-2**). For example, in Pit A and Pit B that are "interconnected", 28.32 % of the highwall is Sandstone and 10.15 % is Clay.

Table 2-2: Percentage of lithological units present on pit high walls.

Lithology	Pits A & B Volume (%)	Pits C, D & E Volume (%)	Pit F Volume (%)	Pit Y Volume (%)
Alluvium	1.27%			
Carbonaceous Mudstone	0.37%	0.38%	1.01%	2.63%
Carbonaceous Siltstone		4.48%		0.42%
Clay	10.15%	2.28%	14.33%	14.71%
Claystone	5.88%	0.49%	6.67%	0.56%
Coal Aries 1	0.59%	0.60%		
Coal Aries A12				0.07%
Coal Aries A21		0.26%	0.49%	1.13%
Coal Aries A22			0.31%	0.34%
Coal Aries/Castor		4.26%		
Coal Castor			1.41%	2.09%
Coal Pollux			4.80%	3.60%
Coaly Claystone			0.01%	
Coaly Mudstone				0.02%
Gravel	3.05%			
Sand	6.96%	0.67%		1.38%
Sandstone	28.32%	54.40%	33.66%	42.53%
Silcrete			3.21%	0.07%
Silt	0.27%			
Siltstone	39.74%	31.67%	33.40%	30.33%
Soil	3.39%	0.52%	0.58%	0.11%
Sooty Coal			0.11%	

2.5.2 Stratigraphic units

The lithological 3D pit face model and geological logs were used to derive inferred pre-mine volumes for the Quaternary Sediments, Tertiary Sediments and Permian Sediments (**Table 2-3**). The pre-mine topography was calculated using a linear method from the crest of the highwall to the eastern edge of the deepest mined surface. The dip, and dip direction of Permian and Tertiary units was taken to be consistent and the Quaternary sediments were taken to be parallel to the predicted surface. These in-pit volumes can then be used to derive the relative proportion of these strata in the backfilled pits.

Table 2-3: Percentage of Quaternary, Tertiary and Permian by Pit(s)

Pit	Lithology Age	Volume (m^3)	% of total models	% of Pit
Pit A and B	Permian	197,788,217	53.42%	84.32%
Pit A and B	Tertiary	4,260,329	1.15%	1.82%
Pit A and B	Quaternary	32,519,381	8.78%	13.86%
Pit C, D and E	Permian	113,271,629	30.59%	96.94%
Pit C, D and E	Quaternary	3,578,582	0.97%	3.06%
Pit F	Permian	5,656,660	1.53%	76.97%
Pit F	Tertiary	660,867	0.18%	8.99%
Pit F	Quaternary	1,031,458	0.28%	14.04%
Pit Y	Permian	10,692,492	2.89%	93.07%
Pit Y	Tertiary	64,880	0.02%	0.56%
Pit Y	Quaternary	731,799	0.20%	6.37%

2.6 In-pit stage area storage curves

The height, area and volume of reshaped backfilled spoil in each pit was calculated for each option using 5 m stage heights (**Figure 2-6**). These in-pit spoil and in-pit void stage area storage curves can be utilised in the water balance and water quality model to calculate the volume of water that may be entrained in spoil if pits are filled with water either temporarily (refer to **Figure 1-1**) or permanent inundation (refer to **Figure 1-2**). These calculations could also be used to calculate the storage capacity (and therefore time for groundwater recovery) in the spoil under an option where the pits are completely backfilled with spoil (**Figure 1-3**).

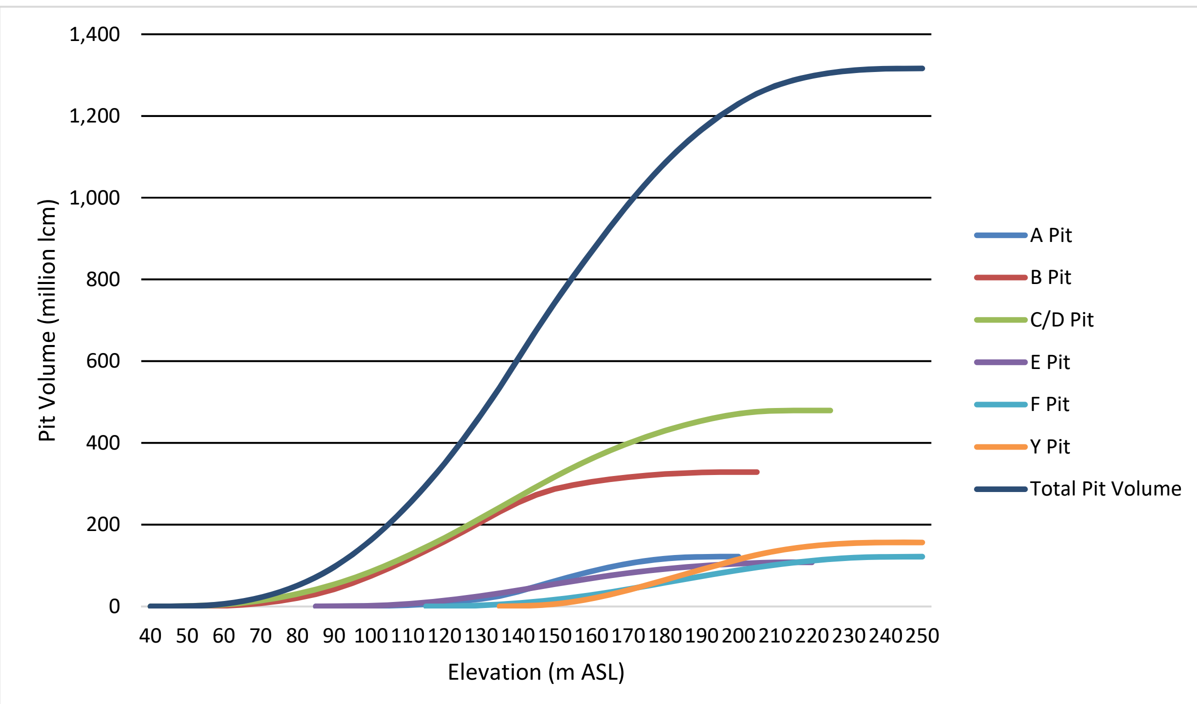

Figure 2-6: In-Pit Final Reshaped Spoil Stage Area Storage Curve

3 Geochemical and physical material sampling and analysis program

3.1 Geochemical drill hole sampling and analysis

The overall drill core sampling process was guided by the requirements of Australian (DME, 1995; DEHP, 2013 and COA, 2016) and international (INAP, 2009) technical guidelines. RGS initially reviewed geological logs and requested drill core or chip samples from the provided logs. Through three iterations of this process it was determined that there was no available drill core or drill chips from previous drilling programs. Two of the nine drill hole locations requested from Ensham were sampled (**Table 3-1; Figure 4-1**). A total of 92 drill core samples from the two drill holes were obtained and processed for static geochemical testing (**Table 3-2**) to support static and kinetic geochemical work undertaken by previous consultants (URS 2006 – 66 samples from 9 drill holes and 8 KLC tests and URS, 2015 – 34 drill chip samples). The sample IDs for the 92 samples are in **Table 3-3** and **Table 3-4**. The shading in **Figure 3-1** represents topography: highest elevation is red through to lowest elevation that is blue.

Table 3-1: Drill hole sample locations

Borehole Site ID	Easting	Northing	Approx. TD	Comments
RGS3_C5286 Drill water from Ramp 83 fill point.	653555	7413504	92m	Highwall of Yongala Central pit. 100% core samples to TD.
RGS2_C5285 Drill water from Ramp 24 fill point.	651053	7405180	126m	Highwall of D-pit. 100% core samples to TD.

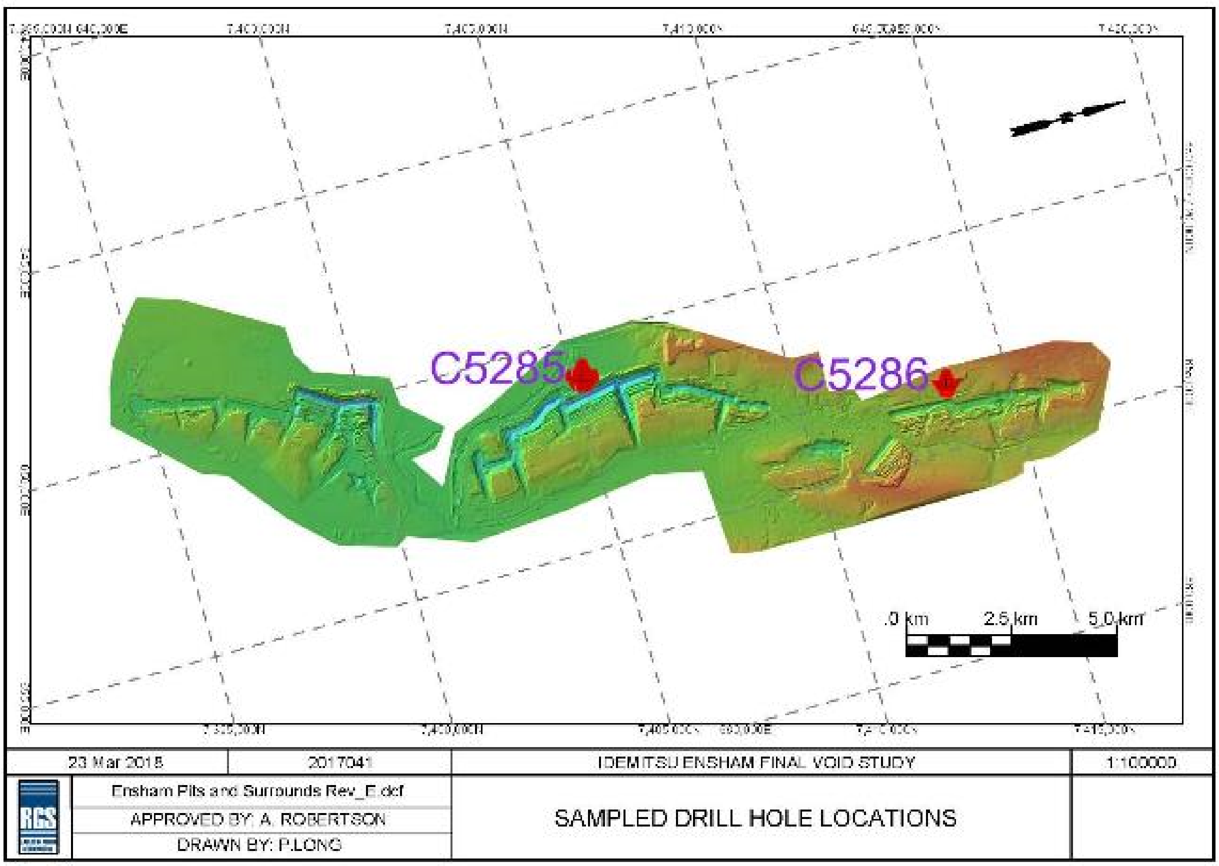

Figure 3-1: Sampled drill hole locations

Table 3-2: Static geochemical analysis summary

Analysis Type	Digest Time	Sample Particle Size	Limit of detection	Units	C5285 # of samples	C5286 # of samples	In-Pit Spoil # of samples	Pit void water # of samples	Pit Seeps # of samples	Groundwater # of samples	Surface water # of samples	KLC # of samples
EA002: pH (Soils) 1:5 1 hr leach	1 hr	Pulp (< 75 um)	0.1	pH Unit	51	41	6	1	3	699	112	6
EA005P: pH by PC Titrator 1:3 16 hr leach	16 hr	Sieved (< 19 mm)	0.01	pH Unit	51	0	0	0	0	0	0	0
EA009: Net Acid Production Potential		Pulp (< 75 um)	0.5	kg H_2SO_4/t	51	41	6	0	0	0	0	6
EA010: Conductivity 1:5 1 hr leach	1 hr	Pulp (< 75 um)	1	µS/cm	51	41	6	1	3	699	112	6
EA010P: Conductivity by PC Titrator 1:3 16 hr leach	16 hr	Sieved (< 19 mm)	1	µS/cm	51	0	0	0	0	0	0	0
EA013: Acid Neutralising Capacity		Pulp (< 75 um)	0.5	kg H_2SO_4/t	51	41	6	0	0	0	0	6
EA026: Chromium Reducible Sulfur		Pulp (< 75 um)	50	ppm	51	0	0	0	0	0	0	6
ED008: Exchangeable Cations		Sieved (< 2.36 mm)	0.2	meq/100g	51	41	6	0	0	0	0	6
ED037: Alkalinity 1:3 16 hr leach	16 hr	Sieved (< 19 mm)	1	mg/L	51	0	0	1	3	699	0	6
ED038A: Acidity			1	mg/L	0	0	0	1	0	0	0	6
ED040S: Soluble Sulfate by ICPAES 1:5 1 hr leach	1 hr	Pulp (< 75 um)	10	mg/kg	51	0	0	0	0	699	0	0
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA 1:3 16 hr leach	16 hr	Sieved (< 19 mm)	1	mg/L	51	41	0	1	0	0	0	0
ED042T: Total Sulfur by LECO		Pulp (< 75 um)	100	mg/kg	51	41	6	0	0	0	0	6
ED045G: Chloride by Discrete Analyser 1:3 16 hr leach	16 hr	Sieved (< 19 mm)	1	mg/L	51	41	6	1	0	699	0	0
ED093F: Major Ions 1:3 16 hr leach	16 hr	Sieved (< 19 mm)	1	mg/L	51	41	6	1	3	699	112	6
EG005W: Water Leachable Metals by ICPAES		Pulp (< 75 um)	0.1	mg/L	0	0	6	0	3	699	0	6
EK067G: Total Phosphorus as P by Discrete Analyser		Pulp (< 75 um)	2	mg/kg	0	0	6	0	0	0	0	0
EP003: Total Organic Carbon (TOC) in Soil		Pulp (< 75 um)	0.02	%	0	0	6	0	0	0	0	0
ME-MS41: Ultra Trace Aqua Regia ICP-MS Metals		Pulp (< 75 um)	0.01	ppm	0	41	6	1	3	699	0	0

Table 3-3: Drill hole log C5286 Y Pit

Seam	ALS Sample ID	Top	Base	Thickness	Rock	Grain size	Lithology adjective	Colour	Weathering
RWGP		0.00	0.57	0.57	NL				
SOIL	EB1804203001	0.00	0.57	0.57	SO		IS	BN	1
	EB1804203002	0.57	1.17	0.60	SA	VF	IS	GY	2
		1.17	1.36	0.19	SA	VF	IS	GY	2
	EB1804203003	1.36	2.27	0.91	KL				
		2.27	3.05	0.78	SS	VF	IS	GY	2
	EB1804203004	3.05	4.46	1.41	CL		IS	GY	2
		4.46	4.85	0.39	CL		SA	GY	3
		4.85	5.44	0.59	KL				
	EB1804203005	5.44	6.34	0.90	SS	VF	CL	GY	3
		6.34	7.88	1.54	SS	VF	CL	GY	3
		7.88	9.04	1.16	KL				
	EB1804203006	9.04	12.04	3.00	CL		SA	GY	3
	EB1804203007	12.04	15.10	3.06	CL		SA	BN	3
	EB1804203008	15.10	17.87	2.77	CL		SA	BN	3
	EB1804203009	17.87	20.95	3.08	CL		SA	BN	3
	EB1804203010	20.95	23.77	2.82	CL		IS	BN	3
	EB1804203011	23.77	23.97	0.20	SS	VF	CL	BN	3
		23.97	26.49	2.52	SS	VF	CL	BN	3
	EB1804203012	26.49	27.00	0.51	SS	VF		GY	4
BHW		27.00	28.50	1.50	NL				
		28.50	30.08	1.58	SS	VF	AB	GY	6
	EB1804203013	30.08	31.35	1.27	SL		SS	GY	6
		31.35	31.39	0.04	SL			GY	6
		31.39	32.84	1.45	SL		SS	GY	6
	EB1804203014	32.84	32.92	0.08	SS	FN		GY	6
RGCM		32.92	34.20	1.28	NL				
	EB1804203015	34.20	36.14	1.94	SS	FN	QL	GY	6
		36.14	37.32	1.18	SS	FC	QL	GY	6
		37.32	37.39	0.07	ZM			BN	6
	EB1804203016	37.39	38.92	1.53	SS	FM	QL	GY	6
		38.92	39.04	0.12	SS	FN	AB	GY	6
		39.04	39.82	0.78	SS	FN	AB	GY	6
	EB1804203017	39.82	40.96	1.14	SS	FN	QL	GY	6
		40.96	41.28	0.32	SS	FN	QL	GY	6
		41.28	41.77	0.49	SS	FN	QL	GY	6
		41.77	42.19	0.42	SS	FN	AB	GY	6
	EB1804203018	42.19	42.94	0.75	SS	FN	QL	GY	6
		42.94	43.71	0.77	SS	FN	QL	GY	6
		43.71	44.49	0.78	SS	FN	AB	GY	6
		44.49	44.67	0.18	SS	FN	AB	GY	6
	EB1804203019	44.67	45.79	1.12	SS	FN	QL	GY	6
		45.79	47.53	1.74	SS	FM	QL	GY	6
	EB1804203020	47.53	48.56	1.03	SS	FN	AB	GY	6
		48.56	48.59	0.03	CO			BK	6
		48.59	48.78	0.19	SS	FN	AB	GY	6
		48.78	48.84	0.06	CG	PB		GY	6
		48.84	48.91	0.07	SS	FN	OC	GY	6
	EB1804203021	48.91	50.17	1.26	SS	FN	QL	GY	6
		50.17	50.80	0.63	SS	FC	AB	GY	6
		50.80	51.01	0.21	SS	FN	QL	GY	6
		51.01	51.14	0.13	CG		PB	GY	6
		51.14	51.18	0.04	SL			GY	6
		51.18	51.48	0.30	SS	FN	QL	GY	6
	EB1804203022	51.48	53.09	1.61	SS	FN	AB	GY	6
		53.09	53.65	0.56	SS	FN		GY	6
		53.65	54.50	0.85	SS	FM	QL	GY	6
	EB1804203023	54.50	56.55	2.05	SS	FC	OC	GY	6
	EB1804203024	56.55	57.11	0.56	CG	FG	QL	GY	6
		57.11	57.57	0.46	SS	FM	QL	GY	6
		57.57	58.05	0.48	SS	FN	QL	GY	6
A21	EB1804203025	58.05	58.61	0.56	CO		DB	BK	6
A21		58.61	58.62	0.01	XM			BN	6
A21		58.62	58.67	0.05	CO		DB	BK	6
		58.67	59.43	0.76	XM			GY	6
A22		59.43	59.69	0.26	CO		DB	BK	6

Seam	ALS Sample ID	Top	Base	Thickness	Rock	Grain size	Lithology adjective	Colour	Weathering
	EB1804203026	59.69	60.57	0.88	SL			BK	6
		60.57	61.31	0.74	SL		SS	GY	6
	EB1804203027	61.31	62.62	1.31	SS	VF	AB	GY	6
	EB1804203028	62.62	63.67	1.05	SL		AB	GY	6
		63.67	64.05	0.38	SL		AB	GY	6
	EB1804203029	64.05	64.21	0.16	XM			GY	6
C1		64.21	64.28	0.07	DM			BK	6
C1		64.28	64.72	0.44	CO		DY	BK	6
C1		64.72	64.93	0.21	XM			GY	6
C1		64.93	65.10	0.17	CO		DB	BK	6
	EB1804203030	65.10	66.30	1.20	SL			BK	6
		66.30	66.67	0.37	SS	VF		GY	6
	EB1804203031	66.67	69.71	3.04	SS	VF	AB	GY	6
	EB1804203032	69.71	72.72	3.01	SS	FN	QL	GY	6
	EB1804203033	72.72	75.71	2.99	SS	FM	QL	GY	6
	EB1804203034	75.71	76.56	0.85	SS	FN	CO	GY	6
		76.56	76.60	0.04	CO		DY	BK	6
		76.60	76.66	0.06	SS	FN		GY	6
	EB1804203035	76.66	76.88	0.22	SL			GY	6
		76.88	78.48	1.60	SS	FN	QL	GY	6
	EB1804203036	78.48	78.70	0.22	SS	FN	AB	GY	6
		78.70	79.34	0.64	SS	FN	AB	GY	6
		79.34	81.11	1.77	SS	FN	QL	GY	6
	EB1804203037	81.11	81.71	0.60	SL			GY	6
		81.71	82.17	0.46	SS	VF	AB	GY	6
		82.17	83.09	0.92	SL		SN		
		83.09	83.42	0.33	SL		OC	GY	6
	EB1804203038	83.42	84.71	1.29	XM		OC	GY	6
	EB1804203039	84.71	86.32	1.61	SS	FN	AB	GY	6
		86.32	86.33	0.01	CO			BK	6
		86.33	86.38	0.05	XS	FN		GY	6
		86.38	86.73	0.35	SS	FN		GY	6
		86.73	86.86	0.13	SS	FN	AB	GY	6
	EB1804203040	86.86	87.14	0.28	SL			GY	6
		87.14	87.16	0.02	CO			BK	6
		87.16	87.22	0.06	SS	FM		GY	6
		87.22	87.74	0.52	SL			GY	6
		87.74	88.86	1.12	SL			GY	6
	EB1804203041	88.86	89.13	0.27	SL		CO	GY	6
		89.13	89.53	0.40	SL			GY	6

Table 3-4: Drill hole log C5285 C Pit

Seam	ALS Sample ID	Top	Base	Thickness	Rock	Grain size	Lithology adjective	Colour	Weathering
SOIL	EB1803494001	0.00	1.00	1.00	CL		IS	BN	2
RWGP	EB1803494002	1.00	3.10	2.10	CL		IS	BN	2
	EB1803494003	3.10	4.03	0.93	CL		IS	BN	2
		4.03	4.13	0.10	SS	VF		BN	3
		4.13	4.36	0.23	CL		IS	BN	3
		4.36	4.39	0.03	SS	VF		BN	3
		4.39	5.06	0.67	CL		IS	BN	2
	EB1803494004	5.06	6.20	1.14	SS	VF		BN	3
		6.20	6.74	0.54	SS	VF		BN	3
	EB1803494005	6.74	9.30	2.56	SL			BN	3
	EB1803494006	9.30	11.34	2.04	SL			BN	3
	EB1803494007	11.34	12.36	1.02	SL		OC	BN	3
BHW		12.36	12.76	0.40	NL				
	EB1803494008	12.76	15.49	2.73	SS	VF	QL	GY	6
		15.49	18.48	2.99	SS	FM	AB	GY	6

Seam	ALS Sample ID	Top	Base	Thickness	Rock	Grain size	Lithology adjective	Colour	Weathering
		18.48	19.25	0.77	SS	FN	AB	GY	6
		19.25	19.79	0.54	SS	VF	AB	GY	6
		19.79	21.00	1.21	SS	FN		GY	6
	EB1803494009	21.00	21.48	0.48	SS	FN		GY	6
		21.48	22.81	1.33	SS	VF	OC	GY	6
	EB1803494010	22.81	23.00	0.19	SL			GY	6
		23.00	24.50	1.50	SL			GY	6
	EB1803494011	24.50	27.54	3.04	SS	VF	AB	GY	6
	EB1803494012	27.54	29.30	1.76	SS	VF		GY	6
		29.30	30.60	1.30	SS	VF	AB	GY	6
	EB1803494013	30.60	33.55	2.95	SL			GY	6
	EB1803494014	33.55	33.98	0.43	SS	VF	SI	GY	6
		33.98	34.13	0.15	SL			BN	6
	EB1803494015	34.13	36.60	2.47	SS	FN	AB	BN	6
	EB1803494016	36.60	37.95	1.35	SS	VF	AB	GY	6
	EB1803494017	37.95	38.47	0.52	SS	VF		GY	6
		38.47	38.76	0.29	SL		AR	GY	6
		38.76	39.55	0.79	SS	VF	AB	GY	6
	EB1803494018	39.55	42.21	2.66	SS	VF	AB	GY	6
	EB1803494019	42.21	42.40	0.19	SS	VF	AB	GY	6
		42.40	42.56	0.16	XS	VF	AB	GY	6
	EB1803494020	42.56	44.43	1.87	SS	VF	OC	GY	6
	EB1803494021	44.43	45.34	0.91	SS	VF		GY	6
		45.34	45.59	0.25	SS	VF		GY	6
		45.59	46.09	0.50	SS	VF		GY	6
	EB1803494022	46.09	47.06	0.97	SS	VF		GY	6
		47.06	48.09	1.03	SS	VF	AB	GY	6
		48.09	48.61	0.52	SS	VF	SN	GY	6
	EB1803494023	48.61	50.78	2.17	SS	VF	AB	GY	6
	EB1803494025	51.63	53.73	2.10	SS	VF	SB	GY	6
	EB1803494026	53.73	54.00	0.27	XM			GY	6
		54.00	54.60	0.60	SS	VF		GY	6
	EB1803494027	54.60	57.66	3.06	SS	VF	OC	GY	6
	EB1803494028	57.66	58.71	1.05	SS	VF	AB	GY	6
		58.71	59.14	0.43	SS	VF		GY	6
	EB1803494029	59.14	59.44	0.30	SL			GY	6
		59.44	59.87	0.43	SS	VF		GY	6
		59.87	60.67	0.80	SL		SS	GY	6
	EB1803494030	60.67	61.44	0.77	SS	VF	OC	GY	6
		61.44	61.56	0.12	SS	FN		GY	6
	EB1803494031	61.56	61.61	0.05	SL			GY	6
		61.61	63.43	1.82	SS	VF	AB	GY	6
	EB1803494032	63.43	63.67	0.24	SS	VF		GY	6
		63.67	64.43	0.76	SS	FN		GY	6
	EB1803494033	64.43	66.42	1.99	SS	VF	AB	GY	6
	EB1803494034	66.42	66.67	0.25	SL			GY	6
		66.67	67.88	1.21	SS	VF	OC	GY	6
	EB1803494035	67.88	68.35	0.47	SL			GY	6
		68.35	69.72	1.37	SS	VF	AB	GY	6

Seam	ALS Sample ID	Top	Base	Thickness	Rock	Grain size	Lithology adjective	Colour	Weathering
	EB1803494036	69.72	72.74	3.02	SS	FN	OC	GY	6
	EB1803494037	72.74	73.14	0.40	SS	VF		GY	6
		73.14	75.74	2.60	SS	VF	OC	GY	6
	EB1803494038	75.74	77.09	1.35	SS	FN	QL	GY	6
	EB1803494039	77.09	77.73	0.64	SL			GY	6
		77.73	78.80	1.07	SL			GY	6
RGCM		77.73	80.45	2.72	NL				
	EB1803494040	78.80	80.45	1.65	SL		SN	GY	6
	EB1803494041	80.45	83.32	2.87	SS	VF			
		83.32	83.50	0.18	SS	VF			
	EB1803494042	83.50	84.38	0.88	SL				
		84.38	84.83	0.45	SL				
	EB1803494043	84.83	87.49	2.66	SS	VF	AB		
	EB1803494044	87.49	88.32	0.83	SL		OC		
	EB1803494045	88.32	90.60	2.28	SS	VF	AB		
	EB1803494046	90.60	90.83	0.23	SS	FN	OC	GY	6
A1		90.83	91.66	0.83	CO		DB	BK	6
		91.66	92.89	1.23	SS	VF	AB	GY	6
	EB1803494047	92.89	92.97	0.08	SD			BN	6
		92.97	93.62	0.65	SS	VF		GY	6
		93.62	96.35	2.73	SS	FN	AB	GY	6
	EB1803494048	96.35	96.41	0.06	XS	VF		BK	6
		96.41	96.70	0.29	SS	FN		GY	6
		96.70	97.20	0.50	SS	FN	QL	GY	6
		97.20	99.06	1.86	SS	FN	QL	GY	6
	EB1803494049	99.06	99.57	0.51	SL			GY	6
		99.57	99.68	0.11	XM			GY	6
		99.68	100.46	0.78	XM			GY	6
		100.46	101.42	0.96	SL		OC	GY	6
	EB1803494050	101.42	101.79	0.37	SS	VF	AB	GY	6
		101.79	101.98	0.19	SS	VF	AB	GY	6
		101.98	102.07	0.09	SS	VF		GY	6
		102.07	102.73	0.66	SS	VF	AB	GY	6
		102.73	103.89	1.16	SS	FM	QL	GY	6
	EB1803494051	103.89	104.19	0.30	SS	FN	AB	GY	6
		104.19	104.26	0.07	SS	VF	AB	GY	6
		104.26	104.36	0.10	SS	FN		GY	6
		104.36	104.71	0.35	SS	VF	AB	GY	6
		104.71	104.77	0.06	SS	FN	QL	GY	6
		104.77	105.18	0.41	SS	VF	AB	GY	6
		105.18	105.31	0.13	SS	FN	QL	GY	6
		105.31	105.76	0.45	SS	VF	AB	GY	6
	EB1803494052	105.76	105.96	0.20	SS	VF	AB	GY	6
		105.96	106.22	0.26	XM			GY	6

3.1.1 Drilling fluids

Saline water (**Appendix A.3.5**) and drill mud was used for the diamond core drilling program. The water was from site-based water stores (**Table 3-1**). Water for the C pit hole (C5285) was from R24 fill point dam. Water for the Y pit hole (C5286) was from Ramp 10. The additives used by the drilling company in the two fully cored boreholes were: Liqui Mud, CRP, Pressure Lube and Terge.

As the core was washed prior to preparation for the KLC test program, fluids used for drilling are unlikely to have an effect on the competent Tertiary and Permian drill core tested in the KLC test program.

3.2 In-pit aged spoil sampling and analysis

Six aged bulk spoil samples from B, D and Y pit (approximately 30 kg each) were collected by Ensham personnel in February 2018 for the KLC program and analysed (**Table 3-2**). The samples were collected were:

- Quaternary, Tertiary and Permian spoil from B Pit
- Quaternary and Permian samples from Y Pit from the old ponded landform.
- Permian sample from D Pit near the top of the ramp (exposed for approximately 20 years).

Samples were collected by hand using a shovel from the upper 0.5 m of the spoil. Images of the six aged spoil sample locations are in **Figure 3-2**. Sample material ranged in size from cobble to silt/clay sized sedimentary material. Grain sizes of the sedimentary material ranged from coarse sand to silt/clay sized.

Ensham site personnel subsequently collected an additional 29 bulk samples in May 2018 from in-pit spoil for Quaternary, Tertiary and Permian materials to provide additional data on the static geochemical properties of the spoil.

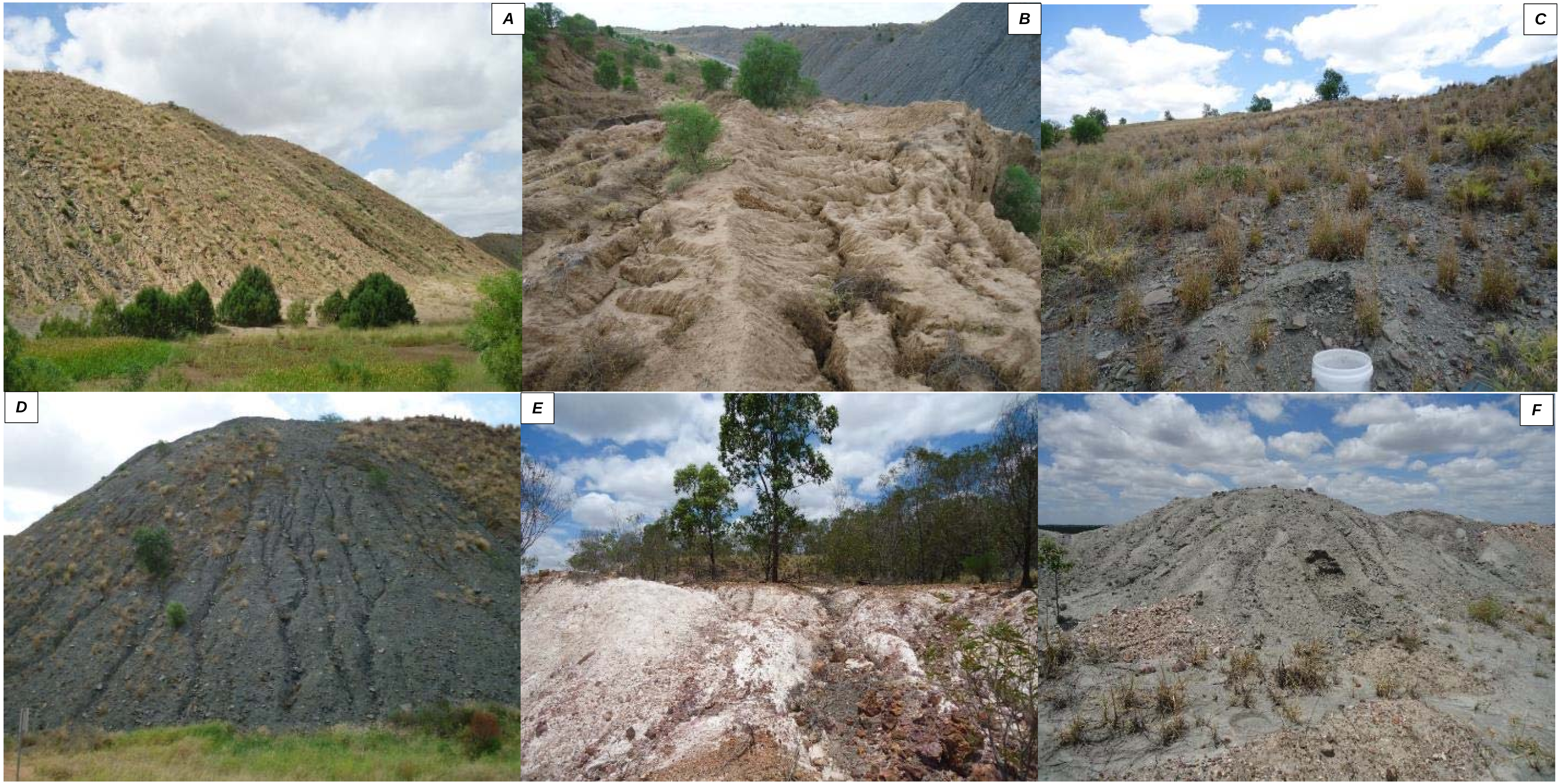

Figure 3-2: Aged spoil sample locations

(A) B Pit Quaternary spoil, (B) B Pit Tertiary spoil, (C) B Pit Permian spoil, (D) D Pit Permian Spoil, (E) Y Pit Quaternary Spoil and (F) Y Pit Permian Spoil

3.3 Pit void water sampling and analysis

Six 15 L drums of water were provided to RGS from Ramp 22 in A Pit. The pit water was used as part of the KLC test program.

3.4 Pit seeps sampling and analysis

There are no in-pit seepage records in the site surface or groundwater databases. Three seepage samples were collected from two locations and sent for analysis by Ensham staff. Seepage Sample 1 was collected on 28 February 2018 on Ramp 4 and was analysed on 1 March. This seep is hypothesised to be coming from an in-pit dam via a fault when the dam overflows. The 2 samples from Seepage 2 were analysed on 1 and 6 March 2018. These samples were collected from Ramp 4 and are thought to be seepage from spoil. The analyses of the seep samples are provided in **Appendix A.4.2** and the locations of collection are shown in **Figure 3-3**.

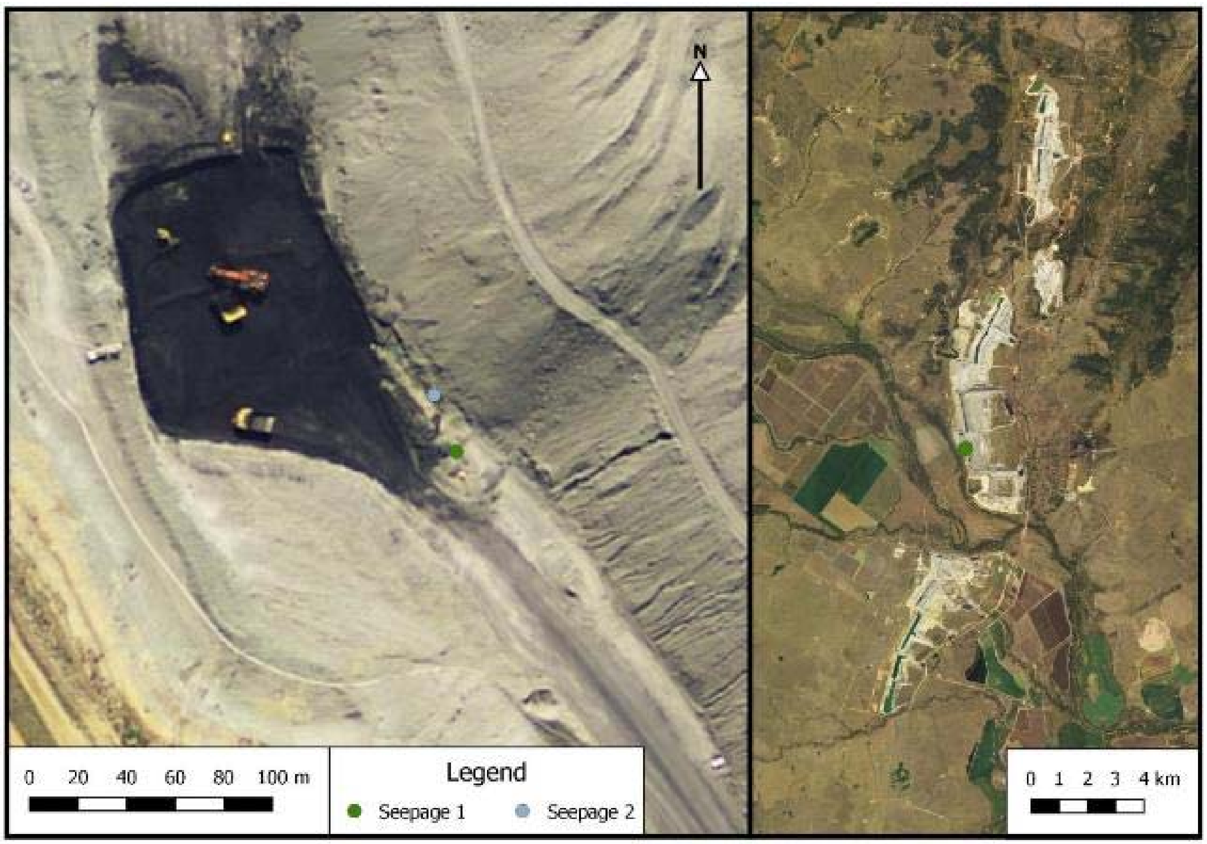

Figure 3-3: Seepage sample locations

3.5 Groundwater sampling and analysis

Groundwater samples were collected by Ensham staff from 2006 to 2017 from 58 bores in the Ensham coal mine area (**Figure 3-4**). Results from these analyses are presented in **Appendix A.4.3**.

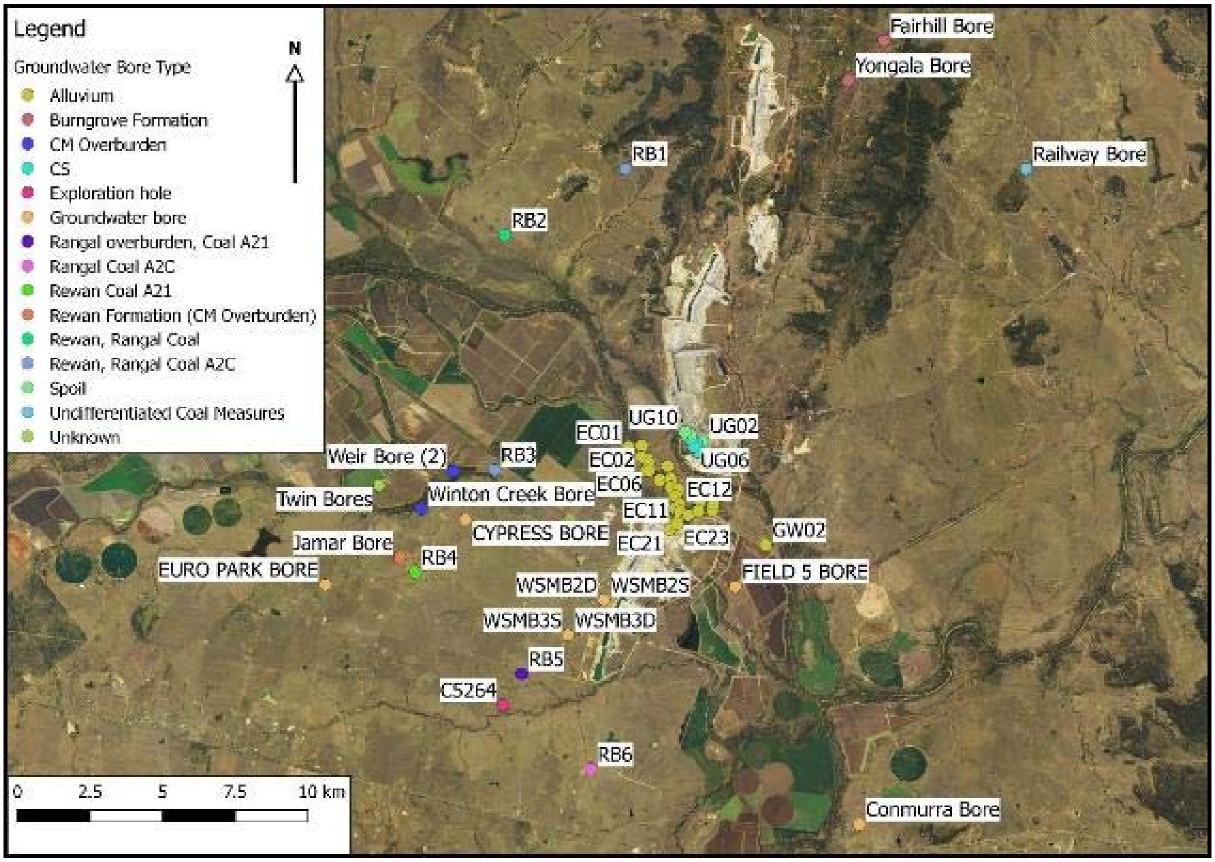

Figure 3-4: Groundwater bore locations, coloured by bore type

3.6 Surface water sampling and analysis

Surface water samples were collected and analysed by Ensham personnel from Ramp 10, Ramp 20, Ramp 21 and Ramp 22 (**Figure 3-5**) (i.e. where water had collected and could be sampled) and results are presented and discussed in **Appendix A.4.4** to provide some context on the quality of the water in the pits at the site.

Surface water samples were collected by Ensham staff between 31 January 2006 to 26 October 2017 from the Nogoa River: results for the Nogoa River are provided in **Appendix 0**.

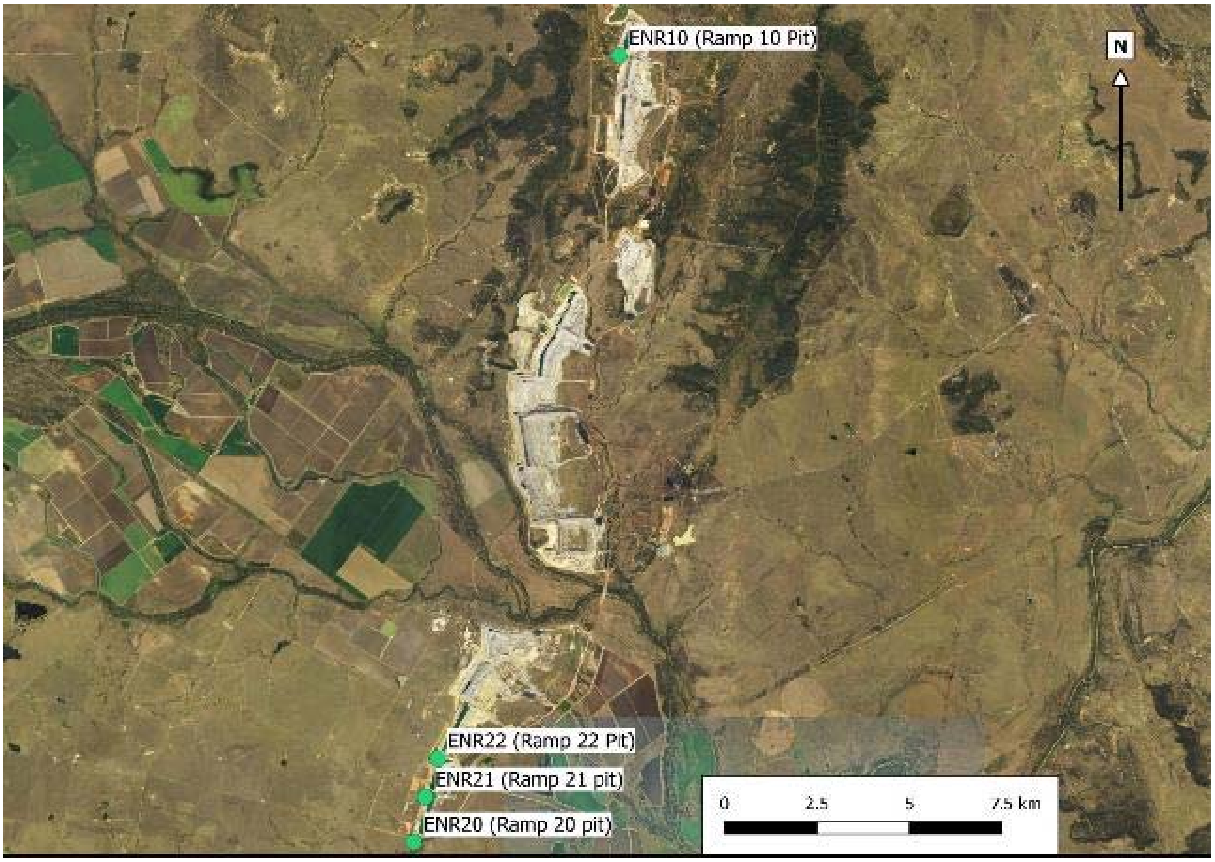

Figure 3-5: Surface water sample locations

3.7 Kinetic leach cell testing program

KLC leach testing has commenced on selected representative sample materials and data for reporting is currently available for four months of testing. KLC testing may be extended to ensure that sulfide oxidation issues remain negligible and verify that salt and metal(loid) concentrations continue to decrease over time.

A sample from each of the composites to be used in the KLC tests was submitted for static analysis before the composites were placed in the columns. For the fresh core and aged spoil samples, RGS conducted 6 weekly leach cycles and then 4 fortnightly leach cycles (10 leach cycles in total over ≈4 months).

The KLC column dimensions are 20 cm diameter by 65 cm high and approximately 11 kg of sample was used in each column. All samples were crushed to < 19 mm particle size distribution prior to use.

Photographs of the Tertiary and Permian drill core samples and Tertiary/Quaternary/Permian spoil samples are in **Figure 3-6, Figure 3-7 and Figure 3-8**. The sample preparation and data utilisation processes are provided in **Figure 3-9**.

Unsaturated Free Draining KLC testing

Initially the samples were ‘wet-up’ with de-ionised water to obtain 1 L of leachate for analysis by ALS. Subsequent leach events utilised approximately 0.7 L of water that is equivalent to 25 mm of water applied to the top of the column.

The permeability of the material varies with the physical properties of the sample. The volume (in and out), pH, EC and Eh of the sample collected from the column is measured at 8 hours for free draining samples, and at 24 and 48 hours for samples that have a higher clay content and lower permeability.

The pH, EC, acidity, alkalinity, major ions and metal(loid)s in the leachate were measured by ALS.

Saline Saturated KLC testing

For the saline saturated columns, water from A Pit was added to saturate the spoil samples. There was insufficient pit water to maintain zero head space in these samples. The intent of these KLC tests was to leach the spoil samples over the duration of the KLC program with saline water to evaluate the effect this would have on the spoil samples.

For each leach event approximately 0.5 L of water, equivalent to 15 mm, was drained from the KLC and removed from the bottom of the cell over an approximately an 8-hour period.

The volume (in and out), pH, EC and Eh of the sample collected from the column was measured at 8 hours for free draining samples, and at 24 and 48 hours for samples which had a higher clay content and lower permeability. The pH, EC, acidity, alkalinity, major ions and metals in the leachate were measured by ALS.

Deionised Water Saturated KLC testing

For the non-saline saturated columns deionised water was added to saturate the spoil samples.

The intent of these KLC tests was to leach the spoil samples over the duration of the KLC program with non-saline water to evaluate the effect this would have on the spoil samples.

An Eh probe was placed into the centre of the sample as the column was being filled with the sample. A lid was placed on top of the column and sealed with silicon. The fill port on the top of the lid and the cable port for the Eh probe was sealed with silicon to ensure there was no air within the flow through cell. Initially the samples were wet-up with deionised water to fill pore voids and remove any air from the cell. The Eh was measured every hour from 7 am to 3 pm for 2 weeks, every day until no changes in Eh were evident and then weekly.

For each leach event 0.5 L of water, equivalent to 15 mm, was added to the top of the cell and 0.5 L was removed from the bottom of the cell over an approximately an 8-hour period. This was done to minimise air entry into or out of the column.

The volume (in and out), pH, EC and Eh of the sample collected from the column was measured at 8 hours for free draining samples, and at 24 and 48 hours for samples that have a higher clay content and lower permeability. The pH, EC, acidity, alkalinity, major ions and metals in the leachate were measured by ALS.

Approximately one pore volume of deionised water was leached through these columns between the 4th and 6th leach cycle, the second pore volume was leached through the column after the 8th or 9th leach cycle and the third pore volume was leached through the columns on the 9th or 10th leach cycle.

Figure 3-6: C Pit Permian drill core (left) Tertiary drill core (right)

Figure 3-7: Y Pit Permian spoil (left) Quaternary/Tertiary Spoil (right)

Figure 3-8: Permian spoil (left) Quaternary/Tertiary Spoil (right)

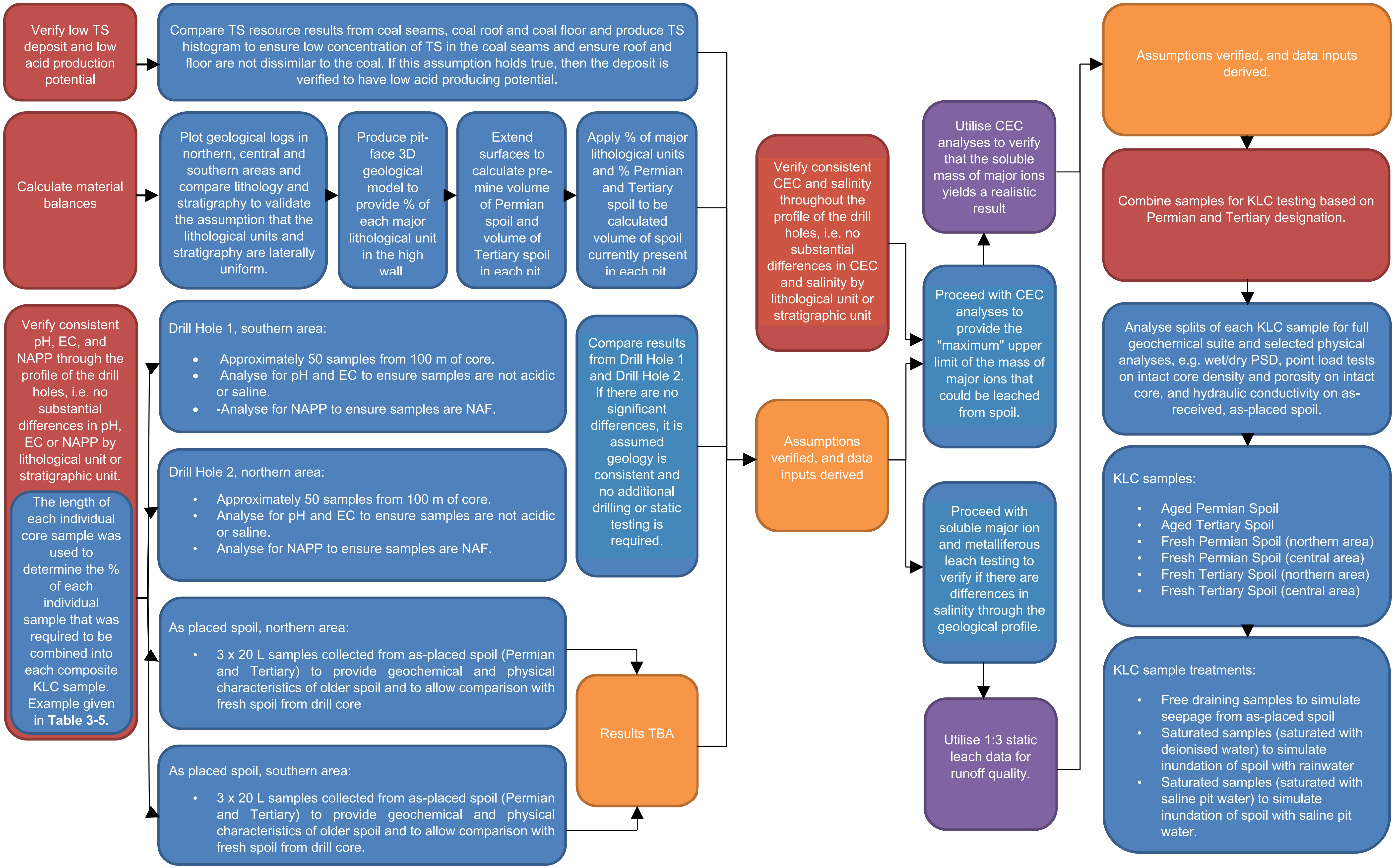

Figure 3-9: Sample process flow chart

3.7.1 Kinetic leach cell testing – fresh core samples

The less than 19 mm size sample size fraction was used in the KLC columns. After the static results were provided by ALS, the 95 samples were used to composite 4 bulk samples for KLC testing that included:

- 1 x Tertiary sandstone/siltstone and 1 x Permian sandstone/siltstone sample from each drill hole (4 samples);
- Subjecting the 4 samples to free draining leach testing to simulate the leaching of spoil within unsaturated (vadose) zones;
- Subjecting the 4 samples to fully saturated leach testing to simulate geochemical processes of spoil inundated by rainwater; and,
- Subjecting the 4 samples to fully saturated leach testing to simulate geochemical processes of spoil inundated by either saline ≈8,000 µS/cm pit or groundwater to simulate what may happen if the spoil is pushed into the final void water (e.g. will the porewater EC value increase).

The compositing of the 95 samples was done using the chemical and lithological data from the samples to provide bulk samples that are representative of the material within the drill holes. In general terms samples of Tertiary and Permian strata were obtained from each drill hole. An example of how the samples were composited is in **Table 3-5**.

3.7.2 Kinetic leach cell testing – aged spoil samples

RGS obtained 6 x 20 L (approx. 30kg) aged spoil samples from ECM (**Section 3.2**). Sub-samples from each of the 20 L samples was analysed using the static analytical program to evaluate differences in the different material types. The in-pit spoil samples were combined into 2 x 60 L samples (approx. 120 kg) (representing mixed aged spoil) for the following KLC testing.

- Subjecting the 2 samples to free draining leach testing to simulate the leaching of spoil within unsaturated (vadose) zones;
- Subjecting the 2 samples to fully saturated leach testing to simulate geochemical processes of spoil inundated by rainwater; and,
- Subjecting the 2 samples to fully saturated leach testing to simulate geochemical processes of spoil inundated by either saline ≈8,000 µS/cm pit or groundwater to simulate what may happen if the spoil is pushed into the final void water (e.g. will the porewater EC increase).

Table 3-5: KLC composite creation example

From (m)	To (m)	Length (m)	% of each interval within the total core length	Mass of each sample in KLC sample (kg)
0	1	1	7	0.8
1	3	2	13	1.6
3	6	3	20	2.4
6	7	1	7	0.8
7	10	3	20	2.4
10	11.5	1.5	10	1.2
11.5	15	3.5	23	2.8
Total interval length		15	100	
Mass of KLC sample (kg)				12

4 Geochemical and physical material results and interpretation

4.1 Hyperspectral mineralogy

The core from the two drill holes was viewed at the Queensland Department of Natural Resources, Mines and Energy (DNRME previously DNRM) laboratory in Geebung and approximately 9 m of core samples (**Figure 4-1 and Figure 4-2**) were collected for hyperspectral mineralogical analysis to identify non-sulfide mineral content (**Figure 4-3 and Figure 4-4**).

Based on hyperspectral mineralogical analysis, it was interpreted that samples from drill hole C5285 are comprised mostly of quartz and kaolinite. Quaternary and Tertiary core also contain montmorillonite, often in similar proportions to kaolinite. Mixed micaceous minerals were present in the upper 85 m of samples, below this depth core was predominately quartz and kaolinite with minor feldspars. Two samples contained carbonate minerals, the Quaternary core and a Tertiary sample from 15 m depth. The Tertiary sample contained approximately twice as much carbonate as the Quaternary sample. It should be noted that carbonate included both calcite and siderite.

Drill hole C5286 hyperspectral mineralogical analysis results showed that it was comprised mostly of kaolinite in the Quaternary and Tertiary core and montmorillonite in the Permian core. Similar amounts of quartz and albite were seen throughout and minimal amounts of calcite, chlorite and muscovite/phengite were in the Permian core.

Figure 4-1: Drill core form C5285 in C Pit

Figure 4-2: Drill core from C5286 in Y Pit

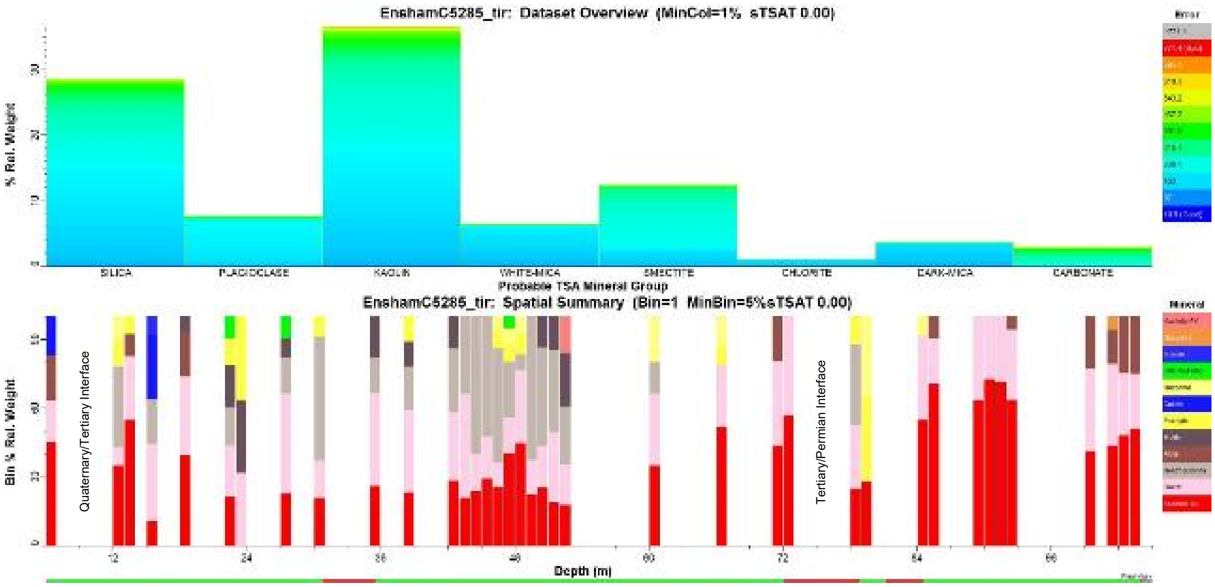

Figure 4-3: C5285 mineralogy

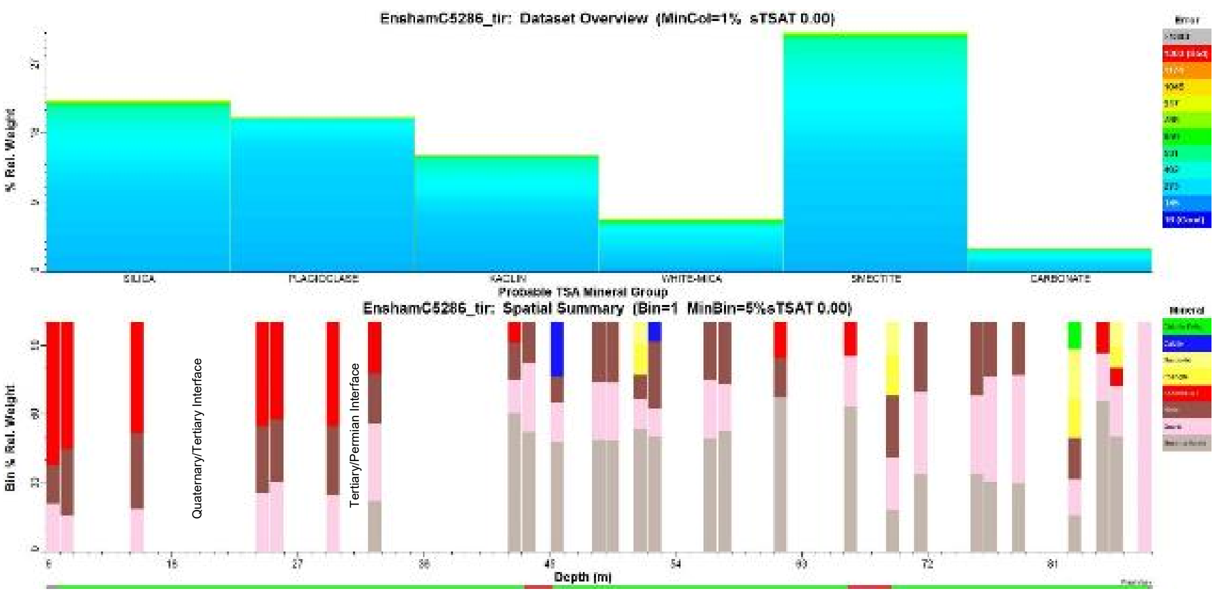

Figure 4-4: C5286 mineralogy

4.2 Drill core physical properties

Following hyperspectral mineralogical analysis, the relevant core was sent to Trilab Pty Ltd for point load testing to quantify core hardness, porosity and density. Overall, the hardness of both cores increased with depth (**Figure 4-5**). Core porosity decreased with depth and is generally inversely related to hardness (**Figure 4-6**). Dry density of the core slightly increased with increasing depth and was generally positively correlated with hardness (**Figure 4-7**).

Core from drill hole C5285 showed a marked increase in hardness and density and decrease of similar magnitude in porosity at approximately 15 m depth. This contrasts with the decrease in hardness at approximately 43 m which showed no change of similar magnitude in density or porosity. Tertiary core from drill hole C5285 had a greater variability in hardness and porosity compared to Permian core. The major variations observed in density, hardness and porosity were most likely due to the geotechnical properties of different rock types. The decreasing magnitude of variation with depth was interpreted as being increased competency and compaction due to increasing pressure from overlying strata (**Figure 4-8**).

Samples from drill hole C5286 were less dense than samples from a similar depth in drill hole C5285 and density increases with depth by a larger magnitude than in C5285. Compared to Tertiary and Permian samples, Quaternary samples were softer and more porous. This is most likely due to their comparatively shallow burial and relatively recent deposition. There is little variation in hardness, density and porosity in Tertiary sediments, this may be due to the small sample size of Tertiary core (n=2). Permian strata showed some variation, which is again thought to be largely a reflection of the type of lithological unit tested. As with drill hole C5285, the magnitude of variation generally decreased with increasing depth (**Figure 4-9**).

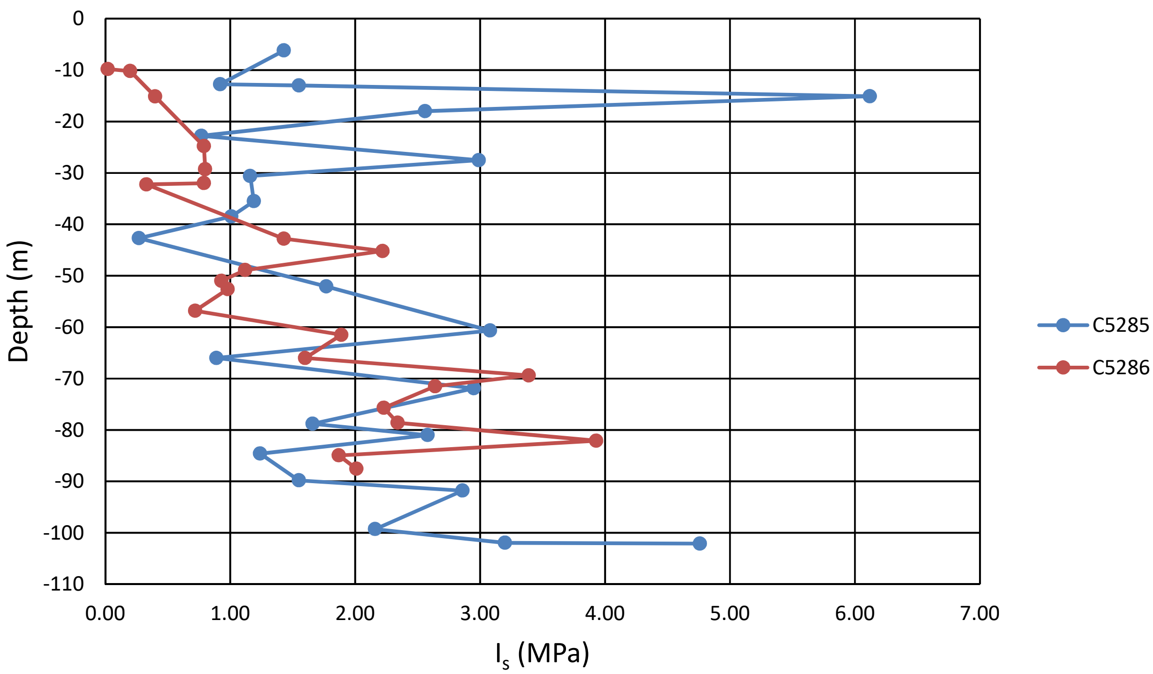

Figure 4-5: Hardness by depth

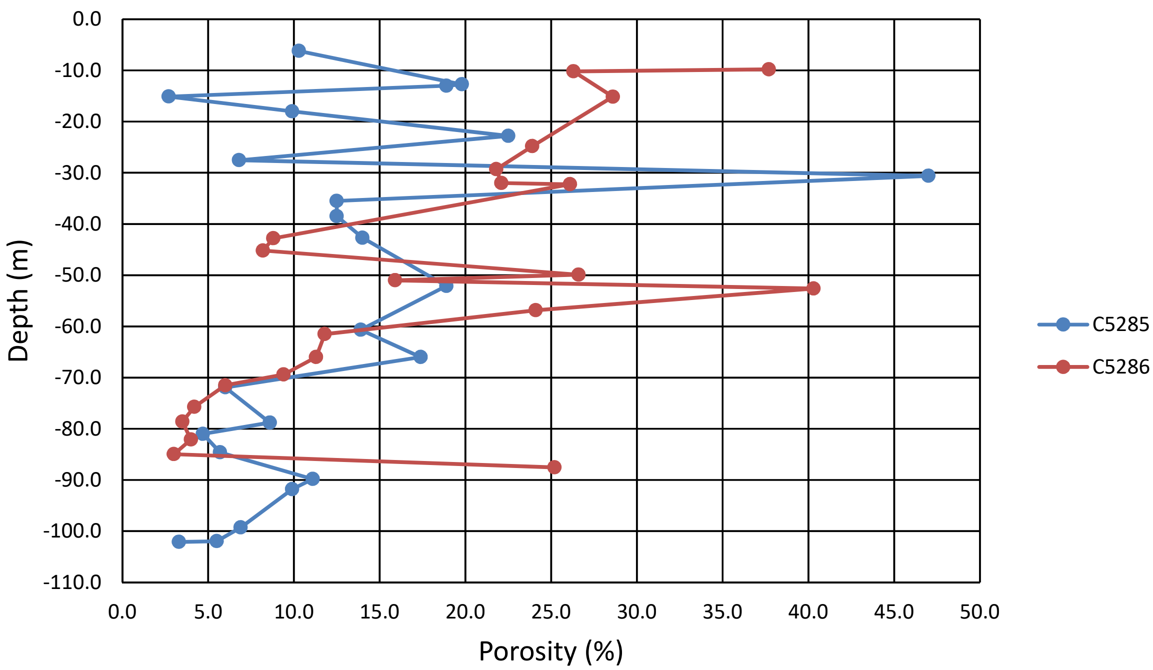

Figure 4-6: Porosity by depth

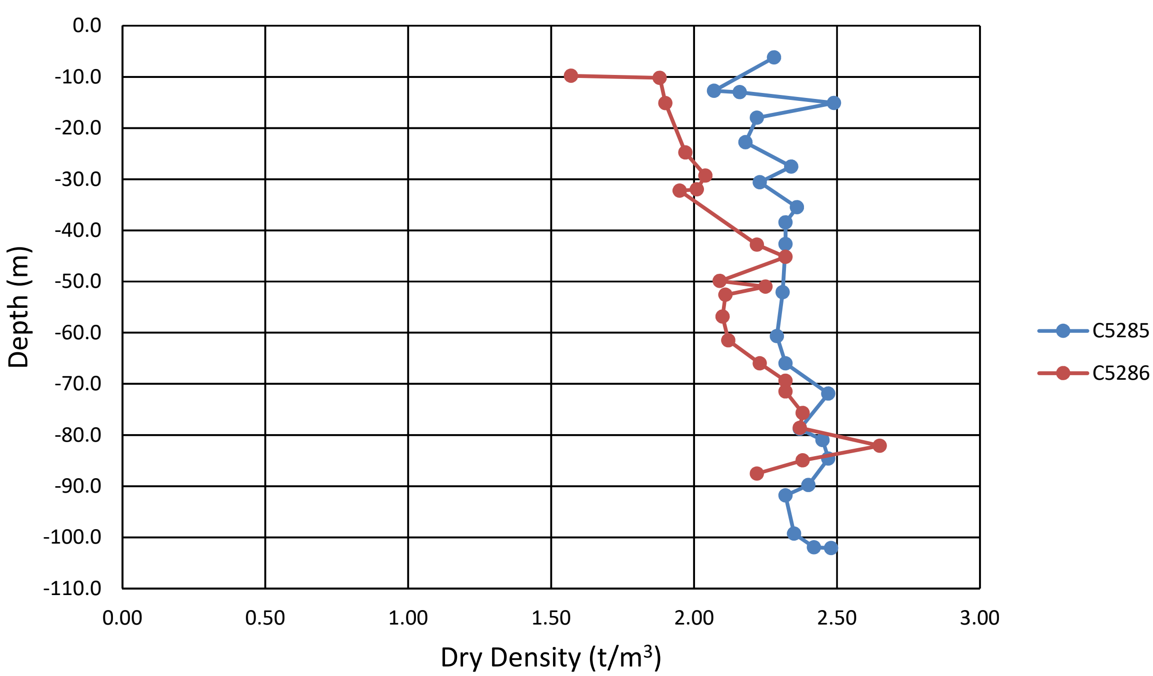

Figure 4-7: Dry density by depth

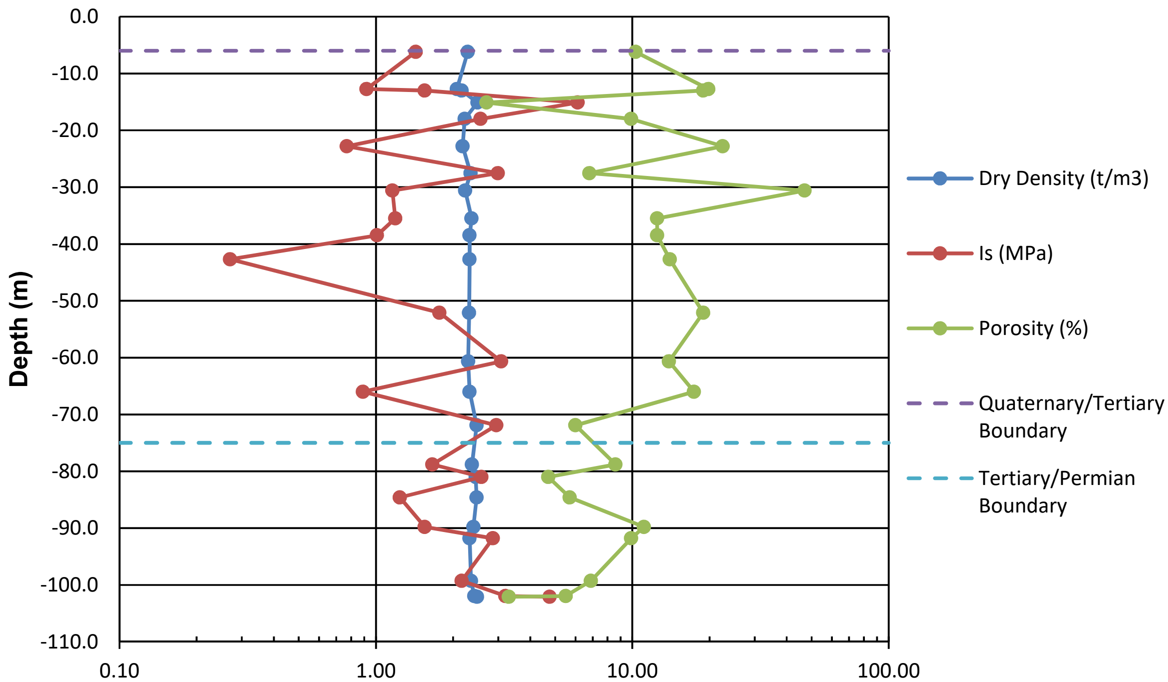

Figure 4-8: Physical properties of C5285

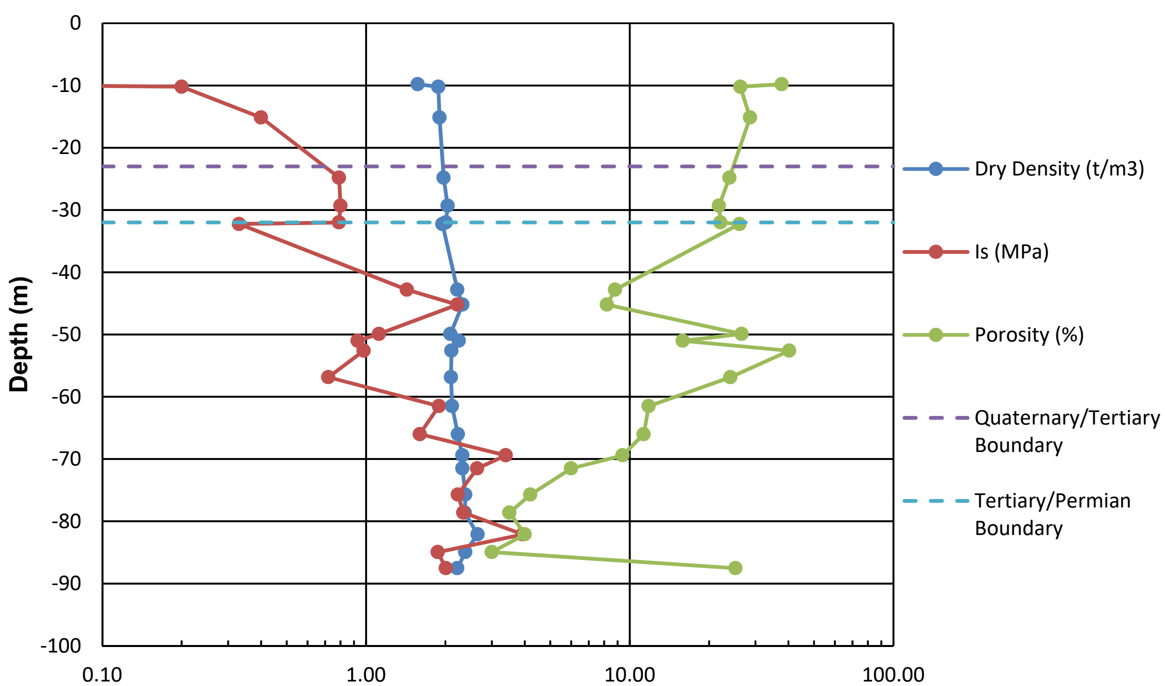

Figure 4-9: Physical properties of C5286

4.3 Static drill core results

Static core geochemistry results are shown in **Figure 4-10, Figure 4-11, Figure 4-12 and Figure 4-13**. Acid Base Accounting was undertaken for the drill hole samples. The potential for acid generation and the criteria used to classify the samples is summarised in **Table 4-1**. The coal on the high wall and pit floors and the overburden and interburden contains minor sulfide minerals that will oxidise and potentially produce acidity and associated salts and metal(loid)s, but the acid will be neutralised by the excess alkalinity resulting in neutral pH drainage.

All static laboratory results received from ALS environmental laboratory are provided in **Appendix A.3**.

Table 4-1: Potential AMD classification for drill hole samples

Classification	1:5 pH	Total Sulfur %	NPR	No. of Samples (n=92)
Non-Acid Forming (Barren)	> 5	≤ 0.05	≥ 3	75
Non-Acid Forming	> 5	> 0.05 and < 0.2%	≥ 3	6
Potentially Acid Forming – Low Capacity (PAF-LC)	> 5	< 0.1	< 3	5
Potentially Acid Forming (PAF)	> 5	> 0.1	< 3	6

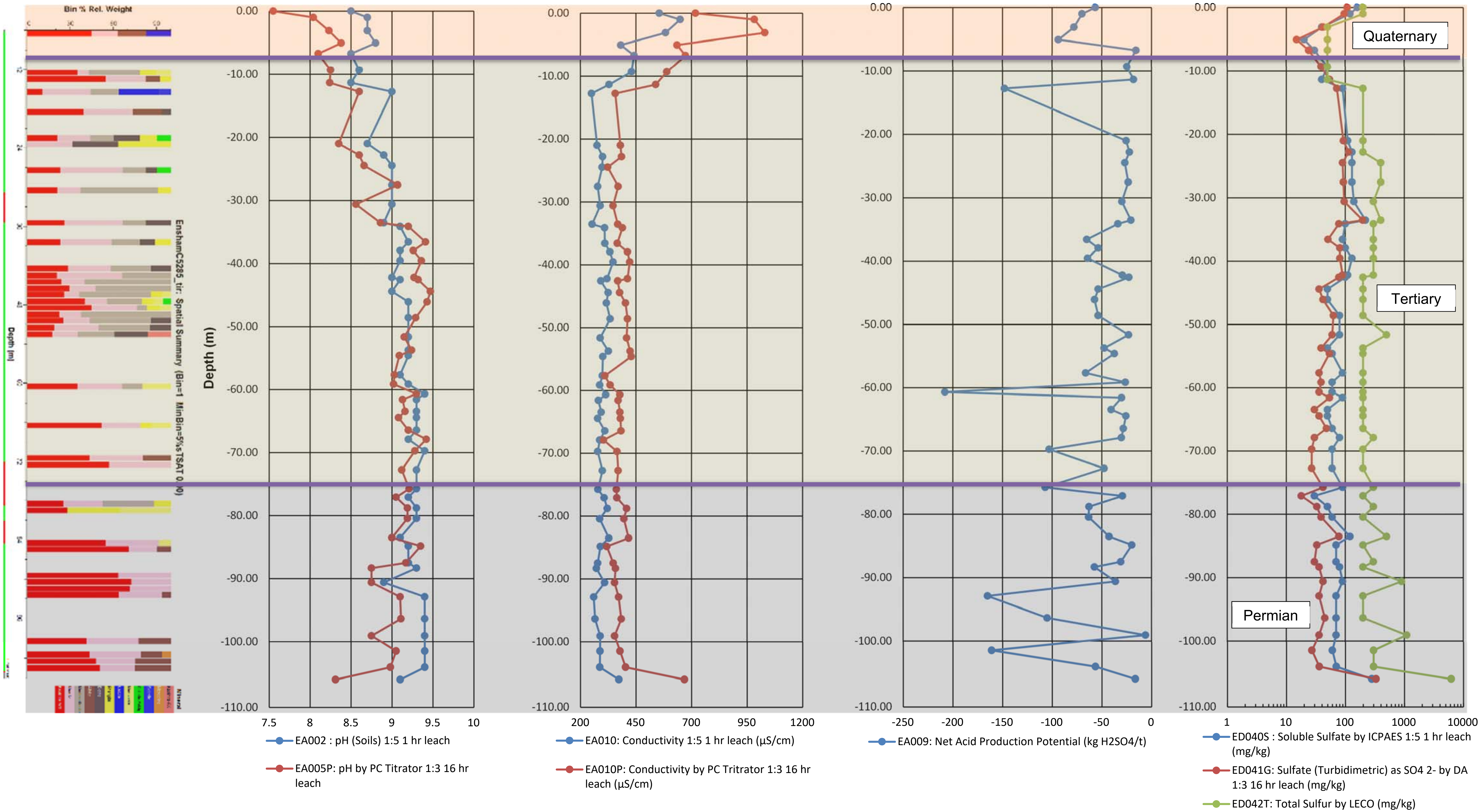

Figure 4-10: Drill hole C5285 static analysis pH, EC, NAPP, sulfate/total sulfur results

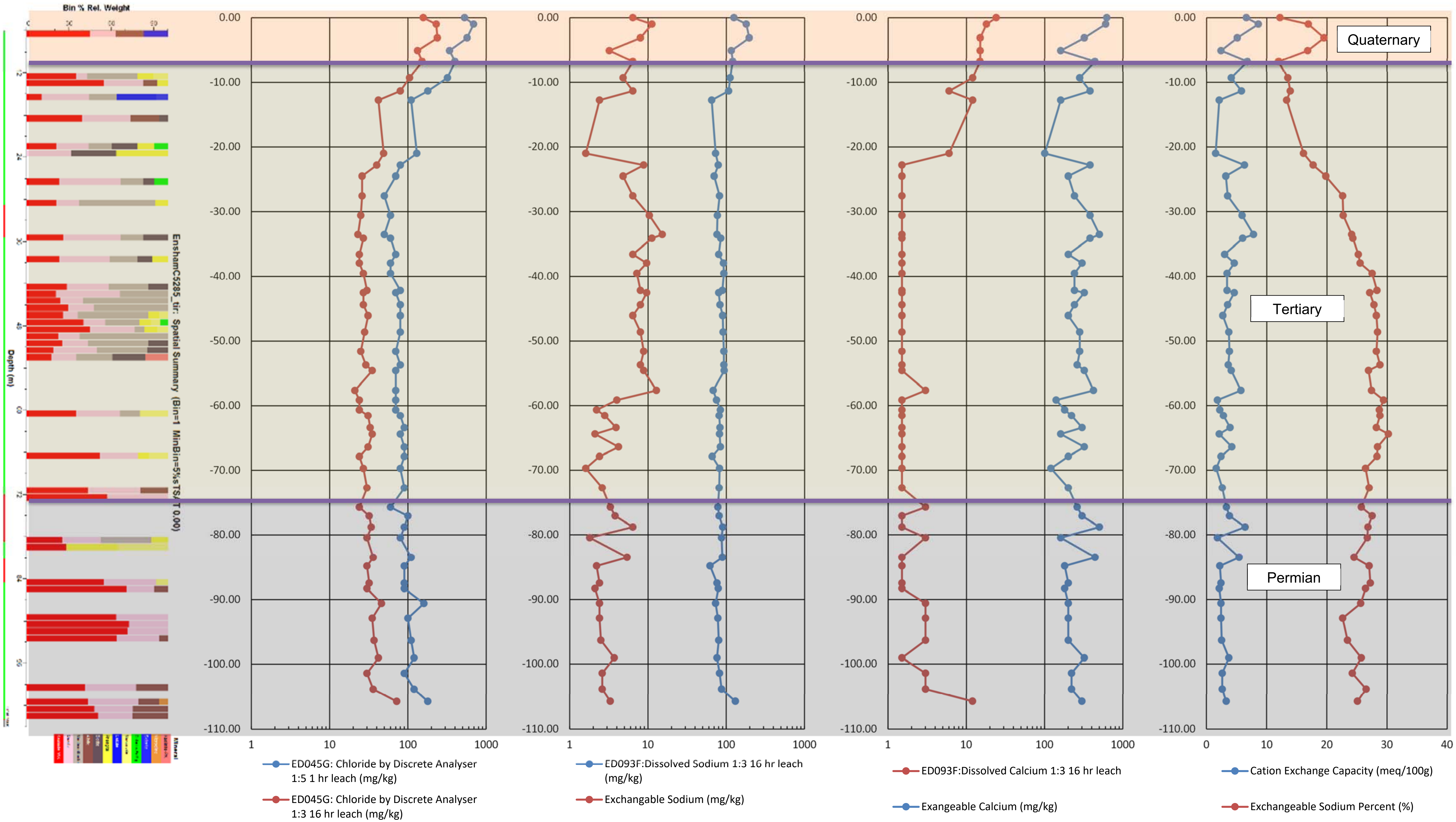

Figure 4-11: Drill hole C5285 static analysis chloride, sodium, calcium, CEC results

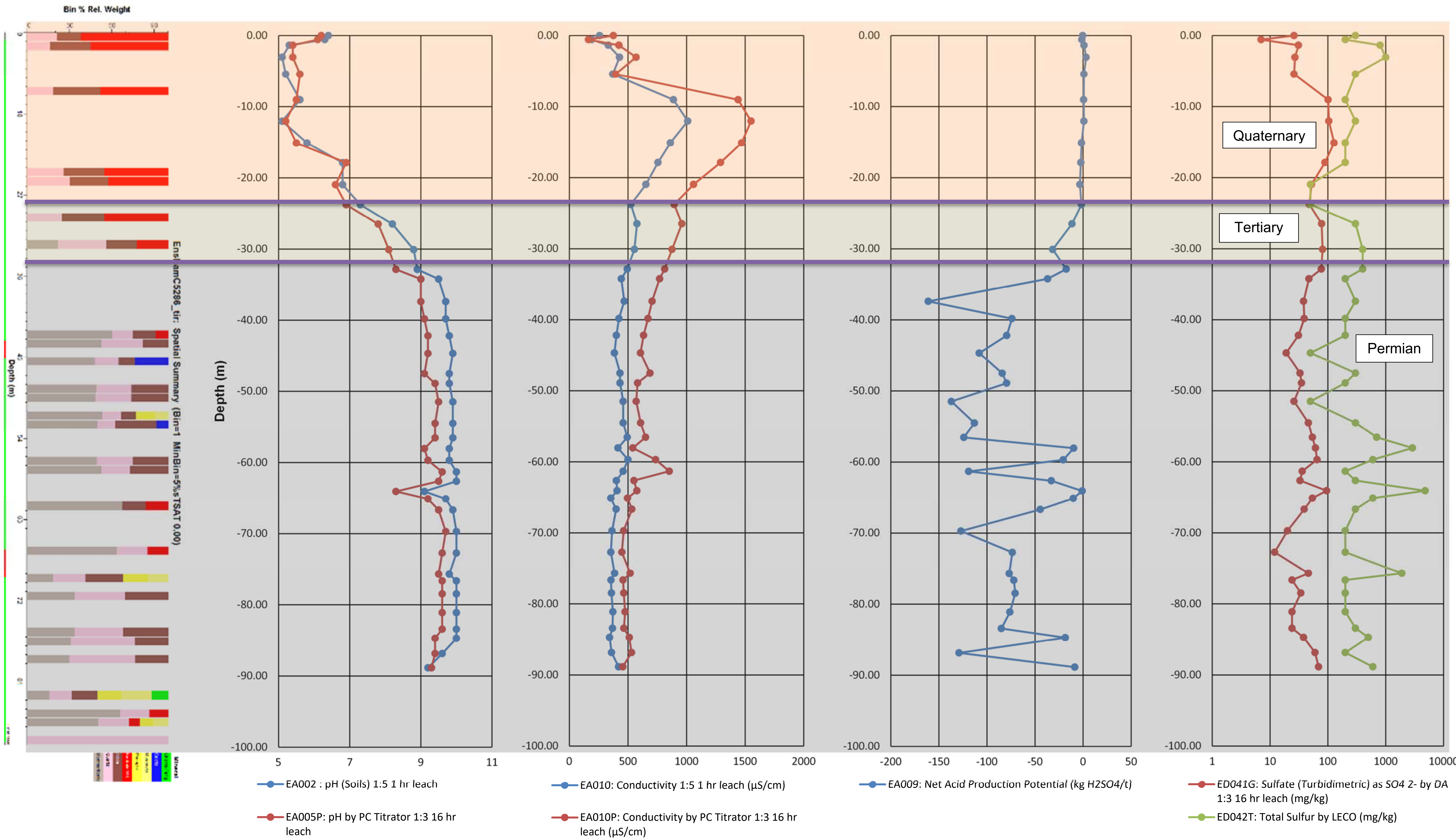

Figure 4-12: Drill hole C5286 static analysis pH, EC, NAPP, sulfate/total sulfur results

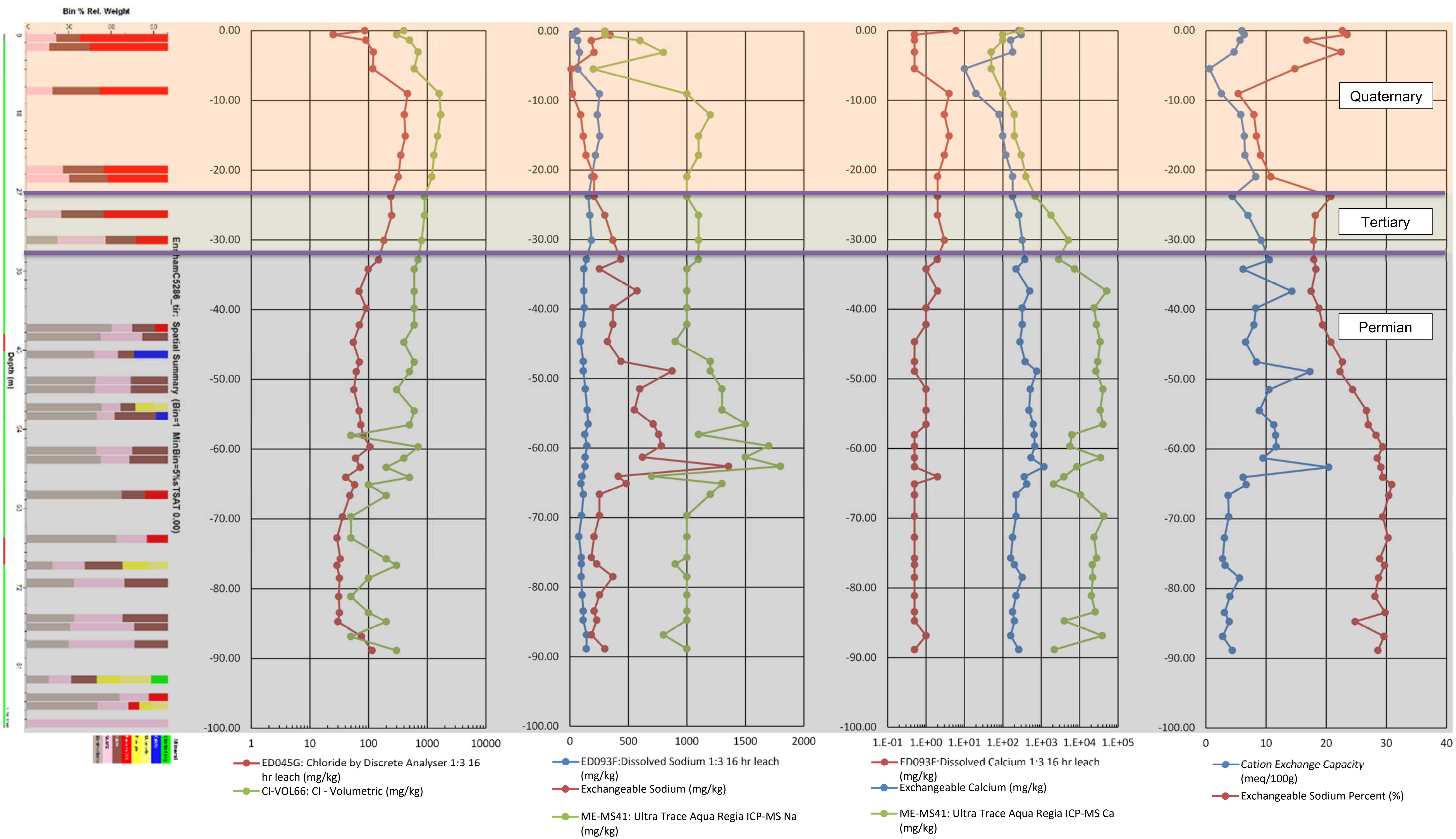

Figure 4-13: Drill hole C5286 static analysis chloride, sodium, calcium, CEC results

4.3.1 pH

The pH measures the concentration of H^+ ions. A pH of 7 is considered neutral, with values below 6 acidic and values above 8 alkaline. The 1:5 and 1:3 leaches both required the mixing of the sample material with deionised water. The deionised water used in the 1:5 and 1:3 leaches had pH values of 5.3 and 5.2 respectively. The pH results from drill hole C5285 were basic in both leaches with the 1:5 leach generally having a higher pH.

Results from drill hole C5286 show increasing pH with depth. Quaternary samples were slightly acidic, but no more acidic than the deionised water used in the analysis. Results became circum-neutral at the Quaternary/Tertiary contact. Sample pH was increasingly alkaline through the Tertiary and into the Permian stratigraphy. Permian aged samples almost all had pH values of approximately 10 except for a sample from 65 m depth which was observed to contain sulfides (**Figure 4-14**). Despite the presence of sulfides in this sample, it still recorded a pH of approximately 8.5 (1:3 leach) to 9.0 (1:5 leach).

Figure 4-14: Pyrite in coal at approximately 65 m depth in drill hole C5286

4.3.2 Salinity

The EC values for both drill holes are less than 2,000 µS/cm (1:3 and 1:5 leaches) and so can be considered low-salinity (Hazelton and Murphy, 2007). Samples from both drill holes show elevated EC levels in Quaternary sediments compared to Tertiary and Permian strata. This is hypothesised to be the result of concentration of salts by evapotranspiration of groundwater and the capture of salts by clays, a large proportion of which are contained in Quaternary sediments. Drill hole C5285 also shows an increase in salinity in the deepest sample. There is a corresponding increase in dissolved Ca^{2+} and SO_4^{2-} from the same sample suggesting the roof of the Aries seam may contain gypsum ($CaSO_4 \cdot 2H_2O$) or anhydrite ($CaSO_4$).

4.3.3 Net Acid Production Potential

NAPP values compare a sample's potential acid generation and neutralising capacity. All NAPP values returned from samples in drill hole C5285 were negative. This suggests that this waste rock material is unlikely to be acid forming and may act as a buffer against acid formation. The NAPP results are variable with depth but show no clear trend with increasing depth or stratigraphic age.

Drill hole C5286 returned positive NAPP values within Quaternary sediments. The positive values were relatively minor however, with a maximum NAPP value of 3.1 kg H_2SO_4/t. The NAPP values decreased with depth through the Tertiary sediments. Generally, Permian strata had the lowest NAPP values however, some near-zero values are associated with coal seams, e.g. the Aries seam at 58 m and Castor seam at 64 m.

4.3.4 Total Sulfur

Most of the total sulfur results in drill hole C5285 and C5286 are considered barren in term of potential acid production with less than 1,000 mg/kg (0.1%) total sulfur. Variations in total sulfur concentrations appear to be associated with individual lithologies, e.g. coal, rather than with Quaternary, Tertiary or Permian stratigraphy. The maximum total sulfur of 6,200 mg/kg (0.6%) occurs in the roof of the Aries seam in Drill Hole C5285.

4.3.5 Chloride

Chloride was most abundant in Quaternary samples. Chloride concentrations rose then fell with increasing depth through the Quaternary sediments suggesting leaching, downward transport and concentration typical of weathering profiles. Soluble chloride (1:3 and 1:5 leach) in samples from drill hole C5285 continued to decrease with depth through Tertiary strata to approximately 25 m depth. From 25 m depth to the base of the Tertiary strata (approximately 75 m) soluble chloride concentrations were roughly consistent. Concentrations then increase slightly with depth through Permian strata.

Overall, soluble (1:3 leach) and solid phase chloride in samples from drill hole C5286 continued to decrease in concentration with increasing depth through Tertiary strata and into Permian rock. Increases in soluble and solid phase chloride concentration associated with siltstone in the roof and floor of coal seams is seen at 60 m, 62 m and 89 m. Solid phase chloride concentrations as determined by titration was below the laboratory limit of reporting of 100 mg/kg in samples at 58 m, 70 m – 73 m, 81 m and 87 m.

4.3.6 Sodium

Dissolved sodium levels in both drill holes are relatively consistent at around 100 mg/kg (1:3 leach). Exchangeable sodium is more variable, dropping initially with depth in Quaternary sediments and then rising again through Tertiary rocks. Concentrations of exchangeable sodium remained very low throughout the rest of drill hole C5285.

Concentrations of exchangeable sodium in drill hole C5286 rose with depth, peaking at approximately 65 m depth then dropped rapidly to slightly higher than dissolved sodium levels.

Solid phase sodium concentrations determined by ICP-MS analysis of samples from drill hole C5286 showed enrichment and depletion within Quaternary sediments hypothesised to be due to fluctuating groundwater levels. Below 10 m concentrations are relatively consistent at around 1,000 mg/kg except for a slight increase around the coal seams at approximately 60 m.

4.3.7 Calcium

Dissolved calcium concentrations are very low throughout both drill holes with many results below the limit of reporting. Exchangeable calcium concentrations show profiles similar to chloride and sodium. Solid phase calcium measured with ICP-MS follows the same general trend as exchangeable calcium, initially decreasing then rising and becoming relatively consistent with increasing depth.

4.3.8 Exchangeable Cations

Cation exchange capacity for all samples is generally low, below 12 meq/100 g (Hazelton and Murphy, 2007). Downhole trends follow those of the exchangeable cations already described.

4.3.9 Exchangeable Sodium Percentage

The exchangeable sodium percentage of both drill holes follows very similar trends. Results decrease with depth through Quaternary sediments and rise again through Tertiary and into Permian strata. Results rarely rise above 30% in deeper Permian stratigraphy.

4.4 Spoil sample results

Quaternary spoil is characterised by elevated salinity and low ANC (**Table 4-2**[1]). The Tertiary spoil sample returned a total sulfur concentration of less than the limit of reporting (highlighted in red). For calculating MPA and NPR half of the limit of reporting was used. All spoil samples except the Pit Y Permian spoil had insufficient total sulfur to be considered acid forming. The Pit Y spoil sample had low enough total sulfur and high enough acid neutralising capacity to be considered NAF. The spoil sample analyses suggest that the spoil poses little-to-no risk of AMD however, Quaternary spoil does pose a risk of producing saline drainage. The evolution of spoil drainage chemistry over time is described in greater detail in **Section 4.6**

Quaternary and Tertiary spoil samples had elevated dissolved sodium and chloride concentrations relative to other major cation concentrations (**Table 4-3**). Dissolved sodium was still elevated relative to other cations in Permian spoil samples but not to the same levels as Quaternary and Tertiary samples. Chloride levels in Permian spoil were similar to the concentrations of other major cations. Pit Y showed an anomalously high sulfate concentration relative to other major cations in that sample however, sulfate in the sample was not sufficiently elevated to be of concern. Total sodium is most concentrated in Quaternary spoil (**Table 4-4**). Pit Y Quaternary spoil is low in potassium, calcium and magnesium relative to other spoil samples. Permian spoil is elevated in calcium and magnesium relative to Quaternary and Tertiary spoil. There is no clear correlation between total and exchangeable cations. The cation exchange capacity of all spoil samples is low. Pit B Tertiary spoil has a higher exchangeable sodium percentage than Quaternary and Permian spoil from the same pit. Total organic carbon for all spoil samples is very low (Hazelton and Murphy, 2007).

The samples were also assayed for the total concentrations of the following metals/metalloids: aluminium, antimony, arsenic, cadmium, chromium, cobalt, copper, iron, lead, manganese, molybdenum, nickel, scandium, thorium, uranium and zinc. All concentrations were similar to average crustal abundance values.

[1] Note that the red font for the numerical values in the tables represent values that are half the reported laboratory detection limit.

Most dissolved metals/metalloids assayed were present in concentrations below the laboratory limit of reporting. All metal/metalloid concentrations detected were present in concentrations similar to freshwater concentrations apart from selenium in the Pit B Tertiary and Pit Y Permian spoil samples and zinc in the Pit Y Quaternary spoil sample. These results are not necessarily indicative of a risk of metalliferous drainage from spoil. The chemistry of spoil drainage over time was assessed using KLC tests and results are presented in **Section 4.6**.

4.5 Supplementary spoil sample results

The pH and the EC results for the 29 spoil samples collected by Ensham in May 2018 are in alignment with the results from the six bulk samples collected for the KLC program. The minimum, average and maximum pH values of the 29 samples was 4.2, 8.2 and 9.7 (only 3 of 29 samples had a pH < 5) and the minimum, average and maximum EC values were 32, 650 and 2,950 µS/cm.

Table 4-2: Spoil samples ABA results

ALS Sample ID	Date	Sample	Stratigraphy	pH	EC (µS/cm)	TS (%)	ANC (kg H_2SO_4/t)	NAPP (kg H_2SO_4/t)	MPA (kg H_2SO_4)	NPR	Classification
EB1804470001	16/02/2018	PIT B - 650380	Quaternary	7.4	2230	0.020	8.3	-7.7	0.6	13.6	Non-acid Forming (Barren)
EB1804470005	16/02/2018	PIT Y - 655102	Quaternary	5.1	2480	0.020	2.6	-2.0	0.6	4.2	Non-acid Forming (Barren)
EB1804470003	16/02/2018	PIT B - 649869	Tertiary	9.2	628	0.005	14.4	-14.4	0.2	94.1	Non-acid Forming (Barren)
EB1804470002	16/02/2018	PIT B - 649937	Permian	9.1	77	0.020	29.9	-29.3	0.6	48.9	Non-acid Forming (Barren)
EB1804470004	16/02/2018	PIT D - 352914	Permian	9.2	100	0.020	44.8	-44.2	0.6	73.2	Non-acid Forming (Barren)
EB1804470006	16/02/2018	PIT Y - 654107	Permian	8.9	446	0.050	19.0	-17.5	1.5	12.4	Non-acid Forming (Barren)

Table 4-3: Spoil sample leachate results

	Sample ID:	PIT B - 650380	PIT Y - 655102	PIT B - 649869	PIT B - 649937	PIT D - 352914	PIT Y - 654107
	Stratigraphy:	Quaternary	Quaternary	Tertiary	Permian	Permian	Permian
Calcium (Ca)	mg/L	128	13	6	2	4	3
Magnesium (Mg)	mg/L	125	135	4	2	5	4
Potassium (K)	mg/L	9	4	2	2	3	9
Sodium (Na)	mg/L	425	650	158	21	13	93
Chloride (Cl)	mg/L	1210	1340	219	6	6	16
Sulfate (SO_4)	mg/L	62	102	42	4	2	131
Aluminium	mg/L	0.050	0.050	0.720	1.140	0.570	1.090
Antimony	mg/L	0.005	0.005	0.010	0.005	0.005	0.005
Arsenic	mg/L	0.005	0.005	0.005	0.010	0.005	0.005
Boron	mg/L	0.600	0.400	0.400	0.300	0.200	0.400
Cadmium	mg/L	0.003	0.003	0.003	0.003	0.003	0.003
Chromium	mg/L	0.005	0.005	0.005	0.005	0.005	0.005
Cobalt	mg/L	0.005	0.005	0.005	0.005	0.005	0.005
Copper	mg/L	0.005	0.005	0.005	0.005	0.005	0.005
Iron	mg/L	0.025	0.025	0.770	0.840	0.280	0.440
Lead	mg/L	0.005	0.010	0.005	0.020	0.005	0.010
Lithium	mg/L	0.010	0.011	0.002	0.003	0.004	0.008
Manganese	mg/L	0.005	0.110	0.030	0.050	0.020	0.030
Molybdenum	mg/L	0.005	0.005	0.005	0.010	0.005	0.005
Nickel	mg/L	0.005	0.020	0.005	0.005	0.005	0.005
Selenium	mg/L	0.020	0.005	0.050	0.005	0.005	0.050
Vanadium	mg/L	0.005	0.005	0.010	0.005	0.005	0.005
Zinc	mg/L	0.160	0.380	0.070	0.050	0.020	0.060

Table 4-4: Spoil sample solids analysis results

	Sample ID:	PIT B - 650380	PIT Y - 655102	PIT B - 649869	PIT B - 649937	PIT D - 352914	PIT Y – 654107
	Stratigraphy:	Quaternary	Quaternary	Tertiary	Permian	Permian	Permian
Total Calcium	mg/kg	2360	100	3000	4120	10600	6080
Total Magnesium	mg/kg	3740	760	1600	5520	5420	5640
Total Potassium	mg/kg	1270	210	430	1050	1220	1190
Total Sodium	mg/kg	1840	2030	830	200	110	640
Exchangeable Calcium	mg/kg	380.7	60.1	180.4	621.2	340.7	260.5
Exchangeable Magnesium	mg/kg	230.9	413.2	97.2	267.4	303.8	194.4
Exchangeable Potassium	mg/kg	25.0	25.0	25.0	25.0	25.0	25.0
Exchangeable Sodium	mg/kg	69.0	25.0	69.0	25.0	25.0	92.0
Cation Exchange Capacity	meq/100g	4.1	5.3	2.1	5.4	4.4	3.5
Exchangeable Sodium Percent	%	7.0	3.9	16.4	0.1	0.1	12.8
Total Carbon	%	0.1	0.0	0.1	0.4	2.0	0.7
Total Organic Carbon	%	0.1	0.0	0.1	0.3	0.6	0.4
Total Inorganic Carbon	%	0.1	0.1	0.1	0.1	1.4	0.2

4.6 KLC test results

4.6.1 Static geochemical data for the KLC samples

The static geochemical results for the samples used the KLC program include:

- six spoil samples described as Quaternary (n=2), Tertiary (n=1) and Permian (n=3) collected from the field (ID 7, 8, 9, 11, 12 and 13 generated under the process described in **Table 3-5**)
- composite sample of Quaternary/Tertiary spoil from B Pit and Y Pit (KLC 10)
- composite sample of Permian spoil from B Pit, D Pit and Y Pit (KLC 14)
- composite sample of Tertiary drill core from C5285 in C Pit (KLC 2)
- composite sample of Permian drill core from C5285 in C Pit (KLC 3)
- composite sample of Tertiary drill core from C5286 in Y Pit (KLC 5)
- composite sample of Permian drill core from C5285 in Y Pit (KLC 6)

The static analyses for the KLC samples presented in **Table 4-5** include pH, EC, TS, Scr, ANC and the NAPP and NPR of the samples. The pH, EC, soluble salinity and exchangeable salt concentrations for the KLC samples are in **Table 4-6**. The average data for the Quaternary spoil samples from C Pit and Y Pit drill core samples are also provided for comparative purposes in **Table 4-7**: Quaternary units were not individually evaluated in the KLC program as they represent a small volume of material compared to Tertiary and Permian units, but potentially could be evaluated in subsequent stages of this project.

The salinity data that is available for the spoil samples indicate that:

- Quaternary drill core samples have higher salinity concentrations than the Tertiary and Permian drill core samples;
- Quaternary spoil samples have higher salinity concentrations than the Tertiary and Permian Spoil samples and Tertiary and Permian drill core samples;
- Salinity in the drill core in Y Pit is higher than the salinity in drill core samples from C Pit;
- there is no substantial difference in the salinity of Quaternary sediment collected from B Pit and Y Pit; and,
- the Tertiary spoil collected from B Pit has higher (within an order of magnitude) salinity than the Tertiary drill core samples.

All composite samples had alkaline pH values, negative NAPP values and MPA results of less than 1 kg H_2SO_4/t. All the composites contained less than 0.05 % sulfide sulfur and two of the composites had sufficient ANC to be considered acid consuming.

As observed in **Section 4.4**, the Quaternary/Tertiary spoil composite had elevated salinity compared to the other composites. This contrasts with the Permian spoil composite which returned the lowest salinity result of all the composites.

4.6.2 Kinetic leach column solid phase elemental content

All metals/metalloids are present at concentrations lower than the median concentration of sedimentary rocks and soils (Bowen, 1979). The geochemical abundance index (GAI) provides a comparison of total metal/metalloid concentrations compared to median soil values (Bowen, 1979). This can be useful in identifying samples with the potential to elevate metal/metalloid concentrations in the surrounding regolith. GAI values alone are not diagnostic but can be used to highlight metals/metalloids that require further investigation. The solubility of these elements over time is typically assessed using KLC tests. GAI values for all elements were less than 3 and the majority of the GAI values was less than 1 verifying low total element concentrations relative to median soil values, inferring low metalliferous drainage potential.

Table 4-5: pH, EC and ABA data for the KLC samples and splits used to compile the spoil samples

			EA002: pH (Soils) 1:5 1 hr leach	EA010: Conductivity 1:5 1 hr leach	EA026: Chromium Reducible Sulfur	ED042T: Total Sulfur by LECO	EA009: Net Acid Production Potential 1:5 1 hr leach	EA013: Acid Neutralising Capacity	EA013: Acid Neutralising Capacity	EA013: Acid Neutralising Capacity
			Pulp sample (< 75 um)							
Drill Hole ID	**Stratigraphy**	**KLC Samples**	**pH Unit**	**µS/cm**	**%**	**%**	**kg H2SO4/t**	**kg H2SO4 equiv./t**	**% CaCO3**	**Fizz Unit**
C5285_0-19.6	Quaternary		8.66	452.50		0.01	-63.09	63.36	6.46	1.75
C5285_19.7-77.73	Tertiary	Tertiary core composite	9.14	300.07	0.03	0.03	-38.20	39.10	4.00	1.00
C5285_77.74-106.1	Permian	Permian core composite	9.26	296.79	0.02	0.08	-79.20	80.40	8.20	2.00
C5286_0-23.6	Quaternary		6.16	570.75		0.03	-63.09	63.36	6.46	1.75
C5286_23.7-32.84	Tertiary	Tertiary core composite	8.85	524.50	0.03	0.04	-85.20	87.30	8.90	2.00
C5286_32.84-89.89	Permian	Permian core composite	9.81	407.74	0.02	0.06	-19.50	20.40	2.10	1.00
PIT B - 650380	Quaternary		7.40	2230.00		0.02	-7.70	8.30	0.80	0.00
PIT B - 649869	Tertiary		9.20	628.00		0.01	-14.40	14.40	1.50	1.00
PIT Y - 655102	Quaternary		5.10	2480.00		0.02	-2.00	2.60	0.30	0.00
Spoil Composite E	Quaternary / Tertiary	Spoil Quaternary / Tertiary composite	8.20	1700.00	0.01	0.02	-11.30	11.90	1.20	1.00
PIT B - 649937	Permian		9.10	77.00		0.02	-29.30	29.90	3.00	1.00
PIT D - 352914	Permian		9.20	100.00		0.02	-44.20	44.80	4.60	2.00
PIT Y - 654107	Permian		8.90	446.00		0.05	-17.50	19.00	1.90	1.00
Spoil Composite F	Permian	Spoil Permian composite	8.90	250.00	0.02	0.04	-26.10	27.30	2.80	1.00

Table 4-6: EC, soluble, exchangeable and total major cation data for the KLC samples and splits used to compile the spoil samples

			EA010: Conductivity 1:5 1 hr leach	ED041G: Sulfate (Turbidimetric) as SO4 2- by DA 1:3 16 hr leach	ED045G: Chloride by Discrete Analyser 1:3 16 hr leach	ED093F:Dissolved Calcium 1:3 16 hr leach	ED093F:Dissolved Magnesium 1:3 16 hr leach	ED093F:Dissolved Sodium 1:3 16 hr leach	ED093F:Dissolved Potassium 1:3 16 hr leach	ED041G: Sulfate (Turbidimetric) as SO4 2- by DA 1:3 16 hr leach	ED045G: Chloride by Discrete Analyser 1:3 16 hr leach	ED093F:Dissolved Calcium 1:3 16 hr leach	ED093F:Dissolved Magnesium 1:3 16 hr leach	ED093F:Dissolved Sodium 1:3 16 hr leach	ED093F:Dissolved Potassium 1:3 16 hr leach	ME-MS41 Ca	ME-MS41 K	ME-MS41 Mg	ME-MS41 Na
			1 hr	1:3 rock water ratio and 16 hour digest												2 acid aqua regia digest			
			Pulp (< 75 um)	Sieved (< 19 mm)	Sieved (< 19 mm)	Sieved (< 19 mm)	Sieved (< 19 mm)	Sieved (< 19 mm)	Sieved (< 19 mm)	Sieved (< 19 mm)	Sieved (< 19 mm)	Sieved (< 19 mm)	Sieved (< 19 mm)	Sieved (< 19 mm)	Sieved (< 19 mm)	Pulp	Pulp	Pulp	Pulp
Drill Hole ID	**EnshamID**	**Regolith**	**µS/cm**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**%**	**%**	**%**	**%**
C5285_0-19.6	Quaternary		452.50	18.75	142.13	4.88	5.38	127.75	2.00	56.25	426.38	14.63	16.13	383.25	6.00				
C5285_19.7-77.73	Tertiary	Tertiary core composite	300.07			0.50	0.50	100.00	3.00	63.52	85.55	1.76	1.66	246.62	6.52	1.06	0.28	0.62	0.09
C5285_77.74-106.1	Permian	Permian core composite	296.79			1.00	0.50	100.00	4.00	58.50	111.86	2.89	1.82	250.93	6.21	2.79	0.25	0.53	0.08
C5286_0-23.6	Quaternary		570.75							179.25	723.67	7.00	27.63	445.50	26.00				
C5286_23.7-32.84	Tertiary	Tertiary core composite	524.50			2.00	2.00	141.00	6.00	237.00	498.00	7.50	19.50	492.00	31.50	2.64	0.21	0.83	0.11
C5286_32.84-89.89	Permian	Permian core composite	407.74			4.00	10.00	198.00	10.00	122.44	180.44	2.22	2.61	336.89	26.44	0.25	0.24	0.45	0.10
PIT B - 650380	Quaternary		2230.00	62.00	1210.00	128.00	125.00	425.00	9.00	186.00	3630.00	384.00	375.00	1275.00	27.00				
PIT B - 649869	Tertiary		628.00	42.00	219.00	6.00	4.00	158.00	2.00	126.00	657.00	18.00	12.00	474.00	6.00				
PIT Y - 655102	Quaternary		2480.00	102.00	1340.00	13.00	135.00	650.00	4.00	306.00	4020.00	39.00	405.00	1950.00	12.00				
Spoil Compoiste E	Quaternary / Tertiary	Spoil Quaternary / Tertiary composite	1700.00	45.67	9.33	67.00	72.00	399.00	8.00	206.00	2769.00	147.00	264.00	1233.00	15.00	0.29	0.02	0.21	0.15
PIT B - 649937	Permian		77.00	4.00	6.00	2.00	2.00	21.00	2.00	12.00	18.00	6.00	6.00	63.00	6.00				
PIT D - 352914	Permian		100.00	2.00	6.00	4.00	5.00	13.00	3.00	6.00	18.00	12.00	15.00	39.00	9.00				
PIT Y - 654107	Permian		446.00	131.00	16.00	3.00	4.00	93.00	9.00	393.00	48.00	9.00	12.00	279.00	27.00				
Spoil Composite F	Permian	Spoil PERMIAN composite	250.00	68.67	923.00	10.00	8.00	53.00	11.00	137.00	28.00	9.00	11.00	127.00	14.00	0.67	0.22	0.57	0.03

Table 4-7: Static dissolved metals for samples used in KLC tests

		Drill Hole ID	**C5285 6.70-77.73**	**C5285 77.74-106.10**	**C5286 23.70-32.84**	**C5286 32.84-89.89**	**Spoil Composite E**	**Spoil Composite F**
		Ensham ID	Tertiary core composite	Permian core composite	Tertiary core composite	Permian core composite	Quaternary / Tertiary	Permian spoil composite
		Regolith	Tertiary	Permian	Tertiary	Permian	Quaternary / Tertiary	Permian
	LOR	**ALS Sample ID**	EB1806061001	EB1806061002	EB1806061003	EB1806061004	EB1806061005	EB1806061006
Al	0.3	**mg/kg**	0.150	0.360	0.150	0.150	2.520	2.070
As	0.03	**mg/kg**	0.120	0.360	0.270	0.030	0.015	0.090
B	0.3	**mg/kg**	0.900	0.900	1.500	1.800	0.600	0.900
Cd	0.015	**mg/kg**	0.008	0.008	0.008	0.008	0.008	0.008
Co	0.03	**mg/kg**	0.015	0.015	0.015	0.015	0.015	0.015
Cr	0.03	**mg/kg**	0.015	0.015	0.015	0.015	0.015	0.015
Cu	0.03	**mg/kg**	0.015	0.015	0.015	0.015	0.015	0.015
Fe	0.15	**mg/kg**	0.075	0.075	0.075	0.075	0.990	0.930
Li	0.003	**mg/kg**	0.009	0.012	0.018	0.090	0.033	0.024
Mn	0.03	**mg/kg**	0.015	0.060	0.015	0.015	1.890	0.015
Mo	0.03	**mg/kg**	0.120	0.150	0.210	0.015	0.015	0.015
Ni	0.03	**mg/kg**	0.015	0.015	0.015	0.015	0.015	0.015
Pb	0.03	**mg/kg**	0.015	0.015	0.015	0.015	0.015	0.015
Sb	0.03	**mg/kg**	0.330	0.015	0.030	0.060	0.060	0.060
Se	0.03	**mg/kg**	0.015	0.060	0.060	0.090	0.060	0.015
U	0.003	**mg/kg**	0.002	0.002	0.002	0.002	0.002	0.002
V	0.03	**mg/kg**	0.030	0.030	0.030	0.015	0.015	0.015
Zn	0.03	**mg/kg**	0.015	0.300	0.015	0.030	0.015	0.180

4.6.3 Kinetic leach column leach testing results

The presentation and discussion of the KLC results is structured around the derivation of the source terms that were utilised by HEC to derive water quality estimates for the final void options.

It is important to understand that KLC results are developed for specific material types and should not be compared directly to water quality guideline values (e.g. to ANZECC and ARMCANZ 2000 freshwater aquatic ecosystem guidelines). The complete set of results for the KLC tests is provided in **Appendix A.1**.

4.6.3.1 pH, acidity and alkalinity

The pH of all kinetic leach composites trended towards slightly to moderately alkaline over time and all KLC samples are leaching moderate alkalinity (Min. 48 mg/L, Av. 223 mg/L and Max. 650 mg/L).

Free leaching composites showed the greatest variability with results ranging from pH 7.5 to 9.0 after eight leach events. Pit water saturated samples remained slightly alkaline with pH of approximately 7.5 to 8.0. The variation in pH results decreased over time in deionised water saturated composites. Initial results ranged from approximately pH 7.0 to 8.5 and moved toward pH 8.0 to 8.5.

The pH results of the KLC samples (albeit limited to four months of leach testing) combined with the static Acid Base Account data from this and previous work (URS, 2006 and 2015), and the site surface and groundwater databases confirm that the potential for AMD at Ensham Coal Mine is negligible.

4.6.3.2 Metalliferous drainage

The overburden at Ensham is low-sulfide bearing geological material with negligible potential to produce AMD. Consequently, the concentration of the metals (e.g. Al, Cu, Fe, Mn, Zn) in the KLC leachate collected at neutral to mildly alkaline pH conditions, are present at low concentrations. Some metalloids such as, Mo and Se are present in leachate from some of the Ensham KLC samples at slightly elevated concentrations, compared to freshwater ecosystem guidelines (ANZECC & ARMCANZ, 2000). However, these metalloids have not been detected at elevated levels in the Ensham surface water and groundwater monitoring programs to date. RGS has completed numerous confidential studies at coal mines in the Bowen Basin where these metalloids have been found at slightly elevated concentrations in leachate from KLC samples of overburden. However, these elements are rarely detected at concentrations above the laboratory limit of reporting in surface water and groundwater monitoring programs. At Ensham, the spoil dumps are unlikely to be wetted up produce seeps for several decades and therefore in the unlikely event of minor metalloid load breakthrough in seeps in future, these would be subject to significant dilution and are not a material consideration.

The addition of metal and metalloids in the water quality modelling programs at this stage of the final void project is not recommended by RGS. However, this approach could be considered in future phases of the final void study using mass balance methods to confirm that metals and metalloids are not present at concentrations of environmental concern. The Se results from KLC tests are included in **Figure 4-15** and indicate that under laboratory conditions, the concentration of soluble Se leached from the KLC samples decreases over time. The on-site water quality monitoring program at Ensham can be used to confirm whether this trend is also exhibited under field conditions.

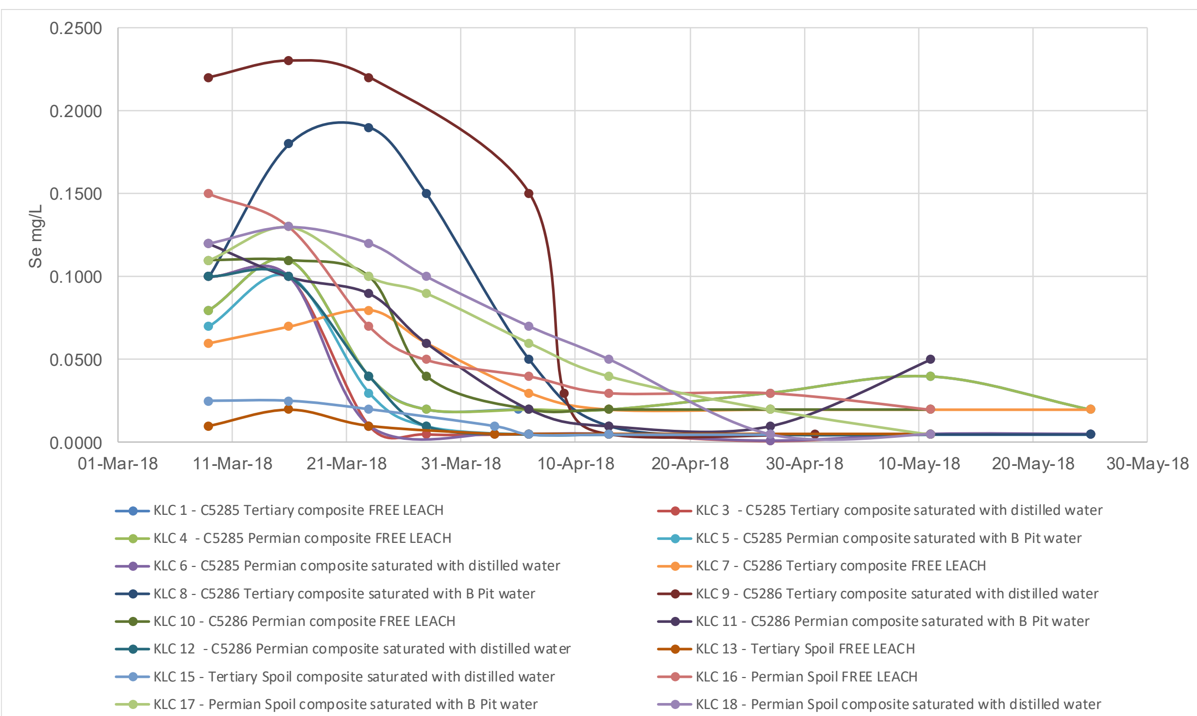

Figure 4-15: KLC test results for dissolved Se

4.6.3.3 Salinity

Free draining KLC samples (KLC 1, 4, 7, 10 and 16)

The free draining Tertiary and Permian drill core KLC samples and Permian spoil sample respond in a similar fashion, in terms of the measured pH and salinity and initially returned EC concentrations of 1,700 to 2,700 µS/cm, then peaked at of 1,700 to 3,470 µS/cm (**Figure 4-16_A**). After the 3rd leach cycle salinity decreased and after the 10th leach cycle the EC was 489 to 1,680 µS/cm. From a physical perspective the C Pit Tertiary (KLC 1) sample and all Permian samples (KLC 4, KLC 10 and KLC 16) are free draining and leachate is obtained within 1 to 2 hours: this is because these samples have a low % clay, slit and sand. However, the Y Pit Tertiary drill core sample (KLC7) has low permeability and typically requires 12 to 24 hours to obtain a 500 mL sample for analysis by ALS: this is due to a high fines content with 97% < 4.75 mm PSD and 56% < 0.075mm PSD.

Saline saturated KLC samples (KLC 5, 8, 11 and 17)

KLC 2 and KLC 14 were discontinued due to failed fittings after 3 and 1 weeks, respectively. The EC of the A Pit water used in the KLC tests was 8,580 µS/cm and was dominated by Cl^- (2,470 mg/L), Na^+ (1,378 mg/L) and SO_4^{2-} (596 mg/L). The intention of leaching the samples with saline pit water from A Pit was to verify and quantify the effect that this would have on porewater, if spoil was pushed into saline pit water, or spoil was inundated with saline water. These samples were not maintained under a zero head space and therefore had some exposure to atmospheric conditions. The Eh of the porewater within these samples was measured in-situ over the duration of the tests. As expected, in all cases the addition of saline pit water to the core and spoil samples increased the EC of the samples (**Figure 4-16_B**). The initial leach cycle EC was 9,260 to 11,400 µS/cm and peaked during the 3rd leach cycle at 9,550 to 13,800 µS/cm. The EC in the Tertiary core sample from Y Pit has remained elevated, but decreased over the remaining leach cycles and was 9,530 µS/cm after the 9th leach cycle: the EC of the A Pit used in these columns was 8,580 µS/cm.

The findings of these KLC tests are that:

- The inundation of the samples resulted in a low rate of displacement in comparison to free leaching columns.
- The low rate of displacement increased contact time between the solid phase and the water increasing the dissolution process of the minerals in the spoil.
- While the dissolution of the minerals in the spoil adds major ions to the system, the mass of mobilised major ions is not substantially different to the mass of the major ions mobilised in the free draining KLC tests.
- Salinity measured in the recovered leachate was in the range of the salinity of the Pit water initially added to the column i.e. there was an increase in the EC, but it was not as significant as the addition of the saline pit water.

Non-saline (distilled water) saturated KLC samples (KLC 3, 6, 9, 12 and 15)

The intention of leaching the samples with non-saline pit water was to evaluate and quantify the effect this would have on spoil porewater if spoil was inundated with non-saline water (**Figure 4-16_C**). Over the duration of the KLC program 10 leach cycles were conducted resulting in three pore volumes of water being put through each sample. Pore volume one occurred over five leach cycles, pore volume two occurred over four leach cycles and the third pore volume was put through the samples on the tenth leach cycle.

The deionised water saturated Tertiary sample from C Pit (KLC3) and the Permian drill core (KLC6 and KLC12) and Permian spoil sample (KLC18) respond in a similar fashion as the free draining samples in terms of the measured pH and salinity and returned initial EC concentrations of 1,640 to 2,750 µS/cm for the initial leach cycle and peaked at 3,470 µS/cm (**Figure 4-16_C**). After the 2nd leach cycle salinity decreased and after the 10th leach cycle the EC was 145 to 561 µS/cm.

The exception to these results is the Tertiary Spoil from Y Pit (KLC9) that had elevated salinity from the 1st leach cycle of 7,400 µS/cm and peaked at 7,780 µS/cm during the 2nd leach cycle. Salt concentrations in this sample decreased over time and the EC was 716 µS/cm after the 10th leach cycle. The salinity in KLC9 was higher than the free draining sample. The reasons for this are attributed to differences in mineralogy; the Tertiary sample from Y Pit appears to have a higher proportion of more soluble saline minerals that the tertiary core from C Pit.

The KLC source term data for the DI saturated KLC samples in Table 4-8 are presented in terms of the total dissolved solids (TDS) mass leached from the KLC sample for pore volumes one two and three.

Table 4-8: DI Saturated KLC pore volume TDS mass (mg/kg)

	Pore Vol 1	Pore Vol 2	Pore Vol 3
Excluding Quaternary (mg/kg)	708	697	118
Including Quaternary (mg/kg)	2199	1122	119

Quaternary / Tertiary spoil sample

The Quaternary/Tertiary spoil sample (KLC 13) has responded in a substantially different way to the other samples (**Figure 4-16_D**). This sample has very low permeability and took 48 to 72 hours to obtain a 500 mL sample. This material is dominated by fines: 100% of the sample is < 4.75 mm PSD and 90% < 0.075mm PSD. The initial EC of this sample was 30,100 µS/cm and it peaked during the 2nd leach cycle at 34,600 µS/cm. The EC decreased rapidly and was 1,860 µS/cm after the 9th leach cycle. The elevated EC in the leachate from these KLC samples is a function of the:

- higher EC in these materials compared to the Tertiary and Permian samples (the static EC values of the Quaternary samples was 2,230 and 2,480 µS/cm compared to 77 to 628 µS/cm for the Tertiary and Permian samples **Table 4-2)**;
- mineralogy that is dominated by highly soluble NaCl minerals; and,
- extremely low permeability of the samples that led to high salt loads and low volumes in the KLC leachate.

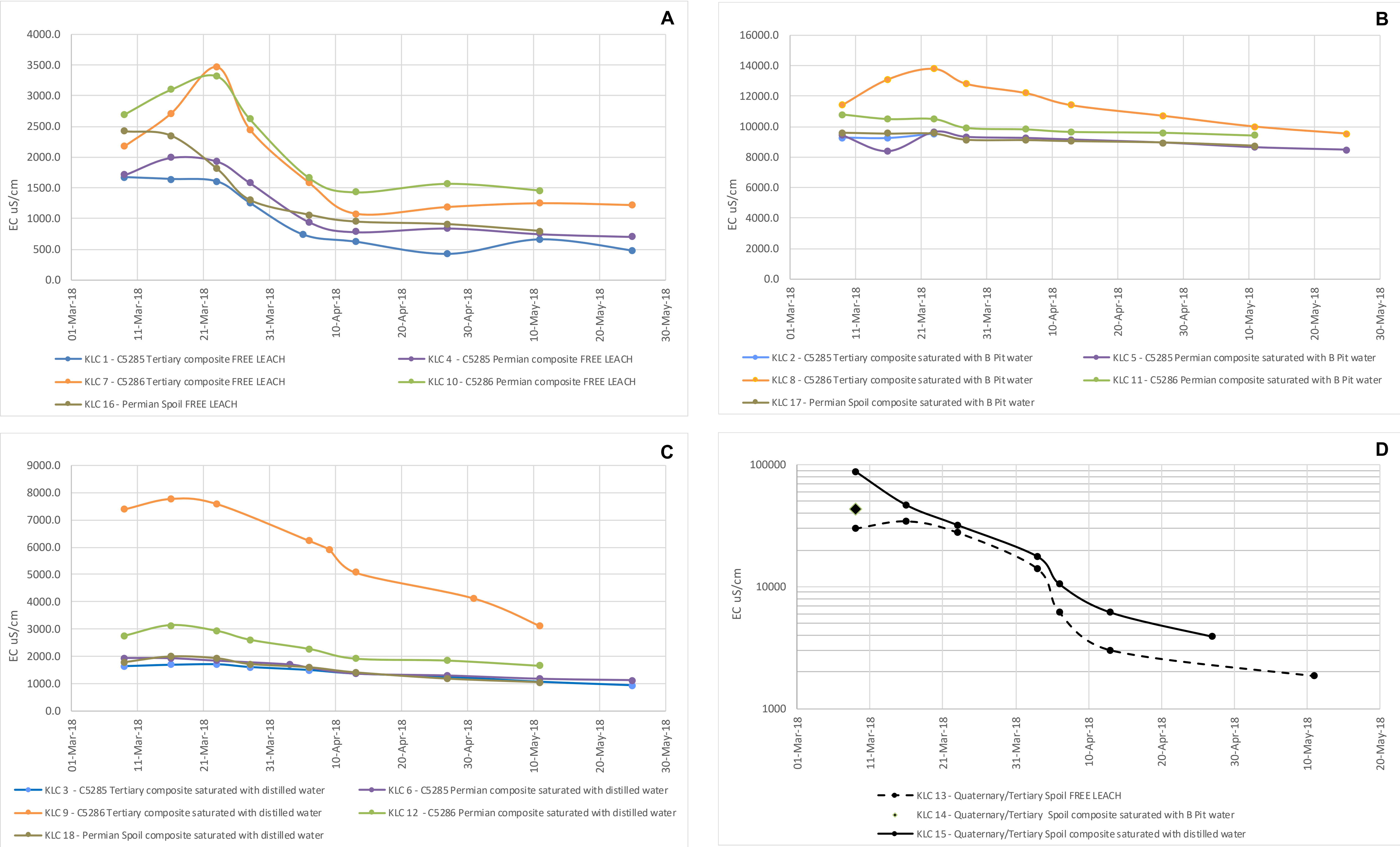

Figure 4-16: KLC test results for EC

5 Hydrological and hydrogeochemical considerations for water modelling of pit void water quality

This section of the report includes general information on numerical modelling, including the limitations of numerical modelling, background information on spoil hydrology, the Ensham pit void 2008 flood event, and other aspects that were considered by RGS during the development of hydrogeochemical source terms for numerical models.

5.1 Numerical models – basis of design and limitations

Water models provide additional insight into complex system behaviour and when appropriately designed, can assist in improving conceptual understanding. When a water model has demonstrated an ability to reasonably reproduce past behaviour, it can forecast the outcome of future behaviour, support decision-making and allow the exploration of alternative management approaches. Importantly, there should be no expectation of a single true model, and there will always be some uncertainty associated with model outputs. As such, all model outputs presented to stakeholders and decision-makers benefit from the inclusion of some estimate of how good or uncertain the modeller considers the results (Barnett. et al., 2012).

For this study RGS recommended that Ensham adopt the modelling framework in the Australian Groundwater Modelling (AGM) Guideline that has been developed to promote a consistent and sound approach to the development of a surface and groundwater flow and solute transport models in Australia (refer to Figure ES1 in Barnett. et al., 2012). The AGM Guideline provides a robust and phased approach to the development of a numerical model that ensures that the aim, objectives and phases of development are undertaken in a progressive, logical and transparent manner moving from planning to conceptualisation, model design and construction, calibration and sensitivity analysis, prediction, uncertainty analysis and reporting.

The AGM guidelines encourage regular reassessment of the conceptual model at all stages of the project, with refinements made as other stages of the process suggest that these may be appropriate or necessary Barnett. et al., 2012. In many cases the conceptual model may not be unique (i.e. different conceptual models can explain various observations) and it is encouraged to propose and maintain alternative conceptualisations for as long as possible through the modelling project. In some cases, this may lead to the development and use of alternative numerical models Barnett. et al., 2012.

For this study RGS developed and provided hydrochemical and geochemical source terms for the mass balance water modelling being undertaken by HEC. The mass balance modelling will provide reasonable water quality estimates, but as with all numerical modelling there is an inherent understanding that there will be some level of uncertainty in the model outputs. Some of the supplementary aspects that have been considered in the conceptualisation of the model development by RGS include, evaluation of measured data from the 2008 flood event and limnological, spoil hydrological, and hydrochemical aspects which are summarised below.

5.2 Spoil Hydrology

To predict the long-term movement of water between a final void and the receiving environment, it is necessary to characterise the processes controlling water movement. The hydraulic properties of overburden strata will be altered following their removal and incorporation into spoil piles. Groundwater movement and recharge to the final void will be controlled by the physical characteristics of the spoil such as surface crusting, large scale heterogeneities in hydraulic properties and changes in site hydrology. These factors may result in non-uniform and even non-Darcian flow through spoil aquifers. Because only a limited fraction of the total porosity may transmit water, mine spoil aquifers may be best described using multiple porosity model or pseudokarstic concepts.

5.2.1 Mining method

During the process of coal mining, the coal seam is excavated from the initial box cut in a downward dip direction, until the volume of overburden to be moved makes further mining uneconomical. Prior to mining the coal seam, itself is often saturated although it may not transmit appreciable volumes of water due to limited transmissivity. Flow in coal aquifers is often controlled by fractures. After mining the regional hydraulic gradient will be towards the void and groundwater will pass through coal spoil prior to reaching the final void. Mine spoil is a highly heterogeneous and anisotropic material.

Dragline dumping results in ridges and valleys within the spoil pile, while end tipping from trucks, especially down long slopes, results in segregation with coarser rock at the base of the slope. A coarser rubble zone at the base of the spoil pile may form flow paths within the spoil and may be confined or unconfined by relatively impermeable clays. At Ensham, overburden was managed predominantly by side cast dragline mining methods.

At Ensham the spoil characteristics vary within a dump and includes intermingled Quaternary, Tertiary and Permian side cast tip heads with variable physical characteristics ranging from fine grade Tertiary sediment (**Figure 5-1 and Figure 5-2**) through to a coarser grade of spoil that is still predominantly finer than cobble size material (**Figure 5-3 and Figure 5-4**).

Figure 5-1: A Pit Low wall – Permian dominated side cast spoil

Figure 5-2: B Pit Low wall – Tertiary and Quaternary dominated spoil

Figure 5-3: C Pit Low wall adjacent to the Ramp

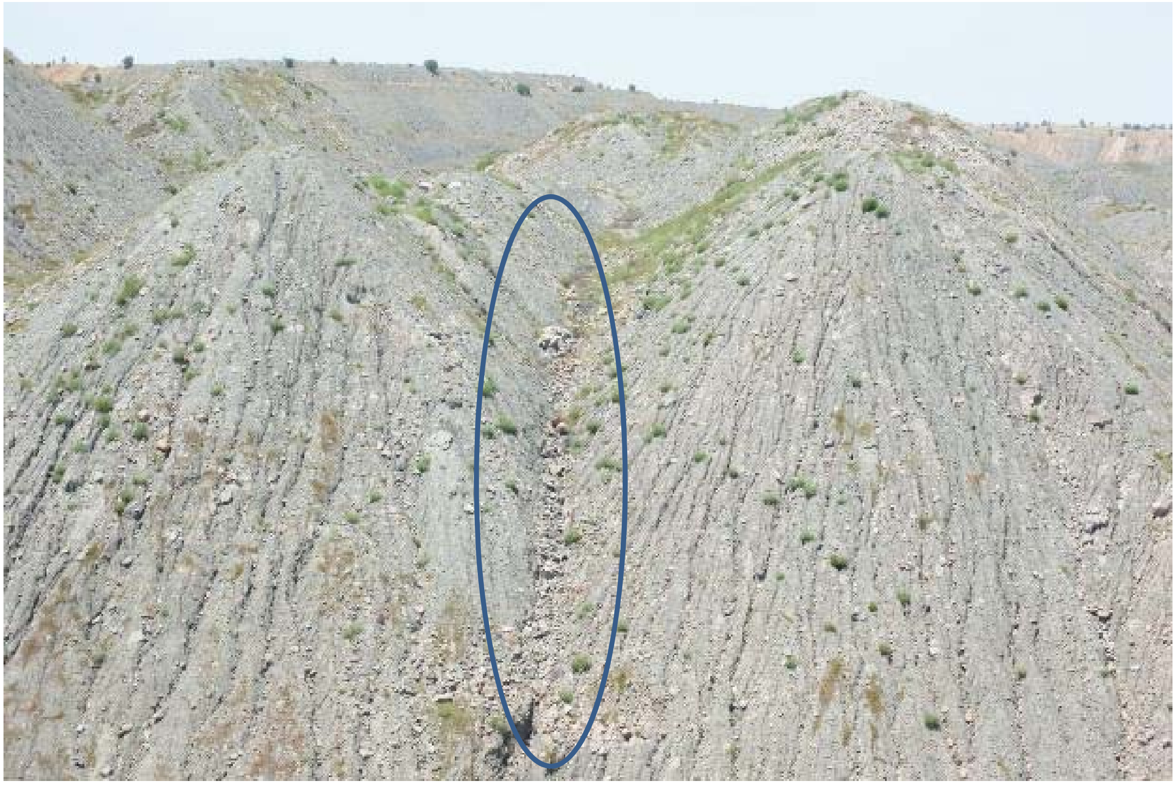

Figure 5-4: C Pit Low wall adjacent to the Ramp – side cast dragline spoil coarse graded potential preferential flow path

5.2.2 Spoil dump hydrology

Surface crusting and hard setting are common phenomena in Bowen Basin spoil materials. Surface crusts of dispersive low hydraulic conductivity can limit infiltration of water into a porous medium such as spoil. Cracking associated with surface crusting can also result in spatially non-uniform infiltration (Hawley and Cunning, 2017).

5.2.3 Spoil dump erosion

Surface erosion is evident at Ensham on exposed high walls, the low walls and on as-placed spoil. Prior to rehabilitation, erosion and the movement of sediment from unrehabilitated spoil dumps into the final void is a transport mechanism for natural sediment transfer into the final void. Surface erosion of unrehabilitated landforms can also carry major ions in surface runoff to the contained water body.

5.2.4 Spoil dump hydrogeology

The hydrogeology of spoil dumps is complex, and spoil ridges created by draglines may have lower permeabilities than valleys filled in by bulldozers (Hawley and Cunning, 2017). Later, blocks of material accumulating in valleys between spoil ridges may be loosely compacted and contain large voids. The discontinuous nature of the high permeability zones formed at the base of spoil aquifer can result in highly non-uniform groundwater level and flow and multiple water tables and stagnant zones have been observed within spoil aquifers (Hawley and Cunning, 2017).

Data from aquifer tests have suggested that large cavities may exist within mine spoil causing pseudokarstic behaviour during recharge events (Hawley and Cunning, 2017). A pseudokarstic aquifer is like a true karstic aquifer in that groundwater flow is facilitated by large cavities and conduits, only the mechanism of cavity formation of the two systems differ. Multiple piezometric surfaces are common in karst aquifers and groundwater may flow via unconnected three-dimensional conduits. Large cavities within the spoil are most likely to control groundwater movement during transient flow conditions and extreme recharge events may even results in non-Darcian flow. During steady state conditions the lower permeability material between large conduits is more likely to control flow and the spoil material behaves more like a porous medium (Hawley and Cunning, 2017).

5.2.5 Current understanding of dragline spoil dumps and hydrology

The following text is a precis of the current understanding of dragline spoil dumps and spoil hydrology from Hawley and Cunning, 2017.

"Dragline waste dumps are formed by repeated stripping processes, resulting in a pattern of particle deposition that has predictable features and a scale-dependent segregation of particle sizes that is partly randomised in location. The waste material particles may or may not be water saturated, and the void spaces within the waste will be variably saturated, depending on the climatic conditions at and following the time of placement. A proportion of precipitation may infiltrate the dump, with the remainder being dissipated by runoff and evaporation.

Surprisingly little is known about the fate of water within the void space of a dragline dump. Observational experience from the Bowen Basin of central Queensland, Australia, which has a relatively hot and dry climate, suggests that very little, if any, free water flows out of dragline dumps except at the lowest point near the contact with the foundation. This implies that most of the free interstitial water will flow downward relatively easily through preferential, inclined, coarser-grained pathways under the influence of gravity. It also implies that some interstitial water may be effectively held within the waste mass either by suction or by slaking processes.

Under the stress levels within a dragline dump, the interstitial void spaces remain relatively large and open and are unlikely to become saturated with free water until a flow barrier is encountered. The most obvious flow barrier is the contact with foundation rock or other low-permeability foundation zones. A basal wetted zone would then be expected to build up to an extent, with the profile controlled by free-flow diffusion processes and boundary conditions. A model for the wetted zone was developed from limited direct observations and an extensive body of operational experience and back-analyses that adopt a wetted zone of maximum 5 m thickness capped by a phreatic surface for routine in-pit dragline dumping. Recently, the model has been generalised to include additional observations, but the basic premise of a saturated basal zone should always be considered. Other scenarios for wetted-zone depth and phreatic surface development can be derived, for example, when a significant depth of water accumulates within a void over a sufficient period for infiltration to develop into a steady-state wetted condition.

Groundwater pressure and flow conditions within dragline waste must be considered carefully in the context of existing knowledge applicable to rockfill and earth fill dams. As in any mixed granular medium, seepage exit gradients and flow velocities may combine with relatively loose packing structures and low confining stresses to cause internal movements of smaller particles (suffusion) that may lead to the formation of preferential water flow channels or 'pipes'. Development of internal piping does not necessarily lead to unlimited or uncontrolled erosion. any mines operate with multiple dragline pits where some voids may be used on a short-term or long-term basis for water storage. It is common in such situations for significant lateral flows of water to develop through waste, at or near the contact with the foundation rock, and to form concentrated discharges from preferential flow channels (Image 4). It is important to regularly monitor such outflows for evidence of ongoing piping erosion, and to prepare contingency plans for filtering and buttressing to control erosion-induced instability. Monitoring of outflow rates and measurements of wetted zone dimensions are essential components of site-specific models for groundwater in waste.

It is now common for dragline dumps to be surcharged by additional spoil dumping processes. Surcharging increases the stress levels towards the base of the dump, causing compression that reduces the interstitial void space. Depending on the water content and compressibility condition of the dragline waste profile, surcharging may progress to the extent that the more highly stressed basal *component becomes mechanically saturated and could lead to static liquefaction failure of the dump. Such a condition warrants specialised assessment because of its implications for the thickness of the saturated zone and the location of the phreatic surface, both of which may be critical factors that control dump stability.*

For routine design purposes, the conceptual waste dump groundwater model utilising a 5 m basal saturated zone (Simmons and McManus, 2004) may be adopted, but only after giving due consideration to the expected particle size range within the waste, the prevailing hydrological conditions and relevant local experience regarding groundwater within waste dumps. The basal 5 m conceptual model is admittedly simplistic, and if there are any uncertainties regarding its applicability, then a more rigorous assessment is required to manage design-level instability risks. The nature of dragline strip mining results in large and deep voids with catchments large enough to accumulate significant volumes of ponded water. Void flooding may occur due to a heavy rainfall event. In other circumstances, voids may be used for water storage or transfer. Ponded water will generate a transient wetting front that progresses into the waste mass, eventually reaching a steady-state condition where the phreatic surface gradient equilibrates to the external pond level. Simultaneous with the pond wetting front, other infiltration mechanisms may also be acting to transfer interstitial water flows into the basal zone. Based on reasonable estimates of the relative permeabilities of the floor rock, basal wetted zone and overlying unsaturated zone with preferential flow paths, the time frame for equilibration of the wetting front to the pond water level is likely to be measured in days or weeks rather than months".

5.3 Spoil vadose water modelling

Whilst there is inherent uncertainty related to the hydraulic processes within as-placed dragline spoil dumps (as outlined above), it was necessary to undertake scoping level numerical modelling to provide some basis for the numerical values associated with the water balance within the surface (7 to 8 m) zone (unsaturated/ vadose zone) of the rehabilitated spoil dumps (**Figure 5-5**).

Figure 5-5: Typical rehabilitated spoil at Ensham on B Pit

The modelling scenarios and results are provided in this section of the report and the complete report for this work is in **Appendix A.5**.

5.3.1 Modelling scenarios

Several modelling sensitivities and scenarios were undertaken. The base-case cover configuration has been maintained consistent for the majority of the model simulations (i.e. growth/soil medium (0.5 m) overlying spoil; Scenario 1); however, several simulations were also undertaken with a 1 m growth/soil medium overlying spoil (Scenario 2) (**Figure 5-6**); this somewhat reflects variability that is likely to occur while constructing the cover.

Since there is limited information on the topsoil/growth medium properties, a range of simulations were undertaken including different Soil Water Characteristic Curves (SWCC's), which are indicative of a sand, clayey/sand and clay. For each of these scenarios, models were simulated with and without vegetation (good grass) establishment. For select models, different annual precipitation regimes were simulated. For example, a historical 48-hour extreme rainfall event was applied to the dataset and run on select models. The models were run as transient based on daily time steps.

The various model scenarios (and sensitivities) are summarised in **Table 5-1**.

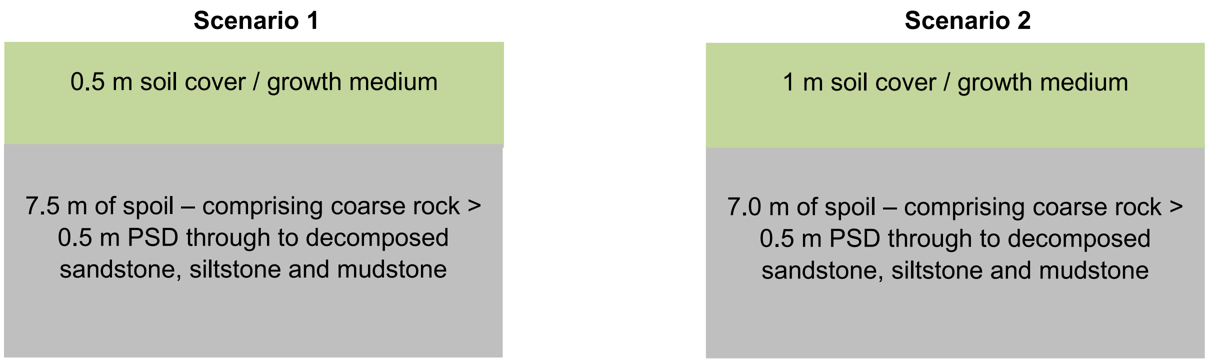

Figure 5-6: Soil Cover Configuration.
***7.5 m spoil used for the sake of modelling the cover; actual spoil piles can be up to 30 m in profile.**

Table 5-1: Model Scenarios and Sensitivities

Scenario	Vegetation	Topsoil/ growth medium	Climate
Scenario 1 (0.5 m topsoil/ growth medium)	Yes – good grass	Sand	Average
	Yes – good grass	Clayey/ sand	Average
	Yes – good grass	Clayey/ sand	Extreme
	Yes – good grass	Clay	Average
	No	Sand	Average
	No	Clayey/ sand	Average
	No	Clay	Average
Scenario 2 (1 m topsoil/ growth medium)	Yes – good grass	Sand	Average
	Yes – good grass	Clayey/ sand	Average
	Yes – good grass	Clay	Average

5.3.2 Modelling results

The main results of the modelling simulations are inferred user defined values based on previous experience (i.e. not measured site data) and are summarised in the following sections. The data output from the modelling is extensive, so only relevant information has been included in the summary below. The results have been input from the middle of the model, which may affect runoff and infiltration results as the results may vary depending on position along a slope (e.g. runoff at the bottom of the slope will be higher than for the top).

5.3.3 Surface water balance

The results of the surface water balance are summarised for each of the simulations in **Table 5-2**; the results summarised in **Table 5-2** are for the net values reported after a 6-year simulation relative to rainfall. Infiltration can exceed precipitation because water from higher slopes may runoff and then infiltrate at a later time-step.

Similarly, evaporation is not entirely associated with precipitation as evaporation is most dominant during dry periods. Discussing the surface water balance independent of rainfall events and intensity may create misunderstanding of the key surface water balance processes. It is therefore pertinent to discuss the results relative to rainfall events. The summary statistics are shown for each of the simulations according to rainfall event (**Table 5-2** and **Table 5-3** for Scenario 1 and Scenario 2, respectively).

The key results of the modelling are summarised in the following points:

- Increasing the soil cover from 0.5 m to 1.0 m has little effect on the surface water balance.
- The surface water balance is controlled by the intensity of rainfall events. Low intensity rainfall events (> 0 – 5mm) results in high infiltration and low runoff, while with increasing rainfall intensity, there is a relative increase in runoff and decrease in infiltration.
- Runoff is much higher and infiltration lower for the clayey/sand and clay soils due to the lower permeability. Conversely, the sandy soils have very high infiltration and low runoff.
- The simulations show that surface evaporation is significantly higher for the non-vegetated soil cover, with low surface evaporation evident for the good grass simulations due to the shading provided by the grass canopy. Plant transpiration was the dominant process for the cases with good grass by which water was removed from the model domain. Plant transpiration includes plant root uptake (not shown) and evaporation from aerial parts (reported as transpiration), which indicates why plant transpiration may exceed precipitation for a given time step.
- For all simulations, there was a net negative change in water storage under average rainfall conditions due to high evapotranspiration and runoff. During an extreme rainfall event, excess rainfall is typically removed via runoff.
- The combination of runoff and evapotranspiration remove nearly all water from the soil cover, with limited percolation below the root zone (2 m).
- The net percentage of average annual precipitation that would percolate below 2 m and 4 m below ground level in **Table 5-4** ranges from 0.16 to 2.24 % with an average of < 1 % i.e. the model suggests that less than 1 % of the average annual rainfall may recharge the rehabilitated spoil dumps.

Table 5-2: Water Balance Summary (net over 6-year simulation)

Scenario	Vegetation	Topsoil	Climate	Evaporation (%)	RO (%)	Infiltration (%)*	Transpiration (%) (surface)
Scenario 1	Yes	Sand	Average	46.2	7.0	100	4.7
	Yes	Clayey/ sand	Average	50.2	42.3	100	4.6
	Yes	Clayey/ sand	Extreme	42.5	50.3	100	3.8
	Yes	Clay	Average	46.2	66.0	100	4.6
	No	Sand	Average	92.8	0.0	19.4	0.0
	No	Clayey/ sand	Average	48.6	44.3	7.1	0.0
	No	Clay	Average	19.2	80.9	0.6	0.0
Scenario 2	Yes	Sand	Average	45.0	8.1	100	4.7
	Yes	Clayey/ sand	Average	46.1	39.6	100	4.6
	Yes	Clay	Average	38.9	69.4	100	4.6

*Infiltration may exceed rainfall due to runoff from higher domains.

Table 5-3: Water Balance Summary for Scenario 1 (0.5m soil cover) Various Sensitivity Analysis

Rainfall event (24 hours)	Rainfall Frequency (in 2 years)	RO (%)	Infiltration (%)	Evapotranspiration (%) (surface)
Sand				
> 0 - 5 mm	116	0.6	79.8	26.4
5 - 10 mm	27	2.9	97.2	0.9
10 - 15 mm	10	0.0	99.6	0.6
15 - 20 mm	10	7.7	91.9	0.4
20 - 25 mm	8	0.0	99.7	0.3
25 - 40 mm	10	8.7	91.0	0.2
40 - 70 mm	1	0.0	100.0	0.0
70 - 100 mm	2	0.0	100.0	0.0
Clayey/ Sand				
> 0 - 5 mm	116	4.8	77.5	26.4
5 - 10 mm	27	16.7	85.7	0.8
10 - 15 mm	10	7.0	92.4	0.6
15 - 20 mm	10	40.6	66.0	0.4
20 - 25 mm	8	38.7	61.0	0.3
25 - 40 mm	10	53.9	46.0	0.2
40 - 70 mm	1	68.2	31.8	0.0
70 - 100 mm	2	87.9	12.1	0.0
Clay				
> 0 - 5 mm	116	2.6	81.4	26.4
5 - 10 mm	27	34.8	64.5	0.7

Table 5-4: Net percolation results

Scenario	Vegetation	Topsoil	Climate	Evaporation (%)	RO (%)	Infiltration (%)*	Transpiration (%) (surface)	Net Percolation (%) of percolation at > 2 m	Net Percolation (%) of percolation at > 4 m
Scenario 1	Yes	Sand	Average	46.2	7	100	4.7	2.24	1.36
	Yes	Clayey/ sand	Average	50.2	42.3	100	4.6	0.95	0.64
	Yes	Clayey/ sand	Extreme	42.5	50.3	100	3.8	0.95	0.64
	Yes	Clay	Average	46.2	66	100	4.6	0.53	0.35
	No	Sand	Average	92.8	0	19.4	0		
	No	Clayey/ sand	Average	48.6	44.3	7.1	0		
	No	Clay	Average	19.2	80.9	0.6	0		
Scenario 2	Yes	Sand	Average	45	8.1	100	4.7	0.95	0.71
	Yes	Clayey/ sand	Average	46.1	39.6	100	4.6	0.52	0.37
	Yes	Clay	Average	38.9	69.4	100	4.6	0.21	0.16

5.4 2008 Nogoa River flood event

RGS was requested to interpret the data from the 2008 flood event to support the derivation of the source terms for seepage quality that may report from the backfilled spoil during subsequent (controlled) filling and dewatering programs.

On January 19th of 2008 a large flood event occurred in Emerald on the Nogoa River and Theresa Creek systems that resulted in flooding of A Pit, B Pit and C-D Pit. The flood event, and the data related to the quantity and quality of the water that was pumped from A, B and C-D pits after the event provides useful measured data that is applicable to understanding how the quality of the water in these pits may change under the options being considered.

5.4.1 Interpretation of the 2008 Nogoa River flood event

On 28th January 2008 flood water from the Nogoa River breached flood levees on B and C-D Pits. As a result, a pumping program was implemented to dewater the inundated pits. The daily rainfall data after the flood event and daily measured electrical conductivity (EC) of the water that was pumped from A Pit, B Pit and C Pit are provided in **Figure 5-7**. The rainfall data verify that there was unlikely to be any substantial dilution of the water in the pits over the dewatering program and certainly no impacts from dilution related to rain in the last month of the dewatering program.

The final EC in A Pit, when the pit was essentially empty and the pumps were switched off, was approximately 2,500 µS/cm: the final EC in B Pit and C-D Pit was 5,260 µS/cm and 7,010 µS/cm, respectively. The higher TDS concentrations in B Pit and C-D Pit could be attributed to:

- differences in the relative volumes of Quaternary, Tertiary and Permian spoil;
- the larger spoil volumes relative to the mined void volume in the pits;
- the volume of drain-down relative to the volume of water contained in the pit that dictates the relative ratio between the seepage volume and the pit volume; and
- the rate of drawdown, the higher the rate of drawdown the more rapid the outflow from the spoil would be and the less the volume of water that would be lost to groundwater.

The pH of the water pumped from A Pit after the flood event was 7.2 to 8.6, and this was similar to the pH in B and C-D Pits.

The salinity of the water removed from the pits varied between A Pit, B Pit and C Pit (**Figure 5-7**). The reasons for differences in the EC of the water in the pits is likely to be a function of the:

- potential interaction with groundwater inflow
- variability in the hydraulic properties of the spoil
- geology and composition of the spoil in the backfilled pits (**Table 5-5**)
- the differences in the proportion of spoil above and below the elevation of the flood water and the mined pit void (**Figure 5-8** and **Figure 5-9**).

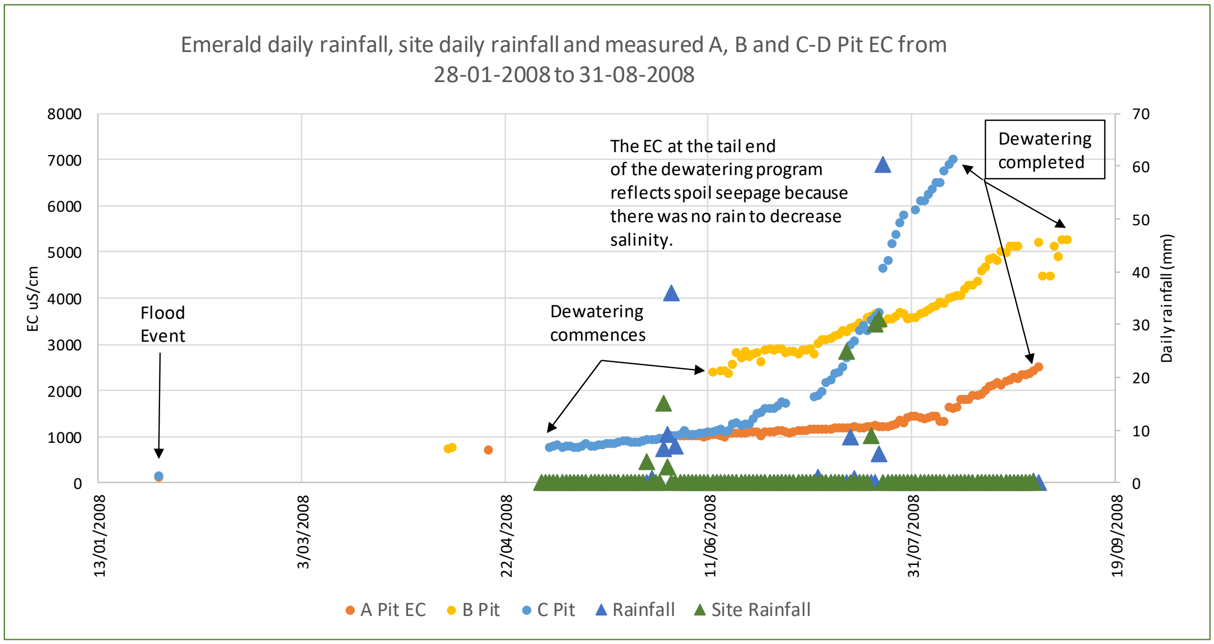

Figure 5-7: A, B and C-D Pit flood salinity data

Table 5-5: Summary of Quaternary, Tertiary and Permian material in A, B, C and D Pits

Pit	Lithology Age	% of mined material
A	Tertiary	3%
A	Permian	85%
A	Quaternary	12%
B	Permian	84%
B	Quaternary	16%
C	Permian	66%
C	Tertiary	24%
C	Quaternary	11%
D	Permian	98%
D	Quaternary	2%

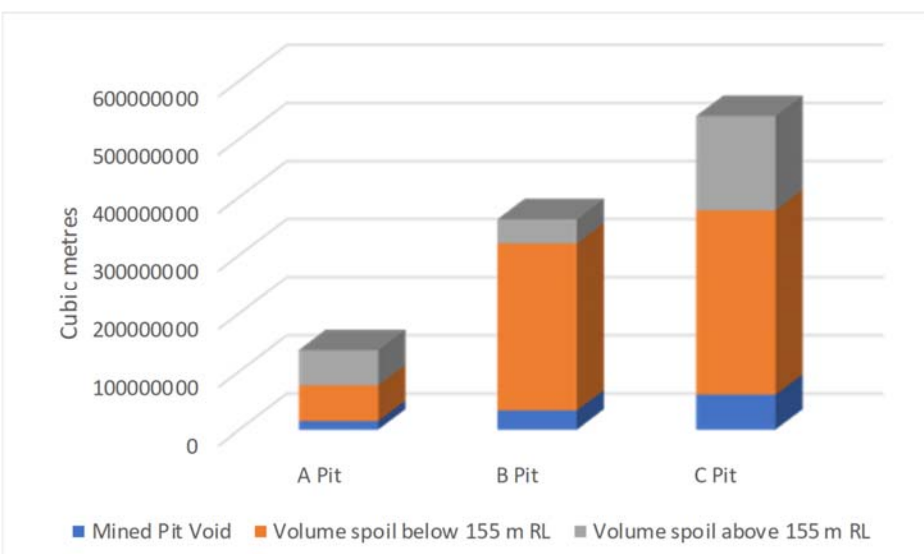

Figure 5-8 Volume and elevation of spoil in A, B and C Pits

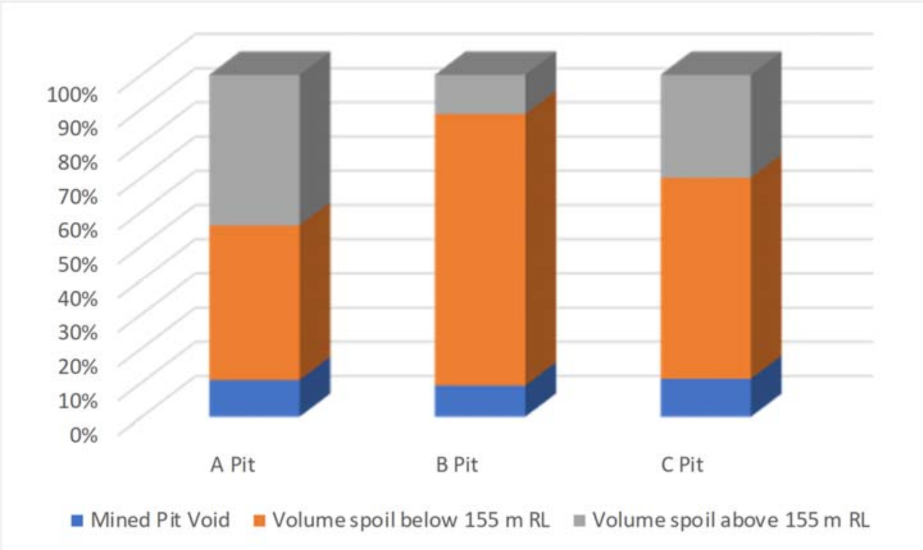

Figure 5-9: Percentage of spoil relative to select elevations in A, B and C Pits

The next RGS task in the supplementary scope of work was to evaluate the flood data, provide a conceptual model for A Pit to define the hydrological and geochemical processes that may have occurred in the inundated spoil and develop numerical models (spreadsheets) that would recreate the flood event. The numerical models may then provide a basis for evaluating future events in A Pit. The supplementary scope was limited to A Pit.

The concentration of TDS reporting as seepage from the A Pit in-pit spoil dump is a function of a number of geochemical, physical and hydraulic processes. The environmental system in a mine spoil dump is dynamic and changes in the physical properties of the spoil subsequently affect the hydraulic processes relating to the porosity and permeability of the spoil.

A conceptual representation of the A Pit in-pit spoil dump associated with the 2008 flood event includes the following.

- Prior to the flood event it is assumed that the in-pit spoil was mostly devoid of pore water, although it is likely that at least the initial moisture present in the spoil when it was mined, and a proportion of incident rainfall would have accumulated in the spoil during construction of the dump.
- The dump was progressively rehabilitated over time and rain falling on the rehabilitated surface would have (and continues to) leach salts down through the spoil towards the pit floor. This is a very slow process and water does not move downwards until field capacity is reached, which is in the range of 20% of the total pore space. Based on the site climate and assumed properties of the spoil, it could take in the order of 10 years for water to move vertically through 20 m of spoil. It is therefore unlikely that the wetting front would have intercepted the phreatic surface within the spoil at the time of the 2008 flood event.
- Source terms for the movement of salts through the unsaturated spoil above the potential phreatic surface will be required, but to do this with a tolerable degree of reliability, will require access to the stage – area – storage curve data for the in-pit rehabilitated spoil dumps. Conceptually the salt and the water moving through the unsaturated spoil will enter the spoil at the potential phreatic surface within the fully saturated spoil progressively over time. The use of an average spoil dump depth was considered, but this would result in the salt mass from the entire dump entering the phreatic zone at the same time, not progressively over time.

The conceptual model for saturation and movement of water and salts through the spoil includes the following.

- Over four months between the filling of the pit and the commencement of dewatering the pit water moved horizontally through the in-pit spoil
- As the water moved through the spoil it mobilised salt (major cations e.g. sodium and anions e.g. chloride and sulfate) moving them from the low wall at the interface of the pit water deeper into the spoil dump. It is likely that: i) not all pore space in the spoil was permeable (some pores fill with water, but do not transmit flow), and, ii) the permeability of the spoil was highly variable and dependent on a number of parameters including particle size distribution, and density.
- Conceptually the process of flooding and saturation of the in-pit spoil reduced the mass and concentration of the salts close to the low wall and increased the mass and equivalent concentration of the pore water deeper into the spoil dump.
- Over the four months that the water in the pit was present, salts from the pit walls and at the interface of the low wall mixed with the Nogoa River water and the TDS increased from 82 mg/L to about 600 mg/L when pumping and daily measurements commenced.
- As the water in the pit was pumped out the porewater in the spoil drained out and mixed with the water in the pit. This resulted in the following:
    - the seepage rate from the in-pit spoil increased over time; and,
    - the TDS concentration in the seepage from the in-pit spoil increased over time as the salt mass was drawn from the back of the spoil dump back to the pit wall.

There is inherent uncertainty associated with these chemical, physical and hydraulic processes, however numerical spreadsheet-based approaches were developed to explain what occurred during the 2008 flood event.

Modelling approach 1

Figure 5-10 below shows the outcome of two numerical approaches that back-calculate the measured TDS of the water pumped from A Pit each day over the 90 days of the dewatering program. The simulations assume a dewatering pump rate of 120 ML for 60 days and 240 ML for 30 days. Both numerical simulations correlate with the measured data and the numerical method is the same for both approaches. However, the key numerical inputs were varied to show how the results vary with changes in the numerical assumptions.

- Simulation 1 (calculated 2 m/day seepage for 4,500 mg/L at approx. 120 ML/day and for 16,000 mg/L at approx. 240 ML/day): these TDS values represent seepage from the spoil during two phases of dewatering; the total volume of seepage draining from the spoil was 570 ML or 3% of the total saturated spoil volume. This represents a likely ‘best estimate’ of concentrations.

- Simulation 2 was calculated using an 8 m/day seepage rate, that is likely to be at the upper end of overall seepage flow rates from the spoil. The resulting seepage quality results from this simulation were 1,250 mg/L at approx. 120 ML/day and for 4,000 mg/L at approx. 240 ML/day. It is noted that these TDS values represent seepage from the spoil during two phases of dewatering; the total volume of seepage draining from the spoil was 2,281 ML or 13% of the total saturated spoil volume – although the pumping rates were not corrected for the additional volumes and concentrations may be underestimated as a result.

It is uncertain which of the outcomes above may best fit the actual conditions that occurred with dewatering of A Pit after the flood event. Nevertheless, these numerical modelling results highlight that a range of assumptions relating to the spoil hydrology and seepage concentrations need to be tested in the numerical modelling that is being undertaken by HEC.

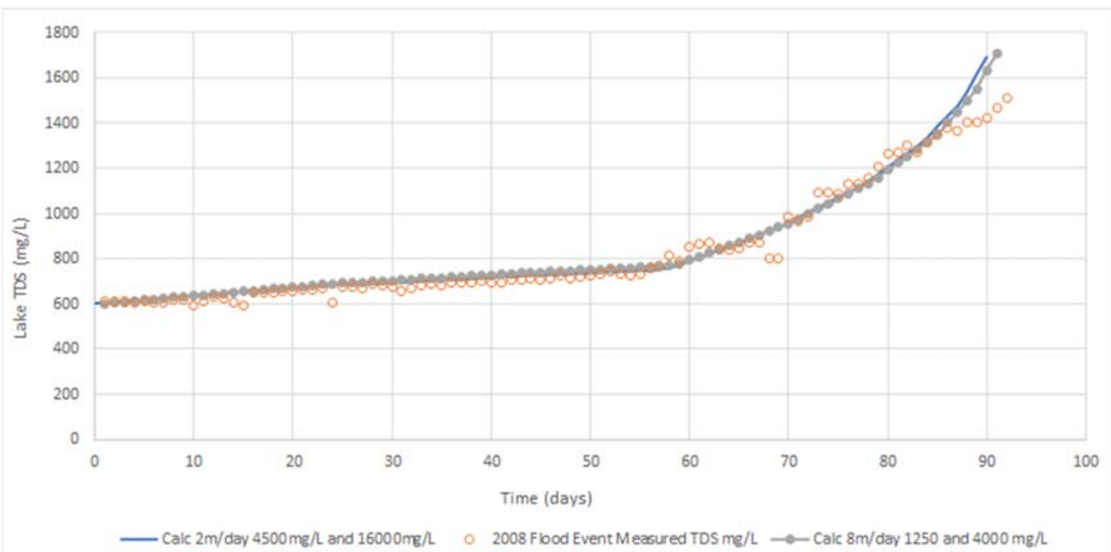

Figure 5-10: Measured TDS of Pit water in A Pit. 01 June 2008 to 28 August 2008

Modelling approach 2

A second mass balance numerical modelling approach was followed using the mass/mass-based loadings derived for the saturated water kinetic leach column testing (DI KLC test). The salt concentration-based results (mg/L) from the DI KLC tests were utilised by converting the measured concentrations in the leachate from the samples to a mg/kg value (**Table 5-6**). The results obtained from the laboratory tests are unlikely to correlate directly with probable concentrations in the field. Amongst other things, this may be attributed to differences in particle size distribution between the laboratory tests that were completed on material that was crushed to pass a 19 mm sieve size, whereas the material in the spoil dumps will include material from fines up to larger rocks, and therefore contains less available TDS. The values from the samples were summed to provide the average mass of TDS leached from the samples after the passage of one, two and three pore volumes of water, with and without the Quaternary sample that has elevated salinity compared with the samples obtained from fresh drill core, and the in-pit Permian spoil samples.

Table 5-6: Saturated water KLC pore volume results

Kinetic Leach Column (KLC)	Pore Volume 1	Pore Volume 2	Pore Volume 3	Sum of Pore Volume 1 to 3
	mg/kg	mg/kg	mg/kg	mg/kg
KLC 3 - C5285 Tertiary composite saturated with distilled water	178	88	42	308
KLC 6 - C5285 Permian composite saturated with distilled water	189	86	69	344
KLC 9 - C5286 Tertiary composite saturated with distilled water	820	310	59	1,189
KLC 12 - C5286 Permian composite saturated with distilled water	309	138	94	542
KLC 15 - Quaternary/Tertiary Spoil composite saturated with distilled water	5,118	280	64	5,462
KLC 18 - Permian Spoil composite saturated with distilled water	237	107	41	385
Average of all samples	1,142	168	61	1,372
Average of samples excluding Quaternary	347	146	61	554

The approach used to derive the results in **Figure 5-11** includes the following.

- A horizontal column of the spoil dump comprising 20 blocks, each with a 1m^2 face and length of 50 m was used to define the spoil dump hydrology including the volume of water that would be needed to bring each block to saturation and the number of pore volumes that would have passed through each block to bring the entire slice to saturation.
- The DI KLC source term of 347 mg/kg was used in the calculation that assumed that 25% or 50% of the available mass was mobilised from each block with the water front that moved through the column of spoil. This results in a large mass of salt being moved with the water from the mined pit void deeper into the spoil.
- It was assumed that the volume of water seeping from the spoil commences at 10 ML per day and that this decreases to 1 ML per day at the end of the dewatering program.
- For the 25% mobilised mass assumption as the spoil drained down the seepage coming out of the spoil dump starts off with a seepage concentration of 602 mg/L TDS and this increases up to 7,425 mg/L TDS at the end of the dewatering program.
- For the 50% mobilised mass assumption as the spoil drained down the seepage coming out of the spoil dump starts off with a seepage concentration of 1,040 mg/L TDS and this increases up to 12,968 mg/L TDS at the end of the dewatering program.

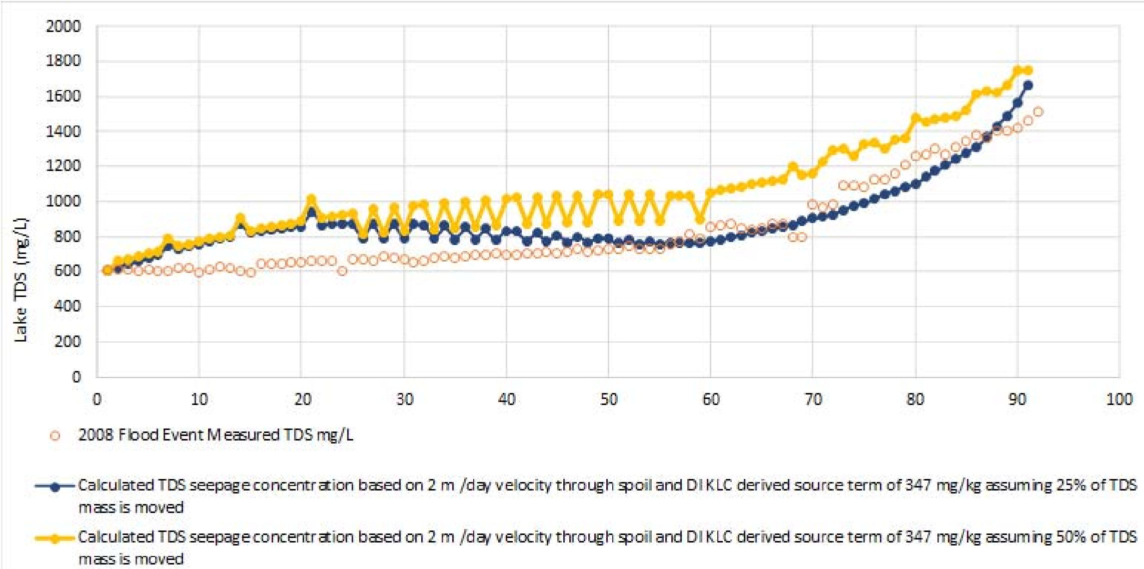

Figure 5-11: Measured TDS of Pit water in A Pit compared to calculated seepage concentrations derived using a DI KLC source term. 01 June 2008 to 28 August 2008

5.5 Post 2008 Pit Management

Since the 2008 flood event when A and B Pits were pumped dry, water has accumulated in the pits. The source of that water includes rain and surface runoff with low TDS, influent groundwater from springs at the base of the pit (with a TDS of about 5,000 mg/L) and other site water stores. The current EC of the water in A and B pits in 2018 is in the order of 5,000 µS/cm. The accumulation of the water in these pits has inundated the spoil with saline water and will have increased the TDS in the saturated spoil pores. As a result, it is likely that the TDS in the inundated spoil porewater and the seepage draining from the spoil will be higher than it was during the 2008 flood event. The precise management plans for dewatering these pits as part of the void management plan could include a wide range of scenarios.

5.5.1 A Pit Seepage Source Terms

The quantity of water moving into, through and then draining from mine spoil is dynamic as is the mass of TDS that is moved through the system. The volume and quality of the seepage from the spoil changes during a dewatering and drawdown event.

RGS recommends the application of stage – storage factors to the source terms (e.g. for A Pit, the initial seepage concentration during phase one of a dewatering program in a pit will be lower and representative of the pit water, but as the water level decreases during phase two and phase three the seepage concentration will increase).

Seepage source terms (mg/kg/pore volume) have been derived for saturated spoil using distilled water kinetic leach column testing methods. The TDS concentration is derived from a geochemical source term and a seepage flow based hydrological source term.

The seepage concentrations obtained from Modelling Approach 1 for A Pit have derived static seepage concentrations of 1,250 mg/L TDS and 4,000 mg/L TDS at the lower end of the scale up to 4,500 mg/L TDS and 16,000 mg/L TDS in the higher range of the seepage calculations.

The seepage concentrations obtained from Modelling Approach 2 have derived dynamic seepage concentrations of 602 mg/L TDS to 7,425 mg/L TDS at the lower end of the scale up to 1,040 mg/L TDS to 12,968 mg/L TDS at the higher range of the seepage calculations.

RGS recommends that the HEC modellers could use a range of TDS (mg/L) based spoil seepage values (source terms) ranging from 1,250 mg/L up to 16,000 mg/L depending on the seepage/pit scenario being simulated. The upper and lower source term values could be used as part of sensitivity analyses in the HEC modelling process.

5.5.2 Source Terms for the Initial Release Event and Drawdown of water from A Pit

The TDS in the A Pit water is currently about 5,000 mg/L and substantially higher than the TDS of water that filled the pit in 2008 that was 82 mg/L. The saturated spoil seepage TDS concentration will therefore be higher than the existing TDS in the pit water.

RGS suggests that the source terms for seepage for the simulation of the initial release event, drawdown and removal of water from A Pit should be towards the upper end of the range of calculated seepage concentrations i.e. 7,425 mg/L, 12,968 mg/L and 16,000 mg/L for phase one, two and three of the dewatering program.

5.5.3 Source Terms for the Stage 1 Filling, Release and Drawdown of water from A Pit

After the existing body of saline water in A Pit is removed from the pit and assuming that the water used to refill the pit is sourced from the Nogoa River, the A pit water will have a much lower starting TDS than the existing water body. The pit TDS will be a combination of 82 mg/L TDS from the Nogoa River combined with the mass of the salts that will be mobilised from pit wall and low wall spoil, potentially increasing the TDS to about 1,000 mg/L. The spoil pore water will still contain residual TDS from the Initial Release Event outlined above.

RGS suggests that the source terms for seepage for the simulation of the Stage 1 filling, drawdown and removal of water from A Pit should be at the upper range of the calculated seepage concentrations i.e. 4,500 mg/L, 7,425 mg/L and 12,968 mg/L for phase one, two and three of the dewatering program.

5.5.4 Source Terms for the Subsequent Filling Release and Drawdown of water from A Pit

For subsequent filling and dewatering programs, the water in the pit will have a TDS of about 82 mg/L from the Nogoa River combined with the mass of the salts that will be mobilised from pit wall and low wall spoil, potentially increasing the TDS to about 500 mg/L. The spoil pore water will begin to have lower TDS concentrations over time as TDS is removed from the system.

RGS suggests that the source terms for seepage for the simulation of the subsequent filling, drawdown and removal of water from A Pit should be at the upper range of the calculated seepage concentrations i.e. 4,000 mg/L, 4,500 mg/L and 7,425 mg/L for phase one, two and three of the dewatering program.

5.6 Final void hydrology and limnology

Evaluation of pit void water quality data including, pH, EC, temperature and oxygen data collected from 2008 after the flood event (through to 2012) confirm that thermoclines and chemoclines have been present in the Ensham pit water in the past, and that the pit water bodies may also have been overturned during this period. Qualitatively it appears that the difference in EC has to be greater than 4,500 µS/cm to induce a development of a saline chemocline (**Figure 5-12**), although the potential for this is also attributed to the difference in the salinity between the water bodies. In Figure 5-12 the upper water body is approximately 1,250 µS/cm at the surface and this transcends quickly to 4,500 µS/cm at 30 m below water level.

In June 2018 Ensham commissioned pit water profiling and the results indicated that there no chemoclines or thermoclines present in the water bodies. This is hypothesised to be due to overturning of the pit water in February after heavy rainfall.

Chemoclines and thermoclines could have potential effects on water quality modelling that may need to be considered in later stages of the pit void study. RGS recommends profiling the existing pit water on site each quarter over the next 3 years to (1) verify if pit waterbodies are currently stratified after the recent rain on site and (2) whether the stratification changes over the subsequent 12 months.

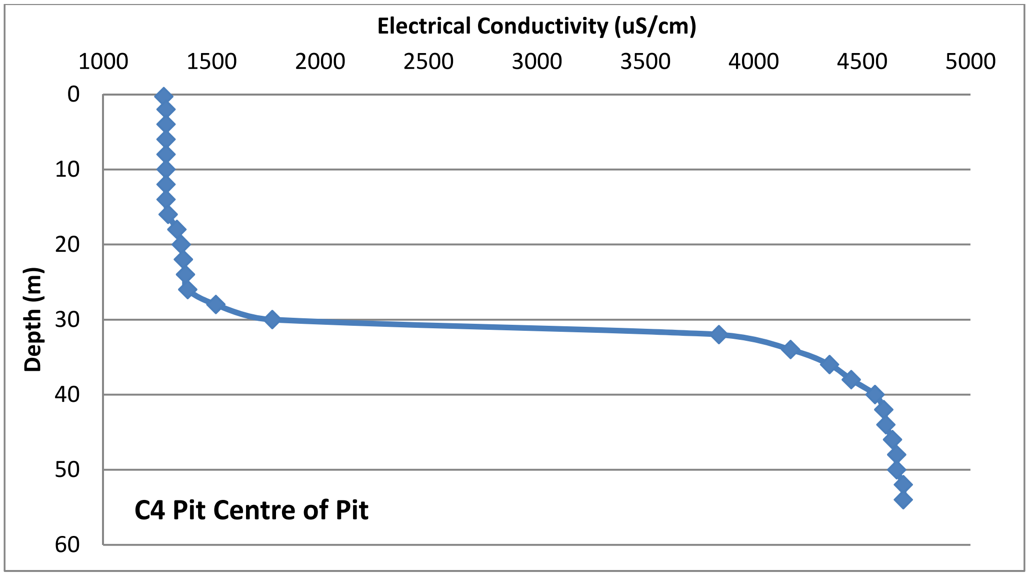

Figure 5-12: C4 EC Pit profile showing chemocline related to salinity (18 June 2009)

5.7 Unsaturated zone hydrology

Several factors complicate modelling groundwater flow through spoil (refer to **Section 5.2**). These include the alteration of the local hydrogeological conditions, the variable nature of the groundwater recovery in the spoil, heterogeneity within the spoil, preferential flow processes, and the variable nature of saturation in the system.

The localised nature of flow and pseudokarstic behaviour of spoil aquifers limits the ability of models based on porous media predictions for the dynamics of groundwater flow in spoil especially under transient flow conditions. The hydraulic properties of the spoil may also change with time complicating the use of groundwater flow models as a predictive tool.

There is some uncertainty regarding the current moisture content and phreatic surface in the spoil dumps, e.g. how much rainfall percolates through the spoil to the final voids, how much of the seepage that makes it to the toe of the spoil dump(s) is lost as evaporation, and how these processes change over time. The complexity of unsaturated zone hydrology includes consideration of:

- how quickly the spoil will become saturated;
- how quickly the saturated spoil would drain if the water level in the final void is reduced;
- whether the pore water in the saturated spoil would recharge the groundwater system; and,
- how the quality of the porewater would be affected by the quality of the final void water.

RGS completed unsaturated zone modelling to provide a basis for some aspects of the water balance that include deriving an average annual percentage for deep percolation of rain through the root zone of the rehabilitated spoil piles. The outcome of the modelling suggested that in the order of 1 to 2% of average rainfall may percolate through the root zone to deeper spoil (refer to **Appendix A.5**). RGS understand that a value of 1 to 2% could be on the low side but it does provide a lower bound for the water balance modellers to use.

RGS has provided some recommendations in **Section 8** as to how the level of uncertainty can be reduced in future work programs associated with the project.

5.8 Hydrogeochemical aspects of spoil dumps

5.8.1 Supplemental TDS Inputs from unsaturated Spoil

It is recognised that the TDS contained in the spoil above the saturated spoil zone will move progressively into and through the spoil and will be added to the salt balance over time. Additional work will be required to account for these inputs. However, because the salt from this spoil will be added slowly over time (years to decades) the effect on the seepage concentrations is not expected to be substantial. The fluxes to the saturated spoil zone will be a function of the seepage rate and porewater concentration. The IPR suggests a first approximation of 16,000 mg/L TDS in seepage reporting through the unsaturated spoil.

5.8.2 Major ions (salts)

Salinity refers to the content of soluble salts in soils. Common chemical components include sodium (Na^+), chloride (Cl^-), calcium (Ca^{2+}), magnesium (Mg^{2+}), potassium (K^+) and sulfate (SO_4^2). In Australia accumulation of NaCl in soil, regolith and older sediment is from the rainfall, weathering of soil and rock minerals (Taylor and Eggleston (2001)). Some stored salts can also be from marine deposition in earlier geological periods (Bui and Moran 2000; Chivas et al. 1991). Studies by Herczeg et al. (2001) indicated that the source of salinity in the Australian continent is mainly through rainfall. Sodium chloride dominates in most of Australian saline soils, accounting for 50–80 % of the total salt content.

Major ions including Ca^{2+}, Mg^{2+}, Na^+, K^+, Cl^-, SO_4^{2-} are present in overburden within a range of minerals and are subsequently released from mined spoil at concentrations greater than unmined overburden primarily because of a substantial change in the particle size distribution and consequent increase in the surface area of the mined spoil as it is blasted and side cast to in-pit spoil dumps. The oxidation of sulfide minerals present within the coal, coal roof and floor and sedimentary units (if present) also contributes to the release of sulfate, but at Ensham the proportion of sulfate in water is very low compared to NaCl.

Overburden of different geological age and physical properties are excavated and dumped as spoil in the in-pit spoil dumps. Dissolution of historically accumulated salts and rapid weathering of minerals contributes most to the labile ion pool. Saline ions can be moved away along with surface and underground water movement and may impact the surrounding environment

At Ensham, the salinity is higher in the surficial alluvium and clay in the Quaternary sediment than it is within the Tertiary and Permian sedimentary rock. This is attributed primarily to the effect of a changed particle size distribution and consequent increase in surface area in the extremely to completely weathered alluvium and clay in the oxide zone that extends from surface to about 5 m bgl in C5285 and about 20 m bgl in C5286. The increased surface area of these materials provides a comparatively larger interface for dissolution reactions to occur. Below these surficial sedimentary materials, the salinity is more consistent and typically lower through the profile to the coal seam.

5.8.3 Transition and post transition metals (metalloids)

Transition metals such as cadmium (Cd), cobalt (Co), copper (Cu), iron (Fe), manganese (Mn) and zinc (Zn) and post transition metals such as aluminium (Al) will precipitate from solution under increasing pH: above a pH of 9 some of these elements can be remobilised. The typical metalliferous elements that may have some potential to be leached from coal and coal mine spoil include Al, Fe, Mn and Zn. Other elements including cobalt (Co), copper (Cu), nickel (Ni) and lead (Pb) may also occur in carbonaceous strata including coal. Typically, the concentration of these elements is low, unless the coal and spoil are prone to sulfide oxidation processes that result in AMD. At Ensham, a relatively small amount of pyrite/marcasite is present in the coal and potentially in selected overburden and interburden strata, but the very low concentration and distribution of the sulfide minerals coupled with a moderate calcium carbonate presence results in neutral/slightly alkaline and saline drainage rather than AMD.

Arsenic (As), molybdenum (Mo) and selenium (Se) and classed as a metalloid, transition metal and a non-metal in the periodic table and are present in the KLC leachate with (typically) Se > As > Mo. At some coal mines, these three elements can be present in solution under neutral pH conditions and can be present in coal seeps and surface runoff. Selenium bearing pyrite is believed to be the source of Se in coal mine water (Fadlelmawla et al., 1994). In Appalachian coal overburden in the USA, nearly all Se occurs in a reduced state in largely unweathered, sedimentary rock (Ziemkiewicz and Lovett, 2016). Vesper et al. (2008 in Ziemkiewicz and Lovett, 2016) reported Se concentrations in southern West Virginia coal overburden rock ranging from about 0.84 in sandstone to 4.10 mg/kg in organic shale with higher Se concentrations coinciding with the highest sulfide levels. Diehl et al. (2005 in Ziemkiewicz and Lovett, 2016) determined Se in pyrite in southern Appalachian coals by a variety of microanalytical techniques. Up to 670 mg/kg of Se was found in pyrite samples. The minimum sulfur to Se ratios in their pyrite samples were near 1,000. Whole coal values for Se ranged from 25 to 247 mg/kg. At one to two percent sulfur content (estimated, sulfur content was not reported), the pyrite contained roughly 2 to 20% of the Se in the coal.

The Se percentage found in pyrite correlates well with the fraction found in the sulfidic extract by Roy (2005), who found 8 % of the total Se in the pyrite fraction of coal and 13 % in shale. Diehl et al. (2005) concluded that trace element enrichment was post-depositional to pyrite formation. The source of the Se in mined spoil is considered to be from the dissolution of soluble Se salts (weathering products from the Se bearing sulfide minerals) from the unsaturated zone within the overburden / spoil dumps and the mobility of the Se can be enhanced by the presence of dissolved organic carbon (Martin et al., 1988; Naftz and Rice, 1989 in Fadlelmawla et al., 1994). The concentration of the Se typically reduces over time and this may be a result of either chemical or microbial reduction of selenate (SeO_4^{2-}) to selenite ($SeO3^{2-}$) or bi-selenite ($HSeO^{3-}$).

6 Hydrogeochemical source terms for the water quality model

Source terms derived from static and kinetic geochemical data need to be scaled up from laboratory scale to field scale conditions in an appropriate and reasonable manner by numerical modellers. At Ensham (and many other in-pit spoil dumps) there is currently some understanding of spoil hydrology although RGS acknowledges that in the pre-feasibility stage of the work program, it is not possible to accurately quantify several hydrological aspects of the in-pit spoil dumps; i.e. to quantify how:

- much of the rain falling on the as-placed spoil and rehabilitated spoil is stored and then subsequently lost as evapotranspiration;
- how long it takes for water to move through the spoil (residence time);
- spoil geometry (length, height and volume) of placed spoil affects spoil hydrology;
- the passage of time affects solute release from as placed materials;
- much of the seepage moving through the spoil is lost to evaporation; and ultimately,
- much of the rain that percolated through the spoil reports as seepage at the toe of the dump.

The processes above can affect the quality of the water reporting from the toe of a spoil dump, and RGS acknowledges that the quality of the water varies from point to point and over time. However, the vast range of environmental processes occurring cannot be addressed in the first stage of a numerical model and RGS anticipates that additional studies will be undertaken over time to verify the assumptions and model inputs enabling increasing levels of reliability in model outputs to be derived.

Based on the results of the static and kinetic geochemical tests and measured surface water and groundwater quality from the site, salinity is likely to present some risk to environmental values at the final void project.

The presence of salts and metals/metalloids in the KLC leachate was investigated and considered by RGS and Ensham in the derivation of the geochemical source terms for the project. Whilst As, Mo and Se were present in the KLC leachate the concentration of these elements in surface water, groundwater, pit water and spoil seepage data from site were low, as is typically the case at low sulfur coal mines in the Bowen Basin. This indicates that whilst these elements are present in and have some potential to be leached from the coal and overburden/interburden there are hydro-geochemical controls on the solubility of these elements that contribute to reduced concentrations in receiving water bodies. In potential future work programs, a mass balance approach for As, Mo and Se could provide an order of magnitude assessment, however there may be a requirement to utilise geochemical code such as PHREEQC to further improve the level of confidence in the results and reflect probable hydro-geochemical controls.

Because the concentration of the salts was substantially higher than that of the metals/metalloids, the focus of the source terms development was major ion concentrations and salinity. Future stages of the project may benefit from studies to confirm that the predicted dissolved metals/metalloids concentrations in the final void water will be low.

RGS provided source terms for the Ensham pre-feasibility project phase for:

- existing water bodies in the **Ensham pits** that extrapolated data from the Ensham surface water database;
- the **Nogoa River** upstream of the mine that were extrapolated from the Ensham surface water database;
- **groundwater seepage** entering the pits through the pit floor from the underlying coal seam provided by Ensham;
- **surface runoff from rehabilitated areas**;
- **in-pit spoil seepage** from:
    - measured in-pit seepage data;
    - KLC testing; and,
- **surface runoff from high and low wall spoil**.

RGS has provided reference data that can be used as source terms by HEC.

- measured in-pit seepage data in **Appendix A.4.2** (limited to three samples);
- reference data for the derivation of source terms **Table 6-1;**
- initial pit water quality **Table 6-2;**
- pit wall runoff **Table 6-3;**
- concentration based source term data inputs – KLC leachate data from free draining leach column tests by material type **Table 6-4;**
- concentration based source term data inputs - KLC leachate data from free draining leach column tests by material type by major stratigraphic type **Table 6-5;**
- mass release rate based (mg/kg) source term data inputs – KLC leachate data from saturated leach column tests by material type **Table 6-6**; and,
- concentration-based water quality source terms for spoil seepage **Table 6-7.**

Table 6-1: Reference data for source terms

Water source term	Parameter	Location/application		
A Pit Ramp 22 saline pit water used for KLC testing		**A Pit water - single sample obtained by Ensham 4/02/2018 for KLC testing**		
	Calcium-Dissolved (mg/L)		46.00	
	Chloride (mg/L)		2470.00	
	Magnesium-Dissolved (mg/L)		186.00	
	Potassium-Dissolved (mg/L)		16.00	
	Sodium-Dissolved (mg/L)		1380.00	
	Sulfate as SO_4 Dissolved (mg/L)		596.00	
	As (mg/L)		0.0020	
	Mo (mg/L)		0.0060	
	Se (mg/L)		< 0.0100	
	Total dissolved solids(mg/L)		4694.01	
A Pit Ramp 22 groundwater seep flowing into the pit		**Ramp 24 groundwater seep - single sample obtained by Ensham 27/04/2017**		
	Calcium-Dissolved (mg/L)		360.00	
	Chloride (mg/L)		3200.00	
	Magnesium-Dissolved (mg/L)		320.00	
	Potassium-Dissolved (mg/L)		18.00	
	Sodium-Dissolved (mg/L)		1580.00	
	Sulfate as SO_4 Dissolved (mg/L)		480.00	
	Total dissolved solids(mg/L)		5958.00	
C Pit toe spoil seepage		**Spoil toe seepage based on 3 samples 14 March 2018**		
	Calcium-Dissolved (mg/L)	25	30	61
	Chloride (mg/L)	28	30	55
	Magnesium-Dissolved (mg/L)	10	6	8
	Potassium-Dissolved (mg/L)	248	269	459
	Sodium-Dissolved (mg/L)	172	246	463
	Sulfate as SO_4 Dissolved (mg/L)	170	155	260
	As (mg/L) (below detection)		0.0003	
	Mo (mg/L)	0.0003	0.0018	0.0030
	Se (mg/L) (below detection)		0.0003	
	Total dissolved solids(mg/L)	653.00	736.00	1306.00
Rehabilitated Spoil: 15 data points in 2017		**River flow affected values**		
		Upper Range (or low flow value)	**Average Range**	**Lower Range (or high flow value)**
	Calcium-Dissolved (mg/L)	21.00	14.00	9.00
	Chloride (mg/L)	245.00	140.00	66.00
	Magnesium-Dissolved (mg/L)	30.00	18.00	11.00
	Potassium-Dissolved (mg/L)	18.00	8.00	3.00
	Sodium-Dissolved (mg/L)	162.00	100.00	44.00
	Sulfate as SO_4 Dissolved (mg/L)	187.00	68.00	8.00
	Total dissolved solids(mg/L)	663.00	348.00	141.00
Nogoa River water ENMP02 sourced from 50 data points from Nov 2009 to Oct 2017		**River flow affected values**		
		Upper Range (or low flow value for Nogoa River)	**Average Range**	**Lower Range (or high flow value for Nogoa River)**
	Calcium-Dissolved (mg/L)	15.67	17.00	14.00
	Chloride (mg/L)	107.00	17.68	5.00
	Magnesium-Dissolved (mg/L)	6.90	6.20	5.70
	Potassium-Dissolved (mg/L)	6.00	5.13	4.00
	Sodium-Dissolved (mg/L)	307.00	55.80	11.00
	Sulfate as SO_4 Dissolved (mg/L)	75.00	12.95	0.50
	As (mg/L)	0.0070	0.0022	0.0001
	Mo (mg/L)	0.0030	0.0018	0.0005
	Total dissolved solids(mg/L)	517.58	114.77	40.20

Table 6-2: Pit void water quality source terms – initial pit water quality

		Maximum	Average	Minimum
A Pit - South	Calcium-Dissolved (mg/L)	71.00	68.00	64.00
	Chloride (mg/L)	2630.00	2560.00	2430.00
	Magnesium-Dissolved (mg/L)	209.00	198.00	190.00
	Potassium-Dissolved (mg/L)	16.00	15.75	15.00
	Sodium-Dissolved (mg/L)	1510.00	1392.50	1290.00
	Sulfate as SO_4 - Turbidimetric-Dissolved (mg/L)	662.00	629.88	603.00
	As (mg/L)	0.0020	0.0010	0.0001
	Mo (mg/L)	0.0070	0.0060	0.0050
	Se (mg/L) (below detection)	0.0005	0.0005	0.0005
	Total dissolved solids(mg/L)	5098.00	4864.13	4592.00
A Pit - North	Calcium-Dissolved (mg/L)	57.00	50.00	46.00
	Chloride (mg/L)	2570.00	2282.86	1750.00
	Magnesium-Dissolved (mg/L)	201.00	178.00	132.00
	Potassium-Dissolved (mg/L)	18.00	18.00	18.00
	Sodium-Dissolved (mg/L)	1700.00	1438.89	1240.00
	Sulfate as SO_4 - Turbidimetric-Dissolved (mg/L)	657.00	584.59	524.00
	As (mg/L)	0.0030	0.0020	0.0010
	Mo (mg/L)	0.0090	0.0070	0.0050
	Se (mg/L) (below detection)	0.0005	0.0005	0.0005
	Total dissolved solids(mg/L)	5203.00	4552.34	3710.00
B Pit	Calcium-Dissolved (mg/L)	295.00	274.75	235.00
	Chloride (mg/L)	3260.00	3120.00	2950.00
	Magnesium-Dissolved (mg/L)	277.00	147.25	25.00
	Potassium-Dissolved (mg/L)	18.00	17.50	17.00
	Sodium-Dissolved (mg/L)	1610.00	1513.33	1450.00
	Sulfate as SO_4 - Turbidimetric-Dissolved (mg/L)	497.00	346.67	50.00
	As (mg/L)	0.0030	0.0020	0.0010
	Mo (mg/L)	0.0050	0.0040	0.0030
	Se (mg/L) (below detection)	0.0005	0.0005	0.0005
	Total dissolved solids(mg/L)	5957.00	5419.50	4727.00
C Pit	Calcium-Dissolved (mg/L)	216	148	90
	Chloride (mg/L)	3200	2600	2200
	Magnesium-Dissolved (mg/L)	295	242	143
	Potassium-Dissolved (mg/L)	19	16.5	13
	Sodium-Dissolved (mg/L)	2070	1409	339
	Sulfate as SO_4 - Turbidimetric-Dissolved (mg/L)	1200	465	50
	As (mg/L)	0.008	0.001	0.0005
	Mo (mg/L)	0.0140	0.0040	0.0020
	Se (mg/L) (below detection)	0.0005	0.0005	0.0005
	Total dissolved solids(mg/L)	7000.01	4880.50	2835.00

Table 6-3: Pit wall runoff quality source terms – surface runoff from non-rehabilitated areas

		ED041G: Sulfate (Turbidimetric) as SO42- by DA 1:3 16 hr leach	ED045G: Chloride by Discrete Analyser 1:3 16 hr leach	ED093F:Dissolved Calcium 1:3 16 hr leach	ED093F:Dissolved Magnesium 1:3 16 hr leach	ED093F:Dissolved Sodium 1:3 16 hr leach	ED093F:Dissolved Potassium 1:3 16 hr leach	ED037P_Total Alkalinity as CaCO3 1:3 16 hr leach	Total Dissolved Solids 1:3 16 hr leach
Source term for mass:mass use		**mg/kg > 25mm rainfall event**							
Source term for mass:area use		**mg/m²/ > 25mm rainfall event**							
Fresh drill core	**Tertiary**	84	256	5	8	303	10	293	958
	Permian	102	221	3	6	311	16	360	1020
As-placed spoil	**Tertiary**	206	2769	147	264	1233	15	402	5036
	Permian	137	28	9	11	127	14	109	435

Rain	**Rain from (mm)**	**Rain to (mm)**	**Rain events per year**
Low	> 1	< 10	45
Moderate	> 10	< 25	17
High	> 25		7

Predictions for this project
High rainfall events trigger erosion from exposed soil, spoil and overburden
1 kg of sediment is eroded from each m^2 during each rain event (10 t/ha)
The soluble mass of salt present in the soil, spoil, overburden mixes with receiving water
If the spatial distribution of Tertiary and Permian material as placed spoil or exposed high walls is not known, then an average of all data may be appropriate.
1 kg of spoil taken to cover 1 m^2 to a depth of 1 mm
7 erosion events predicted per year.
Erosion rate of 70 tonne / ha /yr predicted for exposed spoil.
References
Average soil formation is 0.1 mm/yr (Morgan, 2005)
Mean annual soil loss of < 5.5 t/ha/yr considered acceptable for managed agricultural land
On the Darling Downs, soil losses from unprotected cultivation in upland cropping areas can average between 20 and 60 tonnes per hectare, per year. Steep, unprotected cropping lands in tropical areas can average soil losses of up to 400 tonnes of soil per hectare, per year (DERM, 2009).

Table 6-4: Concentration based source term data inputs – KLC leachate data from free draining leach column tests by material type

MATERIAL A - KLC 1 and KLC7	**Fresh Drill Core - 2 samples unmined Tertiary Sedimentary Rock**									
Leach event	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Week	**1**	**2**	**3**	**4**	**5**	**7**	**9**	**11**	**13**	**15**
Calcium (mg/L)	13	15	19	13	8	5	5	6	6	9
Potassium (mg/L)	10	13	15	11	7	5	6	6	6	8
Magnesium (mg/L)	21	27	38	27	16	10	11	11	12	19
Sodium (mg/L)	345	374	427	326	208	152	138	165	142	189
Chloride (mg/L)	469	522	555	399	266	161	156	178	163	211
Sulfate (mg/L)	169	193	205	149	92	74	69	90	82	101
TDS _ major cations and anions	1028	1146	1263	931	606	420	399	474	431	561
As (mg/L)	0.0255	0.0200	0.0195	0.0195	0.0165	0.0170	0.0181	0.0223	0.0173	0.0163
Mo (mg/L)	0.0695	0.0705	0.0805	0.0610	0.0340	0.0340	0.0160	0.0290	0.0195	0.0145
Se (mg/L)	0.0700	0.0750	0.0750	0.0600	0.0250	0.0200	0.0150	0.0200	0.0150	0.0250
MATERIAL B - KLC 4 and KLC 10	**Fresh Drill Core - 2 samples unmined Permian Sedimentary Rock**									
Leach event	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Week	**1**	**2**	**3**	**4**	**5**	**7**	**9**	**11**	**13**	**15**
Calcium (mg/L)	24	18	18	13	7	5	7	6	6	9
Potassium (mg/L)	12	12	13	11	7	6	8	7	4	7
Magnesium (mg/L)	20	18	20	15	8	6	9	8	9	10
Sodium (mg/L)	463	469	501	420	272	235	257	225	219	191
Chloride (mg/L)	488	532	471	349	174	89	65	46	44	15
Sulfate (mg/L)	261	280	274	222	124	102	102	103	96	72
TDS _ major cations and anions	1268	1333	1301	1036	601	456	462	412	400	328
As (mg/L)	0.0265	0.0265	0.0290	0.0380	0.0235	0.0205	0.0120	0.0095	0.0065	0.0040
Mo (mg/L)	0.1540	0.2065	0.2230	0.1910	0.1020	0.0700	0.0435	0.0295	0.0195	0.0085
Se (mg/L)	0.0950	0.1100	0.0700	0.0300	0.0200	0.0200	0.0250	0.0300	0.0200	0.0200
MATERIAL C - KLC1, 4, 7 and 10	**Fresh Drill Core - Average of Material A and Material B**									
Leach event	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Week	**1**	**2**	**3**	**4**	**5**	**7**	**9**	**11**	**13**	**15**
Calcium (mg/L)	18	16	18	13	7	5	6	6	6	9
Potassium (mg/L)	11	12	14	11	7	6	7	6	5	7
Magnesium (mg/L)	21	23	29	21	12	8	10	9	10	15
Sodium (mg/L)	404	422	464	373	240	193	197	195	180	190
Chloride (mg/L)	478	527	513	374	220	125	110	112	103	113
Sulfate (mg/L)	215	236	239	186	108	88	85	96	89	86
TDS _ major cations and anions	1148	1239	1282	984	603	438	431	443	415	444
As (mg/L)	0.0260	0.0233	0.0243	0.0288	0.0200	0.0188	0.0150	0.0159	0.0119	0.0101
Mo (mg/L)	0.1118	0.1385	0.1518	0.1260	0.0680	0.0520	0.0298	0.0293	0.0195	0.0115
Se (mg/L)	0.0825	0.0925	0.0725	0.0450	0.0225	0.0200	0.0200	0.0250	0.0175	0.0225
MATERIAL D - KLC 13	**In-pit Spoil Sample - Quaternary/Tertiary Spoil**									
Leach event	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Week	**1**	**2**	**3**	**4**	**5**	**7**	**9**	**11**	**13**	**15**
Calcium (mg/L)	1060	1340	960	264	59	24	10	10	6	
Potassium (mg/L)	23	26	22	11	6	3	2	2	1	
Magnesium (mg/L)	1220	1420	1020	293	109	33	13	10	5	

Sodium (mg/L)	3940	4010	3570	1960	1120	640	401	354	237	
Chloride (mg/L)	10800	12700	9390	4660	1580	553	170	77	16	
Sulfate (mg/L)	742	930	868	635	390	200	116	82	34	
TDS _ major cations and anions	17842	20547	15969	8040	3583	2004	714	538	0	
As (mg/L)	0.0030	0.0020	0.0020	0.0010	0.0010	0.0020	0.0030	0.0040	0.0050	
Mo (mg/L)	0.0070	0.0070	0.0070	0.0030	0.0040	0.0120	0.0190	0.0230	0.0390	
Se (mg/L)	0.0100	0.0200	0.0100	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	
MATERIAL E - KLC 16	**In-pit Spoil Sample - Permian Spoil**									
Leach event	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Week	**1**	**2**	**3**	**4**	**5**	**7**	**9**	**11**	**13**	**15**
Calcium (mg/L)	145	145	92	63	47	38	33	26	25	18
Potassium (mg/L)	28	29	23	20	17	16	16	14	13	11
Magnesium (mg/L)	113	109	71	52	39	34	33	23	22	16
Sodium (mg/L)	233	218	172	133	118	111	105	91	85	68
Chloride (mg/L)	86	50	28	17	13	11	9	8	6	3
Sulfate (mg/L)	1150	1110	771	451	376	306	266	198	166	88
TDS _ major cations and anions	1797	1775	1284	875	747	661	463	361	318	205
As (mg/L)	0.0030	0.0030	0.0030	0.0040	0.0020	0.0020	0.0020	0.0020	0.0010	0.0020
Mo (mg/L)	0.0100	0.0010	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Se (mg/L)	0.1500	0.1300	0.0700	0.0500	0.0400	0.0300	0.0300	0.0200	0.0200	0.0050
MATERIAL F - Material C, KLC13 and 16	**Mixed Fresh Drill Core and Mixed Spoil Samples**									
Leach event	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Week	**1**	**2**	**3**	**4**	**5**	**7**	**9**	**11**	**13**	**15**
Calcium (mg/L)	310	379	272	88	30	18	14	12	11	12
Potassium (mg/L)	18	20	18	13	9	8	8	7	6	9
Magnesium (mg/L)	344	394	287	97	43	21	16	13	12	15
Sodium (mg/L)	1245	1268	1167	710	430	284	225	209	171	149
Chloride (mg/L)	2961	3451	2611	1356	508	204	100	77	57	76
Sulfate (mg/L)	580	628	529	364	246	170	138	118	95	87
TDS _ major cations and anions	5484	6200	4954	2720	1384	885	510	446	287	364
As (mg/L)	0.0145	0.0129	0.0134	0.0156	0.0108	0.0104	0.0088	0.0094	0.0074	0.0074
Mo (mg/L)	0.0601	0.0713	0.0778	0.0639	0.0351	0.0291	0.0198	0.0205	0.0196	0.0078
Se (mg/L)	0.0813	0.0838	0.0563	0.0363	0.0225	0.0188	0.0188	0.0188	0.0150	0.0167

Table 6-5: Concentration based source term data inputs – KLC leachate data from free draining leach column tests by material type by major stratigraphic type

PERMIAN										
Leach event	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Week	**1**	**2**	**3**	**4**	**5**	**7**	**9**	**11**	**13**	**15**
Calcium (mg/L)	84	81	55	38	27	22	20	16	16	TBA
Potassium (mg/L)	20	21	18	15	12	11	12	10	9	TBA
Magnesium (mg/L)	67	64	46	34	23	20	21	15	15	TBA
Sodium (mg/L)	348	344	337	276	195	173	181	158	152	TBA
Chloride (mg/L)	287	291	249	183	94	50	37	27	25	TBA
Sulfate (mg/L)	705	695	522	337	250	204	184	150	131	TBA
TDS _ major cations and anions	1532	1554	1292	955	674	558	462	386	359	TBA
As (mg/L)	0.015	0.015	0.016	0.021	0.013	0.011	0.007	0.006	0.004	TBA
Mo (mg/L)	0.082	0.104	0.112	0.096	0.051	0.035	0.022	0.015	0.010	TBA
Se (mg/L)	0.123	0.120	0.070	0.040	0.030	0.025	0.028	0.025	0.020	TBA
TERTIARY										
Leach event	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Week	**1**	**2**	**3**	**4**	**5**	**7**	**9**	**11**	**13**	**15**
Calcium (mg/L)	13	15	19	13	8	5	5	6	6	TBA
Potassium (mg/L)	10	13	15	11	7	5	6	6	6	TBA
Magnesium (mg/L)	21	27	38	27	16	10	11	11	12	TBA
Sodium (mg/L)	345	374	427	326	208	152	138	165	142	TBA
Chloride (mg/L)	469	522	555	399	266	161	156	178	163	TBA
Sulfate (mg/L)	169	193	205	149	92	74	69	90	82	TBA
TDS _ major cations and anions	1028	1146	1263	931	606	420	399	474	431	TBA
As (mg/L)	0.026	0.020	0.020	0.020	0.017	0.017	0.018	0.022	0.017	TBA
Mo (mg/L)	0.070	0.071	0.081	0.061	0.034	0.034	0.016	0.029	0.020	TBA
Se (mg/L)	0.070	0.075	0.075	0.060	0.025	0.020	0.015	0.020	0.015	TBA
QUATERNARY										
Leach event	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Week	**1**	**2**	**3**	**4**	**5**	**7**	**9**	**11**	**13**	**15**
Calcium (mg/L)	1060	1340	960	264	59	24	10	10	TBA	TBA
Potassium (mg/L)	23	26	22	11	6	3	2	2	TBA	TBA
Magnesium (mg/L)	1220	1420	1020	293	109	33	13	10	TBA	TBA
Sodium (mg/L)	3940	4010	3570	1960	1120	640	401	354	TBA	TBA
Chloride (mg/L)	10800	12700	9390	4660	1580	553	170	77	TBA	TBA
Sulfate (mg/L)	742	930	868	635	390	200	116	82	TBA	TBA
TDS _ major cations and anions	17842	20547	15969	8040	3583	2004	714	538	TBA	TBA
As (mg/L)	0.003	0.002	0.002	0.001	0.001	0.002	0.003	0.004	TBA	TBA
Mo (mg/L)	0.007	0.007	0.007	0.003	0.004	0.012	0.019	0.023	TBA	TBA
Se (mg/L)	0.010	0.020	0.010	0.005	0.005	0.005	0.005	0.005	TBA	TBA

Table 6-6: Mass release rate based (mg/kg) source term data inputs – KLC leachate data from saturated leach column tests by material type

	TDS mg/kg		TDS mg/kg
Free Draining KLC Major ion sum from 10 leach cycles (incl. Cl & SO4) – Pore Volume 1	414	Free Draining KLC Major ion sum from 10 leach cycles (incl. Cl & SO4) & inclusive of Quaternary – Pore Volume 1	880
DI sat. KLC Sum after 1 pore volumes (incl. Cl & SO4) excluding Quaternary – Pore Volume 2	347	DI sat. KLC Sum after 1 pore volumes (incl. Cl & SO4) & inclusive of Quaternary – Pore Volume 2	1142
DI sat. KLC Sum after 2 pore volumes (incl. Cl & SO4) excluding Quaternary – Pore Volume 3	146	DI sat. KLC Sum after 2 pore volumes (incl. Cl & SO4) & inclusive of Quaternary – Pore Volume 3	168
DI sat. KLC Sum after 3 pore volumes (incl. Cl & SO4) excluding Quaternary	61	DI sat. KLC Sum after 3 pore volumes (incl. Cl & SO4) & inclusive of Quaternary	61
DI sat. KLC Sum of PV1, 2 and 3 excluding Quaternary	554	DI sat. KLC Sum of PV1, 2 and 3 including Quaternary	1372
1:3 Sum of major ions using < 19 mm PSD and 16-hour leach (incl. Cl & SO4)	1782		

Proposed source terms for spoil seepage in **Table 6-7** below represents:

- **Phase 1** - Initial flooding: water concentration in the waterbody commences at value calculated from water balance; to this is added an initial solute loading of 150 tonnes TDS /ha of wall rock exposed as wall rocks are inundated – other solutes to be calculated.
- **Phase 2** - Initial drawdown: when water is drawn down for irrigation the recharge from the waterbody is initially extracted so that the concentration in porewater released from the spoil will the greater of the calculated waterbody concentration or the concentration in the table.
- **Phase 3** – deeper drawdown: waterbody levels fall below the elevation where the salt front is reversed and drawn back into the waterbody. Seepage concentrations increase to the range shown.

Table 6-7: Concentration-based water quality source terms for spoil seepage

Phase	Source	Seepage Source		Wall rock source	Comment
		Concentration (mg/L)	Water Elevation range	tonne/ha wall rock	
1	Wall rock release	-	-	70	Initial flooding: Net release following to initial flooding from wall rocks and exposed spoil face (assume A-Pit wall exposure of 70 ha and total TDS release of 6,200 tonnes calculated from TDS increase in waterbody (82 to 600 mg/L)
2	Initial seepage	4,500 – 7,000; or waterbody concentration - whichever is greater	Drop of <15 m in water level from full supply	n/a	Initial seepage represents release of recharge to spoil
3	Secondary Seepage	12,000 to 16,000	Drop of > 15 m in level from full supply	n/a	Secondary seepage constitutes deeper pore water release

Repeated for first 3 cycles flood and pump down. Thereafter the concentrations in the seepage is decreased by 50% for consecutive flood events.

7 Conclusions

AMD potential

The coal and mine waste materials generated at Ensham can generally be described as having a low sulfur content and excess acid buffering capacity. Most materials are classified as NAF and have a high factor of safety with respect to potential for acid generation.

Based on an evaluation of the Ensham Coal Mine surface and groundwater databases, previous geochemical reports, and the geochemical dataset described herein, it is expected that the risk of Ensham experiencing any acid issues will be low.

Metalliferous drainage potential

The total metal/metalloid concentrations measured in coal and mine waste samples are typically low and only elevated in a small number of samples. The KLC test data demonstrate that most metal/metalloids are sparingly soluble in leachate and concentrations are relatively low.

Based on an evaluation of the Ensham Coal Mine surface and groundwater databases, previous geochemical reports, and the geochemical dataset described herein, it is expected that, it is expected that the risk of Ensham experiencing elevated concentrations of metals/metalloids in surface water and groundwater resources will be low.

Saline drainage potential

Based on an evaluation of the Ensham Coal Mine surface and groundwater databases, previous geochemical reports, and the geochemical dataset described herein, the management and control of potential inflows with elevated salinity should be a key focus of rehabilitation design for the site.

The salinity of regional groundwater in the project area is elevated under natural (pre-mine) conditions. In particular, elevated salinity in groundwater associated with the shallow groundwater system and Quaternary alluvium, and to a lesser extent with the deeper groundwater systems in the Tertiary and Permian strata, is already apparent.

The pit void water within the mine are open systems and have received surface runoff from the as placed and as-mined low and high wall spoil, rehabilitated landforms, direct precipitation and water from other pits and groundwater from underground mining sources. The existing water quality in the pits does not therefore provide a clear reference point to predict how the water quality in the pits may evolve over time. The pit void water is known to have developed chemoclines and thermoclines, and this may occur again in the future. Whilst these phenomena can potentially work in favour of water management, future studies may be required to confirm this outcome.

The three major overburden units at Ensham include Quaternary, Tertiary and Permian rock units. The static geochemical testing identified some notable differences in the salinity of these material types with the EC of the Quaternary sediment in the drill core ranging from 329 to 1,030 in C Pit and 163 to 1,550 µS/cm in Y Pit. The 1:5 EC of the Quaternary spoil samples collected from the in-pit spoil dumps ranged from 2,230 to 2,480 µS/cm. These EC values were substantially lower than the KLC leach data for Quaternary sediment that was more than an order of magnitude higher in the initial KLC test leach cycle. Therefore, RGS has taken the relative amounts of these materials at each pit into account in the development of geochemical source terms for subsequent HEC water quality modelling.

Whilst the salinity of the Quaternary/Tertiary spoil samples was elevated, the salinity decreased rapidly and was in the order of 2,000 µS/cm towards the end of the four-month KLC test program. This data suggests that the saline minerals in the in-situ Quaternary spoil and as placed Quaternary spoil may include comparatively less soluble sodium carbonate-based minerals that dissolve at a slower rate than the highly soluble sodium chloride minerals (i.e. the static leach tests mobilise highly soluble minerals and the slower KLC leach tests that provide a longer contact time dissolve the less soluble mineral phases). Again, this finding has been considered in the development of geochemical source terms for subsequent HEC water quality modelling.

There were no substantial differences in the static or kinetic leach test results within or between the Tertiary and Permian drill core samples with the EC from the KLC tests for these samples ranging from 1,700 to 2,700 µS/cm for the initial leach cycle and peaked at 1,700 to 3,470 µS/cm. The leachate salinity decreased after the third leach cycle salinity and at the end of the test period, the EC was 475 to 1,375 µS/cm.

In-pit spoil hydrology and hydrogeochemistry

The available information from the Ensham site has been used to quantify the water balance within as-placed spoil and rehabilitated spoil, the latter of which has vigorous and sustainable pasture cover. Vadose/W unsaturated soil modelling using predicted numerical inputs was used to determine how much of the rain at the site is likely to report as surface runoff, be lost as evapotranspiration, or pass through the soil cover and root zone into the spoil dumps. The Vadose/W modelling determined that, on average, approximately 1% of rainfall reports into deeper spoil below the zone of effective evaporation and zone of transpiration at the root zone. Observations at site indicate that the spoil dumps do not lose much water as seepage and this is consistent with predicted vadose hydrological processes in other spoil dumps in Queensland.

At the commencement of the study there were no measured in-pit toe seepage water quality or quantity data. To derive water quality source terms for toe seepage, which represent the major source of solutes that may enter the pit water bodies, KLC testing was undertaken on Quaternary and Tertiary spoil samples and Tertiary and Permian drill core.

Three toe seepage samples were collected by site personnel in C Pit in March 2018 and this water quality data validates the KLC results (i.e. that the EC of the seepage from in-pit spoil was 1,440 to 2,800 µS/cm and the EC of the initial KLC test leachate for Tertiary and Permian material was 1,670 to 2,700 µS/cm. The KLC leach program then provides additional longer-term data to quantify the changes in concentrations over time.

Source terms and their application in the water quality model

The source terms (numerical values) used in the water quality model developed by HEC, were derived by RGS from measured surface water data collected by Ensham and static and kinetic geochemical analyses undertaken on Quaternary, Tertiary and Permian sedimentary units.

The application of the source terms and the results of the mass balance numerical modelling is described in the HEC report.

8 Recommendations

The recommendations in this report are provided to enable the project to further improve existing knowledge related to some of the technical aspects of the project.

In-pit spoil geochemical and physical properties

There is some variability in the salinity of the spoil within the pits and within the major strata (refer to **Section 5-4**). Due to the variability observed in the 29 supplementary spoil samples additional sampling and analysis of the in-pit as placed spoil should be considered by Ensham in subsequent stages of the development of the mine. The work that should be considered includes the following:

- Mapping of Quaternary, Tertiary and Permian material on existing profiled faces to evaluate if this material is present on areas that are scheduled for rehabilitation.
- Collection of in-pit Quaternary, Tertiary and Permian surface samples using the mapping mentioned above from the:
    - upper surface of the spoil dumps before rehabilitation; and,
    - re-profiled low walls before rehabilitation.
- Basic geochemical analyses of the samples including pH, EC, CEC, TS and ANC analysis.
- Physical analysis of the in-pit samples including soil water characteristic curve (SWCC), particle size distribution (PSD), density, porosity, optimum moisture content, and permeability measurements that would be used to evaluate the porosity, permeability and transmissivity of the in-pit spoil under various levels of compaction.
- The installation of automated soil moisture sensors in rehabilitated areas to provide a direct measure of infiltration rates.
- Site based permeability testing should be undertaken on as-placed spoil, profiled spoil and rehabilitated spoil to obtain measured permeability data to support in-pit spoil hydrological predictions.

RGS acknowledges that some of this work has already been commenced by Ensham e.g. collection and static geochemical analysis of an additional 29 samples of spoil in May 2018.

In-pit spoil and highwall geochemical, hydrogeological and physical properties

- Drilling within rehabilitated spoil dumps and installation of groundwater monitoring bores that would be used to measure existing water levels and quality in the spoil dumps and be used to monitor changes in water level and quality over time under the various options being considered by Ensham. Utilisation of the core from these in-pit and high wall drilling programs for the geochemical and physical testing outlined above.

- Drilling within the high wall and installation of groundwater monitoring bores that would be used to measure existing water levels and quality in and be used to monitor changes in water level and quality over time under the various options being considered by Ensham. Utilisation of the core from these in-pit and high wall drilling programs for the geochemical and physical testing outlined above.

- There should be further evaluation of spoil hydrological aspects to determine how much water can be stored or transmitted from the spoil. To do this there should be detailed records kept from all pit dewatering programs on site to quantify the volume and associated quality of the water that is removed from the pits. This would verify how much water is stored within the in-pit spoil, how long it takes for the water to drain from the spoil and verify how the quality of the seepage changes over time. As part of this work any historic data associated with spoil hydrology and water quality should also be assessed.

Final Void water hydro-geo-limnological properties

- RGS acknowledges that Ensham completed pit water physico-chemical profiling in May 2018 which indicated that there was not chemocline or thermocline present in the pit water bodies at that time.
- There should be ongoing monitoring of the existing final void water bodies to quantify the hydrological, geochemical and limnological processes that will drive the changes in water quality over time.
- In-pit water quality profiling, sampling and analysis should be done September, March and July each year to verify changes in water quality and verify if the pit water bodies stratify / overturn. Sampling after climatic events with the potential to impact the water bodies, e.g. high rainfall events, is also recommended.
- It is recommended that pH/EC/Redox/Thermocouple probes lowered into the water bodies be used for depth profiling. This will enable the production of continuous depth profiles.

Continuation of KLC testing

- There should be ongoing monitoring of the existing KLC samples to ascertain when the steady state conditions relating to the quality of the leachate are attained (e.g. for a further 8-month period). The longer term KLC testing will also confirm the low risk of AMD being produced in the longer term.

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A.1 Appendix 1 Kinetic leach column data tables

KLC 1 - C5285 Tertiary composite FREE LEACH

		KLC 1 - C5285 Tertiary composite FREE LEACH											
		Weight (kg)	11.60	Total S (%)	0.03	ANC	39.1	Volume L	8.2	Pore void (L)	2.45	% Silt	2
		pH (1:5)	9.50	Scr (%)	0.025	NAPP	-38.2	Density	1.4			% Sand	15
		EC (µS/cm)	304	MPA	0.9	ANC:MPA	42.6	Pore void (%)	30.0			% Gravel	83
Date		09-Mar-18	16-Mar-18	23-Mar-18	28-Mar-18	05-Apr-18	13-Apr-18	27-Apr-18	11-May-18	25-May-18	03-Jul-18		
Number of Weeks		1	2	3	4	5	7	9	11	13	15		
Leach Number		1	2	3	4	5	6	7	8	9	10		
ALS Laboratory Number		EB1806403	EB1807004	EB1807664	EB1808044	EB1808680	EB1809205001	EB1810435001	EB1811540001	EB1812860001	EB1816067		
Volume On (L)		2.0	1.2	1.2	0.0	0.8	0.8	1.0	0.8	0.8	0.8		
Volume Collected (L)		0.8	0.8	0.8	0.6	0.5	0.6	0.7	0.7	0.6	0.6		
Volume Sent to ALS (L)		0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5		
Cum. Volume (L)		2.0	3.2	4.4	4.4	5.2	5.9	6.9	7.7	8.4	9.2		
Cum Vol Off		0.8	1.6	2.4	3.0	3.5	4.1	4.8	5.5	6.0	6.6		
Pore Volumes													
pH (RGS Measurement)		7.9	7.6	7.8	7.9	7.7	7.6	9.0	7.9	7.2	8.2		
pH (ALS Measurement)		8.3	7.8	8.8	8.3	7.9	8.2	8.7	8.2	8.1	8.5		
EC (RGS Measurement) (µS/cm)		1636.0	1590.0	1525.0	1238.0	664.0	598.0	402.0	615.0	451.0	484.0		
EC (ALS Measurement) (µS/cm)		1670.0	1640.0	1600.0	1250.0	738.0	619.0	421.0	657	475	489.0		
Acidity (mg/L)*		0.5	0.5	0.5	0.5	0.5	2.0	0.5	0.5	0.5	0.5		
Alkalinity (mg/L)*		102.0	138.0	191.0	165.0	113.0	121.0	94.0	156	137	161.0		
Major Ions (mg/L)	LoR												
Calcium (Ca)	1	9	9	8	6	5	4	2	4	3	3		
Potassium (K)	1	6	8	8	4	2	2	2	2	2	2		
Magnesium (Mg)	1	8	8	7	6	3	3	2	3	2	2		
Sodium (Na)	1	339	309	292	248	151	124	80	134	97	104		
Chloride (Cl)	1	375	350	276	201	97	56	25	37	22	20		
Fluoride (F)	0.1	1	1	1	1	1	1	0	0.5	0.4	0		
Sulfate (SO_4)	1	160	185	153	136	77	73	47	78	61	54		
TDS including alkalinity		1000	1008	936	767	449	384	252	158	158			
Trace metals/ metalloids (mg/L)	LoR												
Aluminium (Al)	0.01	0.2400	0.1000	0.0400	0.0600	0.1200	0.4000	1.28	0.64	0.62	1.3000		
Arsenic (As)	0.001	0.0480	0.0380	0.0360	0.0370	0.0320	0.0330	0.036	0.044	0.034	0.0320		
Boron (B)	0.05	0.0800	0.1000	0.1100	0.1100	0.0700	0.0600	0.06	0.06	0.06	0.0600		
Cadmium (Cd)	0.0001	0.0001	0.0001	0.0002	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001		
Cobalt (Co)	0.001	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.001	0.0005	0.0005	0.0005		
Chromium (Cr)	0.001	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.002	0.0005	0.0005	0.0005		
Copper (Cu)	0.001	0.0020	0.0020	0.0040	0.0030	0.0005	0.0005	0.003	0.0005	0.001	0.0020		
Iron (Fe)	0.05	0.0025	0.0025	0.0025	0.0025	0.0025	0.09	0.49	0.14	0.23	0.3200		
Lithium (Li)	0.001	0.0060	0.0070	0.0070	0.0070	0.0040	0.003	0.003	0.007	0.003	0.0030		
Manganese (Mn)	0.001	0.0050	0.0060	0.0070	0.0060	0.0040	0.003	0.006	0.0005	0.004	0.0030		
Molybdenum (Mo)	0.001	0.1200	0.1210	0.1360	0.1080	0.0540	0.058	0.023	0.051	0.035	0.0260		
Nickel (Ni)	0.001	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.002	0.0005	0.002	0.0010		
Lead (Pb)	0.001	0.0005	0.0005	0.0005	0.0005	0.0010	0.0005	0.001	0.0005	0.0005	0.0005		
Antimony (Sb)	0.001	0.0040	0.0040	0.0050	0.0040	0.0030	0.003	0.002	0.003	0.002	0.0020		
Selenium (Se)	0.01	0.0800	0.0800	0.0700	0.0600	0.0200	0.02	0.01	0.02	0.01	0.0200		
Uranium (U)	0.001	0.0010	0.0010	0.0020	0.0020	0.0005	0.0005	0.0005	0.002	0.001	0.0010		
Vanadium	0.01	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050		
Zinc (Zn)	0.005	0.0025	0.0025	0.0050	0.0025	0.0025	0.0025	0.01	0.0025	0.0025	0.0025		

KLC 2 - C5285 Tertiary composite saturated with A Pit water

		KLC 2 - C5285 Tertiary composite saturated with B Pit water											
		Weight (kg)	11.50	**Total S (%)**	0.03	**ANC**	39.1	**Volume L**	8.1	**Pore void (L)**	2.43	**% Silt**	2
		pH (1:5)	9.50	**Scr (%)**	0.025	**NAPP**	-38.2	**Density**	1.42			**% Sand**	15
		EC (µS/cm)	304	**MPA**	0.9	**ANC:MPA**	42.6	**Pore void (L)**	30			**% Gravel**	83
Date		**09-Mar-18**	**16-Mar-18**	**23-Mar-18**									
Number of Weeks		**1**	**2**	**3**									
Leach Number		**1**	**2**	**3**									
ALS Laboratory Number		EB1806403	EB1807004	EB1807664	Discontinued - connection failure on column								
Volume On (L)		Filled and drained - limited water to continue this column - discontinued after 3 leach events											
Volume Collected (L)													
Volume Sent to ALS (L)		0.500	0.500	0.500									
Cum. Volume (L)		0.50	1.00	1.50									
Cum Vol Off		0.5	1.0	1.5									
Pore Volumes		0.2	0.4	0.6									
pH (RGS Measurement)		7.3	7.3	7.3									
pH (ALS Measurement)		8.2	7.6	8.5									
EC (RGS Measurement) (µS/cm)		7700.0	8150.0	8440.0									
EC (ALS Measurement) (µS/cm)		9260.0	9230.0	9520.0									
Acidity (mg/L)*		10.0	1.0	6.0									
Alkalinity (mg/L)*		188.0	150.0	159.0									
Major Ions (mg/L)	**LoR**												
Calcium (Ca)	1	161	176	178									
Potassium (K)	1	23	22	22									
Magnesium (Mg)	1	156	161	165									
Sodium (Na)	1	1570	1520	1580									
Chloride (Cl)	1	2770	2870	2630									
Fluoride (F)	0.1	0	0	0									
Sulfate (SO_4)	1	697	738	740									
TDS including alkalinity		5565	5637	5474									
Trace metals/ metalloids (mg/L)	**LoR**												
Aluminium (Al)	0.01	0.0100	0.0050	0.0050									
Arsenic (As)	0.001	0.0220	0.0110	0.0100									
Boron (B)	0.05	0.2100	0.2000	0.1900									
Cadmium (Cd)	0.0001	0.0004	0.0004	0.0003									
Cobalt (Co)	0.001	0.0020	0.0020	0.0020									
Chromium (Cr)	0.001	0.0005	0.0005	0.0005									
Copper (Cu)	0.001	0.0010	0.0020	0.0050									
Iron (Fe)	0.05	0.0250	0.0250	0.0250									
Lithium (Li)	0.001	0.0440	0.0390	0.0400									
Manganese (Mn)	0.001	0.0490	0.0700	0.0710									
Molybdenum (Mo)	0.001	0.1000	0.1160	0.1340									
Nickel (Ni)	0.001	0.0030	0.0030	0.0030									
Lead (Pb)	0.001	0.0005	0.0005	0.0005									
Antimony (Sb)	0.001	0.0030	0.0030	0.0030									
Selenium (Se)	0.01	0.0600	0.0900	0.0800									
Uranium (U)	0.001	0.0080	0.0060	0.0060									
Vanadium	0.01	0.0050	0.0050	0.0050									
Zinc (Zn)	0.005	0.0180	0.0180	0.0120									

KLC 3 - C5285 Tertiary composite saturated with distilled water

		KLC 3 - C5285 Tertiary composite saturated with distilled water											
		Weight (kg)	11.50	**Total S (%)**	0.03	**ANC**	39.1	**Volume L**	8.1	**Pore void (L)**	2.43	**% Silt**	2
		pH (1:5)	9.50	**Scr (%)**	0.025	**NAPP**	-38.2	**Density**	1.42			**% Sand**	15
		EC (μS/cm)	304	**MPA**	0.9	**ANC:MPA**	42.6	**Pore void (L)**	30			**% Gravel**	83
Date		**09-Mar-18**	**16-Mar-18**	**23-Mar-18**	**28-Mar-18**	**05-Apr-18**	**13-Apr-18**	**27-Apr-18**	**11-May-18**	**25-May-18**	**03-Jul-18**		
Number of Weeks		**1**	**2**	**3**	**4**	**5**	**7**	**9**	**11**	**13**	**15**		
Leach Number		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**		
ALS Laboratory Number		EB1806403	EB1807004	EB1807664	EB1808044	EB1808680	EB1809205002	EB1810435002	EB1811540003	EB1812860002	EB1816067		
Volume On (L)		Filled and retained full with DI water - no head space											
Volume Collected (L)													
Volume Sent to ALS (L)		0.500	0.500	0.500	0.500	0.500	0.505	0.489	0.501	0.500	2.700		
Cum. Volume (L)		0.50	1.00	1.50	2.00	2.50	3.01	3.49	4.00	4.50	7.20		
Cum Vol Off		0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	7.2		
Pore Volumes		0.2	0.4	0.6	0.8	1.0	1.2	1.4	1.6	1.9	3.0		
pH (RGS Measurement)		8.2	8.0	8.0	8.0	7.9	7.8	7.9	8.0	7.4	8.7		
pH (ALS Measurement)		8.5	8.3	8.8	8.4	8.3	8.5	8.49	8.4	8.6	8.9		
EC (RGS Measurement) (μS/cm)		1469.0	1691.0	1682.0	1516.0	1283.0	1332.0	1332.0	1015.0	870.0	776.0		
EC (ALS Measurement) (μS/cm)		1640.0	1690.0	1710.0	1610.0	1500.0	1370.0	1250	1070	943	561.0		
Acidity (mg/L)*		0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5		
Alkalinity (mg/L)*		113.0	171.0	185.0	180.0	191.0	209.0	232	253	268	256.0		
Major Ions (mg/L)	**LoR**												
Calcium (Ca)	1	9	10	10	9	8	6	5	3	4	2		
Potassium (K)	1	6	6	6	6	5	7	5	4	3	2		
Magnesium (Mg)	1	8	9	9	8	7	6	5	4	3	2		
Sodium (Na)	1	312	314	325	305	300	287	251	208	195	130		
Chloride (Cl)	1	360	355	313	292	290	227	178	133	96	20		
Fluoride (F)	0.1	1	1	1	1	1	0.9	1	1	1	1		
Sulfate (SO_4)	1	166	186	158	152	150	130	114	89	70	20		
TDS including alkalinity		975	1052	1007	953	952	873	791	442	372	177		
Trace metals/ metalloids (mg/L)	**LoR**												
Aluminium (Al)	0.01	0.1400	0.0700	0.0800	0.2400	0.3900	0.75	0.49	0.37	0.3	0.5900		
Arsenic (As)	0.001	0.0430	0.0370	0.0360	0.0370	0.0360	0.036	0.038	0.041	0.038	0.0430		
Boron (B)	0.05	0.1000	0.1100	0.1200	0.1400	0.1300	0.13	0.13	0.12	0.11	0.1000		
Cadmium (Cd)	0.0001	0.0001	0.0002	0.0002	0.0002	0.0002	0.0001	0.0002	0.0001	0.0002	0.0001		
Cobalt (Co)	0.001	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005		
Chromium (Cr)	0.001	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005		
Copper (Cu)	0.001	0.0005	0.0020	0.0030	0.0020	0.0005	0.002	0.0005	0.0005	0.0005	0.0010		
Iron (Fe)	0.05	0.0250	0.0250	0.0250	0.0250	0.0800	0.16	0.1	0.06	0.07	0.1100		
Lithium (Li)	0.001	0.0060	0.0070	0.0080	0.0080	0.0070	0.007	0.006	0.006	0.005	0.0030		
Manganese (Mn)	0.001	0.0040	0.0060	0.0070	0.0090	0.0030	0.009	0.007	0.005	0.004	0.0005		
Molybdenum (Mo)	0.001	0.1350	0.1670	0.1950	0.1940	0.2100	0.261	0.2	0.229	0.201	0.0720		
Nickel (Ni)	0.001	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.001	0.0005		
Lead (Pb)	0.001	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005		
Antimony (Sb)	0.001	0.0040	0.0040	0.0040	0.0050	0.0050	0.005	0.005	0.007	0.006	0.0060		
Selenium (Se)	0.01	0.0700	0.0800	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050		
Uranium (U)	0.001	0.0005	0.0010	0.0020	0.0020	0.0020	0.002	0.002	0.002	0.002	0.0010		
Vanadium	0.01	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050		
Zinc (Zn)	0.005	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025		

KLC 4 - C5285 Permian composite FREE LEACH

		KLC 4 - C5285 Permian composite FREE LEACH											
		Weight (kg)	11.65	Total S (%)	0.04	ANC	80.4	Volume L	8.3	Pore void (L)	2.50	% Silt	5
		pH (1:5)	9.70	Scr (%)	0.019	NAPP	-79.2	Density	1.4			% Sand	22
		EC (µS/cm)	301	MPA	1.2	ANC:MPA	65.6	Pore void (L)	30			% Gravel	73
Date		09-Mar-18	16-Mar-18	23-Mar-18	28-Mar-18	05-Apr-18	13-Apr-18	27-Apr-18	11-May-18	25-May-18	03-Jul-18		
Number of Weeks		1	2	3	4	5	7	9	11	13	15		
Leach Number		1	2	3	4	5	6	7	8	9	10		
ALS Laboratory Number		EB1806403	EB1807004	EB1807664	EB1808044	EB1808680	EB1809205003	EB1810435003	EB1811540004	EB1812860003	EB1816067		
Volume On (L)		2.0	1.2	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8		
Volume Collected (L)		1.5	0.8	0.8	0.5	0.7	0.7	0.5	0.6	0.6	0.6		
Volume Sent to ALS (L)		0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.500	0.500	0.500		
Cum. Volume (L)		0.50	1.00	1.50	2.00	2.50	3.00	3.50	4.00	4.50	5.00		
Cum Vol Off		1.5	2.3	3.1	3.6	4.3	5.0	5.5	6.1	6.7	7.3		
Pore Volumes		0.6	0.9	1.2	1.4	1.7	2.0	2.2	2.4	2.7	2.9		
pH (RGS Measurement)										7.7	8.3		
pH (ALS Measurement)		8.2	8.1	8.8	8.5	8.6	8.6	8.55	8.5	8.6	8.6		
EC (RGS Measurement) (µS/cm)		1626.0	1921.0	1792.0	1574.0	854.0	774.0	789.0	732.0	670.0	649.0		
EC (ALS Measurement) (µS/cm)		1710.0	1990.0	1930.0	1580.0	943.0	783.0	843	750	706	611.0		
Acidity (mg/L)*		1.0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5		
Alkalinity (mg/L)*		118.0	206.0	275.0	290.0	235.0	234.0	300	279	278	279.0		
Major Ions (mg/L)	LoR												
Calcium (Ca)	1	18	16	14	10	5	4	6	4	6	7		
Potassium (K)	1	6	7	7	6	4	3	4	3	4	4		
Magnesium (Mg)	1	8	8	8	6	3	2	3	3	3	4		
Sodium (Na)	1	318	374	371	324	203	157	180	157	151	131		
Chloride (Cl)	1	365	412	321	232	82	28	16	10	7	2		
Fluoride (F)	0.1	0	1	1	1	1	0.4	0.4	0.4	0.3	0		
Sulfate (SO_4)	1	176	190	171	143	80	70	68	74	70	50		
TDS including alkalinity		1009	1214	1168	1012	613	498	577	251	241	198		
Trace metals/ metalloids (mg/L)	LoR												
Aluminium (Al)	0.01	0.0200	0.0200	0.0200	0.0200	0.1100	0.12	0.08	0.08	0.07	0.0300		
Arsenic (As)	0.001	0.0390	0.0420	0.0460	0.0620	0.0400	0.035	0.02	0.016	0.011	0.0060		
Boron (B)	0.05	0.0700	0.1000	0.1000	0.1200	0.0900	0.08	0.08	0.06	0.06	0.0250		
Cadmium (Cd)	0.0001	0.0002	0.0002	0.0003	0.0002	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001		
Cobalt (Co)	0.001	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005		
Chromium (Cr)	0.001	0.0005	0.0020	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005		
Copper (Cu)	0.001	0.0010	0.0020	0.0040	0.0010	0.0005	0.0005	0.0005	0.0005	0.0005	0.0010		
Iron (Fe)	0.05	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250		
Lithium (Li)	0.001	0.0070	0.0100	0.0110	0.0120	0.0070	0.006	0.007	0.007	0.007	0.0070		
Manganese (Mn)	0.001	0.1420	0.0330	0.0210	0.0150	0.0005	0.002	0.003	0.0005	0.0005	0.0005		
Molybdenum (Mo)	0.001	0.1500	0.2480	0.2680	0.2300	0.1120	0.072	0.039	0.028	0.019	0.0090		
Nickel (Ni)	0.001	0.0010	0.0005	0.0010	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005		
Lead (Pb)	0.001	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005		
Antimony (Sb)	0.001	0.0070	0.0090	0.0090	0.0090	0.0070	0.006	0.005	0.004	0.003	0.0020		
Selenium (Se)	0.01	0.0800	0.1100	0.0400	0.0200	0.0200	0.02	0.03	0.04	0.02	0.0200		
Uranium (U)	0.001	0.0010	0.0030	0.0030	0.0030	0.0010	0.0005	0.001	0.002	0.001	0.0010		
Vanadium	0.01	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050		
Zinc (Zn)	0.005	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025		

KLC 5 - C5285 Permian composite saturated with A Pit water

		KLC 5 - C5285 Permian composite saturated with B Pit water											
		Weight (kg)	11.45	**Total S (%)**	0.04	**ANC**	80.4	**Volume L**	8.2	**Pore void (L)**	2.45	**% Silt**	5
		pH (1:5)	9.70	**Scr (%)**	0.019	**NAPP**	-79.2	**Density**	1.4			**% Sand**	22
		EC (µS/cm)	301	**MPA**	1.2	**ANC:MPA**	65.6	**Pore void (L)**	30			**% Gravel**	73
Date		**09-Mar-18**	**16-Mar-18**	**23-Mar-18**	**28-Mar-18**	**06-Apr-18**	**13-Apr-18**	**27-Apr-18**	**11-May-18**	**25-May-18**	**03-Jul-18**		
Number of Weeks		**1**	**2**	**3**	**4**	**5**	**7**	**9**	**11**	**13**	**15**		
Leach Number		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**		
ALS Laboratory Number		EB1806403	EB1807004	EB1807664	EB1808044	EB1808680	EB1809205004	EB1810435004	EB1811540005	EB1812860004	EB1816067		
Volume On (L)		Filled and drained											
Volume Collected (L)													
Volume Sent to ALS (L)		0.500	0.500	0.500	0.500	0.500	0.494	0.502	0.492	0.500	3.000		
Cum. Volume (L)		0.50	1.00	1.50	2.00	2.50	2.99	3.50	3.99	4.49	7.49		
Cum Vol Off		0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	7.5		
Pore Volumes		0.2	0.4	0.6	0.8	1.0	1.2	1.4	1.6	1.8	3.1		
pH (RGS Measurement)		7.4	7.3	7.3	7.4	7.3	7.4	7.4	7.4	7.0	7.8		
pH (ALS Measurement)		8.1	7.5	8.5	8.0	7.8	8.1	7.95	7.7	8.0			
EC (RGS Measurement) (µS/cm)		8060.0	8220.0	8380.0	8030.0	7680.0	8140.0	8020.0	7290.0	7720.0	7270.0		
EC (ALS Measurement) (µS/cm)		9420.0	8380.0	9630.0	9310.0	9240.0	9140.0	8940	8640	8480	7520.0		
Acidity (mg/L)*		8.0	1.0	8.0	0.5	4.0	0.5	8	8	0.5	3.0		
Alkalinity (mg/L)*		177.0	174.0	197.0	182.0	181.0	192.0	202	213	229	269.0		
Major Ions (mg/L)	**LoR**												
Calcium (Ca)	1	166	186	189	184	176	146	176	124	153	128		
Potassium (K)	1	24	25	25	25	23	23	26	21	21	19		
Magnesium (Mg)	1	142	136	136	135	133	130	141	112	120	124		
Sodium (Na)	1	1630	1580	1650	1600	1620	1580	1690	1400	1450	1400		
Chloride (Cl)	1	2740	2880	2660	2600	3060	2680	2610	2620	2570	2370		
Fluoride (F)	0.1	0	0	0	0	0	0.2	0.2	0.2	0.2	0		
Sulfate (SO_4)	1	722	750	730	694	735	677	685	649	637	558		
TDS including alkalinity		5601	5731	5587	5420	5928	5428	5530	4926	4951	4599		
Trace metals/ metalloids (mg/L)	**LoR**												
Aluminium (Al)	0.01	0.0050	0.0050	0.0050	0.0100	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050		
Arsenic (As)	0.001	0.0150	0.0130	0.0160	0.0220	0.0240	0.028	0.031	0.031	0.022	0.0070		
Boron (B)	0.05	0.2300	0.2200	0.2000	0.2100	0.2000	0.2	0.2	0.19	0.19	0.2400		
Cadmium (Cd)	0.0001	0.0002	0.0003	0.0003	0.0005	0.0003	0.0006	0.0003	0.0001	0.0002	0.0001		
Cobalt (Co)	0.001	0.0050	0.0040	0.0050	0.0060	0.0040	0.007	0.004	0.004	0.004	0.0040		
Chromium (Cr)	0.001	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005		
Copper (Cu)	0.001	0.0010	0.0020	0.0040	0.0050	0.0005	0.002	0.0005	0.001	0.001	0.0005		
Iron (Fe)	0.05	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250		
Lithium (Li)	0.001	0.0600	0.0530	0.0560	0.0600	0.0580	0.055	0.056	0.05	0.054	0.0620		
Manganese (Mn)	0.001	0.2590	0.1720	0.1620	0.1620	0.1410	0.167	0.164	0.162	0.159	0.1330		
Molybdenum (Mo)	0.001	0.1240	0.1510	0.1730	0.1720	0.1620	0.18	0.133	0.15	0.125	0.0590		
Nickel (Ni)	0.001	0.0080	0.0080	0.0080	0.0080	0.0060	0.006	0.006	0.005	0.008	0.0090		
Lead (Pb)	0.001	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005		
Antimony (Sb)	0.001	0.0030	0.0030	0.0040	0.0030	0.0020	0.001	0.001	0.0005	0.0005	0.0020		
Selenium (Se)	0.01	0.0700	0.1000	0.0300	0.0100	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050		
Uranium (U)	0.001	0.0090	0.0090	0.0080	0.0090	0.0070	0.007	0.007	0.008	0.009	0.0130		
Vanadium	0.01	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050		
Zinc (Zn)	0.005	0.0160	0.0200	0.0150	0.0120	0.0080	0.017	0.013	0.009	0.008	0.0060		

KLC 6 - C5285 Permian composite saturated with distilled water

		KLC 6 - C5285 Permian composite saturated with distilled water											
		Weight (kg)	11.60	**Total S (%)**	0.04	**ANC**	80.4	**Volume L**	8.3	**Pore void (L)**	2.49	**% Silt**	5
		pH (1:5)	9.70	**Scr (%)**	0.019	**NAPP**	-79.2	**Density**	1.4			**% Sand**	22
		EC (µS/cm)	301	**MPA**	1.2	**ANC:MPA**	65.6	**Pore void (L)**	30			**% Gravel**	73
Date		**09-Mar-18**	**16-Mar-18**	**23-Mar-18**	**28-Mar-18**	**05-Apr-18**	**13-Apr-18**	**27-Apr-18**	**11-May-18**	**25-May-18**	**03-Jul-18**		
Number of Weeks		**1**	**2**	**3**	**4**	**5**	**7**	**9**	**11**	**13**	**15**		
Leach Number		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**		
ALS Laboratory Number		EB1806403	EB1807004	EB1807664	EB1808044	EB1808680	EB1809205005	EB1810435005	EB1811540006	EB1812860005	EB1816067		
Volume On (L)		Filled and retained full with DI water - no head space											
Volume Collected (L)													
Volume Sent to ALS (L)		0.500	0.500	0.500	0.485	0.500	0.503	0.509	0.507	0.502	3.000		
Cum. Volume (L)		0.50	1.00	1.50	1.99	2.49	2.99	3.50	4.00	4.51	7.51		
Cum Vol Off		0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	7.5		
Pore Volumes		0.2	0.4	0.6	0.8	1.0	1.2	1.4	1.6	1.8	3.0		
pH (RGS Measurement)		8.1	8.0	8.1	8.0	8.0	8.1	8.1	8.1	7.9	8.4		
pH (ALS Measurement)		8.5	8.3	8.8	8.6	8.4	8.6	8.5	8.4	8.5	8.6		
EC (RGS Measurement) (µS/cm)		1932.0	1948.0	1772.0	1638.0	1425.0	1359.0	1252.0	1209.0	1048.0	687.0		
EC (ALS Measurement) (µS/cm)		1940.00	1930.00	1840.00	1700.00	1580.00	1360.00	1290.00	1170.00	1120	821.00		
Acidity (mg/L)*		0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5		
Alkalinity (mg/L)*		150.0	217.0	256.0	289.0	296.0	329.0	344	371	374	354.0		
Major Ions (mg/L)	**LoR**												
Calcium (Ca)	1	11	12	11	10	10	6	6	5	6	4		
Potassium (K)	1	7	7	7	6	6	5	6	5	4	3		
Magnesium (Mg)	1	7	8	7	6	6	5	4	4	4	3		
Sodium (Na)	1	371	372	357	338	340	303	276	248	233	189		
Chloride (Cl)	1	426	387	306	272	268	180	145	117	99	42		
Fluoride (F)	0.1	1	1	1	1	1	0.6	0.5	0.5	0.5	1		
Sulfate (SO_4)	1	179	199	164	148	147	104	90	68	57	25		
TDS including alkalinity		1152	1203	1109	1070	1074	933	872	448	404	267		
Trace metals/ metalloids (mg/L)	**LoR**												
Aluminium (Al)	0.01	0.1100	0.1000	0.0500	0.0600	0.0500	0.09	0.06	0.05	0.81	0.0700		
Arsenic (As)	0.001	0.1050	0.0840	0.0680	0.0600	0.0540	0.05	0.047	0.043	0.035	0.0290		
Boron (B)	0.05	0.0900	0.1000	0.1000	0.1200	0.1300	0.12	0.12	0.1	0.1	0.0900		
Cadmium (Cd)	0.0001	0.0002	0.0003	0.0003	0.0003	0.0003	0.0002	0.0003	0.0001	0.0002	0.0001		
Cobalt (Co)	0.001	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0001	0.0005	0.0005	0.0005		
Chromium (Cr)	0.001	0.0005	0.0005	0.0005	0.0005	0.0010	0.0005	0.0001	0.0005	0.001	0.0005		
Copper (Cu)	0.001	0.0005	0.0010	0.0020	0.0020	0.0005	0.002	0.0001	0.0005	0.002	0.0005		
Iron (Fe)	0.05	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.14	0.0250		
Lithium (Li)	0.001	0.0100	0.0100	0.0110	0.0120	0.0120	0.01	0.01	0.01	0.009	0.0080		
Manganese (Mn)	0.001	0.0080	0.0100	0.0090	0.0130	0.0080	0.009	0.006	0.007	0.007	0.0050		
Molybdenum (Mo)	0.001	0.2470	0.2550	0.3070	0.3400	0.3200	0.336	0.232	0.242	0.21	0.1100		
Nickel (Ni)	0.001	0.0005	0.0010	0.0010	0.0010	0.0010	0.0005	0.0001	0.0005	0.003	0.0010		
Lead (Pb)	0.001	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0001	0.0005	0.0005	0.0005		
Antimony (Sb)	0.001	0.0070	0.0080	0.0080	0.0080	0.0090	0.008	0.008	0.009	0.008	0.0070		
Selenium (Se)	0.01	0.1000	0.1000	0.0100	0.0050	0.0050	0.0050	0.0010	0.0050	0.0050	0.0050		
Uranium (U)	0.001	0.0020	0.0020	0.0030	0.0040	0.0030	0.003	0.002	0.002	0.002	0.0010		
Vanadium	0.01	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0010	0.0050	0.0050	0.0050		
Zinc (Zn)	0.005	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025		

KLC 7 - C5286 Tertiary composite FREE LEACH

		KLC 7 - C5286 Tertiary composite FREE LEACH											
		Weight (kg)	11.75	**Total S (%)**	0.07	**ANC**	87.3	**Volume L**	7.2	**Pore void (L)**	3.24	**% Silt**	56
		pH (1:5)	9.70	**Scr (%)**	0.026	**NAPP**	-85.2	**Density**	1.63			**% Sand**	41
		EC (µS/cm)	418	**MPA**	2.1	**ANC:MPA**	40.7	**Pore void (L)**	45			**% Gravel**	3
Date		**09-Mar-18**	**16-Mar-18**	**23-Mar-18**	**28-Mar-18**	**06-Apr-18**	**13-Apr-18**	**27-Apr-18**	**11-May-18**	**25-May-18**	**03-Jul-18**		
Number of Weeks		**1**	**2**	**3**	**4**	**5**	**7**	**9**	**11**	**13**	**15**		
Leach Number		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**		
ALS Laboratory Number		EB1806403	EB1807004	EB1807664	EB1808044	EB1808680	EB1809205006	EB1810435006	EB1811540007	EB1812860006	EB1816067		
Volume On (L)		2.0	1.2	0.8	0.8	0.75	0.75	0.75	0.8	0.8	1.1		
Volume Collected (L)		0.8	0.8	0.8	0.5	0.7	0.5	0.5	0.5	0.5	0.7		
Volume Sent to ALS (L)		0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.500	0.5	0.5		
Cum. Volume (L)		2.0	3.2	4.0	4.8	5.5	6.3	7.0	7.8	8.5	9.6		
Cum Vol Off		0.8	1.6	2.4	2.9	3.6	4.1	4.6	5.1	5.6	6.3		
Pore Volumes										1.7	2.0		
pH (RGS Measurement)		7.7	7.5	7.4	7.8	7.8	7.7	7.9	7.9	7.2	7.8		
pH (ALS Measurement)		7.9	7.5	8.2	8.1	7.9	7.9	7.7	7.5	7.7	8.0		
EC (RGS Measurement) (µS/cm)		2064.0	2557.0	3070.0	2423.0	1416.0	1046.0	1124.0	1211.0	1167.0	1376.0		
EC (ALS Measurement) (µS/cm)		2180.0	2710.0	3470.0	2450.0	1580.0	1080.0	1190	1250	1220	1680.0		
Acidity (mg/L)*		4.0	1.0	8.0	0.5	0.5	0.5	3	1	1	2.0		
Alkalinity (mg/L)*		59.0	141.0	180.0	149.0	92.0	70.0	60	66	75	153.0		
Major Ions (mg/L)	**LoR**												
Calcium (Ca)	1	17	20	29	19	11	6	7	7	8	15		
Potassium (K)	1	13	17	22	17	11	8	9	9	9	13		
Magnesium (Mg)	1	34	46	68	47	28	17	20	19	22	36		
Sodium (Na)	1	350	439	561	404	265	180	195	196	186	274		
Chloride (Cl)	1	563	693	833	596	434	266	287	319	303	401		
Fluoride (F)	0.1	1	2	2	1	1	0.9	0.8	0.8	0.7	1		
Sulfate (SO_4)	1	178	200	257	162	107	74	90	101	103	147		
TDS including alkalinity		1215	1558	1952	1395	949	622	669	652	632	887		
Trace metals/ metalloids (mg/L)	**LoR**												
Aluminium (Al)	0.01	0.0200	0.0050	0.0050	0.0050	0.0050	0.0050	0.03	0.0050	0.0050	0.0050		
Arsenic (As)	0.001	0.0030	0.0020	0.0030	0.0020	0.0010	0.001	0.0001	0.0005	0.0005	0.0005		
Boron (B)	0.05	0.2900	0.4100	0.4200	0.3300	0.2600	0.17	0.16	0.15	0.13	0.2100		
Cadmium (Cd)	0.0001	0.0004	0.0004	0.0004	0.0002	0.0001	0.0001	0.0000	0.0001	0.0001	0.0001		
Cobalt (Co)	0.001	0.0050	0.0070	0.0110	0.0080	0.0040	0.003	0.003	0.002	0.0005	0.0005		
Chromium (Cr)	0.001	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0001	0.0005	0.0005	0.0005		
Copper (Cu)	0.001	0.0020	0.0040	0.0070	0.0020	0.0020	0.001	0.0001	0.0005	0.001	0.0020		
Iron (Fe)	0.05	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	<0.05		
Lithium (Li)	0.001	0.0260	0.0360	0.0510	0.0420	0.0250	0.017	0.016	0.017	0.016	0.0260		
Manganese (Mn)	0.001	0.1850	0.3370	0.5540	0.3910	0.2470	0.165	0.152	0.068	0.013	0.0050		
Molybdenum (Mo)	0.001	0.0190	0.0200	0.0250	0.0140	0.0140	0.01	0.009	0.007	0.004	0.0030		
Nickel (Ni)	0.001	0.0030	0.0040	0.0060	0.0040	0.0020	0.0005	0.0001	0.0005	0.002	0.0040		
Lead (Pb)	0.001	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0001	0.0005	0.0005	0.0005		
Antimony (Sb)	0.001	0.0170	0.0220	0.0170	0.0110	0.0120	0.006	0.004	0.005	0.003	0.0060		
Selenium (Se)	0.01	0.0600	0.0700	0.0800	0.0600	0.0300	0.02	0.02	0.02	0.02	0.0300		
Uranium (U)	0.001	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0001	0.0005	0.0005	0.0005		
Vanadium	0.01	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0010	0.0050	0.0050	0.0050		
Zinc (Zn)	0.005	0.0500	0.0600	0.0760	0.0340	0.0200	0.015	0.022	0.013	0.021	0.0610		

KLC 8 - C5286 Tertiary composite saturated with A Pit water

		KLC 8 - C5286 Tertiary composite saturated with B Pit water											
		Weight (kg)	11.65	**Total S (%)**	0.07	**ANC**	87.3	**Volume L**	7.1	**Pore void (L)**	3.22	**% Silt**	56
		pH (1:5)	9.70	**Scr (%)**	0.026	**NAPP**	-85.2	**Density**	1.63			**% Sand**	41
		EC (µS/cm)	418	**MPA**	2.1	**ANC:MPA**	40.7	**Pore void (L)**	45			**% Gravel**	3
Date		**09-Mar-18**	**16-Mar-18**	**23-Mar-18**	**28-Mar-18**	**05-Apr-18**	**13-Apr-18**	**27-Apr-18**	**11-May-18**	**25-May-18**			
Number of Weeks		**1**	**2**	**3**	**4**	**5**	**7**	**9**	**11**	**13**			
Leach Number		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**			
ALS Laboratory Number		EB1806403	EB1807004	EB1807664	EB1808044	EB1808680	EB1809205007	EB1810435007	EB1811540008	EB1812860007			
Volume On (L)		Filled and drained											
Volume Collected (L)													
Volume Sent to ALS (L)		0.500	0.500	0.500	0.500	0.500	0.501	0.511	0.489	0.500			
Cum. Volume (L)		0.50	1.00	1.50	2.00	2.50	3.00	3.51	4.00	4.50			
Cum Vol Off		0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5			
Pore Volumes		0.2	0.3	0.5	0.6	0.8	0.9	1.1	1.2	1.4			
pH (RGS Measurement)		7.4	7.3	7.3	7.6	7.5	7.6	7.6	7.7	7.4			
pH (ALS Measurement)		8.1	7.6	8.2	8.0	7.9	8.2	8.09	7.9	8.1			
EC (RGS Measurement) (µS/cm)		9260.0	11500.0	11540.0	10790.0	9810.0	9890.0	9390.0	8400.0	8720.0			
EC (ALS Measurement) (µS/cm)		11400.0	13100.0	13800.0	12800.0	12200.0	11400.0	10700	9990	9530			
Acidity (mg/L)*		12.0	2.0	15.0	0.5	3.0	0.5	11	4	0.5			
Alkalinity (mg/L)*		211.0	233.0	239.0	263.0	264.0	274.0	282	292	309			
Major Ions (mg/L)	**LoR**												
Calcium (Ca)	1	124	167	180	166	142	120	133	111	101			
Potassium (K)	1	43	53	58	54	50	47	50	42	39			
Magnesium (Mg)	1	311	402	433	403	349	323	336	267	245			
Sodium (Na)	1	1830	1960	2140	1970	1860	1770	1860	1620	1500			
Chloride (Cl)	1	3460	4280	4090	3850	3980	3440	3170	3110	2930			
Fluoride (F)	0.1	1	2	2	1	2	1.7	1.8	1.6	1.6			
Sulfate (SO_4)	1	841	1060	856	975	1010	904	887	843	786			
TDS including alkalinity		6821	8157	7998	7682	7657	6880	6720	5995	5603			
Trace metals/ metalloids (mg/L)	**LoR**												
Aluminium (Al)	0.01	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050			
Arsenic (As)	0.001	0.0040	0.0040	0.0040	0.0040	0.0040	0.004	0.005	0.005	0.004			
Boron (B)	0.05	0.5600	0.6400	0.6800	0.6400	0.6400	0.63	0.65	0.62	0.53			
Cadmium (Cd)	0.0001	0.0029	0.0027	0.0025	0.0021	0.0016	0.0016	0.0011	0.0008	0.0008			
Cobalt (Co)	0.001	0.0310	0.0450	0.0530	0.0470	0.0380	0.034	0.031	0.028	0.023			
Chromium (Cr)	0.001	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005			
Copper (Cu)	0.001	0.0100	0.0120	0.0130	0.0190	0.0140	0.012	0.009	0.007	0.006			
Iron (Fe)	0.05	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250			
Lithium (Li)	0.001	0.1080	0.1280	0.1480	0.1520	0.1440	0.133	0.125	0.109	0.111			
Manganese (Mn)	0.001	1.0800	1.6500	1.8200	1.7400	1.4700	1.32	1.52	1.14	1.19			
Molybdenum (Mo)	0.001	0.0240	0.0280	0.0320	0.0320	0.0340	0.04	0.031	0.037	0.036			
Nickel (Ni)	0.001	0.0160	0.0240	0.0270	0.0230	0.0190	0.015	0.015	0.012	0.014			
Lead (Pb)	0.001	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005			
Antimony (Sb)	0.001	0.0200	0.0280	0.0260	0.0240	0.0200	0.023	0.023	0.026	0.018			
Selenium (Se)	0.01	0.1000	0.1800	0.1900	0.1500	0.0500	0.01	0.0050	0.0050	0.0050			
Uranium (U)	0.001	0.0020	0.0030	0.0030	0.0040	0.0030	0.003	0.003	0.003	0.004			
Vanadium	0.01	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050			
Zinc (Zn)	0.005	0.2590	0.3340	0.3100	0.2540	0.2050	0.192	0.199	0.172	0.145			

KLC 9 - C5286 Tertiary composite saturated with distilled water

		KLC 9 - C5286 Tertiary composite saturated with distilled water											
		Weight (kg)	12.05	**Total S (%)**	0.07	**ANC**	87.3	**Volume L**	7.4	**Pore void (L)**	3.33	**% Silt**	56
		pH (1:5)	9.70	**Scr (%)**	0.026	**NAPP**	-85.2	**Density**	1.63			**% Sand**	41
		EC (µS/cm)	418	**MPA**	2.1	**ANC:MPA**	40.7	**Pore void (L)**	45			**% Gravel**	3
Date		**09-Mar-18**	**16-Mar-18**	**23-Mar-18**	**28-Mar-18**	**05-Apr-18**	**13-Apr-18**	**27-Apr-18**	**11-May-18**	**25-May-18**	**03-Jul-18**		
Number of Weeks		**1**	**2**	**3**	**4**	**5**	**7**	**9**	**11**	**13**	**15**		
Leach Number		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**		
ALS Laboratory Number		EB1806403	EB1807004	EB1807664	EB1808044	EB1808680	EB1809205008	EB1810658001	EB1811540009	EB1812860008	EB1816067		
Volume On (L)		Filled and retained full with DI water - no head space											
Volume Collected (L)													
Volume Sent to ALS (L)		0.500	0.500	0.500	0.471	0.500	0.490	0.500	0.487	0.500	3.000		
Cum. Volume (L)		0.50	1.00	1.50	1.97	2.47	2.96	3.46	3.95	4.45	7.45		
Cum Vol Off		0.5	1.0	1.5	2.0	2.5	3.0	3.5	3.9	4.4	7.4		
Pore Volumes		0.2	0.4	0.6	0.8	1.0	1.2	1.4	1.6	1.3	2.2		
pH (RGS Measurement)		7.1	7.2	7.4	7.5	7.6	7.8	7.2	7.8	8.0	8.5		
pH (ALS Measurement)		7.7	7.4	8.3	8.3	8.0	8.3	8.18	8.0	8.5	8.4		
										8.3	8.0		
EC (RGS Measurement) (µS/cm)		6240.0	6870.0	6560.0	6250.0	4900.0	4600.0	3780.0	2750.0	2115.0	1674.0		
EC (ALS Measurement) (µS/cm)		7400.0	7780.0	7590.0	6240.0	5920.0	5080.0	4130	3120	2370	766.0		
Acidity (mg/L)*		6.0	2.0	10.0	0.5	0.5	0.5	0.5	0.5	0.5	0.5		
Alkalinity (mg/L)*		43.0	125.0	200.0	246.0	265.0	296.0	323	362	412	354.0		
Major Ions (mg/L)	**LoR**												
Calcium (Ca)	1	90	87	85	73	57	39	30	15	11	2		
Potassium (K)	1	66	40	41	38	32	28	26	17	14	6		
Magnesium (Mg)	1	201	205	199	169	138	104	80	42	28	5		
Sodium (Na)	1	1180	1200	1210	1100	990	833	725	535	433	177		
Chloride (Cl)	1	2130	2350	1990	1530	1530	1200	798	655	429	25		
Fluoride (F)	0.1	1	1	2	2	2	1.9	2.1	2.1	2.5	4		
Sulfate (SO_4)	1	652	712	654	616	605	514	439	328	232	18		
TDS including alkalinity		4363	4720	4381	3774	3619	3016	2100	1594	1150	237		
Trace metals/ metalloids (mg/L)	**LoR**												
Aluminium (Al)	0.01	0.0800	0.0100	0.0100	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050		
Arsenic (As)	0.001	0.0010	0.0005	0.0010	0.0010	0.0010	0.002	0.004	0.005	0.004	0.0050		
Boron (B)	0.05	0.3700	0.4600	0.5400	0.5100	0.5300	0.5	0.49	0.45	0.4	0.3800		
Cadmium (Cd)	0.0001	0.0008	0.0005	0.0004	0.0004	0.0002	0.0002	0.0001	0.0001	0.0001	0.0001		
Cobalt (Co)	0.001	0.0350	0.0230	0.0220	0.0190	0.0160	0.012	0.006	0.005	0.002	0.0005		
Chromium (Cr)	0.001	0.0005	0.0005	0.0005	0.0005	0.0020	0.0005	0.0005	0.0005	0.0005	0.0005		
Copper (Cu)	0.001	0.0540	0.0040	0.0060	0.0040	0.0020	0.005	0.004	0.0005	0.001	0.0005		
Iron (Fe)	0.05	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250		
Lithium (Li)	0.001	0.0800	0.0850	0.0970	0.0970	0.0900	0.075	0.062	0.047	0.039	0.0180		
Manganese (Mn)	0.001	1.5100	1.3700	1.2800	1.1500	0.8320	0.618	0.481	0.329	0.202	0.0410		
Molybdenum (Mo)	0.001	0.0080	0.0170	0.0290	0.0340	0.0330	0.044	0.049	0.055	0.067	0.0660		
Nickel (Ni)	0.001	0.0270	0.0110	0.0100	0.0080	0.0070	0.002	0.002	0.0005	0.002	0.0005		
Lead (Pb)	0.001	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005		
Antimony (Sb)	0.001	0.0005	0.0010	0.0020	0.0010	0.0010	0.002	0.001	0.002	0.002	0.0020		
Selenium (Se)	0.01	0.2200	0.2300	0.2200	0.1500	0.0300	0.0050	0.0050	0.0050	0.0050	0.0050		
Uranium (U)	0.001	0.0005	0.0010	0.0040	0.0050	0.0030	0.003	0.002	0.002	0.002	0.0005		
Vanadium	0.01	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050		
Zinc (Zn)	0.005	0.1260	0.0820	0.0700	0.0530	0.0450	0.032	0.015	0.009	0.007	0.0025		

KLC 10 - C5286 Permian composite FREE LEACH

		KLC 10 - C5286 Permian composite FREE LEACH											
		Weight (kg)	11.55	**Total S (%)**	0.03	**ANC**	20.4	**Volume L**	7.6	**Pore void (L)**	3.42	**% Silt**	57
		pH (1:5)	8.20	**Scr (%)**	0.018	**NAPP**	-19.5	**Density**	1.52			**% Sand**	33
		EC (µS/cm)	614	**MPA**	0.9	**ANC:MPA**	22.2	**Pore void (L)**	45			**% Gravel**	10
Date		**09-Mar-18**	**16-Mar-18**	**23-Mar-18**	**28-Mar-18**	**05-Apr-18**	**13-Apr-18**	**27-Apr-18**	**11-May-18**	**25-May-18**	**03-Jul-18**		
Number of Weeks		**1**	**2**	**3**	**4**	**5**	**7**	**9**	**11**	**13**	**15**		
Leach Number		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**		
ALS Laboratory Number		EB1806403	EB1807004	EB1807664	EB1808044	EB1808680	EB1809205009	EB1810658002	EB1811540010	EB1812860009	EB1816067		
Volume On (L)		1.5	1.2	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8		
Volume Collected (L)		0.7	0.9	0.5	0.5	0.7	0.7	0.5	0.5	0.5	0.5		
Volume Sent to ALS (L)		0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.500	0.500	0.500		
Cum. Volume (L)		1.5	2.7	3.5	4.3	5.0	5.8	6.5	7.3				
Cum Vol Off		0.7	1.6	2.1	2.6	3.3	4.0	4.5	5.0	5.5	5.9		
Pore Volumes										1.6	1.7		
pH (RGS Measurement)		7.7	7.7	7.8	8.2	8.4	8.4	8.3	8.6	8.1	8.5		
pH (ALS Measurement)		8.1	7.9	8.6	8.3	8.6	8.6	8.9	8.7	8.8	8.5		
EC (RGS Measurement) (µS/cm)		2627.0	2930.0	3050.0	2567.0	1524.0	1430.0	1399.0	1399.0	1301.0	1279.0		
EC (ALS Measurement) (µS/cm)		2700.0	3100.0	3320.0	2620.0	1660.0	1430.0	1570	1460	1350	1170.0		
Acidity (mg/L)*		4.0	0.5	3.0	0.5	0.5	0.5	0.5	0.5	0.5	0.5		
Alkalinity (mg/L)*		107.0	280.0	354.0	372.0	307.0	364.0	480	499	500	523.0		
Major Ions (mg/L)	**LoR**												
Calcium (Ca)	1	29	19	21	15	8	6	8	7	8	10		
Potassium (K)	1	17	17	18	15	10	9	12	10	10	10		
Magnesium (Mg)	1	32	28	32	24	12	10	14	12	14	16		
Sodium (Na)	1	608	564	631	515	341	312	333	292	287	251		
Chloride (Cl)	1	610	652	620	465	266	150	113	82	81	27		
Fluoride (F)	0.1	1	1	1	1	1	0.6	0.6	0.5	0.5	0		
Sulfate (SO_4)	1	345	370	376	301	168	134	135	131	122	93		
TDS including alkalinity		1749	1931	2053	1708	1113	986	616	535	505	407		
Trace metals/ metalloids (mg/L)	**LoR**												
Aluminium (Al)	0.01	0.0200	0.0100	0.0100	0.0100	0.0200	0.02	0.02	0.02	0.01	0.0100		
Arsenic (As)	0.001	0.0140	0.0110	0.0120	0.0140	0.0070	0.006	0.004	0.003	0.002	0.0020		
Boron (B)	0.05	0.3100	0.4200	0.5000	0.4700	0.3600	0.33	0.33	0.29	0.23	0.1800		
Cadmium (Cd)	0.0001	0.0002	0.0002	0.0002	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001		
Cobalt (Co)	0.001	0.0030	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005		
Chromium (Cr)	0.001	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005		
Copper (Cu)	0.001	0.0020	0.0020	0.0030	0.0010	0.0005	0.0005	0.001	0.0005	0.0005	0.0005		
Iron (Fe)	0.05	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250		
Lithium (Li)	0.001	0.0230	0.0280	0.0360	0.0350	0.0220	0.021	0.024	0.023	0.023	0.0250		
Manganese (Mn)	0.001	0.3800	0.0610	0.0570	0.0350	0.0005	0.006	0.0005	0.003	0.002	0.0020		
Molybdenum (Mo)	0.001	0.1580	0.1650	0.1780	0.1520	0.0920	0.068	0.048	0.031	0.02	0.0080		
Nickel (Ni)	0.001	0.0080	0.0010	0.0010	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005		
Lead (Pb)	0.001	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005		
Antimony (Sb)	0.001	0.0020	0.0030	0.0040	0.0040	0.0030	0.003	0.002	0.002	0.001	0.0005		
Selenium (Se)	0.01	0.1100	0.1100	0.1000	0.0400	0.0200	0.02	0.02	0.02	0.02	0.0200		
Uranium (U)	0.001	0.0020	0.0030	0.0050	0.0040	0.0020	0.002	0.002	0.002	0.002	0.0010		
Vanadium	0.01	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050		
Zinc (Zn)	0.005	0.0170	0.0110	0.0100	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025		

KLC 11 - C5286 Permian composite saturated with A Pit water

		KLC 11 - C5286 Permian composite saturated with B Pit water											
		Weight (kg)	11.75	**Total S (%)**	0.03	**ANC**	20.4	**Volume L**	7.7	**Pore void (L)**	3.48	**% Silt**	57
		pH (1:5)	8.20	**Scr (%)**	0.018	**NAPP**	-19.5	**Density**	1.52			**% Sand**	33
		EC (µS/cm)	614	**MPA**	0.9	**ANC:MPA**	22.2	**Pore void (L)**	45			**% Gravel**	10
Date		**09-Mar-18**	**16-Mar-18**	**23-Mar-18**	**28-Mar-18**	**05-Apr-18**	**13-Apr-18**	**27-Apr-18**	**11-May-18**	**25-May-18**	**03-Jul-18**		
Number of Weeks		**1**	**2**	**3**	**4**	**5**	**7**	**9**	**11**	**13**	**15**		
Leach Number		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**		
ALS Laboratory Number		EB1806403	EB1807004	EB1807664	EB1808044	EB1808680	EB1809205010	EB1810435008	EB1811540011	EB1812860010	EB1816067		
Volume On (L)							Filled and drained						
Volume Collected (L)													
Volume Sent to ALS (L)		0.500	0.500	0.500	0.500	0.500	0.513	0.506	0.509	0.500	3.000		
Cum. Volume (L)		0.50	1.00	1.50	2.00	2.50	3.01	3.52	4.03	4.53	7.53		
Cum Vol Off		0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	7.5		
Pore Volumes		0.2	0.4	0.6	0.8	1.0	1.2	1.4	1.6	1.3	2.2		
pH (RGS Measurement)		7.6	7.5	7.4	7.6	7.6	7.6	7.6	7.7	7.4	7.9		
pH (ALS Measurement)		8.1	7.7	8.1	8.0	7.9	8.2	8.08	7.8	8.1	8.0		
										8.3	8.0		
EC (RGS Measurement) (µS/cm)		8810.0	8540.0	8850.0	8860.0	8210.0	8610.0	8480.0	7960.0	8530.0	7900.0		
EC (ALS Measurement) (µS/cm)		10800.0	10500.0	10500.0	9920.0	9820.0	9660.0	9600	9420	9280	8450.0		
Acidity (mg/L)*		8.0	0.5	10.0	0.5	1.0	0.5	7	6	0.5	2.0		
Alkalinity (mg/L)*		200.0	222.0	206.0	228.0	231.0	241.0	247	257	278	302.0		
Major Ions (mg/L)	**LoR**												
Calcium (Ca)	1	139	138	126	119	110	94	97	100	100	89		
Potassium (K)	1	44	40	41	40	38	37	37	35	34	33		
Magnesium (Mg)	1	234	211	206	202	194	190	193	178	179	180		
Sodium (Na)	1	2010	1700	1750	1710	1740	1660	1660	1640	1560	1580		
Chloride (Cl)	1	3240	3180	2880	2810	3210	2810	2810	2890	2850	2720		
Fluoride (F)	0.1	1	1	1	1	1	0.4	0.4	0.4	0.4	0		
Sulfate (SO_4)	1	901	918	821	754	799	730	736	733	723	646		
TDS including alkalinity		6769	6410	6031	5864	6323	5762	5533	5576	5446	5248		
Trace metals/ metalloids (mg/L)	**LoR**												
Aluminium (Al)	0.01	0.1000	0.0200	0.0100	0.0100	0.0050	0.0050	0.0050	0.0500	0.0050	0.0050		
Arsenic (As)	0.001	0.0200	0.0150	0.0150	0.0150	0.0180	0.019	0.018	0.016	0.013	0.0080		
Boron (B)	0.05	0.5000	0.5800	0.5800	0.6100	0.5800	0.57	0.55	0.57	0.49	0.5000		
Cadmium (Cd)	0.0001	0.0006	0.0005	0.0004	0.0005	0.0003	0.0003	0.0002	0.0001	0.0002	0.0001		
Cobalt (Co)	0.001	0.0070	0.0070	0.0070	0.0080	0.0060	0.007	0.006	0.006	0.005	0.0050		
Chromium (Cr)	0.001	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005		
Copper (Cu)	0.001	0.0050	0.0030	0.0070	0.0050	0.0020	0.002	0.0005	0.0005	0.002	0.0010		
Iron (Fe)	0.05	0.0250	0.0250	0.0250	0.0250	0.1000	0.0250	0.0250	0.0250	0.0250	0.0250		
Lithium (Li)	0.001	0.0990	0.0930	0.0950	0.1070	0.1040	0.099	0.095	0.094	0.096	0.1010		
Manganese (Mn)	0.001	0.2090	0.2060	0.2120	0.2030	0.1860	0.187	0.174	0.174	0.152	0.1270		
Molybdenum (Mo)	0.001	0.2060	0.1650	0.1600	0.1490	0.1380	0.16	0.121	0.137	0.116	0.0880		
Nickel (Ni)	0.001	0.0060	0.0060	0.0060	0.0060	0.0060	0.004	0.005	0.004	0.007	0.0080		
Lead (Pb)	0.001	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005		
Antimony (Sb)	0.001	0.0030	0.0030	0.0030	0.0030	0.0030	0.003	0.003	0.003	0.002	0.0020		
Selenium (Se)	0.01	0.1200	0.1000	0.0900	0.0600	0.0200	0.01	0.01	0.0500	0.0050	0.0050		
Uranium (U)	0.001	0.0060	0.0060	0.0060	0.0060	0.0060	0.006	0.006	0.006	0.006	0.0060		
Vanadium	0.01	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0500	0.0050	0.0050		
Zinc (Zn)	0.005	0.0340	0.0240	0.0260	0.0200	0.0180	0.024	0.017	0.017	0.017	0.0120		

KLC 12 - C5286 Permian composite saturated with distilled water

		KLC 12 - C5286 Permian composite saturated with distilled water											
		Weight (kg)	11.75	**Total S (%)**	0.03	**ANC**	20.4	**Volume L**	7.7	**Pore void (L)**	3.48	**% Silt**	57
		pH (1:5)	8.20	**Scr (%)**	0.018	**NAPP**	-19.5	**Density**	1.52			**% Sand**	33
		EC (µS/cm)	614	**MPA**	0.9	**ANC:MPA**	22.2	**Pore void (L)**	45			**% Gravel**	10
Date		**09-Mar-18**	**16-Mar-18**	**23-Mar-18**	**28-Mar-18**	**05-Apr-18**	**13-Apr-18**	**27-Apr-18**	**11-May-18**	**25-May-18**	**03-Jul-18**		
Number of Weeks		**1**	**2**	**3**	**4**	**5**	**7**	**9**	**11**	**13**	**15**		
Leach Number		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**		
ALS Laboratory Number		EB1806403	EB1807004	EB1807664	EB1808044	EB1808680	EB1809205011	EB1810435009	EB1811540012	EB1812860011	EB1816067		
Volume On (L)		Filled and retained full - no head space											
Volume Collected (L)													
Volume Sent to ALS (L)		0.500	0.500	0.500	0.500	0.500	0.490	0.502	0.483	0.500	3.000		
Cum. Volume (L)		0.50	1.00	1.50	2.00	2.50	2.99	3.49	3.98	4.48	7.48		
Cum Vol Off		0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	7.5		
Pore Volumes		0.2	0.4	0.6	0.8	1.0	1.2	1.4	1.6	1.3	2.1		
pH (RGS Measurement)		7.7	7.8	7.9	8.0	8.1	8.2	8.1	8.3	8.1	8.6		
pH (ALS Measurement)		8.3	7.9	8.4	8.3	8.3	8.5	8.41	8.3	8.4	8.5		
EC (RGS Measurement) (µS/cm)		2560.0	2940.0	2448.0	2490.0	2006.0	1871.0	1766.0	1592.0	1430.0	899.0		
EC (ALS Measurement) (µS/cm)		2750.0	3130.0	2920.0	2600.0	2270.0	1920.0	1850	1660	1510	961.0		
Acidity (mg/L)*		4.0	0.5	2.0	0.5	0.5	0.5	0.5	0.5	0.5	0.5		
Alkalinity (mg/L)*		136.0	230.0	239.0	263.0	259.0	263.0	292	306	328	325.0		
Major Ions (mg/L)	**LoR**												
Calcium (Ca)	1	26	20	18	14	12	8	7	5	6	4		
Potassium (K)	1	15	17	16	15	13	10	11	9	9	6		
Magnesium (Mg)	1	26	27	24	22	18	13	12	9	9	4		
Sodium (Na)	1	531	554	540	486	443	394	365	324	302	213		
Chloride (Cl)	1	599	672	569	485	462	339	294	257	212	80		
Fluoride (F)	0.1	1	1	1	1	1	0.9	0.9	0.8	0.9	1		
Sulfate (SO_4)	1	368	388	348	292	247	195	183	162	143	62		
TDS including alkalinity		1702	1909	1755	1578	1455	1223	873	767	682	370		
Trace metals/ metalloids (mg/L)	**LoR**												
Aluminium (Al)	0.01	0.0050	0.0100	0.0200	0.0200	0.0200	0.02	0.02	0.02	0.02	0.0300		
Arsenic (As)	0.001	0.0120	0.0090	0.0120	0.0140	0.0200	0.024	0.023	0.022	0.018	0.0150		
Boron (B)	0.05	0.3300	0.4200	0.4400	0.4400	0.4200	0.39	0.38	0.37	0.33	0.2600		
Cadmium (Cd)	0.0001	0.0002	0.0003	0.0002	0.0003	0.0003	0.0001	0.0003	0.0001	0.0002	0.0002		
Cobalt (Co)	0.001	0.0010	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005		
Chromium (Cr)	0.001	0.0005	0.0005	0.0010	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005		
Copper (Cu)	0.001	0.0040	0.0030	0.0030	0.0040	0.0010	0.001	0.0005	0.0005	0.001	0.0020		
Iron (Fe)	0.05	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250		
Lithium (Li)	0.001	0.0210	0.0260	0.0260	0.0280	0.0230	0.02	0.019	0.018	0.016	0.0120		
Manganese (Mn)	0.001	0.2650	0.0700	0.0450	0.0370	0.0540	0.06	0.072	0.075	0.069	0.0190		
Molybdenum (Mo)	0.001	0.1960	0.2540	0.2740	0.2810	0.2740	0.313	0.244	0.281	0.264	0.1610		
Nickel (Ni)	0.001	0.0030	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.001	0.0005		
Lead (Pb)	0.001	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005		
Antimony (Sb)	0.001	0.0020	0.0030	0.0040	0.0040	0.0040	0.005	0.005	0.005	0.005	0.0040		
Selenium (Se)	0.01	0.1000	0.1000	0.0400	0.0100	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050		
Uranium (U)	0.001	0.0020	0.0030	0.0040	0.0040	0.0020	0.002	0.002	0.002	0.002	0.0005		
Vanadium	0.01	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050		
Zinc (Zn)	0.005	0.0140	0.0130	0.0110	0.0060	0.0050	0.0025	0.0025	0.0025	0.0025	0.0025		

KLC 13 - Tertiary Spoil FREE LEACH

		KLC 13 - Quaternary/Tertiary Spoil FREE LEACH											
		Weight (kg)	11.45	**Total S (%)**	0.04	**ANC**	80.4	**Volume L**	7.5	**Pore void (L)**	2.26	**% Silt**	90
		pH (1:5)	9.70	**Scr (%)**	0.019	**NAPP**	-79.2	**Density**	1.52			**% Sand**	10
		EC (µS/cm)	301	**MPA**	1.2	**ANC:MPA**	65.6	**Pore void (L)**	30			**% Gravel**	0
Date		**09-Mar-18**	**16-Mar-18**	**23-Mar-18**	**28-Mar-18**	**05-Apr-18**	**13-Apr-18**	**27-Apr-18**	**11-May-18**	**25-May-18**			
Number of Weeks		**1**	**2**	**3**	**4**	**5**	**7**	**9**	**11**	**13**			
Leach Number		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**			
ALS Laboratory Number		EB1806403	EB1807004	EB1807664	EB1808044	EB1808680	EB1810435010	EB1811540013	EB1812860012	EB1816067			
Volume On (L)		2.5	0.0	0.6	0.6	0.8	0.8	0.8	0.8	0.8			
Volume Collected (L)		0.5	0.5	0.5	0.8	0.6	0.5	0.4	0.3	0.4			
Volume Sent to ALS (L)		0.5	0.5	0.5	0.5	0.5	0.5	0.4	0.3	0.4			
Cum. Volume (L)		2.5	2.5	3.1	3.7	4.5	5.2	6.0	6.7				
Cum Vol Off		0.5	1.0	1.5	2.3	2.9	3.4	3.9	4.2	4.6			
Pore Volumes									1.9	2.1			
pH (RGS Measurement)		6.9	7.2	7.1	7.8	8.3	8.8	9.0	8.7	8.9			
pH (ALS Measurement)		7.5	7.4	7.8	8.2	8.6	8.97	9.0	9.0	9.0			
EC (RGS Measurement) (µS/cm)		20180.0	24440.0	21380.0	14280.0	5750.0	2830.0	1714.0	1537.0	1242.0			
EC (ALS Measurement) (µS/cm)		30100.0	34600.0	28000.0	14100.0	6200.0	3030	1860	1580	992.0			
Acidity (mg/L)*		17.0	15.0	24.0	0.5	0.5	0.5	0.5	0.5	0.5			
Alkalinity (mg/L)*		57.0	120.0	138.0	216.0	318.0	549	632	650	491.0			
Major Ions (mg/L)	**LoR**												
Calcium (Ca)	1	1060	1340	960	264	59	24	10	10	6			
Potassium (K)	1	23	26	22	11	6	3	2	2	1			
Magnesium (Mg)	1	1220	1420	1020	293	109	33	13	10	5			
Sodium (Na)	1	3940	4010	3570	1960	1120	640	401	354	237			
Chloride (Cl)	1	10800	12700	9390	4660	1580	553	170	77	16			
Fluoride (F)	0.1	0	1	1	1	1.1	2	2.4	3.1	4			
Sulfate (SO_4)	1	742	930	868	635	390	200	116	82	34			
TDS including alkalinity		17842	20547	15969	8040	3583	2004	714	538				
Trace metals/ metalloids (mg/L)	**LoR**												
Aluminium (Al)	0.01	0.0050	0.0050	0.0050	0.0400	0.0050	0.0050	0.02	0.08	0.6100			
Arsenic (As)	0.001	0.0030	0.0020	0.0020	0.0010	0.001	0.002	0.003	0.004	0.0050			
Boron (B)	0.05	0.3600	0.6700	0.7500	0.7600	0.83	0.77	0.75	0.67	0.4700			
Cadmium (Cd)	0.0001	0.0010	0.0008	0.0004	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001			
Cobalt (Co)	0.001	0.0040	0.0030	0.0020	0.0020	0.0005	0.0005	0.0005	0.0005	0.0005			
Chromium (Cr)	0.001	0.0020	0.0020	0.0020	0.0020	0.005	0.006	0.004	0.005	0.0050			
Copper (Cu)	0.001	0.0120	0.0090	0.0120	0.0040	0.005	0.004	0.008	0.009	0.0060			
Iron (Fe)	0.05	0.0250	0.0250	0.0250	0.6800	0.0250	0.0250	0.0250	0.0250	0.0900			
Lithium (Li)	0.001	0.0360	0.0420	0.0380	0.0220	0.013	0.007	0.005	0.004	0.0020			
Manganese (Mn)	0.001	0.1260	0.1150	0.0650	0.0710	0.004	0.0005	0.002	0.0005	0.0005			
Molybdenum (Mo)	0.001	0.0070	0.0070	0.0070	0.0030	0.004	0.012	0.019	0.023	0.0390			
Nickel (Ni)	0.001	0.0140	0.0130	0.0100	0.0070	0.0005	0.004	0.001	0.004	0.0030			
Lead (Pb)	0.001	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005			
Antimony (Sb)	0.001	0.0005	0.0005	0.0010	0.0010	0.001	0.002	0.002	0.002	0.0010			
Selenium (Se)	0.01	0.0100	0.0200	0.0100	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050			
Uranium (U)	0.001	0.0010	0.0060	0.0080	0.0090	0.01	0.011	0.016	0.017	0.0120			
Vanadium	0.01	0.0050	0.0050	0.0050	0.0050	0.0050	0.01	0.02	0.02	0.0200			
Zinc (Zn)	0.005	0.0720	0.0380	0.0320	0.0100	0.0025	0.0025	0.0025	0.0025	0.0025			

KLC 15 - Tertiary Spoil composite saturated with distilled water

		KLC 15 - Quaternary/Tertiary Spoil composite saturated with distilled water											
		Weight (kg)	11.70	**Total S (%)**	0.02	**ANC**	11.9	**Volume L**	7.7	**Pore void (L)**	2.31	**% Silt**	90
		pH (1:5)	8.20	**Scr (%)**	0.006	**NAPP**	-11.3	**Density**	1.52			**% Sand**	10
		EC (µS/cm)	1,700	**MPA**	0.6	**ANC:MPA**	19.4	**Pore void (L)**	30			**% Gravel**	0
Date		**09-Mar-18**	**16-Mar-18**	**23-Mar-18**	**28-Mar-18**	**05-Apr-18**	**13-Apr-18**	**27-Apr-18**	**11-May-18**	**25-May-18**	**03-Jul-18**		
Number of Weeks		**1**	**2**	**3**	**4**	**5**	**7**	**9**	**11**	**13**	**15**		
Leach Number		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**		
ALS Laboratory Number			EB1806403	EB1807004	EB1807664	EB1808044	EB1808680	EB1810658003	EB1811540015	EB1812860013	EB1816067		
Volume On (L)		Filled and retained full with DI water - no head space											
Volume Collected (L)													
Volume Sent to ALS (L)		0.500	0.500	0.500	0.432	0.500	0.384	0.500	0.490	0.500	2.700		
Cum. Volume (L)		0.50	1.00	1.50	1.93	2.43	2.82	3.32	3.81	4.31	7.01		
Cum Vol Off		0.5	1.0	1.5	1.9	2.4	2.8	3.3	3.8	4.3	7.0		
Pore Volumes		0.2	0.4	0.6	0.8	1.0	1.1	1.3	1.5	1.9	3.0		
pH (RGS Measurement)		6.5	6.9	7.1	7.3	7.0	7.9	8.3	8.3	8.3	8.8		
pH (ALS Measurement)		7.1	7.2	7.8	8.1	8.0	8.4	8.6	8.3	8.7	8.8		
EC (RGS Measurement) (µS/cm)				22610.0	14130.0	7880.0	5330.0	3530.0	2660.0	2060.0	1590.0		
EC (ALS Measurement) (µS/cm)		87600.0	46500.0	31900.0	17600.0	10500.0	6160.0	3900	2900	2180	853.0		
Acidity (mg/L)*		48.0	22.0	30.0	0.5	0.5	0.5	0.5	0.5	0.5	0.5		
Alkalinity (mg/L)*		56.0	132.0	161.0	270.0	348.0	454.0	511	522	547	370.0		
Major Ions (mg/L)	**LoR**												
Calcium (Ca)	1	3550	1830	927	411	173	79	36	18	13	4		
Potassium (K)	1	52	30	20	12	8	5	6	3	2	2		
Magnesium (Mg)	1	4030	2040	993	442	196	97	48	23	15	3		
Sodium (Na)	1	11400	6630	4260	2520	1610	1080	744	549	431	199		
Chloride (Cl)	1	36300	17100	10500	5610	3420	1540	816	586	368	41		
Fluoride (F)	0.1	0	0	1	1	1	1.1	1.3	1.6	2.1	7		
Sulfate (SO_4)	1	2350	1900	1390	799	585	348	212	161	113	22		
TDS including alkalinity		57738	29662	18252	10065	6341	3604	1863	1342	944	278		
Trace metals/ metalloids (mg/L)	**LoR**												
Aluminium (Al)	0.01	0.0250	0.0250	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.03	1.8400		
Arsenic (As)	0.001	0.0025	0.0025	0.0020	0.0020	0.0020	0.002	0.003	0.003	0.003	0.0090		
Boron (B)	0.05	0.4800	0.8400	0.7800	0.8100	0.8400	0.86	0.86	0.83	0.68	0.4700		
Cadmium (Cd)	0.0001	0.0048	0.0015	0.0005	0.0003	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001		
Cobalt (Co)	0.001	0.0130	0.0025	0.0030	0.0020	0.0010	0.001	0.0005	0.0005	0.0005	0.0005		
Chromium (Cr)	0.001	0.0025	0.0025	0.0030	0.0030	0.0060	0.004	0.002	0.0005	0.0005	0.0020		
Copper (Cu)	0.001	0.0150	0.0130	0.0140	0.0090	0.0080	0.01	0.01	0.007	0.007	0.0100		
Iron (Fe)	0.05	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.3000		
Lithium (Li)	0.001	0.0980	0.0650	0.0390	0.0270	0.0180	0.012	0.009	0.007	0.005	0.0020		
Manganese (Mn)	0.001	0.7080	0.3390	0.1180	0.0480	0.0190	0.008	0.007	0.005	0.005	0.0020		
Molybdenum (Mo)	0.001	0.0025	0.0025	0.0030	0.0020	0.0080	0.004	0.006	0.008	0.011	0.0510		
Nickel (Ni)	0.001	0.0510	0.0300	0.0130	0.0070	0.0040	0.0005	0.002	0.001	0.004	0.0060		
Lead (Pb)	0.001	0.0025	0.0025	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0020		
Antimony (Sb)	0.001	0.0025	0.0025	0.0005	0.0010	0.0005	0.0005	0.001	0.0005	0.0005	0.0010		
Selenium (Se)	0.01	0.0250	0.0250	0.0200	0.0100	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050		
Uranium (U)	0.001	0.0060	0.0070	0.0090	0.0120	0.0100	0.011	0.01	0.012	0.012	0.0080		
Vanadium	0.01	0.0250	0.0250	0.0050	0.0050	0.0050	0.0050	0.01	0.01	0.01	0.0300		
Zinc (Zn)	0.005	0.1400	0.0830	0.0310	0.0150	0.0060	0.008	0.0025	0.0025	0.0025	0.0025		

KLC 16 - Permian Spoil FREE LEACH

		KLC 16 - Permian Spoil FREE LEACH											
		Weight (kg)	11.85	Total S (%)	0.04	ANC	27.3	Volume L	8.0	Pore void (L)	3.58	% Silt	30
		pH (1:5)	8.90	Scr (%)	0.018	NAPP	-26.1	Density	1.49			% Sand	35
		EC (µS/cm)	250	MPA	1.2	ANC:MPA	22.3	Pore void (L)	45			% Gravel	35
Date		**09-Mar-18**	**16-Mar-18**	**23-Mar-18**	**28-Mar-18**	**05-Apr-18**	**13-Apr-18**	**27-Apr-18**	**11-May-18**	**25-May-18**	**03-Jul-18**		
Number of Weeks		**1**	**2**	**3**	**4**	**5**	**7**	**9**	**11**	**13**	**15**		
Leach Number		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**		
ALS Laboratory Number		EB1806403	EB1807004	EB1807664	EB1808044	EB1808680	EB1809205016	EB1810435011	EB1811540016	EB1812860014	EB1816067		
Volume On (L)		2.5	1.2	1.2	0.8	0.8	0.8	0.8	0.8	0.8	0.8		
Volume Collected (L)		0.5	0.5	0.5	0.5	0.6	0.6	0.5	0.5	0.4	0.7		
Volume Sent to ALS (L)		0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.500	0.500	0.500		
Cum. Volume (L)		2.5	3.7	4.9	5.7	6.4	7.2	7.9	8.7				
Cum Vol Off		0.5	1.0	1.5	2.0	2.6	3.3	3.8	4.3	4.7	5.3		
Pore Volumes										1.3	1.5		
pH (RGS Measurement)		7.4	7.6	7.8	8.0	8.3	8.3	8.0	8.5	8.4	8.4		
pH (ALS Measurement)		7.8	7.5	8.2	8.2	8.2	8.4	8.34	8.2	8.4	8.4		
EC (RGS Measurement) (µS/cm)		2399.0	2262.0	1713.0	1297.0	995.0	930.0	871.0	769.0	661.0	590.0		
EC (ALS Measurement) (µS/cm)		2420.0	2350.0	1810.0	1300.0	1060.0	949.0	907	797	707	519.0		
Acidity (mg/L)*		4.0	1.0	2.0	0.5	0.5	0.5	0.5	0.5	0.5	0.5		
Alkalinity (mg/L)*		41.0	113.0	126.0	138.0	136.0	144.0	157	164	173	177.0		
Major Ions (mg/L)	**LoR**												
Calcium (Ca)	1	145	145	92	63	47	38	33	26	25	18		
Potassium (K)	1	28	29	23	20	17	16	16	14	13	11		
Magnesium (Mg)	1	113	109	71	52	39	34	33	23	22	16		
Sodium (Na)	1	233	218	172	133	118	111	105	91	85	68		
Chloride (Cl)	1	86	50	28	17	13	11	9	8	6	3		
Fluoride (F)	0.1	1	1	1	1	1	0.8	0.7	0.7	0.7	1		
Sulfate (SO_4)	1	1150	1110	771	451	376	306	266	198	166	88		
TDS including alkalinity		1797	1775	1284	875	747	661	463	361	318	205		
Trace metals/ metalloids (mg/L)	**LoR**												
Aluminium (Al)	0.01	0.0700	0.0200	0.0200	0.0200	0.0300	0.02	0.02	0.03	0.02	0.0200		
Arsenic (As)	0.001	0.0030	0.0030	0.0030	0.0040	0.0020	0.002	0.002	0.002	0.001	0.0020		
Boron (B)	0.05	0.0700	0.1000	0.1000	0.1200	0.1200	0.11	0.12	0.14	0.1	0.0900		
Cadmium (Cd)	0.0001	0.0002	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001		
Cobalt (Co)	0.001	0.0060	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005		
Chromium (Cr)	0.001	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.001	0.0005	0.0005	0.0005		
Copper (Cu)	0.001	0.0320	0.0100	0.0080	0.0040	0.0050	0.006	0.002	0.003	0.004	0.0040		
Iron (Fe)	0.05	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250		
Lithium (Li)	0.001	0.0220	0.0220	0.0200	0.0200	0.0160	0.015	0.014	0.014	0.012	0.0100		
Manganese (Mn)	0.001	0.2910	0.0190	0.0030	0.0020	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005		
Molybdenum (Mo)	0.001	0.0040	0.0060	0.0060	0.0100	0.0070	0.007	0.006	0.007	0.007	0.0070		
Nickel (Ni)	0.001	0.0100	0.0010	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005		
Lead (Pb)	0.001	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005		
Antimony (Sb)	0.001	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005		
Selenium (Se)	0.01	0.1500	0.1300	0.0700	0.0500	0.0400	0.03	0.03	0.02	0.02	0.0050		
Uranium (U)	0.001	0.0010	0.0010	0.0020	0.0020	0.0010	0.002	0.002	0.002	0.001	0.0005		
Vanadium	0.01	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050		
Zinc (Zn)	0.005	0.0200	0.0180	0.0060	0.0025	0.0025	0.0025	0.007	0.0025	0.0025	0.0025		

KLC 17 - Permian Spoil composite saturated with A Pit water

		KLC 17 - Permian Spoil composite saturated with B Pit water											
		Weight (kg)	11.65	Total S (%)	0.04	ANC	27.3	Volume L	7.8	Pore void (L)	3.52	% Silt	30
		pH (1:5)	8.90	Scr (%)	0.018	NAPP	-26.1	Density	1.49			% Sand	35
		EC (µS/cm)	250	MPA	1.2	ANC:MPA	22.3	Pore void (L)	45			% Gravel	35
Date		**09-Mar-18**	**16-Mar-18**	**23-Mar-18**	**28-Mar-18**	**05-Apr-18**	**13-Apr-18**	**27-Apr-18**	**11-May-18**	**25-May-18**	**03-Jul-18**		
Number of Weeks		**1**	**2**	**3**	**4**	**5**	**7**	**9**	**11**	**13**	**15**		
Leach Number		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**		
ALS Laboratory Number		EB1806403	EB1807004	EB1807664	EB1808044	EB1808680	EB1809205016	EB1810435012	EB1811540017	EB1812860015	EB1816067		
Volume On (L)							Filled and drained						
Volume Collected (L)													
Volume Sent to ALS (L)		0.500	0.500	0.500	0.500	0.500	0.496	0.499	0.493	0.500	3.000		
Cum. Volume (L)		0.50	1.00	1.50	2.00	2.50	3.00	3.50	3.99	4.49	7.49		
Cum Vol Off		0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	7.5		
Pore Volumes		0.2	0.4	0.6	0.8	1.0	1.2	1.4	1.6	1.3	2.1		
pH (RGS Measurement)		7.2	7.4	7.4	7.4	7.6	7.6	7.5	7.7	7.4	7.9		
pH (ALS Measurement)		7.9	7.5	8.0	7.9	7.8	8.1	7.97	7.7	8.0	8.1		
EC (RGS Measurement) (µS/cm)		7520.0	7750.0	7870.0	7790.0	7210.0	7690.0	7560.0	7320.0	7670.0	7340.0		
EC (ALS Measurement) (µS/cm)		9610.0	9550.0	9550.0	9130.0	9110.0	9040.0	8950	8730	8700	7930.0		
Acidity (mg/L)*		6.0	3.0	13.0	2.0	4.0	0.5	10	5	3	2.0		
Alkalinity (mg/L)*		131.0	148.0	150.0	164.0	158.0	162.0	157	157	164	184.0		
Major Ions (mg/L)	**LoR**												
Calcium (Ca)	1	472	493	460	421	384	333	339	267	302	226		
Potassium (K)	1	62	64	63	60	56	54	55	50	48	42		
Magnesium (Mg)	1	386	399	372	365	346	323	324	282	277	230		
Sodium (Na)	1	997	938	989	1020	1070	1070	1080	1020	1070	1250		
Chloride (Cl)	1	2690	2690	2530	2460	2890	2530	2580	2690	2690	2630		
Fluoride (F)	0.1	0	0	0	0	0	0.4	0.4	0.4	0.4	0		
Sulfate (SO_4)	1	1500	1550	1420	1250	1160	1030	1000	920	866	654		
TDS including alkalinity		6238	6282	5984	5740	6064	5502	5378	5229	5253	5032		
Trace metals/ metalloids (mg/L)	**LoR**												
Aluminium (Al)	0.01	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.02	0.0050	0.0050		
Arsenic (As)	0.001	0.0020	0.0020	0.0020	0.0020	0.0020	0.002	0.002	0.002	0.002	0.0010		
Boron (B)	0.05	0.1100	0.1300	0.1400	0.1600	0.1500	0.15	0.15	0.15	0.13	0.1600		
Cadmium (Cd)	0.0001	0.0002	0.0001	0.0001	0.0004	0.0001	0.0003	0.0001	0.0001	0.0001	0.0001		
Cobalt (Co)	0.001	0.0030	0.0005	0.0005	0.0020	0.0005	0.001	0.0005	0.0005	0.0005	0.0005		
Chromium (Cr)	0.001	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005		
Copper (Cu)	0.001	0.0030	0.0030	0.0040	0.0060	0.0010	0.003	0.0005	0.0005	0.002	0.0005		
Iron (Fe)	0.05	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250		
Lithium (Li)	0.001	0.0610	0.0580	0.0630	0.0740	0.0690	0.064	0.061	0.058	0.055	0.0570		
Manganese (Mn)	0.001	0.3560	0.0400	0.0110	0.0140	0.0110	0.031	0.06	0.068	0.117	0.0950		
Molybdenum (Mo)	0.001	0.0050	0.0050	0.0050	0.0060	0.0060	0.007	0.008	0.009	0.01	0.0100		
Nickel (Ni)	0.001	0.0080	0.0030	0.0020	0.0020	0.0020	0.0005	0.0005	0.0005	0.003	0.0020		
Lead (Pb)	0.001	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005		
Antimony (Sb)	0.001	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005		
Selenium (Se)	0.01	0.1100	0.1300	0.1000	0.0900	0.0600	0.04	0.02	0.0050	0.0050	0.0050		
Uranium (U)	0.001	0.0080	0.0080	0.0080	0.0080	0.0070	0.007	0.006	0.006	0.006	0.0060		
Vanadium	0.01	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050		
Zinc (Zn)	0.005	0.0200	0.0160	0.0140	0.0160	0.0120	0.017	0.012	0.011	0.01	0.0025		

KLC 18 - Permian Spoil composite saturated with distilled water

		KLC 18 - Permian Spoil composite saturated with distilled water											
		Weight (kg)	11.95	**Total S (%)**	0.04	**ANC**	27.3	**Volume L**	8.0	**Pore void (L)**	3.61	**% Silt**	30
		pH (1:5)	8.90	**Scr (%)**	0.018	**NAPP**	-26.1	**Density**	1.49			**% Sand**	35
		EC (µS/cm)	250	**MPA**	1.2	**ANC:MPA**	22.3	**Pore void (L)**	45			**% Gravel**	35
Date		**09-Mar-18**	**16-Mar-18**	**23-Mar-18**	**28-Mar-18**	**05-Apr-18**	**13-Apr-18**	**27-Apr-18**	**11-May-18**	**25-May-18**	**03-Jul-18**		
Number of Weeks		**1**	**2**	**3**	**4**	**5**	**7**	**9**	**11**	**13**	**15**		
Leach Number		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**		
ALS Laboratory Number		EB1806403	EB1807004	EB1807664	EB1808044	EB1808680	EB1809205016	EB1810435013	EB1811540018	EB1812860016	EB1816067		
Volume On (L)		Filled and retained full - no head space											
Volume Collected (L)													
Volume Sent to ALS (L)		0.500	0.500	0.500	0.500	0.500	0.509	0.493	0.491	0.500	3.000		
Cum. Volume (L)		0.50	1.00	1.50	2.00	2.50	3.01	3.50	3.99	4.49	7.49		
Cum Vol Off		0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	7.5		
Pore Volumes		0.2	0.4	0.6	0.8	1.0	1.2	1.4	1.6	1.2	2.1		
pH (RGS Measurement)		7.5	7.7	7.8	7.8	7.9	7.9	8.0	8.2	7.9	8.5		
pH (ALS Measurement)		7.9	7.5	8.2	8.1	8.0	8.3	8.24	8.0	8.2	8.4		
EC (RGS Measurement) (µS/cm)		1704.0	1840.0	1711.0	1651.0	1392.0	1324.0	1115.0	1019.0	867.0	574.0		
EC (ALS Measurement) (µS/cm)		1780.0	1990.0	1920.0	1710.0	1590.0	1400.0	1170	1040	908	409.0		
Acidity (mg/L)*		3.0	0.5	3.0	0.5	0.5	0.5	0.5	0.5	0.5	0.5		
Alkalinity (mg/L)*		58.0	103.0	125.0	144.0	144.0	150.0	154	157	162	145.0		
Major Ions (mg/L)	**LoR**												
Calcium (Ca)	1	85	98	94	82	70	56	40	30	28	10		
Potassium (K)	1	24	28	28	26	24	22	19	16	15	10		
Magnesium (Mg)	1	63	77	75	68	62	53	41	29	27	10		
Sodium (Na)	1	188	206	209	191	188	173	147	126	116	66		
Chloride (Cl)	1	51	53	44	36	35	44	20	19	16	7		
Fluoride (F)	0.1	1	1	1	1	1	0.8	0.9	0.9	0.9	1		
Sulfate (SO_4)	1	747	836	766	588	627	526	411	326	259	58		
TDS including alkalinity		1217	1402	1342	1136	1151	1025	679	547	462	162		
Trace metals/ metalloids (mg/L)	**LoR**												
Aluminium (Al)	0.01	0.0050	0.0050	0.0050	0.0100	0.0050	0.0050	0.01	0.01	0.0050	0.0200		
Arsenic (As)	0.001	0.0020	0.0020	0.0020	0.0020	0.0020	0.002	0.003	0.003	0.003	0.004		
Boron (B)	0.05	0.0700	0.1000	0.1100	0.1300	0.1200	0.12	0.12	0.11	0.09	0.08		
Cadmium (Cd)	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001		
Cobalt (Co)	0.001	0.0030	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005		
Chromium (Cr)	0.001	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005		
Copper (Cu)	0.001	0.0020	0.0030	0.0030	0.0030	0.0010	0.002	0.0005	0.0005	0.001	0.0005		
Iron (Fe)	0.05	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250		
Lithium (Li)	0.001	0.0190	0.0220	0.0250	0.0270	0.0240	0.022	0.018	0.017	0.014	0.009		
Manganese (Mn)	0.001	0.2560	0.0350	0.0050	0.0030	0.0060	0.012	0.035	0.069	0.071	0.024		
Molybdenum (Mo)	0.001	0.0050	0.0060	0.0070	0.0080	0.0090	0.014	0.014	0.02	0.02	0.018		
Nickel (Ni)	0.001	0.0060	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.001	0.0005		
Lead (Pb)	0.001	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005		
Antimony (Sb)	0.001	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005		
Selenium (Se)	0.01	0.1200	0.1300	0.1200	0.1000	0.0700	0.05	0.0050	0.0050	0.0050	0.0050		
Uranium (U)	0.001	0.0005	0.0010	0.0020	0.0030	0.0020	0.002	0.002	0.002	0.002	0.0005		
Vanadium	0.01	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050		
Zinc (Zn)	0.005	0.0150	0.0160	0.0120	0.0080	0.0090	0.009	0.009	0.007	0.008	0.0025		

A.2 Appendix 2 Geochemical Assessment Methods

The acid producing potential of a coal mine waste materials can be completed using a range of analyses that may include total sulfur (TS), sulfide sulfur (SS), the hydrogen ion concentration (pH), electrical conductivity (EC), acid neutralising capacity (ANC) and mineralogy, (INAP, 2009; COA, 2016). However, it is often unnecessary to undertake all of these analyses on every sample and screening of all samples using some of these tests is generally applied in the initial phase of testing.

In the initial phase of testing, RGS undertook pH, EC, TS and ANC on all samples to screen them and undertook supplementary analyses on specific samples to understand anomalies or to verify predictions.

A.2.1 Appendix 2i Maximum potential acidity

A.2.1.1 Appendix 2i.i Actual acidity

Actual acidity can be divided into soluble acidity and retained acidity. Soluble acidity is defined here as acidity measured using a 1:5 (soil:water) extract whereas retained acidity is defined as the acidity that is not recorded in such an extraction. However, there is no clear-cut distinction between soluble acidity and retained acidity because part of the retained forms of acidity can be released during successive extractions with water. Soluble acidity can be subdivided into active soluble acidity and buffered acidity. Active soluble acidity accounts for the activity of hydrogen ion (H^+) whereas buffered soluble acidity accounts for other soluble acidic cations (mainly Fe^{2+}, $AlSO_4^+$ and Al^{3+}) that can produce hydrogen ions when they hydrolyse (Lin et al., 2002). Retained acidity can be sub-divided into (a) exchangeable acidity, (b) acidity carried by protonated, variably charged particles, such as clays, and (c) acidity carried by sulfate minerals. These retained forms of acidity are temporarily immobilised by soils and are subject to re-mobilisation if geochemical conditions change, such as occur in liming or re-flooding with brackish tidal water. Exchangeable acidity is acidity that is retained through cation exchange reactions (Lin et al, 2002). Jarosite is a common sulfate mineral in acid sulfate soil and acid mine waste. One mole of jarosite contains three moles of acidity that can be released by hydrolysis:

$$KFe_3(OH)_6(SO_4)_2 + 3OH^- \dashrightarrow 3Fe(OH)_3 + 2SO_4^{2-} + K^+$$

Acidity that is buffered through protonation of variably charged particles can be released through their de-protonation, e.g.

$$[Al(OH)]^{2+}\text{-}SO_4^{2-} + 2OH^- \dashrightarrow Al(OH)_3 + SO_4^{2-}$$

A.2.1.2 Appendix 2i.ii Potential acidity

TS is measured by combustion of the sample in a furnace at 1,350ºC in the presence of strong oxidants/catalysts. This method measures the total concentration of sulfur, including elemental sulfur, sulfur present in sulfide and sulfate minerals as well as organic sulfur. The most environmentally conservative approach to calculate maximum potential acidity (MPA) is to count all sulfur in a sample as potentially reactive sulfide and therefore capable of generating acid. By convention in Acid Base Account studies, the sulfide sulfur content is conservatively taken being present as pyrite (FeS_2). Therefore, the stoichiometry of pyrite oxidation is used to calculate a theoretical maximum amount of sulfuric acid that could be generated. However, this ignores the fact that not all sulfur will contribute to the generation of acidity, e.g. sulfate sulfur in gypsum and barite. As a result, the TS concentration may overestimate the acid generation potential of a sample which is expressed in kg H_2SO_4/tonne.

Sulfur can be present within acid producing primary minerals such as pyrite (FeS_2), chalcopyrite ($CuFeS_2$) and bornite (Cu_5FeS_4) and non-acid producing primary minerals such as galena (PbS) and sphalerite (ZnS). TS can also be also present as many non-acid producing secondary minerals such as, gypsum ($CaSO_4 \bullet 2(H_2O)$) through to minerals such as jarosite ($KFe^{3+}{}_3(OH)_6(SO_4)_2$) and alunite ($KAl_3(SO_4)_2(OH)_6$) that can store and release acidity and trace, minor and major elements.

To differentiate between total sulfur and sulfide sulfur the chromium reducible sulfur (Scr) method was used to measure the sulfide sulfur. The Scr method (Standards Australia, 2008) provides a direct measure of reduced inorganic sulfur over the wide range of values encountered in acid sulfate soils and mineral waste in geological materials. The selectivity of the Scr test in samples containing residual organic sulfur makes it an ideal choice analytically to measure sulfide within primary sulfide minerals. While this method excludes sulfur present as sulfate, or organic sulfur it does not differentiate between acid producing (e.g. pyrite) and non-acid producing (e.g. sphalerite) minerals.

Acid generation is caused by the exposure of sulfide minerals, most commonly pyrite, to atmospheric oxygen and water. Sulfur assay results are used to calculate the maximum acid that could be generated by the sample by either directly determining the pyritic sulfur content or assuming that all sulfur not present as sulfate occurs as pyrite. Pyrite reacts under oxidising conditions to generate acid according to the following overall reaction:

$$4FeS_2 + 15O_2 + 14H_2O \rightarrow 4Fe(OH)_3 + 8H_2SO_4.$$

According to this reaction, the maximum potential acidity (MPA) of a sample containing 1% S as pyrite would be 30.6 kg H_2SO_4/t. The chemical components of the acid generation process consist of the above sulfide oxidation reaction and acid neutralization, which is mainly provided by inherent carbonates and, to a lesser extent, silicate materials. The amount and rate of acid generation is determined by the interaction and overall balance of the acid generation and neutralisation components.

A.2.2 Appendix 2ii Total ANC

The total ANC can be measured by the peroxide siderite correction for the Sobek method that utilises digestion of a pulp sample with 0.5 M HCl, boiling and addition of 5mL of 30% H_2O_2. The sample is then back titrated with NaOH to measure the amount of acid consumed by reaction with the sample and provides the ANC in kg H_2SO_4/t. ANC is expressed in kg H_2SO_4/t of material representing the capacity of the solids to neutralise acid, but not necessarily implying that calcite ($CaCO_3$) is present. This is the method used for this work.

The primary minerals in geological materials that are readily able to neutralise acidity are calcium and magnesium carbonates. Secondary neutralising minerals accounted for in the measurement of total ANC include basic silicates such as calcic feldspars, olivine, amphiboles, and biotite. However, due to their slower dissolution rates, their contribution to the overall ANC is generally considered to be small under ambient conditions. Felsic silicates such as sodic and potassic feldspars, muscovite, most clay minerals, and quartz do not contribute significantly to the ANC. In addition, carbonate minerals that contain iron and/or manganese do not report to the ANC measurement. The relative reactivity of acid consuming minerals at pH 5 is provided in **Table A.2-1.**

A.2.3 Appendix 2iii Reactive ANC

The reactive (available) ANC is determined using the ABCC (AMIRA, 2002) method that was derived from the British Columbia Research Incorporated Initial Neutralisation Potential method (Duncan and Bruynesteyn, 1979). The measurements of reactive ANC (ABCC) involves slow titration of a sample with the addition of hydrochloric or sulfuric acid over set time intervals while continuously measuring the pH. The method is used to estimate the ANC of the material and the buffering capacity available at a pre-determined pH value. When acid is added to finely ground particles or aggregates the material will react with the acid neutralising components and reduce the pH of the solution. The amount of acid required to reach each pH interval is dependent on the amount of neutralisation present. ‘Buffering’ occurs where a significant amount of acid is added before the pH drops, thereby producing a ‘step-like’ curve in a plot of pH versus volume of acid added. RGS has not included reactive ANC testing in this assessment as it has been established that TS values in Ensham spoil are very low and there is excess ANC.

Table A.2-1 Relative Mineral Reactivity

Mineral Group	Typical Minerals	Relative Reactivity at pH 5
Dissolving	Calcite, aragonite, dolomite, magnesite, brucite	1.0
Fast weathering	Anorthite, nepheline, olivine, jadeite, leucite, spodumene, diopside, wollastonite	0.6
Intermediate weathering	Epidote, zoisite, enstatite, hypersthene, augite, hedenbergite, hornblende, glaucophane, tremolite, actinolite, anthophyllite, serpentine, chrysotile, talc, chlorite, biotite	0.4
Slow weathering	Albite, oligoclase, labradorite, montmorillonite, vermiculite, gibbsite, kaolinite	0.02
Very slow weathering	K-feldspars, muscovite	0.01
Inert	Quartz, rutile, zircon	0.004

(Source http://technology.infomine.com/enviromine/ard/acid-base%20accounting/ABAdiscussion.htm)

A.2.4 Appendix 2iv Net acid producing potential and neutralisation potential ratio

Geochemical classification is achieved using the net acid producing potential (NAPP) of a sample, which is calculated from acid base accounting (ABA) procedures (COA, 2016). The NAPP value is derived as the difference between the maximum potential acidity and total ANC of a sample.

The ANC:MPA ratio, or Neutralising Potential Ratio (NPR), is also used as a means of assessing the risk of acid generation from mine waste materials. The purpose of the ANC:MPA ratio is to provide an indication of the relative margin of safety within a material. Generally, an ANC:MPA ratio of 2 or more signifies that there is a high probability that the material will remain at a circum-neutral pH (AMIRA, 2002; INAP, 2009).

A.2.5 Appendix 2v Net Acid Generation

The single addition NAG test involves a single addition of 250 mL of 15% H_2O_2 to a 2.5 g of pulverised (less than 75 µm) sample. The sample is then allowed to react overnight. The entire sample is heated until gently bubbling for approximately 1-2 h to remove excess H_2O_2 and encourage release of inherent neutralising capacity. Once the sample has cooled to room temperature, the pH and titrated acidity to pH 4.5 and 7.0 (in kg H_2SO_4/t of sample) of the solution are measured. A NAG_{pH} less than 4.5 generally indicates the sample is acid producing.

A NAG_{pH} value can be used in combination with NAPP values to classify the geochemical nature of samples. The Australian Government Leading Practice Handbook on Acid and Metalliferous Drainage (COA, 2016) suggests that "the risks of misclassifying Non-Acid Forming (NAF) material as Potentially Acid Forming (PAF) and PAF material as NAF, are substantially reduced by conducting both NAPP and NAG tests."

The standard NAG method is also known to have several limitations, especially for testing coal mine waste materials with elevated organic carbon content, that should be considered in the interpretation of data (INAP, 2009). RGS has not included NAG testing in this assessment.

A.2.6 Appendix 2vi Metalliferous drainage potential

The potential of a geological material to leach trace, minor or major elements (salts, metals and metalloids) is a function of the fractionation and speciation of the elements and the way the mine waste materials will be managed. The static methods used in this assessment have measured the "total" and "water soluble" fractions of these elements.

The geochemical abundance index (GAI) quantifies a "total" assay result for an element in terms of the average crustal abundance for that element (COA, 2016). The index, based on a $\log^2$ scale, is expressed in seven integer increments (0 to 6), which correspond to enrichment factors from 0 to over 96 times average crustal abundance, as shown in **Table A.2-2.**

Table A.2-2 Geochemical Abundance Index (GAI) values and Enrichment Factor

GAI	Enrichment factor	GAI	Enrichment factor
0	Less than 3-fold enrichment	4	24 – 48 fold enrichment
1	3 – 6 fold enrichment	5	48 – 96 fold enrichment
2	6 – 12 fold enrichment	6	Greater than 96 fold enrichment
3	12 – 24 fold enrichment		

Generally, a GAI greater than or equal to three indicates element enrichment to a level that may warrant further investigation (INAP, 2009). This is the case with some environmentally important 'trace' elements, such as As, Cd, Cu and Zn, rather than with major rock-forming elements, such as Ca, Mg, K and Na. Elements identified as enriched may not necessarily be a concern for revegetation, drainage water quality or public health, but their significance should still be evaluated. Similarly, because an element is not enriched does not mean it will never be a concern, because under some conditions (e.g. low pH) the solubility of common environmentally important elements such as Al, Cu, Cd, Fe and Zn increases significantly.

A 1:3 (solid:solute) leach can be used to measure the pH, EC, and the concentration of major ions and trace metals/metalloids in water extracts. It should be recognised that direct comparison of geochemical data from 1:3 water extracts with guideline values can be misleading.

RGS has a preference to evaluate the solubility of metals and major ions from mine waste and tailings using kinetic leach cell testing that, for low sulfur materials, provides a good reflection of the rate of weathering and an indication of release rates into leachate.

A.2.7 Appendix 2vii Saline drainage potential

Saline drainage can come from the release of major cations and anions from geological units due to weathering of the host rock, or from the accumulation of elements over time e.g. accumulation of NaCl in soil from rising groundwater.

Saline drainage can also be attributed to sulfide oxidation process that release sulfate and or the weathering of sulfate minerals such as gypsum. Sulfate (SO_4^{2-}) and other major ions such as Na^+ and Cl^- can be present under both acidic and neutral pH conditions.

A.2.8 Appendix 2viii AMD classification

Terms used to **classify mined materials** can include the following.

- **PAF-HC** (High Capacity – Potentially Acid Forming) - has the potential to produce substantial acidity
- **PAF-LC** (Low Capacity – Potentially Acid Forming) - has the potential to produce minor acidity
- **NAF** (Non-Acid Forming) - will not produce acidity, but may leach salts and some metals/metalloids due to the presence of low sulfide bearing material
- **AC** (Acid Consuming) - has some ANC that will contribute to ongoing acid neutralisation e.g. calcite in Basalt

Other terminology used to classify geological materials include the following.

- **Saline** - material may leach salts dominated by NaCl and or sulfate
- **Sodic** – this material has a proportionally high concentration of exchangeable Na and has the potential to disperse and tunnel

General industry terms that can be used to **describe water quality** at mines include the following.

- Acid Rock Drainage
- Acid and Metalliferous Drainage
- Neutral Drainage
- Saline Drainage
- Mine Impacted Water

In this report we use the term mine impacted water (MIW) as a general term to describe water that contacts disturbed ground. Mine impacted water (MIW) can be classified as having:

- acidic, neutral or alkaline pH
- variable concentrations of major ions (salts e.g. calcium, magnesium, potassium, sodium, chloride, sulfate, boron or fluoride)
- variable concentrations of metals (e.g. Al, Fe, Mn and Zn) or metalloids (e.g. Be, Mo, Se and V) with the concentrations often linked to pH.

Potential sources of acidity in MIW at mine sites can include:

- oxidation of sulfide minerals such as pyrite that produce sulfuric acid (INAP, 2009)
- oxidation of coal that can produce humic acid like materials and organic acid
- rainfall and leaching of cations such as Ca, Mg, K and Na that reduce soil acidification by atmospheric carbonic, nitric or sulfuric acid
- organic matter decay
- use of ammonium-based nitrogen fertilisers.

Potential sources of salts in MIW at mine sites can include:

- oxidation of sulfide minerals, the production of sulfuric acid and subsequent neutralisation reactions that mobilise major ions such as sulfate (SO_4^{2-}) and calcium (Ca^{2+})
- chemical weathering of adjacent soil and rock by sulfuric acid that releases major ions such as sodium (Na^+), potassium (K^+), magnesium (Mg^{2+}) and chloride (Cl^-)
- the mobilisation of sodium chloride (NaCl) or sodium bi-carbonate ($NaHCO_3$) that are present within geological units and groundwater and then released in fluxes as mined materials are extracted (blasted), processed (crushed) and placed into mine landforms

Potential sources of metals (e.g. Al, Fe, Mn and Zn) and oxyanions (e.g. Mo, Se and V) in water at mine sites that can include elements present:

- as ancillary minerals within primary sulfide minerals like pyrite or marcasite that weather very slowly;
- in the solid phase of geological units in a range of minerals with increasing environmental mobility that include immobile oxide <<< carbonate << exchangeable < water soluble.
- in pore water.

A.3 Appendix 3 ALS results

A.3.1 Appendix 3i C5285 ALS results

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **EB1803494**	Page	: 1 of 13
Client	: **RGS ENVIRONMENTAL PTY LTD**	Laboratory	: Environmental Division Brisbane
Contact	: MR ALAN ROBERTSON	Contact	: Customer Services EB
Address	: PO Box 3091 SUNNYBANK SOUTH QLD, AUSTRALIA 4109	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: +61 07 3344 1222	Telephone	: +61-7-3243 7222
Project	: 2017041 - Ensham Project	Date Samples Received	: 05-Feb-2018 15:15
Order number	: ----	Date Analysis Commenced	: 13-Feb-2018
C-O-C number	: ----	Issue Date	: 23-Feb-2018 09:25
Sampler	: ----		
Site	: ----		
Quote number	: BN/035/18 V2		
No. of samples received	: 51		
No. of samples analysed	: 51		

ilac-MRA NATA

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

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

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

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

Signatories

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

Signatories	*Position*	*Accreditation Category*
Andrew Epps	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Ben Felgendrejeris		Brisbane Acid Sulphate Soils, Stafford, QLD
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Merrin Avery	Supervisor - Inorganic	Newcastle - Inorganics, Mayfield West, NSW
Satishkumar Trivedi	Acid Sulfate Soils Supervisor	Brisbane Acid Sulphate Soils, Stafford, QLD

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

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

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

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

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

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

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

- ASS: EA013 (ANC) Fizz Rating: 0- None; 1- Slight; 2- Moderate; 3- Strong; 4- Very Strong; 5- Lime.

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	C5285 0-1	C5285 1-3.1	C5285 3.1-5.06	C5285 5.06-6.74	C5285 6.74-9.3
			Client sampling date / time	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00
Compound	CAS Number	LOR	Unit	EB1803494-001	EB1803494-002	EB1803494-003	EB1803494-004	EB1803494-005
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	8.3	8.5	8.5	8.7	8.3
pH Value	----	0.1	pH Unit	8.5	8.7	8.7	8.8	8.5
EA009: Nett Acid Production Potential								
Net Acid Production Potential	----	0.5	kg H2SO4/t	-56.5	-69.9	-78.0	-93.8	-15.6
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	810	938	829	541	642
Electrical Conductivity @ 25°C	----	1	µS/cm	555	649	583	382	442
EA013: Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	57.1	70.5	78.0	93.8	15.6
ANC as CaCO3	----	0.1	% CaCO3	5.8	7.2	8.0	9.6	1.6
Fizz Rating	----	0	Fizz Unit	2	2	2	2	1
ED040S : Soluble Sulfate by ICPAES								
Sulfate as SO4 2-	14808-79-8	10	mg/kg	160	120	40	20	30
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	0.02	0.02	<0.01	<0.01	<0.01
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	10	mg/kg	530	690	570	340	400
EK040T: Fluoride Total								
Fluoride	16984-48-8	40	mg/kg	160	270	330	210	170

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	C5285 9.3-11.34	C5285 11.34-12.76	C5285 12.76-21	C5285 21-22.81	C5285 22.81-24.5
			Client sampling date / time	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00
Compound	CAS Number	LOR	Unit	EB1803494-006	EB1803494-007	EB1803494-008	EB1803494-009	EB1803494-010
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	8.4	8.3	8.8	8.6	8.7
pH Value	----	0.1	pH Unit	8.6	8.5	9.0	8.7	8.9
EA009: Nett Acid Production Potential								
Net Acid Production Potential	----	0.5	kg H2SO4/t	-24.8	-18.1	-148	-25.5	-22.2
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	607	497	355	390	426
Electrical Conductivity @ 25°C	----	1	µS/cm	430	329	250	275	300
EA013: Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	24.8	18.1	149	26.1	22.8
ANC as CaCO3	----	0.1	% CaCO3	2.5	1.8	15.2	2.7	2.3
Fizz Rating	----	0	Fizz Unit	1	1	3	1	1
ED040S : Soluble Sulfate by ICPAES								
Sulfate as SO4 2-	14808-79-8	10	mg/kg	50	40	90	110	130
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	<0.01	<0.01	0.02	0.02	0.02
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	10	mg/kg	320	180	110	130	80
EK040T: Fluoride Total								
Fluoride	16984-48-8	40	mg/kg	160	140	280	160	170

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	C5285 24.5-27.54	C5285 27.54-30.6	C5285 30.6-33.55	C5285 33.55-34.13	C5285 34.13-36.6
			Client sampling date / time	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00
Compound	CAS Number	LOR	Unit	EB1803494-011	EB1803494-012	EB1803494-013	EB1803494-014	EB1803494-015
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	8.8	8.9	8.8	8.9	8.9
pH Value	----	0.1	pH Unit	9.0	9.0	9.0	8.9	9.1
EA009: Nett Acid Production Potential								
Net Acid Production Potential	----	0.5	kg H2SO4/t	-26.8	-23.4	-29.8	-20.7	-33.8
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	414	404	419	407	427
Electrical Conductivity @ 25°C	----	1	µS/cm	298	278	289	253	309
EA013: Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	28.0	24.6	30.7	21.9	34.7
ANC as CaCO3	----	0.1	% CaCO3	2.8	2.5	3.1	2.2	3.5
Fizz Rating	----	0	Fizz Unit	1	1	1	1	1
ED040S : Soluble Sulfate by ICPAES								
Sulfate as SO4 2-	14808-79-8	10	mg/kg	130	130	140	220	100
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	0.04	0.04	0.03	0.04	0.03
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	10	mg/kg	70	50	60	50	60
EK040T: Fluoride Total								
Fluoride	16984-48-8	40	mg/kg	150	140	270	150	190

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	C5285 36.6-37.95	C5285 37.95-39.55	C5285 39.55-42.21	C5285 42.21-42.56	C5285 42.56-44.43
			Client sampling date / time	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00
Compound	CAS Number	LOR	Unit	EB1803494-016	EB1803494-017	EB1803494-018	EB1803494-019	EB1803494-020
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	9.1	9.0	8.9	8.9	9.0
pH Value	----	0.1	pH Unit	9.2	9.1	9.1	9.0	9.1
EA009: Nett Acid Production Potential								
Net Acid Production Potential	----	0.5	kg H2SO4/t	-65.1	-53.6	-64.3	-29.3	-22.7
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	414	451	481	448	427
Electrical Conductivity @ 25°C	----	1	µS/cm	310	333	347	320	292
EA013: Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	66.0	54.5	65.2	30.2	23.3
ANC as CaCO3	----	0.1	% CaCO3	6.7	5.6	6.6	3.1	2.4
Fizz Rating	----	0	Fizz Unit	2	2	2	1	1
ED040S : Soluble Sulfate by ICPAES								
Sulfate as SO4 2-	14808-79-8	10	mg/kg	90	100	130	110	100
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	0.03	0.03	0.03	0.03	0.02
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	10	mg/kg	70	60	60	80	70
EK040T: Fluoride Total								
Fluoride	16984-48-8	40	mg/kg	160	220	380	170	220

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	C5285 44.43-46.06	C5285 46.09-48.61	C5285 48.61-50.78	C5285 51.63-53.73	C5285 53.73-54.6
			Client sampling date / time	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00
Compound	CAS Number	LOR	Unit	EB1803494-021	EB1803494-022	EB1803494-023	EB1803494-025	EB1803494-026
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	8.9	9.0	9.0	9.0	9.0
pH Value	----	0.1	pH Unit	9.0	9.2	9.2	9.2	9.2
EA009: Nett Acid Production Potential								
Net Acid Production Potential	----	0.5	kg H2SO4/t	-53.6	-57.3	-53.7	-23.1	-47.6
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	438	423	451	403	441
Electrical Conductivity @ 25°C	----	1	µS/cm	325	317	334	289	326
EA013: Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	54.2	57.9	54.3	24.6	48.2
ANC as CaCO3	----	0.1	% CaCO3	5.5	5.9	5.5	2.5	4.9
Fizz Rating	----	0	Fizz Unit	2	2	2	1	2
ED040S : Soluble Sulfate by ICPAES								
Sulfate as SO4 2-	14808-79-8	10	mg/kg	50	50	80	80	50
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	0.02	0.02	0.02	0.05	0.02
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	10	mg/kg	80	80	80	70	80
EK040T: Fluoride Total								
Fluoride	16984-48-8	40	mg/kg	350	190	200	190	220

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	C5285 54.6-57.66	C5285 57.66-59.14	C5285 59.14-60.67	C5285 60.67-61.56	C5285 61.56-63.43
			Client sampling date / time	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00
Compound	CAS Number	LOR	Unit	EB1803494-027	EB1803494-028	EB1803494-029	EB1803494-030	EB1803494-031
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	9.0	8.9	9.0	9.2	9.2
pH Value	----	0.1	pH Unit	9.2	9.1	9.2	9.4	9.3
EA009: Nett Acid Production Potential								
Net Acid Production Potential	----	0.5	kg H2SO4/t	-37.3	-66.3	-26.3	-208	-30.1
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	410	414	401	420	398
Electrical Conductivity @ 25°C	----	1	µS/cm	301	299	287	314	281
EA013: Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	37.9	66.9	26.9	209	30.7
ANC as CaCO3	----	0.1	% CaCO3	3.9	6.8	2.7	21.3	3.1
Fizz Rating	----	0	Fizz Unit	2	2	1	4	1
ED040S : Soluble Sulfate by ICPAES								
Sulfate as SO4 2-	14808-79-8	10	mg/kg	60	90	60	60	90
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	0.02	0.02	0.02	0.02	0.02
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	10	mg/kg	70	70	70	70	80
EK040T: Fluoride Total								
Fluoride	16984-48-8	40	mg/kg	210	420	190	340	270

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	C5285 63.43-64.43	C5285 64.43-66.42	C5285 66.42-67.88	C5285 67.88-69.72	C5285 69.72-72.74
			Client sampling date / time	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00
Compound	*CAS Number*	*LOR*	*Unit*	EB1803494-032	EB1803494-033	EB1803494-034	EB1803494-035	EB1803494-036
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	9.1	9.1	9.2	9.0	9.2
pH Value	----	0.1	pH Unit	9.3	9.3	9.3	9.2	9.4
EA009: Nett Acid Production Potential								
Net Acid Production Potential	----	0.5	kg H2SO4/t	-40.6	-25.7	-28.3	-30.3	-103
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	399	386	438	395	385
Electrical Conductivity @ 25°C	----	1	µS/cm	294	278	310	287	278
EA013: Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	41.2	26.3	28.9	31.2	104
ANC as CaCO3	----	0.1	% CaCO3	4.2	2.7	2.9	3.2	10.6
Fizz Rating	----	0	Fizz Unit	2	1	1	1	2
ED040S : Soluble Sulfate by ICPAES								
Sulfate as SO4 2-	14808-79-8	10	mg/kg	50	50	60	80	60
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	0.02	0.02	0.02	0.03	0.02
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	10	mg/kg	90	80	90	90	80
EK040T: Fluoride Total								
Fluoride	16984-48-8	40	mg/kg	210	180	200	240	200

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	C5285 72.74-75.74	C5285 75.74-77.09	C5285 77.09-78.8	C5285 78.8-80.45	C5285 80.45-83.5
			Client sampling date / time	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00
Compound	CAS Number	LOR	Unit	EB1803494-037	EB1803494-038	EB1803494-039	EB1803494-040	EB1803494-041
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	9.1	9.1	9.1	9.1	9.0
pH Value	----	0.1	pH Unit	9.3	9.3	9.2	9.3	9.3
EA009: Nett Acid Production Potential								
Net Acid Production Potential	----	0.5	kg H2SO4/t	-47.7	-107	-29.2	-62.9	-63.2
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	414	390	434	446	398
Electrical Conductivity @ 25°C	----	1	µS/cm	299	279	307	321	287
EA013: Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	48.3	108	29.8	63.8	63.8
ANC as CaCO3	----	0.1	% CaCO3	4.9	11.0	3.0	6.5	6.5
Fizz Rating	----	0	Fizz Unit	2	2	1	2	2
ED040S : Soluble Sulfate by ICPAES								
Sulfate as SO4 2-	14808-79-8	10	mg/kg	60	90	30	50	60
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	0.02	0.03	0.02	0.03	0.02
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	10	mg/kg	90	60	100	90	80
EK040T: Fluoride Total								
Fluoride	16984-48-8	40	mg/kg	190	150	210	210	180

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	C5285 83.5-84.83	C5285 84.83-87.49	C5285 87.49-88.32	C5285 88.32-90.6	C5285 90.6-92.89
			Client sampling date / time	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00
Compound	CAS Number	LOR	Unit	EB1803494-042	EB1803494-043	EB1803494-044	EB1803494-045	EB1803494-046
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	8.8	9.0	8.9	9.1	8.6
pH Value	----	0.1	pH Unit	9.1	9.2	9.2	9.3	8.9
EA009: Nett Acid Production Potential								
Net Acid Production Potential	----	0.5	kg H2SO4/t	-42.7	-19.8	-30.9	-57.4	-36.3
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	459	399	392	375	444
Electrical Conductivity @ 25°C	----	1	µS/cm	328	290	278	272	309
EA013: Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	44.2	20.4	31.8	58.0	39.1
ANC as CaCO3	----	0.1	% CaCO3	4.5	2.1	3.2	5.9	4.0
Fizz Rating	----	0	Fizz Unit	2	1	1	2	2
ED040S : Soluble Sulfate by ICPAES								
Sulfate as SO4 2-	14808-79-8	10	mg/kg	120	70	70	80	90
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	0.05	0.02	0.03	0.02	0.09
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	10	mg/kg	110	90	90	90	160
EK040T: Fluoride Total								
Fluoride	16984-48-8	40	mg/kg	220	130	190	210	130

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	C5285 92.89-96.35	C5285 96.35-99.06	C5285 99.06-101.42	C5285 101.42-103.89	C5285 103.89-105.76
			Client sampling date / time	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00
Compound	CAS Number	LOR	Unit	EB1803494-047	EB1803494-048	EB1803494-049	EB1803494-050	EB1803494-051
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	9.1	9.2	9.2	9.2	9.1
pH Value	----	0.1	pH Unit	9.4	9.4	9.4	9.4	9.4
EA009: Nett Acid Production Potential								
Net Acid Production Potential	----	0.5	kg H2SO4/t	-165	-105	-6.0	-161	-56.5
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	361	373	401	392	395
Electrical Conductivity @ 25°C	----	1	µS/cm	260	266	289	288	287
EA013: Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	166	106	9.4	162	57.4
ANC as CaCO3	----	0.1	% CaCO3	17.0	10.8	1.0	16.6	5.8
Fizz Rating	----	0	Fizz Unit	3	2	1	3	2
EA026 : Chromium Reducible Sulfur								
Chromium Reducible Sulphur	----	0.005	%	----	----	0.016	----	----
ED040S : Soluble Sulfate by ICPAES								
Sulfate as SO4 2-	14808-79-8	10	mg/kg	70	70	70	60	70
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	0.02	0.02	0.11	0.03	0.03
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	10	mg/kg	100	110	120	90	120
EK040T: Fluoride Total								
Fluoride	16984-48-8	40	mg/kg	160	180	200	210	160

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	C5285 105.76-106.22	----	----	----	----
			Client sampling date / time	05-Feb-2018 00:00	----	----	----	----
Compound	CAS Number	LOR	Unit	EB1803494-052	--------	--------	--------	--------
				Result	----	----	----	----
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	**8.9**	----	----	----	----
pH Value	----	0.1	pH Unit	**9.1**	----	----	----	----
EA009: Nett Acid Production Potential								
Net Acid Production Potential	----	0.5	kg H2SO4/t	**-16.4**	----	----	----	----
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	**539**	----	----	----	----
Electrical Conductivity @ 25°C	----	1	µS/cm	**373**	----	----	----	----
EA013: Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	**35.4**	----	----	----	----
ANC as CaCO3	----	0.1	% CaCO3	**3.6**	----	----	----	----
Fizz Rating	----	0	Fizz Unit	**2**	----	----	----	----
EA026 : Chromium Reducible Sulfur								
Chromium Reducible Sulphur	----	0.005	%	**0.499**	----	----	----	----
ED040S : Soluble Sulfate by ICPAES								
Sulfate as SO4 2-	14808-79-8	10	mg/kg	**280**	----	----	----	----
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	**0.62**	----	----	----	----
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	10	mg/kg	**180**	----	----	----	----
EK040T: Fluoride Total								
Fluoride	16984-48-8	40	mg/kg	**200**	----	----	----	----

CERTIFICATE OF ANALYSIS

Work Order	: **EB1804061**	Page	: 1 of 34
Client	: **RGS ENVIRONMENTAL PTY LTD**	Laboratory	: Environmental Division Brisbane
Contact	: MR ALAN ROBERTSON	Contact	: Customer Services EB
Address	: PO Box 3091 SUNNYBANK SOUTH QLD, AUSTRALIA 4109	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: +61 07 3344 1222	Telephone	: +61-7-3243 7222
Project	: 2017041 - Ensham Project	Date Samples Received	: 05-Feb-2018 15:15
Order number	: ----	Date Analysis Commenced	: 14-Feb-2018
C-O-C number	: ----	Issue Date	: 26-Feb-2018 07:22
Sampler	: ----		
Site	: ----		
Quote number	: BN/035/18 V2		
No. of samples received	: 102		
No. of samples analysed	: 102		

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

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

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

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

Signatories

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

Signatories	*Position*	*Accreditation Category*
Greg Vogel	Laboratory Manager	Brisbane Acid Sulphate Soils, Stafford, QLD
Greg Vogel	Laboratory Manager	Brisbane Inorganics, Stafford, QLD
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

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

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

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

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

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

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

- ED006 (Exchangeable Cations on Alkaline Soils): It is recognised that the Exchangeable Potassium LCS biases low, however this is deemed acceptable as the target concentration is at LOR and the Cation Exchange Capacity LCS is within acceptable limits.
- ED006 (Exchangeable Cations on Alkaline Soils): Magnesium/Potassium ratio could not be determined as both the Magnesium and Potassium results were less than reportable limits for some samples.
- ED006 (Exchangeable Cations on Alkaline Soils): Samples EB1804061-078 (C5285 57.66-59.14) and EB1804061-088 (C5285 75.74-77.09) shows poor duplicate results due to sample heterogeneity. Confirmed by visual inspection.
- ED006 (Exchangeable Cations on Alkaline Soils): Samples EB1803682-031 shows poor duplicate results due to sample heterogeneity. Confirmed by visual inspection.
- Analysis on pulp has been added to work order EB1803494 as this is not yet released. This has been done as per Carsten Emrich.
- ED007 and ED008: When Exchangeable Al is reported from these methods, it should be noted that Rayment & Lyons (2011) suggests Exchange Acidity by 1M KCl - Method 15G1 (ED005) is a more suitable method for the determination of exchange acidity (H+ + Al3+).

Analytical Results

Sub-Matrix: **DI WATER LEACHATE** (Matrix: **WATER**)			Client sample ID	C5285 0-1 <19mm	C5285 1-3.1 <19mm	C5285 3.1-5.06 <19mm	C5285 5.06-6.74 <19mm	C5285 6.74-9.3 <19mm
			Client sampling date / time	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00
Compound	CAS Number	LOR	Unit	EB1804061-001	EB1804061-002	EB1804061-003	EB1804061-004	EB1804061-005
				Result	Result	Result	Result	Result
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	7.55	8.04	8.23	8.38	8.10
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	718	983	1030	635	673
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	<1	10	<1
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	70	91	124	86	88
Total Alkalinity as CaCO3	----	1	mg/L	70	91	124	96	88
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	36	32	14	5	8
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	157	230	238	133	152
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	8	6	5	5	5
Magnesium	7439-95-4	1	mg/L	6	7	7	6	6
Sodium	7440-23-5	1	mg/L	125	180	196	116	121
Potassium	7440-09-7	1	mg/L	2	2	2	2	2

Analytical Results

Sub-Matrix: DI WATER LEACHATE (Matrix: WATER)			Client sample ID	C5285 9.3-11.34 <19mm	C5285 11.34-12.76 <19mm	C5285 12.76-21 <19mm	C5285 21-22.81 <19mm	C5285 22.81-24.5 <19mm
			Client sampling date / time	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00
Compound	CAS Number	LOR	Unit	EB1804061-006	EB1804061-007	EB1804061-008	EB1804061-009	EB1804061-010
				Result	Result	Result	Result	Result
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	8.25	8.24	8.60	8.35	8.60
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	589	539	357	380	385
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	18	4	18
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	110	119	64	71	68
Total Alkalinity as CaCO3	----	1	mg/L	110	119	82	75	86
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	13	18	24	31	38
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	105	80	42	49	40
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	4	2	4	2	<1
Magnesium	7439-95-4	1	mg/L	5	3	3	2	<1
Sodium	7440-23-5	1	mg/L	112	107	65	73	79
Potassium	7440-09-7	1	mg/L	2	2	2	3	2

Analytical Results

Sub-Matrix: DI WATER LEACHATE (Matrix: WATER)			Client sample ID	C5285 24.5-27.54 <19mm	C5285 27.54-30.6 <19mm	C5285 30.6-33.55 <19mm	C5285 33.55-34.13 <19mm	C5285 34.13-36.6 <19mm
			Client sampling date / time	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00
Compound	CAS Number	LOR	Unit	EB1804061-011	EB1804061-012	EB1804061-013	EB1804061-014	EB1804061-015
				Result	Result	Result	Result	Result
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	8.66	9.07	8.56	8.86	9.20
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	323	370	347	368	389
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	19	34	16	22	41
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	74	77	86	66	84
Total Alkalinity as CaCO3	----	1	mg/L	93	112	102	88	126
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	30	31	32	66	26
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	26	26	25	23	27
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	<1	<1	<1	<1	<1
Magnesium	7439-95-4	1	mg/L	<1	<1	<1	<1	<1
Sodium	7440-23-5	1	mg/L	70	82	77	76	85
Potassium	7440-09-7	1	mg/L	2	2	2	2	2

Analytical Results

Sub-Matrix: DI WATER LEACHATE (Matrix: WATER)			Client sample ID	C5285 36.6-37.95 <19mm	C5285 37.95-39.55 <19mm	C5285 39.55-42.21 <19mm	C5285 42.21-42.56 <19mm	C5285 42.56-44.43 <19mm
			Client sampling date / time	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00
Compound	CAS Number	LOR	Unit	EB1804061-016	EB1804061-017	EB1804061-018	EB1804061-019	EB1804061-020
				Result	Result	Result	Result	Result
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	**9.41**	**9.26**	**9.36**	**9.27**	**9.32**
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	**366**	**412**	**422**	**412**	**368**
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	**58**	**47**	**57**	**46**	**43**
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	**70**	**92**	**82**	**79**	**72**
Total Alkalinity as CaCO3	----	1	mg/L	**128**	**139**	**138**	**125**	**115**
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	**17**	**27**	**27**	**30**	**26**
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	**24**	**24**	**27**	**30**	**27**
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	<1	<1	<1	<1	<1
Magnesium	7439-95-4	1	mg/L	<1	<1	<1	<1	<1
Sodium	7440-23-5	1	mg/L	**80**	**92**	**93**	**89**	**80**
Potassium	7440-09-7	1	mg/L	**2**	**2**	**3**	**2**	**2**

Analytical Results

Sub-Matrix: DI WATER LEACHATE (Matrix: WATER)			Client sample ID	C5285 44.43-46.06 <19mm	C5285 46.09-48.61 <19mm	C5285 48.61-50.78 <19mm	C5285 51.63-53.73 <19mm	C5285 53.73-54.6 <19mm
			Client sampling date / time	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00
Compound	CAS Number	LOR	Unit	EB1804061-021	EB1804061-022	EB1804061-023	EB1804061-024	EB1804061-025
				Result	Result	Result	Result	Result
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	9.47	9.43	9.29	9.15	9.24
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	377	403	412	408	424
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	62	63	54	43	50
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	73	77	88	103	104
Total Alkalinity as CaCO3	----	1	mg/L	134	140	143	146	155
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	12	14	21	20	13
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	27	31	28	25	29
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	<1	<1	<1	<1	<1
Magnesium	7439-95-4	1	mg/L	<1	<1	<1	<1	<1
Sodium	7440-23-5	1	mg/L	83	90	91	93	93
Potassium	7440-09-7	1	mg/L	2	2	2	3	3

Analytical Results

Sub-Matrix: DI WATER LEACHATE (Matrix: WATER)			Client sample ID	C5285 54.6-57.66 <19mm	C5285 57.66-59.14 <19mm	C5285 59.14-60.67 <19mm	C5285 60.67-61.56 <19mm	C5285 61.56-63.43 <19mm
			Client sampling date / time	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00
Compound	CAS Number	LOR	Unit	EB1804061-026	EB1804061-027	EB1804061-028	EB1804061-029	EB1804061-030
				Result	Result	Result	Result	Result
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	9.09	9.03	9.02	9.30	9.13
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	429	310	334	378	370
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	38	92	33	52	37
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	103	38	83	86	80
Total Alkalinity as CaCO3	----	1	mg/L	141	130	116	139	117
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	18	12	13	12	18
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	35	21	24	24	31
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	<1	1	<1	<1	<1
Magnesium	7439-95-4	1	mg/L	<1	<1	<1	<1	<1
Sodium	7440-23-5	1	mg/L	94	68	75	84	81
Potassium	7440-09-7	1	mg/L	3	2	2	2	2

Analytical Results

Sub-Matrix: DI WATER LEACHATE (Matrix: WATER)			Client sample ID	C5285 63.43-64.43 <19mm	C5285 64.43-66.42 <19mm	C5285 66.42-67.88 <19mm	C5285 67.88-69.72 <19mm	C5285 69.72-72.74 <19mm
			Client sampling date / time	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00
Compound	CAS Number	LOR	Unit	EB1804061-031	EB1804061-032	EB1804061-033	EB1804061-034	EB1804061-035
				Result	Result	Result	Result	Result
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	9.16	9.08	9.20	9.42	9.28
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	378	380	383	304	365
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	37	33	41	46	47
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	90	88	86	57	84
Total Alkalinity as CaCO3	----	1	mg/L	127	122	127	104	131
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	10	12	16	10	9
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	33	35	31	24	27
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	<1	<1	<1	<1	<1
Magnesium	7439-95-4	1	mg/L	<1	<1	<1	<1	<1
Sodium	7440-23-5	1	mg/L	83	82	84	66	82
Potassium	7440-09-7	1	mg/L	2	2	2	2	2

Analytical Results

Sub-Matrix: DI WATER LEACHATE (Matrix: WATER)			Client sample ID	C5285 72.74-75.74 <19mm	C5285 75.74-77.09 <19mm	C5285 77.09-78.8 <19mm	C5285 78.8-80.45 <19mm	C5285 80.45-83.5 <19mm
			Client sampling date / time	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00
Compound	CAS Number	LOR	Unit	EB1804061-036	EB1804061-037	EB1804061-038	EB1804061-039	EB1804061-040
				Result	Result	Result	Result	Result
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	9.12	9.21	9.05	9.19	9.19
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	370	362	364	408	396
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	36	42	32	42	45
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	95	87	95	100	92
Total Alkalinity as CaCO3	----	1	mg/L	131	129	127	142	138
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	9	14	6	11	13
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	30	24	32	34	30
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	<1	1	<1	<1	1
Magnesium	7439-95-4	1	mg/L	<1	<1	<1	<1	<1
Sodium	7440-23-5	1	mg/L	81	78	81	90	87
Potassium	7440-09-7	1	mg/L	2	2	2	2	2

Analytical Results

Sub-Matrix: DI WATER LEACHATE (Matrix: WATER)			Client sample ID	C5285 83.5-84.83 <19mm	C5285 84.83-87.49 <19mm	C5285 87.49-88.32 <19mm	C5285 88.32-90.6 <19mm	C5285 90.6-92.89 <19mm
			Client sampling date / time	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00
Compound	CAS Number	LOR	Unit	EB1804061-041	EB1804061-042	EB1804061-043	EB1804061-044	EB1804061-045
				Result	Result	Result	Result	Result
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	9.00	9.35	9.17	8.75	8.75
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	417	319	348	358	354
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	29	40	36	20	18
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	91	60	82	99	69
Total Alkalinity as CaCO3	----	1	mg/L	121	100	118	119	86
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	26	11	10	12	14
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	36	30	32	30	46
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	<1	<1	<1	<1	1
Magnesium	7439-95-4	1	mg/L	<1	<1	<1	<1	<1
Sodium	7440-23-5	1	mg/L	89	62	76	79	73
Potassium	7440-09-7	1	mg/L	2	1	2	2	2

Analytical Results

Sub-Matrix: DI WATER LEACHATE (Matrix: WATER)			Client sample ID	C5285 92.89-96.35 <19mm	C5285 96.35-99.06 <19mm	C5285 99.06-101.42 <19mm	C5285 101.42-103.89 <19mm	C5285 103.89-105.76 <19mm
			Client sampling date / time	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00
Compound	CAS Number	LOR	Unit	EB1804061-046	EB1804061-047	EB1804061-048	EB1804061-049	EB1804061-050
				Result	Result	Result	Result	Result
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	9.10	9.11	8.75	9.05	8.98
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	372	384	354	378	403
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	33	35	19	35	31
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	82	84	76	98	100
Total Alkalinity as CaCO3	----	1	mg/L	115	119	95	133	131
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	12	15	12	9	12
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	35	37	42	30	36
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	1	1	<1	1	1
Magnesium	7439-95-4	1	mg/L	<1	<1	<1	<1	<1
Sodium	7440-23-5	1	mg/L	78	80	76	82	87
Potassium	7440-09-7	1	mg/L	2	2	2	2	2

Analytical Results

Sub-Matrix: DI WATER LEACHATE (Matrix: WATER)			Client sample ID	C5285 105.76-106.22 <19mm	----	----	----	----
			Client sampling date / time	05-Feb-2018 00:00	----	----	----	----
Compound	CAS Number	LOR	Unit	EB1804061-051	--------	--------	--------	--------
				Result	----	----	----	----
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	8.31	----	----	----	----
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	668	----	----	----	----
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	----	----	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	4	----	----	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	94	----	----	----	----
Total Alkalinity as CaCO3	----	1	mg/L	97	----	----	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	110	----	----	----	----
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	72	----	----	----	----
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	4	----	----	----	----
Magnesium	7439-95-4	1	mg/L	2	----	----	----	----
Sodium	7440-23-5	1	mg/L	131	----	----	----	----
Potassium	7440-09-7	1	mg/L	4	----	----	----	----

Analytical Results

Sub-Matrix: SOIL
(Matrix: SOIL)

			Client sample ID	C5285 0-1 <19mm	C5285 1-3.1 <19mm	C5285 3.1-5.06 <19mm	C5285 5.06-6.74 <19mm	C5285 6.74-9.3 <19mm
			Client sampling date / time	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00
Compound	CAS Number	LOR	Unit	EB1804061-001	EB1804061-002	EB1804061-003	EB1804061-004	EB1804061-005
				Result	Result	Result	Result	Result
Sample Preparation Method								
Amount	----	0.1	g	1.0	1.0	1.0	1.0	1.0

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	C5285 9.3-11.34 <19mm	C5285 11.34-12.76 <19mm	C5285 12.76-21 <19mm	C5285 21-22.81 <19mm	C5285 22.81-24.5 <19mm
			Client sampling date / time	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00
Compound	CAS Number	LOR	Unit	EB1804061-006	EB1804061-007	EB1804061-008	EB1804061-009	EB1804061-010
				Result	Result	Result	Result	Result
Sample Preparation Method								
Amount	----	0.1	g	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	C5285 24.5-27.54 <19mm	C5285 27.54-30.6 <19mm	C5285 30.6-33.55 <19mm	C5285 33.55-34.13 <19mm	C5285 34.13-36.6 <19mm
			Client sampling date / time	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00
Compound	CAS Number	LOR	Unit	EB1804061-011	EB1804061-012	EB1804061-013	EB1804061-014	EB1804061-015
				Result	Result	Result	Result	Result
Sample Preparation Method								
Amount	----	0.1	g	1.0	1.0	1.0	1.0	1.0

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	C5285 36.6-37.95 <19mm	C5285 37.95-39.55 <19mm	C5285 39.55-42.21 <19mm	C5285 42.21-42.56 <19mm	C5285 42.56-44.43 <19mm
			Client sampling date / time	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00
Compound	CAS Number	LOR	Unit	EB1804061-016	EB1804061-017	EB1804061-018	EB1804061-019	EB1804061-020
				Result	Result	Result	Result	Result
Sample Preparation Method								
Amount	----	0.1	g	1.0	1.0	1.0	1.0	1.0

Analytical Results

Sub-Matrix: **SOIL**
(Matrix: **SOIL**)

			Client sample ID	C5285 44.43-46.06 <19mm	C5285 46.09-48.61 <19mm	C5285 48.61-50.78 <19mm	C5285 51.63-53.73 <19mm	C5285 53.73-54.6 <19mm
			Client sampling date / time	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00
Compound	CAS Number	LOR	Unit	EB1804061-021	EB1804061-022	EB1804061-023	EB1804061-024	EB1804061-025
				Result	Result	Result	Result	Result
Sample Preparation Method								
Amount	----	0.1	g	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	C5285 54.6-57.66 <19mm	C5285 57.66-59.14 <19mm	C5285 59.14-60.67 <19mm	C5285 60.67-61.56 <19mm	C5285 61.56-63.43 <19mm
			Client sampling date / time	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00
Compound	CAS Number	LOR	Unit	EB1804061-026	EB1804061-027	EB1804061-028	EB1804061-029	EB1804061-030
				Result	Result	Result	Result	Result
Sample Preparation Method								
Amount	----	0.1	g	1.0	1.0	1.0	1.0	1.0

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	C5285 63.43-64.43 <19mm	C5285 64.43-66.42 <19mm	C5285 66.42-67.88 <19mm	C5285 67.88-69.72 <19mm	C5285 69.72-72.74 <19mm
			Client sampling date / time	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00
Compound	CAS Number	LOR	Unit	EB1804061-031	EB1804061-032	EB1804061-033	EB1804061-034	EB1804061-035
				Result	Result	Result	Result	Result
Sample Preparation Method								
Amount	----	0.1	g	1.0	1.0	1.0	1.0	1.0

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	C5285 72.74-75.74 <19mm	C5285 75.74-77.09 <19mm	C5285 77.09-78.8 <19mm	C5285 78.8-80.45 <19mm	C5285 80.45-83.5 <19mm
			Client sampling date / time	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00
Compound	CAS Number	LOR	Unit	EB1804061-036	EB1804061-037	EB1804061-038	EB1804061-039	EB1804061-040
				Result	Result	Result	Result	Result
Sample Preparation Method								
Amount	----	0.1	g	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	C5285 83.5-84.83 <19mm	C5285 84.83-87.49 <19mm	C5285 87.49-88.32 <19mm	C5285 88.32-90.6 <19mm	C5285 90.6-92.89 <19mm
			Client sampling date / time	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00
Compound	CAS Number	LOR	Unit	EB1804061-041	EB1804061-042	EB1804061-043	EB1804061-044	EB1804061-045
				Result	Result	Result	Result	Result
Sample Preparation Method								
Amount	----	0.1	g	1.0	1.0	1.0	1.0	1.0

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	C5285 92.89-96.35 <19mm	C5285 96.35-99.06 <19mm	C5285 99.06-101.42 <19mm	C5285 101.42-103.89 <19mm	C5285 103.89-105.76 <19mm
			Client sampling date / time	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00
Compound	CAS Number	LOR	Unit	EB1804061-046	EB1804061-047	EB1804061-048	EB1804061-049	EB1804061-050
				Result	Result	Result	Result	Result
Sample Preparation Method								
Amount	----	0.1	g	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	C5285 105.76-106.22 <19mm	C5285 0-1 <2.36mm	C5285 1-3.1 <2.36mm	C5285 3.1-5.06 <2.36mm	C5285 5.06-6.74 <2.36mm
			Client sampling date / time	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00
Compound	CAS Number	LOR	Unit	EB1804061-051	EB1804061-052	EB1804061-053	EB1804061-054	EB1804061-055
				Result	Result	Result	Result	Result
ED006: Exchangeable Cations on Alkaline Soils								
Exchangeable Calcium	----	0.2	meq/100g	----	3.1	3.0	1.6	0.8
Exchangeable Magnesium	----	0.2	meq/100g	----	2.7	4.2	2.5	1.2
Exchangeable Potassium	----	0.2	meq/100g	----	<0.2	<0.2	<0.2	<0.2
Exchangeable Sodium	----	0.2	meq/100g	----	0.8	1.4	1.0	0.4
Cation Exchange Capacity	----	0.2	meq/100g	----	6.6	8.6	5.1	2.4
Exchangeable Sodium Percent	----	0.2	%	----	12.2	16.9	19.5	16.8
Calcium/Magnesium Ratio	----	0.2	-	----	1.1	0.7	0.6	0.7
Sample Preparation Method								
Amount	----	0.1	g	1.0	----	----	----	----

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	C5285 6.74-9.3 <2.36mm	C5285 9.3-11.34 <2.36mm	C5285 11.34-12.76 <2.36mm	C5285 12.76-21 <2.36mm	C5285 21-22.81 <2.36mm
			Client sampling date / time	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00
Compound	CAS Number	LOR	Unit	EB1804061-056	EB1804061-057	EB1804061-058	EB1804061-059	EB1804061-060
				Result	Result	Result	Result	Result
ED006: Exchangeable Cations on Alkaline Soils								
Exchangeable Calcium	----	0.2	meq/100g	**2.2**	**1.4**	**1.9**	**0.8**	**0.5**
Exchangeable Magnesium	----	0.2	meq/100g	**3.8**	**2.2**	**3.1**	**1.0**	**0.7**
Exchangeable Potassium	----	0.2	meq/100g	<0.2	<0.2	<0.2	<0.2	<0.2
Exchangeable Sodium	----	0.2	meq/100g	**0.8**	**0.6**	**0.8**	**0.3**	**0.2**
Cation Exchange Capacity	----	0.2	meq/100g	**6.8**	**4.1**	**5.8**	**2.1**	**1.5**
Exchangeable Sodium Percent	----	0.2	%	**12.0**	**13.5**	**13.9**	**13.3**	**16.1**
Calcium/Magnesium Ratio	----	0.2	-	**0.6**	**0.6**	**0.6**	**0.8**	**0.7**

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	C5285 22.81-24.5 <2.36mm	C5285 24.5-27.54 <2.36mm	C5285 27.54-30.6 <2.36mm	C5285 30.6-33.55 <2.36mm	C5285 33.55-34.13 <2.36mm
			Client sampling date / time	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00
Compound	CAS Number	LOR	Unit	EB1804061-061	EB1804061-062	EB1804061-063	EB1804061-064	EB1804061-065
				Result	Result	Result	Result	Result
ED006: Exchangeable Cations on Alkaline Soils								
Exchangeable Calcium	----	0.2	meq/100g	1.9	1.0	1.2	1.9	2.5
Exchangeable Magnesium	----	0.2	meq/100g	3.1	1.6	1.6	2.5	3.2
Exchangeable Potassium	----	0.2	meq/100g	<0.2	<0.2	<0.2	<0.2	0.2
Exchangeable Sodium	----	0.2	meq/100g	1.1	0.6	0.8	1.3	1.9
Cation Exchange Capacity	----	0.2	meq/100g	6.3	3.2	3.5	5.9	7.8
Exchangeable Sodium Percent	----	0.2	%	17.7	19.8	22.6	22.7	24.1
Calcium/Magnesium Ratio	----	0.2	-	0.6	0.6	0.7	0.8	0.8
Magnesium/Potassium Ratio	----	0.2	-	----	----	----	----	12.2

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	C5285 34.13-36.6 <2.36mm	C5285 36.6-37.95 <2.36mm	C5285 37.95-39.55 <2.36mm	C5285 39.55-42.21 <2.36mm	C5285 42.21-42.56 <2.36mm
			Client sampling date / time	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00
Compound	CAS Number	LOR	Unit	EB1804061-066	EB1804061-067	EB1804061-068	EB1804061-069	EB1804061-070
				Result	Result	Result	Result	Result
ED006: Exchangeable Cations on Alkaline Soils								
Exchangeable Calcium	----	0.2	meq/100g	1.9	1.0	1.5	1.2	1.2
Exchangeable Magnesium	----	0.2	meq/100g	2.3	1.2	1.6	1.2	1.2
Exchangeable Potassium	----	0.2	meq/100g	0.2	<0.2	0.2	<0.2	<0.2
Exchangeable Sodium	----	0.2	meq/100g	1.4	0.8	1.2	0.9	1.0
Cation Exchange Capacity	----	0.2	meq/100g	6.0	3.0	4.6	3.4	3.4
Exchangeable Sodium Percent	----	0.2	%	24.3	25.2	25.5	27.5	28.3
Calcium/Magnesium Ratio	----	0.2	-	0.8	0.9	0.9	1.0	1.0
Magnesium/Potassium Ratio	----	0.2	-	10.8	----	7.4	----	----

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	C5285 42.56-44.43 <2.36mm	C5285 44.43-46.06 <2.36mm	C5285 46.09-48.61 <2.36mm	C5285 48.61-50.78 <2.36mm	C5285 51.63-53.73 <2.36mm
			Client sampling date / time	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00
Compound	CAS Number	LOR	Unit	EB1804061-071	EB1804061-072	EB1804061-073	EB1804061-074	EB1804061-075
				Result	Result	Result	Result	Result
ED006: Exchangeable Cations on Alkaline Soils								
Exchangeable Calcium	----	0.2	meq/100g	**1.6**	**1.2**	**1.0**	**1.4**	**1.4**
Exchangeable Magnesium	----	0.2	meq/100g	**1.6**	**1.1**	**1.0**	**1.1**	**1.2**
Exchangeable Potassium	----	0.2	meq/100g	<0.2	<0.2	<0.2	<0.2	<0.2
Exchangeable Sodium	----	0.2	meq/100g	**1.2**	**1.0**	**0.8**	**1.0**	**1.1**
Cation Exchange Capacity	----	0.2	meq/100g	**4.6**	**3.5**	**2.7**	**3.7**	**3.8**
Exchangeable Sodium Percent	----	0.2	%	**27.1**	**27.8**	**28.2**	**28.4**	**28.2**
Calcium/Magnesium Ratio	----	0.2	-	**1.0**	**1.1**	**1.0**	**1.2**	**1.2**

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	C5285 53.73-54.6 <2.36mm	C5285 54.6-57.66 <2.36mm	C5285 57.66-59.14 <2.36mm	C5285 59.14-60.67 <2.36mm	C5285 60.67-61.56 <2.36mm
			Client sampling date / time	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00
Compound	CAS Number	LOR	Unit	EB1804061-076	EB1804061-077	EB1804061-078	EB1804061-079	EB1804061-080
				Result	Result	Result	Result	Result
ED006: Exchangeable Cations on Alkaline Soils								
Exchangeable Calcium	----	0.2	meq/100g	1.3	1.6	2.1	0.7	0.9
Exchangeable Magnesium	----	0.2	meq/100g	1.1	1.3	1.8	0.6	0.7
Exchangeable Potassium	----	0.2	meq/100g	<0.2	<0.2	0.2	<0.2	<0.2
Exchangeable Sodium	----	0.2	meq/100g	1.0	1.1	1.6	0.5	0.6
Cation Exchange Capacity	----	0.2	meq/100g	3.6	4.1	5.7	1.8	2.2
Exchangeable Sodium Percent	----	0.2	%	28.8	26.9	27.4	29.4	28.7
Calcium/Magnesium Ratio	----	0.2	-	1.1	1.2	1.2	1.2	1.3
Magnesium/Potassium Ratio	----	0.2	-	----	----	8.4	----	----

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	C5285 61.56-63.43 <2.36mm	C5285 63.43-64.43 <2.36mm	C5285 64.43-66.42 <2.36mm	C5285 66.42-67.88 <2.36mm	C5285 67.88-69.72 <2.36mm
			Client sampling date / time	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00
Compound	CAS Number	LOR	Unit	EB1804061-081	EB1804061-082	EB1804061-083	EB1804061-084	EB1804061-085
				Result	Result	Result	Result	Result
ED006: Exchangeable Cations on Alkaline Soils								
Exchangeable Calcium	----	0.2	meq/100g	1.1	1.5	0.8	1.6	1.0
Exchangeable Magnesium	----	0.2	meq/100g	0.9	1.1	0.6	1.2	0.8
Exchangeable Potassium	----	0.2	meq/100g	<0.2	<0.2	<0.2	<0.2	<0.2
Exchangeable Sodium	----	0.2	meq/100g	0.8	1.1	0.6	1.2	0.7
Cation Exchange Capacity	----	0.2	meq/100g	2.8	3.9	2.1	4.2	2.4
Exchangeable Sodium Percent	----	0.2	%	28.8	28.2	30.2	28.4	28.3
Calcium/Magnesium Ratio	----	0.2	-	1.2	1.3	1.4	1.3	1.2

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	C5285 69.72-72.74 <2.36mm	C5285 72.74-75.74 <2.36mm	C5285 75.74-77.09 <2.36mm	C5285 77.09-78.8 <2.36mm	C5285 78.8-80.45 <2.36mm
			Client sampling date / time	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00
Compound	CAS Number	LOR	Unit	EB1804061-086	EB1804061-087	EB1804061-088	EB1804061-089	EB1804061-090
				Result	Result	Result	Result	Result
ED006: Exchangeable Cations on Alkaline Soils								
Exchangeable Calcium	----	0.2	meq/100g	**0.6**	**1.0**	**1.3**	**1.5**	**2.5**
Exchangeable Magnesium	----	0.2	meq/100g	**0.5**	**0.8**	**1.1**	**1.1**	**1.8**
Exchangeable Potassium	----	0.2	meq/100g	<0.2	<0.2	<0.2	<0.2	**0.3**
Exchangeable Sodium	----	0.2	meq/100g	**0.4**	**0.7**	**0.8**	**1.0**	**1.7**
Cation Exchange Capacity	----	0.2	meq/100g	**1.6**	**2.6**	**3.3**	**3.8**	**6.4**
Exchangeable Sodium Percent	----	0.2	%	**26.4**	**27.0**	**25.7**	**27.5**	**26.8**
Calcium/Magnesium Ratio	----	0.2	-	**1.2**	**1.2**	**1.2**	**1.3**	**1.4**
Magnesium/Potassium Ratio	----	0.2	-	----	----	----	----	**6.6**

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	C5285 80.45-83.5 <2.36mm	C5285 83.5-84.83 <2.36mm	C5285 84.83-87.49 <2.36mm	C5285 87.49-88.32 <2.36mm	C5285 88.32-90.6 <2.36mm
			Client sampling date / time	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00
Compound	CAS Number	LOR	Unit	EB1804061-091	EB1804061-092	EB1804061-093	EB1804061-094	EB1804061-095
				Result	Result	Result	Result	Result
ED006: Exchangeable Cations on Alkaline Soils								
Exchangeable Calcium	----	0.2	meq/100g	**0.8**	**2.2**	**0.9**	**1.0**	**0.9**
Exchangeable Magnesium	----	0.2	meq/100g	**0.6**	**1.7**	**0.7**	**0.7**	**0.6**
Exchangeable Potassium	----	0.2	meq/100g	<0.2	<0.2	<0.2	<0.2	<0.2
Exchangeable Sodium	----	0.2	meq/100g	**0.5**	**1.3**	**0.6**	**0.7**	**0.6**
Cation Exchange Capacity	----	0.2	meq/100g	**1.8**	**5.4**	**2.2**	**2.4**	**2.1**
Exchangeable Sodium Percent	----	0.2	%	**26.7**	**24.5**	**27.0**	**27.2**	**26.4**
Calcium/Magnesium Ratio	----	0.2	-	**1.3**	**1.3**	**1.4**	**1.4**	**1.4**

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	C5285 90.6-92.89 <2.36mm	C5285 92.89-96.35 <2.36mm	C5285 96.35-99.06 <2.36mm	C5285 99.06-101.42 <2.36mm	C5285 101.42-103.89 <2.36mm
			Client sampling date / time	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00	05-Feb-2018 00:00
Compound	*CAS Number*	*LOR*	*Unit*	EB1804061-096	EB1804061-097	EB1804061-098	EB1804061-099	EB1804061-100
				Result	Result	Result	Result	Result
ED006: Exchangeable Cations on Alkaline Soils								
Exchangeable Calcium	----	0.2	meq/100g	**1.0**	**1.0**	**1.0**	**1.6**	**1.1**
Exchangeable Magnesium	----	0.2	meq/100g	**0.7**	**0.8**	**0.9**	**1.1**	**0.8**
Exchangeable Potassium	----	0.2	meq/100g	<0.2	<0.2	<0.2	<0.2	<0.2
Exchangeable Sodium	----	0.2	meq/100g	**0.6**	**0.5**	**0.6**	**1.0**	**0.6**
Cation Exchange Capacity	----	0.2	meq/100g	**2.4**	**2.4**	**2.5**	**3.7**	**2.6**
Exchangeable Sodium Percent	----	0.2	%	**25.6**	**22.6**	**23.4**	**25.7**	**24.2**
Calcium/Magnesium Ratio	----	0.2	-	**1.4**	**1.3**	**1.2**	**1.4**	**1.3**

Analytical Results

Sub-Matrix: **SOIL**
(Matrix: **SOIL**)

			Client sample ID	C5285 103.89-105.76 <2.36mm	C5285 105.76-106.22 <2.36mm	----	----	----
			Client sampling date / time	05-Feb-2018 00:00	05-Feb-2018 00:00	----	----	----
Compound	CAS Number	LOR	Unit	EB1804061-101	EB1804061-102	--------	--------	--------
				Result	Result	----	----	----
ED006: Exchangeable Cations on Alkaline Soils								
Exchangeable Calcium	----	0.2	meq/100g	**1.1**	**1.5**	----	----	----
Exchangeable Magnesium	----	0.2	meq/100g	**0.8**	**1.0**	----	----	----
Exchangeable Potassium	----	0.2	meq/100g	<0.2	<0.2	----	----	----
Exchangeable Sodium	----	0.2	meq/100g	**0.7**	**0.8**	----	----	----
Cation Exchange Capacity	----	0.2	meq/100g	**2.6**	**3.3**	----	----	----
Exchangeable Sodium Percent	----	0.2	%	**26.5**	**25.1**	----	----	----
Calcium/Magnesium Ratio	----	0.2	-	**1.3**	**1.6**	----	----	----

A.3.2 Appendix 3ii C5286 ALS results

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **EB1804203**	Page	: 1 of 21
Client	: **RGS ENVIRONMENTAL PTY LTD**	Laboratory	: Environmental Division Brisbane
Contact	: MR GREG MADDOCKS	Contact	: Customer Services EB
Address	: PO Box 3091 SUNNYBANK SOUTH QLD, AUSTRALIA 4109	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: +61 07 3344 1222	Telephone	: +61-7-3243 7222
Project	: 2017041 - Ensham Project	Date Samples Received	: 14-Feb-2018 16:20
Order number	: ----	Date Analysis Commenced	: 20-Feb-2018
C-O-C number	: ----	Issue Date	: 16-Mar-2018 13:10
Sampler	: ----		
Site	: ----		
Quote number	: BN/035/18 V2		
No. of samples received	: 43		
No. of samples analysed	: 43		

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

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

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

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

Signatories

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

Signatories	*Position*	*Accreditation Category*
Andrew Epps	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Ben Felgendrejeris	Senior Acid Sulfate Soil Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Kim McCabe	Senior Inorganic Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Satishkumar Trivedi	Senior Acid Sulfate Soil Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Tom Maloney	Nutrients Section Supervisor	Brisbane Inorganics, Stafford, QLD

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

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

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

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

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

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

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

- ED006 (Exchangeable Cations on Alkaline Soils): Sample EB1804203-021 shows poor duplicate results due to sample heterogeneity. Confirmed by visual inspection.
- ED008(Exchangeable Cations with pre-treatment): Unable to calculate Magnesium/Potassium Ratio for samples EB1804203-006 as the required results for Magnesium/Potassium are below LOR.
- ED006 (Exchangeable Cations on Alkaline Soils): It is recognised that the Exchangeable K LCS biases low, however this is deemed acceptable as the target concentration is at LOR and the Cation Exchange Capacity LCS is within acceptable limits.
- ED006 (Exchangeable Cations on Alkaline Soils): Magnesium/Potassium ratio could not be determined as both the Magnesium and Potassium results were less than reportable limits for some samples.
- ED006 (Exchangeable Cations on Alkaline Soils): Samples EB1804203-031 (66.67-69.71) and EB1804203-041 (88.86-89.53) shows poor duplicate results due to sample heterogeneity. Confirmed by visual inspection.
- ASS: EA013 (ANC) Fizz Rating: 0- None; 1- Slight; 2- Moderate; 3- Strong; 4- Very Strong; 5- Lime.
- ED007 and ED008: When Exchangeable Al is reported from these methods, it should be noted that Rayment & Lyons (2011) suggests Exchange Acidity by 1M KCl - Method 15G1 (ED005) is a more suitable method for the determination of exchange acidity (H+ + Al3+).

Analytical Results

Sub-Matrix: LEACHATE (Matrix: WATER)			Client sample ID	C5286 0.00-0.57	C5286 0.57-1.36	C5286 1.36-3.05	C5286 3.05-5.44	C5286 5.44-9.04
			Client sampling date / time	14-Feb-2018 00:00	14-Feb-2018 00:00	14-Feb-2018 00:00	14-Feb-2018 00:00	14-Feb-2018 00:00
Compound	CAS Number	LOR	Unit	EB1804203-001	EB1804203-002	EB1804203-003	EB1804203-004	EB1804203-005
				Result	Result	Result	Result	Result
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	**26**	**7**	**31**	**27**	**26**
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	**86**	**25**	**90**	**121**	**118**
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	**6**	<1	<1	<1	<1
Magnesium	7439-95-4	1	mg/L	**6**	<1	<1	<1	**7**
Sodium	7440-23-5	1	mg/L	**58**	**24**	**68**	**83**	**69**
Potassium	7440-09-7	1	mg/L	**4**	**1**	**4**	**5**	**3**
EG005C: Leachable Metals by ICPAES								
Boron	7440-42-8	0.1	mg/L	**0.4**	**0.2**	**0.5**	**0.4**	**0.3**
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	**0.3**	**0.2**	**0.3**	**0.3**	**0.2**

Analytical Results

Sub-Matrix: LEACHATE (Matrix: WATER)			Client sample ID	C5286 9.04-12.04	C5286 12.04-15.10	C5286 15.10-17.87	C5286 17.87-20.95	C5286 20.95-23.77
			Client sampling date / time	14-Feb-2018 00:00	14-Feb-2018 00:00	14-Feb-2018 00:00	14-Feb-2018 00:00	14-Feb-2018 00:00
Compound	*CAS Number*	*LOR*	*Unit*	EB1804203-006	EB1804203-007	EB1804203-008	EB1804203-009	EB1804203-010
				Result	Result	Result	Result	Result
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	101	104	128	89	52
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	463	407	423	355	320
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	4	3	4	3	2
Magnesium	7439-95-4	1	mg/L	25	17	21	13	9
Sodium	7440-23-5	1	mg/L	253	235	256	219	188
Potassium	7440-09-7	1	mg/L	18	16	17	13	10
EG005C: Leachable Metals by ICPAES								
Boron	7440-42-8	0.1	mg/L	0.6	0.8	0.8	0.6	0.7
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	0.2	0.3	0.5	2.1	1.1

Analytical Results

Sub-Matrix: LEACHATE (Matrix: WATER)			Client sample ID	C5286 23.77-26.49	C5286 26.49-30.08	C5286 30.08-32.84	C5286 32.84-34.20	C5286 34.20-37.39
			Client sampling date / time	14-Feb-2018 00:00	14-Feb-2018 00:00	14-Feb-2018 00:00	14-Feb-2018 00:00	14-Feb-2018 00:00
Compound	CAS Number	LOR	Unit	EB1804203-011	EB1804203-012	EB1804203-013	EB1804203-014	EB1804203-015
				Result	Result	Result	Result	Result
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	**48**	**78**	**81**	**77**	**47**
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	**240**	**248**	**183**	**149**	**99**
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	**2**	**2**	**3**	**2**	**1**
Magnesium	7439-95-4	1	mg/L	**5**	**6**	**7**	**6**	**2**
Sodium	7440-23-5	1	mg/L	**158**	**171**	**185**	**143**	**120**
Potassium	7440-09-7	1	mg/L	**5**	**8**	**13**	**8**	**7**
EG005C: Leachable Metals by ICPAES								
Boron	7440-42-8	0.1	mg/L	**0.6**	**0.6**	**0.6**	**0.4**	**0.4**
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	**1.6**	**2.1**	**3.1**	**2.1**	**1.1**

Analytical Results

Sub-Matrix: LEACHATE (Matrix: WATER)			Client sample ID	C5286 37.39-39.82	C5286 39.82-42.19	C5286 42.19-44.67	C5286 44.67-47.53	C5286 47.53-48.91
			Client sampling date / time	14-Feb-2018 00:00	14-Feb-2018 00:00	14-Feb-2018 00:00	14-Feb-2018 00:00	14-Feb-2018 00:00
Compound	CAS Number	LOR	Unit	EB1804203-016	EB1804203-017	EB1804203-018	EB1804203-019	EB1804203-020
				Result	Result	Result	Result	Result
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	**38**	**39**	**31**	**19**	**33**
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	**69**	**91**	**70**	**55**	**70**
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	**2**	**1**	**1**	<1	<1
Magnesium	7439-95-4	1	mg/L	**4**	**2**	**1**	<1	**1**
Sodium	7440-23-5	1	mg/L	**119**	**124**	**109**	**91**	**115**
Potassium	7440-09-7	1	mg/L	**8**	**6**	**5**	**3**	**4**
EG005C: Leachable Metals by ICPAES								
Boron	7440-42-8	0.1	mg/L	**0.4**	**0.5**	**0.5**	**0.5**	**0.5**
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	**0.7**	**0.9**	**0.7**	**0.5**	**0.4**

Analytical Results

Sub-Matrix: LEACHATE (Matrix: WATER)			Client sample ID	C5286 48.91-51.48	C5286 51.48-54.50	C5286 54.50-56.55	C5286 56.55-58.05	C5286 58.05-59.69
			Client sampling date / time	14-Feb-2018 00:00	14-Feb-2018 00:00	14-Feb-2018 00:00	14-Feb-2018 00:00	14-Feb-2018 00:00
Compound	CAS Number	LOR	Unit	EB1804203-021	EB1804203-022	EB1804203-023	EB1804203-024	EB1804203-025
				Result	Result	Result	Result	Result
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	35	26	46	54	61
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	62	56	69	74	81
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	<1	1	1	1	<1
Magnesium	7439-95-4	1	mg/L	<1	1	1	1	<1
Sodium	7440-23-5	1	mg/L	115	132	148	157	128
Potassium	7440-09-7	1	mg/L	4	4	4	4	4
EG005C: Leachable Metals by ICPAES								
Boron	7440-42-8	0.1	mg/L	0.5	0.5	0.5	0.5	0.6
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	0.4	0.4	0.6	0.8	0.9

Analytical Results

Sub-Matrix: LEACHATE (Matrix: WATER)			Client sample ID	C5286 59.69-61.31	C5286 61.31-62.62	C5286 62.62-64.05	C5286 64.05-65.10	C5286 65.10-66.67
			Client sampling date / time	14-Feb-2018 00:00	14-Feb-2018 00:00	14-Feb-2018 00:00	14-Feb-2018 00:00	14-Feb-2018 00:00
Compound	CAS Number	LOR	Unit	EB1804203-026	EB1804203-027	EB1804203-028	EB1804203-029	EB1804203-030
				Result	Result	Result	Result	Result
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	65	36	33	95	54
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	106	60	72	41	58
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	<1	<1	<1	2	<1
Magnesium	7439-95-4	1	mg/L	<1	<1	<1	1	<1
Sodium	7440-23-5	1	mg/L	146	131	131	104	95
Potassium	7440-09-7	1	mg/L	3	3	3	4	2
EG005C: Leachable Metals by ICPAES								
Boron	7440-42-8	0.1	mg/L	0.6	0.5	0.6	0.4	0.7
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	1.0	0.7	0.6	0.4	0.9

Analytical Results

Sub-Matrix: **LEACHATE**
(Matrix: **WATER**)

			Client sample ID	C5286 66.67-69.71	C5286 69.71-72.72	C5286 72.72-75.71	C5286 75.71-76.66	C5286 76.66-78.48
			Client sampling date / time	14-Feb-2018 00:00	14-Feb-2018 00:00	14-Feb-2018 00:00	14-Feb-2018 00:00	14-Feb-2018 00:00
Compound	CAS Number	LOR	Unit	EB1804203-031	EB1804203-032	EB1804203-033	EB1804203-034	EB1804203-035
				Result	Result	Result	Result	Result
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	39	20	12	46	24
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	48	36	29	33	29
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	<1	<1	<1	<1	<1
Magnesium	7439-95-4	1	mg/L	<1	<1	<1	<1	<1
Sodium	7440-23-5	1	mg/L	116	100	77	98	99
Potassium	7440-09-7	1	mg/L	3	2	2	3	3
EG005C: Leachable Metals by ICPAES								
Boron	7440-42-8	0.1	mg/L	0.4	0.4	0.4	0.3	0.3
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	0.4	0.3	0.3	0.2	0.2

Analytical Results

Sub-Matrix: LEACHATE (Matrix: WATER)			Client sample ID	C5286 78.48-81.11	C5286 81.11-83.42	C5286 83.42-84.71	C5286 84.71-86.86	C5286 86.86-88.86
			Client sampling date / time	14-Feb-2018 00:00	14-Feb-2018 00:00	14-Feb-2018 00:00	14-Feb-2018 00:00	14-Feb-2018 00:00
Compound	CAS Number	LOR	Unit	EB1804203-036	EB1804203-037	EB1804203-038	EB1804203-039	EB1804203-040
				Result	Result	Result	Result	Result
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	**34**	**24**	**24**	**38**	**60**
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	**32**	**31**	**32**	**30**	**76**
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	<1	<1	<1	<1	**1**
Magnesium	7439-95-4	1	mg/L	<1	<1	<1	<1	**1**
Sodium	7440-23-5	1	mg/L	**97**	**105**	**115**	**114**	**143**
Potassium	7440-09-7	1	mg/L	**3**	**3**	**3**	**3**	**4**
EG005C: Leachable Metals by ICPAES								
Boron	7440-42-8	0.1	mg/L	**0.3**	**0.4**	**0.3**	**0.3**	**0.4**
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	**0.3**	**0.4**	**0.5**	**0.6**	**1.3**

Analytical Results

Sub-Matrix: LEACHATE (Matrix: WATER)			Client sample ID	C5286 88.86-89.53	----	----	----	----
			Client sampling date / time	14-Feb-2018 00:00	----	----	----	----
Compound	CAS Number	LOR	Unit	EB1804203-041	--------	--------	--------	--------
				Result	----	----	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	**69**	----	----	----	----
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	**115**	----	----	----	----
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	<1	----	----	----	----
Magnesium	7439-95-4	1	mg/L	<1	----	----	----	----
Sodium	7440-23-5	1	mg/L	**141**	----	----	----	----
Potassium	7440-09-7	1	mg/L	**3**	----	----	----	----
EG005C: Leachable Metals by ICPAES								
Boron	7440-42-8	0.1	mg/L	**0.4**	----	----	----	----
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	**1.7**	----	----	----	----

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	C5286 0.00-0.57	C5286 0.57-1.36	C5286 1.36-3.05	C5286 3.05-5.44	C5286 5.44-9.04
			Client sampling date / time	14-Feb-2018 00:00	14-Feb-2018 00:00	14-Feb-2018 00:00	14-Feb-2018 00:00	14-Feb-2018 00:00
Compound	CAS Number	LOR	Unit	EB1804203-001	EB1804203-002	EB1804203-003	EB1804203-004	EB1804203-005
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	6.2	6.1	5.4	5.4	5.6
pH Value	----	0.1	pH Unit	6.4	6.3	5.3	5.1	5.2
EA009: Nett Acid Production Potential								
Net Acid Production Potential	----	0.5	kg H2SO4/t	-0.4	-1.2	1.0	3.1	0.9
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	375	163	423	569	394
Electrical Conductivity @ 25°C	----	1	µS/cm	258	190	332	428	370
EA013: Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	1.3	1.8	1.4	<0.5	<0.5
ANC as CaCO3	----	0.1	% CaCO3	0.1	0.2	0.1	<0.1	<0.1
Fizz Rating	----	0	Fizz Unit	0	0	0	0	0
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	1.0	%	2.0	1.8	7.4	10.8	<1.0
ED005: Exchange Acidity								
Exchange Acidity	----	0.1	meq/100g	----	----	0.8	0.8	0.2
Exchangeable Aluminium	----	0.1	meq/100g	----	----	0.5	0.5	<0.1
ED007: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	2.0	1.2	----	----	----
Exchangeable Magnesium	----	0.1	meq/100g	2.2	3.2	----	----	----
Exchangeable Potassium	----	0.1	meq/100g	0.3	0.3	----	----	----
Exchangeable Sodium	----	0.1	meq/100g	1.3	1.5	----	----	----
Cation Exchange Capacity	----	0.1	meq/100g	6.0	6.4	----	----	----
Exchangeable Sodium Percent	----	0.1	%	22.7	23.5	----	----	----
Calcium/Magnesium Ratio	----	0.1	-	0.9	0.4	----	----	----
Magnesium/Potassium Ratio	----	0.1	-	6.4	9.2	----	----	----
ED008: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	----	----	0.6	0.2	<0.1
Exchangeable Magnesium	----	0.1	meq/100g	----	----	3.1	2.5	0.4
Exchangeable Potassium	----	0.1	meq/100g	----	----	0.4	0.3	<0.1
Exchangeable Sodium	----	0.1	meq/100g	----	----	0.8	0.9	<0.1
Cation Exchange Capacity	----	0.1	meq/100g	----	----	5.7	4.7	0.6
Exchangeable Sodium Percent	----	0.1	%	----	----	16.8	22.5	14.8
Calcium/Magnesium Ratio	----	0.1	-	----	----	0.2	<0.1	<0.1

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	C5286 0.00-0.57	C5286 0.57-1.36	C5286 1.36-3.05	C5286 3.05-5.44	C5286 5.44-9.04
			Client sampling date / time	14-Feb-2018 00:00	14-Feb-2018 00:00	14-Feb-2018 00:00	14-Feb-2018 00:00	14-Feb-2018 00:00
Compound	CAS Number	LOR	Unit	EB1804203-001	EB1804203-002	EB1804203-003	EB1804203-004	EB1804203-005
				Result	Result	Result	Result	Result
ED008: Exchangeable Cations - Continued								
Magnesium/Potassium Ratio	----	0.1	-	----	----	8.9	8.2	----
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	0.03	0.02	0.08	0.10	0.03
Sample Preparation Method								
Amount	----	0.1	g	1.0	1.0	1.0	1.0	1.0

Analytical Results

Sub-Matrix: SOIL
(Matrix: SOIL)

Compound	CAS Number	LOR	Unit	C5286 9.04-12.04	C5286 12.04-15.10	C5286 15.10-17.87	C5286 17.87-20.95	C5286 20.95-23.77
Client sampling date / time				14-Feb-2018 00:00	14-Feb-2018 00:00	14-Feb-2018 00:00	14-Feb-2018 00:00	14-Feb-2018 00:00
				EB1804203-006	EB1804203-007	EB1804203-008	EB1804203-009	EB1804203-010
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	5.5	5.2	5.5	6.9	6.6
pH Value	----	0.1	pH Unit	5.6	5.1	5.8	6.8	6.8
EA009: Nett Acid Production Potential								
Net Acid Production Potential	----	0.5	kg H2SO4/t	0.6	0.9	-1.6	-2.3	-3.3
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	1440	1550	1470	1290	1060
Electrical Conductivity @ 25°C	----	1	µS/cm	888	1010	862	756	653
EA013: Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	<0.5	<0.5	2.2	2.9	3.3
ANC as CaCO3	----	0.1	% CaCO3	<0.1	<0.1	0.2	0.3	0.3
Fizz Rating	----	0	Fizz Unit	0	0	0	0	0
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	1.0	%	5.5	8.1	7.6	8.0	5.8
ED005: Exchange Acidity								
Exchange Acidity	----	0.1	meq/100g	<0.1	0.3	<0.1	----	----
Exchangeable Aluminium	----	0.1	meq/100g	<0.1	0.1	<0.1	----	----
ED008: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	0.3	0.7	1.0	1.0	1.4
Exchangeable Magnesium	----	0.1	meq/100g	1.9	4.0	4.4	4.6	5.6
Exchangeable Potassium	----	0.1	meq/100g	0.2	0.4	0.4	0.4	0.4
Exchangeable Sodium	----	0.1	meq/100g	0.1	0.4	0.5	0.6	0.9
Cation Exchange Capacity	----	0.1	meq/100g	----	5.8	----	----	----
Cation Exchange Capacity	----	0.1	meq/100g	2.6	----	6.4	6.5	8.3
Exchangeable Sodium Percent	----	0.1	%	5.4	8.0	8.4	9.1	10.8
Calcium/Magnesium Ratio	----	0.1	-	0.2	0.2	0.2	0.2	0.2
Magnesium/Potassium Ratio	----	0.1	-	9.6	9.7	11.4	12.4	13.1
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	0.02	0.03	0.02	0.02	<0.01
Sample Preparation Method								
Amount	----	0.1	g	1.0	1.0	1.0	1.0	1.0

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	C5286 23.77-26.49	C5286 26.49-30.08	C5286 30.08-32.84	C5286 32.84-34.20	C5286 34.20-37.39
			Client sampling date / time	14-Feb-2018 00:00	14-Feb-2018 00:00	14-Feb-2018 00:00	14-Feb-2018 00:00	14-Feb-2018 00:00
Compound	CAS Number	LOR	Unit	EB1804203-011	EB1804203-012	EB1804203-013	EB1804203-014	EB1804203-015
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	6.9	7.8	8.1	8.3	9.0
pH Value	----	0.1	pH Unit	7.3	8.2	8.8	8.9	9.5
EA009: Nett Acid Production Potential								
Net Acid Production Potential	----	0.5	kg H2SO4/t	-1.7	-11.5	-31.6	-17.5	-36.9
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	895	960	876	813	770
Electrical Conductivity @ 25°C	----	1	µS/cm	525	577	555	494	443
EA013: Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	1.7	12.4	32.8	18.7	37.5
ANC as CaCO3	----	0.1	% CaCO3	0.2	1.3	3.3	1.9	3.8
Fizz Rating	----	0	Fizz Unit	0	1	2	1	2
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	1.0	%	3.8	5.4	5.1	5.5	5.5
ED006: Exchangeable Cations on Alkaline Soils								
Exchangeable Calcium	----	0.2	meq/100g	0.6	1.1	1.6	1.9	1.2
Exchangeable Magnesium	----	0.2	meq/100g	2.7	4.3	5.5	6.4	3.6
Exchangeable Potassium	----	0.2	meq/100g	<0.2	0.3	0.4	0.5	0.2
Exchangeable Sodium	----	0.2	meq/100g	0.9	1.3	1.6	1.9	1.1
Cation Exchange Capacity	----	0.2	meq/100g	4.4	7.0	9.2	10.6	6.2
Exchangeable Sodium Percent	----	0.2	%	20.8	18.2	17.9	18.0	18.3
Calcium/Magnesium Ratio	----	0.2	-	0.2	0.3	0.3	0.3	0.3
Magnesium/Potassium Ratio	----	0.2	-	----	13.8	12.1	13.3	15.0
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	<0.01	0.03	0.04	0.04	0.02
Sample Preparation Method								
Amount	----	0.1	g	1.0	1.0	1.0	1.0	1.0

Analytical Results

Sub-Matrix: **SOIL**
(Matrix: **SOIL**)

Compound	CAS Number	LOR	Unit	C5286 37.39-39.82	C5286 39.82-42.19	C5286 42.19-44.67	C5286 44.67-47.53	C5286 47.53-48.91
Client sampling date / time				14-Feb-2018 00:00	14-Feb-2018 00:00	14-Feb-2018 00:00	14-Feb-2018 00:00	14-Feb-2018 00:00
				EB1804203-016	EB1804203-017	EB1804203-018	EB1804203-019	EB1804203-020
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	9.0	9.1	9.2	9.2	9.1
pH Value	----	0.1	pH Unit	9.7	9.7	9.8	9.9	9.8
EA009: Nett Acid Production Potential								
Net Acid Production Potential	----	0.5	kg H2SO4/t	-161	-74.0	-79.4	-108	-84.1
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	706	671	633	607	688
Electrical Conductivity @ 25°C	----	1	µS/cm	468	423	401	384	432
EA013: Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	162	74.6	80.0	108	85.0
ANC as CaCO3	----	0.1	% CaCO3	16.5	7.6	8.2	11.0	8.7
Fizz Rating	----	0	Fizz Unit	3	2	2	3	2
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	1.0	%	3.5	4.1	3.3	3.1	4.2
ED006: Exchangeable Cations on Alkaline Soils								
Exchangeable Calcium	----	0.2	meq/100g	2.9	1.8	1.7	1.3	1.7
Exchangeable Magnesium	----	0.2	meq/100g	8.4	4.7	4.4	3.6	4.5
Exchangeable Potassium	----	0.2	meq/100g	0.5	0.3	0.3	0.2	0.3
Exchangeable Sodium	----	0.2	meq/100g	2.5	1.6	1.6	1.4	1.9
Cation Exchange Capacity	----	0.2	meq/100g	14.3	8.3	8.0	6.6	8.4
Exchangeable Sodium Percent	----	0.2	%	17.5	18.8	19.4	20.8	22.7
Calcium/Magnesium Ratio	----	0.2	-	0.3	0.4	0.4	0.4	0.4
Magnesium/Potassium Ratio	----	0.2	-	17.8	14.8	14.7	16.1	16.7
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	0.03	0.02	0.02	<0.01	0.03
Sample Preparation Method								
Amount	----	0.1	g	1.0	1.0	1.0	1.0	1.0

Analytical Results

Sub-Matrix: SOIL
(Matrix: SOIL)

Client sample ID				C5286 48.91-51.48	C5286 51.48-54.50	C5286 54.50-56.55	C5286 56.55-58.05	C5286 58.05-59.69
Client sampling date / time				14-Feb-2018 00:00	14-Feb-2018 00:00	14-Feb-2018 00:00	14-Feb-2018 00:00	14-Feb-2018 00:00
Compound	CAS Number	LOR	Unit	EB1804203-021	EB1804203-022	EB1804203-023	EB1804203-024	EB1804203-025
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	9.4	9.5	9.4	9.4	9.1
pH Value	----	0.1	pH Unit	9.8	9.9	9.9	9.9	9.8
EA009: Nett Acid Production Potential								
Net Acid Production Potential	----	0.5	kg H2SO4/t	-79.5	-137	-113	-124	-9.8
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	582	570	608	650	541
Electrical Conductivity @ 25°C	----	1	µS/cm	432	459	459	494	414
EA013: Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	80.1	137	114	126	18.7
ANC as CaCO3	----	0.1	% CaCO3	8.2	14.0	11.7	12.9	1.9
Fizz Rating	----	0	Fizz Unit	2	3	3	3	1
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	1.0	%	4.0	3.8	4.0	3.8	6.4
ED006: Exchangeable Cations on Alkaline Soils								
Exchangeable Calcium	----	0.2	meq/100g	3.6	2.1	1.8	2.3	2.4
Exchangeable Magnesium	----	0.2	meq/100g	9.3	5.5	4.5	5.7	5.4
Exchangeable Potassium	----	0.2	meq/100g	0.5	0.3	0.2	0.3	0.4
Exchangeable Sodium	----	0.2	meq/100g	3.8	2.6	2.4	3.1	3.3
Cation Exchange Capacity	----	0.2	meq/100g	17.3	10.5	8.9	11.3	11.6
Exchangeable Sodium Percent	----	0.2	%	22.3	24.4	26.7	27.0	28.3
Calcium/Magnesium Ratio	----	0.2	-	0.4	0.4	0.4	0.4	0.4
Magnesium/Potassium Ratio	----	0.2	-	17.5	16.9	17.5	16.4	12.1
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	0.02	<0.01	0.03	0.07	0.29
Sample Preparation Method								
Amount	----	0.1	g	1.0	1.0	1.0	1.0	1.0

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	C5286 59.69-61.31	C5286 61.31-62.62	C5286 62.62-64.05	C5286 64.05-65.10	C5286 65.10-66.67
			Client sampling date / time	14-Feb-2018 00:00	14-Feb-2018 00:00	14-Feb-2018 00:00	14-Feb-2018 00:00	14-Feb-2018 00:00
Compound	CAS Number	LOR	Unit	EB1804203-026	EB1804203-027	EB1804203-028	EB1804203-029	EB1804203-030
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	9.2	9.6	9.5	8.3	9.2
pH Value	----	0.1	pH Unit	9.8	10.0	10.0	9.1	9.7
EA009: Nett Acid Production Potential								
Net Acid Production Potential	----	0.5	kg H2SO4/t	-20.6	-119	-33.0	-0.9	-10.2
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	736	582	551	576	496
Electrical Conductivity @ 25°C	----	1	µS/cm	500	459	401	407	354
EA013: Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	22.4	120	33.9	15.6	12.0
ANC as CaCO3	----	0.1	% CaCO3	2.3	12.2	3.5	1.6	1.2
Fizz Rating	----	0	Fizz Unit	1	3	1	1	1
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	1.0	%	4.8	3.3	4.4	3.9	3.9
ED006: Exchangeable Cations on Alkaline Soils								
Exchangeable Calcium	----	0.2	meq/100g	2.6	2.1	4.6	1.6	1.6
Exchangeable Magnesium	----	0.2	meq/100g	5.3	4.3	9.2	2.6	2.8
Exchangeable Potassium	----	0.2	meq/100g	0.4	0.4	0.6	<0.2	0.3
Exchangeable Sodium	----	0.2	meq/100g	3.4	2.7	5.9	1.8	2.1
Cation Exchange Capacity	----	0.2	meq/100g	11.7	9.5	20.4	6.2	6.7
Exchangeable Sodium Percent	----	0.2	%	29.4	28.5	29.1	29.4	30.9
Calcium/Magnesium Ratio	----	0.2	-	0.5	0.5	0.5	0.6	0.6
Magnesium/Potassium Ratio	----	0.2	-	13.6	10.3	14.1	----	10.3
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	0.06	0.02	0.03	0.48	0.06
Sample Preparation Method								
Amount	----	0.1	g	1.0	1.0	1.0	1.0	1.0

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	C5286 66.67-69.71	C5286 69.71-72.72	C5286 72.72-75.71	C5286 75.71-76.66	C5286 76.66-78.48
			Client sampling date / time	14-Feb-2018 00:00	14-Feb-2018 00:00	14-Feb-2018 00:00	14-Feb-2018 00:00	14-Feb-2018 00:00
Compound	CAS Number	LOR	Unit	EB1804203-031	EB1804203-032	EB1804203-033	EB1804203-034	EB1804203-035
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	9.5	9.7	9.6	9.5	9.6
pH Value	----	0.1	pH Unit	9.9	10.0	10.0	9.8	10.0
EA009: Nett Acid Production Potential								
Net Acid Production Potential	----	0.5	kg H2SO4/t	-44.5	-127	-73.6	-76.8	-72.0
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	533	463	448	519	458
Electrical Conductivity @ 25°C	----	1	µS/cm	399	364	354	386	355
EA013: Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	45.4	128	74.2	82.6	72.6
ANC as CaCO3	----	0.1	% CaCO3	4.6	13.0	7.6	8.4	7.4
Fizz Rating	----	0	Fizz Unit	2	3	2	2	2
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	1.0	%	3.2	1.8	2.3	2.2	2.3
ED006: Exchangeable Cations on Alkaline Soils								
Exchangeable Calcium	----	0.2	meq/100g	1.0	1.0	0.8	0.8	0.9
Exchangeable Magnesium	----	0.2	meq/100g	1.5	1.5	1.3	1.1	1.4
Exchangeable Potassium	----	0.2	meq/100g	<0.2	<0.2	<0.2	<0.2	<0.2
Exchangeable Sodium	----	0.2	meq/100g	1.1	1.1	0.9	0.8	1.0
Cation Exchange Capacity	----	0.2	meq/100g	3.7	3.8	3.1	2.8	3.2
Exchangeable Sodium Percent	----	0.2	%	30.4	29.4	30.3	28.9	29.7
Calcium/Magnesium Ratio	----	0.2	-	0.6	0.7	0.6	0.7	0.7
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	0.03	0.02	0.02	0.19	0.02
Sample Preparation Method								
Amount	----	0.1	g	1.0	1.0	1.0	1.0	1.0

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	C5286 78.48-81.11	C5286 81.11-83.42	C5286 83.42-84.71	C5286 84.71-86.86	C5286 86.86-88.86
			Client sampling date / time	14-Feb-2018 00:00	14-Feb-2018 00:00	14-Feb-2018 00:00	14-Feb-2018 00:00	14-Feb-2018 00:00
Compound	CAS Number	LOR	Unit	EB1804203-036	EB1804203-037	EB1804203-038	EB1804203-039	EB1804203-040
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	9.6	9.6	9.6	9.4	9.4
pH Value	----	0.1	pH Unit	10.0	10.0	10.0	10.0	9.6
EA009: Nett Acid Production Potential								
Net Acid Production Potential	----	0.5	kg H2SO4/t	-70.6	-76.1	-85.0	-18.5	-129
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	464	475	465	511	530
Electrical Conductivity @ 25°C	----	1	µS/cm	359	371	368	343	360
EA013: Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	71.2	76.7	85.9	20.0	130
ANC as CaCO3	----	0.1	% CaCO3	7.2	7.8	8.8	2.0	13.2
Fizz Rating	----	0	Fizz Unit	2	2	2	1	3
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	1.0	%	2.7	2.4	2.2	1.7	3.3
ED006: Exchangeable Cations on Alkaline Soils								
Exchangeable Calcium	----	0.2	meq/100g	1.5	1.1	0.9	1.3	0.8
Exchangeable Magnesium	----	0.2	meq/100g	2.3	1.6	1.3	1.4	1.2
Exchangeable Potassium	----	0.2	meq/100g	<0.2	<0.2	<0.2	<0.2	<0.2
Exchangeable Sodium	----	0.2	meq/100g	1.6	1.1	0.9	1.0	0.8
Cation Exchange Capacity	----	0.2	meq/100g	5.6	4.0	3.1	3.9	2.8
Exchangeable Sodium Percent	----	0.2	%	28.7	28.1	29.8	24.8	29.6
Calcium/Magnesium Ratio	----	0.2	-	0.6	0.7	0.7	0.9	0.7
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	0.02	0.02	0.03	0.05	0.02
Sample Preparation Method								
Amount	----	0.1	g	1.0	1.0	1.0	1.0	1.0

Analytical Results

Sub-Matrix: SOIL
(Matrix: SOIL)

Compound	CAS Number	LOR	Unit	C5286 88.86-89.53	pH & EC - 1:5 DI Water	pH & EC - 1:3 DI Water	----	----
Client sampling date / time				14-Feb-2018 00:00	19-Feb-2018 00:00	19-Feb-2018 00:00	----	----
				EB1804203-041	EB1804203-043	EB1804203-044	--------	--------
				Result	Result	Result	----	----
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	9.3	----	----	----	----
pH Value	----	0.1	pH Unit	9.2	5.3	5.2	----	----
EA009: Nett Acid Production Potential								
Net Acid Production Potential	----	0.5	kg H2SO4/t	-8.6	----	----	----	----
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	456	----	----	----	----
Electrical Conductivity @ 25°C	----	1	µS/cm	420	<1	<1	----	----
EA013: Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	10.4	----	----	----	----
ANC as CaCO3	----	0.1	% CaCO3	1.1	----	----	----	----
Fizz Rating	----	0	Fizz Unit	1	----	----	----	----
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	1.0	%	4.4	----	----	----	----
ED006: Exchangeable Cations on Alkaline Soils								
Exchangeable Calcium	----	0.2	meq/100g	1.2	----	----	----	----
Exchangeable Magnesium	----	0.2	meq/100g	1.8	----	----	----	----
Exchangeable Potassium	----	0.2	meq/100g	<0.2	----	----	----	----
Exchangeable Sodium	----	0.2	meq/100g	1.3	----	----	----	----
Cation Exchange Capacity	----	0.2	meq/100g	4.4	----	----	----	----
Exchangeable Sodium Percent	----	0.2	%	28.6	----	----	----	----
Calcium/Magnesium Ratio	----	0.2	-	0.6	----	----	----	----
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	0.06	----	----	----	----
Sample Preparation Method								
Amount	----	0.1	g	1.0	----	----	----	----

BR18046313 - Finalized
CLIENT : "ALSENV - ALS Environmental"
# of SAMPLES : 41
DATE RECEIVED : 2018-03-02 DATE FINALIZED : 2018-03-16
PROJECT : "EB1804203"
CERTIFICATE COMMENTS : ""
PO NUMBER : "MS41

	F	Cl & B"																							
	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	F-ELE81a	Cl-VOL66	B-ICP69
SAMPLE	Ag	Al	As	Ca	Cd	Co	Cr	Cu	Fe	Hg	K	Mg	Mn	Mo	Na	Ni	Pb	S	Se	U	V	Zn	F	Cl	B
DESCRIPTION	ppm	%	ppm	%	ppm	ppm	ppm	ppm	%	ppm	%	%	%	ppm	%	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm	%	ppm
EB1804203-001	0.1	1.07	7.6	0.03	0.01	3.2	260	15.1	16.1	0.01	0.03	0.03	0.0038	0.8	0.03	8.3	10.4	0.02	1.6	0.94	350	27	320	0.04	20
EB1804203-002	0.01	0.71	3.9	0.01	<0.01	1.5	99	6	6.31	<0.01	0.04	0.04	0.002	0.23	0.03	3.4	4.1	0.01	1.2	0.39	141	4	370	0.03	30
EB1804203-003	<0.01	0.67	8.3	0.01	<0.01	2.3	73	7.9	7.31	<0.01	0.07	0.05	0.0021	0.66	0.06	6.2	4.7	0.04	2.6	0.2	149	13	380	0.05	80
EB1804203-004	<0.01	0.62	8.8	<0.01	<0.01	0.9	46	5.8	1.95	<0.01	0.08	0.05	0.0005	0.37	0.08	3.2	5.6	0.04	2.3	0.18	146	14	550	0.07	60
EB1804203-005	0.01	0.15	0.1	<0.01	<0.01	0.2	23	1.7	0.23	<0.01	0.01	0.01	<0.0005	0.06	0.02	1.1	2.1	0.01	<0.2	0.24	12	42	130	0.06	20
EB1804203-006	0.01	0.69	1.5	0.01	<0.01	1.5	27	17.2	0.64	<0.01	0.09	0.04	0.0006	<0.05	0.1	7.9	7.2	0.03	0.2	0.41	55	279	330	0.16	40
EB1804203-007	0.06	1.07	2.5	0.02	0.02	16.2	41	51.7	2.91	<0.01	0.17	0.09	0.0153	0.11	0.12	41.8	10.2	0.03	0.2	1.38	79	287	560	0.17	40
EB1804203-008	0.01	1.13	4.1	0.02	0.03	26.8	26	69.6	6.35	<0.01	0.19	0.13	0.0534	0.19	0.11	67.3	11.6	0.03	<0.2	1.93	54	357	600	0.15	80
EB1804203-009	0.01	1.02	4.1	0.03	0.06	38.5	23	66.9	5.61	<0.01	0.16	0.16	0.0665	0.17	0.11	94.4	12	0.02	0.2	0.89	41	803	570	0.13	40
EB1804203-010	0.05	1.1	6.1	0.04	0.16	56.2	23	38.2	7.16	0.01	0.17	0.24	0.0891	0.26	0.1	206	14.6	0.01	<0.2	0.8	39	389	490	0.12	50
EB1804203-011	0.01	1.1	3.9	0.07	0.14	55.3	19	52.6	4.79	0.12	0.17	0.21	0.0812	0.12	0.1	151	14.6	0.02	0.2	0.75	42	328	480	0.09	50
EB1804203-012	0.06	1.25	11	0.18	0.29	43.9	16	46.1	4.15	0.08	0.19	0.38	0.104	0.35	0.11	53.3	14.3	0.04	0.5	0.72	45	169	610	0.09	50
EB1804203-013	0.08	1.67	6.8	0.51	0.14	35.6	20	53	5.48	0.04	0.18	0.83	0.251	0.8	0.11	43.3	16	0.05	0.2	0.68	56	128	560	0.08	40
EB1804203-014	0.08	1.71	7.6	0.29	0.08	30.7	20	51.4	4.24	0.04	0.18	0.75	0.182	0.92	0.11	39.6	16.8	0.06	0.2	0.42	51	361	490	0.07	50
EB1804203-015	0.03	1.6	14.2	0.74	0.06	16.2	25	18.7	4.82	0.03	0.14	0.9	0.177	0.52	0.1	28.4	11.7	0.04	<0.2	0.42	52	267	360	0.06	30
EB1804203-016	0.03	0.97	13	5.1	0.07	17.1	16	23.5	6.35	0.03	0.13	1.04	0.293	0.91	0.1	18.2	9.7	0.03	0.2	0.36	52	82	410	0.06	20
EB1804203-017	0.04	1.56	18.9	2.4	0.08	17	19	24.4	3.77	0.04	0.14	0.79	0.094	0.81	0.1	23.9	8.8	0.03	0.2	0.34	42	96	380	0.06	30
EB1804203-018	0.04	1.44	15.6	2.74	0.07	17.1	21	25.9	4.26	0.03	0.13	0.76	0.0925	0.55	0.1	23.9	10.1	0.02	<0.2	0.32	47	80	560	0.06	30
EB1804203-019	0.03	1.29	7.7	3.43	0.05	11	22	14.9	2.84	0.03	0.13	0.63	0.0681	0.34	0.09	17.1	8.1	0.02	<0.2	0.25	36	74	520	0.04	30
EB1804203-020	0.03	1.54	6.9	2.96	0.05	14.2	20	19.4	4.48	0.03	0.15	0.77	0.0921	0.37	0.12	20.9	11.1	0.04	<0.2	0.27	50	67	520	0.06	30
EB1804203-021	0.03	1.34	16.4	2.66	0.06	17.2	21	24.4	3.73	0.03	0.13	0.75	0.0819	0.61	0.12	25.2	10.6	0.02	<0.2	0.25	49	79	220	0.05	20
EB1804203-022	0.02	1.29	6.9	4.07	0.07	15.7	28	24.8	4.29	0.03	0.15	0.95	0.112	0.44	0.13	21.3	8.8	0.02	0.2	0.29	67	85	280	0.03	30
EB1804203-023	0.02	1.75	9.7	3.46	0.1	26.2	37	26.2	5.42	0.05	0.14	1.04	0.129	0.7	0.13	27.8	20.5	0.05	<0.2	0.25	93	114	820	0.06	30
EB1804203-024	0.03	1.59	10.4	4.06	0.07	23	20	27.8	6.59	0.05	0.15	1.01	0.17	1.28	0.15	20.3	26.3	0.03	0.2	0.37	93	75	500	0.05	30
EB1804203-025	0.05	0.88	3.9	0.63	0.11	9.1	15	32	1.44	0.06	0.11	0.36	0.0297	0.62	0.11	14.8	8.7	0.12	0.3	0.52	43	67	160	<0.01	40
EB1804203-026	0.09	1.55	4.1	0.56	0.1	12.2	12	46.6	2.13	0.08	0.19	0.69	0.0235	0.53	0.17	23.9	16.4	0.06	0.3	0.37	29	82	400	0.07	50
EB1804203-027	0.05	0.94	13.8	3.53	0.08	9.1	8	28.8	2.52	0.07	0.18	0.99	0.0727	0.82	0.15	19	11.6	0.03	0.2	0.55	22	79	770	0.04	40
EB1804203-028	0.08	1.44	4.6	0.85	0.09	8.4	11	44.5	3.16	0.06	0.21	0.84	0.0537	0.7	0.18	20.8	16.6	0.04	0.2	0.63	24	87	860	0.02	50
EB1804203-029	0.03	0.89	2.4	0.39	0.07	8.9	8	24.6	2.88	0.05	0.07	0.42	0.086	0.36	0.07	12.2	8.6	0.22	0.8	0.48	21	36	250	0.05	30
EB1804203-030	0.09	1.35	7.1	0.21	0.09	6.5	16	51.9	1.43	0.06	0.17	0.51	0.0065	0.2	0.13	23.8	13.9	0.06	0.2	0.41	32	115	700	0.01	50
EB1804203-031	0.06	1.43	11.3	1.06	0.1	17.2	21	34.8	2.51	0.05	0.15	0.76	0.0418	0.99	0.12	33.2	10.6	0.03	0.2	0.39	39	97	380	0.02	30
EB1804203-032	0.03	1.02	3.7	4.31	0.06	13.2	16	19.4	2.52	0.02	0.12	0.73	0.0773	0.41	0.1	23.7	16.7	0.02	<0.2	0.3	33	72	1110	<0.01	20
EB1804203-033	0.03	1.26	2.5	2.38	0.07	11.8	22	19.2	2.88	0.02	0.13	0.77	0.0637	0.33	0.1	26.3	11.7	0.02	<0.2	0.3	40	86	890	<0.01	30
EB1804203-034	0.04	1.25	7.7	2.78	0.08	30.8	32	19.6	5.33	0.03	0.12	0.82	0.128	1.38	0.1	43.8	10.9	0.2	<0.2	0.28	70	91	310	0.02	30
EB1804203-035	0.03	1.06	6.9	2.15	0.06	18.8	19	19.8	3.24	0.02	0.12	0.71	0.0866	0.78	0.09	31.9	13.1	0.02	<0.2	0.27	33	65	330	0.03	30
EB1804203-036	0.04	1.2	6.8	2.19	0.07	21.6	26	21.6	3.25	0.03	0.13	0.76	0.0831	1.29	0.1	32	11.2	0.03	<0.2	0.29	38	73	410	0.01	30
EB1804203-037	0.06	1.23	7.9	2.03	0.09	16.7	16	36.8	3.98	0.03	0.15	0.86	0.0823	0.72	0.1	29.1	11	0.02	<0.2	0.37	40	84	430	<0.01	40
EB1804203-038	0.06	0.96	11	2.54	0.09	12.9	14	35	3.04	0.03	0.15	0.78	0.0833	0.81	0.1	23.1	10.2	0.03	<0.2	0.33	32	90	360	0.01	40
EB1804203-039	0.08	1.19	8.8	0.4	0.12	11.8	13	45.6	3.31	0.05	0.14	0.62	0.078	0.5	0.1	24.8	15.4	0.04	0.2	0.4	35	103	400	0.02	50
EB1804203-040	0.04	0.87	9.9	3.9	0.07	11.5	12	24.2	2.93	0.04	0.14	0.85	0.0903	0.54	0.08	20.3	8.5	0.03	<0.2	0.33	30	80	350	<0.01	40
EB1804203-041	0.07	1.37	4.2	0.22	0.17	10.9	14	50.1	1.78	0.06	0.18	0.55	0.0165	0.39	0.1	23.2	16.9	0.05	0.2	0.32	40	110	460	0.03	60

A.3.3 Appendix 3iii composite spoil samples

CERTIFICATE OF ANALYSIS

Work Order	: **EB1804470**	Page	: 1 of 8
Amendment	: **1**		
Client	: **RGS ENVIRONMENTAL PTY LTD**	Laboratory	: Environmental Division Brisbane
Contact	: MR ALAN ROBERTSON	Contact	: Customer Services EB
Address	: PO Box 3091 SUNNYBANK SOUTH QLD, AUSTRALIA 4109	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: +61 07 3344 1222	Telephone	: +61-7-3243 7222
Project	: 2017041 - Ensham Project	Date Samples Received	: 16-Feb-2018 15:50
Order number	: ----	Date Analysis Commenced	: 21-Feb-2018
C-O-C number	: ----	Issue Date	: 06-Apr-2018 17:34
Sampler	: MARY MACELROY		
Site	: ----		
Quote number	: BN/035/18 V2		
No. of samples received	: 6		
No. of samples analysed	: 6		

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

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

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

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

Signatories

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

Signatories	*Position*	*Accreditation Category*
Andrew Epps	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Ben Felgendrejeris	Senior Acid Sulfate Soil Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Kim McCabe	Senior Inorganic Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Merrin Avery	Supervisor - Inorganic	Newcastle - Inorganics, Mayfield West, NSW

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

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

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

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

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

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

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

- ED006 (Exchangeable Cations on Alkaline Soils): It is recognised that the Exchangeable Potassium LCS biases low, however this is deemed acceptable as the target concentration is at LOR and the Cation Exchange Capacity LCS is within acceptable limits.
- Amendment (03/04/2018): This report has been amended and re-released to allow the reporting of additional analytical data.
- ASS: EA013 (ANC) Fizz Rating: 0- None; 1- Slight; 2- Moderate; 3- Strong; 4- Very Strong; 5- Lime.
- ED007 and ED008: When Exchangeable Al is reported from these methods, it should be noted that Rayment & Lyons (2011) suggests Exchange Acidity by 1M KCl - Method 15G1 (ED005) is a more suitable method for the determination of exchange acidity (H+ + Al3+).

Analytical Results

Sub-Matrix: LEACHATE (Matrix: WATER)			Client sample ID	PIT B - 650380	PIT B - 649937	PIT B - 649869	PIT D - 352914	PIT Y - 655102
			Client sampling date / time	16-Feb-2018 00:00	16-Feb-2018 00:00	16-Feb-2018 00:00	16-Feb-2018 00:00	16-Feb-2018 00:00
Compound	CAS Number	LOR	Unit	EB1804470-001	EB1804470-002	EB1804470-003	EB1804470-004	EB1804470-005
				Result	Result	Result	Result	Result
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	62	4	42	2	102
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	1210	6	219	6	1340
ED093W: Water Leachable Major Cations								
Calcium	7440-70-2	1	mg/L	128	2	6	4	13
Magnesium	7439-95-4	1	mg/L	125	2	4	5	135
Sodium	7440-23-5	1	mg/L	425	21	158	13	650
Potassium	7440-09-7	1	mg/L	9	2	2	3	4
EG005W: Water Leachable Metals by ICPAES								
Aluminium	7429-90-5	0.10	mg/L	<0.10	1.14	0.72	0.57	<0.10
Antimony	7440-36-0	0.01	mg/L	<0.01	<0.01	0.01	<0.01	<0.01
Arsenic	7440-38-2	0.01	mg/L	<0.01	0.01	<0.01	<0.01	<0.01
Boron	7440-42-8	0.1	mg/L	0.6	0.3	0.4	0.2	0.4
Cadmium	7440-43-9	0.005	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005
Chromium	7440-47-3	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Cobalt	7440-48-4	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Copper	7440-50-8	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Iron	7439-89-6	0.05	mg/L	<0.05	0.84	0.77	0.28	<0.05
Lead	7439-92-1	0.01	mg/L	<0.01	0.02	<0.01	<0.01	0.01
Manganese	7439-96-5	0.01	mg/L	<0.01	0.05	0.03	0.02	0.11
Nickel	7440-02-0	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	0.02
Selenium	7782-49-2	0.01	mg/L	0.02	<0.01	0.05	<0.01	<0.01
Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	0.01	<0.01	<0.01
Zinc	7440-66-6	0.01	mg/L	0.16	0.05	0.07	0.02	0.38
Molybdenum	7439-98-7	0.01	mg/L	<0.01	0.01	<0.01	<0.01	<0.01
EG020W: Water Leachable Metals by ICP-MS								
Lithium	7439-93-2	0.001	mg/L	0.010	0.003	0.002	0.004	0.011

Analytical Results

Sub-Matrix: LEACHATE (Matrix: WATER)			Client sample ID	PIT Y - 654107	----	----	----	----
			Client sampling date / time	16-Feb-2018 00:00	----	----	----	----
Compound	CAS Number	LOR	Unit	EB1804470-006	--------	--------	--------	--------
				Result	----	----	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	**131**	----	----	----	----
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	**16**	----	----	----	----
ED093W: Water Leachable Major Cations								
Calcium	7440-70-2	1	mg/L	**3**	----	----	----	----
Magnesium	7439-95-4	1	mg/L	**4**	----	----	----	----
Sodium	7440-23-5	1	mg/L	**93**	----	----	----	----
Potassium	7440-09-7	1	mg/L	**9**	----	----	----	----
EG005W: Water Leachable Metals by ICPAES								
Aluminium	7429-90-5	0.10	mg/L	**1.09**	----	----	----	----
Antimony	7440-36-0	0.01	mg/L	<0.01	----	----	----	----
Arsenic	7440-38-2	0.01	mg/L	<0.01	----	----	----	----
Boron	7440-42-8	0.1	mg/L	**0.4**	----	----	----	----
Cadmium	7440-43-9	0.005	mg/L	<0.005	----	----	----	----
Chromium	7440-47-3	0.01	mg/L	<0.01	----	----	----	----
Cobalt	7440-48-4	0.01	mg/L	<0.01	----	----	----	----
Copper	7440-50-8	0.01	mg/L	<0.01	----	----	----	----
Iron	7439-89-6	0.05	mg/L	**0.44**	----	----	----	----
Lead	7439-92-1	0.01	mg/L	**0.01**	----	----	----	----
Manganese	7439-96-5	0.01	mg/L	**0.03**	----	----	----	----
Nickel	7440-02-0	0.01	mg/L	<0.01	----	----	----	----
Selenium	7782-49-2	0.01	mg/L	**0.05**	----	----	----	----
Vanadium	7440-62-2	0.01	mg/L	<0.01	----	----	----	----
Zinc	7440-66-6	0.01	mg/L	**0.06**	----	----	----	----
Molybdenum	7439-98-7	0.01	mg/L	<0.01	----	----	----	----
EG020W: Water Leachable Metals by ICP-MS								
Lithium	7439-93-2	0.001	mg/L	**0.008**	----	----	----	----

Analytical Results

Sub-Matrix: **SOIL** (Matrix: **SOIL**)			*Client sample ID*	**PIT B - 650380**	**PIT B - 649937**	**PIT B - 649869**	**PIT D - 352914**	**PIT Y - 655102**
			Client sampling date / time	16-Feb-2018 00:00	16-Feb-2018 00:00	16-Feb-2018 00:00	16-Feb-2018 00:00	16-Feb-2018 00:00
Compound	*CAS Number*	*LOR*	*Unit*	**EB1804470-001**	**EB1804470-002**	**EB1804470-003**	**EB1804470-004**	**EB1804470-005**
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	**7.4**	**9.1**	**9.2**	**9.2**	**5.1**
EA009: Nett Acid Production Potential								
Net Acid Production Potential	----	0.5	kg H_2SO_4/t	**-7.7**	**-29.3**	**-14.4**	**-44.2**	**-2.0**
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	**2230**	**77**	**628**	**100**	**2480**
EA013: Acid Neutralising Capacity								
ANC as H_2SO_4	----	0.5	kg H_2SO_4 equiv./t	**8.3**	**29.9**	**14.4**	**44.8**	**2.6**
ANC as $CaCO_3$	----	0.1	% $CaCO_3$	**0.8**	**3.0**	**1.5**	**4.6**	**0.3**
Fizz Rating	----	0	Fizz Unit	**0**	**1**	**1**	**2**	**0**
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	1.0	%	**1.7**	**2.8**	**1.1**	**3.0**	**2.0**
ED005: Exchange Acidity								
Exchange Acidity	----	0.1	meq/100g	----	----	----	----	<0.1
Exchangeable Aluminium	----	0.1	meq/100g	----	----	----	----	<0.1
ED006: Exchangeable Cations on Alkaline Soils								
Exchangeable Calcium	----	0.2	meq/100g	**1.9**	**3.1**	**0.9**	**1.7**	----
Exchangeable Magnesium	----	0.2	meq/100g	**1.9**	**2.2**	**0.8**	**2.5**	----
Exchangeable Potassium	----	0.2	meq/100g	<0.2	<0.2	<0.2	<0.2	----
Exchangeable Sodium	----	0.2	meq/100g	**0.3**	<0.2	**0.3**	<0.2	----
Cation Exchange Capacity	----	0.2	meq/100g	**4.1**	**5.4**	**2.1**	**4.4**	----
Exchangeable Sodium Percent	----	0.2	%	**7.0**	<0.2	**16.4**	<0.2	----
ED008: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	----	----	----	----	**0.3**
Exchangeable Magnesium	----	0.1	meq/100g	----	----	----	----	**3.4**
Exchangeable Potassium	----	0.1	meq/100g	----	----	----	----	<0.1
Exchangeable Sodium	----	0.1	meq/100g	----	----	----	----	**0.2**
Cation Exchange Capacity	----	0.1	meq/100g	----	----	----	----	**3.9**
Exchangeable Sodium Percent	----	0.1	%	----	----	----	----	**5.3**
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	**0.02**	**0.02**	<0.01	**0.02**	**0.02**
ED093T: Total Major Cations								
Sodium	7440-23-5	50	mg/kg	**1840**	**200**	**830**	**110**	**2030**
Potassium	7440-09-7	50	mg/kg	**1270**	**1050**	**430**	**1220**	**210**

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	PIT B - 650380	PIT B - 649937	PIT B - 649869	PIT D - 352914	PIT Y - 655102
			Client sampling date / time	16-Feb-2018 00:00	16-Feb-2018 00:00	16-Feb-2018 00:00	16-Feb-2018 00:00	16-Feb-2018 00:00
Compound	CAS Number	LOR	Unit	EB1804470-001	EB1804470-002	EB1804470-003	EB1804470-004	EB1804470-005
				Result	Result	Result	Result	Result
ED093T: Total Major Cations - Continued								
Calcium	7440-70-2	50	mg/kg	2360	4120	3000	10600	100
Magnesium	7439-95-4	50	mg/kg	3740	5520	1600	5420	760
EK040T: Fluoride Total								
Fluoride	16984-48-8	40	mg/kg	150	180	110	170	90
EK067G: Total Phosphorus as P by Discrete Analyser								
Total Phosphorus as P	----	2	mg/kg	323	292	81	329	186
EP003: Total Organic Carbon (TOC) in Soil								
Total Organic Carbon	----	0.02	%	0.08	0.34	0.05	0.57	0.03
EP003TC: Total Carbon (TC) in Soil								
Total Carbon	TC	0.02	%	0.09	0.42	0.10	1.97	0.04
EP003TIC: Total inorganic Carbon (TIC) in Soil								
Total Inorganic Carbon	----	0.02	%	<0.02	0.08	0.05	1.40	<0.02
Sample Preparation Method								
Amount	----	0.1	g	1.0	1.0	1.0	1.0	1.0

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	PIT Y - 654107	----	----	----	----
			Client sampling date / time	16-Feb-2018 00:00	----	----	----	----
Compound	CAS Number	LOR	Unit	EB1804470-006	--------	--------	--------	--------
				Result	----	----	----	----
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	**8.9**	----	----	----	----
EA009: Nett Acid Production Potential								
Net Acid Production Potential	----	0.5	kg H2SO4/t	**-17.5**	----	----	----	----
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	**446**	----	----	----	----
EA013: Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	**19.0**	----	----	----	----
ANC as CaCO3	----	0.1	% CaCO3	**1.9**	----	----	----	----
Fizz Rating	----	0	Fizz Unit	**1**	----	----	----	----
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	1.0	%	**1.3**	----	----	----	----
ED006: Exchangeable Cations on Alkaline Soils								
Exchangeable Calcium	----	0.2	meq/100g	**1.3**	----	----	----	----
Exchangeable Magnesium	----	0.2	meq/100g	**1.6**	----	----	----	----
Exchangeable Potassium	----	0.2	meq/100g	<0.2	----	----	----	----
Exchangeable Sodium	----	0.2	meq/100g	**0.4**	----	----	----	----
Cation Exchange Capacity	----	0.2	meq/100g	**3.5**	----	----	----	----
Exchangeable Sodium Percent	----	0.2	%	**12.8**	----	----	----	----
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	**0.05**	----	----	----	----
ED093T: Total Major Cations								
Sodium	7440-23-5	50	mg/kg	**640**	----	----	----	----
Potassium	7440-09-7	50	mg/kg	**1190**	----	----	----	----
Calcium	7440-70-2	50	mg/kg	**6080**	----	----	----	----
Magnesium	7439-95-4	50	mg/kg	**5640**	----	----	----	----
EK040T: Fluoride Total								
Fluoride	16984-48-8	40	mg/kg	**280**	----	----	----	----
EK067G: Total Phosphorus as P by Discrete Analyser								
Total Phosphorus as P	----	2	mg/kg	**1160**	----	----	----	----
EP003: Total Organic Carbon (TOC) in Soil								
Total Organic Carbon	----	0.02	%	**0.43**	----	----	----	----
EP003TC: Total Carbon (TC) in Soil								

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	PIT Y - 654107	----	----	----	----
			Client sampling date / time	16-Feb-2018 00:00	----	----	----	----
Compound	CAS Number	LOR	Unit	EB1804470-006	--------	--------	--------	--------
				Result	----	----	----	----
EP003TC: Total Carbon (TC) in Soil - Continued								
Total Carbon	TC	0.02	%	**0.66**	----	----	----	----
EP003TIC: Total inorganic Carbon (TIC) in Soil								
Total Inorganic Carbon	----	0.02	%	**0.23**	----	----	----	----
Sample Preparation Method								
Amount	----	0.1	g	**1.0**	----	----	----	----

BR18039589 - Finalized
CLIENT : "ALSENV - ALS Environmental"
# of SAMPLES : 6
DATE RECEIVED : 2018-02-22 DATE FINALIZED : 2018-02-28
PROJECT : "EB1804470"
CERTIFICATE COMMENTS : ""
PO NUMBER : "ME-MS41+B"

	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41
SAMPLE	Al	As	B	Cd	Co	Cr	Cu	Fe	Mn	Mo	Ni	Pb	Sb	Sc	Th	U	Zn
DESCRIPTION	%	ppm	ppm	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
EB1804470-001	1.3	2.5	<10	0.02	11.2	37	13.8	2.13	379	0.3	24.4	7.7	0.11	4.4	4.8	0.62	39
EB1804470-002	2.54	7.5	<10	0.13	16.7	29	39.6	4.41	489	0.24	39.6	15.1	0.17	8.4	4.4	1	88
EB1804470-003	0.96	2.3	<10	0.01	6.5	45	8.8	1.58	142	0.23	16.8	4.5	0.09	2.8	3.4	0.64	23
EB1804470-004	1.37	6.8	<10	0.07	15.8	23	33.9	6.87	1160	0.31	34.8	11.8	0.14	9.4	3.8	0.47	65
EB1804470-005	0.49	2.2	<10	<0.01	1.3	29	7.1	0.61	8	0.22	5.9	5.2	0.13	6.5	2.3	0.4	9
EB1804470-006	1.49	6.7	<10	0.12	22.1	18	48.7	3.27	1340	0.18	40.4	16.9	0.18	7	4.3	0.68	83

A.3.4 Appendix 3iv KLC samples

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **EB1806403**	Page	: 1 of 10
Client	: **RGS ENVIRONMENTAL PTY LTD**	Laboratory	: Environmental Division Brisbane
Contact	: MR ALAN ROBERTSON	Contact	: Customer Services EB
Address	: PO Box 3091 SUNNYBANK SOUTH QLD, AUSTRALIA 4109	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: +61 07 3344 1222	Telephone	: +61-7-3243 7222
Project	: 2017041 - Ensham Project	Date Samples Received	: 09-Mar-2018 17:30
Order number	: 439936765	Date Analysis Commenced	: 12-Mar-2018
C-O-C number	: ----	Issue Date	: 20-Mar-2018 10:20
Sampler	: MARY MACELROY		
Site	: ----		
Quote number	: EN/222/17		
No. of samples received	: 18		
No. of samples analysed	: 18		

NATA

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

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

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

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

Signatories

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

Signatories	*Position*	*Accreditation Category*
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

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

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

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

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

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

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

- EG020-F (Dissolved Metals by ICP-MS): Limit of reporting raised for some samples due to matrix interference.

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	KLC 1	KLC 2	KLC 3	KLC 4	KLC 5
			Client sampling date / time	09-Mar-2018 00:00	09-Mar-2018 00:00	09-Mar-2018 00:00	09-Mar-2018 00:00	09-Mar-2018 00:00
Compound	CAS Number	LOR	Unit	EB1806403-001	EB1806403-002	EB1806403-003	EB1806403-004	EB1806403-005
				Result	Result	Result	Result	Result
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	8.25	8.15	8.47	8.24	8.14
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	1670	9260	1640	1710	9420
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	11	<1	<1
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	102	188	102	118	177
Total Alkalinity as CaCO3	----	1	mg/L	102	188	113	118	177
ED038A: Acidity								
Acidity as CaCO3	----	1	mg/L	<1	10	<1	1	8
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	160	697	166	176	722
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	375	2770	360	365	2740
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	9	161	9	18	166
Magnesium	7439-95-4	1	mg/L	8	156	8	8	142
Sodium	7440-23-5	1	mg/L	339	1570	312	318	1630
Potassium	7440-09-7	1	mg/L	6	23	6	6	24
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	0.24	0.01	0.14	0.02	<0.01
Antimony	7440-36-0	0.001	mg/L	0.004	0.003	0.004	0.007	0.003
Arsenic	7440-38-2	0.001	mg/L	0.048	0.022	0.043	0.039	0.015
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	0.0004	0.0001	0.0002	0.0002
Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Cobalt	7440-48-4	0.001	mg/L	<0.001	0.002	<0.001	<0.001	0.005
Copper	7440-50-8	0.001	mg/L	0.002	0.001	<0.001	0.001	0.001
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Lithium	7439-93-2	0.001	mg/L	0.006	0.044	0.006	0.007	0.060
Manganese	7439-96-5	0.001	mg/L	0.005	0.049	0.004	0.142	0.259
Molybdenum	7439-98-7	0.001	mg/L	0.120	0.100	0.135	0.150	0.124
Nickel	7440-02-0	0.001	mg/L	<0.001	0.003	<0.001	0.001	0.008
Selenium	7782-49-2	0.01	mg/L	0.08	0.06	0.07	0.08	0.07
Uranium	7440-61-1	0.001	mg/L	0.001	0.008	<0.001	0.001	0.009

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	KLC 1	KLC 2	KLC 3	KLC 4	KLC 5
			Client sampling date / time	09-Mar-2018 00:00	09-Mar-2018 00:00	09-Mar-2018 00:00	09-Mar-2018 00:00	09-Mar-2018 00:00
Compound	CAS Number	LOR	Unit	EB1806403-001	EB1806403-002	EB1806403-003	EB1806403-004	EB1806403-005
				Result	Result	Result	Result	Result
EG020F: Dissolved Metals by ICP-MS - Continued								
Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	7440-66-6	0.005	mg/L	<0.005	**0.018**	<0.005	<0.005	**0.016**
Boron	7440-42-8	0.05	mg/L	**0.08**	**0.21**	**0.10**	**0.07**	**0.23**
Iron	7439-89-6	0.05	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	**0.6**	**0.3**	**0.7**	**0.4**	**0.2**
EN055: Ionic Balance								
Total Anions	----	0.01	meq/L	**15.9**	**96.4**	**15.9**	**16.3**	**95.9**
Total Cations	----	0.01	meq/L	**16.0**	**89.8**	**14.8**	**15.5**	**91.5**
Ionic Balance	----	0.01	%	**0.18**	**3.57**	**3.38**	**2.44**	**2.34**

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	KLC 6	KLC 7	KLC 8	KLC 9	KLC 10
			Client sampling date / time	09-Mar-2018 00:00	09-Mar-2018 00:00	09-Mar-2018 00:00	09-Mar-2018 00:00	09-Mar-2018 00:00
Compound	CAS Number	LOR	Unit	EB1806403-006	EB1806403-007	EB1806403-008	EB1806403-009	EB1806403-010
				Result	Result	Result	Result	Result
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	8.49	7.88	8.13	7.66	8.05
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	1940	2180	11400	7400	2700
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	12	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	138	59	211	43	107
Total Alkalinity as CaCO3	----	1	mg/L	150	59	211	43	107
ED038A: Acidity								
Acidity as CaCO3	----	1	mg/L	<1	4	12	6	4
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	179	178	841	652	345
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	426	563	3460	2130	610
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	11	17	124	90	29
Magnesium	7439-95-4	1	mg/L	7	34	311	201	32
Sodium	7440-23-5	1	mg/L	371	350	1830	1180	608
Potassium	7440-09-7	1	mg/L	7	13	43	66	17
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	0.11	0.02	<0.01	0.08	0.02
Antimony	7440-36-0	0.001	mg/L	0.007	0.017	0.020	<0.001	0.002
Arsenic	7440-38-2	0.001	mg/L	0.105	0.003	0.004	0.001	0.014
Cadmium	7440-43-9	0.0001	mg/L	0.0002	0.0004	0.0029	0.0008	0.0002
Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Cobalt	7440-48-4	0.001	mg/L	<0.001	0.005	0.031	0.035	0.003
Copper	7440-50-8	0.001	mg/L	<0.001	0.002	0.010	0.054	0.002
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Lithium	7439-93-2	0.001	mg/L	0.010	0.026	0.108	0.080	0.023
Manganese	7439-96-5	0.001	mg/L	0.008	0.185	1.08	1.51	0.380
Molybdenum	7439-98-7	0.001	mg/L	0.247	0.019	0.024	0.008	0.158
Nickel	7440-02-0	0.001	mg/L	<0.001	0.003	0.016	0.027	0.008
Selenium	7782-49-2	0.01	mg/L	0.10	0.06	0.10	0.22	0.11
Uranium	7440-61-1	0.001	mg/L	0.002	<0.001	0.002	<0.001	0.002

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	KLC 6	KLC 7	KLC 8	KLC 9	KLC 10
			Client sampling date / time	09-Mar-2018 00:00	09-Mar-2018 00:00	09-Mar-2018 00:00	09-Mar-2018 00:00	09-Mar-2018 00:00
Compound	CAS Number	LOR	Unit	EB1806403-006	EB1806403-007	EB1806403-008	EB1806403-009	EB1806403-010
				Result	Result	Result	Result	Result
EG020F: Dissolved Metals by ICP-MS - Continued								
Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	7440-66-6	0.005	mg/L	<0.005	**0.050**	**0.259**	**0.126**	**0.017**
Boron	7440-42-8	0.05	mg/L	**0.09**	**0.29**	**0.56**	**0.37**	**0.31**
Iron	7439-89-6	0.05	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	**0.5**	**1.2**	**1.3**	**0.8**	**0.6**
EN055: Ionic Balance								
Total Anions	----	0.01	meq/L	**18.7**	**20.8**	**119**	**74.5**	**26.5**
Total Cations	----	0.01	meq/L	**17.4**	**19.2**	**112**	**74.0**	**31.0**
Ionic Balance	----	0.01	%	**3.59**	**3.91**	**2.95**	**0.32**	**7.71**

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	KLC 11	KLC 12	KLC 13	KLC 14	KLC 15
			Client sampling date / time	09-Mar-2018 00:00	09-Mar-2018 00:00	09-Mar-2018 00:00	09-Mar-2018 00:00	09-Mar-2018 00:00
Compound	CAS Number	LOR	Unit	EB1806403-011	EB1806403-012	EB1806403-013	EB1806403-014	EB1806403-015
				Result	Result	Result	Result	Result
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	8.12	8.25	7.50	7.69	7.11
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	10800	2750	30100	42900	87600
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	200	136	57	156	56
Total Alkalinity as CaCO3	----	1	mg/L	200	136	57	156	56
ED038A: Acidity								
Acidity as CaCO3	----	1	mg/L	8	4	17	46	48
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	901	368	742	1680	2350
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	3240	599	10800	15200	36300
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	139	26	1060	1530	3550
Magnesium	7439-95-4	1	mg/L	234	26	1220	1770	4030
Sodium	7440-23-5	1	mg/L	2010	531	3940	6190	11400
Potassium	7440-09-7	1	mg/L	44	15	23	30	52
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	0.10	<0.01	<0.01	<0.05	<0.05
Antimony	7440-36-0	0.001	mg/L	0.003	0.002	<0.001	<0.005	<0.005
Arsenic	7440-38-2	0.001	mg/L	0.020	0.012	0.003	<0.005	<0.005
Cadmium	7440-43-9	0.0001	mg/L	0.0006	0.0002	0.0010	0.0011	0.0048
Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	0.002	<0.005	<0.005
Cobalt	7440-48-4	0.001	mg/L	0.007	0.001	0.004	<0.005	0.013
Copper	7440-50-8	0.001	mg/L	0.005	0.004	0.012	<0.005	0.015
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	<0.001	<0.005	<0.005
Lithium	7439-93-2	0.001	mg/L	0.099	0.021	0.036	0.089	0.098
Manganese	7439-96-5	0.001	mg/L	0.209	0.265	0.126	0.152	0.708
Molybdenum	7439-98-7	0.001	mg/L	0.206	0.196	0.007	<0.005	<0.005
Nickel	7440-02-0	0.001	mg/L	0.006	0.003	0.014	0.018	0.051
Selenium	7782-49-2	0.01	mg/L	0.12	0.10	0.01	<0.05	<0.05
Uranium	7440-61-1	0.001	mg/L	0.006	0.002	0.001	0.010	0.006

Analytical Results

Sub-Matrix: **WATER**
(Matrix: **WATER**)

			Client sample ID	KLC 11	KLC 12	KLC 13	KLC 14	KLC 15
			Client sampling date / time	09-Mar-2018 00:00	09-Mar-2018 00:00	09-Mar-2018 00:00	09-Mar-2018 00:00	09-Mar-2018 00:00
Compound	*CAS Number*	*LOR*	*Unit*	**EB1806403-011**	**EB1806403-012**	**EB1806403-013**	**EB1806403-014**	**EB1806403-015**
				Result	Result	Result	Result	Result
EG020F: Dissolved Metals by ICP-MS - Continued								
Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.05	<0.05
Zinc	7440-66-6	0.005	mg/L	**0.034**	**0.014**	**0.072**	**0.036**	**0.140**
Boron	7440-42-8	0.05	mg/L	**0.50**	**0.33**	**0.36**	**0.52**	**0.48**
Iron	7439-89-6	0.05	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	**0.5**	**0.7**	**0.4**	**0.3**	**0.2**
EN055: Ionic Balance								
Total Anions	----	0.01	meq/L	**114**	**27.3**	**321**	**467**	**1070**
Total Cations	----	0.01	meq/L	**115**	**26.9**	**325**	**492**	**1010**
Ionic Balance	----	0.01	%	**0.26**	**0.66**	**0.62**	**2.62**	**3.27**

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	KLC 16	KLC 17	KLC 18	----	----
			Client sampling date / time	09-Mar-2018 00:00	09-Mar-2018 00:00	09-Mar-2018 00:00	----	----
Compound	CAS Number	LOR	Unit	EB1806403-016	EB1806403-017	EB1806403-018	--------	--------
				Result	Result	Result	----	----
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	7.75	7.93	7.90	----	----
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	2420	9610	1780	----	----
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	<1	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	41	131	58	----	----
Total Alkalinity as CaCO3	----	1	mg/L	41	131	58	----	----
ED038A: Acidity								
Acidity as CaCO3	----	1	mg/L	4	6	3	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	1150	1500	747	----	----
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	86	2690	51	----	----
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	145	472	85	----	----
Magnesium	7439-95-4	1	mg/L	113	386	63	----	----
Sodium	7440-23-5	1	mg/L	233	997	188	----	----
Potassium	7440-09-7	1	mg/L	28	62	24	----	----
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	0.07	<0.01	<0.01	----	----
Antimony	7440-36-0	0.001	mg/L	<0.001	<0.001	<0.001	----	----
Arsenic	7440-38-2	0.001	mg/L	0.003	0.002	0.002	----	----
Cadmium	7440-43-9	0.0001	mg/L	0.0002	0.0002	<0.0001	----	----
Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	<0.001	----	----
Cobalt	7440-48-4	0.001	mg/L	0.006	0.003	0.003	----	----
Copper	7440-50-8	0.001	mg/L	0.032	0.003	0.002	----	----
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	<0.001	----	----
Lithium	7439-93-2	0.001	mg/L	0.022	0.061	0.019	----	----
Manganese	7439-96-5	0.001	mg/L	0.291	0.356	0.256	----	----
Molybdenum	7439-98-7	0.001	mg/L	0.004	0.005	0.005	----	----
Nickel	7440-02-0	0.001	mg/L	0.010	0.008	0.006	----	----
Selenium	7782-49-2	0.01	mg/L	0.15	0.11	0.12	----	----
Uranium	7440-61-1	0.001	mg/L	0.001	0.008	<0.001	----	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	KLC 16	KLC 17	KLC 18	----	----
			Client sampling date / time	09-Mar-2018 00:00	09-Mar-2018 00:00	09-Mar-2018 00:00	----	----
Compound	CAS Number	LOR	Unit	EB1806403-016	EB1806403-017	EB1806403-018	--------	--------
				Result	Result	Result	----	----
EG020F: Dissolved Metals by ICP-MS - Continued								
Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	<0.01	----	----
Zinc	7440-66-6	0.005	mg/L	**0.020**	**0.020**	**0.015**	----	----
Boron	7440-42-8	0.05	mg/L	**0.07**	**0.11**	**0.07**	----	----
Iron	7439-89-6	0.05	mg/L	<0.05	<0.05	<0.05	----	----
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	**0.5**	**0.3**	**0.5**	----	----
EN055: Ionic Balance								
Total Anions	----	0.01	meq/L	**27.2**	**110**	**18.2**	----	----
Total Cations	----	0.01	meq/L	**27.4**	**100**	**18.2**	----	----
Ionic Balance	----	0.01	%	**0.36**	**4.50**	**0.19**	----	----

CERTIFICATE OF ANALYSIS

Work Order	: **EB1807004**	Page	: 1 of 10
Client	: **RGS ENVIRONMENTAL PTY LTD**	Laboratory	: Environmental Division Brisbane
Contact	: MR ALAN ROBERTSON	Contact	: Customer Services EB
Address	: PO Box 3091 SUNNYBANK SOUTH QLD, AUSTRALIA 4109	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: +61 07 3344 1222	Telephone	: +61-7-3243 7222
Project	: 2017041 - Ensham Project	Date Samples Received	: 16-Mar-2018 16:30
Order number	:	Date Analysis Commenced	: 19-Mar-2018
C-O-C number	: ----	Issue Date	: 22-Mar-2018 16:20
Sampler	: MARY MACELROY		
Site	: ----		
Quote number	: EN/222/17		
No. of samples received	: 17		
No. of samples analysed	: 17		

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

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

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

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

Signatories

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

Signatories	*Position*	*Accreditation Category*
Andrew Epps	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

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

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

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

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

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

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

- EG020-F (Dissolved Metals by ICP-MS): Limit of reporting raised due to matrix interference.

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	KLC 1	KLC 2	KLC 3	KLC 4	KLC 5
			Client sampling date / time	16-Mar-2018 00:00	16-Mar-2018 00:00	16-Mar-2018 00:00	16-Mar-2018 00:00	16-Mar-2018 00:00
Compound	CAS Number	LOR	Unit	EB1807004-001	EB1807004-002	EB1807004-003	EB1807004-004	EB1807004-005
				Result	Result	Result	Result	Result
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	7.80	7.61	8.29	8.05	7.53
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	1640	9230	1690	1990	9410
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	4	<1	<1
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	138	150	167	206	174
Total Alkalinity as CaCO3	----	1	mg/L	138	150	171	206	174
ED038A: Acidity								
Acidity as CaCO3	----	1	mg/L	<1	1	<1	<1	1
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	185	738	186	190	750
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	350	2870	355	412	2880
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	9	176	10	16	186
Magnesium	7439-95-4	1	mg/L	8	161	9	8	136
Sodium	7440-23-5	1	mg/L	309	1520	314	374	1580
Potassium	7440-09-7	1	mg/L	8	22	6	7	25
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	0.10	<0.01	0.07	0.02	<0.01
Antimony	7440-36-0	0.001	mg/L	0.004	0.003	0.004	0.009	0.003
Arsenic	7440-38-2	0.001	mg/L	0.038	0.011	0.037	0.042	0.013
Cadmium	7440-43-9	0.0001	mg/L	0.0001	0.0004	0.0002	0.0002	0.0003
Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	<0.001	0.002	<0.001
Cobalt	7440-48-4	0.001	mg/L	<0.001	0.002	<0.001	<0.001	0.004
Copper	7440-50-8	0.001	mg/L	0.002	0.002	0.002	0.002	0.002
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Lithium	7439-93-2	0.001	mg/L	0.007	0.039	0.007	0.010	0.053
Manganese	7439-96-5	0.001	mg/L	0.006	0.070	0.006	0.033	0.172
Molybdenum	7439-98-7	0.001	mg/L	0.121	0.116	0.167	0.248	0.151
Nickel	7440-02-0	0.001	mg/L	<0.001	0.003	<0.001	<0.001	0.008
Selenium	7782-49-2	0.01	mg/L	0.08	0.09	0.08	0.11	0.10
Uranium	7440-61-1	0.001	mg/L	0.001	0.006	0.001	0.003	0.009

Analytical Results

Sub-Matrix: **WATER**
(Matrix: **WATER**)

			Client sample ID	KLC 1	KLC 2	KLC 3	KLC 4	KLC 5
			Client sampling date / time	16-Mar-2018 00:00	16-Mar-2018 00:00	16-Mar-2018 00:00	16-Mar-2018 00:00	16-Mar-2018 00:00
Compound	*CAS Number*	*LOR*	*Unit*	**EB1807004-001**	**EB1807004-002**	**EB1807004-003**	**EB1807004-004**	**EB1807004-005**
				Result	Result	Result	Result	Result
EG020F: Dissolved Metals by ICP-MS - Continued								
Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	7440-66-6	0.005	mg/L	<0.005	**0.018**	<0.005	<0.005	**0.020**
Boron	7440-42-8	0.05	mg/L	**0.10**	**0.20**	**0.11**	**0.10**	**0.22**
Iron	7439-89-6	0.05	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	**0.7**	**0.3**	**0.8**	**0.5**	**0.2**
EN055: Ionic Balance								
Total Anions	----	0.01	meq/L	**16.5**	**99.3**	**17.3**	**19.7**	**100**
Total Cations	----	0.01	meq/L	**14.8**	**88.7**	**15.0**	**17.9**	**89.8**
Ionic Balance	----	0.01	%	**5.54**	**5.64**	**6.96**	**4.76**	**5.52**

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	KLC 6	KLC 7	KLC 8	KLC 9	KLC 10
			Client sampling date / time	16-Mar-2018 00:00	16-Mar-2018 00:00	16-Mar-2018 00:00	16-Mar-2018 00:00	16-Mar-2018 00:00
Compound	CAS Number	LOR	Unit	EB1807004-006	EB1807004-007	EB1807004-008	EB1807004-009	EB1807004-010
				Result	Result	Result	Result	Result
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	8.27	7.45	7.64	7.35	7.92
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	1930	2710	13100	7780	3100
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	2	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	216	141	233	125	280
Total Alkalinity as CaCO3	----	1	mg/L	217	141	233	125	280
ED038A: Acidity								
Acidity as CaCO3	----	1	mg/L	<1	1	2	2	<1
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	199	200	1060	712	370
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	387	693	4280	2350	652
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	12	20	167	87	19
Magnesium	7439-95-4	1	mg/L	8	46	402	205	28
Sodium	7440-23-5	1	mg/L	372	439	1960	1200	564
Potassium	7440-09-7	1	mg/L	7	17	53	40	17
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	0.10	<0.01	<0.01	0.01	0.01
Antimony	7440-36-0	0.001	mg/L	0.008	0.022	0.028	0.001	0.003
Arsenic	7440-38-2	0.001	mg/L	0.084	0.002	0.004	<0.001	0.011
Cadmium	7440-43-9	0.0001	mg/L	0.0003	0.0004	0.0027	0.0005	0.0002
Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Cobalt	7440-48-4	0.001	mg/L	<0.001	0.007	0.045	0.023	<0.001
Copper	7440-50-8	0.001	mg/L	0.001	0.004	0.012	0.004	0.002
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Lithium	7439-93-2	0.001	mg/L	0.010	0.036	0.128	0.085	0.028
Manganese	7439-96-5	0.001	mg/L	0.010	0.337	1.65	1.37	0.061
Molybdenum	7439-98-7	0.001	mg/L	0.255	0.020	0.028	0.017	0.165
Nickel	7440-02-0	0.001	mg/L	0.001	0.004	0.024	0.011	0.001
Selenium	7782-49-2	0.01	mg/L	0.10	0.07	0.18	0.23	0.11
Uranium	7440-61-1	0.001	mg/L	0.002	<0.001	0.003	0.001	0.003

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	KLC 6	KLC 7	KLC 8	KLC 9	KLC 10
			Client sampling date / time	16-Mar-2018 00:00	16-Mar-2018 00:00	16-Mar-2018 00:00	16-Mar-2018 00:00	16-Mar-2018 00:00
Compound	CAS Number	LOR	Unit	EB1807004-006	EB1807004-007	EB1807004-008	EB1807004-009	EB1807004-010
				Result	Result	Result	Result	Result
EG020F: Dissolved Metals by ICP-MS - Continued								
Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	7440-66-6	0.005	mg/L	<0.005	**0.060**	**0.334**	**0.082**	**0.011**
Boron	7440-42-8	0.05	mg/L	**0.10**	**0.41**	**0.64**	**0.46**	**0.42**
Iron	7439-89-6	0.05	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	**0.6**	**1.7**	**1.6**	**1.3**	**0.8**
EN055: Ionic Balance								
Total Anions	----	0.01	meq/L	**19.4**	**26.5**	**147**	**83.6**	**31.7**
Total Cations	----	0.01	meq/L	**17.6**	**24.3**	**128**	**74.4**	**28.2**
Ionic Balance	----	0.01	%	**4.80**	**4.36**	**7.05**	**5.81**	**5.79**

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	KLC 11	KLC 12	KLC 13	KLC 15	KLC 16
			Client sampling date / time	16-Mar-2018 00:00	16-Mar-2018 00:00	16-Mar-2018 00:00	16-Mar-2018 00:00	16-Mar-2018 00:00
Compound	CAS Number	LOR	Unit	EB1807004-011	EB1807004-012	EB1807004-013	EB1807004-015	EB1807004-016
				Result	Result	Result	Result	Result
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	7.69	7.91	7.39	7.22	7.52
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	10500	3130	34600	46500	2350
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	222	230	120	132	113
Total Alkalinity as CaCO3	----	1	mg/L	222	230	120	132	113
ED038A: Acidity								
Acidity as CaCO3	----	1	mg/L	<1	<1	15	22	1
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	918	388	930	1900	1110
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	3180	672	12700	17100	50
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	138	20	1340	1830	145
Magnesium	7439-95-4	1	mg/L	211	27	1420	2040	109
Sodium	7440-23-5	1	mg/L	1700	554	4010	6630	218
Potassium	7440-09-7	1	mg/L	40	17	26	30	29
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	0.02	0.01	<0.01	<0.05	0.02
Antimony	7440-36-0	0.001	mg/L	0.003	0.003	<0.001	<0.005	<0.001
Arsenic	7440-38-2	0.001	mg/L	0.015	0.009	0.002	<0.005	0.003
Cadmium	7440-43-9	0.0001	mg/L	0.0005	0.0003	0.0008	0.0015	<0.0001
Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	0.002	<0.005	<0.001
Cobalt	7440-48-4	0.001	mg/L	0.007	<0.001	0.003	<0.005	<0.001
Copper	7440-50-8	0.001	mg/L	0.003	0.003	0.009	0.013	0.010
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	<0.001	<0.005	<0.001
Lithium	7439-93-2	0.001	mg/L	0.093	0.026	0.042	0.065	0.022
Manganese	7439-96-5	0.001	mg/L	0.206	0.070	0.115	0.339	0.019
Molybdenum	7439-98-7	0.001	mg/L	0.165	0.254	0.007	<0.005	0.006
Nickel	7440-02-0	0.001	mg/L	0.006	<0.001	0.013	0.030	0.001
Selenium	7782-49-2	0.01	mg/L	0.10	0.10	0.02	<0.05	0.13
Uranium	7440-61-1	0.001	mg/L	0.006	0.003	0.006	0.007	0.001

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	KLC 11	KLC 12	KLC 13	KLC 15	KLC 16
			Client sampling date / time	16-Mar-2018 00:00	16-Mar-2018 00:00	16-Mar-2018 00:00	16-Mar-2018 00:00	16-Mar-2018 00:00
Compound	CAS Number	LOR	Unit	EB1807004-011	EB1807004-012	EB1807004-013	EB1807004-015	EB1807004-016
				Result	Result	Result	Result	Result
EG020F: Dissolved Metals by ICP-MS - Continued								
Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.05	<0.01
Zinc	7440-66-6	0.005	mg/L	**0.024**	**0.013**	**0.038**	**0.083**	**0.018**
Boron	7440-42-8	0.05	mg/L	**0.58**	**0.42**	**0.67**	**0.84**	**0.10**
Iron	7439-89-6	0.05	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	**0.5**	**1.0**	**0.5**	**0.4**	**0.7**
EN055: Ionic Balance								
Total Anions	----	0.01	meq/L	**113**	**31.6**	**380**	**524**	**26.8**
Total Cations	----	0.01	meq/L	**99.2**	**27.8**	**359**	**548**	**26.4**
Ionic Balance	----	0.01	%	**6.60**	**6.53**	**2.87**	**2.22**	**0.65**

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	KLC 17	KLC 18	----	----	----
			Client sampling date / time	16-Mar-2018 00:00	16-Mar-2018 00:00	----	----	----
Compound	CAS Number	LOR	Unit	EB1807004-017	EB1807004-018	--------	--------	--------
				Result	Result	----	----	----
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	7.49	7.49	----	----	----
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	9550	1990	----	----	----
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as $CaCO_3$	DMO-210-001	1	mg/L	<1	<1	----	----	----
Carbonate Alkalinity as $CaCO_3$	3812-32-6	1	mg/L	<1	<1	----	----	----
Bicarbonate Alkalinity as $CaCO_3$	71-52-3	1	mg/L	148	103	----	----	----
Total Alkalinity as $CaCO_3$	----	1	mg/L	148	103	----	----	----
ED038A: Acidity								
Acidity as $CaCO_3$	----	1	mg/L	3	<1	----	----	----
ED041G: Sulfate (Turbidimetric) as SO_4 2- by DA								
Sulfate as SO_4 - Turbidimetric	14808-79-8	1	mg/L	1550	836	----	----	----
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	2690	53	----	----	----
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	493	98	----	----	----
Magnesium	7439-95-4	1	mg/L	399	77	----	----	----
Sodium	7440-23-5	1	mg/L	938	206	----	----	----
Potassium	7440-09-7	1	mg/L	64	28	----	----	----
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	<0.01	<0.01	----	----	----
Antimony	7440-36-0	0.001	mg/L	<0.001	<0.001	----	----	----
Arsenic	7440-38-2	0.001	mg/L	0.002	0.002	----	----	----
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	----	----	----
Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	----	----	----
Cobalt	7440-48-4	0.001	mg/L	<0.001	<0.001	----	----	----
Copper	7440-50-8	0.001	mg/L	0.003	0.003	----	----	----
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	----	----	----
Lithium	7439-93-2	0.001	mg/L	0.058	0.022	----	----	----
Manganese	7439-96-5	0.001	mg/L	0.040	0.035	----	----	----
Molybdenum	7439-98-7	0.001	mg/L	0.005	0.006	----	----	----
Nickel	7440-02-0	0.001	mg/L	0.003	<0.001	----	----	----
Selenium	7782-49-2	0.01	mg/L	0.13	0.13	----	----	----
Uranium	7440-61-1	0.001	mg/L	0.008	0.001	----	----	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	KLC 17	KLC 18	----	----	----
			Client sampling date / time	16-Mar-2018 00:00	16-Mar-2018 00:00	----	----	----
Compound	CAS Number	LOR	Unit	EB1807004-017	EB1807004-018	--------	--------	--------
				Result	Result	----	----	----
EG020F: Dissolved Metals by ICP-MS - Continued								
Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	----	----	----
Zinc	7440-66-6	0.005	mg/L	**0.016**	**0.016**	----	----	----
Boron	7440-42-8	0.05	mg/L	**0.13**	**0.10**	----	----	----
Iron	7439-89-6	0.05	mg/L	<0.05	<0.05	----	----	----
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	**0.4**	**0.8**	----	----	----
EN055: Ionic Balance								
Total Anions	----	0.01	meq/L	**111**	**21.0**	----	----	----
Total Cations	----	0.01	meq/L	**99.9**	**20.9**	----	----	----
Ionic Balance	----	0.01	%	**5.32**	**0.13**	----	----	----

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **EB1807664**	Page	: 1 of 10
Amendment	: **1**		
Client	: **RGS ENVIRONMENTAL PTY LTD**	Laboratory	: Environmental Division Brisbane
Contact	: MARY MACELROY	Contact	: Customer Services EB
Address	: PO Box 3091 SUNNYBANK SOUTH QLD, AUSTRALIA 4109	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: +61 07 3344 1222	Telephone	: +61-7-3243 7222
Project	: 2017041 - Ensham Project	Date Samples Received	: 23-Mar-2018 16:40
Order number	: 2017041	Date Analysis Commenced	: 28-Mar-2018
C-O-C number	: ----	Issue Date	: 03-May-2018 17:13
Sampler	: MARY MACELROY		
Site	:		
Quote number	: EN/222/17		
No. of samples received	: 17		
No. of samples analysed	: 17		

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

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

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

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

Signatories

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

Signatories	*Position*	*Accreditation Category*
Andrew Epps	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

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

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

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

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

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

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

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	KLC 1	KLC 2	KLC 3	KLC 4	KLC 5
			Client sampling date / time	09-Mar-2018 00:00	09-Mar-2018 00:00	09-Mar-2018 00:00	09-Mar-2018 00:00	09-Mar-2018 00:00
Compound	CAS Number	LOR	Unit	EB1807664-001	EB1807664-002	EB1807664-003	EB1807664-004	EB1807664-005
				Result	Result	Result	Result	Result
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	8.76	8.54	8.81	8.79	8.49
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	1600	9520	1710	1930	9630
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	35	28	36	48	29
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	156	131	150	228	168
Total Alkalinity as CaCO3	----	1	mg/L	191	159	185	275	197
ED038A: Acidity								
Acidity as CaCO3	----	1	mg/L	<1	6	<1	<1	8
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	153	740	158	171	730
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	276	2630	313	321	2660
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	8	178	10	14	189
Magnesium	7439-95-4	1	mg/L	7	165	9	8	136
Sodium	7440-23-5	1	mg/L	292	1580	325	371	1650
Potassium	7440-09-7	1	mg/L	8	22	6	7	25
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	0.04	<0.01	0.08	0.02	<0.01
Antimony	7440-36-0	0.001	mg/L	0.005	0.003	0.004	0.009	0.004
Arsenic	7440-38-2	0.001	mg/L	0.036	0.010	0.036	0.046	0.016
Cadmium	7440-43-9	0.0001	mg/L	0.0002	0.0003	0.0002	0.0003	0.0003
Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Copper	7440-50-8	0.001	mg/L	0.004	0.005	0.003	0.004	0.004
Cobalt	7440-48-4	0.001	mg/L	<0.001	0.002	<0.001	<0.001	0.005
Nickel	7440-02-0	0.001	mg/L	<0.001	0.003	<0.001	0.001	0.008
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Zinc	7440-66-6	0.005	mg/L	0.005	0.012	<0.005	<0.005	0.015
Lithium	7439-93-2	0.001	mg/L	0.007	0.040	0.008	0.011	0.056
Manganese	7439-96-5	0.001	mg/L	0.007	0.071	0.007	0.021	0.162
Molybdenum	7439-98-7	0.001	mg/L	0.136	0.134	0.195	0.268	0.173
Selenium	7782-49-2	0.01	mg/L	0.07	0.08	<0.01	0.04	0.03

Analytical Results

Sub-Matrix: **WATER** (Matrix: **WATER**)			Client sample ID	KLC 1	KLC 2	KLC 3	KLC 4	KLC 5
			Client sampling date / time	09-Mar-2018 00:00	09-Mar-2018 00:00	09-Mar-2018 00:00	09-Mar-2018 00:00	09-Mar-2018 00:00
Compound	CAS Number	LOR	Unit	EB1807664-001	EB1807664-002	EB1807664-003	EB1807664-004	EB1807664-005
				Result	Result	Result	Result	Result
EG020F: Dissolved Metals by ICP-MS - Continued								
Uranium	7440-61-1	0.001	mg/L	**0.002**	**0.006**	**0.002**	**0.003**	**0.008**
Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Boron	7440-42-8	0.05	mg/L	**0.11**	**0.19**	**0.12**	**0.10**	**0.20**
Iron	7439-89-6	0.05	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	**0.7**	**0.3**	**0.8**	**0.5**	**0.2**
EN055: Ionic Balance								
Total Anions	----	0.01	meq/L	**14.8**	**92.8**	**15.8**	**18.1**	**94.2**
Total Cations	----	0.01	meq/L	**13.9**	**91.8**	**15.5**	**17.7**	**93.0**
Ionic Balance	----	0.01	%	**3.16**	**0.55**	**0.91**	**1.22**	**0.61**

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	KLC 6	KLC 7	KLC 8	KLC 9	KLC 10
			Client sampling date / time	09-Mar-2018 00:00	09-Mar-2018 00:00	09-Mar-2018 00:00	09-Mar-2018 00:00	09-Mar-2018 00:00
Compound	CAS Number	LOR	Unit	EB1807664-006	EB1807664-007	EB1807664-008	EB1807664-009	EB1807664-010
				Result	Result	Result	Result	Result
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	8.79	8.16	8.19	8.26	8.58
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	1840	3470	13800	7590	3320
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	42	<1	<1	<1	30
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	213	180	239	200	324
Total Alkalinity as CaCO3	----	1	mg/L	256	180	239	200	354
ED038A: Acidity								
Acidity as CaCO3	----	1	mg/L	<1	8	15	10	3
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	164	257	856	654	376
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	306	833	4090	1990	620
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	11	29	180	85	21
Magnesium	7439-95-4	1	mg/L	7	68	433	199	32
Sodium	7440-23-5	1	mg/L	357	561	2140	1210	631
Potassium	7440-09-7	1	mg/L	7	22	58	41	18
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	0.05	<0.01	<0.01	0.01	0.01
Antimony	7440-36-0	0.001	mg/L	0.008	0.017	0.026	0.002	0.004
Arsenic	7440-38-2	0.001	mg/L	0.068	0.003	0.004	0.001	0.012
Cadmium	7440-43-9	0.0001	mg/L	0.0003	0.0004	0.0025	0.0004	0.0002
Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Copper	7440-50-8	0.001	mg/L	0.002	0.007	0.013	0.006	0.003
Cobalt	7440-48-4	0.001	mg/L	<0.001	0.011	0.053	0.022	<0.001
Nickel	7440-02-0	0.001	mg/L	0.001	0.006	0.027	0.010	0.001
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Zinc	7440-66-6	0.005	mg/L	<0.005	0.076	0.310	0.070	0.010
Lithium	7439-93-2	0.001	mg/L	0.011	0.051	0.148	0.097	0.036
Manganese	7439-96-5	0.001	mg/L	0.009	0.554	1.82	1.28	0.057
Molybdenum	7439-98-7	0.001	mg/L	0.307	0.025	0.032	0.029	0.178
Selenium	7782-49-2	0.01	mg/L	0.01	0.08	0.19	0.22	0.10

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	KLC 6	KLC 7	KLC 8	KLC 9	KLC 10
			Client sampling date / time	09-Mar-2018 00:00	09-Mar-2018 00:00	09-Mar-2018 00:00	09-Mar-2018 00:00	09-Mar-2018 00:00
Compound	CAS Number	LOR	Unit	EB1807664-006	EB1807664-007	EB1807664-008	EB1807664-009	EB1807664-010
				Result	Result	Result	Result	Result
EG020F: Dissolved Metals by ICP-MS - Continued								
Uranium	7440-61-1	0.001	mg/L	**0.003**	<0.001	**0.003**	**0.004**	**0.005**
Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Boron	7440-42-8	0.05	mg/L	**0.10**	**0.42**	**0.68**	**0.54**	**0.50**
Iron	7439-89-6	0.05	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	**0.5**	**1.6**	**1.8**	**1.8**	**0.8**
EN055: Ionic Balance								
Total Anions	----	0.01	meq/L	**17.2**	**32.4**	**138**	**73.7**	**32.4**
Total Cations	----	0.01	meq/L	**16.8**	**32.0**	**139**	**74.3**	**31.6**
Ionic Balance	----	0.01	%	**0.97**	**0.68**	**0.44**	**0.37**	**1.25**

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	KLC 11	KLC 12	KLC 13	KLC 15	KLC 16
			Client sampling date / time	09-Mar-2018 00:00	09-Mar-2018 00:00	09-Mar-2018 00:00	09-Mar-2018 00:00	09-Mar-2018 00:00
Compound	CAS Number	LOR	Unit	EB1807664-011	EB1807664-012	EB1807664-013	EB1807664-014	EB1807664-015
				Result	Result	Result	Result	Result
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	8.11	8.41	7.83	7.82	8.18
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	10500	2920	28000	31900	1810
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	10	<1	<1	<1
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	206	229	138	161	126
Total Alkalinity as CaCO3	----	1	mg/L	206	239	138	161	126
ED038A: Acidity								
Acidity as CaCO3	----	1	mg/L	10	2	24	30	2
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	821	348	868	1390	771
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	2880	569	9390	10500	28
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	126	18	960	927	92
Magnesium	7439-95-4	1	mg/L	206	24	1020	993	71
Sodium	7440-23-5	1	mg/L	1750	540	3570	4260	172
Potassium	7440-09-7	1	mg/L	41	16	22	20	23
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	0.01	0.02	<0.01	<0.01	0.02
Antimony	7440-36-0	0.001	mg/L	0.003	0.004	0.001	<0.001	<0.001
Arsenic	7440-38-2	0.001	mg/L	0.015	0.012	0.002	0.002	0.003
Cadmium	7440-43-9	0.0001	mg/L	0.0004	0.0002	0.0004	0.0005	<0.0001
Chromium	7440-47-3	0.001	mg/L	<0.001	0.001	0.002	0.003	<0.001
Copper	7440-50-8	0.001	mg/L	0.007	0.003	0.012	0.014	0.008
Cobalt	7440-48-4	0.001	mg/L	0.007	<0.001	0.002	0.003	<0.001
Nickel	7440-02-0	0.001	mg/L	0.006	<0.001	0.010	0.013	<0.001
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Zinc	7440-66-6	0.005	mg/L	0.026	0.011	0.032	0.031	0.006
Lithium	7439-93-2	0.001	mg/L	0.095	0.026	0.038	0.039	0.020
Manganese	7439-96-5	0.001	mg/L	0.212	0.045	0.065	0.118	0.003
Molybdenum	7439-98-7	0.001	mg/L	0.160	0.274	0.007	0.003	0.006
Selenium	7782-49-2	0.01	mg/L	0.09	0.04	0.01	0.02	0.07

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	KLC 11	KLC 12	KLC 13	KLC 15	KLC 16
			Client sampling date / time	09-Mar-2018 00:00	09-Mar-2018 00:00	09-Mar-2018 00:00	09-Mar-2018 00:00	09-Mar-2018 00:00
Compound	CAS Number	LOR	Unit	EB1807664-011	EB1807664-012	EB1807664-013	EB1807664-014	EB1807664-015
				Result	Result	Result	Result	Result
EG020F: Dissolved Metals by ICP-MS - Continued								
Uranium	7440-61-1	0.001	mg/L	**0.006**	**0.004**	**0.008**	**0.009**	**0.002**
Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Boron	7440-42-8	0.05	mg/L	**0.58**	**0.44**	**0.75**	**0.78**	**0.10**
Iron	7439-89-6	0.05	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	**0.5**	**1.0**	**0.7**	**0.6**	**0.7**
EN055: Ionic Balance								
Total Anions	----	0.01	meq/L	**102**	**28.1**	**286**	**328**	**19.4**
Total Cations	----	0.01	meq/L	**100**	**26.8**	**288**	**314**	**18.5**
Ionic Balance	----	0.01	%	**1.00**	**2.37**	**0.35**	**2.27**	**2.26**

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	KLC 17	KLC 18	----	----	----
			Client sampling date / time	09-Mar-2018 00:00	09-Mar-2018 00:00	----	----	----
Compound	CAS Number	LOR	Unit	EB1807664-016	EB1807664-017	--------	--------	--------
				Result	Result	----	----	----
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	**8.01**	**8.16**	----	----	----
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	**9550**	**1920**	----	----	----
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	----	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	----	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	**150**	**125**	----	----	----
Total Alkalinity as CaCO3	----	1	mg/L	**150**	**125**	----	----	----
ED038A: Acidity								
Acidity as CaCO3	----	1	mg/L	**13**	**3**	----	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	**1420**	**766**	----	----	----
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	**2530**	**44**	----	----	----
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	**460**	**94**	----	----	----
Magnesium	7439-95-4	1	mg/L	**372**	**75**	----	----	----
Sodium	7440-23-5	1	mg/L	**989**	**209**	----	----	----
Potassium	7440-09-7	1	mg/L	**63**	**28**	----	----	----
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	<0.01	<0.01	----	----	----
Antimony	7440-36-0	0.001	mg/L	<0.001	<0.001	----	----	----
Arsenic	7440-38-2	0.001	mg/L	**0.002**	**0.002**	----	----	----
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	----	----	----
Chromium	7440-47-3	0.001	mg/L	<0.001	**0.001**	----	----	----
Copper	7440-50-8	0.001	mg/L	**0.004**	**0.003**	----	----	----
Cobalt	7440-48-4	0.001	mg/L	<0.001	<0.001	----	----	----
Nickel	7440-02-0	0.001	mg/L	**0.002**	<0.001	----	----	----
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	----	----	----
Zinc	7440-66-6	0.005	mg/L	**0.014**	**0.012**	----	----	----
Lithium	7439-93-2	0.001	mg/L	**0.063**	**0.025**	----	----	----
Manganese	7439-96-5	0.001	mg/L	**0.011**	**0.005**	----	----	----
Molybdenum	7439-98-7	0.001	mg/L	**0.005**	**0.007**	----	----	----
Selenium	7782-49-2	0.01	mg/L	**0.10**	**0.12**	----	----	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	KLC 17	KLC 18	----	----	----
			Client sampling date / time	09-Mar-2018 00:00	09-Mar-2018 00:00	----	----	----
Compound	CAS Number	LOR	Unit	EB1807664-016	EB1807664-017	--------	--------	--------
				Result	Result	----	----	----
EG020F: Dissolved Metals by ICP-MS - Continued								
Uranium	7440-61-1	0.001	mg/L	**0.008**	**0.002**	----	----	----
Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	----	----	----
Boron	7440-42-8	0.05	mg/L	**0.14**	**0.11**	----	----	----
Iron	7439-89-6	0.05	mg/L	<0.05	<0.05	----	----	----
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	**0.4**	**0.8**	----	----	----
EN055: Ionic Balance								
Total Anions	----	0.01	meq/L	**104**	**19.7**	----	----	----
Total Cations	----	0.01	meq/L	**98.2**	**20.7**	----	----	----
Ionic Balance	----	0.01	%	**2.83**	**2.44**	----	----	----

CERTIFICATE OF ANALYSIS

Work Order	: **EB1808044**	Page	: 1 of 8
Client	: **RGS ENVIRONMENTAL PTY LTD**	Laboratory	: Environmental Division Brisbane
Contact	: MR ALAN ROBERTSON	Contact	: Customer Services EB
Address	: PO Box 3091 SUNNYBANK SOUTH QLD, AUSTRALIA 4109	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: +61 07 3344 1222	Telephone	: +61-7-3243 7222
Project	: 2017041 - Ensham Project	Date Samples Received	: 28-Mar-2018 13:30
Order number	:	Date Analysis Commenced	: 29-Mar-2018
C-O-C number	: ----	Issue Date	: 06-Apr-2018 14:09
Sampler	: MARY MACELROY		
Site	: ----		
Quote number	: EN/222/17		
No. of samples received	: 12		
No. of samples analysed	: 12		

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

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

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- General Comments
- Analytical Results

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

Signatories

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

Signatories	*Position*	*Accreditation Category*
Andrew Epps	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

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Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.

LOR = Limit of reporting

^ = This result is computed from individual analyte detections at or above the level of reporting

ø = ALS is not NATA accredited for these tests.

~ = Indicates an estimated value.

Analytical Results

Sub-Matrix: LEACHATE (Matrix: WATER)			Client sample ID	KLC 1	KLC 3	KLC 4	KLC 5	KLC 7
			Client sampling date / time	28-Mar-2018 00:00	28-Mar-2018 00:00	28-Mar-2018 00:00	28-Mar-2018 00:00	28-Mar-2018 00:00
Compound	CAS Number	LOR	Unit	EB1808044-001	EB1808044-002	EB1808044-003	EB1808044-004	EB1808044-005
				Result	Result	Result	Result	Result
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	8.31	8.36	8.50	7.95	8.10
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	1250	1610	1580	9310	2450
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	2	4	17	<1	<1
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	163	176	273	182	149
Total Alkalinity as CaCO3	----	1	mg/L	165	180	290	182	149
ED038A: Acidity								
Acidity as CaCO3	----	1	mg/L	<1	<1	<1	<1	<1
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	136	152	143	694	162
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	201	292	232	2600	596
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	6	9	10	184	19
Magnesium	7439-95-4	1	mg/L	6	8	6	135	47
Sodium	7440-23-5	1	mg/L	248	305	324	1600	404
Potassium	7440-09-7	1	mg/L	4	6	6	25	17
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	0.06	0.24	0.02	0.01	<0.01
Antimony	7440-36-0	0.001	mg/L	0.004	0.005	0.009	0.003	0.011
Arsenic	7440-38-2	0.001	mg/L	0.037	0.037	0.062	0.022	0.002
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	0.0002	0.0002	0.0005	0.0002
Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Copper	7440-50-8	0.001	mg/L	0.003	0.002	0.001	0.005	0.002
Cobalt	7440-48-4	0.001	mg/L	<0.001	<0.001	<0.001	0.006	0.008
Nickel	7440-02-0	0.001	mg/L	<0.001	<0.001	<0.001	0.008	0.004
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Zinc	7440-66-6	0.005	mg/L	<0.005	<0.005	<0.005	0.012	0.034
Lithium	7439-93-2	0.001	mg/L	0.007	0.008	0.012	0.060	0.042
Manganese	7439-96-5	0.001	mg/L	0.006	0.009	0.015	0.162	0.391
Molybdenum	7439-98-7	0.001	mg/L	0.108	0.194	0.230	0.172	0.014
Selenium	7782-49-2	0.01	mg/L	0.06	<0.01	0.02	0.01	0.06

Analytical Results

Sub-Matrix: LEACHATE (Matrix: WATER)			Client sample ID	KLC 1	KLC 3	KLC 4	KLC 5	KLC 7
			Client sampling date / time	28-Mar-2018 00:00	28-Mar-2018 00:00	28-Mar-2018 00:00	28-Mar-2018 00:00	28-Mar-2018 00:00
Compound	CAS Number	LOR	Unit	EB1808044-001	EB1808044-002	EB1808044-003	EB1808044-004	EB1808044-005
				Result	Result	Result	Result	Result
EG020F: Dissolved Metals by ICP-MS - Continued								
Uranium	7440-61-1	0.001	mg/L	**0.002**	**0.002**	**0.003**	**0.009**	<0.001
Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Boron	7440-42-8	0.05	mg/L	**0.11**	**0.14**	**0.12**	**0.21**	**0.33**
Iron	7439-89-6	0.05	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	**0.6**	**0.8**	**0.5**	**0.2**	**1.2**
EN055: Ionic Balance								
Total Anions	----	0.01	meq/L	**11.8**	**15.0**	**15.3**	**91.4**	**23.2**
Total Cations	----	0.01	meq/L	**11.7**	**14.5**	**15.2**	**90.5**	**22.8**
Ionic Balance	----	0.01	%	**0.49**	**1.59**	**0.25**	**0.50**	**0.74**

Analytical Results

Sub-Matrix: LEACHATE (Matrix: WATER)			Client sample ID	KLC 8	KLC 10	KLC 11	KLC 12	KLC 16
			Client sampling date / time	28-Mar-2018 00:00	28-Mar-2018 00:00	28-Mar-2018 00:00	28-Mar-2018 00:00	28-Mar-2018 00:00
Compound	CAS Number	LOR	Unit	EB1808044-006	EB1808044-007	EB1808044-008	EB1808044-009	EB1808044-010
				Result	Result	Result	Result	Result
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	8.04	8.31	8.04	8.34	8.17
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	12800	2620	9920	2600	1300
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	4	<1	9	<1
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	263	369	228	253	138
Total Alkalinity as CaCO3	----	1	mg/L	263	372	228	263	138
ED038A: Acidity								
Acidity as CaCO3	----	1	mg/L	<1	<1	<1	<1	<1
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	975	301	754	292	451
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	3850	465	2810	485	17
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	166	15	119	14	63
Magnesium	7439-95-4	1	mg/L	403	24	202	22	52
Sodium	7440-23-5	1	mg/L	1970	515	1710	486	133
Potassium	7440-09-7	1	mg/L	54	15	40	15	20
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	<0.01	0.01	0.01	0.02	0.02
Antimony	7440-36-0	0.001	mg/L	0.024	0.004	0.003	0.004	<0.001
Arsenic	7440-38-2	0.001	mg/L	0.004	0.014	0.015	0.014	0.004
Cadmium	7440-43-9	0.0001	mg/L	0.0021	0.0001	0.0005	0.0003	<0.0001
Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Copper	7440-50-8	0.001	mg/L	0.019	0.001	0.005	0.004	0.004
Cobalt	7440-48-4	0.001	mg/L	0.047	<0.001	0.008	<0.001	<0.001
Nickel	7440-02-0	0.001	mg/L	0.023	<0.001	0.006	<0.001	<0.001
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Zinc	7440-66-6	0.005	mg/L	0.254	<0.005	0.020	0.006	<0.005
Lithium	7439-93-2	0.001	mg/L	0.152	0.035	0.107	0.028	0.020
Manganese	7439-96-5	0.001	mg/L	1.74	0.035	0.203	0.037	0.002
Molybdenum	7439-98-7	0.001	mg/L	0.032	0.152	0.149	0.281	0.010
Selenium	7782-49-2	0.01	mg/L	0.15	0.04	0.06	0.01	0.05

Analytical Results

Sub-Matrix: LEACHATE (Matrix: WATER)			Client sample ID	KLC 8	KLC 10	KLC 11	KLC 12	KLC 16
			Client sampling date / time	28-Mar-2018 00:00	28-Mar-2018 00:00	28-Mar-2018 00:00	28-Mar-2018 00:00	28-Mar-2018 00:00
Compound	CAS Number	LOR	Unit	EB1808044-006	EB1808044-007	EB1808044-008	EB1808044-009	EB1808044-010
				Result	Result	Result	Result	Result
EG020F: Dissolved Metals by ICP-MS - Continued								
Uranium	7440-61-1	0.001	mg/L	**0.004**	**0.004**	**0.006**	**0.004**	**0.002**
Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Boron	7440-42-8	0.05	mg/L	**0.64**	**0.47**	**0.61**	**0.44**	**0.12**
Iron	7439-89-6	0.05	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	**1.1**	**0.6**	**0.8**	**0.8**	**0.7**
EN055: Ionic Balance								
Total Anions	----	0.01	meq/L	**134**	**26.8**	**99.5**	**25.0**	**12.6**
Total Cations	----	0.01	meq/L	**128**	**25.5**	**98.0**	**24.0**	**13.7**
Ionic Balance	----	0.01	%	**2.14**	**2.50**	**0.79**	**2.00**	**4.15**

Analytical Results

Sub-Matrix: LEACHATE (Matrix: WATER)			Client sample ID	KLC 17	KLC 18	----	----	----
			Client sampling date / time	28-Mar-2018 00:00	28-Mar-2018 00:00	----	----	----
Compound	CAS Number	LOR	Unit	EB1808044-011	EB1808044-012	--------	--------	--------
				Result	Result	----	----	----
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	7.92	8.11	----	----	----
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	9130	1710	----	----	----
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	----	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	----	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	164	144	----	----	----
Total Alkalinity as CaCO3	----	1	mg/L	164	144	----	----	----
ED038A: Acidity								
Acidity as CaCO3	----	1	mg/L	2	<1	----	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	1250	588	----	----	----
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	2460	36	----	----	----
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	421	82	----	----	----
Magnesium	7439-95-4	1	mg/L	365	68	----	----	----
Sodium	7440-23-5	1	mg/L	1020	191	----	----	----
Potassium	7440-09-7	1	mg/L	60	26	----	----	----
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	<0.01	0.01	----	----	----
Antimony	7440-36-0	0.001	mg/L	<0.001	<0.001	----	----	----
Arsenic	7440-38-2	0.001	mg/L	0.002	0.002	----	----	----
Cadmium	7440-43-9	0.0001	mg/L	0.0004	<0.0001	----	----	----
Chromium	7440-47-3	0.001	mg/L	<0.001	0.002	----	----	----
Copper	7440-50-8	0.001	mg/L	0.006	0.003	----	----	----
Cobalt	7440-48-4	0.001	mg/L	0.002	<0.001	----	----	----
Nickel	7440-02-0	0.001	mg/L	0.002	<0.001	----	----	----
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	----	----	----
Zinc	7440-66-6	0.005	mg/L	0.016	0.008	----	----	----
Lithium	7439-93-2	0.001	mg/L	0.074	0.027	----	----	----
Manganese	7439-96-5	0.001	mg/L	0.014	0.003	----	----	----
Molybdenum	7439-98-7	0.001	mg/L	0.006	0.008	----	----	----
Selenium	7782-49-2	0.01	mg/L	0.09	0.10	----	----	----

Analytical Results

Sub-Matrix: LEACHATE (Matrix: WATER)			Client sample ID	KLC 17	KLC 18	----	----	----
			Client sampling date / time	28-Mar-2018 00:00	28-Mar-2018 00:00	----	----	----
Compound	CAS Number	LOR	Unit	EB1808044-011	EB1808044-012	--------	--------	--------
				Result	Result	----	----	----
EG020F: Dissolved Metals by ICP-MS - Continued								
Uranium	7440-61-1	0.001	mg/L	**0.008**	**0.003**	----	----	----
Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	----	----	----
Boron	7440-42-8	0.05	mg/L	**0.16**	**0.13**	----	----	----
Iron	7439-89-6	0.05	mg/L	<0.05	<0.05	----	----	----
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	**0.2**	**0.6**	----	----	----
EN055: Ionic Balance								
Total Anions	----	0.01	meq/L	**98.7**	**16.1**	----	----	----
Total Cations	----	0.01	meq/L	**97.0**	**18.7**	----	----	----
Ionic Balance	----	0.01	%	**0.89**	**7.26**	----	----	----

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **EB1808680**	Page	: 1 of 8
Client	: **RGS ENVIRONMENTAL PTY LTD**	Laboratory	: Environmental Division Brisbane
Contact	: MR ALAN ROBERTSON	Contact	: Customer Services EB
Address	: PO Box 3091 SUNNYBANK SOUTH QLD, AUSTRALIA 4109	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: +61 07 3344 1222	Telephone	: +61-7-3243 7222
Project	: 2017041 - Ensham Project	Date Samples Received	: 06-Apr-2018 14:05
Order number	:	Date Analysis Commenced	: 07-Apr-2018
C-O-C number	: ----	Issue Date	: 16-Apr-2018 11:38
Sampler	: MARY MACELROY		
Site	: ----		
Quote number	: EN/222/17		
No. of samples received	: 15		
No. of samples analysed	: 15		

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

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

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

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

Signatories

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

Signatories	*Position*	*Accreditation Category*
Andrew Epps	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Greg Vogel	Laboratory Manager	Brisbane Inorganics, Stafford, QLD
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD

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

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

Analytical Results

Sub-Matrix: LEACHATE (Matrix: WATER)			Client sample ID	KLC 1	KLC 3	KLC 4	KLC 5	KLC 6
			Client sampling date / time	09-Mar-2018 00:00	09-Mar-2018 00:00	09-Mar-2018 00:00	09-Mar-2018 00:00	09-Mar-2018 00:00
Compound	CAS Number	LOR	Unit	EB1808680-001	EB1808680-002	EB1808680-003	EB1808680-004	EB1808680-005
				Result	Result	Result	Result	Result
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	7.90	8.27	8.56	7.81	8.37
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	738	1500	943	9240	1580
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	24	<1	15
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	113	191	212	181	282
Total Alkalinity as CaCO3	----	1	mg/L	113	191	235	181	296
ED038A: Acidity								
Acidity as CaCO3	----	1	mg/L	<1	<1	<1	4	<1
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	77	150	80	735	147
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	97	290	82	3060	268
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	5	8	5	176	10
Magnesium	7439-95-4	1	mg/L	3	7	3	133	6
Sodium	7440-23-5	1	mg/L	151	300	203	1620	340
Potassium	7440-09-7	1	mg/L	2	5	4	23	6
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	0.12	0.39	0.11	<0.01	0.05
Antimony	7440-36-0	0.001	mg/L	0.003	0.005	0.007	0.002	0.009
Arsenic	7440-38-2	0.001	mg/L	0.032	0.036	0.040	0.024	0.054
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	0.0002	0.0001	0.0003	0.0003
Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	0.001
Copper	7440-50-8	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Cobalt	7440-48-4	0.001	mg/L	<0.001	<0.001	<0.001	0.004	<0.001
Nickel	7440-02-0	0.001	mg/L	<0.001	<0.001	<0.001	0.006	0.001
Lead	7439-92-1	0.001	mg/L	0.001	<0.001	<0.001	<0.001	<0.001
Zinc	7440-66-6	0.005	mg/L	<0.005	<0.005	<0.005	0.008	<0.005
Lithium	7439-93-2	0.001	mg/L	0.004	0.007	0.007	0.058	0.012
Manganese	7439-96-5	0.001	mg/L	0.004	0.003	<0.001	0.141	0.008
Molybdenum	7439-98-7	0.001	mg/L	0.054	0.210	0.112	0.162	0.320
Selenium	7782-49-2	0.01	mg/L	0.02	<0.01	0.02	<0.01	<0.01

Analytical Results

Sub-Matrix: **LEACHATE**
(Matrix: **WATER**)

			Client sample ID	KLC 1	KLC 3	KLC 4	KLC 5	KLC 6
			Client sampling date / time	09-Mar-2018 00:00	09-Mar-2018 00:00	09-Mar-2018 00:00	09-Mar-2018 00:00	09-Mar-2018 00:00
Compound	*CAS Number*	*LOR*	*Unit*	EB1808680-001	EB1808680-002	EB1808680-003	EB1808680-004	EB1808680-005
				Result	Result	Result	Result	Result
EG020F: Dissolved Metals by ICP-MS - Continued								
Uranium	7440-61-1	0.001	mg/L	<0.001	**0.002**	**0.001**	**0.007**	**0.003**
Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Boron	7440-42-8	0.05	mg/L	**0.07**	**0.13**	**0.09**	**0.20**	**0.13**
Iron	7439-89-6	0.05	mg/L	<0.05	**0.08**	<0.05	<0.05	<0.05
EG035F: Dissolved Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	**0.5**	**0.8**	**0.5**	**0.2**	**0.6**
EN055: Ionic Balance								
Total Anions	----	0.01	meq/L	**6.60**	**15.1**	**8.67**	**105**	**16.5**
Total Cations	----	0.01	meq/L	**7.12**	**14.2**	**9.43**	**90.8**	**15.9**
Ionic Balance	----	0.01	%	**3.78**	**3.30**	**4.17**	**7.37**	**1.84**

Analytical Results

Sub-Matrix: LEACHATE (Matrix: WATER)			Client sample ID	KLC 7	KLC 8	KLC 9	KLC 10	KLC 11
			Client sampling date / time	09-Mar-2018 00:00	09-Mar-2018 00:00	09-Mar-2018 00:00	09-Mar-2018 00:00	09-Mar-2018 00:00
Compound	CAS Number	LOR	Unit	EB1808680-006	EB1808680-007	EB1808680-008	EB1808680-009	EB1808680-010
				Result	Result	Result	Result	Result
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	7.91	7.89	7.96	8.58	7.91
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	1580	12200	5920	1660	9820
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	<1	32	<1
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	92	264	265	275	231
Total Alkalinity as CaCO3	----	1	mg/L	92	264	265	307	231
ED038A: Acidity								
Acidity as CaCO3	----	1	mg/L	<1	3	<1	<1	1
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	107	1010	605	168	799
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	434	3980	1530	266	3210
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	11	142	57	8	110
Magnesium	7439-95-4	1	mg/L	28	349	138	12	194
Sodium	7440-23-5	1	mg/L	265	1860	990	341	1740
Potassium	7440-09-7	1	mg/L	11	50	32	10	38
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	<0.01	<0.01	<0.01	0.02	<0.01
Antimony	7440-36-0	0.001	mg/L	0.012	0.020	0.001	0.003	0.003
Arsenic	7440-38-2	0.001	mg/L	0.001	0.004	0.001	0.007	0.018
Cadmium	7440-43-9	0.0001	mg/L	0.0001	0.0016	0.0002	<0.0001	0.0003
Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	0.002	<0.001	<0.001
Copper	7440-50-8	0.001	mg/L	0.002	0.014	0.002	<0.001	0.002
Cobalt	7440-48-4	0.001	mg/L	0.004	0.038	0.016	<0.001	0.006
Nickel	7440-02-0	0.001	mg/L	0.002	0.019	0.007	<0.001	0.006
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Zinc	7440-66-6	0.005	mg/L	0.020	0.205	0.045	<0.005	0.018
Lithium	7439-93-2	0.001	mg/L	0.025	0.144	0.090	0.022	0.104
Manganese	7439-96-5	0.001	mg/L	0.247	1.47	0.832	<0.001	0.186
Molybdenum	7439-98-7	0.001	mg/L	0.014	0.034	0.033	0.092	0.138
Selenium	7782-49-2	0.01	mg/L	0.03	0.05	0.03	0.02	0.02

Analytical Results

Sub-Matrix: LEACHATE (Matrix: WATER)			Client sample ID	KLC 7	KLC 8	KLC 9	KLC 10	KLC 11
			Client sampling date / time	09-Mar-2018 00:00	09-Mar-2018 00:00	09-Mar-2018 00:00	09-Mar-2018 00:00	09-Mar-2018 00:00
Compound	CAS Number	LOR	Unit	EB1808680-006	EB1808680-007	EB1808680-008	EB1808680-009	EB1808680-010
				Result	Result	Result	Result	Result
EG020F: Dissolved Metals by ICP-MS - Continued								
Uranium	7440-61-1	0.001	mg/L	<0.001	**0.003**	**0.003**	**0.002**	**0.006**
Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Boron	7440-42-8	0.05	mg/L	**0.26**	**0.64**	**0.53**	**0.36**	**0.58**
Iron	7439-89-6	0.05	mg/L	<0.05	<0.05	<0.05	<0.05	**0.10**
EG035F: Dissolved Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	**1.1**	**1.8**	**1.8**	**0.7**	**0.5**
EN055: Ionic Balance								
Total Anions	----	0.01	meq/L	**16.3**	**138**	**61.0**	**17.1**	**112**
Total Cations	----	0.01	meq/L	**14.7**	**118**	**58.1**	**16.5**	**98.1**
Ionic Balance	----	0.01	%	**5.32**	**8.02**	**2.49**	**1.96**	**6.52**

Analytical Results

Sub-Matrix: LEACHATE (Matrix: WATER)			Client sample ID	KLC 12	KLC 15	KLC 16	KLC 17	KLC 18
			Client sampling date / time	09-Mar-2018 00:00	09-Mar-2018 00:00	09-Mar-2018 00:00	09-Mar-2018 00:00	09-Mar-2018 00:00
Compound	CAS Number	LOR	Unit	EB1808680-011	EB1808680-012	EB1808680-013	EB1808680-014	EB1808680-015
				Result	Result	Result	Result	Result
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	8.25	8.04	8.22	7.80	8.00
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	2270	10500	1060	9110	1590
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	259	348	136	158	144
Total Alkalinity as CaCO3	----	1	mg/L	259	348	136	158	144
ED038A: Acidity								
Acidity as CaCO3	----	1	mg/L	<1	<1	<1	4	<1
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	247	585	376	1160	627
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	462	3420	13	2890	35
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	12	173	47	384	70
Magnesium	7439-95-4	1	mg/L	18	196	39	346	62
Sodium	7440-23-5	1	mg/L	443	1610	118	1070	188
Potassium	7440-09-7	1	mg/L	13	8	17	56	24
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	0.02	<0.01	0.03	<0.01	<0.01
Antimony	7440-36-0	0.001	mg/L	0.004	<0.001	<0.001	<0.001	<0.001
Arsenic	7440-38-2	0.001	mg/L	0.020	0.002	0.002	0.002	0.002
Cadmium	7440-43-9	0.0001	mg/L	0.0003	<0.0001	<0.0001	<0.0001	<0.0001
Chromium	7440-47-3	0.001	mg/L	<0.001	0.006	<0.001	<0.001	<0.001
Copper	7440-50-8	0.001	mg/L	0.001	0.008	0.005	0.001	0.001
Cobalt	7440-48-4	0.001	mg/L	<0.001	0.001	<0.001	<0.001	<0.001
Nickel	7440-02-0	0.001	mg/L	<0.001	0.004	<0.001	0.002	<0.001
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Zinc	7440-66-6	0.005	mg/L	0.005	0.006	<0.005	0.012	0.009
Lithium	7439-93-2	0.001	mg/L	0.023	0.018	0.016	0.069	0.024
Manganese	7439-96-5	0.001	mg/L	0.054	0.019	<0.001	0.011	0.006
Molybdenum	7439-98-7	0.001	mg/L	0.274	0.008	0.007	0.006	0.009
Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	0.04	0.06	0.07

Analytical Results

Sub-Matrix: **LEACHATE** (Matrix: **WATER**)			Client sample ID	KLC 12	KLC 15	KLC 16	KLC 17	KLC 18
			Client sampling date / time	09-Mar-2018 00:00	09-Mar-2018 00:00	09-Mar-2018 00:00	09-Mar-2018 00:00	09-Mar-2018 00:00
Compound	CAS Number	LOR	Unit	EB1808680-011	EB1808680-012	EB1808680-013	EB1808680-014	EB1808680-015
				Result	Result	Result	Result	Result
EG020F: Dissolved Metals by ICP-MS - Continued								
Uranium	7440-61-1	0.001	mg/L	**0.002**	**0.010**	**0.001**	**0.007**	**0.002**
Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Boron	7440-42-8	0.05	mg/L	**0.42**	**0.84**	**0.12**	**0.15**	**0.12**
Iron	7439-89-6	0.05	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05
EG035F: Dissolved Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	**0.9**	**1.0**	**0.8**	**0.4**	**0.8**
EN055: Ionic Balance								
Total Anions	----	0.01	meq/L	**23.3**	**116**	**10.9**	**109**	**16.9**
Total Cations	----	0.01	meq/L	**21.7**	**95.0**	**11.1**	**95.6**	**17.4**
Ionic Balance	----	0.01	%	**3.70**	**9.78**	**0.95**	**6.46**	**1.36**

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **EB1809205**	Page	: 1 of 10
Client	: **RGS ENVIRONMENTAL PTY LTD**	Laboratory	: Environmental Division Brisbane
Contact	: MR ALAN ROBERTSON	Contact	: Customer Services EB
Address	: PO Box 3091 SUNNYBANK SOUTH QLD, AUSTRALIA 4109	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: +61 07 3344 1222	Telephone	: +61-7-3243 7222
Project	: 2017041 - Ensham Project	Date Samples Received	: 13-Apr-2018 13:10
Order number	:	Date Analysis Commenced	: 14-Apr-2018
C-O-C number	: ----	Issue Date	: 18-Apr-2018 17:02
Sampler	: MARY MACELROY		
Site	: ----		
Quote number	: BN/035/18 V2		
No. of samples received	: 16		
No. of samples analysed	: 16		

NATA

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

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

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

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

Signatories

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

Signatories	*Position*	*Accreditation Category*
Andrew Epps	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

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

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

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

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

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

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

Analytical Results

Sub-Matrix: WATER
(Matrix: WATER)

Compound	CAS Number	LOR	Unit	KLC 1	KLC 3	KLC 4	KLC 5	KLC 6
			Client sampling date / time	09-Mar-2018 00:00	09-Mar-2018 00:00	09-Mar-2018 00:00	09-Mar-2018 00:00	09-Mar-2018 00:00
				EB1809205-001	EB1809205-002	EB1809205-003	EB1809205-004	EB1809205-005
				Result	Result	Result	Result	Result
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	8.17	8.47	8.61	8.08	8.61
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	619	1370	783	9140	1360
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	15	26	<1	31
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	121	194	208	192	298
Total Alkalinity as CaCO3	----	1	mg/L	121	209	234	192	329
ED038A: Acidity								
Acidity as CaCO3	----	1	mg/L	2	<1	<1	<1	<1
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	73	130	70	677	104
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	56	227	28	2680	180
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	4	6	4	146	6
Magnesium	7439-95-4	1	mg/L	3	6	2	130	5
Sodium	7440-23-5	1	mg/L	124	287	157	1580	303
Potassium	7440-09-7	1	mg/L	2	7	3	23	5
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	0.40	0.75	0.12	<0.01	0.09
Antimony	7440-36-0	0.001	mg/L	0.003	0.005	0.006	0.001	0.008
Arsenic	7440-38-2	0.001	mg/L	0.033	0.036	0.035	0.028	0.050
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	0.0001	<0.0001	0.0006	0.0002
Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Cobalt	7440-48-4	0.001	mg/L	<0.001	<0.001	<0.001	0.007	<0.001
Copper	7440-50-8	0.001	mg/L	<0.001	0.002	<0.001	0.002	0.002
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Lithium	7439-93-2	0.001	mg/L	0.003	0.007	0.006	0.055	0.010
Manganese	7439-96-5	0.001	mg/L	0.003	0.009	0.002	0.167	0.009
Molybdenum	7439-98-7	0.001	mg/L	0.058	0.261	0.072	0.180	0.336
Nickel	7440-02-0	0.001	mg/L	<0.001	<0.001	<0.001	0.006	<0.001
Selenium	7782-49-2	0.01	mg/L	0.02	<0.01	0.02	<0.01	<0.01
Uranium	7440-61-1	0.001	mg/L	<0.001	0.002	<0.001	0.007	0.003

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	KLC 1	KLC 3	KLC 4	KLC 5	KLC 6
			Client sampling date / time	09-Mar-2018 00:00	09-Mar-2018 00:00	09-Mar-2018 00:00	09-Mar-2018 00:00	09-Mar-2018 00:00
Compound	CAS Number	LOR	Unit	EB1809205-001	EB1809205-002	EB1809205-003	EB1809205-004	EB1809205-005
				Result	Result	Result	Result	Result
EG020F: Dissolved Metals by ICP-MS - Continued								
Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	7440-66-6	0.005	mg/L	<0.005	<0.005	<0.005	**0.017**	<0.005
Boron	7440-42-8	0.05	mg/L	**0.06**	**0.13**	**0.08**	**0.20**	**0.12**
Iron	7439-89-6	0.05	mg/L	**0.09**	**0.16**	<0.05	<0.05	<0.05
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	**0.5**	**0.9**	**0.4**	**0.2**	**0.6**
EN055: Ionic Balance								
Total Anions	----	0.01	meq/L	**5.52**	**13.3**	**6.92**	**93.5**	**13.8**
Total Cations	----	0.01	meq/L	**5.89**	**13.4**	**7.27**	**87.3**	**14.0**
Ionic Balance	----	0.01	%	**3.28**	**0.64**	**2.45**	**3.45**	**0.73**

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	KLC 7	KLC 8	KLC 9	KLC 10	KLC 11
			Client sampling date / time	09-Mar-2018 00:00	09-Mar-2018 00:00	09-Mar-2018 00:00	09-Mar-2018 00:00	09-Mar-2018 00:00
Compound	CAS Number	LOR	Unit	EB1809205-006	EB1809205-007	EB1809205-008	EB1809205-009	EB1809205-010
				Result	Result	Result	Result	Result
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	7.92	8.18	8.33	8.63	8.17
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	1080	11400	5080	1430	9660
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	9	36	<1
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	70	274	288	328	241
Total Alkalinity as CaCO3	----	1	mg/L	70	274	296	364	241
ED038A: Acidity								
Acidity as CaCO3	----	1	mg/L	<1	<1	<1	<1	<1
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	74	904	514	134	730
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	266	3440	1200	150	2810
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	6	120	39	6	94
Magnesium	7439-95-4	1	mg/L	17	323	104	10	190
Sodium	7440-23-5	1	mg/L	180	1770	833	312	1660
Potassium	7440-09-7	1	mg/L	8	47	28	9	37
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	<0.01	<0.01	<0.01	0.02	<0.01
Antimony	7440-36-0	0.001	mg/L	0.006	0.023	0.002	0.003	0.003
Arsenic	7440-38-2	0.001	mg/L	0.001	0.004	0.002	0.006	0.019
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	0.0016	0.0002	<0.0001	0.0003
Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Cobalt	7440-48-4	0.001	mg/L	0.003	0.034	0.012	<0.001	0.007
Copper	7440-50-8	0.001	mg/L	0.001	0.012	0.005	<0.001	0.002
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Lithium	7439-93-2	0.001	mg/L	0.017	0.133	0.075	0.021	0.099
Manganese	7439-96-5	0.001	mg/L	0.165	1.32	0.618	0.006	0.187
Molybdenum	7439-98-7	0.001	mg/L	0.010	0.040	0.044	0.068	0.160
Nickel	7440-02-0	0.001	mg/L	<0.001	0.015	0.002	<0.001	0.004
Selenium	7782-49-2	0.01	mg/L	0.02	0.01	<0.01	0.02	0.01
Uranium	7440-61-1	0.001	mg/L	<0.001	0.003	0.003	0.002	0.006

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	KLC 7	KLC 8	KLC 9	KLC 10	KLC 11
			Client sampling date / time	09-Mar-2018 00:00	09-Mar-2018 00:00	09-Mar-2018 00:00	09-Mar-2018 00:00	09-Mar-2018 00:00
Compound	CAS Number	LOR	Unit	EB1809205-006	EB1809205-007	EB1809205-008	EB1809205-009	EB1809205-010
				Result	Result	Result	Result	Result
EG020F: Dissolved Metals by ICP-MS - Continued								
Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	7440-66-6	0.005	mg/L	**0.015**	**0.192**	**0.032**	<0.005	**0.024**
Boron	7440-42-8	0.05	mg/L	**0.17**	**0.63**	**0.50**	**0.33**	**0.57**
Iron	7439-89-6	0.05	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	**0.9**	**1.7**	**1.9**	**0.6**	**0.4**
EN055: Ionic Balance								
Total Anions	----	0.01	meq/L	**10.4**	**121**	**50.5**	**14.3**	**99.3**
Total Cations	----	0.01	meq/L	**9.73**	**111**	**47.4**	**14.9**	**93.5**
Ionic Balance	----	0.01	%	**3.52**	**4.55**	**3.08**	**2.16**	**3.01**

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	KLC 12	KLC 13	KLC 15	KLC 16	KLC 17
			Client sampling date / time	09-Mar-2018 00:00	09-Mar-2018 00:00	09-Mar-2018 00:00	09-Mar-2018 00:00	09-Mar-2018 00:00
Compound	CAS Number	LOR	Unit	EB1809205-011	EB1809205-012	EB1809205-013	EB1809205-014	EB1809205-015
				Result	Result	Result	Result	Result
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	8.48	8.56	8.44	8.36	8.06
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	1920	6200	6160	949	9040
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	20	42	34	6	<1
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	243	276	420	138	162
Total Alkalinity as CaCO3	----	1	mg/L	263	318	454	144	162
ED038A: Acidity								
Acidity as CaCO3	----	1	mg/L	<1	<1	<1	<1	<1
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	195	390	348	306	1030
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	339	1580	1540	11	2530
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	8	59	79	38	333
Magnesium	7439-95-4	1	mg/L	13	109	97	34	323
Sodium	7440-23-5	1	mg/L	394	1120	1080	111	1070
Potassium	7440-09-7	1	mg/L	10	6	5	16	54
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	0.02	<0.01	<0.01	0.02	<0.01
Antimony	7440-36-0	0.001	mg/L	0.005	0.001	<0.001	<0.001	<0.001
Arsenic	7440-38-2	0.001	mg/L	0.024	0.001	0.002	0.002	0.002
Cadmium	7440-43-9	0.0001	mg/L	0.0001	<0.0001	<0.0001	<0.0001	0.0003
Chromium	7440-47-3	0.001	mg/L	<0.001	0.005	0.004	<0.001	<0.001
Cobalt	7440-48-4	0.001	mg/L	<0.001	<0.001	0.001	<0.001	0.001
Copper	7440-50-8	0.001	mg/L	0.001	0.005	0.010	0.006	0.003
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Lithium	7439-93-2	0.001	mg/L	0.020	0.013	0.012	0.015	0.064
Manganese	7439-96-5	0.001	mg/L	0.060	0.004	0.008	<0.001	0.031
Molybdenum	7439-98-7	0.001	mg/L	0.313	0.004	0.004	0.007	0.007
Nickel	7440-02-0	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	<0.01	0.03	0.04
Uranium	7440-61-1	0.001	mg/L	0.002	0.010	0.011	0.002	0.007

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	KLC 12	KLC 13	KLC 15	KLC 16	KLC 17
			Client sampling date / time	09-Mar-2018 00:00	09-Mar-2018 00:00	09-Mar-2018 00:00	09-Mar-2018 00:00	09-Mar-2018 00:00
Compound	CAS Number	LOR	Unit	EB1809205-011	EB1809205-012	EB1809205-013	EB1809205-014	EB1809205-015
				Result	Result	Result	Result	Result
EG020F: Dissolved Metals by ICP-MS - Continued								
Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	7440-66-6	0.005	mg/L	<0.005	<0.005	**0.008**	<0.005	**0.017**
Boron	7440-42-8	0.05	mg/L	**0.39**	**0.83**	**0.86**	**0.11**	**0.15**
Iron	7439-89-6	0.05	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	**0.9**	**1.1**	**1.1**	**0.8**	**0.4**
EN055: Ionic Balance								
Total Anions	----	0.01	meq/L	**18.9**	**59.0**	**59.8**	**9.56**	**96.0**
Total Cations	----	0.01	meq/L	**18.9**	**60.8**	**59.0**	**9.93**	**91.1**
Ionic Balance	----	0.01	%	**0.04**	**1.45**	**0.61**	**1.92**	**2.63**

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	KLC 18	----	----	----	----
			Client sampling date / time	09-Mar-2018 00:00	----	----	----	----
Compound	CAS Number	LOR	Unit	EB1809205-016	--------	--------	--------	--------
				Result	----	----	----	----
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	**8.26**	----	----	----	----
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	**1400**	----	----	----	----
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	----	----	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	----	----	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	**150**	----	----	----	----
Total Alkalinity as CaCO3	----	1	mg/L	**150**	----	----	----	----
ED038A: Acidity								
Acidity as CaCO3	----	1	mg/L	<1	----	----	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	**526**	----	----	----	----
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	**44**	----	----	----	----
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	**56**	----	----	----	----
Magnesium	7439-95-4	1	mg/L	**53**	----	----	----	----
Sodium	7440-23-5	1	mg/L	**173**	----	----	----	----
Potassium	7440-09-7	1	mg/L	**22**	----	----	----	----
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	<0.01	----	----	----	----
Antimony	7440-36-0	0.001	mg/L	<0.001	----	----	----	----
Arsenic	7440-38-2	0.001	mg/L	**0.002**	----	----	----	----
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	----	----	----	----
Chromium	7440-47-3	0.001	mg/L	<0.001	----	----	----	----
Cobalt	7440-48-4	0.001	mg/L	<0.001	----	----	----	----
Copper	7440-50-8	0.001	mg/L	**0.002**	----	----	----	----
Lead	7439-92-1	0.001	mg/L	<0.001	----	----	----	----
Lithium	7439-93-2	0.001	mg/L	**0.022**	----	----	----	----
Manganese	7439-96-5	0.001	mg/L	**0.012**	----	----	----	----
Molybdenum	7439-98-7	0.001	mg/L	**0.014**	----	----	----	----
Nickel	7440-02-0	0.001	mg/L	<0.001	----	----	----	----
Selenium	7782-49-2	0.01	mg/L	**0.05**	----	----	----	----
Uranium	7440-61-1	0.001	mg/L	**0.002**	----	----	----	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	KLC 18	----	----	----	----
			Client sampling date / time	09-Mar-2018 00:00	----	----	----	----
Compound	CAS Number	LOR	Unit	EB1809205-016	--------	--------	--------	--------
				Result	----	----	----	----
EG020F: Dissolved Metals by ICP-MS - Continued								
Vanadium	7440-62-2	0.01	mg/L	<0.01	----	----	----	----
Zinc	7440-66-6	0.005	mg/L	**0.009**	----	----	----	----
Boron	7440-42-8	0.05	mg/L	**0.12**	----	----	----	----
Iron	7439-89-6	0.05	mg/L	<0.05	----	----	----	----
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	**0.8**	----	----	----	----
EN055: Ionic Balance								
Total Anions	----	0.01	meq/L	**15.2**	----	----	----	----
Total Cations	----	0.01	meq/L	**15.2**	----	----	----	----
Ionic Balance	----	0.01	%	**0.18**	----	----	----	----

CERTIFICATE OF ANALYSIS

Work Order	: **EB1810658**	Page	: 1 of 4
Client	: **RGS ENVIRONMENTAL PTY LTD**	Laboratory	: Environmental Division Brisbane
Contact	: MR ALAN ROBERTSON	Contact	: Customer Services EB
Address	: PO Box 3091 SUNNYBANK SOUTH QLD, AUSTRALIA 4109	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: +61 07 3344 1222	Telephone	: +61-7-3243 7222
Project	: 2017041 Ensham	Date Samples Received	: 01-May-2018 15:00
Order number	:	Date Analysis Commenced	: 02-May-2018
C-O-C number	: ----	Issue Date	: 09-May-2018 12:32
Sampler	: VERONICA CANALES		
Site	: ----		
Quote number	: BN/035/18 V2		
No. of samples received	: 3		
No. of samples analysed	: 3		

NATA

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

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

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

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

Signatories

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

Signatories	*Position*	*Accreditation Category*
Andrew Epps	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

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

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

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

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

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

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

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	KLC 9	KLC 10	KLC 15	----	----
			Client sampling date / time	01-May-2018 00:00	01-May-2018 00:00	01-May-2018 00:00	----	----
Compound	CAS Number	LOR	Unit	EB1810658-001	EB1810658-002	EB1810658-003	--------	--------
				Result	Result	Result	----	----
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	8.18	8.86	8.59	----	----
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	4130	1570	3900	----	----
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	87	57	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	323	393	454	----	----
Total Alkalinity as CaCO3	----	1	mg/L	323	480	511	----	----
ED038A: Acidity								
Acidity as CaCO3	----	1	mg/L	<1	<1	<1	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	439	135	212	----	----
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	798	113	816	----	----
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	30	8	36	----	----
Magnesium	7439-95-4	1	mg/L	80	14	48	----	----
Sodium	7440-23-5	1	mg/L	725	333	744	----	----
Potassium	7440-09-7	1	mg/L	26	12	6	----	----
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	<0.01	0.02	<0.01	----	----
Antimony	7440-36-0	0.001	mg/L	0.001	0.002	0.001	----	----
Arsenic	7440-38-2	0.001	mg/L	0.004	0.004	0.003	----	----
Cadmium	7440-43-9	0.0001	mg/L	0.0001	<0.0001	<0.0001	----	----
Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	0.002	----	----
Copper	7440-50-8	0.001	mg/L	0.004	0.001	0.010	----	----
Cobalt	7440-48-4	0.001	mg/L	0.006	<0.001	<0.001	----	----
Nickel	7440-02-0	0.001	mg/L	0.002	<0.001	0.002	----	----
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	<0.001	----	----
Zinc	7440-66-6	0.005	mg/L	0.015	<0.005	<0.005	----	----
Lithium	7439-93-2	0.001	mg/L	0.062	0.024	0.009	----	----
Manganese	7439-96-5	0.001	mg/L	0.481	<0.001	0.007	----	----
Molybdenum	7439-98-7	0.001	mg/L	0.049	0.048	0.006	----	----
Selenium	7782-49-2	0.01	mg/L	<0.01	0.02	<0.01	----	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	KLC 9	KLC 10	KLC 15	----	----
			Client sampling date / time	01-May-2018 00:00	01-May-2018 00:00	01-May-2018 00:00	----	----
Compound	CAS Number	LOR	Unit	EB1810658-001	EB1810658-002	EB1810658-003	--------	--------
				Result	Result	Result	----	----
EG020F: Dissolved Metals by ICP-MS - Continued								
Uranium	7440-61-1	0.001	mg/L	**0.002**	**0.002**	**0.010**	----	----
Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	**0.01**	----	----
Boron	7440-42-8	0.05	mg/L	**0.49**	**0.33**	**0.86**	----	----
Iron	7439-89-6	0.05	mg/L	<0.05	<0.05	<0.05	----	----
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	**2.1**	**0.6**	**1.3**	----	----
EN055: Ionic Balance								
Total Anions	----	0.01	meq/L	**38.1**	**15.6**	**37.6**	----	----
Total Cations	----	0.01	meq/L	**40.3**	**16.3**	**38.3**	----	----
Ionic Balance	----	0.01	%	**2.78**	**2.36**	**0.82**	----	----

CERTIFICATE OF ANALYSIS

Work Order	: **EB1811540**	Page	: 1 of 10
Client	: **RGS ENVIRONMENTAL PTY LTD**	Laboratory	: Environmental Division Brisbane
Contact	: MR ALAN ROBERTSON	Contact	: Customer Services EB
Address	: PO Box 3091 SUNNYBANK SOUTH QLD, AUSTRALIA 4109	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: +61 07 3344 1222	Telephone	: +61-7-3243 7222
Project	: 2017041 - Ensham Project	Date Samples Received	: 11-May-2018 16:30
Order number	:	Date Analysis Commenced	: 14-May-2018
C-O-C number	: ----	Issue Date	: 18-May-2018 10:33
Sampler	: MARY MACELROY		
Site	: ----		
Quote number	: BN/035/18 V2		
No. of samples received	: 16		
No. of samples analysed	: 16		

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

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

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

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

Signatories

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

Signatories	*Position*	*Accreditation Category*
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

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

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

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

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

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

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

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	KLC 1	KLC 3	KLC 4	KLC 5	KLC 6
			Client sampling date / time	11-May-2018 00:00	11-May-2018 00:00	11-May-2018 00:00	11-May-2018 00:00	11-May-2018 00:00
Compound	CAS Number	LOR	Unit	EB1811540-001	EB1811540-003	EB1811540-004	EB1811540-005	EB1811540-006
				Result	Result	Result	Result	Result
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	8.24	8.38	8.53	7.71	8.35
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	657	1070	750	8640	1170
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	15	27	<1	16
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	156	237	251	213	355
Total Alkalinity as CaCO3	----	1	mg/L	156	253	279	213	371
ED038A: Acidity								
Acidity as CaCO3	----	1	mg/L	<1	<1	<1	8	<1
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	78	89	74	649	68
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	37	133	10	2620	117
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	4	3	4	124	5
Magnesium	7439-95-4	1	mg/L	3	4	3	112	4
Sodium	7440-23-5	1	mg/L	134	208	157	1400	248
Potassium	7440-09-7	1	mg/L	2	4	3	21	5
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	0.64	0.37	0.08	<0.01	0.05
Antimony	7440-36-0	0.001	mg/L	0.003	0.007	0.004	<0.001	0.009
Arsenic	7440-38-2	0.001	mg/L	0.044	0.041	0.016	0.031	0.043
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	<0.0001	0.0001	<0.0001
Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Cobalt	7440-48-4	0.001	mg/L	<0.001	<0.001	<0.001	0.004	<0.001
Copper	7440-50-8	0.001	mg/L	<0.001	<0.001	<0.001	0.001	<0.001
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Lithium	7439-93-2	0.001	mg/L	0.007	0.006	0.007	0.050	0.010
Manganese	7439-96-5	0.001	mg/L	<0.001	0.005	<0.001	0.162	0.007
Molybdenum	7439-98-7	0.001	mg/L	0.051	0.229	0.028	0.150	0.242
Nickel	7440-02-0	0.001	mg/L	<0.001	<0.001	<0.001	0.005	<0.001
Selenium	7782-49-2	0.01	mg/L	0.02	<0.01	0.04	<0.01	<0.01
Uranium	7440-61-1	0.001	mg/L	0.002	0.002	0.002	0.008	0.002

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	KLC 1	KLC 3	KLC 4	KLC 5	KLC 6
			Client sampling date / time	11-May-2018 00:00	11-May-2018 00:00	11-May-2018 00:00	11-May-2018 00:00	11-May-2018 00:00
Compound	CAS Number	LOR	Unit	EB1811540-001	EB1811540-003	EB1811540-004	EB1811540-005	EB1811540-006
				Result	Result	Result	Result	Result
EG020F: Dissolved Metals by ICP-MS - Continued								
Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	7440-66-6	0.005	mg/L	<0.005	<0.005	<0.005	**0.009**	<0.005
Boron	7440-42-8	0.05	mg/L	**0.06**	**0.12**	**0.06**	**0.19**	**0.10**
Iron	7439-89-6	0.05	mg/L	**0.14**	**0.06**	<0.05	<0.05	<0.05
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	**0.5**	**1.0**	**0.4**	**0.2**	**0.5**
EN055: Ionic Balance								
Total Anions	----	0.01	meq/L	**5.78**	**10.6**	**7.40**	**91.7**	**12.1**
Total Cations	----	0.01	meq/L	**6.33**	**9.63**	**7.35**	**76.8**	**11.5**
Ionic Balance	----	0.01	%	**4.47**	**5.08**	**0.30**	**8.80**	**2.69**

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	KLC 7	KLC 8	KLC 9	KLC 10	KLC 11
			Client sampling date / time	11-May-2018 00:00	11-May-2018 00:00	11-May-2018 00:00	11-May-2018 00:00	11-May-2018 00:00
Compound	*CAS Number*	*LOR*	*Unit*	EB1811540-007	EB1811540-008	EB1811540-009	EB1811540-010	EB1811540-011
				Result	Result	Result	Result	Result
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	**7.54**	**7.93**	**7.99**	**8.69**	**7.81**
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	**1250**	**9990**	**3120**	**1460**	**9420**
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	<1	**69**	<1
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	**66**	**292**	**362**	**429**	**257**
Total Alkalinity as CaCO3	----	1	mg/L	**66**	**292**	**362**	**499**	**257**
ED038A: Acidity								
Acidity as CaCO3	----	1	mg/L	**1**	**4**	<1	<1	**6**
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	**101**	**843**	**328**	**131**	**733**
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	**319**	**3110**	**655**	**82**	**2890**
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	**7**	**111**	**15**	**7**	**100**
Magnesium	7439-95-4	1	mg/L	**19**	**267**	**42**	**12**	**178**
Sodium	7440-23-5	1	mg/L	**196**	**1620**	**535**	**292**	**1640**
Potassium	7440-09-7	1	mg/L	**9**	**42**	**17**	**10**	**35**
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	<0.01	<0.01	<0.01	**0.02**	<0.01
Antimony	7440-36-0	0.001	mg/L	**0.005**	**0.026**	**0.002**	**0.002**	**0.003**
Arsenic	7440-38-2	0.001	mg/L	<0.001	**0.005**	**0.005**	**0.003**	**0.016**
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	**0.0008**	<0.0001	<0.0001	<0.0001
Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Cobalt	7440-48-4	0.001	mg/L	**0.002**	**0.028**	**0.005**	<0.001	**0.006**
Copper	7440-50-8	0.001	mg/L	<0.001	**0.007**	<0.001	<0.001	<0.001
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Lithium	7439-93-2	0.001	mg/L	**0.017**	**0.109**	**0.047**	**0.023**	**0.094**
Manganese	7439-96-5	0.001	mg/L	**0.068**	**1.14**	**0.329**	**0.003**	**0.174**
Molybdenum	7439-98-7	0.001	mg/L	**0.007**	**0.037**	**0.055**	**0.031**	**0.137**
Nickel	7440-02-0	0.001	mg/L	<0.001	**0.012**	<0.001	<0.001	**0.004**
Selenium	7782-49-2	0.01	mg/L	**0.02**	<0.01	<0.01	**0.02**	<0.01
Uranium	7440-61-1	0.001	mg/L	<0.001	**0.003**	**0.002**	**0.002**	**0.006**

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	KLC 7	KLC 8	KLC 9	KLC 10	KLC 11
			Client sampling date / time	11-May-2018 00:00	11-May-2018 00:00	11-May-2018 00:00	11-May-2018 00:00	11-May-2018 00:00
Compound	CAS Number	LOR	Unit	EB1811540-007	EB1811540-008	EB1811540-009	EB1811540-010	EB1811540-011
				Result	Result	Result	Result	Result
EG020F: Dissolved Metals by ICP-MS - Continued								
Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	7440-66-6	0.005	mg/L	**0.013**	**0.172**	**0.009**	<0.005	**0.017**
Boron	7440-42-8	0.05	mg/L	**0.15**	**0.62**	**0.45**	**0.29**	**0.57**
Iron	7439-89-6	0.05	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	**0.8**	**1.6**	**2.1**	**0.5**	**0.4**
EN055: Ionic Balance								
Total Anions	----	0.01	meq/L	**12.4**	**111**	**32.5**	**15.0**	**102**
Total Cations	----	0.01	meq/L	**10.7**	**99.0**	**27.9**	**14.3**	**91.9**
Ionic Balance	----	0.01	%	**7.58**	**5.74**	**7.66**	**2.44**	**5.18**

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	KLC 12	KLC 13	KLC 15	KLC 16	KLC 17
			Client sampling date / time	11-May-2018 00:00	11-May-2018 00:00	11-May-2018 00:00	11-May-2018 00:00	11-May-2018 00:00
Compound	CAS Number	LOR	Unit	EB1811540-012	EB1811540-013	EB1811540-015	EB1811540-016	EB1811540-017
				Result	Result	Result	Result	Result
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	**8.25**	**9.04**	**8.30**	**8.19**	**7.72**
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	**1660**	**1860**	**2900**	**797**	**8730**
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	**193**	**8**	<1	<1
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	**306**	**439**	**514**	**164**	**157**
Total Alkalinity as CaCO3	----	1	mg/L	**306**	**632**	**522**	**164**	**157**
ED038A: Acidity								
Acidity as CaCO3	----	1	mg/L	<1	<1	<1	<1	**5**
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	**162**	**116**	**161**	**198**	**920**
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	**257**	**170**	**586**	**8**	**2690**
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	**5**	**10**	**18**	**26**	**267**
Magnesium	7439-95-4	1	mg/L	**9**	**13**	**23**	**23**	**282**
Sodium	7440-23-5	1	mg/L	**324**	**401**	**549**	**91**	**1020**
Potassium	7440-09-7	1	mg/L	**9**	**2**	**3**	**14**	**50**
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	**0.02**	**0.02**	<0.01	**0.03**	**0.02**
Antimony	7440-36-0	0.001	mg/L	**0.005**	**0.002**	<0.001	<0.001	<0.001
Arsenic	7440-38-2	0.001	mg/L	**0.022**	**0.003**	**0.003**	**0.002**	**0.002**
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	**0.0001**
Chromium	7440-47-3	0.001	mg/L	<0.001	**0.004**	<0.001	<0.001	<0.001
Cobalt	7440-48-4	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Copper	7440-50-8	0.001	mg/L	<0.001	**0.008**	**0.007**	**0.003**	<0.001
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Lithium	7439-93-2	0.001	mg/L	**0.018**	**0.005**	**0.007**	**0.014**	**0.058**
Manganese	7439-96-5	0.001	mg/L	**0.075**	**0.002**	**0.005**	<0.001	**0.068**
Molybdenum	7439-98-7	0.001	mg/L	**0.281**	**0.019**	**0.008**	**0.007**	**0.009**
Nickel	7440-02-0	0.001	mg/L	<0.001	**0.001**	**0.001**	<0.001	<0.001
Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	<0.01	**0.02**	<0.01
Uranium	7440-61-1	0.001	mg/L	**0.002**	**0.016**	**0.012**	**0.002**	**0.006**

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	KLC 12	KLC 13	KLC 15	KLC 16	KLC 17
			Client sampling date / time	11-May-2018 00:00	11-May-2018 00:00	11-May-2018 00:00	11-May-2018 00:00	11-May-2018 00:00
Compound	CAS Number	LOR	Unit	EB1811540-012	EB1811540-013	EB1811540-015	EB1811540-016	EB1811540-017
				Result	Result	Result	Result	Result
EG020F: Dissolved Metals by ICP-MS - Continued								
Vanadium	7440-62-2	0.01	mg/L	<0.01	**0.02**	**0.01**	<0.01	<0.01
Zinc	7440-66-6	0.005	mg/L	<0.005	<0.005	<0.005	<0.005	**0.011**
Boron	7440-42-8	0.05	mg/L	**0.37**	**0.75**	**0.83**	**0.14**	**0.15**
Iron	7439-89-6	0.05	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	**0.8**	**2.4**	**1.6**	**0.7**	**0.4**
EN055: Ionic Balance								
Total Anions	----	0.01	meq/L	**16.7**	**19.8**	**30.3**	**7.62**	**98.2**
Total Cations	----	0.01	meq/L	**15.3**	**19.1**	**26.7**	**7.51**	**82.2**
Ionic Balance	----	0.01	%	**4.44**	**1.99**	**6.25**	**0.78**	**8.87**

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	KLC 18	----	----	----	----
			Client sampling date / time	11-May-2018 00:00	----	----	----	----
Compound	CAS Number	LOR	Unit	EB1811540-018	--------	--------	--------	--------
				Result	----	----	----	----
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	**8.01**	----	----	----	----
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	**1040**	----	----	----	----
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	----	----	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	----	----	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	**157**	----	----	----	----
Total Alkalinity as CaCO3	----	1	mg/L	**157**	----	----	----	----
ED038A: Acidity								
Acidity as CaCO3	----	1	mg/L	<1	----	----	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	**326**	----	----	----	----
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	**19**	----	----	----	----
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	**30**	----	----	----	----
Magnesium	7439-95-4	1	mg/L	**29**	----	----	----	----
Sodium	7440-23-5	1	mg/L	**126**	----	----	----	----
Potassium	7440-09-7	1	mg/L	**16**	----	----	----	----
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	**0.01**	----	----	----	----
Antimony	7440-36-0	0.001	mg/L	<0.001	----	----	----	----
Arsenic	7440-38-2	0.001	mg/L	**0.003**	----	----	----	----
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	----	----	----	----
Chromium	7440-47-3	0.001	mg/L	<0.001	----	----	----	----
Cobalt	7440-48-4	0.001	mg/L	<0.001	----	----	----	----
Copper	7440-50-8	0.001	mg/L	<0.001	----	----	----	----
Lead	7439-92-1	0.001	mg/L	<0.001	----	----	----	----
Lithium	7439-93-2	0.001	mg/L	**0.017**	----	----	----	----
Manganese	7439-96-5	0.001	mg/L	**0.069**	----	----	----	----
Molybdenum	7439-98-7	0.001	mg/L	**0.020**	----	----	----	----
Nickel	7440-02-0	0.001	mg/L	<0.001	----	----	----	----
Selenium	7782-49-2	0.01	mg/L	<0.01	----	----	----	----
Uranium	7440-61-1	0.001	mg/L	**0.002**	----	----	----	----

Analytical Results

Sub-Matrix: **WATER** (Matrix: **WATER**)			Client sample ID	**KLC 18**	**----**	**----**	**----**	**----**
			Client sampling date / time	11-May-2018 00:00	----	----	----	----
Compound	*CAS Number*	*LOR*	*Unit*	**EB1811540-018**	**--------**	**--------**	**--------**	**--------**
				Result	----	----	----	----
EG020F: Dissolved Metals by ICP-MS - Continued								
Vanadium	7440-62-2	0.01	mg/L	<0.01	----	----	----	----
Zinc	7440-66-6	0.005	mg/L	**0.007**	----	----	----	----
Boron	7440-42-8	0.05	mg/L	**0.11**	----	----	----	----
Iron	7439-89-6	0.05	mg/L	<0.05	----	----	----	----
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	**0.9**	----	----	----	----
EN055: Ionic Balance								
Total Anions	----	0.01	meq/L	**10.5**	----	----	----	----
Total Cations	----	0.01	meq/L	**9.77**	----	----	----	----
Ionic Balance	----	0.01	%	**3.39**	----	----	----	----

CERTIFICATE OF ANALYSIS

Work Order	: **EB1812860**	Page	: 1 of 10
Client	: **RGS ENVIRONMENTAL PTY LTD**	Laboratory	: Environmental Division Brisbane
Contact	: MR ALAN ROBERTSON	Contact	: Customer Services EB
Address	: PO Box 3091 SUNNYBANK SOUTH QLD, AUSTRALIA 4109	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: +61 07 3344 1222	Telephone	: +61-7-3243 7222
Project	: 2017041 Ensham	Date Samples Received	: 25-May-2018 17:05
Order number	:	Date Analysis Commenced	: 28-May-2018
C-O-C number	: ----	Issue Date	: 01-Jun-2018 12:14
Sampler	: MARY MACELROY		
Site	: ----		
Quote number	: BN/035/18 V2		
No. of samples received	: 16		
No. of samples analysed	: 16		

NATA

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

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

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

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

Signatories

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

Signatories	*Position*	*Accreditation Category*
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

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

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

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

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

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

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

- Sodium Adsorption Ratio (where reported): Where results for Na, Ca or Mg are <LOR, a concentration at half the reported LOR is incorporated into the SAR calculation. This represents a conservative approach for Na relative to the assumption that <LOR = zero concentration and a conservative approach for Ca & Mg relative to the assumption that <LOR is equivalent to the LOR concentration.

Analytical Results

Sub-Matrix: WASTE (Matrix: WATER)			Client sample ID	KLC 1	KLC 3	KLC 4	KLC 5	KLC 6
			Client sampling date / time	25-May-2018 00:00	25-May-2018 00:00	25-May-2018 00:00	25-May-2018 00:00	25-May-2018 00:00
Compound	CAS Number	LOR	Unit	EB1812860-001	EB1812860-002	EB1812860-003	EB1812860-004	EB1812860-005
				Result	Result	Result	Result	Result
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	8.12	8.55	8.60	8.00	8.49
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	475	943	706	8480	1120
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	24	25	<1	23
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	137	244	253	229	351
Total Alkalinity as CaCO3	----	1	mg/L	137	268	278	229	374
ED038A: Acidity								
Acidity as CaCO3	----	1	mg/L	<1	<1	<1	<1	<1
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	61	70	70	637	57
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	22	96	7	2570	99
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	3	4	6	153	6
Magnesium	7439-95-4	1	mg/L	2	3	3	120	4
Sodium	7440-23-5	1	mg/L	97	195	151	1450	233
Potassium	7440-09-7	1	mg/L	2	3	4	21	4
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	0.62	0.30	0.07	<0.01	0.81
Antimony	7440-36-0	0.001	mg/L	0.002	0.006	0.003	<0.001	0.008
Arsenic	7440-38-2	0.001	mg/L	0.034	0.038	0.011	0.022	0.035
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	0.0002	<0.0001	0.0002	0.0002
Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	0.001
Cobalt	7440-48-4	0.001	mg/L	<0.001	<0.001	<0.001	0.004	<0.001
Copper	7440-50-8	0.001	mg/L	0.001	<0.001	<0.001	0.001	0.002
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Lithium	7439-93-2	0.001	mg/L	0.003	0.005	0.007	0.054	0.009
Manganese	7439-96-5	0.001	mg/L	0.004	0.004	<0.001	0.159	0.007
Molybdenum	7439-98-7	0.001	mg/L	0.035	0.201	0.019	0.125	0.210
Nickel	7440-02-0	0.001	mg/L	0.002	0.001	<0.001	0.008	0.003
Selenium	7782-49-2	0.01	mg/L	0.01	<0.01	0.02	<0.01	<0.01
Uranium	7440-61-1	0.001	mg/L	0.001	0.002	0.001	0.009	0.002

Analytical Results

Sub-Matrix: **WASTE** (Matrix: **WATER**)			Client sample ID	**KLC 1**	**KLC 3**	**KLC 4**	**KLC 5**	**KLC 6**
			Client sampling date / time	25-May-2018 00:00	25-May-2018 00:00	25-May-2018 00:00	25-May-2018 00:00	25-May-2018 00:00
Compound	CAS Number	LOR	Unit	**EB1812860-001**	**EB1812860-002**	**EB1812860-003**	**EB1812860-004**	**EB1812860-005**
				Result	Result	Result	Result	Result
EG020F: Dissolved Metals by ICP-MS - Continued								
Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	7440-66-6	0.005	mg/L	<0.005	<0.005	<0.005	**0.008**	<0.005
Boron	7440-42-8	0.05	mg/L	**0.06**	**0.11**	**0.06**	**0.19**	**0.10**
Iron	7439-89-6	0.05	mg/L	**0.23**	**0.07**	<0.05	<0.05	**0.14**
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	**0.4**	**1.0**	**0.3**	**0.2**	**0.5**
EN055: Ionic Balance								
Total Anions	----	0.01	meq/L	**4.63**	**9.52**	**7.21**	**90.3**	**11.4**
Total Cations	----	0.01	meq/L	**4.58**	**9.00**	**7.22**	**81.1**	**10.9**
Ionic Balance	----	0.01	%	**0.47**	**2.78**	**0.05**	**5.37**	**2.63**

Analytical Results

Sub-Matrix: WASTE (Matrix: WATER)			Client sample ID	KLC 7	KLC 8	KLC 9	KLC 10	KLC 11
			Client sampling date / time	25-May-2018 00:00	25-May-2018 00:00	25-May-2018 00:00	25-May-2018 00:00	25-May-2018 00:00
Compound	CAS Number	LOR	Unit	EB1812860-006	EB1812860-007	EB1812860-008	EB1812860-009	EB1812860-010
				Result	Result	Result	Result	Result
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	7.70	8.12	8.48	8.76	8.08
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	1220	9530	2370	1350	9280
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	26	60	<1
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	75	309	386	440	278
Total Alkalinity as CaCO3	----	1	mg/L	75	309	412	500	278
ED038A: Acidity								
Acidity as CaCO3	----	1	mg/L	1	<1	<1	<1	<1
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	103	786	232	122	723
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	303	2930	429	81	2850
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	8	101	11	8	100
Magnesium	7439-95-4	1	mg/L	22	245	28	14	179
Sodium	7440-23-5	1	mg/L	186	1500	433	287	1560
Potassium	7440-09-7	1	mg/L	9	39	14	10	34
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	<0.01	<0.01	<0.01	0.01	<0.01
Antimony	7440-36-0	0.001	mg/L	0.003	0.018	0.002	0.001	0.002
Arsenic	7440-38-2	0.001	mg/L	<0.001	0.004	0.004	0.002	0.013
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	0.0008	<0.0001	<0.0001	0.0002
Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Cobalt	7440-48-4	0.001	mg/L	<0.001	0.023	0.002	<0.001	0.005
Copper	7440-50-8	0.001	mg/L	0.001	0.006	0.001	<0.001	0.002
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Lithium	7439-93-2	0.001	mg/L	0.016	0.111	0.039	0.023	0.096
Manganese	7439-96-5	0.001	mg/L	0.013	1.19	0.202	0.002	0.152
Molybdenum	7439-98-7	0.001	mg/L	0.004	0.036	0.067	0.020	0.116
Nickel	7440-02-0	0.001	mg/L	0.002	0.014	0.002	<0.001	0.007
Selenium	7782-49-2	0.01	mg/L	0.02	<0.01	<0.01	0.02	<0.01
Uranium	7440-61-1	0.001	mg/L	<0.001	0.004	0.002	0.002	0.006

Analytical Results

Sub-Matrix: WASTE (Matrix: WATER)			Client sample ID	KLC 7	KLC 8	KLC 9	KLC 10	KLC 11
			Client sampling date / time	25-May-2018 00:00	25-May-2018 00:00	25-May-2018 00:00	25-May-2018 00:00	25-May-2018 00:00
Compound	CAS Number	LOR	Unit	EB1812860-006	EB1812860-007	EB1812860-008	EB1812860-009	EB1812860-010
				Result	Result	Result	Result	Result
EG020F: Dissolved Metals by ICP-MS - Continued								
Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	7440-66-6	0.005	mg/L	**0.021**	**0.145**	**0.007**	<0.005	**0.017**
Boron	7440-42-8	0.05	mg/L	**0.13**	**0.53**	**0.40**	**0.23**	**0.49**
Iron	7439-89-6	0.05	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	**0.7**	**1.6**	**2.5**	**0.5**	**0.4**
EN055: Ionic Balance								
Total Anions	----	0.01	meq/L	**12.2**	**105**	**25.2**	**14.8**	**101**
Total Cations	----	0.01	meq/L	**10.5**	**91.4**	**22.0**	**14.3**	**88.4**
Ionic Balance	----	0.01	%	**7.30**	**6.99**	**6.60**	**1.80**	**6.63**

Analytical Results

Sub-Matrix: **WASTE** (Matrix: **WATER**)			Client sample ID	**KLC 12**	**KLC 13**	**KLC 15**	**KLC 16**	**KLC 17**
			Client sampling date / time	25-May-2018 00:00	25-May-2018 00:00	25-May-2018 00:00	25-May-2018 00:00	25-May-2018 00:00
Compound	*CAS Number*	*LOR*	*Unit*	**EB1812860-011**	**EB1812860-012**	**EB1812860-013**	**EB1812860-014**	**EB1812860-015**
				Result	Result	Result	Result	Result
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	**8.40**	**9.02**	**8.65**	**8.37**	**7.97**
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	**1510**	**1580**	**2180**	**707**	**8700**
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	**14**	**156**	**57**	**8**	<1
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	**314**	**494**	**490**	**165**	**164**
Total Alkalinity as CaCO3	----	1	mg/L	**328**	**650**	**547**	**173**	**164**
ED038A: Acidity								
Acidity as CaCO3	----	1	mg/L	<1	<1	<1	<1	**3**
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	**143**	**82**	**113**	**166**	**866**
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	**212**	**77**	**368**	**6**	**2690**
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	**6**	**10**	**13**	**25**	**302**
Magnesium	7439-95-4	1	mg/L	**9**	**10**	**15**	**22**	**277**
Sodium	7440-23-5	1	mg/L	**302**	**354**	**431**	**85**	**1070**
Potassium	7440-09-7	1	mg/L	**9**	**2**	**2**	**13**	**48**
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	**0.02**	**0.08**	**0.03**	**0.02**	<0.01
Antimony	7440-36-0	0.001	mg/L	**0.005**	**0.002**	<0.001	<0.001	<0.001
Arsenic	7440-38-2	0.001	mg/L	**0.018**	**0.004**	**0.003**	**0.001**	**0.002**
Cadmium	7440-43-9	0.0001	mg/L	**0.0002**	<0.0001	<0.0001	<0.0001	<0.0001
Chromium	7440-47-3	0.001	mg/L	<0.001	**0.005**	<0.001	<0.001	<0.001
Cobalt	7440-48-4	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Copper	7440-50-8	0.001	mg/L	**0.001**	**0.009**	**0.007**	**0.004**	**0.002**
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Lithium	7439-93-2	0.001	mg/L	**0.016**	**0.004**	**0.005**	**0.012**	**0.055**
Manganese	7439-96-5	0.001	mg/L	**0.069**	<0.001	**0.005**	<0.001	**0.117**
Molybdenum	7439-98-7	0.001	mg/L	**0.264**	**0.023**	**0.011**	**0.007**	**0.010**
Nickel	7440-02-0	0.001	mg/L	**0.001**	**0.004**	**0.004**	<0.001	**0.003**
Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	<0.01	**0.02**	<0.01
Uranium	7440-61-1	0.001	mg/L	**0.002**	**0.017**	**0.012**	**0.001**	**0.006**

Analytical Results

Sub-Matrix: WASTE (Matrix: WATER)			Client sample ID	KLC 12	KLC 13	KLC 15	KLC 16	KLC 17
			Client sampling date / time	25-May-2018 00:00	25-May-2018 00:00	25-May-2018 00:00	25-May-2018 00:00	25-May-2018 00:00
Compound	CAS Number	LOR	Unit	EB1812860-011	EB1812860-012	EB1812860-013	EB1812860-014	EB1812860-015
				Result	Result	Result	Result	Result
EG020F: Dissolved Metals by ICP-MS - Continued								
Vanadium	7440-62-2	0.01	mg/L	<0.01	**0.02**	**0.01**	<0.01	<0.01
Zinc	7440-66-6	0.005	mg/L	<0.005	<0.005	<0.005	<0.005	**0.010**
Boron	7440-42-8	0.05	mg/L	**0.33**	**0.67**	**0.68**	**0.10**	**0.13**
Iron	7439-89-6	0.05	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	**0.9**	**3.1**	**2.1**	**0.7**	**0.4**
EN055: Ionic Balance								
Total Anions	----	0.01	meq/L	**15.5**	**16.9**	**23.7**	**7.08**	**97.2**
Total Cations	----	0.01	meq/L	**14.4**	**16.8**	**20.7**	**7.09**	**85.6**
Ionic Balance	----	0.01	%	**3.69**	**0.28**	**6.72**	**0.04**	**6.32**

Analytical Results

Sub-Matrix: WASTE (Matrix: WATER)			Client sample ID	KLC 18	----	----	----	----
			Client sampling date / time	25-May-2018 00:00	----	----	----	----
Compound	CAS Number	LOR	Unit	EB1812860-016	--------	--------	--------	--------
				Result	----	----	----	----
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	**8.24**	----	----	----	----
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	**908**	----	----	----	----
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	----	----	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	----	----	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	**162**	----	----	----	----
Total Alkalinity as CaCO3	----	1	mg/L	**162**	----	----	----	----
ED038A: Acidity								
Acidity as CaCO3	----	1	mg/L	<1	----	----	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	**259**	----	----	----	----
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	**16**	----	----	----	----
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	**28**	----	----	----	----
Magnesium	7439-95-4	1	mg/L	**27**	----	----	----	----
Sodium	7440-23-5	1	mg/L	**116**	----	----	----	----
Potassium	7440-09-7	1	mg/L	**15**	----	----	----	----
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	<0.01	----	----	----	----
Antimony	7440-36-0	0.001	mg/L	<0.001	----	----	----	----
Arsenic	7440-38-2	0.001	mg/L	**0.003**	----	----	----	----
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	----	----	----	----
Chromium	7440-47-3	0.001	mg/L	<0.001	----	----	----	----
Cobalt	7440-48-4	0.001	mg/L	<0.001	----	----	----	----
Copper	7440-50-8	0.001	mg/L	**0.001**	----	----	----	----
Lead	7439-92-1	0.001	mg/L	<0.001	----	----	----	----
Lithium	7439-93-2	0.001	mg/L	**0.014**	----	----	----	----
Manganese	7439-96-5	0.001	mg/L	**0.071**	----	----	----	----
Molybdenum	7439-98-7	0.001	mg/L	**0.020**	----	----	----	----
Nickel	7440-02-0	0.001	mg/L	**0.001**	----	----	----	----
Selenium	7782-49-2	0.01	mg/L	<0.01	----	----	----	----
Uranium	7440-61-1	0.001	mg/L	**0.002**	----	----	----	----

Analytical Results

Sub-Matrix: **WASTE** (Matrix: **WATER**)			Client sample ID	**KLC 18**	----	----	----	----
			Client sampling date / time	25-May-2018 00:00	----	----	----	----
Compound	*CAS Number*	*LOR*	*Unit*	**EB1812860-016**	--------	--------	--------	--------
				Result	----	----	----	----
EG020F: Dissolved Metals by ICP-MS - Continued								
Vanadium	7440-62-2	0.01	mg/L	<0.01	----	----	----	----
Zinc	7440-66-6	0.005	mg/L	**0.008**	----	----	----	----
Boron	7440-42-8	0.05	mg/L	**0.09**	----	----	----	----
Iron	7439-89-6	0.05	mg/L	<0.05	----	----	----	----
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	**0.9**	----	----	----	----
EN055: Ionic Balance								
Total Anions	----	0.01	meq/L	**9.08**	----	----	----	----
Total Cations	----	0.01	meq/L	**9.05**	----	----	----	----
Ionic Balance	----	0.01	%	**0.18**	----	----	----	----

CERTIFICATE OF ANALYSIS

Work Order	: **EB1814029**	Page	: 1 of 10
Client	: **RGS ENVIRONMENTAL PTY LTD**	Laboratory	: Environmental Division Brisbane
Contact	: MR ALAN ROBERTSON	Contact	: Customer Services EB
Address	: PO Box 3091 SUNNYBANK SOUTH QLD, AUSTRALIA 4109	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: +61 07 3344 1222	Telephone	: +61-7-3243 7222
Project	: 2017041 - Ensham Project	Date Samples Received	: 08-Jun-2018 16:35
Order number	:	Date Analysis Commenced	: 11-Jun-2018
C-O-C number	: ----	Issue Date	: 14-Jun-2018 13:48
Sampler	: MARY MACELROY		
Site	: ----		
Quote number	: BN/035/18 V2		
No. of samples received	: 16		
No. of samples analysed	: 16		

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

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

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

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

Signatories

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

Signatories	*Position*	*Accreditation Category*
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

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

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

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

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

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

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

- Sodium Adsorption Ratio (where reported): Where results for Na, Ca or Mg are <LOR, a concentration at half the reported LOR is incorporated into the SAR calculation. This represents a conservative approach for Na relative to the assumption that <LOR = zero concentration and a conservative approach for Ca & Mg relative to the assumption that <LOR is equivalent to the LOR concentration.

Analytical Results

Sub-Matrix: WATER
(Matrix: WATER)

Compound	CAS Number	LOR	Unit	KLC 1	KLC 3	KLC 4	KLC 5	KLC 6
			Client sampling date / time	08-Jun-2018 00:00	08-Jun-2018 00:00	08-Jun-2018 00:00	08-Jun-2018 00:00	08-Jun-2018 00:00
				EB1814029-001	EB1814029-002	EB1814029-003	EB1814029-004	EB1814029-005
				Result	Result	Result	Result	Result
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	**8.33**	**8.59**	**8.61**	**8.24**	**8.65**
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	**518**	**802**	**705**	**8320**	**781**
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	**7**	**29**	**30**	<1	**34**
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	**139**	**234**	**258**	**249**	**275**
Total Alkalinity as CaCO3	----	1	mg/L	**147**	**263**	**289**	**249**	**309**
ED038A: Acidity								
Acidity as CaCO3	----	1	mg/L	<1	<1	<1	<1	<1
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	**60**	**45**	**63**	**566**	**25**
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	**21**	**60**	**4**	**2380**	**48**
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	**4**	**3**	**7**	**138**	**5**
Magnesium	7439-95-4	1	mg/L	**2**	**3**	**4**	**118**	**2**
Sodium	7440-23-5	1	mg/L	**103**	**165**	**146**	**1360**	**160**
Potassium	7440-09-7	1	mg/L	**2**	**3**	**3**	**18**	**3**
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	**0.40**	**0.42**	**0.04**	<0.01	**0.13**
Antimony	7440-36-0	0.001	mg/L	**0.002**	**0.005**	**0.002**	**0.002**	**0.005**
Arsenic	7440-38-2	0.001	mg/L	**0.033**	**0.044**	**0.009**	**0.015**	**0.025**
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	**0.0001**	<0.0001	**0.0004**	<0.0001
Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Copper	7440-50-8	0.001	mg/L	**0.002**	**0.002**	<0.001	**0.001**	<0.001
Cobalt	7440-48-4	0.001	mg/L	<0.001	<0.001	<0.001	**0.005**	<0.001
Nickel	7440-02-0	0.001	mg/L	<0.001	<0.001	<0.001	**0.008**	<0.001
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Zinc	7440-66-6	0.005	mg/L	**0.006**	<0.005	<0.005	**0.025**	<0.005
Lithium	7439-93-2	0.001	mg/L	**0.003**	**0.004**	**0.007**	**0.058**	**0.007**
Manganese	7439-96-5	0.001	mg/L	**0.005**	**0.003**	**0.002**	**0.156**	**0.008**
Molybdenum	7439-98-7	0.001	mg/L	**0.030**	**0.137**	**0.013**	**0.077**	**0.103**
Selenium	7782-49-2	0.01	mg/L	**0.02**	<0.01	**0.02**	<0.01	<0.01

Analytical Results

Sub-Matrix: WATER
(Matrix: WATER)

Compound	CAS Number	LOR	Unit	KLC 1	KLC 3	KLC 4	KLC 5	KLC 6
			Client sampling date / time	08-Jun-2018 00:00	08-Jun-2018 00:00	08-Jun-2018 00:00	08-Jun-2018 00:00	08-Jun-2018 00:00
				EB1814029-001	EB1814029-002	EB1814029-003	EB1814029-004	EB1814029-005
				Result	Result	Result	Result	Result
EG020F: Dissolved Metals by ICP-MS - Continued								
Uranium	7440-61-1	0.001	mg/L	**0.001**	**0.002**	**0.001**	**0.010**	<0.001
Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Boron	7440-42-8	0.05	mg/L	**0.06**	**0.10**	<0.05	**0.20**	**0.06**
Iron	7439-89-6	0.05	mg/L	**0.23**	**0.15**	<0.05	<0.05	<0.05
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	**0.4**	**1.0**	**0.3**	**0.2**	**0.4**
EN055: Ionic Balance								
Total Anions	----	0.01	meq/L	**4.78**	**7.88**	**7.20**	**83.9**	**8.05**
Total Cations	----	0.01	meq/L	**4.90**	**7.65**	**7.10**	**76.2**	**7.45**
Ionic Balance	----	0.01	%	**1.21**	**1.50**	**0.65**	**4.80**	**3.86**

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	KLC 7	KLC 8	KLC 9	KLC 10	KLC 11
			Client sampling date / time	08-Jun-2018 00:00	08-Jun-2018 00:00	08-Jun-2018 00:00	08-Jun-2018 00:00	08-Jun-2018 00:00
Compound	CAS Number	LOR	Unit	EB1814029-006	EB1814029-007	EB1814029-008	EB1814029-009	EB1814029-010
				Result	Result	Result	Result	Result
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	**7.88**	**8.30**	**8.73**	**8.84**	**8.35**
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	**1510**	**9350**	**1830**	**1390**	**9200**
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	**6**	**63**	**102**	**16**
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	**103**	**301**	**369**	**446**	**276**
Total Alkalinity as CaCO3	----	1	mg/L	**103**	**307**	**432**	**548**	**292**
ED038A: Acidity								
Acidity as CaCO3	----	1	mg/L	**1**	<1	<1	<1	<1
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	**126**	**705**	**146**	**119**	**672**
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	**358**	**2760**	**253**	**42**	**2680**
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	**12**	**92**	**8**	**10**	**88**
Magnesium	7439-95-4	1	mg/L	**28**	**223**	**18**	**16**	**176**
Sodium	7440-23-5	1	mg/L	**225**	**1420**	**346**	**285**	**1500**
Potassium	7440-09-7	1	mg/L	**10**	**34**	**11**	**10**	**28**
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	<0.01	<0.01	<0.01	**0.01**	<0.01
Antimony	7440-36-0	0.001	mg/L	**0.008**	**0.022**	**0.001**	**0.001**	**0.002**
Arsenic	7440-38-2	0.001	mg/L	<0.001	**0.004**	**0.006**	**0.002**	**0.009**
Cadmium	7440-43-9	0.0001	mg/L	**0.0001**	**0.0007**	<0.0001	<0.0001	**0.0002**
Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Copper	7440-50-8	0.001	mg/L	**0.002**	**0.005**	**0.001**	<0.001	**0.001**
Cobalt	7440-48-4	0.001	mg/L	<0.001	**0.023**	**0.002**	<0.001	**0.004**
Nickel	7440-02-0	0.001	mg/L	**0.002**	**0.012**	**0.002**	<0.001	**0.005**
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Zinc	7440-66-6	0.005	mg/L	**0.045**	**0.147**	**0.005**	<0.005	**0.016**
Lithium	7439-93-2	0.001	mg/L	**0.021**	**0.104**	**0.032**	**0.025**	**0.093**
Manganese	7439-96-5	0.001	mg/L	**0.006**	**1.00**	**0.136**	**0.003**	**0.102**
Molybdenum	7439-98-7	0.001	mg/L	**0.004**	**0.032**	**0.073**	**0.013**	**0.066**
Selenium	7782-49-2	0.01	mg/L	**0.02**	<0.01	<0.01	**0.02**	<0.01

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	KLC 7	KLC 8	KLC 9	KLC 10	KLC 11
			Client sampling date / time	08-Jun-2018 00:00	08-Jun-2018 00:00	08-Jun-2018 00:00	08-Jun-2018 00:00	08-Jun-2018 00:00
Compound	CAS Number	LOR	Unit	EB1814029-006	EB1814029-007	EB1814029-008	EB1814029-009	EB1814029-010
				Result	Result	Result	Result	Result
EG020F: Dissolved Metals by ICP-MS - Continued								
Uranium	7440-61-1	0.001	mg/L	<0.001	**0.004**	**0.001**	**0.002**	**0.005**
Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Boron	7440-42-8	0.05	mg/L	**0.17**	**0.50**	**0.37**	**0.20**	**0.44**
Iron	7439-89-6	0.05	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	**0.7**	**1.6**	**2.8**	**0.5**	**0.3**
EN055: Ionic Balance								
Total Anions	----	0.01	meq/L	**14.8**	**98.7**	**18.8**	**14.6**	**95.4**
Total Cations	----	0.01	meq/L	**12.9**	**85.6**	**17.2**	**14.5**	**84.8**
Ionic Balance	----	0.01	%	**6.62**	**7.10**	**4.43**	**0.49**	**5.87**

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	KLC 12	KLC 13	KLC 15	KLC 16	KLC 17
			Client sampling date / time	08-Jun-2018 00:00	08-Jun-2018 00:00	08-Jun-2018 00:00	08-Jun-2018 00:00	08-Jun-2018 00:00
Compound	CAS Number	LOR	Unit	EB1814029-011	EB1814029-012	EB1814029-013	EB1814029-014	EB1814029-015
				Result	Result	Result	Result	Result
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	8.60	8.99	8.85	8.41	8.15
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	961	1320	1790	653	8770
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	30	146	109	18	<1
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	235	444	424	156	180
Total Alkalinity as CaCO3	----	1	mg/L	265	590	533	174	180
ED038A: Acidity								
Acidity as CaCO3	----	1	mg/L	<1	<1	<1	<1	2
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	71	53	79	136	750
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	100	36	230	5	2620
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	4	8	10	24	245
Magnesium	7439-95-4	1	mg/L	5	8	10	19	240
Sodium	7440-23-5	1	mg/L	188	298	357	77	1140
Potassium	7440-09-7	1	mg/L	5	2	2	11	40
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	0.03	0.31	0.03	0.02	<0.01
Antimony	7440-36-0	0.001	mg/L	0.003	0.001	<0.001	<0.001	<0.001
Arsenic	7440-38-2	0.001	mg/L	0.012	0.004	0.004	0.001	0.002
Cadmium	7440-43-9	0.0001	mg/L	0.0001	<0.0001	<0.0001	<0.0001	0.0001
Chromium	7440-47-3	0.001	mg/L	<0.001	0.005	<0.001	<0.001	<0.001
Copper	7440-50-8	0.001	mg/L	<0.001	0.007	0.007	0.004	0.001
Cobalt	7440-48-4	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	0.001
Nickel	7440-02-0	0.001	mg/L	<0.001	0.003	0.004	<0.001	0.001
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Zinc	7440-66-6	0.005	mg/L	<0.005	<0.005	<0.005	<0.005	0.010
Lithium	7439-93-2	0.001	mg/L	0.011	0.003	0.004	0.011	0.055
Manganese	7439-96-5	0.001	mg/L	0.039	<0.001	0.004	0.001	0.142
Molybdenum	7439-98-7	0.001	mg/L	0.136	0.027	0.017	0.007	0.010
Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	<0.01	0.01	<0.01

Analytical Results

Sub-Matrix: **WATER** (Matrix: **WATER**)			Client sample ID	KLC 12	KLC 13	KLC 15	KLC 16	KLC 17
			Client sampling date / time	08-Jun-2018 00:00	08-Jun-2018 00:00	08-Jun-2018 00:00	08-Jun-2018 00:00	08-Jun-2018 00:00
Compound	CAS Number	LOR	Unit	EB1814029-011	EB1814029-012	EB1814029-013	EB1814029-014	EB1814029-015
				Result	Result	Result	Result	Result
EG020F: Dissolved Metals by ICP-MS - Continued								
Uranium	7440-61-1	0.001	mg/L	<0.001	**0.015**	**0.012**	**0.001**	**0.006**
Vanadium	7440-62-2	0.01	mg/L	<0.01	**0.02**	**0.02**	<0.01	<0.01
Boron	7440-42-8	0.05	mg/L	**0.21**	**0.56**	**0.60**	**0.08**	**0.14**
Iron	7439-89-6	0.05	mg/L	<0.05	**0.05**	<0.05	<0.05	<0.05
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	**0.6**	**3.0**	**2.5**	**0.7**	**0.4**
EN055: Ionic Balance								
Total Anions	----	0.01	meq/L	**9.59**	**13.9**	**18.8**	**6.45**	**93.1**
Total Cations	----	0.01	meq/L	**8.92**	**14.1**	**16.9**	**6.39**	**82.6**
Ionic Balance	----	0.01	%	**3.66**	**0.58**	**5.27**	**0.44**	**5.99**

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	KLC 18	----	----	----	----
			Client sampling date / time	08-Jun-2018 00:00	----	----	----	----
Compound	CAS Number	LOR	Unit	EB1814029-016	--------	--------	--------	--------
				Result	----	----	----	----
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	8.35	----	----	----	----
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	619	----	----	----	----
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	----	----	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	10	----	----	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	135	----	----	----	----
Total Alkalinity as CaCO3	----	1	mg/L	145	----	----	----	----
ED038A: Acidity								
Acidity as CaCO3	----	1	mg/L	<1	----	----	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	136	----	----	----	----
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	11	----	----	----	----
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	19	----	----	----	----
Magnesium	7439-95-4	1	mg/L	16	----	----	----	----
Sodium	7440-23-5	1	mg/L	88	----	----	----	----
Potassium	7440-09-7	1	mg/L	11	----	----	----	----
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	0.01	----	----	----	----
Antimony	7440-36-0	0.001	mg/L	<0.001	----	----	----	----
Arsenic	7440-38-2	0.001	mg/L	0.004	----	----	----	----
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	----	----	----	----
Chromium	7440-47-3	0.001	mg/L	<0.001	----	----	----	----
Copper	7440-50-8	0.001	mg/L	<0.001	----	----	----	----
Cobalt	7440-48-4	0.001	mg/L	<0.001	----	----	----	----
Nickel	7440-02-0	0.001	mg/L	<0.001	----	----	----	----
Lead	7439-92-1	0.001	mg/L	<0.001	----	----	----	----
Zinc	7440-66-6	0.005	mg/L	<0.005	----	----	----	----
Lithium	7439-93-2	0.001	mg/L	0.011	----	----	----	----
Manganese	7439-96-5	0.001	mg/L	0.050	----	----	----	----
Molybdenum	7439-98-7	0.001	mg/L	0.016	----	----	----	----
Selenium	7782-49-2	0.01	mg/L	<0.01	----	----	----	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	KLC 18	----	----	----	----
			Client sampling date / time	08-Jun-2018 00:00	----	----	----	----
Compound	*CAS Number*	*LOR*	*Unit*	EB1814029-016	--------	--------	--------	--------
				Result	----	----	----	----
EG020F: Dissolved Metals by ICP-MS - Continued								
Uranium	7440-61-1	0.001	mg/L	**0.001**	----	----	----	----
Vanadium	7440-62-2	0.01	mg/L	<0.01	----	----	----	----
Boron	7440-42-8	0.05	mg/L	**0.07**	----	----	----	----
Iron	7439-89-6	0.05	mg/L	<0.05	----	----	----	----
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	**0.9**	----	----	----	----
EN055: Ionic Balance								
Total Anions	----	0.01	meq/L	**6.04**	----	----	----	----
Total Cations	----	0.01	meq/L	**6.37**	----	----	----	----
Ionic Balance	----	0.01	%	**2.70**	----	----	----	----

A.3.5 Appendix 3v Pit water used for KLC testing

CERTIFICATE OF ANALYSIS

Work Order	: **EB1804468**	Page	: 1 of 4
Amendment	: **1**		
Client	: **RGS ENVIRONMENTAL PTY LTD**	Laboratory	: Environmental Division Brisbane
Contact	: MR ALAN ROBERTSON	Contact	: Customer Services EB
Address	: PO Box 3091 SUNNYBANK SOUTH QLD, AUSTRALIA 4109	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: +61 07 3344 1222	Telephone	: +61-7-3243 7222
Project	: 2017041 - Ensham Project	Date Samples Received	: 16-Feb-2018 15:50
Order number	: ----	Date Analysis Commenced	: 19-Feb-2018
C-O-C number	: ----	Issue Date	: 23-Feb-2018 16:32
Sampler	: MARY MACELROY		
Site	: ----		
Quote number	: BN/035/18 V2		
No. of samples received	: 1		
No. of samples analysed	: 1		

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

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

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

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

Signatories

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

Signatories	*Position*	*Accreditation Category*
Andrew Epps	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

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

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

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

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

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

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

- Amendment (23/02/2018): This report has been amended and re-released to allow the reporting of additional analytical data.

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	GW	----	----	----	----
			Client sampling date / time	16-Feb-2018 00:00	----	----	----	----
Compound	CAS Number	LOR	Unit	EB1804468-001	--------	--------	--------	--------
				Result	----	----	----	----
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	**8.37**	----	----	----	----
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	**8580**	----	----	----	----
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	----	----	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	**23**	----	----	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	**254**	----	----	----	----
Total Alkalinity as CaCO3	----	1	mg/L	**277**	----	----	----	----
ED038A: Acidity								
Acidity as CaCO3	----	1	mg/L	<1	----	----	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	**596**	----	----	----	----
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	**2470**	----	----	----	----
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	**46**	----	----	----	----
Magnesium	7439-95-4	1	mg/L	**186**	----	----	----	----
Sodium	7440-23-5	1	mg/L	**1380**	----	----	----	----
Potassium	7440-09-7	1	mg/L	**16**	----	----	----	----
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	<0.01	----	----	----	----
Antimony	7440-36-0	0.001	mg/L	<0.001	----	----	----	----
Arsenic	7440-38-2	0.001	mg/L	**0.002**	----	----	----	----
Cadmium	7440-43-9	0.0001	mg/L	**0.0002**	----	----	----	----
Uranium	7440-61-1	0.001	mg/L	**0.001**	----	----	----	----
Chromium	7440-47-3	0.001	mg/L	<0.001	----	----	----	----
Copper	7440-50-8	0.001	mg/L	**0.002**	----	----	----	----
Cobalt	7440-48-4	0.001	mg/L	<0.001	----	----	----	----
Nickel	7440-02-0	0.001	mg/L	<0.001	----	----	----	----
Lead	7439-92-1	0.001	mg/L	<0.001	----	----	----	----
Zinc	7440-66-6	0.005	mg/L	**0.010**	----	----	----	----
Manganese	7439-96-5	0.001	mg/L	**0.001**	----	----	----	----
Molybdenum	7439-98-7	0.001	mg/L	**0.006**	----	----	----	----
Selenium	7782-49-2	0.01	mg/L	<0.01	----	----	----	----

Analytical Results

Sub-Matrix: **WATER** (Matrix: **WATER**)			*Client sample ID*	**GW**	----	----	----	----
			Client sampling date / time	16-Feb-2018 00:00	----	----	----	----
Compound	*CAS Number*	*LOR*	*Unit*	**EB1804468-001**	--------	--------	--------	--------
				Result	----	----	----	----
EG020F: Dissolved Metals by ICP-MS - Continued								
Vanadium	7440-62-2	0.01	mg/L	<0.01	----	----	----	----
Boron	7440-42-8	0.05	mg/L	**0.35**	----	----	----	----
Iron	7439-89-6	0.05	mg/L	<0.05	----	----	----	----
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	**0.3**	----	----	----	----

A.3.6 Appendix 3vi KLC leach results

CERTIFICATE OF ANALYSIS

Work Order	: **EB1806061**	Page	: 1 of 6
Client	: **RGS ENVIRONMENTAL PTY LTD**	Laboratory	: Environmental Division Brisbane
Contact	: MR ALAN ROBERTSON	Contact	: Customer Services EB
Address	: PO Box 3091 SUNNYBANK SOUTH QLD, AUSTRALIA 4109	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: +61 07 3344 1222	Telephone	: +61-7-3243 7222
Project	: 2017041 - Ensham Project	Date Samples Received	: 06-Mar-2018 16:00
Order number	: ----	Date Analysis Commenced	: 12-Mar-2018
C-O-C number	: ----	Issue Date	: 21-Mar-2018 13:10
Sampler	: MARY MACELROY		
Site	: ----		
Quote number	: EN/222/17		
No. of samples received	: 7		
No. of samples analysed	: 7		

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

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

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

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

Signatories

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

Signatories	*Position*	*Accreditation Category*
Andrew Epps	Senior Inorganic Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Andrew Epps	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Ben Felgendrejeris	Senior Acid Sulfate Soil Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Kim McCabe	Senior Inorganic Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

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

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

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

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

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

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

- ED037 (Alkalinity): NATA accreditation does not cover the performance of this service.
- ED038 (Acidity): NATA accreditation does not cover the performance of this service.
- ASS: EA013 (ANC) Fizz Rating: 0- None; 1- Slight; 2- Moderate; 3- Strong; 4- Very Strong; 5- Lime.

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	KLC Composite A C5285_6.7-77.73	KLC Composite B C5285_77.74-106.1	KLC Composite C C5285_23.7-32.84	KLC Composite D C5285_32.84-89.89	KLC Composite E Spoil Composite
			Client sampling date / time	06-Mar-2018 00:00	06-Mar-2018 00:00	06-Mar-2018 00:00	06-Mar-2018 00:00	06-Mar-2018 00:00
Compound	CAS Number	LOR	Unit	EB1806061-001	EB1806061-002	EB1806061-003	EB1806061-004	EB1806061-005
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	9.6	9.7	9.7	8.6	8.1
pH Value	----	0.1	pH Unit	9.5	9.7	9.7	8.2	8.2
EA009: Nett Acid Production Potential								
Net Acid Production Potential	----	0.5	kg H2SO4/t	-38.2	-79.2	-85.2	-19.5	-11.3
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	414	404	568	251	2560
Electrical Conductivity @ 25°C	----	1	µS/cm	304	301	418	614	1700
EA013: Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	39.1	80.4	87.3	20.4	11.9
ANC as CaCO3	----	0.1	% CaCO3	4.0	8.2	8.9	2.1	1.2
Fizz Rating	----	0	Fizz Unit	1	2	2	1	1
EA026 : Chromium Reducible Sulfur								
Chromium Reducible Sulphur	----	0.005	%	0.025	0.019	0.026	0.018	0.006
ED006: Exchangeable Cations on Alkaline Soils								
Exchangeable Calcium	----	0.2	meq/100g	2.7	2.1	2.2	1.6	2.2
Exchangeable Magnesium	----	0.2	meq/100g	3.3	1.8	4.8	5.9	3.4
Exchangeable Potassium	----	0.2	meq/100g	0.2	0.3	0.4	0.5	<0.2
Exchangeable Sodium	----	0.2	meq/100g	1.7	1.5	2.3	2.0	0.9
Cation Exchange Capacity	----	0.2	meq/100g	7.9	5.7	9.7	10.0	6.6
Exchangeable Sodium Percent	----	0.2	%	21.3	26.2	24.0	19.6	13.6
ED037: Alkalinity								
Total Alkalinity as CaCO3	----	1	mg/kg	3190	8050	8140	1430	1990
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/kg	2730	7490	7490	1430	1990
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/kg	462	555	648	<5	<5
ED038A: Acidity								
Acidity	----	1	mg/kg	<5	<5	<5	34	38
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	0.03	0.04	0.07	0.03	0.02
Sample Preparation Method								
Amount	----	0.1	g	1.0	1.0	1.0	1.0	1.0

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	KLC Composite F Spoil Composite	UHP water used for pH and EC	----	----	----
			Client sampling date / time	06-Mar-2018 00:00	07-Mar-2018 00:00	----	----	----
Compound	CAS Number	LOR	Unit	EB1806061-006	EB1806061-007	--------	--------	--------
				Result	Result	----	----	----
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	8.8	----	----	----	----
pH Value	----	0.1	pH Unit	8.9	5.6	----	----	----
EA009: Nett Acid Production Potential								
Net Acid Production Potential	----	0.5	kg H2SO4/t	-26.1	----	----	----	----
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	352	----	----	----	----
Electrical Conductivity @ 25°C	----	1	µS/cm	250	<1	----	----	----
EA013: Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	27.3	----	----	----	----
ANC as CaCO3	----	0.1	% CaCO3	2.8	----	----	----	----
Fizz Rating	----	0	Fizz Unit	1	----	----	----	----
EA026 : Chromium Reducible Sulfur								
Chromium Reducible Sulphur	----	0.005	%	0.018	----	----	----	----
ED006: Exchangeable Cations on Alkaline Soils								
Exchangeable Calcium	----	0.2	meq/100g	3.0	----	----	----	----
Exchangeable Magnesium	----	0.2	meq/100g	3.8	----	----	----	----
Exchangeable Potassium	----	0.2	meq/100g	0.4	----	----	----	----
Exchangeable Sodium	----	0.2	meq/100g	0.6	----	----	----	----
Cation Exchange Capacity	----	0.2	meq/100g	7.8	----	----	----	----
Exchangeable Sodium Percent	----	0.2	%	7.1	----	----	----	----
ED037: Alkalinity								
Total Alkalinity as CaCO3	----	1	mg/kg	4020	----	----	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/kg	3840	----	----	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/kg	185	----	----	----	----
ED038A: Acidity								
Acidity	----	1	mg/kg	<5	----	----	----	----
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	0.04	----	----	----	----
Sample Preparation Method								
Amount	----	0.1	g	1.0	----	----	----	----

Analytical Results

Sub-Matrix: WATER LEACHATE (Matrix: WATER)			Client sample ID	KLC Composite A C5285_6.7-77.73	KLC Composite B C5285_77.74-106.1	KLC Composite C C5285_23.7-32.84	KLC Composite D C5285_32.84-89.89	KLC Composite E Spoil Composite
			Client sampling date / time	06-Mar-2018 00:00	06-Mar-2018 00:00	06-Mar-2018 00:00	06-Mar-2018 00:00	06-Mar-2018 00:00
Compound	CAS Number	LOR	Unit	EB1806061-001	EB1806061-002	EB1806061-003	EB1806061-004	EB1806061-005
				Result	Result	Result	Result	Result
ED093W: Water Leachable Major Cations								
Calcium	7440-70-2	1	mg/L	<1	**1**	**2**	**4**	**67**
Magnesium	7439-95-4	1	mg/L	<1	<1	**2**	**10**	**72**
Sodium	7440-23-5	1	mg/L	**100**	**100**	**141**	**198**	**399**
Potassium	7440-09-7	1	mg/L	**3**	**4**	**6**	**10**	**8**
EG005W: Water Leachable Metals by ICPAES								
Aluminium	7429-90-5	0.10	mg/L	<0.10	**0.12**	<0.10	<0.10	**0.84**
Antimony	7440-36-0	0.01	mg/L	**0.11**	<0.01	**0.01**	**0.02**	**0.02**
Arsenic	7440-38-2	0.01	mg/L	**0.04**	**0.12**	**0.09**	**0.01**	<0.01
Boron	7440-42-8	0.1	mg/L	**0.3**	**0.3**	**0.5**	**0.6**	**0.2**
Cadmium	7440-43-9	0.005	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005
Chromium	7440-47-3	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Cobalt	7440-48-4	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Copper	7440-50-8	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Iron	7439-89-6	0.05	mg/L	<0.05	<0.05	<0.05	<0.05	**0.33**
Lead	7439-92-1	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Manganese	7439-96-5	0.01	mg/L	<0.01	**0.02**	<0.01	<0.01	**0.63**
Nickel	7440-02-0	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Selenium	7782-49-2	0.01	mg/L	<0.01	**0.02**	**0.02**	**0.03**	**0.02**
Vanadium	7440-62-2	0.01	mg/L	**0.01**	**0.01**	**0.01**	<0.01	<0.01
Zinc	7440-66-6	0.01	mg/L	<0.01	**0.10**	<0.01	**0.01**	<0.01
Molybdenum	7439-98-7	0.01	mg/L	**0.04**	**0.05**	**0.07**	<0.01	<0.01
EG020W: Water Leachable Metals by ICP-MS								
Lithium	7439-93-2	0.001	mg/L	**0.003**	**0.004**	**0.006**	**0.030**	**0.011**
Uranium	7440-61-1	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001

Analytical Results

Sub-Matrix: WATER LEACHATE (Matrix: WATER)			Client sample ID	KLC Composite F Spoil Composite	----	----	----	----
			Client sampling date / time	06-Mar-2018 00:00	----	----	----	----
Compound	CAS Number	LOR	Unit	EB1806061-006	--------	--------	--------	--------
				Result	----	----	----	----
ED093W: Water Leachable Major Cations								
Calcium	7440-70-2	1	mg/L	**10**	----	----	----	----
Magnesium	7439-95-4	1	mg/L	**8**	----	----	----	----
Sodium	7440-23-5	1	mg/L	**53**	----	----	----	----
Potassium	7440-09-7	1	mg/L	**11**	----	----	----	----
EG005W: Water Leachable Metals by ICPAES								
Aluminium	7429-90-5	0.10	mg/L	**0.69**	----	----	----	----
Antimony	7440-36-0	0.01	mg/L	**0.02**	----	----	----	----
Arsenic	7440-38-2	0.01	mg/L	**0.03**	----	----	----	----
Boron	7440-42-8	0.1	mg/L	**0.3**	----	----	----	----
Cadmium	7440-43-9	0.005	mg/L	<0.005	----	----	----	----
Chromium	7440-47-3	0.01	mg/L	<0.01	----	----	----	----
Cobalt	7440-48-4	0.01	mg/L	<0.01	----	----	----	----
Copper	7440-50-8	0.01	mg/L	<0.01	----	----	----	----
Iron	7439-89-6	0.05	mg/L	**0.31**	----	----	----	----
Lead	7439-92-1	0.01	mg/L	<0.01	----	----	----	----
Manganese	7439-96-5	0.01	mg/L	<0.01	----	----	----	----
Nickel	7440-02-0	0.01	mg/L	<0.01	----	----	----	----
Selenium	7782-49-2	0.01	mg/L	<0.01	----	----	----	----
Vanadium	7440-62-2	0.01	mg/L	<0.01	----	----	----	----
Zinc	7440-66-6	0.01	mg/L	**0.06**	----	----	----	----
Molybdenum	7439-98-7	0.01	mg/L	<0.01	----	----	----	----
EG020W: Water Leachable Metals by ICP-MS								
Lithium	7439-93-2	0.001	mg/L	**0.008**	----	----	----	----
Uranium	7440-61-1	0.001	mg/L	<0.001	----	----	----	----

A.4 Site Water Results

A.4.1 Appendix 4i Pit water results

Water quality of the A Pit surface water sample collected in Feb 2018 and used for the KLC program is provided in **Table A.4-1**. Parameters present in concentrations below the laboratory limit of reporting are denoted by values coloured red at half the laboratory limit of reporting.

Table A.4-1 A Pit water quality

pH Value		pH Unit	8.4
Electrical Conductivity @ 25°C		µS/cm	8580.0
Hydroxide Alkalinity as CaCO3	DMO-210-001	mg/L	0.5
Carbonate Alkalinity as CaCO3	3812-32-6	mg/L	23.0
Bicarbonate Alkalinity as CaCO3	71-52-3	mg/L	254.0
Total Alkalinity as CaCO3		mg/L	277.0
Acidity as CaCO3		mg/L	0.5
Sulfate as SO4 - Turbidimetric	14808-79-8	mg/L	596.000
Chloride	16887-00-6	mg/L	2470.000
Calcium	7440-70-2	mg/L	46.000
Magnesium	7439-95-4	mg/L	186.000
Sodium	7440-23-5	mg/L	1380.000
Potassium	7440-09-7	mg/L	16.000
Aluminium	7429-90-5	mg/L	0.005
Antimony	7440-36-0	mg/L	0.001
Arsenic	7440-38-2	mg/L	0.002
Cadmium	7440-43-9	mg/L	0.000
Chromium	7440-47-3	mg/L	0.001
Cobalt	7440-48-4	mg/L	0.001
Copper	7440-50-8	mg/L	0.002
Lead	7439-92-1	mg/L	0.001
Lithium	7439-93-2	mg/L	0.088
Manganese	7439-96-5	mg/L	0.001
Molybdenum	7439-98-7	mg/L	0.006
Nickel	7440-02-0	mg/L	0.001
Selenium	7782-49-2	mg/L	0.005
Uranium	7440-61-1	mg/L	0.001
Vanadium	7440-62-2	mg/L	0.005
Zinc	7440-66-6	mg/L	0.010
Boron	7440-42-8	mg/L	0.350
Iron	7439-89-6	mg/L	0.025
Fluoride	16984-48-8	mg/L	0.300

Water used for the drilling program for C5285 and C5286 includes the following. Water from Ramp 10 had a TDS concentration of 3,380 mg/L dominated by Cl^- (1,290 mg/L), Na^+ (953 mg/L), SO_4^{2-} (934 mg/l), Mg^{2+} (91 mg/L) and K^+ (14 mg/L). Water from Ramp 24 had a TDS concentration of 7,020 mg/L dominated by Cl^- (3,320 mg/L), Na^+ (2,100 mg/L), SO_4^{2-} (667 mg/l), Mg^{2+} (267 mg/L) and K^+ (20 mg/L).

A.4.2 Appendix 4ii Seepage results

Water quality results from these seepage samples were provided by Ensham personnel (**Table A.4-2**). Analysis of the seepage samples suggests seep waters are mildly alkaline and saline (**Table A.4-2**). Bicarbonate alkalinity makes up the majority of alkalinity in all samples. Sodium and chloride are the major contributors to salinity within the samples. Sulfate is also present in higher concentrations relative to other major ions.

Table A.4-2: Seepage pH, EC and major ion concentrations.

	Sample:	Ramp 4 Seepage 1 (Seepage from base of spoil)	Ramp 4 Seepage 2 (Seepage at base of spoil)	Ramp 4 Seepage 2 (Seepage at base of spoil)
	Date:	01-Mar-18	01-Mar-18	06-Mar-18
Parameters	**Unit of measure**			
pH		8.53	8.26	7.86
Electrical Conductivity	µS/cm	1,440	1,670	2,800
Carbonate Alkalinity	mg $CaCO_3$/L	30	<0.5	<0.5
Bicarbonate Alkalinity	mg $CaCO_3$/L	281	350	495
Hydroxide Alkalinity	mg $CaCO_3$/L	<0.5	<0.5	<0.5
Major Ions				
Calcium (Ca)	mg/L	25	30	61
Magnesium (Mg)	mg/L	28	30	55
Potassium (K)	mg/L	10	6	8
Sodium (Na)	mg/L	248	269	459
Chloride (Cl)	mg/L	172	246	463
Fluoride (F)	mg/L	0.3	0.4	0.3
Sulfate (SO_4)	mg/L	170	155	260
Total Ions				
Total Anions (meq/L)	meq/L	14.6	17.2	28.4
Total Cations (meq/L)	meq/L	14.6	15.8	27.7
Ionic Balance %	%	0.03	4.06	1.11

Seepage samples were analysed for dissolved and total metal(loid) concentrations, respectively (**Table A.4-3** and **Table A.4-4**). Parameters present in concentrations below the laboratory limit of reporting are denoted by values coloured red at half the laboratory limit of reporting. Most analytes are present in concentrations below the laboratory limit of reporting. Spoil seepage is anticipated to have low concentrations of metals, both dissolved and suspended. It is important to note that the analysis is based on a relatively small number of samples as the occurrence of seepage is relatively infrequent. Additional seepage monitoring would increase the level of confidence in the data obtained to date. Further monitoring and analysis of seepage in future is therefore recommended.

Table A.4-3: Seepage dissolved metal concentrations

	Sample:	**Ramp 4 Seepage 1 (Seepage from base of spoil)**	**Ramp 4 Seepage 2 (Seepage at base of spoil)**	**Ramp 4 Seepage 2 (Seepage at base of spoil)**
	Date:	1-Mar-18	1-Mar-18	6-Mar-18
Trace Metals/Metalloids Dissolved	**Unit of measure**			
Aluminium (Al)	mg/L	0.0025	0.0200	0.0025
Antimony (Sb)	mg/L	0.0003	0.0003	0.0003
Arsenic (As) - pentavalent	mg/L	0.0003	0.0003	0.0003
Barium (Ba)	mg/L	0.0320	0.0400	0.0660
Beryllium (Be)	mg/L	0.0003	0.0003	0.0003
Boron (B)	mg/L	0.0125	0.0700	0.2000
Cadmium (Cd)	mg/L	0.00005	0.00005	0.00005
Chromium (Cr)	mg/L	0.0003	0.0003	0.0003
Cobalt (Co)	mg/L	0.0003	0.0003	0.0003
Copper (Cu)	mg/L	0.0003	0.0010	0.0010
Iron (Fe)	mg/L	0.0125	0.0125	0.0125

	Sample:	Ramp 4 Seepage 1 (Seepage from base of spoil)	Ramp 4 Seepage 2 (Seepage at base of spoil)	Ramp 4 Seepage 2 (Seepage at base of spoil)
Lead (Pb)	mg/L	0.0003	0.0003	0.0003
Manganese (Mn)	mg/L	0.0030	0.0320	0.0140
Mercury (Hg)	mg/L	0.00005	0.00005	0.00005
Molybdenum (Mo)	mg/L	0.0003	0.0020	0.0030
Nickel (Ni)	mg/L	0.0003	0.0010	0.0010
Selenium (Se)	mg/L	0.0025	0.0025	0.0025
Silver (mg/L)	mg/L	0.0003	0.0003	0.0003
Uranium (U)	mg/L	0.0003	0.0003	0.0020
Vanadium (V)	mg/L	0.0025	0.0025	0.0025
Zinc (Zn)	mg/L	0.0013	0.0013	0.0013

Table A.4-4: Seepage total (unfiltered) metal concentrations

	Sample:	Ramp 4 Seepage 1 (Seepage from base of spoil)	Ramp 4 Seepage 2 (Seepage at base of spoil)	Ramp 4 Seepage 2 (Seepage at base of spoil)
	Date:	1-Mar-18	1-Mar-18	6-Mar-18
Trace Metals/Metalloids Total	**Unit of measure**			
Aluminium (Al)	mg/L	0.5800	0.4200	1.2800
Antimony (Sb)	mg/L	0.0003	0.0003	0.0003
Arsenic (As) - pentavalent	mg/L	0.0010	0.0003	0.0003
Barium (Ba)	mg/L	0.0340	0.0430	0.0720
Beryllium (Be)	mg/L	0.0003	0.0003	0.0003
Boron (B)	mg/L	0.0800	0.1100	0.1700
Cadmium (Cd)	mg/L	0.00005	0.00005	0.00005
Chromium (Cr) - total	mg/L	0.0003	0.0003	0.0020
Cobalt (Co)	mg/L	0.0003	0.0003	0.0010
Copper (Cu)	mg/L	0.0020	0.0020	0.0040
Iron (Fe)	mg/L	0.6700	0.2700	2.4700
Lead (Pb)	mg/L	0.0003	0.0003	0.0030
Manganese (Mn)	mg/L	0.0100	0.0340	0.0510
Mercury (Hg)	mg/L	0.00005	0.00005	0.00005
Molybdenum (Mo)	mg/L	0.0030	0.0030	0.0030
Nickel (Ni)	mg/L	0.0010	0.0020	0.0030
Selenium (Se)	mg/L	0.0025	0.0025	0.0025
Silver (mg/L)	mg/L	0.0003	0.0003	0.0003
Uranium (U)	mg/L	0.0003	0.0003	0.0020
Vanadium (V)	mg/L	0.0025	0.0025	0.0025
Zinc (Zn)	mg/L	0.0013	0.0013	0.0013

A.4.3 Appendix 4iii Groundwater results

RGS has reviewed of available surface and groundwater monitoring data for the site covering 10 of the past 12 years (no data is available for 2012 and 2013 - the monitoring locations are shown in **Figure 4-4**). The results indicate that groundwater is circum-neutral pH, saline and dominated by NaCl. In summary, there is no evidence of AMD in groundwater over the past 12 years.

Groundwater pH results are circum-neutral, ranging from approximately 6 to 8 (**Figure A.4-1**). Groundwater from Permian lithology tended to be slightly more alkaline than groundwater in Quaternary sediments. This is interpreted to be due to the mixing of slightly acidic meteoric water with the ground water in Quaternary alluvium.

The EC results show a stark contrast between groundwater hosted in Quaternary and Permian aged rocks. Groundwater samples from Quaternary alluvium showed a much larger range of results compared to Permian aged samples (**Figure A.4-2**). The higher range in results is due to the seasonal effects of dilution from rainfall and flow events in the river and evaporation and concentrative effects during the dry season. In most cases median results are similar between the Quaternary and Permian samples. Groundwater conductivity appears to have increased since 2011 with the difference in median values between stratigraphy ages becoming larger in 2016 and 2017.

Median sulfate concentrations tend to be low for all groundwater samples (**Figure A.4-3**). As with EC, samples from Quaternary sediments show strong variability. Groundwater results from Permian strata, excluding outliers, consistently contained less than 200 mg/L of sulfate. The increased variability and concentrations of sulfate observed in groundwater from Quaternary alluvium is thought to be due to minor oxidation of sulfur and the concentration of sulfate by evapotranspiration.

Sodium concentrations in groundwater hosted in Quaternary aged rocks are variable (**Figure A.4-4**). The interquartile range of values became lower and less variable from 2006 to 2011. From 2011 to 2017 samples again became more variable and the median concentration increased each year. These results have not however, become as variable as results from 2006 and 2007. A decrease in sodium concentrations is observed from 2009 to 2010 in Permian aged rocks followed by an increase from 2010 to 2011. From 2011 to 2017 Permian rock hosted groundwater concentrations increased in both variability and median concentration. Recent sodium concentrations (2016 and 2017) are elevated for all groundwater samples (median concentration 1,000 – 2,000 mg/L). The elevated levels of sodium detected suggest that similar to most coal mines in the Bowen Basin, sodium contributes to groundwater salinity at Ensham.

Chloride concentrations in groundwater hosted in Quaternary sediments follow the same general trends of sodium concentrations (**Figure A.4-5**). Results from Quaternary alluvium groundwater are spread over a large range and commonly show outliers compared to groundwater from Permian strata. Despite having a smaller spread of results, groundwater from Permian rocks still contains high levels of chlorine. Most years have a median result of approximately 1,000 mg/L. This suggests that chloride is an important contributor to salinity at the site.

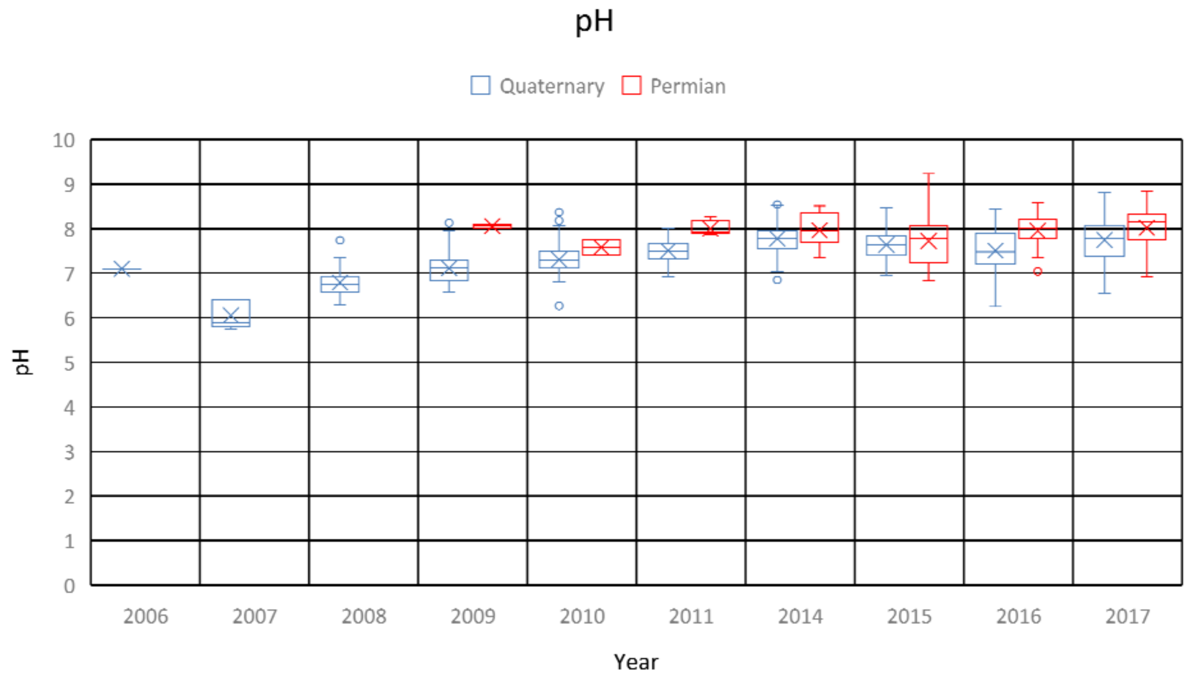


Figure A.4-1: Range, median and mean of groundwater pH results over time

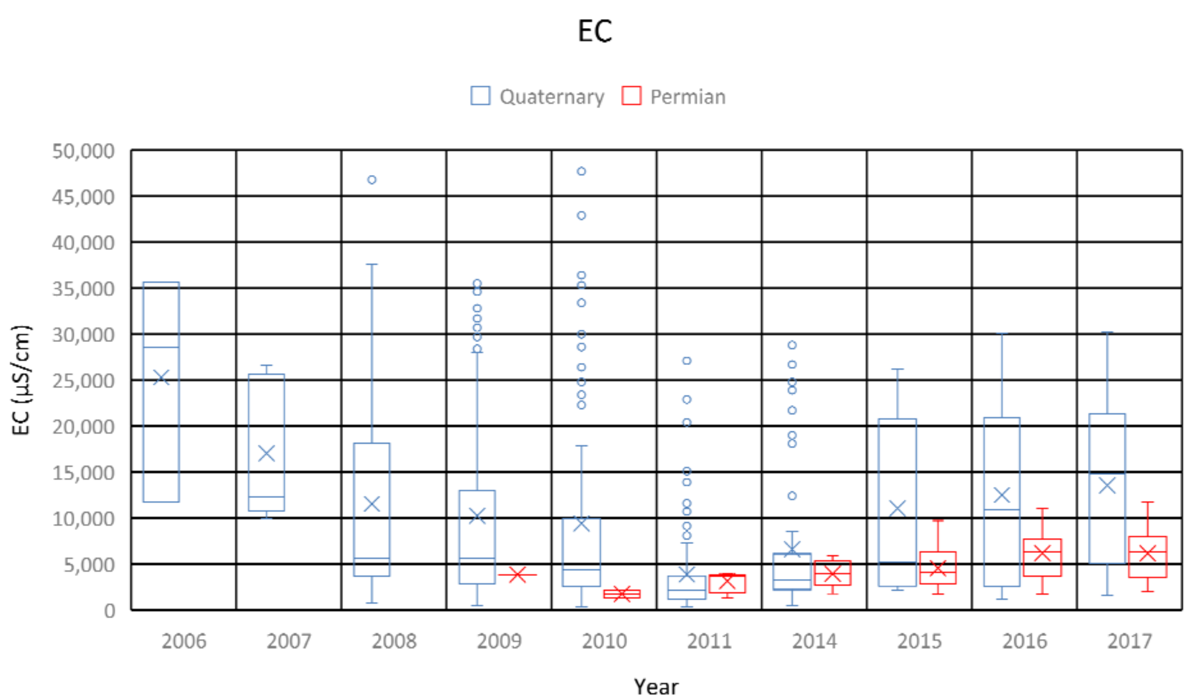


Figure A.4-2: Range, median and mean of groundwater EC results over time

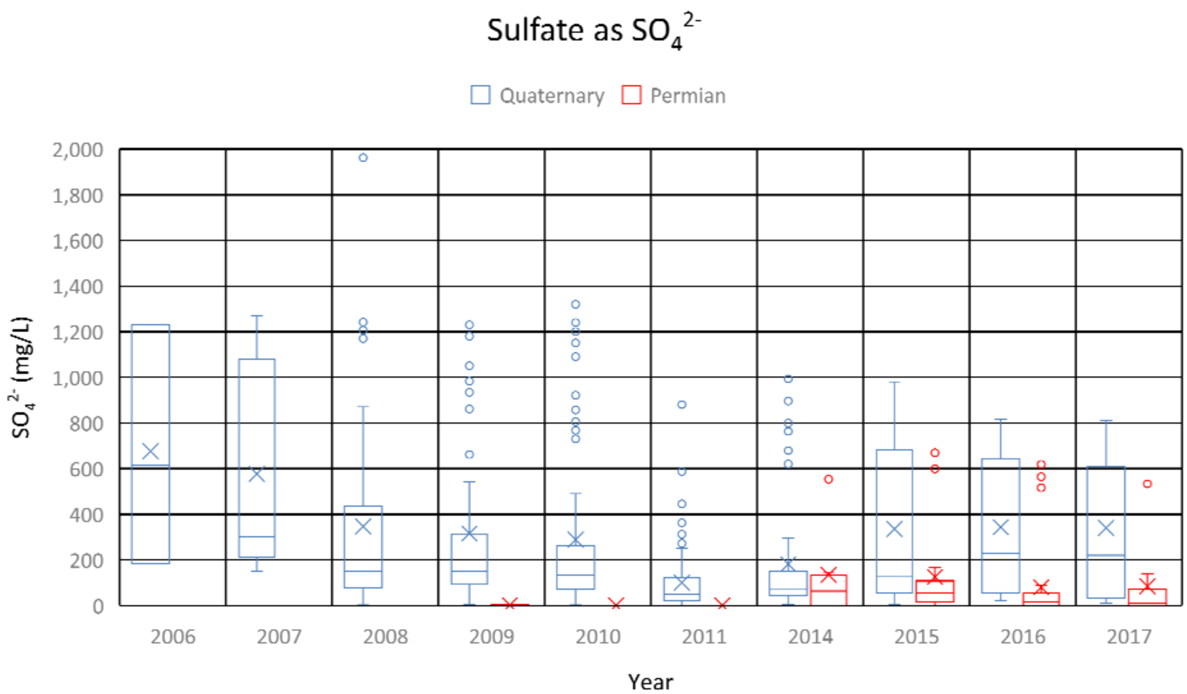


Figure A.4-3: Range, median and mean of groundwater sulfate concentrations over time

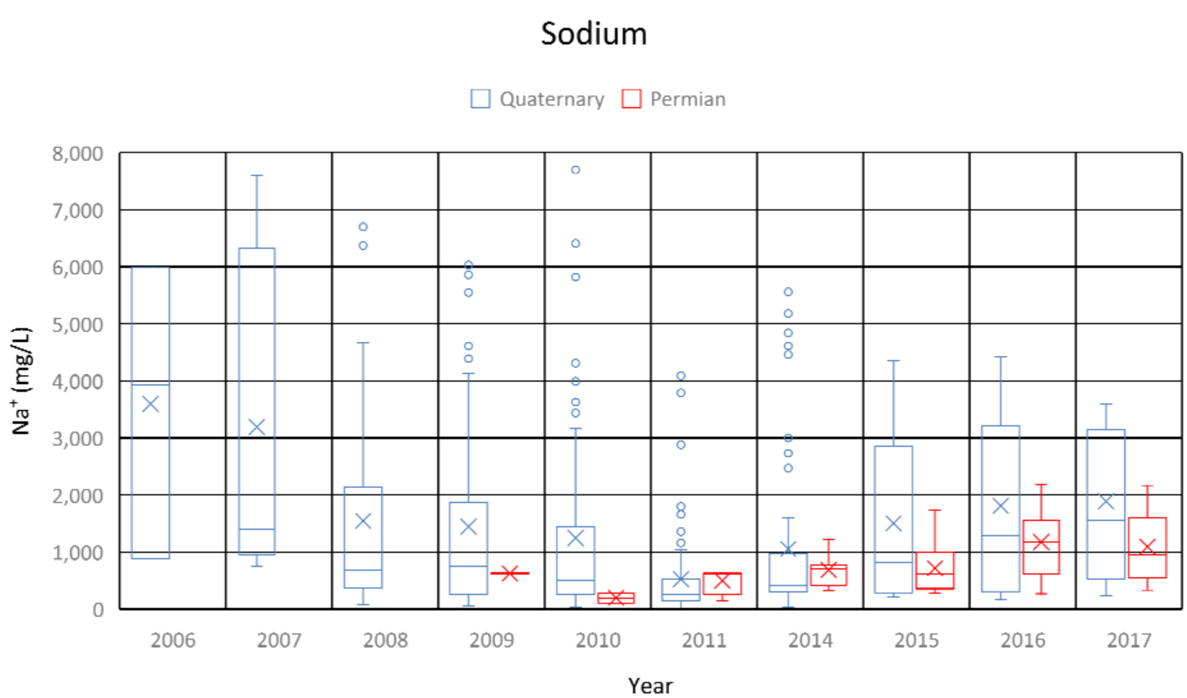


Figure A.4-4: Range, median and mean of groundwater sodium concentrations over time

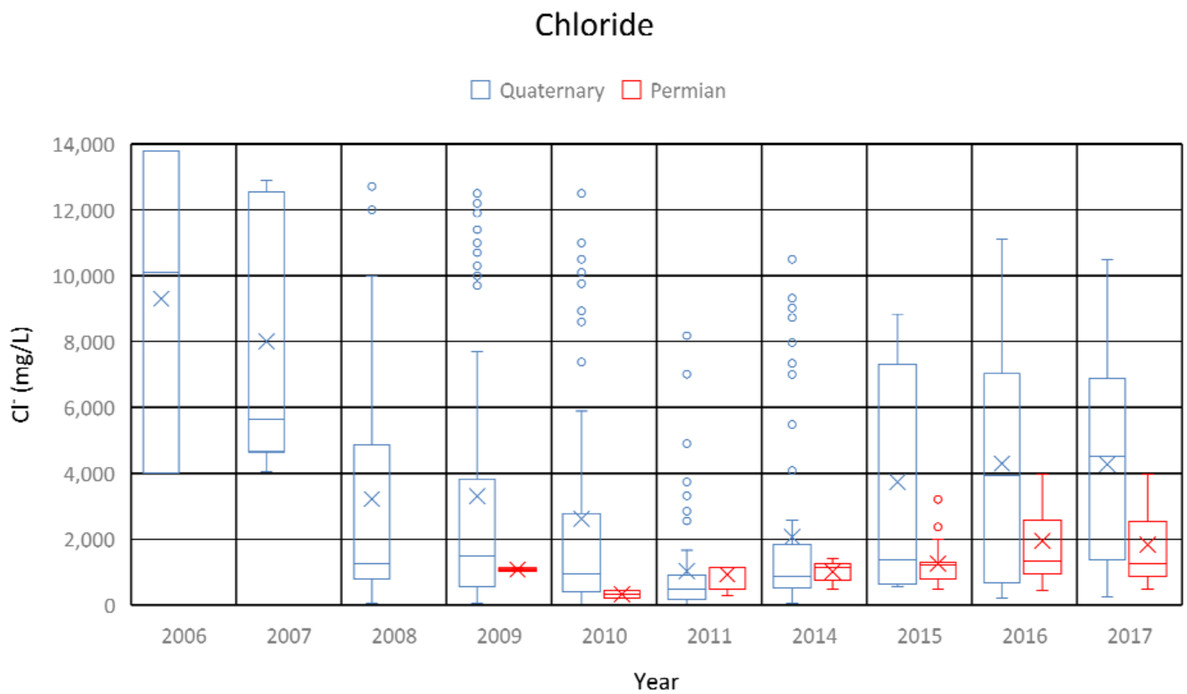


Figure A.4-5: Range, median and mean of groundwater chloride concentrations over time

A.4.4 Appendix 4iv Surface water results in Ensham pits

A review of surface water quality data was completed by RGS to evaluate AMD potential. Ensham collected samples from 4 sites for 7 years, 2006 and 2012 to 2017. Based on the available data set for pit void samples, continued monitoring of surface water chemistry is recommended. Surface water is mildly alkaline and saline with minor levels of sulfate and is dominated by NaCl. There is no evidence of AMD in the surface water samples.

The pH for all surface water samples is slightly alkaline (**Figure A.4-6**). Samples at all sites lie between pH 8 and 9. All samples show little variance and outliers are rare. This indicates consistency in the results. These results indicate that acid generation is either not occurring or that the ANC of the rocks in the pit walls far exceeds any potential for acid formation.

The EC results for three of the sample sites (Ramp 20 pit, Ramp 21 pit and Ramp 22 pit) indicate that materials represented by these samples are saline (**Figure A.4-7**). From 2015 to 2017 the EC results ranged from approximately 7,500 to 9,500 µS/cm. Samples from Ramp 10 pit had lower EC values, ranging from approximately 4,500 to 6,000 µS/cm. It also appears that surface water from further north on the Ensham site is less saline than southern surface waters.

As with the EC results, sulfate results from Ramp 20 pit, Ramp 21 pit and Ramp 22 pit are higher than those from Ramp 10 pit (**Figure A.4-8**). The maximum recorded sulfate concentration was approximately 650 mg/L. Little variance is seen in the results, particularly in 2016 and 2017. These sulfate results are relatively low indicating that sulfate is at most a minor contributor to site salinity and that surface waters have little to no contact with any oxidising sulfides.

Sodium results again show a difference between the northern and southern sample points (**Figure A.4-9**). Samples from southern pits were more saline than northern samples. Given the apparent correlation between sodium concentrations and EC results it is likely that sodium contributes significantly to surface water salinity.

In 2017, chloride concentrations in southern pits ranged from approximately 2,400 to 3,000 mg/L (**Figure A.4-10**). The northern pit contained approximately half as much chloride. These results suggest that, in addition to sodium, chloride is the main contributor to surface water salinity.

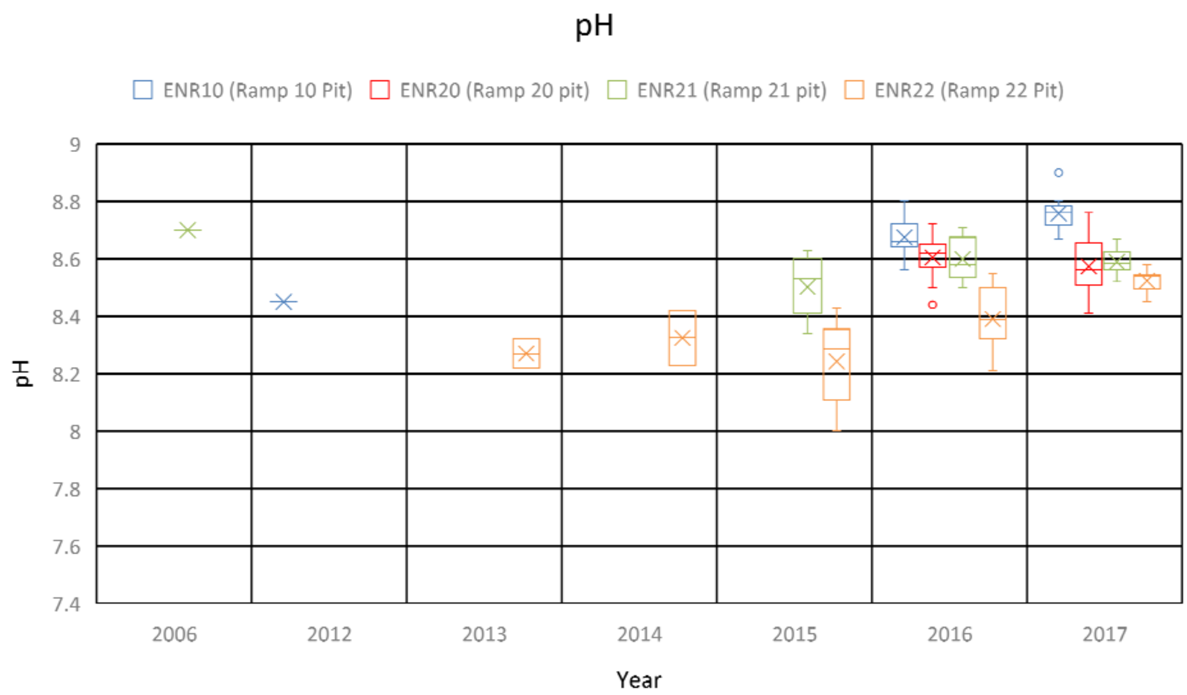


Figure A.4-6: Range, median and mean of surface water pH results over time

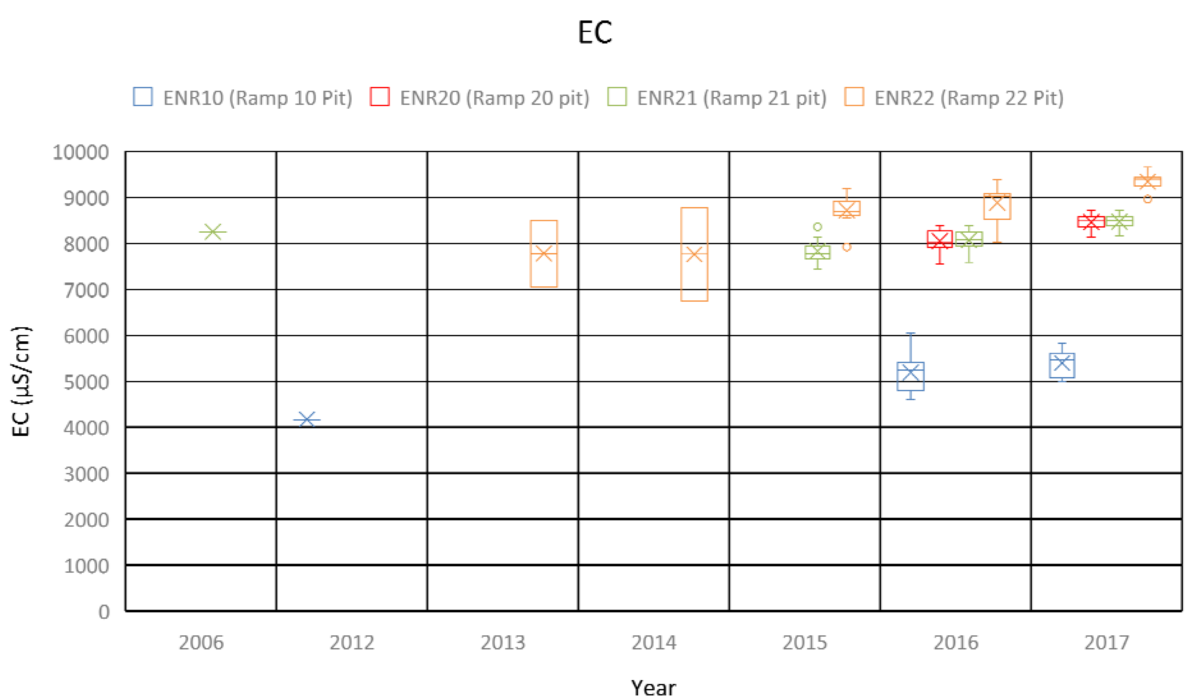


Figure A.4-7: Range, median and mean of surface water EC results over time

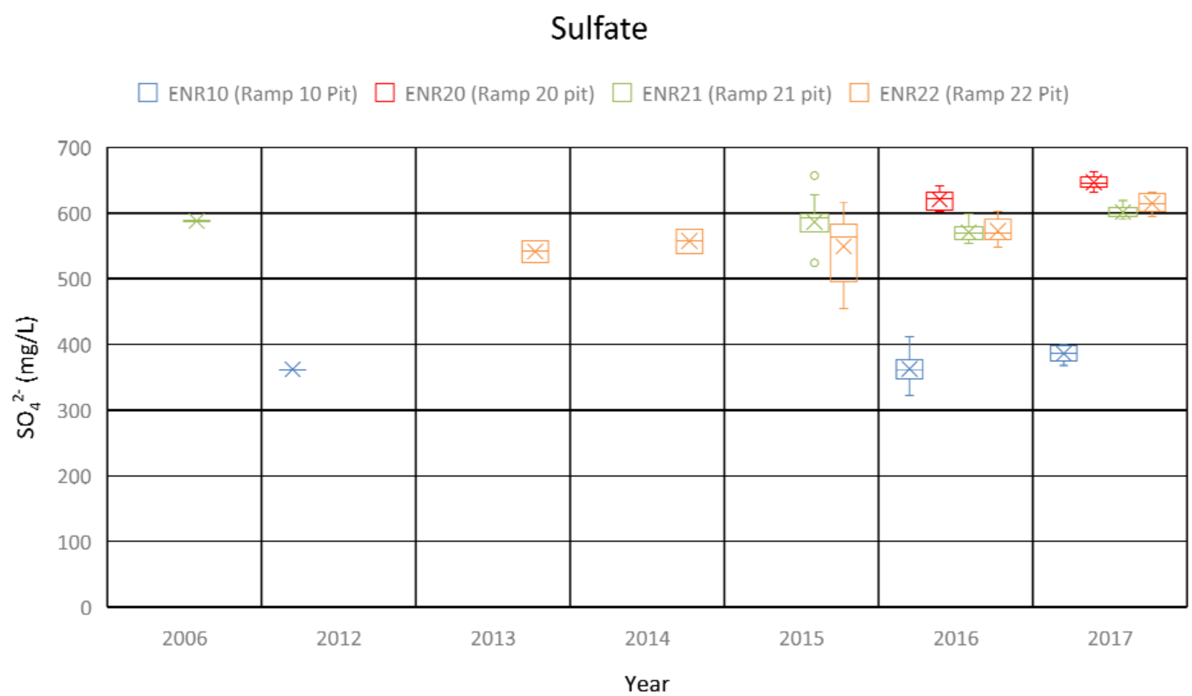


Figure A.4-8: Range, median and mean of surface water sulfate concentrations over time

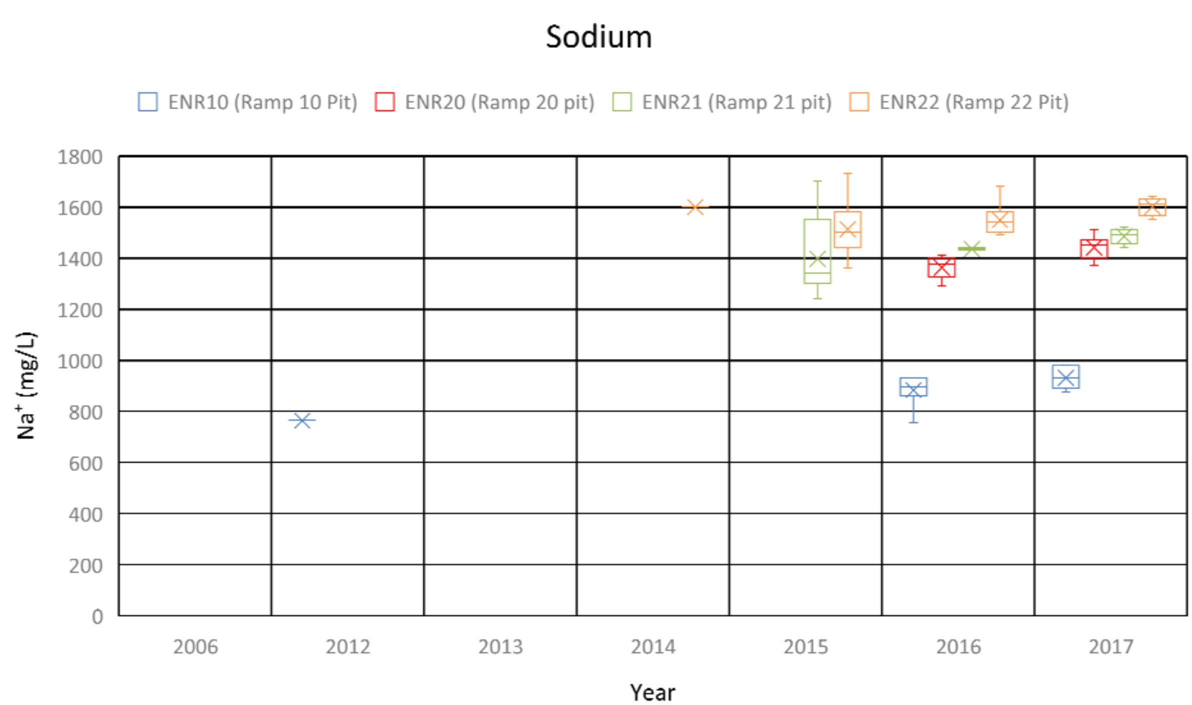


Figure A.4-9: Range, median and mean of surface water sodium concentrations over time

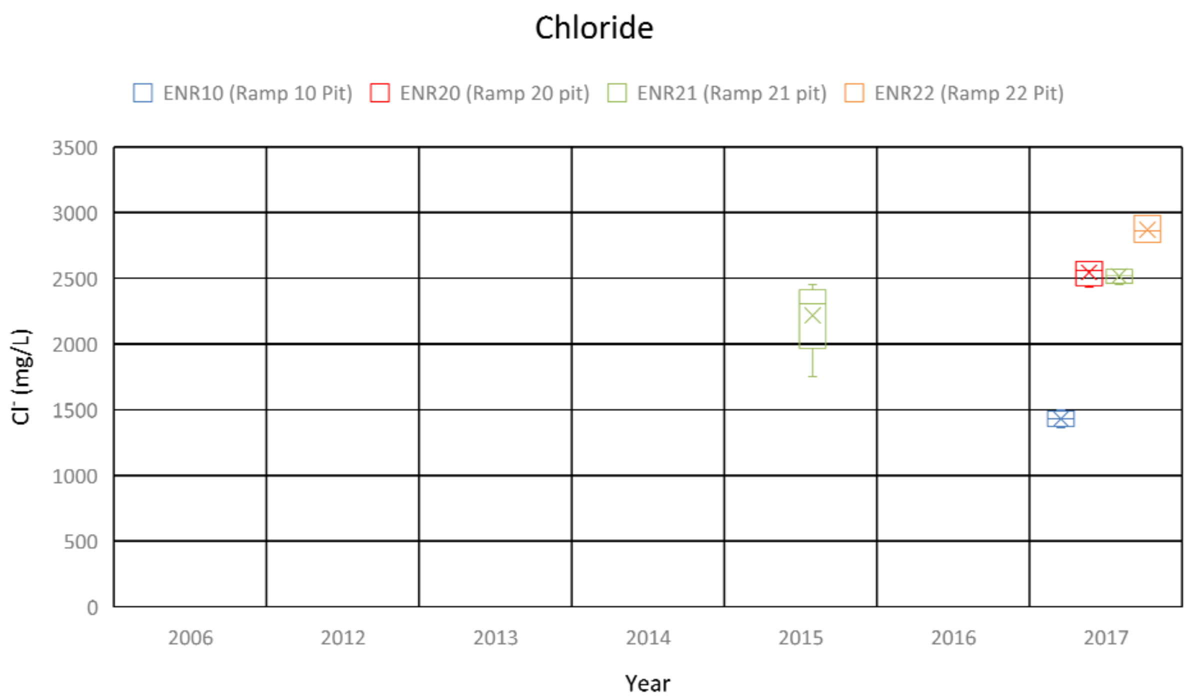


Figure A.4-10: Range, median and mean of surface water chloride concentrations over time

A.4.5 Appendix 4v Surface water results in the Nogoa River

The minimum, average and maximum water quality concentrations from the Nogoa River collected from January 2006 to October 2017 are provided in **Table A.4-5** and indicate broad variability of the river water quality which reflects the differences between high, moderate and low flow in the river system. These data also verify that the concentration of some elements such as Cu and Se are higher than relevant ANZECC guidelines for freshwater ecosystems and these site-specific data should be referred to instead of using standard ANZECC guideline values (ANZECC & ARMCANZ, 2000).

Table A.4-5: Nogoa River water quality values

Date	Aluminium-Dissolved (mg/L)	Arsenic-Dissolved (mg/L)	Calcium (mg/L)	Chloride (mg/L)	Cobalt-Dissolved (mg/L)	Copper-Dissolved (mg/L)	EC	pH	Iron-Dissolved (mg/L)	Magnesium (mg/L)
# of samples	103	103	3	50	101	103	143	143	42	3
Minimum	0.0050	0.0005	14.0000	5.0000	0.0005	0.0005	25.0000	6.8200	0.0050	5.7000
Average	0.1043	0.0022	15.6667	17.6800	0.0005	0.0029	361.1748	7.9136	0.0667	6.2000
Maximum	0.7300	0.0700	17.0000	107.0000	0.0030	0.0050	2180.0000	8.7100	0.3000	6.9000
Date	Manganese-Dissolved (mg/L)	Molybdenum-Dissolved (mg/L)	Nickel-Dissolved (mg/L)	Selenium-Dissolved (mg/L)	Sodium (mg/L)	Sulfate as SO4 - Turbidimetric	Total Alkalinity as CaCO3 (mg/L)	Uranium-Dissolved (mg/L)	Vanadium-Dissolved (mg/L)	Zinc-Dissolved (mg/L)
# of samples	0.001	0.001	0.001	0.001	11.000	0.500	59.000	0.001	0.001	0.003
Minimum	0.001	0.001	0.001	0.001	11.000	0.500	59.000	0.001	0.001	0.003
Average	0.913	0.001	0.003	0.003	55.804	12.946	108.540	0.001	0.006	0.006
Maximum	16.000	0.003	0.005	0.005	307.000	75.000	330.000	0.007	0.025	0.070

A.5 Appendix 5 VADOSE/W Modelling report

1.0 INTRODUCTION

1.1 Modelling Objectives and Scope of Work

The intent of the soil cover is to contribute to Ensham's Closure goals, which specify amongst other criteria, that the final landform should be stable and support vegetation. Therefore, RGS has assumed that the primary cover objectives are to provide a stable surface that will have minimal erosion, retain the integrity of the cover and support vegetation; ultimately reducing net percolation and thus basal/toe seepage from the backfilled spoil piles. The soil cover will be constructed from available local borrow materials which are not yet defined. The intent of this modelling is to provide water balance input to a pit void hydro-geochemical model.

2.0 BACKGROUND

2.1 Cover Configuration

The Ensham spoil cover configuration is shown in **Figure 1**. Ensham have defined the cover function requirements and include:

a) maximise runoff as far as practical;

b) limit rate of water infiltration to spoil;

c) limit the potential for erosion; and,

d) support self-sustaining vegetation cover.

The cover will act as the "base-case" scenario for this modelling. RGS has not deviated far from this cover configuration since the intent of the modelling is to assess the defined cover as opposed to enhancing the performance of the cover. The results will then be used as input to the back filled pit void water balance/ water quality model(s).

The cover simply consists of a growth/soil medium (0.5m) overlying spoil, which is currently sustaining vegetation.

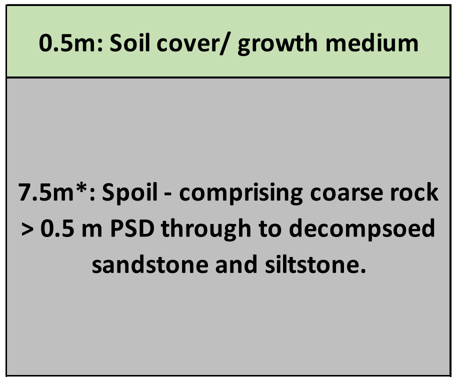


Figure 1: Base case cover configuration used in modelling. *7.5m spoil used for the sake of modelling the cover; actual spoil piles can be up to 30m in profile.

2.2 Modelling Theory

Numerical models endeavour to simulate the performance of highly complex environmental systems. Numerical models such as SEEP/W (GEO-SLOPE, 2018) use mathematical equations to simulate environmental conditions. The mathematical equations include equations imbedded in the software and user defined inputs. The mathematical data inputs may, in some cases, be altered to reflect conditions that cannot be met by measured laboratory values and this may be done using subjective or site-specific knowledge.

The surface boundary condition is the key to accurate vadose (unsaturated) zone modelling. The most important parameters in the model are surface infiltration and actual evapotranspiration (the surface unit flux boundary).

The surface unit flux boundary in SEEP/W is determined by coupling the moisture and heat profiles in the soil with the climate conditions present above the ground surface. The model also incorporates the fundamental flow laws for transient flow of water, heat, vapor and gas.

2.3 Modelling Methodology

Two-dimensional (2-D) modelling using SEEP/W software (Geo-Slope International, 2018) was used to model water movement through the cover and underlying spoil.

SEEP/W is a 2-D (or 1-D) finite element model that can simulate the physical movement of water (and oxygen) through a soil/cover medium. The model predicts pore water pressure (suction) and temperature profiles in the soil/cover profile in response to changes in climatic conditions (e.g. rainfall and evapotranspiration). The model simultaneously deals with heat, mass and vapour flow through both saturated and unsaturated soils. Oxygen transfer is dependent on soil saturation; however, oxygen transfer does not influence the calculation of heat and water flow.

The basic governing equations for the flow and heat transport aspects of the model (after Song and Yanful, 2010), include:

$$m\frac{\partial P}{\partial t} = Q + \frac{1}{\rho_w}\frac{\partial}{\partial x}\left(D_v\frac{\partial P_v}{\partial x}\right) + \frac{1}{\rho_w}\frac{\partial}{\partial y}\left(D_v\frac{\partial P_v}{\partial x}\right) + \frac{\partial}{\partial x}\left(K_x\frac{\partial(P/P_w g+y}{\partial x}\right) + \frac{\partial}{\partial y}(K_y\frac{\partial(P/P_w g+y}{\partial y}$$

Equation 1

$$\lambda_t \frac{\partial T}{\partial x} = Qt + L_v \frac{\partial}{\partial x}\left(D_v \frac{\partial P_v}{\partial x}\right) + L_v \frac{\partial}{\partial y}\left(D_v \frac{\partial P_v}{\partial y}\right) + \frac{\partial}{\partial x}\left(k_{tx} \frac{\partial T}{\partial x}\right) + \frac{\partial}{\partial y}\left(k_{ty} \frac{\partial T}{\partial y}\right) + p_w c_w V_x \frac{\partial T}{\partial x} + p_w c_w V_y \frac{\partial T}{\partial y}$$

Equation 2

Where P= water pressure; m= slope of the soil water characteristic curve (SWCC); Q= applied boundary flux; P_v= vapour pressure of soil moisture; D_v= vapour diffusion coefficient; K_x =hydraulic conductivity in the x direction; K_y =hydraulic conductivity in the y direction; y= elevation head; g_w= density of water; g= acceleration due to gravity; t= time; k_t= apparent volumetric heat capacity in soil; T= temperature; Q_t= thermal boundary flux; L_v= latent heat of vaporisation; k_{tx}= thermal conductivity in the x direction; k_{ty}= thermal conductivity in the y direction; c_w = mass specific heat capacity of water; V_x= Darcy water velocity in the x direction; and, V_y= Darcy water velocity in the y direction.

Water flow and heat transfer are combined via the equation:

$$P_v = P_{vs}(e^{\frac{-PW_v}{P_w RT}})$$ **Equation 3**

Where P_{vs}= saturated vapor pressure of pure free water; W_v= molecular weight of water (0.018 kg/mol); and, R= universal gas constant (8.314 J/mol K).

Actual evaporation (*AE*) is calculated from solar radiation data using the Wilson-Penman method (Wilson, 1990) (**Section 3.3.1; Equation 18**).

SEEP/W numerical modelling involves solving the aforementioned mathematical equations (Equations 1-4) simultaneously using finite element analysis (FEA) and user input data (**Section 3.0**). The key user input data includes SWCC's, hydraulic conductivity function, thermal conductivity function, volumetric specific heat function and climatic data (maximum and minimum temperature and relative humidity, wind speed, rainfall and solar radiation). The equations generate *AE*, *P*, P_v and *T*.

2.3.1 Performance Indicators

Performance Indicators are used to establish how particular cover scenarios are performing relative to one another. The spoil cover is intended to support vegetation and minimise the potential for erosion and as a consequence reduce infiltration into the spoil materials (i.e. net percolation) and thus prevent basal and toe seepage. The typical performance indicators for soil cover systems include net percolation (NP) and oxygen flux. For this investigation, NP will be the primary performance indicator for each model. NP refers to all water that infiltrates below the soil cover and into the spoil; however, the percolation of water through the top of the spoil will also be reported (**Figure 2)**. NP does not include water that may enter the cover system (infiltration of precipitation) and is removed up or laterally by either transpiration, evaporation, runoff or lateral flow (above the spoil within the soil layer). NP will be reported for each of the model simulations where applicable.

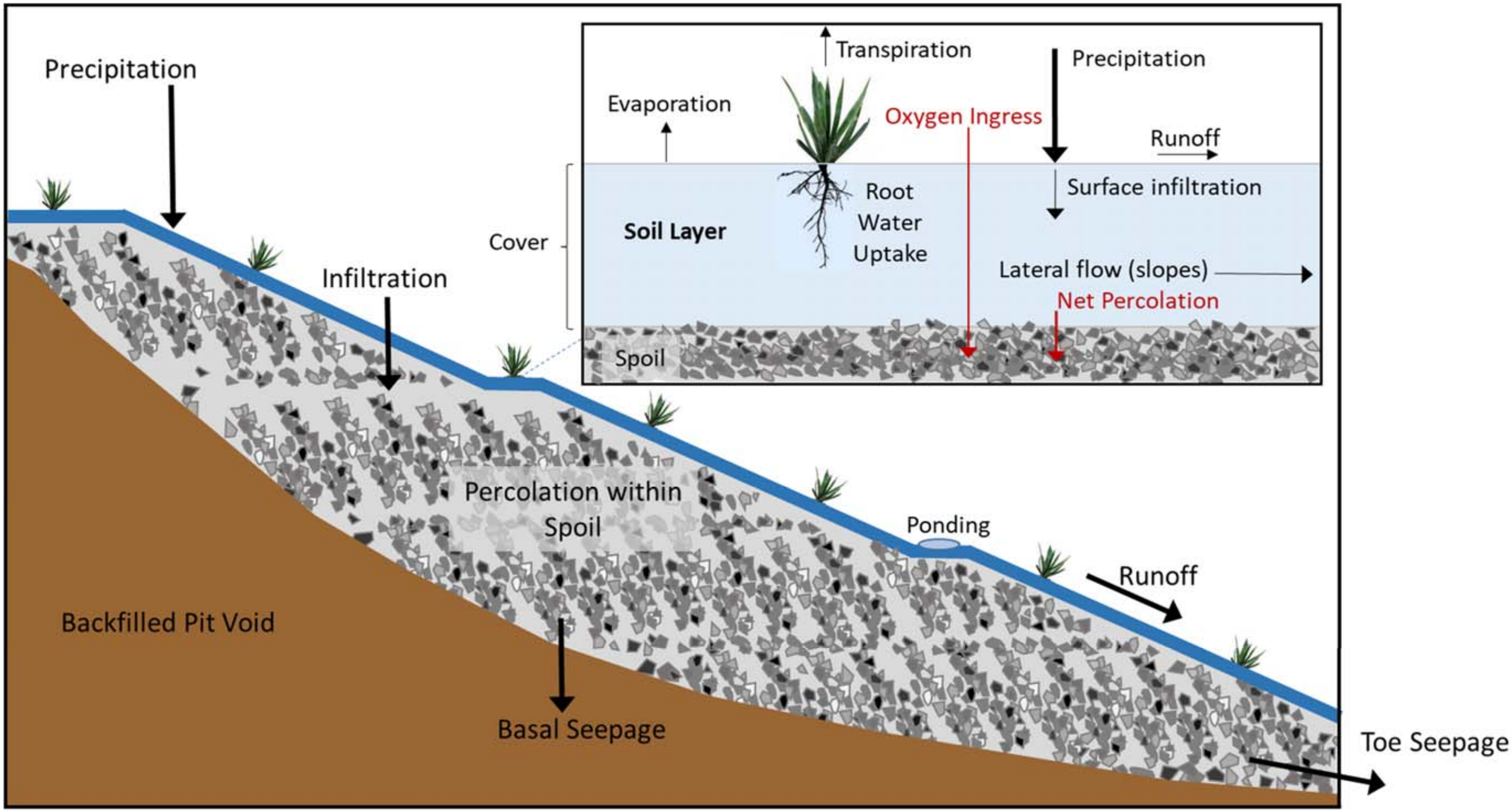


Figure 2: **Conceptual cover water balance**

2.3.2 Model Limitations and Assumptions

- The intent of the modelling is to assess the water balance of the spoil soil cover. The models are based on mathematical equations and user input data, with the conceptual model significantly simplified for the purpose of modelling. As such, the numerical models are limited by the accuracy and details of the user input data.
- Movement of water in the unsaturated zone occurs according to Darcy's law – which describes flow in a porous medium. Darcy's law does not account for flow through preferential pathways (cracks, non-porous flow) that can be a significant flow path in a constructed regolith soil cover, particularly if there are flaws in the construction.
- Measured parameters for K_{sat} and SWCC's were not available at the time of reporting so were assumed based on literature values and RGS's understanding of site conditions. Although sound scientific basis was applied to selecting these functions, there may be some ambiguity around the appropriateness of the curves without detailed field measurements.
- The acceptable seepage volumes that may result in water qualities that meet downstream trigger vales are unknown and do not form part of this investigation. The outcomes of this modelling will provide the initial basis for surface or seepage modelling, and/or reactive transport modelling.
- The cover constructability has not been incorporated into the models. The modelling has assumed that the cover is placed directly over the backfilled coal spoil.
- There is little information available on the spoil depth, phreatic surface and pore water pressures. The assumption is that the spoil piles are nonsaturated unless there is water in the mined pit that then saturates spoil (Hawley and Cunning, 2017).
- Aeolian erosion (after extensive dry periods) and surface runoff (extensive wet periods) are likely to affect the cover system, particularly if not vegetated, and are not included in this investigation.
- Chemical migration – the movement of dissolved chemical constituents resulting from the cover system (e.g. capillary rise of salts, dilution effects) are not considered as part of the present investigation.

2.4 Cover Material Sources

There is limited information on the physical and chemical properties of materials available for Ensham Mine rehabilitation and closure. Hansen Consulting Pty Ltd undertook a soils and capability assessment to assist in planning for a proposed mine expansion project (Ensham Central Project) (Hansen, 2006); as part of the assessment, a field investigation was undertaken in 2004 to identify key soil types. The assessment was supplemented by information gleaned from the Ensham Coal Project Impact Assessment Study (1991). The soil types identified for Ensham can be categorised into six key soil groups, with fifteen sub-units. A summary of the six soil groups is provided in **Table 1** below from Hansen (2006). According to the Rehabilitation section (Section 7) of the Ensham Central Project Environmental Impact Statement (2006), the most suitable sources of topsoil occur in Soil Group 5 and 6, more specifically, soil sub-units 5.1, 5.3, 6.1 and 6.2, all of which contain a high clay component.

Table 1: Summary of key soil groups and sub-units (from Hansen, 2006).

Major Soil Group	Soil sub-unit	Description
1) Shallow Rocky Soils	1.1	Shallow Rocky Soils: Shallow uniform mainly coarse to medium-textured very rock soils, with common rock outcrops.
2) Uniform Gravelly Sands, Loams or Clay Soils	2.1	Thin sandy to sandy loam surface soils underlain by dense silicious gravelly sand-sandy gravels.
	2.2	Thin sandy to loamy surface soil grading through gravelly loam-loamy gravel subsoils underlain by dense gravely colluvium and/or HWR.
	2.3	Stony or thin silt to clay loam surface soils with lenses of gravely clay or clayey gravels underlain by strongly acidic clay subsoils or HWR below 0.1-1.0m.
3) Gradational Red and Yellow Earths	3.1	Sand over clayey sand or sandy loam gradational soils; earthy sands, mainly shallow soils over HWR.
	3.2	Sandy loam to loamy surface soils grading to red, reddish brown or yellowish brown apedal massive sandy clay or light to medium or heavy clay subsoils.
	3.3	Silty to loamy surface soils grading to red light to medium structured clay subsoils locally with considerable laterite gravel throughout the profile.
4) Gradational Red and Yellow Earths	4.1	Shallow to medium deep often stony thin loamy surface duplex soils with dark brown, brown or reddish-brown medium to heavy clay subsoils over HWR.
	4.2	Mostly deep, thin silty to loamy surface duplex soil with dark brown, brown or reddish brown neutral to strongly alkaline medium to heavy clay subsoils.
	4.3	Medium to deep sandy surface duplex soil with a pale or bleached gravely fine sandy to silty A2 horizon and brown, yellowish brown and grey mottled sandy medium to heavy mainly alkaline clay subsoils.
5) Gradational Red and Yellow Earths	5.1	Shallow to medium deep, stony surface, brown, yellowish brown or reddish-brown uniform or weakly gradational medium to heavy and heavy clay soils over HW rock.
	5.2	Mainly deep uniform or weakly gradational brown or yellowish-brown medium to heavy alkaline clay soils with surface stone and some stony lenses included.
	5.3	Deep uniform or weakly gradational brownish black, dark grey-brown or dark brown strongly structured alkaline clay soils of medium to high or high plasticity.
6) Cracking Clay Soils	6.1	Medium deep dark grey-brown or dark brown strongly structured alkaline heavy clay soils over HW rock.
	6.2	Mainly deep dark grey-brown, dark brown or brown uniform strongly structured heavy alkaline clay soils locally with gilgai development designated.

There is no information on the physical or chemical characteristics of coal spoil at Ensham Mine; therefore, a representative example has been sourced from the literature. The literature example (Vosolo, 2017; Mostofa *et al*., 2016) was collected from a coal mine in North Queensland and has similar visual characteristics to coal spoil at Ensham Mine (**Figure 3 and Figure 4**).

Figure 3: Coal Mine Spoil from North Queensland (Vosolo, 2017).

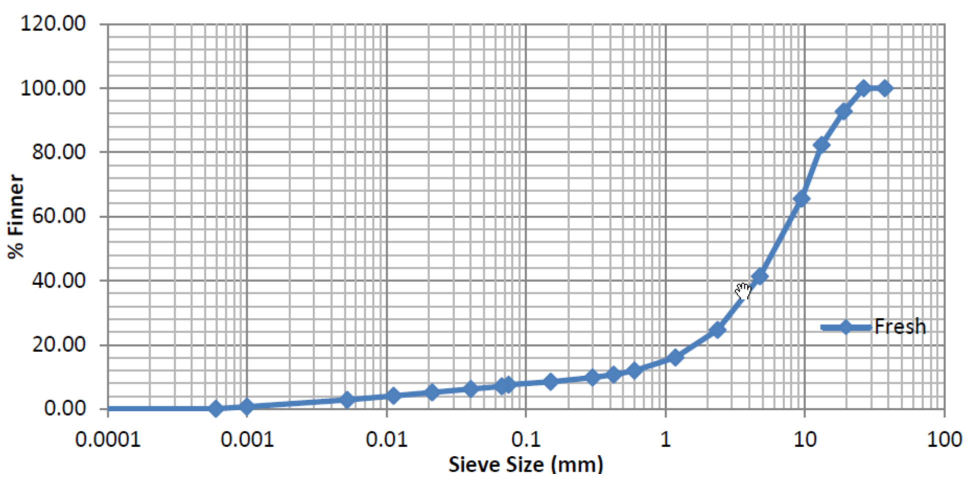


Figure 4: Coal Mine Spoil Particle-Size-Distribution Corresponding to Above Material (Figure 3) (Vosolo, 2017).

Photos of the location of spoil samples collected for geochemical assessment are provided in Figure 5 to Figure 10.

Figure 5: B Pit Permian spoil

Figure 6: B Pit Quaternary spoil

Figure 7: B Pit Tertiary spoil

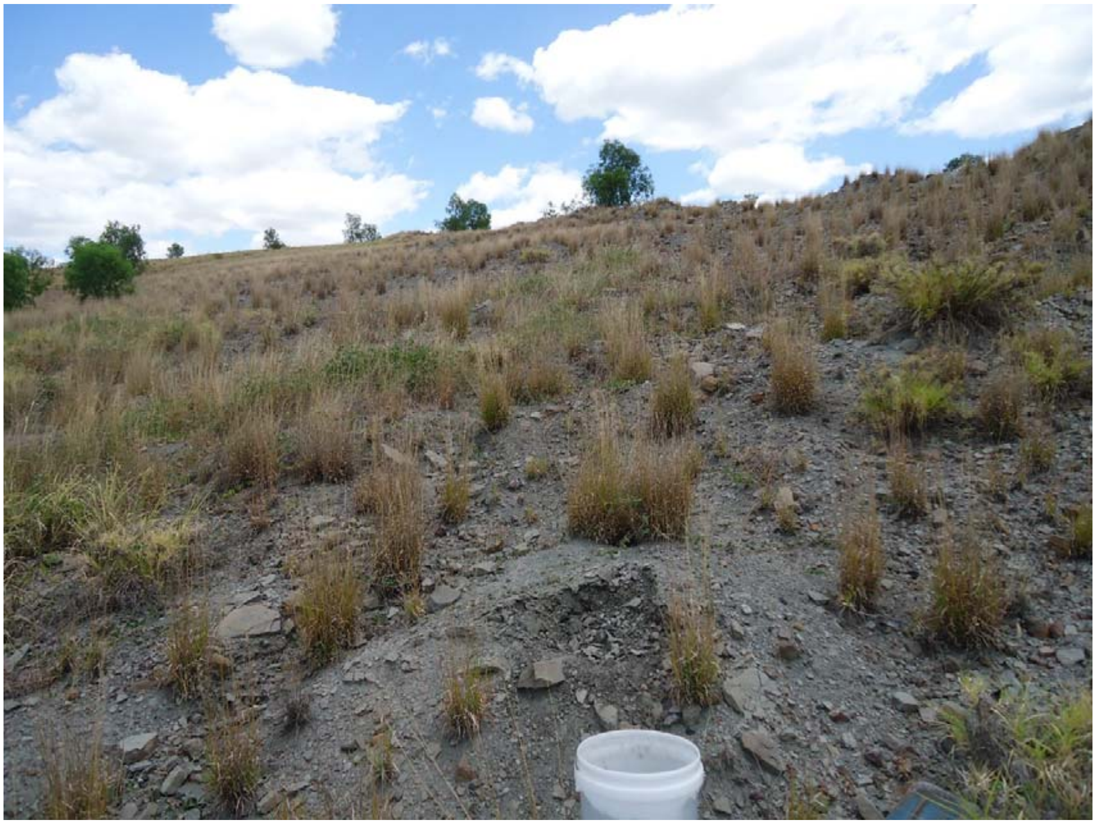


Figure 8: D Pit Permian spoil

Figure 9: Y Pit Permian spoil

Figure 10: Y Pit Tertiary spoil

3.0 MODEL INPUTS

3.1 Material Properties

3.1.1 Soil water characteristic curves (SWCC)

The SWCC (or water retention curve) is the relationship between soil pore water pressure (suction; kPa) and volumetric water content [m^3/m^3]. The SWCC is one of the most important input parameters for the model, as it governs the water movement in the unsaturated soil.

There is currently no SWCC measurements for any of the Ensham materials (cover material or spoil), so these curves were either taken from the literature or assumed based on RGS's experience on other projects. The literature example (Vosolo, 2017; Mostofa *et al*., 2016) mine spoil SWCC which was measured was used, while a range of curves for sand through to clay with varying bulk densities were estimated. The SWCC's are displayed in **Figure 5**.

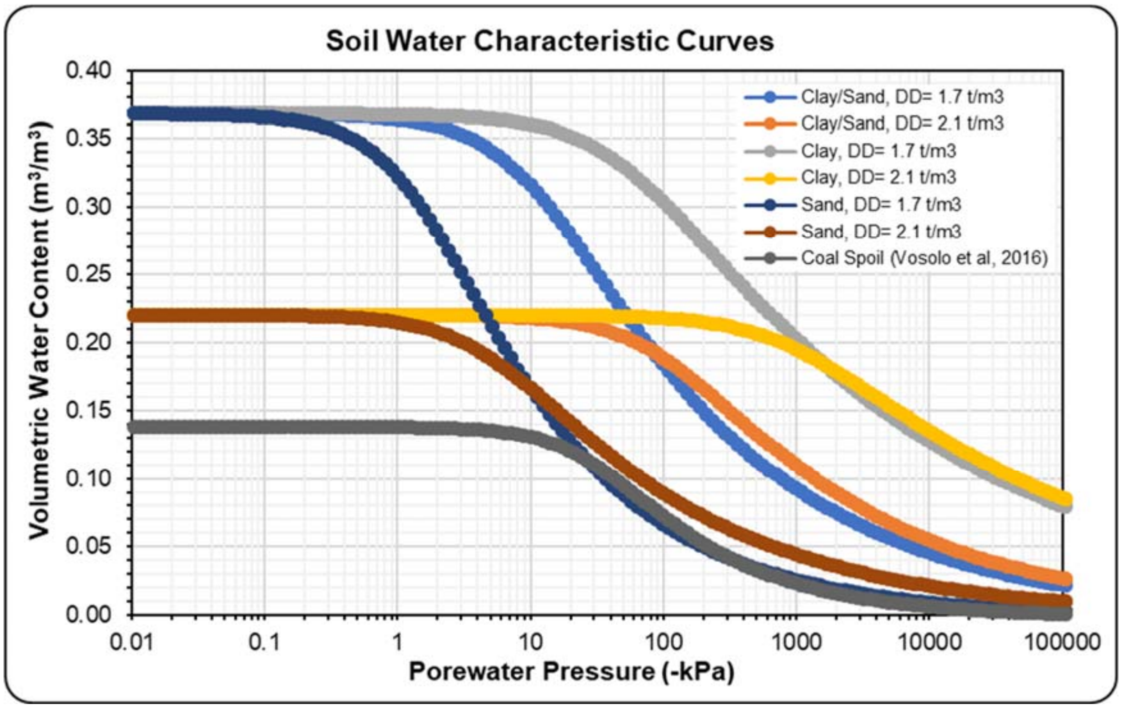


Figure 5. Reference soil water characteristic curves used for the modelling.

Soil water characteristic curve fitting

The measured and estimated data (**Table 2**) was fitted with the equation by Van Genuchten (1980):

$$\Theta_w = \Theta_r \frac{\Theta_s - \Theta_r}{[1+(\frac{\psi}{a})^n]^m} \quad \textbf{Equation 11}$$

Where Θ_w= volumetric water content; Θ_s= saturated volumetric water content; ψ= negative pore-water pressure; and, *a*, *n*, *m*= curve fitting parameters.

The curve fitting parameter *a* is the pivot point of the SWCC at which *n* changes the slope of the function; *n* controls the slope of the SWCC; and, *m* affects the sharpness of the curve at the lower end of the SWCC plateau. residual water content. The fitting parameters and SWCC's are shown in **Table 1** and **Figure 5**, respectively.

Table 2. Van Genuchten (1980) curve fitting parameter for SWCC's

Sample Type (texture)		Dry Density (bulk)	Van Genuchten (1980) Parameters					k_{sat} (estimated)	
			Θ_s	Θ_R	*a*	*n*	*m*		
Units		(t/m³)	(m³/m³)	(m³/m³)	kPa	-	-	m/sec	m/day
Topsoil and Spoil	Sand	1.7	0.37	0	1.4	1.4	0.285	1.00E-04	8.64E+00
		2.1	0.222	0	5	1.3	0.23	5.00E-06	4.32E-01
	Sand/Clay	1.7	0.37	0	10	0.3	0.23	1.00E-07	8.64E-03
		2.1	0.222	0	100	1.3	0.23	5.00E-09	4.32E-04

	Clay	1.7	0.37	0	50	1.2	0.166	1.00E-08	8.64E-04
		2.1	0.222	0	900	1.2	0.166	5.00E-10	4.32E-05
	Spoil		0.14	0	30	1.5	0.333	1.42E-06	1.23E-01

3.1.2 Hydraulic Conductivity Function

Permeability measurements of the materials was again estimated based on RGS's understanding of the range of soil types (sand, sandy/clay and clay) while the mine spoil permeability was taken from measured data from thee literature (Vosolo, 2017; Mostofa *et al*., 2016) which corresponds to the SWCC.

The hydraulic conductivity functions (suction [kPa] versus hydraulic conductivity [m/s]) were estimated using the measured k_{sat} and extrapolated using the Fredlund method (Fredlund et al., 1994). The Fredlund method integrates along the SWCC to develop the unsaturated hydraulic conductivity function (**Section 3.1.1**). The equation is (based on GEO-SLOPE, 2018):

$$k_w = k_s \frac{\sum_{i=j}^{N} \frac{\Theta(e^{y})-\Theta(\psi)}{e^{y_i}}\Theta\prime(e^{y_i})}{\sum_{i=1}^{N} \frac{\Theta(e^{y})-\Theta_s}{e^{y_i}}\Theta'(e^{y_i})}$$ **Equation 12**

Where k_w= calculated conductivity for a specific water content or negative pore-water pressure (m/s); k_s= measured saturated conductivity; Θ_s= volumetric water content; *e*= natural number (2.71828); *y*= dummy variable of integration (representing log of negative pore water pressure); *i*= interval between the range of j to N; *j*= least negative pore-water pressure (described in final function); *N*= maximum negative pore-water pressure (described by final function); ψ= suction corresponding to the j^{th} interval; and, Θ'= first derivative of the equation:

$$\Theta = C(\psi)\frac{\Theta_s}{\{ln[e+(\frac{\psi}{a})^n]\}^m}$$ **Equation 13**

Where *a*= approximately air-entry value of the material; *n*= parameter that controls slope at the inflection point in the SWCC; *m*= parameter that is related to the residual water content; and, $C(\psi)$= correcting function, defined by the equation:

$$C(\psi) = 1 - \frac{\ln(1+\frac{\psi}{C_r})}{\ln(1+\frac{1{,}000{,}000}{C_r})}$$ **Equation 14**

Where C_r= constant related to matric suction corresponding to residual water content.

The hydraulic conductivity functions established for the modelling, using the above-mentioned method, are shown in **Figure 6**.

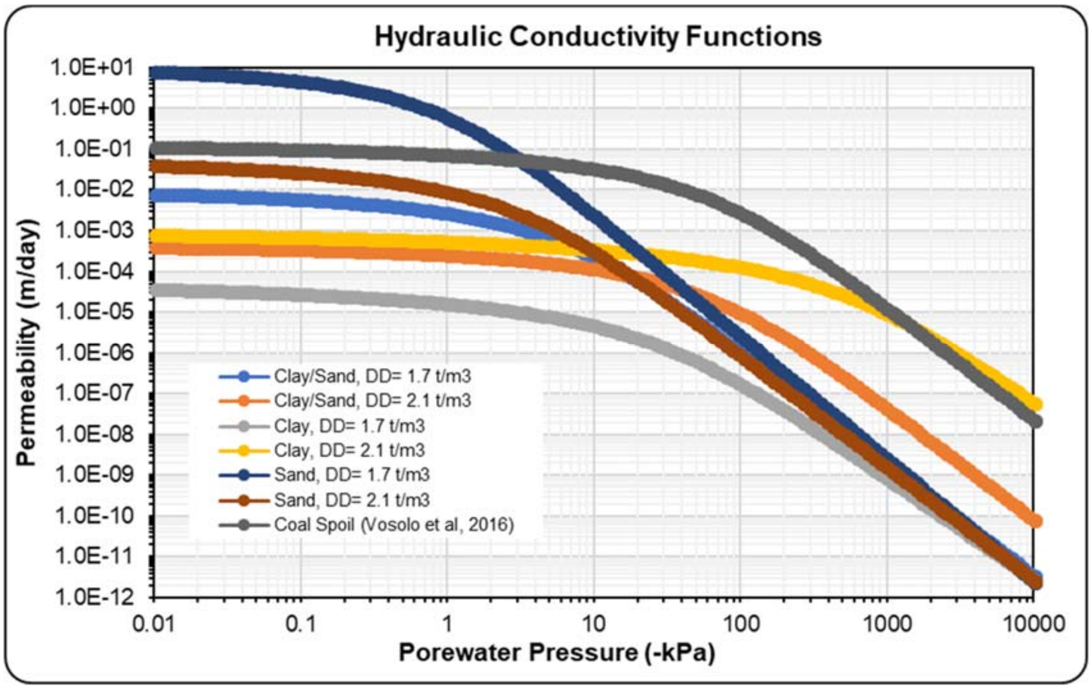


Figure 6. Established hydraulic conductivity functions for various material types

3.1.3 Thermal Conductivity Function

The thermal conductivity function is volumetric water content [m^3/m^3] versus thermal conductivity [kJ/days/m/°C] and describes the heat transfer through the soil. Water content and thermal behaviour of the soil influence each other because unsaturated soils consist of air, water and solids, with air and water having different thermal properties.

The standard thermal properties for a sand, silt or clay material have been used in the modelling depending on the material type, or, estimated according to method by Johansen (1975). The thermal conductivity of dry natural soils (k_{dry}) can be estimated based on its dry density according to the equation:

$$K_{dry} = \frac{0.135\gamma_d + 64.7}{2700 - 0.947\gamma_d} \pm 20\% \quad \textbf{Equation 15}$$

Where γ_d= dry density (kg/m^3).

For dry crushed rock material (e.g. gravel or waste rock), the thermal conductivity is estimated based on its porosity (*n*) using the equation:

$$K_{dry} = 0.039n^{-2.2} \pm 25\% \quad \textbf{Equation 16}$$

For a saturated unfrozen soil, the thermal conductivity (k_{sat}) is estimated based on the thermal conductivities of its components and respective volume fractions:

$$K_{sat} = (K_s)^{1-n}(K_w)^n \quad \textbf{Equation 17}$$

Where K_s and K_w are the thermal conductivities of soil particles and pore-water, respectively.

The ground temperature at this site does not drop below freezing and is fairly uniform so these parameters have little influence on overall results. The Ground freezing function in SEEP/W was disabled.

3.1.4 Volumetric Specific Heat Function

Volumetric Specific Heat Function is the volumetric water content [m^3/m^3] versus volumetric specific heat capacity [kJ/days/m/°C]. The standard thermal properties for a sand, silt or clay material will be used in the modelling depending on the material type.

3.2 Vegetation

SEEP/W allows the modelling of evapotranspiration if a vegetated surface is applied. The influence of vegetation on infiltration and evapotranspiration is a variable that is applied to the surface of the cover (boundary condition). This involves three separate functions to represent the leaf-area-index, the permanent wilting point, and the root depth and structure of site specific species. The root depth and transpiration rates of local grass, shrub and trees is typically not well understood and has been inferred for the modelling based on site observations.

The soil cover has a 0.5m upper layer for supporting vegetation; however, the entire 2 m of cover and spoil must be capable of supporting vegetation because the grass roots are likely to reach >2m (**Section 3.2.2**). RGS has assumed that the cover and spoil material have chemical and physical properties that support and sustain local vegetation.

Vegetation will not establish immediately on the covers, so simulations without vegetation represent the critical time after cover placement. RGS will therefore run the simulations with and without vegetation for select models.

The specific vegetation inputs are included in the following sections.

3.2.1 Leaf-area-index function

The leaf-area-index is a measure of the one-sided leaf area per unit ground surface area. Rhodes grass is currently established on the spoil covers at Ensham which is considered an excellent grass (**Figure 7**); therefore, standard excellent grass functions were used in the modelling. The leaf-area-index function is used by SEEP/W to reduce the amount of net radiation intercepting the soil surface, reducing the computed actual evaporation (AE). The leaf-area-index function was developed to mimic a relatively quick establishment of an excellent grass on the spoil cover material, with a good grass LAI present in drier months.

Figure 7: Rehabilitated spoil at Ensham

3.2.2 Root depth function

The expected root depth of the re-vegetation (currently Rhodes grass) is anticipated to maintain a relatively deep rooting depth and expand laterally to make the most use of surface available nutrients (within the top 50cm of the soil cover); however, it would not be uncommon for Rhodes grass to reach rooting depths of > 450cm, particularly for seasonally dry climates (**Figure 8**; from Fan *et al*., 2017). For the modelling, an excellent perennial grass function was applied with a conservative rooting depth of 200cm; the modelling assumes that roots are already established at the start of the modelling run (which is consistent with fact that Rhodes grass has already established on the covered spoils).

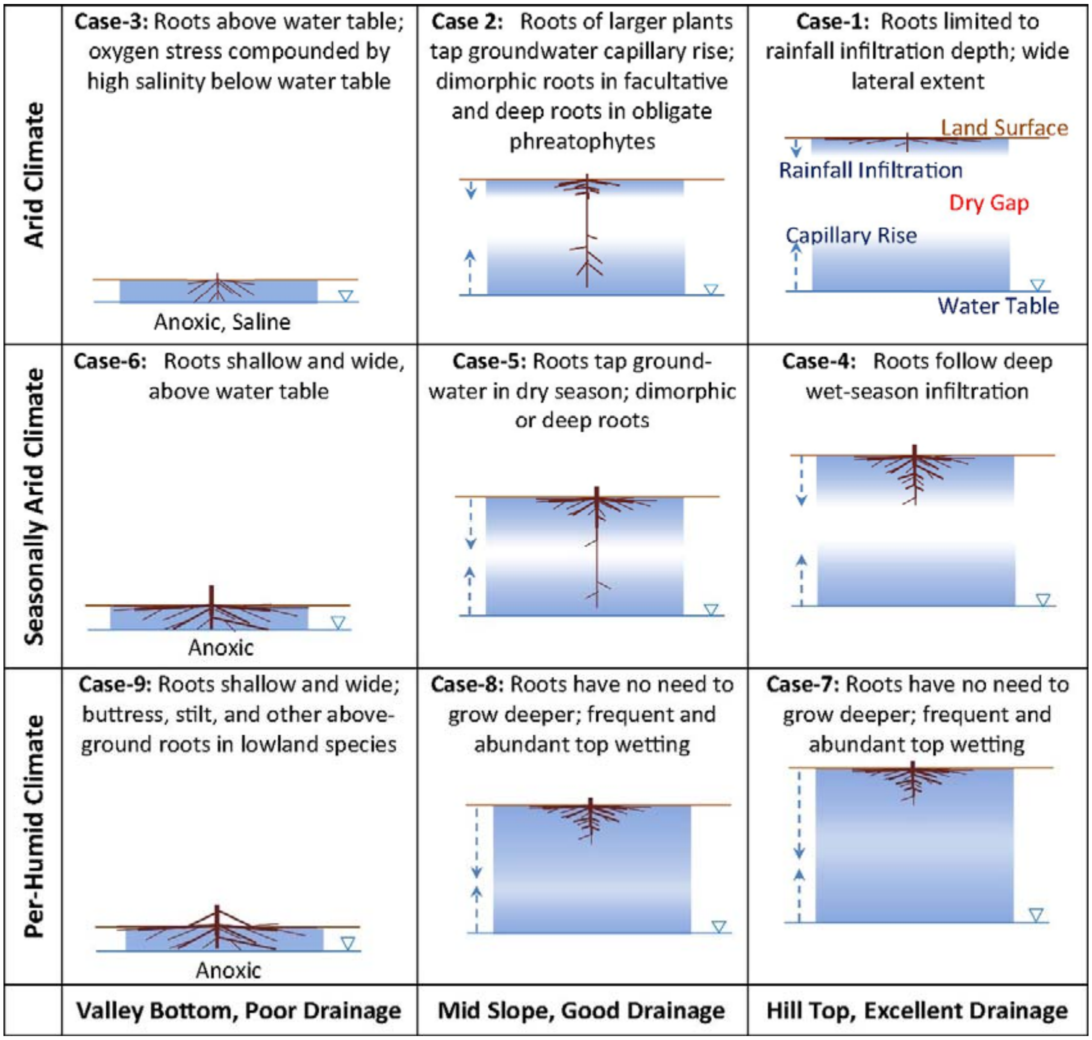


Figure 8: Root depth versus climate and topography (from Fan *et al*., 2017).

3.2.3 Permanent wilting point function

The permanent wilting point (PWP), or plant moisture limiting factor is described by the function shown in **Figure 7**. This variable accounts for the dieback of vegetation from exceedingly dry periods where the matric suction reaches points where plant growth will be limited. The standard and accepted curve for a permanent wilting point at -1,500 kPa is used in this case; this specifies that a plant will reach its water limiting point at a negative pore water pressure of -100 and is unable to draw any water if the pressure reaches -1,500 kPa.

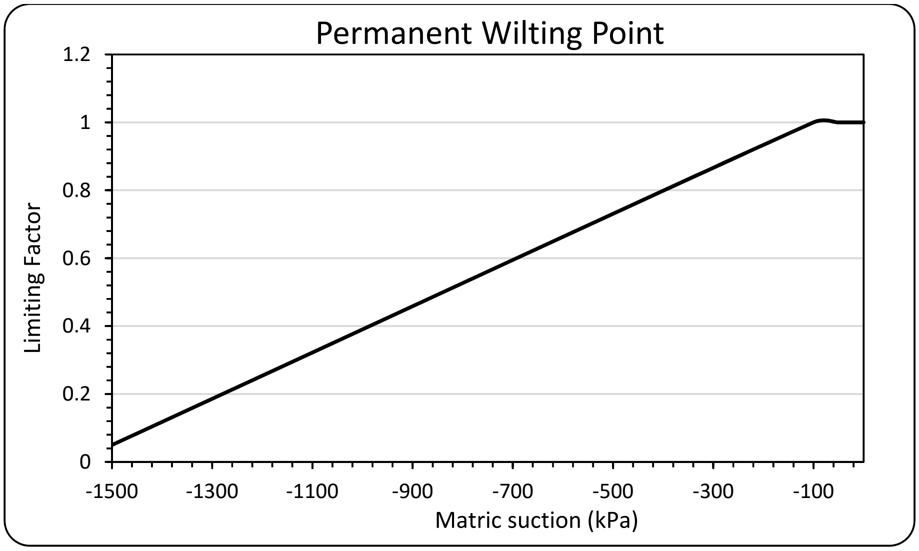


Figure 7: Permanent wilting point function

3.3 Boundary Conditions and Initial Conditions

The "base case" model boundary conditions are summarised in the following sections.

3.3.1 Climatic Conditions – Surface Boundary

The climatic conditions at Ensham Mine are applied as the upper boundary condition. Synthetic climatic data was obtained for the site from Scientific Information for Land Owners (SILO) hosted by the Science Delivery Division of the Department of Science, Information Technology and Innovation (DSITI). The Data Drill was extracted from SILO on the 26/03/2018 and included daily climatic data since 01/01/1889.

Two years of synthetic climatic data (years 2008 and 2016) from the Data Drill has been adapted to simulate average precipitation events. The average climatic conditions at Ensham Mine are summarised in the following points:

- Humid subtropical climate.
- On average, the mean evaporation exceeds mean precipitation for all months of the year.
- Average annual rainfall is 583 mm.
- Wettest months are November to March.
- Driest months are June to September.
- The highest 48 – hour rainfall event was on the 22nd and 23rd of January 1918 and was 232.6 mm.

To simulate an extreme rainfall event, the greatest 48-hour rainfall event on record was applied every two years to the dataset. Synthetic climate datasets for average and wet years including daily maximum and minimum values for temperature and relative humidity, and daily values for wind speed (not shown), precipitation and solar radiation are built into the model (**Figure 8 – Figure 11**).

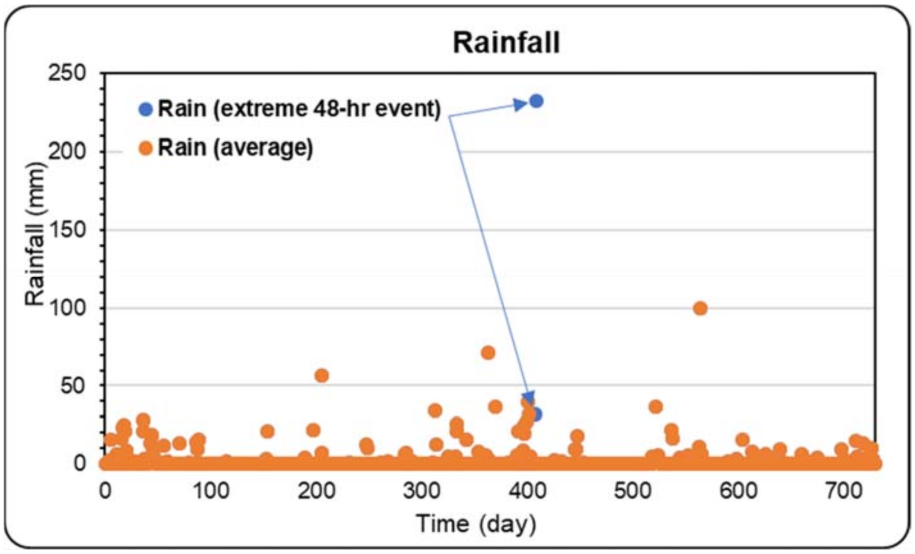


Figure 8. Adapted average and extreme rainfall data for Ensham Mine.

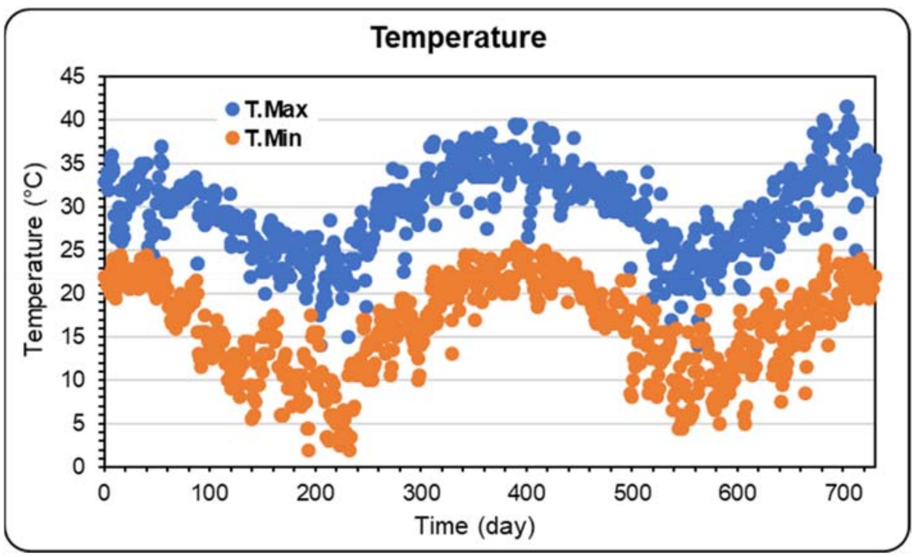


Figure 9. Adapted average maximum and minimum temperature data for Ensham Mine.

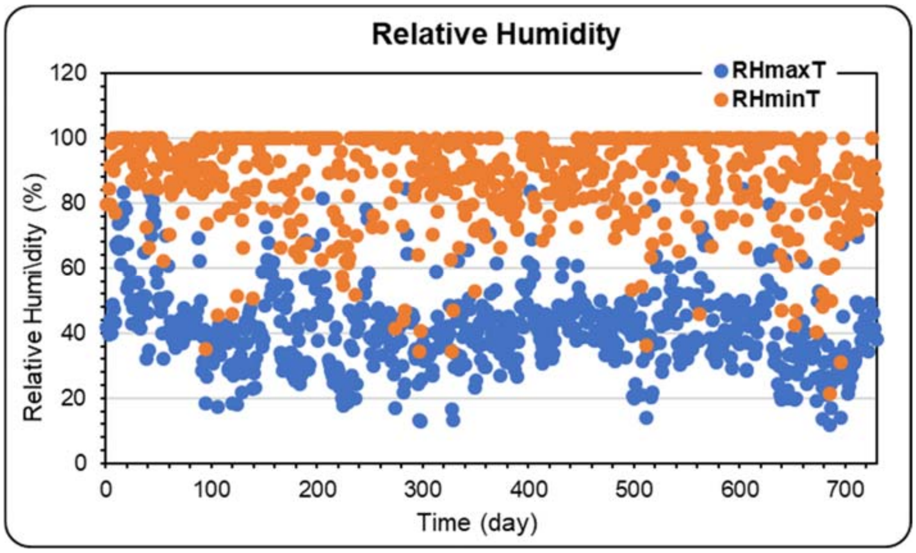


Figure 10. Adapted maximum and minimum relative humidity data for Ensham Mine.

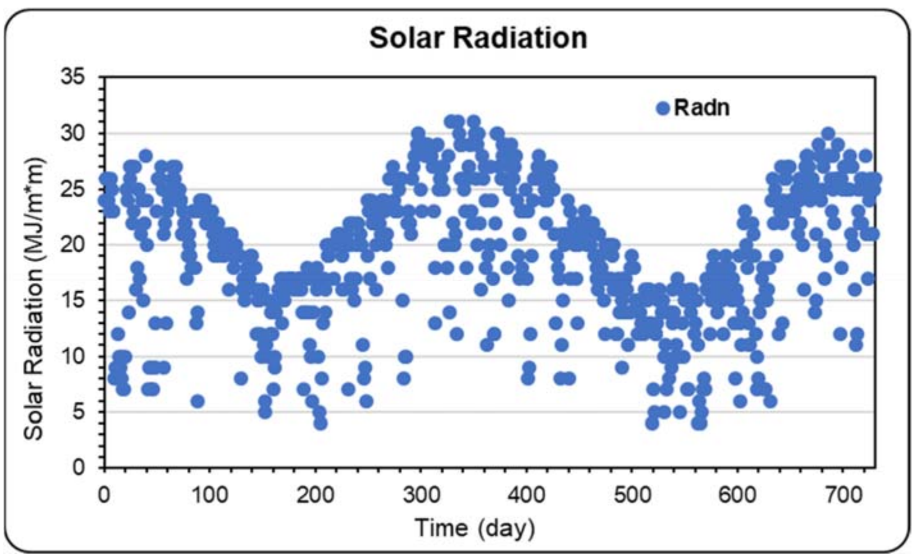


Figure 11. Adapted average solar radiation data for Ensham Mine.

The Wilson-Penman (1990) method is used to calculate the actual evaporation (AE) as opposed to using potential evaporation (PE). AE is computed as a function of PE or net solar radiation for each soil moisture condition and is independent of the cover material type.

$$AE = \frac{\Delta Qn + \upsilon E_a}{\Delta + A\upsilon}$$ **Equation 18**

Where *AE*= actual evaporation; Δ= slope of the saturation vapor pressure versus temperature curve at the mean temperature of air; *Qn*= net radiant energy available at the surface; υ= psychrometric constant; E_a= $f(u)e_a(B-A), f(u) = 0.35(1+0.15\,U)$ which is an expression including wind speed, vapor pressure in air above evaporating surface, relative humidity in air and soil surface.

Temperature, rainfall, relative humidity and radiation will be distributed throughout the day based on a sinusoidal pattern.

3.3.2 Ground Surface

Surface water will be allowed to pond on the ground surface boundary; water is stored on the surface (nodes) and allowed to evaporate or infiltrate during later time steps. For select models, water that ponds on the cover surface will be allowed to flow laterally out of the model once it reaches a defined pressure head (seepage face; **Section 3.3.3**).

3.3.3 Seepage Face (Boundary Condition)

For select models, lateral Interflow (above the spoil) will be removed from the model using a seepage face boundary condition.

3.3.4 Base conditions

RGS has assumed that the spoils are predominantly in an unsaturated state (Hawley and Cunning, 2017) so that there is no water table within the spoil pile under the modelled scenarios. Therefore, the lower boundary condition of the models was simulated with a head boundary with a water table at 8m below the ground surface.

3.4 Model Geometry

The typical model geometry and mesh used for each of the models is shown in **Figure 12**. The 2D SEEP/W models consist of a 5m wide column which is 8m high on the left boundary and 8.2m high on the right boundary; this provides a slope on the surface of 1:25.

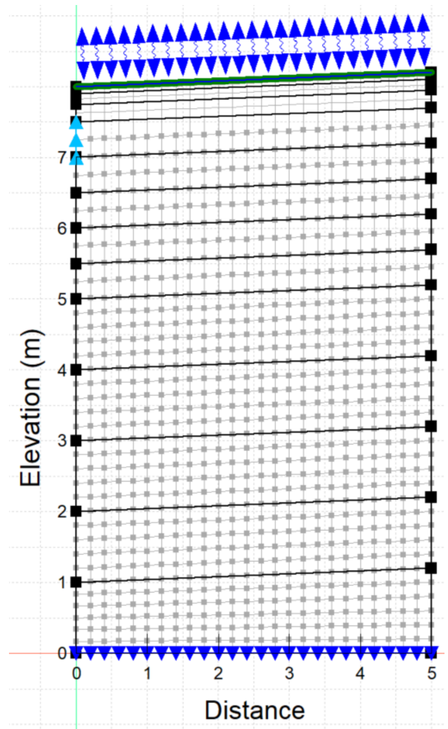


Figure 12. Example Model Geometry

3.5 Modelling Scenarios

Several modelling sensitivities and scenarios have been undertaken. The base-case cover configuration has been maintained consistent for the majority of the model simulations (i.e. growth/soil medium (0.5m) overlying spoil; Scenario 1); however, several simulations were also undertaken with a 1.0m growth/soil medium overlying spoil (Scenario 2) (**Figure 13**); this somewhat reflects inconsistency's that are likely to occur while constructing the cover.

Since there is limited information on the topsoil/growth medium properties, a range of simulations were undertaken including different SWCC's which are indicative of a sand, clayey/sand and clay. For each of these scenarios, several variations in vegetation type (with and without vegetation establishment) have been simulated. For select models, different annual precipitation regimes were simulated. For example, a historical 48-hour extreme rainfall event was applied to the dataset and run on select models. The models were run as transient based on daily time steps.

The various model scenarios and sensitivities are summarised in **Table 3**.

Scenario 1 **Scenario 2**

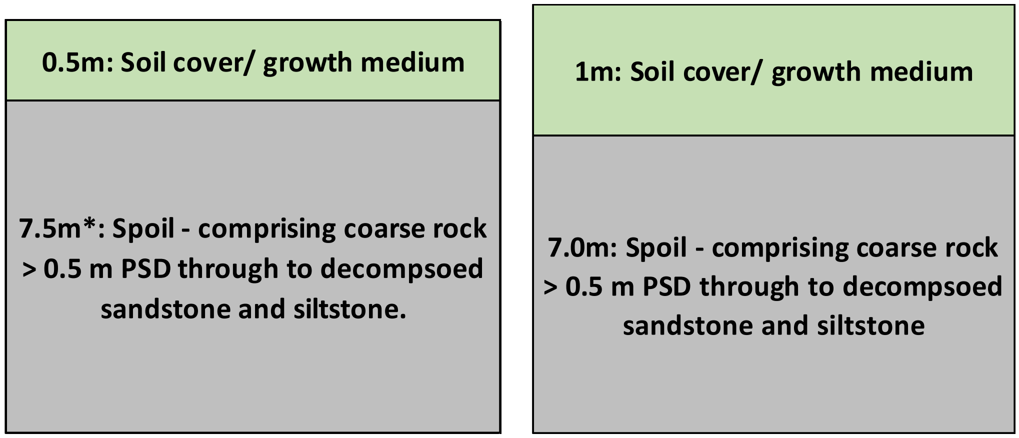


Figure 13. Soil Cover Configuration. *7.5m spoil used for the sake of modelling the cover; actual spoil piles can be up to 30m in profile.

Table 3: Model Scenarios and Sensitivities

Scenario	Vegetation	Topsoil/ growth medium	Climate
Scenario 1 (0.5m topsoil/ growth medium)	Yes – good grass	Sand	Average
	Yes – good grass	Clayey/ sand	Average
	Yes – good grass	Clayey/ sand	Extreme
	Yes – good grass	Clay	Average
	No	Sand	Average
	No	Clayey/ sand	Average
	No	Clay	Average
Scenario 2 (1m topsoil/ growth medium)	Yes – good grass	Sand	Average
	Yes – good grass	Clayey/ sand	Average
	Yes – good grass	Clay	Average

4.0 MODELLING RESULTS

The results of the modelling simulations are summarised in the following sections. The data output from the modelling is extensive, so only relevant information has been included in the summary below. The results have been input from the middle of the model, which may affect runoff and infiltration results as the results may vary depending on position along a slope (e.g. runoff at the bottom of the slope will be higher than for the top).

4.1 Surface Water Balance

The results of the surface water balance are summarised for each of the simulations in **Table 4**; the results summarised in **Table 4** are for the net values reported after a 6-year simulation relative to rainfall. Infiltration can exceed precipitation because water from higher slopes may runoff and then infiltrate at a later time step. Similarly, evaporation is not entirely associated with precipitation as evaporation is most dominant during dry periods. Discussing the surface water balance independent of rainfall events and intensity may create misunderstanding of the key surface water balance processes. It is therefore, pertinent to discuss the results relative to rainfall events. The summary statistics are shown for each of the simulations according to rainfall event (**Table 5** and **Table 6** for Scenario 1 and Scenario 2, respectively).

The key results of the modelling are summarised in the following points:

- Increasing the soil cover from 0.5m to 1.0m has little effect on the surface water balance.
- The surface water balance is controlled by the intensity of rainfall events. Low intensity rainfall events (>0 – 5mm) results in high infiltration and low runoff, while with increasing rainfall intensity, there is a relative increase in runoff and decrease in infiltration.
- Runoff is much higher and infiltration lower for the clayey/sand and clay soils due to the lower permeability. Conversely, the sandy soils have very high infiltration and low runoff.
- The simulations show that surface evaporation is significantly higher for the non-vegetated soil cover, with low surface evaporation evident for the good grass simulations due to the shading provided by the grass canopy. Plant transpiration was the dominant process for the cases with good grass by which water was removed from the model domain. Plant transpiration includes plant root uptake (not shown) and evaporation from aerial parts (reported as transpiration), which indicates why plant transpiration may exceed precipitation for a given time step.
- For all simulations, there was a net negative change in water storage under average rainfall conditions due to high evapotranspiration and runoff. During an extreme rainfall event, excess rainfall is typically removed via runoff.
- The combination of runoff and evapotranspiration remove nearly all water from the soil cover, with limited percolation below the root zone (2m).

Table 4: Water Balance Summary (net over 6-year simulation)

Scenario	Vegetation	Topsoil	Climate	Evaporation (%)	RO (%)	Infiltration (%)*	Transpiration (%) (surface)
Scenario 1	Yes	Sand	Average	46.2	7.0	100	4.7
	Yes	Clayey/ sand	Average	50.2	42.3	100	4.6
	Yes	Clayey/ sand	Extreme	42.5	50.3	100	3.8
	Yes	Clay	Average	46.2	66.0	100	4.6
	No	Sand	Average	92.8	0.0	19.4	0.0
	No	Clayey/ sand	Average	48.6	44.3	7.1	0.0
	No	Clay	Average	19.2	80.9	0.6	0.0
Scenario 2	Yes	Sand	Average	45.0	8.1	100	4.7
	Yes	Clayey/ sand	Average	46.1	39.6	100	4.6
	Yes	Clay	Average	38.9	69.4	100	4.6

*Infiltration may exceed rainfall due to runoff from higher domains.

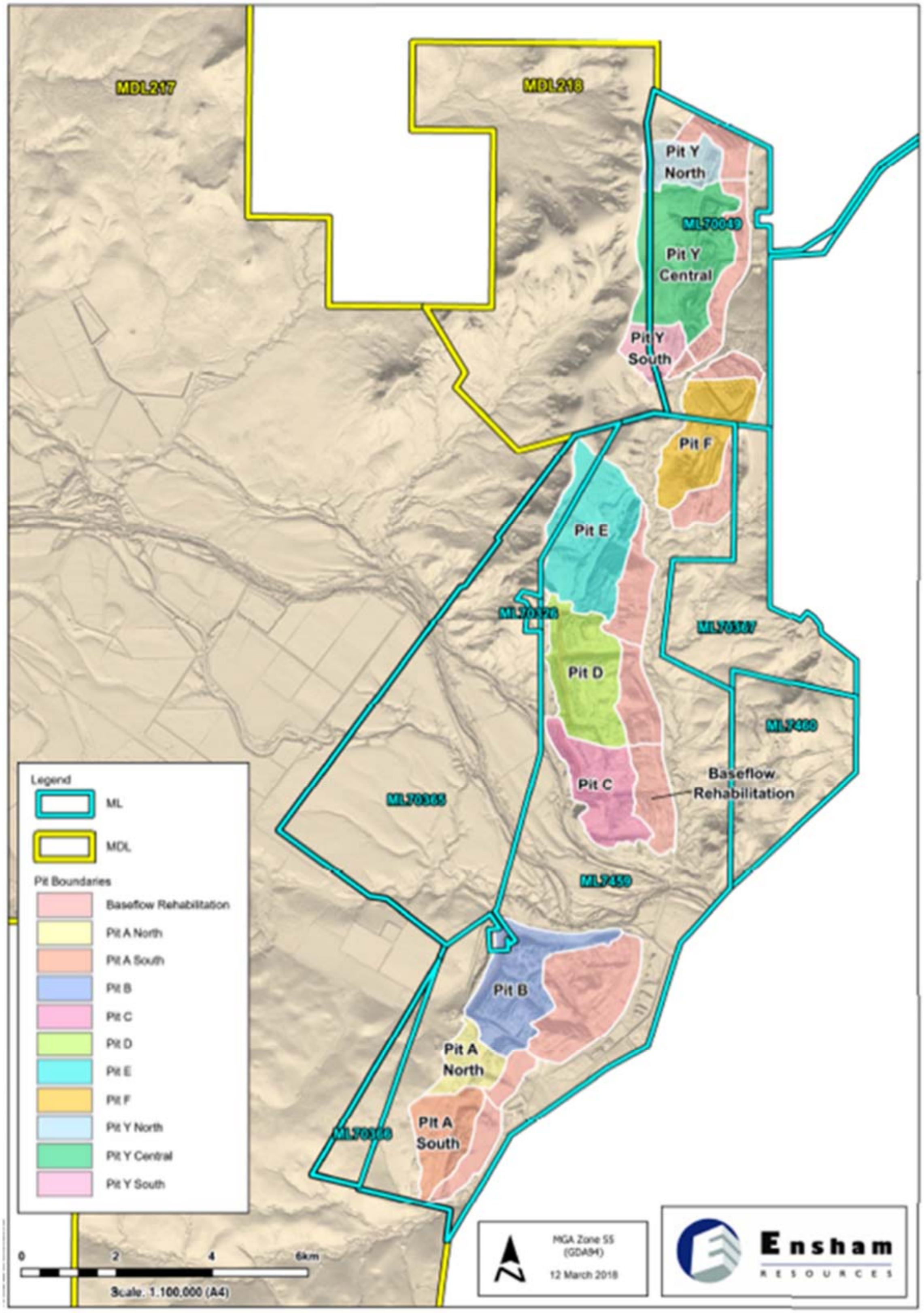
Table 5: Water Balance Summary for Scenario 1 (0.5m soil cover) Various Sensitivity Analysis

Rainfall event (24 hours)	Rainfall Frequency (in 2 years)	RO (%)	Infiltration (%)	Evapotranspiration (%) (surface)
Sand				
> 0 - 5 mm	116	0.6	79.8	26.4
5 - 10 mm	27	2.9	97.2	0.9
10 - 15 mm	10	0.0	99.6	0.6
15 - 20 mm	10	7.7	91.9	0.4
20 - 25 mm	8	0.0	99.7	0.3
25 - 40 mm	10	8.7	91.0	0.2
40 - 70 mm	1	0.0	100.0	0.0
70 - 100 mm	2	0.0	100.0	0.0
Clayey/ Sand				
> 0 - 5 mm	116	4.8	77.5	26.4
5 - 10 mm	27	16.7	85.7	0.8
10 - 15 mm	10	7.0	92.4	0.6
15 - 20 mm	10	40.6	66.0	0.4
20 - 25 mm	8	38.7	61.0	0.3
25 - 40 mm	10	53.9	46.0	0.2
40 - 70 mm	1	68.2	31.8	0.0
70 - 100 mm	2	87.9	12.1	0.0
Clay				
> 0 - 5 mm	116	2.6	81.4	26.4
5 - 10 mm	27	34.8	64.5	0.7
10 - 15 mm	10	35.7	63.9	0.4
15 - 20 mm	10	56.0	43.7	0.4
20 - 25 mm	8	71.9	27.9	0.2
25 - 40 mm	10	79.1	20.8	0.1
40 - 70 mm	1	98.1	1.9	0.0
70 - 100 mm	2	96.2	3.8	0.0

Table 6 Water Balance Summary for Scenario 2 (1.0m soil cover) Various Sensitivity Analysis

Rainfall event (24 hours)	Raifall Frequency (in 2 years)	RO (%)	Infiltration (%)	Evapotranspiration (%) (surface)
Sand				
> 0 - 5 mm	116	0.7	80.2	26.4
5 - 10 mm	27	0.0	99.1	0.9
10 - 15 mm	10	0.0	99.4	0.6
15 - 20 mm	10	0.0	99.6	0.4
20 - 25 mm	8	19.8	92.4	0.3
25 - 40 mm	10	0.0	99.8	0.2
40 - 70 mm	1	0.0	100.0	0.0
70 - 100 mm	2	0.0	100.0	0.0
Clayey/ Sand				
> 0 - 5 mm	116	3.6	75.9	26.4
5 - 10 mm	27	15.4	83.7	0.8
10 - 15 mm	10	6.4	93.0	0.6
15 - 20 mm	10	23.1	76.0	0.4
20 - 25 mm	8	39.2	60.6	0.2
25 - 40 mm	10	53.2	46.7	0.1
40 - 70 mm	1	97.6	2.4	0.0
70 - 100 mm	2	40.5	59.5	0.0
Clay				
> 0 - 5 mm	116	2.3	81.7	26.4
5 - 10 mm	27	33.3	66.0	0.7
10 - 15 mm	10	56.3	43.3	0.3
15 - 20 mm	10	71.2	28.5	0.3
20 - 25 mm	8	62.3	37.5	0.2
25 - 40 mm	10	87.1	12.8	0.1
40 - 70 mm	1	97.3	2.7	0.0
70 - 100 mm	2	96.1	3.8	0.0

A.6 Appendix 6 Ensham pit shell boundaries



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