K + S Salt Australia Pty Ltd

Material Characterisation Study

EPA Assessment No. 2101

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Abbreviations

Abbreviation	
AGIG	Australian Gas and Infrastructure Group
AHD	Australian Height Datum
ANC	Acid neutralising capacity
ARPAMSA	Australian Radiation Protection and Nuclear Safety Agency
ASS	Acid sulfate soils
ASSMP	Acid sulfate soil management plan
ASSS	Acid sulfate soils and sediments
bgl	Below ground level
BoD	Basis of design
BoM	Bureau of Meteorology
CAB	Carnarvon Artesian Basin
CEC	Cation exchange capacity
CP	Concentration pond
CRS	Chromium reducible sulfur
Cza	Alluvium deposits
Czp	Claypan dominated terrain
DAFWA	Department of Agriculture and Food, Western Australia
DBNGP	Dampier to Bunbury Natural Gas Pipeline
DER	Department of Environment and Regulation
DGV	Default guideline values
DMIRS	Department of Mines, Industry Regulation and Safety
DMP	Department of Mines and Petroleum
DoW	Department of Water
DPIRD	Department of Primary Industries and Regional Development
DPLH	Department of Planning, Lands and Heritage
dS	Decisiemens
DWER	Department of Water and Environmental Regulation
EC	Electrical conductivity
EIL	Ecological investigation levels
EPA	Environmental Protection Authority
EP Act	Environmental Protection Act 1986
ERD	Environmental review document
ESD	Environmental scoping document
ESP	Exchangeable sodium percentage
GHD	GHD Pty Ltd
H	Height
ha	hectares
HDPE	High density polyethylene
K + S	K + S Salt Australia
LNG	Liquified natural gas
LOR	Limit of reporting
km	kilometres
m	metres

Abbreviation	
mm	millimetres
MNES	Matters of national environmental significance
MPA	Maximum potential acidity
NAF	Non-acid forming
NAG	Net acid generation
NAPP	Net acid production potential
NATA	National Association of Testing Authorities
NEPM	National environmental protection measure
NMD	Neutral Mine Drainage
NORM	Naturally occurring radioactive material
NPI	Non process infrastructure
OEPA	Office of the Environmental Protection Authority
PASS	Potential acid sulfate soils
PFS	Pre-feasibility study
RL	Relative level
Qe	Mainland remnants
Qp	Claypans
Qs	Beach and coastal dunes
Qsed	Quaternary sediments
Qt	Supratidal flats
Qw	Intertidal flats
Qza	Outwash plain alluvium
SD	Sallie drainage
TDS	Total dissolved solids
TIC	Total Inorganic Carbon
TSS	Total soluble salts
V	Vertical
WA	Western Australia

Executive Summary

K + S Salt Australia (K + S) is the Australian entity of the international resources company K + S Group. K + S (**the Proponent**) have appointed GHD Pty Ltd (GHD) to undertake multiple studies including hydrogeological, geotechnical, Acid Sulfate Soil and Sediment (ASSS) and initial material characterisation investigations for Phase 2 of the Ashburton Solar Salt project (**the Proposal**).

The Proponent is developing a green field solar salt project along the Western Australian coast, approximately 40 km south–west of the township of Onslow, within the Shire of Ashburton.

The Study Area consists of 67,570 hectares (ha) and a maximum of 18,005 ha is proposed to be disturbed as part of the current Proposal (referred to as the Disturbance Footprint). The Disturbance Footprint includes all assets and infrastructure areas excluding the offshore facility and dredged pocket.

The facility is planned to operate with a salt export capacity of 4.7 million tonnes per annum, harvested from the progressive evaporation of seawater in a series of Concentration and Crystalliser Ponds.

This report presents the initial material characterisation study and results obtained from the Phase 2 site investigation conducted in the Study Area between 28th October 2019 and 31st March 2020 to inform management actions for construction and operations and to guide mine closure planning.

The initial material characterisation assessment included screening for the following geochemical properties as summarised below.

Naturally Occurring Radioactive Material

Disturbances within the Study Area will be limited to surficial deposits (colluvium, alluvium and aeolian) and therefore excludes radiological sources (e.g. local basement granitic rocks). Although considered unlikely, sediments in the area may however contain naturally occurring heavy minerals (resistates) concentrated in channels systems, which may be elevated in resistates exhibiting radioactivity above generalised background concentrations. Sediment within these channel systems are not proposed to be disturbed or excavated by the Proposal.

Whilst these channel systems are not proposed to be excavated or disturbed as part of the Proposal, borrow pits for clay located within claypans or drainage diversions could potentially contain such resistates due to receiving material from channel systems. Borrow pits within claypans and drainage diversions will be further assessed using appropriate methodology to assess the potential impacts from radionuclides released into the environment prior to disturbance. Management of material will be addressed (including dust management and monitoring) in the Project Management Plan to be submitted to DMIRS.

Acid Sulfate Soils and Sediments

A Phase 2 Acid Sulfate Soils and Sediment (ASSS) Study was conducted by GHD for this project (GHD, 2021a) and an Acid Sulfate Soils and Sediment Management Plan (ASSSMP) subsequently prepared (GHD, 2021b).

Typically, the higher elevated areas of the Proposal site are between 5 and 10 m AHD and consist of calcareous materials such as calcarenite gravel, coral and shell fragments and present a low risk of oxidation during disturbance. Total Inorganic Carbon analysis completed on the less than 0.5 mm fraction of samples collected indicates significant natural buffering ability would be available within the natural environment in the event of a minor acidification event. Sulfidic material was encountered within the supratidal flats, creek mudflats and lower

lying regions of the Proposal site. Infrastructure requiring excavation in these areas will require management. In addition, testing indicates that dredged marine sediments are likely to contain acid generating material and will require management. The following proposed excavation/disturbance requires management and/or further testing as documented within GHD 2021a and 2021b:

- Jetty Berthing Pocket (dredged)
- Borrow Pits
- Drainage Diversions
- Pond Embankments (if keyed into salt flat surface)
- Seawater Intake Well and Pump Station.

Acidic and or Metalliferous Drainage

Preliminary characterisation using static test data and the AMIRA (2002) Classification System indicated the soils analysed were Non Acid Forming (NAF).

Neutral Mine Drainage and Saline Drainage

Development of infrastructure within the Study Area is primarily limited to the importation of material rather than the extensive disturbance of ground surface and in-situ material. Assessment of the material from within potential areas of disturbance indicate that in-situ materials may assist in the precipitation of metals and metalloids (particularly copper and zinc) under circum-neutral to alkaline pH conditions and concentrations of sulfate are likely to remain elevated due to natural occurrence.

SD and NMD within the identified areas of saline surface water and groundwater seepage around the margins of the pond embankments (GHD, 2021d) should not cause adverse impacts, given that the source seepage waters (saline ponds) and the receptor setting (salt flats) are geochemically similar in nature and that the salt flats are not considered a sensitive receptor to saline drainage. The saline seepage from the ponds and naturally occurring ANC within the environment is likely to have the chemical capacity to neutralise and buffer potential acid generation, which has been identified in the natural subsurface beneath the footprint of the ponds and seepage areas (Refer to Section 6.2.1).

Sodic and/or Dispersive Materials

Soils within the supratidal flats are considered at risk of becoming dispersive under leached conditions due to the high concentration of sodium ions present. These materials would be unsuitable for placement on the outer surface of constructed landforms (bunds) or any sloping surface. Left undisturbed, these soils are unlikely to be dispersive due to the higher concentration of salts, limited permeability of intertidal soils and therefore a reduced risk of electrolyte leaching, which could cause dispersion. It is anticipated that soils within the intertidal flats (Qw) and claypans (Qp) would behave similarly.

Soils sampled from supratidal flats (Qt) and coastal dunes (Qs) are considered non-sodic in nature and is likely attributed to a greater proportion of sand and silt in the samples analysed and unlikely to exhibit dispersive tendencies. Prior to any disturbance in geological units Qt and Qs, further testing and classification of these materials' dispersion characteristics should be undertaken. Only materials classified as having low dispersion risk should be placed on the outer surface of constructed landforms.

Quaternary sediments (geological unit Qsed) consist of dense clayey sand and sandy clay. These clays have the potential to be sodic, and therefore dispersive. Further testing of erosion potential of this material (geological unit Qsed) should be conducted before any disturbance.

If proposed to be used in construction or rehabilitation, it should only be placed on sloping surfaces if sodicity and dispersion risk is classified as low after testing.

Erosive Material

Materials Susceptible to Wind Erosion

Claypan soils (Qp) formed through wind driven blowout between remnant dunes, are expected to continue to be exposed to erosion by wind and water. Surface sealing/crusting and the presence of gravel in the upper soil horizons may offer some protection, however raindrop impact and erosion is anticipated to continue in the natural state.

The longitudinal and network dunes over claypan dominated terrain (Czp) comprise clayey sand. These dunes are largely vegetated with spinifex and samphire, protecting them from wind erosion. Furthermore, the sand component of the soils comprises fine to medium grained quartz with a lower susceptibility to wind erosion.

The supratidal flats (Qt) are considered most at risk of wind erosion due to the higher proportion of clay, salts and gypsum which are more easily mobilised with strong winds; and the infrequent inundation of this tidal zone leaving soils dry and exposed to wind erosion particularly in spring and summer.

The intertidal flats (Qw) are less susceptible to wind erosion as these soils are inundated more frequently and thus retain higher moisture through the soil profile.

The quaternary sediments (Qsed) underlay all soils within the Proposal site, and are therefore unlikely to be subject to wind erosion unless exposed under dry conditions.

The coastal dunes (Qs) are formed of unconsolidated sand and average 3 m in height, but can range to a maximum height of 6 m to 7 m. In the north of the site, near the proposed jetty, the dunes are typically 500 m wide, immobile, and are generally sparsely vegetated with spinifex. Landside of the proposed jetty (BH03) the dune is characterised as extending to 7 m AHD. Observations of the surface and shallow subsurface profile presented calcareous sand with an abundance of coral, shells fragments and calcarenite gravels ranging between fine gravels to larger cobbles and occasional boulder sized particles. Disturbance of the coastal dune to construct the conveyor embankment and jetty could expose areas of the dune to wind erosion. Appropriate erosion protection is recommended such as rock armouring and dune revegetation.

Materials Susceptible to Water Erosion

Tidal soils present in the Study Area in the intertidal (Qw) and supratidal (Qt) zones presented a high clay and slit content and are generally sodic. The higher salt content minimises dispersion risk, however under leached conditions these soils have the potential to be highly erodible. Furthermore, intertidal sediments were observed to have a halite crust (i.e. they are self-mulching) and may be more susceptible to water erosion.

However, while the tidal soils are susceptible to water erosion due to their physical and chemical properties, the environment in which they occur is low energy due to the lower landscape position. Water delivered by the inland connecting creeklines during intense rainfall events accumulates and evaporates. The creeklines experience a comparatively high energy environment, however the deep sands present in the bed and banks of these creeklines are much less prone to erosion.

Within the inland longitudinal and network dunes over claypan (geological unit Czp) there is up to 55% clay content, balanced by fine to medium grained quartz. The material is un-cemented with traces of fine to coarse grained calcrete gravel. This material may not be suitable for placement on sloping surfaces due to high clay content which could facilitate water erosion.

Further testing of erosion potential of this material (geological unit Czp) should be conducted. It should only be placed on sloping surfaces if erosion risk is classified as low after testing.

Fibrous Material

Asbestiform Minerals

Asbestiform minerals are widely distributed in Western Australia (WA) and can be major components of the mafic and ultramafic rocks hosting gold, nickel and base metal deposits located on the WA 'Greenstone Belts' (DMIRS, 2020). Disturbance within the Study Area will be limited to surficial deposits (colluvium, alluvium and aeolian) and therefore the likelihood of asbestiform minerals typically derived from the disturbance and exposure of basement rocks is low.

Silicate Minerals

Quartz sands are present within the remanent islands and dunes across the Study Area (and underlying Quaternary sediments - Qsed) and generally present a low risk during construction and management operations with use of appropriate dust suppression.

Activities which degrade and/or further process silicate materials increase the risk of exposure. The Proposal does not include the processing of silicate materials; however, a generic silicates assay has been conducted on select geological units proposed to be disturbed. Analysis identified significant quarts content in all samples presented values up to 71%, with minerals susceptible to fibrous crystal habit confined to clays/micas. Further assessment of potential dust and workforce inhalation airborne particles should be undertaken prior to ground disturbance works. Dust suppression measures should be implemented in accordance with an appropriate Dust Management Plan during construction phase to minimise the risk of workers inhaling and ingestion of air borne particles. Appropriate dust management and monitoring will be required in the Project Management Plan to be submitted to DMIRS.

Heavy Metals and Metalloids

Representative samples were collected from three geological units (Qt supratidal flats, Qe mainland remnants, Czp longitudinal and network dunes over claypan) and were analysed for heavy metals. Screening of heavy metals and metalloids in comparison to Default Guideline Values (DGVs) for ecological Investigation Levels (EILs) available in the National Environmental Protection Measure (NEPM, 2013) indicated that exceedances of copper, nickel and zinc were recorded. The current concentrations of metals are likely to represent naturally occurring concentrations. An assessment of leachate potential and concentrations for materials proposed to be excavated (whether excavated and stored or re-used) with respect to the proposed re-use strategy should be undertaken. Materials posing a significant environmental concern, with respect to leachable metal concentrations may require to be re-used above saturated ground conditions as a minimum requirement.

Topsoil or Growth Media

Material sourced from remnant islands is the most likely to be suitable for topsoil or growth media during the closure phase of the Proposal.

Additional soils may be suitable for topsoil regrowth and include coastal dunes, alluvium deposits, longitudinal and network dunes over claypan-dominant terrain. These additional sources are potentially suitable however would require further assessment to confirm their suitability. Selection of topsoil and suitable growth media should take into consideration susceptibility to erosion (i.e. piping and dispersion) and other factors that may be prohibitive to plant growth such as high salinity as measured through EC/TDS and toxicity (e.g. AASS, PASS and heavy metal toxicity typically under acidic conditions).

1. Introduction

1.1 General Overview

K + S Salt Australia (K + S) is the Australian entity of the international resources company K + S Group. K + S (**the Proponent**) have appointed GHD Pty Ltd (GHD) to undertake hydrogeological, geotechnical, Acid Sulfate Soil and Sediment (ASSS) investigations and initial material characterisation screening for Phase 2 of the Ashburton Solar Salt project (**the Proposal**).

This report presents the initial material characterisation study to assist in providing further information to inform the preparation of the Environmental Review Document (ERD, which will be assessed under *Part IV of the Environmental Protection Act 1986* (EP Act). This study is also intended to inform management actions for construction and operations and to guide mine closure planning.

The Proposal is located within the coastal region southwest of the town of Onslow, Western Australia (WA), as shown on Figure 1.

GHD previously completed Phase 1 investigations in 2019, which included a site walkover inspection and preparation of a report (GHD 2019). The report presented the site inspection findings and potential Acid Sulfate Soils (ASS), geological and geotechnical issues that could impact the Proposal and also provided recommendations to assist with the mobilising of Phase 2 (this investigation).

The fieldwork component of the multidisciplinary site investigation (hydrogeological, geotechnical, ASS and Sediment and initial material characterisation) for the Proposal was completed in April 2020 and represents the first ground intrusive works carried out in the Study Area (Figure 1).

The investigation was undertaken in accordance with GHD's proposal provided to the Proponent dated 13th September 2019. This report presents the initial material characterisation study and results obtained from the Phase 2 site investigation conducted between 28th October 2019 and 31st March 2020.

1.2 Proposal Overview

The Proponent is developing a green field solar salt farm along the Western Australian coast, approximately 40 km south–west of the township of Onslow, within the Shire of Ashburton. The Study Area consists of 67,570 hectares (ha).

The proposed project is planned to operate with a salt export capacity of 4.7 million tonnes per annum, harvested from the progressive evaporation of seawater in a series of Concentration and Crystalliser Ponds. The Study Area is illustrated on Figure 1. Further details relating to the proposed development are outlined in Section 3.

1.3 Purpose of Report

The Office of the Environmental Protection Authority (OEPA) has determined that the Proposal is required to be assessed under Part IV of the EP Act. The Environmental Scoping Document (ESD) was endorsed by the Environmental Protection Authority (EPA) on 24 January 2018. The ESD has outlined the work and/or studies required to be undertaken and included within the ERD.

The purpose of this material characterisation study in relation to the Proposal is to provide additional information and assessment of data provided for the Study Area. This is with

reference to soil quality including the chemical, physical, biological and aesthetic characteristics, with particular regard to potential for acidification and contamination (mining activities) of soils.

This technical report will assist in the preparation of an overall ERD and provides information and assessment so that the EPA's objective '*to maintain quality of land and soils so that environmental values are protected*' for Terrestrial Environmental Quality is maintained.

1.4 Scope of Work

The scope of work for this Material Characterisation study (herein) includes the following components:

- Desktop review of existing site data with reference to geochemical and physical properties of naturally occurring soils and geological materials proposed to be disturbed or extracted (borrow areas) within the Study Area (Figure 1).
- Material Characterisation sampling during Phase 2 investigations to ascertain physical and geochemical properties of geological units encountered and proposed to be disturbed as part of the Proposal (future construction and or operational activities).
- Identification of potential impacts of disturbing encountered geological units.
- Indicative management measures to address potential impacts identified.
- Provide recommendations for further investigations required to assist in the preparation of relevant and applicable management documentation.

1.5 Contemporary Guidelines

The Material Characterisation study was completed with reference to, and in accordance, with the following national and West Australian contemporary guidelines (where appropriate):

- Department of Mines and Petroleum, *Materials Characterisation Baseline Data Requirements for Mining Proposals – Draft Guidance* (DMP 2016b).
- Environment Protection Authority, *Environmental Factor Guideline: Terrestrial Environmental Quality* (2016).
- Department of Mines and Petroleum, *Guidelines for Managing naturally occurring radioactive material (NORM) in mining and mineral processing: NORM-3.1 Monitoring NORM – pre-operational monitoring requirements* (2010a).
- Department of Mines, Industry Regulation and Safety, *Statutory Guidelines for Mine Closure Plans* (2020c).
- Department of Environment and Regulation (DER), *Acid Sulfate Soil Guideline Series: Identification and investigation of acid sulfate soils and acidic landscapes* (June 2015a).
- Department of Environment and Regulation, *Acid Sulfate Soil Guideline Series: Treatment and management of soils and water in acid sulfate soil landscapes* (June 2015b).

1.6 Scope and Limitations

This report has been prepared by GHD for K + S Salt Australia Pty Ltd and may only be used and relied on by K + S Salt Australia Pty Ltd for the purpose agreed between GHD and the K + S Salt Australia Pty Ltd as set out in section 1.3 of this report.

GHD otherwise disclaims responsibility to any person other than K + S Salt Australia Pty Ltd arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report. GHD disclaims liability arising from any of the assumptions being incorrect.

GHD has prepared this report on the basis of information provided by K + S Salt Australia Pty Ltd and others who provided information to GHD (including Government authorities)], which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

The opinions, conclusions and any recommendations in this report are based on information obtained from, and testing undertaken at or in connection with, specific sample points. Site conditions at other parts of the site may be different from the site conditions found at the specific sample points.

Investigations undertaken in respect of this report are constrained by the particular site conditions, such as the location of buildings, services and vegetation. As a result, not all relevant site features and conditions may have been identified in this report.

Site conditions (including the presence of hazardous substances and/or site contamination) may change after the date of this Report. GHD does not accept responsibility arising from, or in connection with, any change to the site conditions. GHD is also not responsible for updating this report if the site conditions change.

2. Site Identification

2.1 Site Identification

The Proposal is located approximately 40 km south west of the town of Onslow, WA. (Figure 1). The Study Area is 67,570 ha in size.

This area contains various significant physiographic features including coastal dunes, tidal creeks lined with mangroves, intertidal/supratidal flats, undulating sand plains, clay pans and the marine environment.

2.2 Mining Tenements

A search of the Department of Mines, Industry Regulation and Safety (DMIRS) MINEDEX and Materials Titles Online systems was completed in July 2020. The search indicated that K + S currently hold exploration status on five mining tenements which form the preponderance of the Proposal Study Area.

A summary of mining tenement details is presented in Table 1 and the tenements are presented on Figure 2.

Table 1 Mining Tenement Details Summary

Tenement identifier	Date received	Commencement	Expiry	Area (ha)
E 08/1395	03/06/2003	15/06/2004	14/06/2020	22231
E 08/1396	03/06/2003	15/06/2004	14/06/2020	10807
E 08/1399	03/06/2003	15/06/2004	14/06/2020	8576
E 08/1421	15/10/2003	15/06/2004	14/06/2020	7306
E 08/2840	27/04/2016	25/01/2018	24/01/2023	13985

2.3 Zoning

According to the Department of Planning Lands and Heritage, the site is located on land parcels zoned as *'Rural'*, '*Tidal inundation special control area'* and '*Conservation, recreation and nature landscape'* (DPLH 2020).

2.4 Current Land Use

2.4.1 On Site Land Use

The Proposal site is situated on a region of intertidal/supratidal flats, with remnant islands and isolated sand dunes. The Study Area is currently on pastoral land associated with the Urala and Koodarrie Stations. The Study Area is predominately absent of any development, with the exception of an area in the northeast portion of the site that is shared land between the Proposal and the Australian Gas Infrastructure Group (AGIG) Tubridgi Gas Plant. An area of approximately 1969 ha is shared by the Study Area and the AGIG Tubridgi Gas Plant site boundary. According to spatial information provided by AGIG, a single gas production well appears to be located within the Study Area, along with various access tracks and other minor

gas plant support infrastructure. The AGIG and aforementioned land uses are shown on Figure 2.

2.4.2 Surrounding Land Use

The AGIG Tubridgi Gas Plant is located approximately 2.5 km north-east of the site. The Tubridgi Gas Plant facilitates gas storage and delivery to the Dampier to Bunbury Natural Gas Pipeline (DBNGP). A further 13 km north-east of the Study Area is the Macedon Domestic Gas Plant operated by BHP Group Limited and beyond is the Wheatstone Liquefied Natural Gas (LNG) Plant operated by Chevron Australia Pty Ltd (see Figure 2).

The Proposal Study Area is also located 25 km south-west of the Onslow Salt project (Figure 2). The Onslow Salt project is an active solar salt mining operation with an estimated production of 2.5 million tonnes per annum. Similar to the salt manufacturing process outlined in the Proposals Pre-Feasibility Study (Arcadis 2018a) (see further Section 3), the Onslow Salt project pumps seawater from Beadon Creek to concentration ponds, before passing material through a variety of handling methods and infrastructure to process the salt for conveyor loading onto ships from an offshore facility.

A review of available aerial imagery and online data indicates that no coastal or offshore development has occurred proximal to the Proposal Study Area. The coastal boundary of the Proposal Study Area is flanked by the Pilbara Inshore Islands, including the major islands of Thevenard, Bessieres, Serurier, Peak and Murion. These larger islands are located approximately 35 km offshore and are classed as nature reserves. Thevenard Island (35 km north-east) is the site of a former gas plant originally operated by Chevron Australia Pty Ltd which ceased operation in 2014 and is currently in a decommissioning phase. Closer to shore (<10 km), smaller nature reserve classed islands exist. Aerial imagery shows no obvious developments on these islands.

3. Proposed Development

3.1 Overview

The Proposal Study Area consists of 67,570 ha and a maximum of 18,005 ha is proposed to be disturbed as part of the current Proposal (Proposed Disturbance Footprint).

The facility is planned to operate with a salt export capacity of 4.7 million tonnes per annum, harvested from the progressive evaporation of seawater in a series of concentration and crystalliser ponds. It is anticipated that the proposed salt facility will comprise the following infrastructure and/ or components:

- Seawater intake pump station and channel to the salt ponds.
- Salt concentration ponds (concentration ponds).
- Salt crystalliser ponds (crystalliser ponds).
- Brine pond and brine transfer structures including bitterns discharge infrastructure (dilution pond, pipeline and diffuser).
- Salt wash plant.
- Salt stockyard and reclaim conveyor system.
- Non-process infrastructure (NPI) including administration buildings, stores (including fuel stores), workshops, laydowns areas and internal access road network.
- A dedicated jetty and loading platform to facilitate the transport of salt to an offshore anchorage for seagoing vessels.
- Dredging of a small berthing pocket and onshore dredge disposal area.
- Drainage diversions.
- Borrow pit areas for construction materials.

The Study Area and proposed layout is shown on Figure 3 and details of the above is described in more detail in Section 3.2 .

3.2 Proposed Infrastructure

The proposed infrastructure detailed below have been obtained from the pre-feasibility study design report and pre-feasibility study basis of design prepared by Arcadis (2018a and 2018b) and from further design work conducted by K + S since 2018.

3.2.1 Seawater Intake

The proposed location of the seawater intake infrastructure is Urala Creek South due to preferable water chemistry and a flat downstream lake profile conducive to reduced scouring of the creek.

Preliminary designs propose multiple pumps installed to abstract water from a rock armoured sump in Urala Creek South. The pumps will transfer water through a channel which will discharge to Salt Concentration Pond (CP) 1.

3.2.2 Salt Concentration Ponds

The proposed Salt Concentration Ponds are predominately sited on intertidal/supratidal flats as shown on Figure 3. The intertidal/supratidal flats are typically between approximately RL 0.6

m AHD and RL 1.3 m AHD. The surrounding remnant islands to the east are undulating with elevations rising up to approximately RL 21 m AHD.

A summary of the imported fill volumes are presented in Table 2.

Table 2 Concentration Ponds Summary

Parameter	Estimated Import Volume (m^3)
External embankments crest level of RL+3.5 m AHD and width 3.5 m 1(V):1.5(H) slope batters	2,038,000 - 2,209,300
Internal embankments crest level of RL+3.0 m AHD, crest width of 3.5 m 1(V):1.5(H) slope batters	

Table 2. Table source: Arcadis 2018a

3.2.3 Crystalliser Ponds

The Crystalliser Ponds are proposed to be located on the intertidal flats, immediately north of the concentration ponds (Figure 3). The Crystalliser Ponds consist of 12 cells separated by internal embankments and designed in order to optimise existing topography and project operational efficiency. Both the internal and external embankments are proposed to tie into the mainland and the mainland remnant islands.

Approximate disturbance volumes and imported fill volumes are presented in Table 3.

Table 3 Crystalliser Ponds Summary

Parameter	Estimated Disturbance Volume (m^3)
External embankments crest level of RL 3.5 m AHD and 1(V):1.5(H) slope batters	-
Berm on the pond side with a crest level of RL 2.4 m AHD	-
Internal embankments crest level of RL 2.4 m AHD and 1(V):1.5(H) slope batters	-
Earth working of in-situ material to facilitate achievement of design levels	850,000
General fill importation to facilitate achievement of design levels	1,400,000
Rock – scour armour	190,000

Table 3. Table source: Arcadis 2018a

3.2.4 Brine Ponds and Transfer Structures

The seawater intake pump will deliver seawater (brine) into the concentration ponds where it will flow in a north to south direction through CP 1 to 3. From CP 3, the brine will be lifted up by a pump station located on the embankment of CP 3 and 4 for return south to north flow to the salt crystalliser ponds (Arcadis 2018b).

As the brine progresses through the concentration ponds it increases to a critical density at which salt begins to crystallise from the solution. At this density, the brine is referred to as

'maiden brine' and this maiden brine is transferred from concentration pond 8 to the maiden brine feed channel via the maiden brine transfer pump station. The maiden brine feed channel (brine channel), is located along the southern boundary of the crystalliser ponds and has been designed such that the maiden brine will gravity feed the salt crystalliser pond cells. Key design details of the brine pond and transfer infrastructure are shown in Table 4 (Arcadis 2018b).

Table 4 Brine Pond and Transfer Structure Summary

Parameter	Details
Maiden Brine Feed Channel	5.1 km long, 13 m wide, 1.3 m peak brine depth 1.5 (H):1 (V) side slopes, clay lined
Brine Transfer Culverts	Barrel culverts: 3.5 m levee width, HDPE piping flat on pond floor (RL 0.9 – 1.0 m AHD) Bridge structures: 3.5 m levee width
Maiden Brine Pump Station	Pump sump RL 0.168 m AHD, internal levee RL 5.0 m AHD, mudflat concentration pond 8 RL 1 m AHD

Table 4. Table source: Arcadis 2018a and 2018b

3.2.5 Bitterns Discharge

As the brine reaches the second row of the Crystalliser Ponds, it reaches a specific density at which contaminant salts cannot be readily removed by processing at the wash plant – it is at this density that the brine is referred to as 'raw bitterns'. The bitterns dilution pond is located on the northern boundary of the Salt Crystalliser Ponds, it receives the raw bitterns from the Salt Crystalliser Ponds once the brine has deposited the salt and the specific bitterns density is reached.

Seawater will be pumped from CP 1 into the bitterns dilution pond, prior to disposal of the bitterns. Bitterns disposal will occur via a bitterns pipeline that will run from the bitterns dilution pond to the jetty. The bitterns pipeline will be co-located with the conveyor, on a built-up embankment with culverts underneath the embankment to convey necessary surface water flows. Key design details of the bitterns channel and discharge structure are shown in Table 5.

Table 5 Bitterns Channel and Discharge Structure Summary

Parameter	Details
Bitterns dilution pond	70 ha pond, with no liner, 2 m above ground level
Brine discharge channel	Co-located with the conveyor, on a built-up embankment with culverts underneath the embankment to convey necessary surface water flows

Table 5. Table source: Arcadis 2018a and 2018b

3.2.6 Salt Stockyard and Reclaim Conveyor System

The Salt Stockyard will store washed salt to allow for drying of the product prior to ship loading. A centralised rail mounted stacker and reclaimer is proposed. The preferred location for the stockyard is one of the remnant islands (Figure 3). The design level for the salt wash plant was assumed to be approximately RL 6.0 m AHD and founded on shallow concrete strip footings.

3.2.7 Non-Process Infrastructure (NPI)

NPI is proposed on a remnant island close to the salt stockyard (Figure 3). The various components of the non-process infrastructure include:

- Administration building
- Workshop and store facilities
- Amenities and crib buildings
- Refuelling facilities
- Laboratory facilities
- Sewage treatment facilities
- Layout and parking provisions

It is assumed that the NPI will be founded at a level determined by the detailed design and likely to take into consideration the storm surge height. For the purpose of this assessment, this infrastructure is assumed to be founded at approximately RL 6.0 m AHD.

The primary access road is proposed to extend north-east from the NPI area joining to a proposed third party road (Figure 3). The road is proposed to be an 8 m wide sealed roadway with 4(H):1(V) shoulder grade and a minimum of 0.9 m fill above the natural surface.

3.2.8 Marine Jetty and Loading Platform

The proposed jetty extends outwards approximately 700 m into the Exmouth Gulf from the northern coastline and includes a loading platform towards the offshore portion of the jetty. The offshore structure is proposed to be founded of driven piles and the proposed location is shown on Figure 3.

3.2.9 Capital Dredging and Onshore Dredge Disposal Area

A small amount of dredging is proposed at the end of the jetty to accommodate a single berthing pocket for the transhipment barge, which will transport salt to an offshore ocean going vessel anchorage. The proposed area for dredging is approximately 200 m x 35 m and 6 m in total water depth (2.5 m seabed depth to be dredged), with dredged spoil (assumed to be 17,000 m3) proposed to be disposed onshore. The onshore disposal area will be located immediately inshore from the jetty location (Figure 3). Neutralising material will be added to the dredged material as necessary to treat any ASSS detected. Decant water will be retained for a suitable time to allow appropriate water quality standards to be met (confirmed by monitoring) prior to release to the marine environment. Solids will be tested to ensure appropriate environmental standards are met, then will be reclaimed and used in on-site embankment construction.

3.2.10 Drainage Diversions

Water Technology (2021) have determined the locations of drainage diversions required upstream of the proposed concentration ponds, to direct surface water flows around the project area (Figure 3). These drainage diversions will require excavations to re-direct surface flows. The estimated volume of material to be excavated is 455,000 m^3. The majority of excavated material is unlikely to be acid generating as they are assumed to be significantly weathered and have historically been subject to oxidisation and leaching cycles. However, the net acid generating potential has not been accurately determined and pockets or lenses may contain acid generating material, particularly with depth. Further sampling will be conducted

to confirm net acid generating potential prior to excavation and management implemented if necessary.

3.2.11 Borrow Pit Areas for Construction Materials

A summary of the Proposal material reuse potential is presented in Table 6. Based on geotechnical studies conducted by GHD (GHD 2018; GHD 2021c), the locations of borrow pits for project construction have been determined as shown on Figure 3. It is estimated that these borrow pits will cover a total area of 1011 ha, be a maximum depth of 6 m and approximately 38 million m^3 of material will be excavated from them.

Borrow pits 1 and 2 (Figure 3) are considered unlikely to contain acid generating material given they occur on elevated sandy islands and ASS was not identified at 6.5 m depth (excavation will cease at 6 m depth).

Borrow pits 3 and 4 (Figure 3) may contain acid generating material at depth, however, the depth of these borrow pits will be to a maximum of 2 m depth. Further sampling will be conducted to confirm net acid generating potential prior to excavation and management implemented if necessary.

Table 6 Summary of Potential Construction Materials

Domain / Material	Material Re-use Potential			
	General Fill	Select Fill	Low Permeability Fill	Rock Armour
Coastal Dune Sand (Qs)	Yes	Yes	No	No
Intertidal Flats (Qs)	No	No	No	No
Dune Field Sand (Qe)	Yes	Yes	No	No
Supratidal Flats (Qt)	Yes	No	Yes[1]	No
Claypan Terrain (Czp)	Yes	Yes[2]	Yes[3]	No
Outwash Plain Alluvium (Qza)	Yes	Yes	No	No
Coastal Limestone	Yes	Yes	No	No[4]

Table 6. Table source: Arcadis (2018b)

1) Subject to investigation and material characteristics assessment by laboratory testing

2) Borrow operations to target well graded soils with durable gravel and fines content < 12%

3) Borrow operations to target red-brown medium plasticity sandy clay

4) To be confirmed, existing data indicates limestone in coastal fringes is too fractured and of variable strength to generate blocks of sufficient size for rock armour

4. Existing Environment

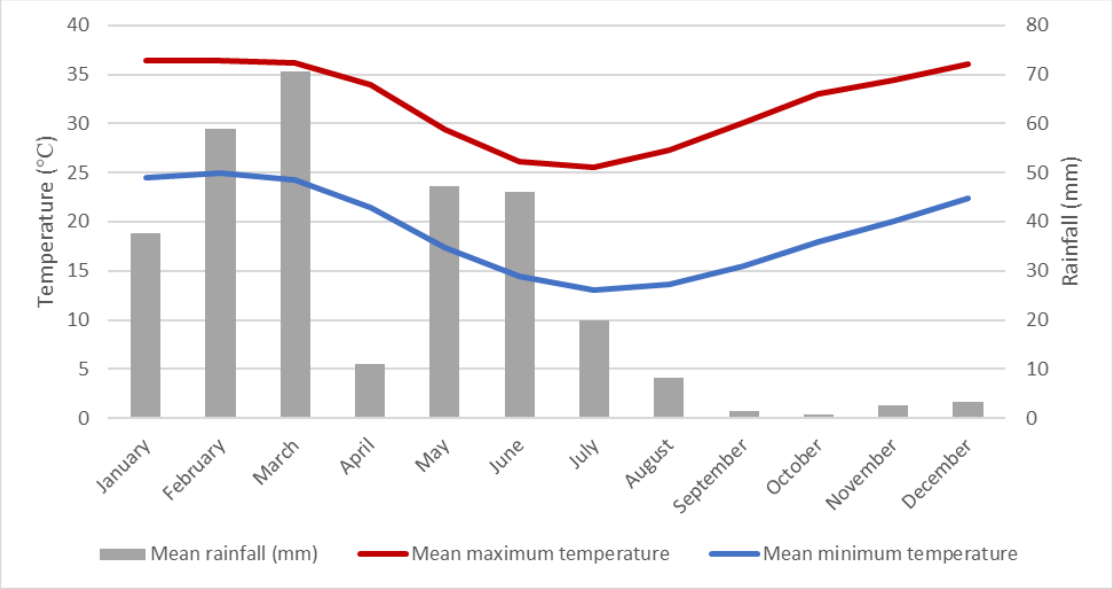
4.1 Climate

The Cape Range area is situated on the border of southwest WA which experiences mostly winter rainfall, and northern WA which experiences summer rainfall. Consequently, the area experiences relatively extreme climate conditions from severe droughts through to major flood events (EnviroWorks 2016).

4.1.1 Temperature

Temperature fluctuations are moderate, with a mean maximum temperature of 36 Degrees Celsius (°C) recorded from December through to March, and a mean minimum temperature of 13°–14° C recorded from June through to August.

Plate A Climate Graph (Onslow Airport – No. 5017)



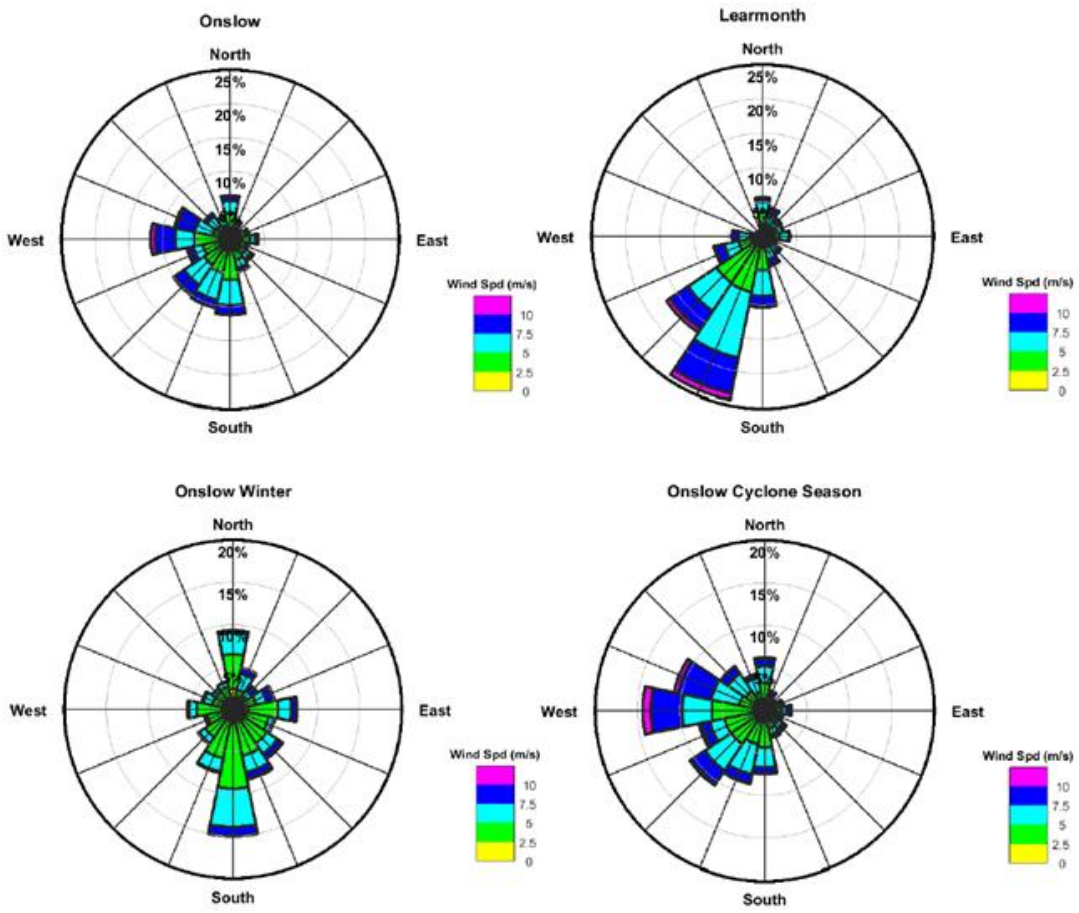
4.1.2 Rainfall

The closest (coastal) Bureau of Meteorology (BoM) weather station is Onslow Airport (Station Number 5017), located approximately 40 km north-east of the Study Area. Rainfall data has been collected at Onslow Airport since 1940 and temperature data since 1943. Monthly averages for both rainfall and temperature are shown on Plate A. The average annual rainfall for the region is 308.4 mm, with the majority falling from January through to March as a result of cyclone activity, then again in May and June when low pressure systems from the south reach further north.

4.1.3 Wind Speed and Direction

Wind roses for Onslow Airport and Learmonth BoM Weather Stations are presented in Plate B.

Plate B Wind Roses Onslow and Learmonth Airports



4.2 Geology

4.2.1 Regional Geology

The geology of the region is mapped within the Yanrey-Ningaloo and Onslow 1:250,000 geological mapping (GSWA 1980 and GSWA 1982) as shown on Figure 4.

The basement geology of the region outcrops east of the Yannarie and Ashburton rivers, and is represented by Precambrian igneous and metamorphic rocks with three distinct lithological groups:

- Gneiss
- Metasedimentary rocks
- Granitoids

The basement rocks are unconformably overlain by another Precambrian-aged group of lithologies, the Uaroo Group. The Precambrian rocks (basement and Uaroo Group) are intruded by dolerite dykes.

The superficial deposits, which overlay the Precambrian rocks and which the proposed development will disturb, comprise unconsolidated alluvial, colluvial and aeolian sediments of Pliocene and Quaternary age. The superficial deposits are summarised in Table 7.

Table 7 Summary of Superficial Deposits Across the Site

Map Unit	Location / Occurrence	Soil Characteristics
Qs	Beaches and coastal foredunes flanking the coastline.	Light grey, unconsolidated and poorly consolidated quartzose calcarenite.
Qw	Intertidal flats and mangrove swamps.	Calcareous clay, silt and sand.
Qe	Remnant dunes as “islands” of residual sand plain within the Supratidal flats area, and as longitudinal dunes at the eastern limit of Supratidal flats.	Red-brown to yellow quartz sand.
Qt	Supratidal flats.	Calcareous clay, silt and sand with authigenic gypsum and superficial algal mats and salt crusts.
Qp	Minor occurrences within claypan-dominated terrain.	Poorly sorted clay, silt, sand and minor pebbles.
Cza	Localised occurrences associated with Chintay Creek and Ashburton River.	Alluvial clay, silt, sand and gravel with calcrete cementation in places.
Czp	Generally east of Supratidal flats. Longitudinal and network dunes over claypan-dominant terrain.	Red-brown Clay. Clay, silt, sand and gravel.

4.2.2 Naturally Occurring Radioactive Material

Naturally Occurring Radioactive Material (NORM) is known to be present at low levels within the environment (soils, water, air). Radioactive decay in soils primarily comes from uranium (238-U), thorium (232-Th) and potassium (40-K). Mining and processing of minerals containing these radioactive isotopes can result in concentrated exposures and/or radioactive waste (DMP 2010a).

In WA uranium deposits have been discovered within surficial (calcrete), sandstone, ‘unconformity related’ veins, and intrusive carbonatite. Commercial deposits of uranium are associated with minerals such as uraninite, carnotite and brannerite (DMP 2013). No uranium deposits have been identified within approximately 150 km of the Proposal (DMP 2013).

The most common source of thorium in Australia is the phosphate mineral monazite, which is often found within heavy mineral sand and rare earth element deposits (Geoscience Australia n.d.). These materials are unlikely to occur based on the regional geology described in Section 4.2.1.

Sources of potassium include evaporite salt deposits containing sylvite (potassium chloride) and minerals alunite and carnallite (Minerals Education Coalition 2020). Feldspars are aluminosilicate minerals with varying amounts of potassium, sodium and calcium. Commonly occurring in pegmatites, potassium-bearing minerals also include potassium feldspar and orthoclase feldspar. Pegmatites are found in all outcropping areas of Precambrian and early Palaeozoic rocks (Department for Energy and Mining SA 2020).

4.2.3 Geological Landforms and Geology

Geological landforms occurring within the Study Area are summarised in Table 8 and shown on Figure 4. Descriptions of these units obtained during a review of published data and site observations and how they relate to key infrastructure areas is provided below.

Coastal Dune – Qs

The Study Area contains areas of foredunes and fringing frontal dunes (Qs). The foredunes are believed to be formed from storm surge deposits, while the fringing frontal dune is developed from windblown sediments of the salt flats.

Along the coastline the foredunes are formed of unconsolidated sand and average 3 m in height, but can range to a maximum height of 6 m to 7 m. In the north of the site, near the proposed jetty, the dunes are typically 500 m wide, immobile, and are generally sparsely vegetated with spinifex. Landside of the proposed jetty (BH03) the dune is characterised as extending to 7 m AHD. Observations of the surface and shallow subsurface profile presented calcareous sand with an abundance of coral, shells fragments and calcarenite gravels ranging between fine gravels to larger cobbles and occasional boulder sized particles. Disturbance of the coastal dune to construct the conveyor embankment and jetty could expose areas of the dune to wind erosion. Appropriate erosion protection is recommended such as rock armouring and dune revegetation.

Intertidal Flats and Mangrove Swamps – Qw and Qt

The intertidal flats and mangrove swamps are primarily confined to the west and northwest of the Study Area and cover the northwestern most area of the Concentration Ponds and the entire Crystalliser Ponds area. The extent to which the unit envelopes around to the eastern and southern sides of the remnant island hosting buildings, stockyard and conveyor belt, is unknown. However, the intertidal zone can be seen on aerial imagery to abut the north of the island and the presence of unit Qw has been confirmed north-east of the island (GHD 2020a).

In the intertidal areas, Qt_1 is also present (see Supratidal Flats below). In places Qw persists to approximately 1.5 m depth, in other places Qw can overlie Qt and vice versa.

In the western area of the salt flats (beyond the western limit of the Concentration Pond footprint but including the seawater intake location), the intertidal sediments (Qw) are found at the surface, with a halite crust grading into an algal mat as the ground elevation lowers to sea level. The zone is characterised by short sinuous tidal creeks, mud/sand flats and a discontinuous mosaic of mangrove biomes. It is anticipated that unit Qw will increase in thickness north-westwards through the salt flats.

Investigations at the fringes of the intertidal flats show the Qw material to be a cohesive, medium plasticity grey clay, with traces of fine grained sub-rounded sand composed of quartz.

The overall depth of the unit in this area was not proven as hand augers were limited to less than 2 m depth. It is anticipated that the unit will increase in thickness north-westwards through the salt flats.

Mainland Remnants – *Qe*

The salt flats are interrupted by elevated sandy areas (loosely termed “islands”) representing remnants of the mainland (Qe). Remnant coastal dunes (islands) remaining within the north eastern and central portion of the site varied in elevation (5 to 10 m AHD). The islands are formed through a period of marine regression and transgression, which eroded through the terrestrial sediments (Qsed and Czp) previously extending from east to west of the site into the Exmouth Gulf. Hence, the majority of the remnants contain longitudinal and network dunes over claypan-dominant terrain (Czp) overlaying basal Quaternary sediments (Qsed).

The surficial surface observed during the walkover indicated residual sand “islands” consisting of red-brown to yellow quartz sand (Pindan Sand). The distribution of coral fragments and shells was observed to be varied across the site, with a greater abundance of fragments within sheltered portions of “islands”. Fragments and shell pieces observed during the Phase 2

investigation indicate acid neutralising capacity (ANC) within soils and a potential for natural available neutralising capacity.

Supratidal Flats – Qt

The supratidal salt flats form a flat featureless plain upon which the Concentration Ponds are located. The supratidal flats are typically only inundated by marine waters under cyclone-generated surge events. At the eastern extent of the salt flats the supratidal sediments abut the terrestrial sediments (Czp) and infill between the mainland remnants (Qe). The supratidal flat unit Qt_1 overlies the intertidal flat unit Qw across Crystalliser Pond area, Bitterns Pond and parts of the conveyor alignment, and inter-finger with Qw in the west.

The surface of the sediment is typically covered with a crust varying in thickness between 1 mm to 40 mm. The crust primarily consists of halite with trace amounts of calcite, silt, clay, and sand. Where below 3 mm thick, the crust becomes sandy and is of predominately fine grained aeolian sand. Where desiccated the crust is relatively dense.

The deposits are typically up to 0.5 m thick where they overlay intertidal flats (Qw). Where they are continuous from the surface to the underlying basal sediments (Qsed), they are up to 7.5 m thick.

Between islands of remnant mainland, the basal contact between supratidal sediments and mainland remnants is not known.

Claypan – Qp

The Study Area contains numerous claypans (Qp) of sufficient size to warrant individual classification. Smaller claypans are characterised within the longitudinal and network dunes over claypan-dominant terrain (Czp). The claypans have formed through wind driven blowout/deflation hollowing of the dunes, which exposed the soil surface to raindrop impact and erosion, leading to surface sealing/crusting.

Clay pans located within the eastern portion of the Yanrey Tidal Flats indicated red brown clayey sands and sandy clays. Shrink and swell cracks were evident at surface to 0.1 m, with an absence of visual neutralising material to neutralise acidity such as carbonates (calcium and magnesium) and organic sources. However, clay materials generally have a higher natural buffering ability and can be resistant to changes in pH due to the retention of hydrogen ions. The buffering ability will vary and is dependent on various factors including clay content and type, cation exchange capacity and presence of organic matter.

The depth of the claypan was observed at two localities during the Phase 2 investigation to vary between 1.0 m to 2.0 m and is underlain by Qsed.

Alluvium – Cza

Alluvial deposits tend to be sheet-wash driven in response to large rainfall events. The largest alluvial landform within the proposal area is Chinty Creek, which discharges to the supratidal flats 700 m south of the proposed access road to the administration buildings island. The alluvial fan at the creek extends 1 km onto the salt flats, and historical outwash deposits are expected to interfinger with the supratidal deposits.

There is very little evidence of historical significant fluvial sediment deposition along the eastern edge of the salt flats, although this may be obscured by more recent supratidal deposits.

Drilling adjacent to where Chinty Creek discharges to the supratidal flats, confirmed a 400 mm thick clayey gravel fluvial deposition (from 2.8 m depth), overlying sandy clay (Czp) and Qsed from 6.0 m depth.

Longitudinal and Network Dunes over Claypan-dominant Terrain – Czp

The terrestrial sediments comprise a sheet sand base over which a longitudinal dune system has formed. The dunes have become largely vegetated with spinifex and samphire, and are no longer mobile, having been formed during more arid historical conditions. Within the dune network, a series of interdunal swales and claypans are present. The longitudinal dunes are generally orientated north/south, and may range in height from 4 m to 7 m. They display a network pattern of historical transverse dunes, the length of which varies greatly. The current land surface is a function of degradation and sand mobilisation.

In some areas of the northeastern portion of the site some dunes have been denuded leaving a relatively flat landscape with sandy clay soils which are laterally stiff to very stiff for several metres.

The depth of transition to Qsed is variable, ranging in depth from 1.9 – 16.5 m or deeper.

Quaternary Sediments – Qsed

The Quaternary sediments underlay the entire site and derive from the historical Ashburton palaeo super delta. They have a characteristic red-brown coloration and are known locally as the Ashburton Red Beds.

Table 8 Summary of Disturbance of Geological Units by Proposed Infrastructure

Unit	Age	Occurrence	Soil Characteristics	Proposal Infrastructure								
				Seawater Intake	Salt Concentration & Crystalliser Ponds	Salt Stockyard & Reclaim Conveyor	NPI	Offshore Facility	Borrow Pits 1-4	Drainage Diversions A - C	Bitterns intake inlet well and pump station	Evaporation, crystalliser and bitterns pond embankments
Qs	Holocene	Beaches and coastal foredunes flanking the coastline.	Light grey, unconsolidated and poorly consolidated quartzose calcarenite.			x		x				x
Qw	Holocene	Intertidal flats and mangrove swamps.	Calcareous clay, silt and sand.	x								
Qe	Holocene to Quaternary	As “islands” of mainland remnants within the Supratidal flats area, and as longitudinal dunes at the eastern limit of Supratidal flats.	Red-brown soft to stiff sandy clay to loose to medium dense clayey sand.	x	x	x	x		x	x		x
Qt	Holocene	Supratidal flats.	Calcareous clay, silt and sand with authigenic gypsum, superficial algal mats, crusts of halite.	x	x	x					x	x
Qp	Holocene	Minor occurrences within claypan-dominated terrain.	Poorly sorted clay, silt, sand and minor pebbles.						x			
Cza	Quaternary to Pliocene	Localised occurrences associated with Chintay Creek and Ashburton River.	Alluvial clay, silt, sand and gravel with calcrete cementation in places.									
Czp	Quaternary to Pliocene	Generally east of Supratidal flats. Longitudinal and network dunes over claypan-dominant terrain.	Red-brown stiff to hard sandy clay to very dense clayey sand.						x	x	x	

Unit	Age	Occurrence	Soil Characteristics	Proposal Infrastructure								
				Seawater Intake	Salt Concentration & Crystalliser Ponds	Salt Stockyard & Reclaim Conveyor	NPI	Offshore Facility	Borrow Pits 1-4	Drainage Diversions A - C	Bitterns intake inlet well and pump station	Evaporation, crystalliser and bitterns pond embankments
Qsed	Quaternary to Pliocene	Ashburton palaeo super delta deposits underlying entire site.	Hard sandy clay to very dense clayey sand, variably lithified and cemented.	x	x	x	x	x				

4.2.4 Western Australian Soil Groups

The Department of Primary Industries and Regional Development (DPIRD) soil landscape mapping for WA (DPIRD-076) identifies three WA Soil Groups within the Proposal Study Area (Figure 5).

Table 9 provides an overview of each soil group and some key characteristics as described by Schoknecht and Pathan (2013).

Table 9 Soil Landscapes Within the Study Area

WA Soil Group	Unit	Description	Australian Soil Classification	Characteristics	Associated Landscapes
Tidal soil (104)	201Li	Coastal areas subject to tidal inundation. Common in the North-west coast, especially parts of the Pilbara and Kimberley coastlines. Locally referred to as mangrove soil or saline mud.	Intertidal, Supratidal or Extratidal Hydrosol	Saline. Wet. Alkaline pH. Permeability is slow.	Intertidal and supratidal areas
Red deep sand (445)	201Du	Red sands greater than 80 cm deep. Gravel (including ironstone) may be present in subsoil. The dominant soil of the Arid Interior. Common near the coast from Kalbarri to Exmouth. Locally referred to as Wandarrie sand, Cockatoo sand and Red sand.	Red-Orthic Tenosol	Neutral to acidic pH. Permeability is rapid. Prone to wind erosion in exposed positions.	Remnant islands and longitudinal and network dunes
Calcareous deep sand (442)	201On	Calcareous sand >80 cm deep. Sands can be white, grey, yellow or occasionally black. Common on coastal dunes from Exmouth to the South Australian border. Locally referred to as Beach dune sand and Calcareous sand.	Shelly Rudosol Shelly Calcarosol	Alkaline pH. Permeability is rapid. Prone to wind erosion in exposed positions. Calcareous throughout.	Coastal dunes and beaches

4.2.5 Vegetation Cover

The intertidal and supratidal flats where the salt concentration and crystalliser ponds are located, are relatively devoid of vegetation due to high salinity. Plant growth in the regularly inundated intertidal flats is limited to a few specialist species (e.g. mangroves; halophytes) in fringing areas. The much less frequently inundated supratidal flats are known to provide conditions suitable for the growth of algal mats (Biota 2016).

The coastal foredunes and remnant dunes / islands are either without vegetation cover, or support a sparse cover of low coastal shrubs (e.g. spinifex; samphire).

4.3 Acid Sulfate Soils and Sediment

A Phase 2 Acid Sulfate Soils and Sediment (ASSS) Study was conducted by GHD for this project (GHD, 2021a) and an Acid Sulfate Soils and Sediment Management Plan (ASSSMP) subsequently prepared (GHD, 2021b).

Typically, the higher elevated areas of the Proposal site are between 5 and 10 m AHD and consist of calcareous materials such as calcarenite gravel, coral and shell fragments and present a low risk of oxidation during disturbance. Total Inorganic Carbon analysis completed on the less than 0.5 mm fraction of samples collected indicates significant natural buffering ability would be available within the natural environment in the event of a minor acidification event. Sulfidic material was encountered within the supratidal flats, creek mudflats and lower lying regions of the Proposal site. Infrastructure requiring excavation in these areas will require management. In addition, testing indicates that dredged marine sediments are likely to contain acid generating material and will require management. The following proposed excavation/disturbance requires management and/or further testing as documented within GHD 2021a and 2021b:

- Jetty Berthing Pocket (dredged)
- Borrow Pits
- Drainage Diversions
- Pond Embankments (if keyed into salt flat surface)
- Seawater Intake Well and Pump Station.

The ASS risk map of the Pilbara Coastline (DER-011) accessed from the Australian Government National Map (2020) is presented in Figure 6.

4.4 Hydrogeology

The hydrogeology of the Study Area has been described in detail within the Hydrogeological Investigation conducted for the project (GHD, 2021d) and that report has been used to formulate the conclusions made in this report.

4.5 Hydrology

4.5.1 Overview

The site is located within the Ashburton River catchment and sub catchment, which falls within the Pilbara Surface Water Area proclaimed under the *Rights in Water and Irrigation Act 1914*.

4.5.2 Watercourses

Surface flows within the Ashburton River catchment exhibit a complex inter-relationship at a landscape scale between watercourses, floodplains, clay pans and a suite of longitudinal and network sand dunes (EnviroWorks 2016). Due to the arid climate and very high evaporation rate, the occurrence of overland flow is rare and is usually only associated with tropical cyclone events. The hydrology of the region is one of extremes, experiencing both severe droughts and major floods (EnviroWorks 2016).

Within the Ashburton River sub-catchment, creek lines discharge over the coastal flats towards the ocean, often via braided flow-paths. Creek flows in this region are mostly a direct response

to rainfall, which is highly seasonal and variable. Most run-off occurs during the period from January to March, with peak flows consistently being recorded in February, usually as a result of major storms and cyclones. Catchment and sub-catchment discharge points are frequently a combination of direct ocean outlets, dispersal through salt flats and coastal mangrove systems, and infiltration to ground (EnviroWorks 2016).

A hydrological study was undertaken for the historical Yannarie Project (Parsons Brinkerhoff 2006). The assessment found that during episodic heavy rainfall events, overland surface water flows converge at the unnamed creeks and basins east of the salt flats. Some of this surface water is lost via evaporation and infiltration, with the majority flowing westward towards the coast accumulating within the salt flats (EnviroWorks 2016).

4.6 Summary of Environmental Factors

Based on a review of the published desktop information available and the data provided, the geochemical and physical properties, which are considered to potentially impact environmental and human health receptors during disturbance are summarised in Table 10.

Table 10 Potential Impacts During Disturbance

Geochemical or Physical Risk	Relevant Supporting Desktop Information	Potential Risk of Occurrence
Acid Sulfate Soils	Proposal is located within an ASS risk area and published information suggests area is conducive to formation of sulfidic material	High
Saline Materials and or Drainage	The geological setting (surficial sediments and tidal flats) indicates that elevated salts stored within the shallow geological profile is likely.	High
Sodic and or Dispersive Material	The geological setting (surficial sediments and tidal flats) indicates that elevated salts stored within the shallow geological profile is likely, which may cause dispersive material	High
Fibrous Material	The geological setting (surficial sediments) excludes the likelihood of asbestos form minerals typically derived from the disturbance and exposure of basement rocks. However, silicate materials (e.g. quartz sediments) are indicated as present across the site.	High
Naturally Occurring Radioactive Material (NORM)	The geological setting (surficial sediments) is considered to exclude a radiological source (e.g.: local basement granitic rocks), which may weather and be subject to mobilisation and concentration of NORMs at concentrations which may be a cause for concern. Although considered unlikely, sediments in the area may however contain naturally occurring heavy minerals (resistates) concentrated in channels systems, which may be elevated in minerals exhibiting radioactivity above generalised background concentrations.	Low/moderate

Geochemical or Physical Risk	Relevant Supporting Desktop Information	Potential Risk of Occurrence
Acidic and or Metalliferous Drainage	The geological setting (surficial sediments) excludes the likelihood of sulphide derived from the weathering of basement rocks, which may form acidic conditions and mobilise metals.	Low
Asbestiform Material	The geological setting (surficial sediments) excludes the likelihood of asbestos form minerals typically derived from the disturbance and exposure of basement rocks.	Low
Heavy Metals	The geological setting (surficial sediments) indicates that metals, other than common rock forming metals (e.g. iron, manganese) are unlikely to be present at concentrations which may weather at concentrations to be a cause for concern.	Low

5. Site Investigation

Representative soil samples recovered from 11 sites within the Study Area as shown in Figure 7. Samples were collected at variables depths within the surficial deposits between 1 m and 8.5 m below ground level. The borehole logs and supplementary sheets are included in Appendix A.

Samples were submitted for laboratory testing at Eurofins Pty Ltd, based in Perth or subcontracted to Intertek Genalysis in Maddington. The laboratories are NATA registered for the tests requested.

Samples were analysed for the following physical and geochemical parameters:

- Moisture content (%)
- pH (aqueous extract)
- pH net acid generation (NAG) (after oxidation)
- Exchangeable Sodium Percentage (ESP)
- Electrical Conductivity (EC)
- Total Soluble Salts (TSS)
- Cation Exchange Capacity (CEC)
- Heavy Metals (Arsenic, Beryllium, Boron, Cadmium, Cobalt, Copper, Lead, Manganese, Mercury, Nickel, Selenium and Zinc)
- Chromium (hexavalent)
- Chromium Reducible Sulfur (CRS)
- Maximum Potential Acidity (MPA)
- Acid Neutralising Capacity (ANC)
- Net Acid Generation (NAG)
- Net Acid Production Potential (NAPP)
- Fibrous material (including asbestiform)

Material characterisation laboratory results are presented in Appendix B and the laboratory report in Appendix C.

6. Material Assessment

6.1 Overview

This section incorporates the desk-top information and the laboratory testing of materials to derive an understanding of the risks posed by the Proposal and disturbance of the setting.

6.2 Physical and Chemical Properties

6.2.1 Acid Sulfate Soils

ASS and sediments have been addressed within the ASSS study and management plan completed by GHD in May 2021 (GHD 2021a and 2021b). Typically, the higher elevated areas of the Proposal site are between 5 and 10 m AHD and consist of calcareous materials such as calcarenite gravel, coral and shell fragments and present a low risk of oxidation during disturbance. Total Inorganic Carbon analysis completed on the less than 0.5 mm fraction of samples collected indicates significant natural buffering ability would be available within the natural environment in the event of a minor acidification event. Sulfidic material was encountered within the supratidal flats, creek mudflats and lower lying regions of the Proposal site. Infrastructure requiring excavation and disturbance in these areas will require management. In addition, testing indicates that dredged marine sediments are likely to contain acid generating material and will require management. The following proposed excavation/disturbance requires management and/or further testing as documented within GHD (2021a) and (2021b):

- Jetty Berthing Pocket (dredged)
- Borrow Pits
- Drainage Diversions
- Pond Embankments (if keyed into salt flat surface)
- Seawater Intake Well and Pump Station.

6.2.2 Acidic and or Metalliferous Drainage

A preliminary characterisation using static test data and the AMIRA (2002) Classifications have been included in Table 11.

Table 11 NAG and NAPP Testing

Bore ID	Sample Depth	Sulphur	MPA	ANC	NAPP	Geochemical Material Type (Amira 2002)
	m	%	Kg H_2SO_4	Kg H_2SO_4	Kg H_2SO_4	
AU03	0.75	<0.005	0.15	27	(-)27.3353	Non Acid Forming
BH01	1.0	<0.005	< 0.15	58	(-)58.0074	Non Acid Forming
	6.5	<0.005	< 0.15	16	(-)16.0845	Non Acid Forming
BH03	3.4	0.023	0.71	57	(-)55.8181	Non Acid Forming
BH05	0.6	0.006	0.18	410	(-)413.0621	Non Acid Forming
BH07	0.75	<0.005	< 0.15	520	(-)521.7809	Non Acid Forming
	1.75	<0.005	< 0.15	480	(-)476.3163	Non Acid Forming
BH10	4.1	<0.005	< 0.15	11	(-)10.9702	Non Acid Forming
	4.1	<0.005	< 0.15	11	(-)10.9395	Non Acid Forming
BH11	1.0	<0.005	< 0.15	160	(-)160.1326	Non Acid Forming

Bore ID	Sample Depth	Sulphur	MPA	ANC	NAPP	Geochemical Material Type (Amira 2002)
	m	%	Kg H_2SO_4	Kg H_2SO_4	Kg H_2SO_4	
BH14	1.0	<0.005	< 0.15	50	(-)49.5164	Non Acid Forming
	5.0	<0.005	< 0.15	11	(-)11.0772	Non Acid Forming
	8.0	<0.005	< 0.15	29	(-)28.9825	Non Acid Forming

Metalliferous drainage includes drainage under circum-neutral pH conditions related to sulfide oxidation and under neutral to alkaline pH conditions unrelated to sulfide oxidation.

The acid generating capacity of the soils tested was low, with most samples containing undetectable concentrations of sulfur (<0.005%). Sulfur was detected in materials from two locations: BH03 (0.023 % S) and BH05 (Qt – supratidal flats) (0.006 % S).

Potential acid generation was readily buffered by acid neutralising minerals in the soils, particularly within the supratidal flats (BH05). Where the ratio of ANC: Maximum Potential Acidity (MPA) is greater than two, there is considered to be a high probability that the materials will remain circum-neutral in pH (AMIRA, 2002).

Materials are generally considered to be Non-Acid Forming (NAF) when the Net Acid Producing Potential (NAPP) is negative and the final NAG pH is equal or greater than pH 4.5. The pH_{NAG} of all samples measured was greater than pH 7.2 and some as high as pH 11, and all NAPP values were negative as per Table 11. The preliminary characterisation indicates the materials sampled to be NAF.

6.2.3 Neutral Mine Drainage and Saline Drainage

NAF material and results discussed above are considered unlikely to be a source of acidic drainage. However, Neutral Mine Drainage (NMD) and Saline Drainage (SD) can result under pH circum-neutral and alkaline conditions. As acidic water contacts sulphide minerals, partial dissolution of the minerals and neutralisation of acidity results and the pH rises. The metals and salts dissolved in these acid-base neutralising reactions can then give rise to metalliferous and/or saline drainage of ions, metals and metalloids that remain soluble under circum-neutral to alkaline pH conditions.

Materials sampled from within the Study Area and proposed to be disturbed as part of the Proposal were tested for pH_F and pH_{FOX}, EC, Total Soluble Salts (TSS) and heavy metals (as listed in Section 5) including Arsenic, Cobalt, Copper, Lead, Manganese, Nickel, Zinc and Boron. pH values ranged between 8.1 and 9.0 for the material samples analysed as part of the material characterisation suite. EC values ranged between 19,000 uS/cm and 2,100 uS/cm and typically declined with depth in boreholes towards the inland areas.

Development of infrastructure within the Study Area is primarily limited to the importation of material rather than the extensive disturbance of ground surface and in-situ material. Assessment of the material from within potential areas of disturbance indicate that in-situ materials may assist in the precipitation of metals and metalloids (particularly copper and zinc) under circum-neutral to alkaline pH conditions and concentrations of sulfate are likely to remain elevated due to natural occurrence.

SD and NMD within the identified areas of saline surface water and groundwater seepage around the margins of the pond embankments (GHD, 2021d) should not cause adverse impacts, given that the source seepage waters (saline ponds) and the receptor setting (salt flats) are geochemically similar in nature and that the salt flats are not considered a sensitive receptor to saline drainage. The saline seepage from the ponds and naturally occurring ANC within the environment is likely to have the chemical capacity to neutralise and buffer

potential acid generation, which has been identified in the natural subsurface beneath the footprint of the ponds and seepage areas (Refer to Section 6.2.1).

6.2.4 Sodic and or Dispersive Materials

Dispersion, a term used to describe the breakdown of clay particles into solution, is dependent upon the interaction between sodicity (ESP) and salinity (EC) (Hazelton and Murphy 2007; DAFWA 2009). Sodicity is the measure of exchangeable sodium cations in the soil which occupy negatively charged exchange sites at the surface of clay particles (Hazelton and Murphy 2007; DAFWA 2009). When the ratio of sodium to other ions (e.g. Ca^{2+}, Mg^{2+}, K^{+}) at exchange sites is high, clay particles are less tightly bound to each other and the soil aggregates easily disperse when the soil becomes wet (DAFWA 2009). Rengasamy *et al.* (1984) developed a chart for predicting soil dispersion based on these measures.

Sodic soils (ESP >6%) were identified at sample locations BH14 (Qt - Salt Concentration Ponds), BH05 (Qt - Brine Channel) and BH10 (Qt - Salt Concentration Ponds) as presented in Figure 7.

The ESP of materials sampled from BH14 ranged from 16 – 28% at sample depths of 1 – 5 m. Given soils at this location are also moderately saline (EC 1.1 – 1.3 dS/m), they fall within dispersion Class 3a as described by Rengasamy *et al.* (1984). Soils within Class 3a are flocculated by nature (forming clusters in solution), however, if electrolytes are leached from the soil profile the ratio of sodium ions to other ions may increase, resulting in dispersive (unstable and highly erodible) sodic soils.

The ESP of materials sampled from BH05 ranged from 1.3 – 9.3%, with the highest percentages recorded in the upper soil profile (0 – 0.6 m depth). Soils at this location were more saline than BH14 (EC 0.96 – 1.9 dS/m) with a smaller proportion of sodium cations and accordingly fall within dispersion classes 3a and 3b, with materials in Class 3b characterised as saline and dominated by non-sodium salts, and therefore unlikely to be prone to dispersion (Rengasamy *et al. 1984*).

Materials sampled from BH10 had very similar characteristics to BH05, also falling within dispersion Class 3b (Rengasamy *et al.* 1984), with a maximum ESP of 7.6% and EC of 1.7 dS/m at a sample depth of 4.1 m bgl. These soils are equally unlikely to be dispersive, primarily due to the high concentration of salts.

Based on the materials characterisation results described above, soils within the supratidal flats are at risk of becoming dispersive under leached conditions due to the high concentration of sodium ions present. These materials would be unsuitable for placement on the outer surface of constructed landforms, or any sloping surface. Left undisturbed, these soils are unlikely to be dispersive due to the higher concentration of salts, and limited permeability of intertidal soils and therefore reduced risk of electrolyte leaching which could cause dispersion. It is anticipated that soils within the intertidal flats (Qw) and claypans (Qp) would behave similarly.

The non-sodic nature of soils sampled from BH07 and BH11 (Qt - supratidal flats), is likely attributed to a greater proportion of sand and silt in the soil profile at these locations.

Coastal dunes (BH01 and AU03) and the location for the proposed NPI, salt stockyard and conveyor and bitterns discharge pipeline are unlikely to exhibit dispersive tendencies.

Piping

Materials with high dispersibility and high permeability are most susceptible to piping (Hazelton and Murphy 2007). Soils with highest dispersibility were identified at BH14 which is located just outside the embankment for the Salt Concentration Ponds within the supratidal flats (Qt). These flats are associated with geological unit Qt and WA Soil Group ‘tidal soil’. As

described in Table 9 these soils comprise '*clayey/silty sand that is typically fine to medium grained'* that could make them susceptible to piping. However, given the supratidal flats are only inundated by marine waters under cyclone-generated surge events, and that tidal soils are generally described as having low permeability, it is unlikely that soils at this location would be a high risk of piping. If placed on the outer surface of a constructed landform, these soils may be at risk of piping due to the presence of dispersible clay and silt.

6.2.5 Erosive Material

Materials Susceptible to Wind Erosion

The susceptibility of soils to wind erosion is determined by soil physical properties, mineralogy, as well as landscape and climate factors (Hazelton and Murphy 2007). Geological units described in Section 4.2 and soil types shown in Table 9 provide information on soil physical characteristics and their landscape position (which influences soil moisture, slope and exposure). Saline soils and minerals such as gypsum are also considered to be more susceptible to wind erosion (Hazelton and Murphy 2007).

All soils encountered within the Study Area, with the exception of the coastal dunes (Qs), were described as having varying proportions of clay particles. Those with the highest clay content and exhibiting the highest plasticity were identified within:

- Qp – claypan (high plasticity clay, up to 55% clay)
- Czp – longitudinal and network dunes over claypan dominated terrain (high plasticity clay, up to 55% clay)
- Qt – supratidal flats (medium to high plasticity clay, >50% clay, traces of gypsum also noted)
- Qw – intertidal flats and mangrove swamps (medium plasticity clay)
- Qsed – quaternary sediments (medium plasticity clay, gypsum noted in sand component).

The most saline soils (EC >1.6 dS/m) were measured at BH10 located within the supratidal flats (Qt) and BH05 at the perimeter of a remnant island (Qe) within the supratidal flats (Figure 7).

Claypan soils (Qp) formed through wind driven blowout between remnant dunes, are expected to continue to be exposed to erosion by wind and water. Surface sealing/crusting and the presence of gravel in the upper soil horizons may offer some protection, however raindrop impact and erosion is expected to continue.

The longitudinal and network dunes over claypan dominated terrain (Czp) comprise clayey sand. These dunes are largely vegetated with spinifex and samphire, protecting them from wind erosion. Furthermore, the sand component of the soils comprises fine to medium grained quartz with a lower susceptibility to wind erosion.

The supratidal flats (Qt) are considered most at risk of wind erosion due to the higher proportion of clay, salts and gypsum more easily mobilised with strong winds; and the infrequent inundation of this tidal zone leaving soils dry and exposed to wind erosion particularly in spring and summer.

The intertidal flats (Qw) are less susceptible to wind erosion as these soils are inundated more frequently and thus retain higher moisture through the soil profile.

The quaternary sediments (Qsed) underlay all soils within the Study Area, and are therefore unlikely to be subject to wind erosion unless exposed under dry conditions.

Materials Susceptible to Water Erosion

Water erodibility is greater in soils with limited aggregate stability (strength of bonds between soil particles) and low infiltration rates which can accelerate erosion in the event of rapid runoff (Hazelton 2007). Soils with a high proportion of silt and clay particles, or those that exhibit self-mulching or dispersive tendencies, are also more susceptible to water erosion. Self-mulching soils generally crack as they dry forming a surface mulch of fine aggregates (<10 mm) which are readily mobilised when re-wet (Hazelton 2007).

Of the three soil groups occurring within the Study Area, tidal soils (Group 104), are least permeable and are present in both the intertidal (Qw) and supratidal (Qt) zones. These soils have a high clay and slit content and are generally sodic. The higher salt content minimises dispersion risk, however under leached conditions these soils have the potential to be highly erodible. Furthermore, intertidal sediments were observed to have a halite crust (i.e. they are self-mulching) and may be more susceptible to water erosion.

However, while the tidal soils are susceptible to soil erosion due to their physical and chemical properties, the environment in which they occur is low energy due to the lower landscape position. Water delivered by the connecting inland creeklines during intense rainfall events accumulates and evaporates. The creeklines experience a comparatively high energy environment, however the deep sands present in the bed and banks of these creeklines are much less prone to erosion.

6.2.6 Fibrous Minerals

Asbestiform Minerals

Asbestiform minerals are widely distributed in WA and can be major components of the mafic and ultramafic rocks hosting gold, nickel and base metal deposits located on the WA 'Greenstone Belts' (DMIRS, 2020). Disturbance within the Proposal Study Area will be limited to surficial deposits (colluvium, alluvium and aeolian) and therefore the likelihood of asbestiform minerals typically derived from the disturbance and exposure of basement rocks is low.

Silicate Minerals

Silicate minerals typically consist of quartz, cristobal and tridymite within WA, with quartz being the most frequently occurring and typically attributed to granites, shales and sandstone basement rocks. Quartz sands are present within the remanent islands and dunes across the Study Area (and underlying Quaternary sediments - Qsed) and generally present a low risk during construction and management operations with use of appropriate dust suppression. Activities which degrade and/or process silicate materials increase the risk of exposure. The Proposal does not include the processing of silicate materials; however a generic silicates assay has been conducted on select geological units proposed to be disturbed. Analysis identified significant quarts content in all samples presented values up to 71%, with minerals susceptible to fibrous crystal habit confined to clays/micas.

6.2.7 Naturally Occurring Radioactive Material

The desktop assessment indicated that sampling for the presence of NORMs was not required to be undertaken and is considered unlikely to be present within the materials proposed to be disturbed or excavated.

Although considered unlikely, sediments in the area may however contain naturally occurring heavy minerals (resistates) concentrated in channel systems, which may be elevated in

minerals exhibiting radioactivity above generalised background concentrations. However, these channel systems are not proposed to be excavated or disturbed as part of the Proposal.

Whilst these channel systems are not proposed to be excavated or disturbed as part of the Proposal, borrow pits for clay located within claypans or drainage diversions could potentially contain such resistates due to receiving material from channel systems. Borrow pits within claypans and drainage diversions will be further assessed using appropriate methodology to assess the potential impacts from radionuclides released into the environment prior to disturbance. Management of material will be addressed (including dust management and monitoring) in the Project Management Plan to be submitted to DMIRS.

6.2.8 Heavy Metals and Metalloids

Representative samples were collected from three geological units and were analysed for heavy metals:

- Qt - supratidal flats (BH05)
- Qe - mainland remnants (BH09 and BH12)
- Czp - longitudinal and network dunes over claypan-dominant terrain (BH13)

The laboratory test results are summarised in Table 1 Appendix B.

At all sites the following heavy metals were detected: Arsenic, Cobalt, Copper, Lead, Manganese, Nickel, and Zinc. Boron was also present at BH05 and BH09.

Concentrations of beryllium, cadmium and mercury were below the limit of detection.

Metal and metalloids analysis was also conducted on samples from various depths at four borehole locations proximal to the proposed infrastructure and areas of assumed disturbance including Crystalliser Pond footprint (BH05), remnant islands (BH09 and BH12) and BH13 (eastern site boundary/ potential borrow areas). A summary of the metal and metalloid results are presented below, with full analytical results presented in Table 1 Appendix B.

- Exceedances of the NEPM 2013 EILs were reported for copper, nickel and zinc.
- No detections above the limit of reporting (LOR) were reported for beryllium, cadmium and mercury.
- Detections above LOR were reported for arsenic, boron, cobalt, lead, mercury and manganese, however these analytes remained below the soil assessment criteria.

The current concentrations of metals are likely to represent naturally occurring concentrations. An assessment of leachate potential and concentrations for materials proposed to be excavated (whether excavated and stored or re-used) with respect to the proposed re-use strategy should be undertaken. Materials posing a significant environmental concern, with respect to leachable metal concentrations may require to be re-used above saturated ground conditions as a minimum requirement.

6.2.9 Topsoil or Growth Media

Selection of topsoil and suitable growth media should take into consideration susceptibility to erosion (i.e. piping and dispersion) and other factors that may be prohibitive to plant growth such as high salinity as measured through EC/TDS and toxicity (e.g. AASS, PASS and heavy metal toxicity typically under acidic conditions).

The DMIRS (2016) guidelines adopt the following EC ranges when determining a material suitability as growth medium in rehabilitation:

- 0 - 0.40 dS/m is suitable for topsoil growth medium

- 0.40 - 1.60 dS/m is suitable for some salt tolerant species
- >1.60 dS/m may not be suitable as a growth medium.

Clay dominated soils with a tendency to slake and/or disperse (as driven by high sodium content compared with other cations) are unsuitable as surface rehabilitation growth media. Placement of dispersive or potentially dispersive materials on the outer surface of sloping landforms should be avoided.

Three geological units within the Study Area have been assessed for the presence of heavy metals as discussed in Section 6.2.8. These materials can still be used for rehabilitation pending other characteristics (i.e. risk of dispersion and acidification / metalliferous / saline drainage), however the acidity of the rehabilitated landscape should be considered and managed to prevent plant death that could result from exposure to toxic concentrations of heavy metals in soils.

Table 12 provides a summary of the suitability of soils associated with each geological unit for use in rehabilitation. This assessment is based on limited data currently available for soils within the Study Area, and therefore should be used to guide future work and mine closure planning.

Table 12 Preliminary Assessment of Soil Suitability in Rehabilitation

Geological unit	Name	Suitability as Growth Media	Properties	Recommendations
Qs	Coastal dune	Potentially suitable	Sand-dominated with gravel (*ESP/EC unconfirmed)*	Until confirmation of ESP/EC - avoid contact with seawater or brine if used as fill in embankments
Qw	Intertidal flats and mangrove swamps	Unsuitable	High clay content, limited permeability, saline soils may be dispersive under leached conditions *(ESP/EC unconfirmed)*	Until confirmation of ESP/EC - avoid placement on the outer surface of constructed landforms
Qe	Mainland remnants	Suitable	Sand-dominated with gravel, non-sodic, EC <0.40 dS/m and heavy metals present	Suitable topsoil and growth medium
Qt	Supratidal flats	Unsuitable	High clay content, limited permeability, saline (and self-mulching), sodic and at risk of becoming dispersive under leached conditions, potential for tunnelling. Heavy metals present	Avoid placement on the outer surface of constructed landforms
Qp	Claypan	Unsuitable	Up to 55% clay content, exhibits surface sealing/crusting. Soils may	Until confirmation of ESP/EC - avoid placement on the outer

Geological unit	Name	Suitability as Growth Media	Properties	Recommendations
			be dispersive under leached conditions like Qt *(ESP/EC unconfirmed)*	surface of constructed landforms
Cza	Alluvium	Potentially suitable	Clayey gravel *(ESP/EC unconfirmed)*	Further testing required - potentially suitable topsoil / growth medium and may have reasonable structure due to presence of gravel
Czp	Longitudinal and network dunes over claypan dominant terrain	Potentially suitable	Up to 55% clay content, balanced by fine to medium grained quartz. Un-cemented with traces of fine to coarse grained calcrete gravel. Heavy metals present Observations indicate spinifex/samphire vegetation *(ESP/EC unconfirmed)*	Further testing required – currently supports vegetation so likely to be a suitable topsoil / growth medium, may not be suitable for placement on sloping surfaces due to high clay content
Qsed	Quaternary Sediments	Potentially suitable	Dense clayey sand and sandy clay *(ESP/EC unconfirmed)*	Further testing required – potential for clays to be sodic and therefore dispersive

7. Preliminary Management Plan

The following legislation and guideline documents have been provided to assist in the preparation of further studies to further progress the environmental approvals process.

7.1 Regulating Legislation, Guidelines and Codes of Practice

7.1.1 Environmental

General Regulations

- *Contaminated Sites Act 2003* (WA)
- Contaminated Sites Regulations 2006 (WA)
- *Environmental Protection Act 1986* (WA)
- Environmental Protection (Clearing of Native Vegetation) Regulations 2004
- Environmental Protection Regulations 1987 (WA)
- *Mining Act 1978* (WA)

Acid Sulfate Soils and Sediments

- Department of Environment and Regulation (DER), Acid Sulfate Soil Guideline Series: Identification and investigation of acid sulfate soils and acidic landscapes (June 2015a)
- Department of Environment and Regulation, Acid Sulfate Soil Guideline Series: Treatment and management of soils and water in acid sulfate soil landscapes (June 2015b)
- Water Quality Australia, National Acid Sulfate Soils Guidance (2018)

Mining and Material Characterisation

- Department of Mines and Petroleum: Guideline for Mining Proposals in Western Australia (2016a)
- Department of Mines and Petroleum: Draft Material Characterisation Guideline (2016b)
- Department of Mines, Industry Regulation and Safety, Statutory Guidelines for Mining Proposals (2020a)
- Department of Mines, Industry Regulation and Safety, Mine Closure Plan Guidance: How to prepare in accordance with Part 1 of the Statutory Guidelines for Mine Closure Plans (2020b)
- Department of Mines, Industry Regulation and Safety, Statutory Guidelines for Mine Closure Plans (2020c)

7.1.2 Occupational Health and Safety

Naturally Occurring Radioactive Material

- The Department of Mines and Petroleum, Guide to submission of a project management plan (PMP) (2012)
- The Department of Mines and Petroleum, Guidelines for Managing naturally occurring radioactive material (NORM) in mining and mineral processing: NORM-3.1 Monitoring NORM – pre-operational monitoring requirements (2010a)

- The Department of Mines and Petroleum, Guidelines for Managing naturally occurring radioactive material (NORM) in mining and mineral processing: NORM-4.2 Controlling NORM – management of radioactive waste (2010b).
- The Department of Mines and Petroleum, Guidelines for Managing naturally occurring radioactive material (NORM) in mining and mineral processing: NORM-5 Dose assessment (2010c).
- Code of Practice and Safety Guide: Radiation Protection and Radioactive Waste Management in Mining and Minerals Processing, Radiation Protection Series Publication No.9, Australian Radiation Protection and Nuclear Safety Agency (ARPANSA), 2005.
- Pre-operational radiation monitoring program which should include analysis of radioisotopes (gross alpha and gross beta activities) in accordance with DMP (2010a) Guideline 'NORM 3.1 Monitoring NORM – pre-operational monitoring requirements'.

7.2 Recommendations

The requirement for further studies and / or the preparation of management plans will be driven by the regulatory authorities, including but not limited to, EPA, Department of Water and Environmental Regulation (DWER) and DMIRS.

However, based on the works competed to date and the information available at the time of writing this report, the following recommendations are made as outlined in Table 13.

Table 13 Recommendations for Materials Management

Material Type	Issue	Recommendation
Acid Sulphate Soils and Sediments	A Phase 2 Acid Sulfate Soils and Sediment (ASSS) Study was conducted by GHD for this project (GHD, 2021a) and an Acid Sulfate Soils and Sediment Management Plan (ASSSMP) subsequently prepared (GHD, 2021b).	Follow recommendations within GHD 2021a and 2021b.
Dispersive Material	Soils within the supratidal flats are considered at risk of becoming dispersive under leached conditions due to the high concentration of sodium ions present. These materials would be unsuitable for placement on the outer surface of constructed landforms (bunds) or any sloping surface. Left undisturbed, these soils are unlikely to be dispersive.	Do not place any material from the supratidal flats (geological unit Qt) on the outer surface of constructed landforms.
Piping	Materials with high dispersibility and high permeability are most susceptible to piping (Hazelton and Murphy 2007). Soils within the supratidal flats are considered at risk of becoming dispersive. If placed on the outer surface of a constructed landform, these soils may be at risk of piping due to the presence of dispersible clay and silt. Left undisturbed, these soils are unlikely to be dispersive.	As above.
Potentially Dispersive Material	Soils within the intertidal flats, mangrove swamps and claypans are considered at risk of becoming dispersive under leached conditions. These materials may be unsuitable for placement on the outer surface of constructed landforms (bunds) or any sloping surface. Left undisturbed, these soils are unlikely to be dispersive. Dispersion, a term used to describe the breakdown of clay particles into solution, is dependent upon the interaction between sodicity, measured as Exchangeable Sodium Percentage (ESP) and salinity, measured as Electrical Conductivity (EC). When ESP >6 the material is sodic and potentially dispersive. The dispersion potential is quantified by the EC value.	Prior to disturbance and use in construction or rehabilitation, the following materials require further testing to confirm ESP/EC: • Intertidal Flats and Mangrove Swamps (geological unit Qw). • Claypans (geological unit Qp). Classification of these materials' dispersion characteristics should be undertaken. Only materials classified as having low dispersion risk should be placed on the outer surface of constructed landforms.
Erosive Material - Susceptible to Wind Erosion	The coastal dunes (Qs) are formed of unconsolidated sand and average 3 m in height, but can range to a maximum height of 6 m to 7 m. In the north of the site, near the proposed jetty, the dunes are typically 500 m wide, immobile, and are generally sparsely vegetated with spinifex. Landside of the proposed jetty (BH03) the dune is characterised as extending to 7 m AHD. Observations of the surface and shallow subsurface profile presented calcareous sand with an abundance of coral, shells fragments and calcarenite gravels ranging between fine gravels to larger cobbles and occasional boulder sized particles. Disturbance of the coastal dune	Appropriate erosion protection is recommended in the coastal dunes (geological unit Qs) at the site of the conveyor and jetty, such as rock armouring and dune revegetation.

Material Type	Issue	Recommendation
	to construct the conveyor embankment and jetty could expose areas of the dune to wind erosion.	
Erosive Material – Susceptible to Water Erosion	Within the inland longitudinal and network dunes over claypan (geological unit Czp) there is up to 55% clay content, balanced by fine to medium grained quartz. The material is un-cemented with traces of fine to coarse grained calcrete gravel. This material may not be suitable for placement on sloping surfaces due to high clay content which could facilitate water erosion.	Further testing of erosion potential of this material (geological unit Czp) should be conducted before any disturbance. If proposed to be used in construction or rehabilitation, it should only be placed on sloping surfaces if erosion risk is classified as low after testing.
Sodic Material	Quaternary sediments (geological unit Qsed) consist of dense clayey sand and sandy clay. These clays have the potential to be sodic, and therefore dispersive.	Further testing of erosion potential of this material (geological unit Qsed) should be conducted before any disturbance. If proposed to be used in construction or rehabilitation, it should only be placed on sloping surfaces if sodicity and dispersion risk is classified as low after testing.
Topsoil/Growth Media	Selection of topsoil and suitable growth media should take into consideration susceptibility to erosion (i.e. piping and dispersion) and other factors that may be prohibitive to plant growth. The following geological units within the project area may be potentially suitable as topsoil/growth media: • Qs – coastal dune • Qe – mainland remnants • Cza – alluvium • Czp – longitudinal and network dunes over claypan • Qsed – quaternary sediments	Selection of topsoil and suitable growth media should take into consideration susceptibility to erosion (i.e. piping and dispersion) and other factors that may be prohibitive to plant growth such as high salinity as measured through EC/TDS and toxicity (e.g. AASS, PASS and heavy metal toxicity typically under acidic conditions).
Fibrous Material - Silicates	A generic silicates assay has been conducted on select geological units proposed to be disturbed. Analysis identified significant quarts content in all samples presented values up to 71%, with minerals susceptible to fibrous crystal habit confined to clays/micas.	Further assessment of potential dust and workforce inhalation airborne particles should be undertaken prior to ground disturbance works. Dust suppression measures should be implemented in accordance with an appropriate Dust Management Plan during construction phase to minimise the risk of workers inhaling and ingestion of air borne particles. Appropriate dust management and monitoring will be required in the Project Management Plan to be submitted to DMIRS.
Naturally Occurring Radioactive Material	Although considered unlikely, sediments in the area may contain naturally occurring heavy minerals (resistates) concentrated in channel systems, which may be elevated in minerals exhibiting radioactivity above generalised background concentrations. Whilst these channel systems are not proposed to be excavated or disturbed as part of the Proposal,	Borrow pits within claypans and drainage diversions should be further assessed prior to disturbance. Testing of material from any borrow pits within claypans (geological unit Qp) and drainage diversions for NORMs should be conducted and if present management of this material considered (including

Material Type	Issue	Recommendation
	borrow pits for clay located within claypans could potentially contain such resistates due to receiving material from channel systems.	dust management and monitoring) in the Project Management Plan to be submitted to DMIRS.
Heavy Metals and Metalloids	Representative samples were collected from three geological units (Qt supratidal flats, Qe mainland remnants, Czp longitudal and network dunes over claypan) and were analysed for heavy metals. Screening of heavy metals and metalloids in comparison to Default Guideline Values (DGVs) for ecological Investigation Levels (EILs) available in the National Environmental Protection Measure (NEPM, 2013) indicated that exceedances of copper, nickel and zinc were recorded.	The current concentrations of metals are likely to represent naturally occurring concentrations. An assessment of leachate potential and concentrations for materials proposed to be excavated (whether excavated and stored or re-used) with respect to the proposed re-use strategy should be undertaken. Materials posing a significant environmental concern, with respect to leachable metal concentrations may require to be re-used above saturated ground conditions as a minimum requirement.
Neutral or Saline Drainage	SD and NMD within the identified areas of saline surface water and groundwater seepage around the margins of the pond embankments (GHD, 2021d) should not cause adverse impacts, given that the source seepage waters (saline ponds) and the receptor setting (salt flats) are geochemically similar in nature and that the salt flats are not considered a sensitive receptor to saline drainage. The saline seepage from the ponds and naturally occurring ANC within the environment is likely to have the chemical capacity to neutralise and buffer potential acid generation, which has been identified in the natural subsurface beneath the footprint of the ponds and seepage areas.	Follow recommendations within GHD 2021a and 2021b for acidic conditions.

8. References

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Figures

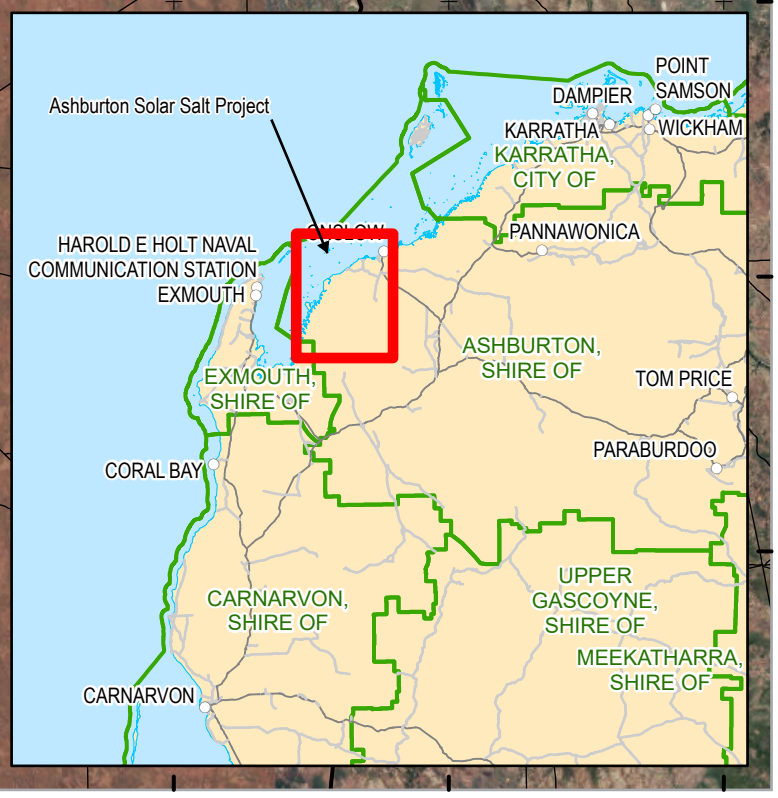
240000 250000 260000 270000 280000 290000 300000 310000

7610000 7600000 7590000 7580000 7570000 7560000 7550000 7540000 7530000

LEGEND

- Study Area
- Road
- Track

Second Av
ONSLOW
Seaview Dr
Onslow Rd
Urala Rd
Old Onslow Rd
Onslow-Peedamulla Rd
Onslow Rd



SLIP

Paper Size ISO A3

0 2 4 6 8

Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

N

GHD

K + S Salt Australia Pty Ltd
Ashburton Solar Salt Project
Phase 2 Site Investigation

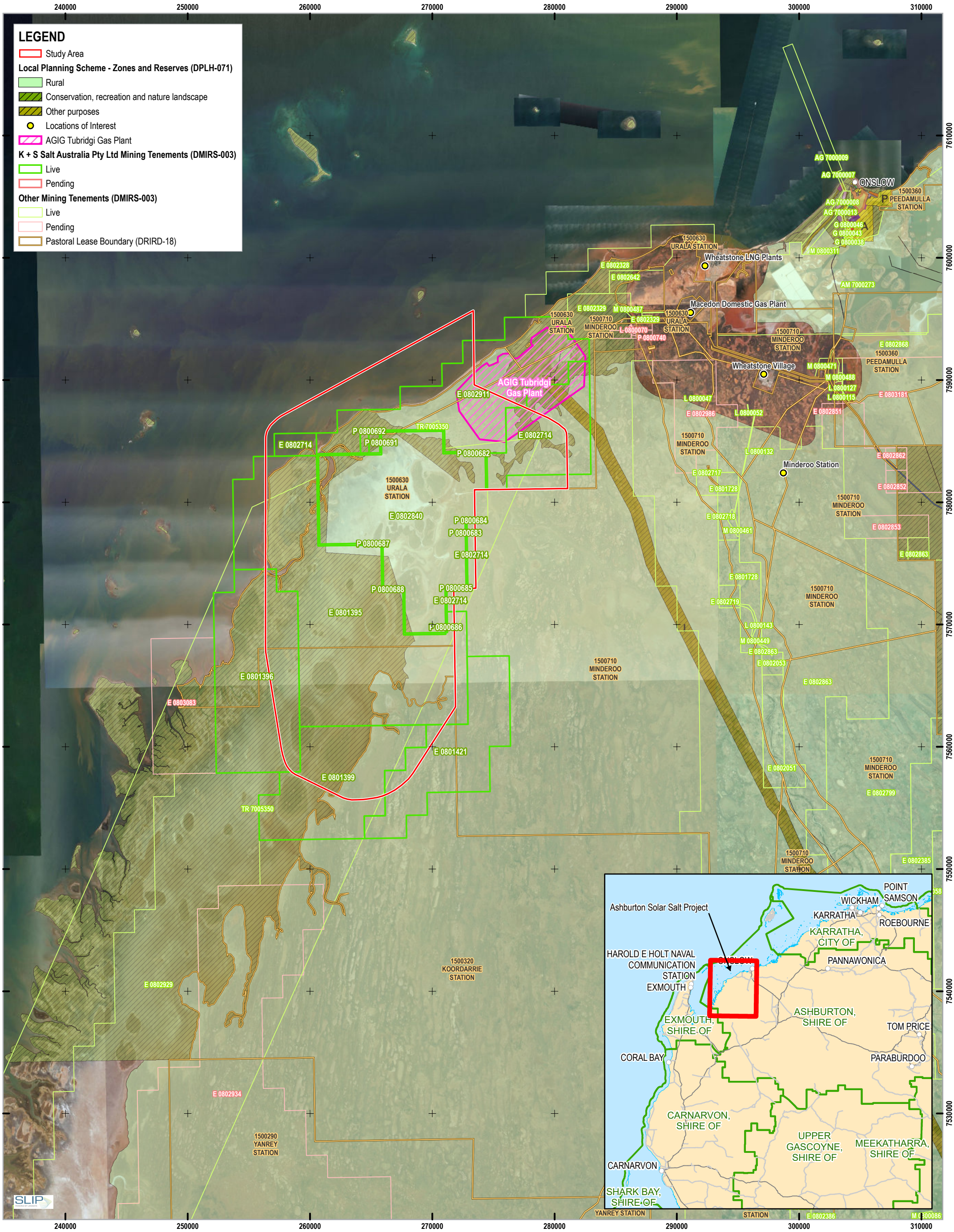
Project No. **12516706**
Revision No. **1**
Date **21 May 2021**

Site Plan

FIGURE 1

\\ghdnet.internal\ghd\AU\Perth\Projects\61\12516706\GIS\Maps\Working\12516706_MaterialCharacterisation\12516706_MaterialCharacterisation.aprx
Print date: 21 May 2021 - 10:39

Data source: SLIP: - accessed 20200724, GHD: Access Roads, Pond Layout - 20190927, Infrastructure Layout - 20190320, GHD: Channels, Proposed Main Access Road - 20200518 Landgate: Imagery - September 2013 to Jan 2018 (accessed - 20200518) WMS: . Created by: bjones2



Paper Size ISO A3

0 2 4 6 8

Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

N

GHD

K + S Salt Australia Pty Ltd
Ashburton Solar Salt Project
Phase 2 Site Investigation

Project No. **12516706**
Revision No. **1**
Date **21 May 2021**

Proposal Location and Land Use

FIGURE 2

\\ghdnet.internal\ghd\AU\Perth\Projects\61\12516706\GIS\Maps\Working\12516706_MaterialCharacterisation\12516706_MaterialCharacterisation.aprx
Print date: 21 May 2021 - 10:39

Data source: SLIP: - accessed 20200724, GHD: Access Roads, Pond Layout - 20190927, Infrastructure Layout - 20190320, GHD: Channels, Proposed Main Access Road - 20200518 Landgate: Imagery - September 2013 to Jan 2018 (accessed - 20200518) SLIP_Public_Services/Property_and_Planning: SLIP / LANDGATE WMS: . Created by: bjones2

255000 260000 265000 270000 275000 280000 285000

7595000 7590000 7585000 7580000 7575000 7570000 7565000 7560000 7555000

Jetty
Berthing Pocket
Reclaim Conveyor System
Salt Wash Plant
Salt Stockyard
Urala Creek North
NPI
Salt Crystalliser Ponds
Maiden Brine Transfer Structure
Seawater Intake Channel
CP8
CP7
2
CP6
CP1
CP5
Urala Creek South
Salt Concentration Ponds
Seawater Intake Pump Station
CP2
CP4
4
CP3
C
B
A

LEGEND

- Study Area
- Maiden Brine Transfer Structure
- Brine/Bitterns Channel (and Transfer Station/Structures)
- Drainage Channel
- Seawater Intake Channel
- 3rd Party Proposed Road
- Access Track
- Salt Concentration Pond Embankments
- Reclaim Conveyor System
- Jetty
- Salt Crystalliser Ponds
- Salt Stockyard
- Salt Wash Plant
- Non Process Infrastructure/Buildings
- Salt Concentration Ponds
- Berthing Pocket
- Borrow Pits
- Drainage_Channel_Box_011_region
- Dredge Spoil Disposal Area
- Seawater Intake Channel
- Seawater Intake Pump Station

SLIP

Paper Size ISO A3

0 1 2 3 4

Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

N

GHD

K + S Salt Australia Pty Ltd
Ashburton Solar Salt Project
Phase 2 Site Investigation

Proposal Layout

Project No. **12516706**
Revision No. **2**
Date **21 May 2021**

FIGURE 3

\\ghdnet.internal\ghd\AU\Perth\Projects\61\12516706\GIS\Maps\Working\12516706_MaterialCharacterisation\12516706_MaterialCharacterisation.aprx
Print date: 21 May 2021 - 10:40

Data source: SLIP: - accessed 20200729, GHD: Access Roads, Pond Layout - 20190927, Infrastructure Layout - 20190320, GHD: Channels, Proposed Main Access Road - 20200518 Landgate: Imagery - September 2013 to Jan 2018 (accessed - 20200518) WMS: . Created by: bjones2

Paper Size ISO A3

0 1 2 3 4

Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

N

GHD

K + S Salt Australia Pty Ltd
Ashburton Solar Salt Project
Phase 2 Site Investigation

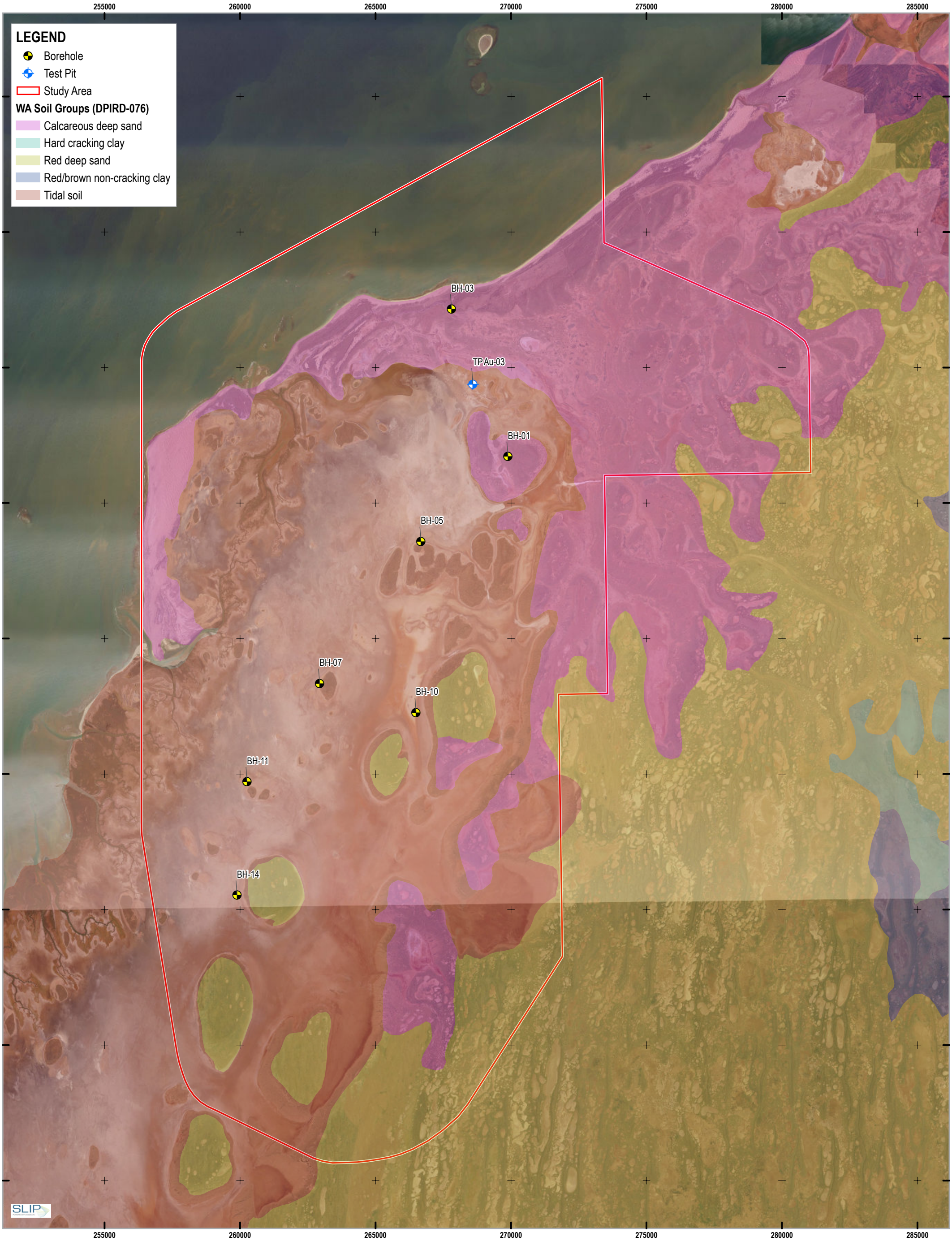
Project No. **12516706**
Revision No. **2**
Date **21 May 2021**

Geological Setting

FIGURE 4

\\ghdnet.internal\ghd\AU\Perth\Projects\61\12516706\GIS\Maps\Working\12516706_MaterialCharacterisation\12516706_MaterialCharacterisation.aprx
Print date: 21 May 2021 - 11:11

Data source: SLIP: - accessed 20200729, GHD: Access Roads, Pond Layout - 20190927, Infrastructure Layout - 20190320, GHD: Channels, Proposed Main Access Road - 20200518 Landgate: Imagery - September 2013 to Jan 2018 (accessed - 20200518) WMS: . Created by: bjones2



Paper Size ISO A3

0 1 2 3 4

Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

N

GHD

K + S Salt Australia Pty Ltd
Ashburton Solar Salt Project
Phase 2 Site Investigation

Project No. **12516706**
Revision No. **1**
Date **21 May 2021**

Western Australian Soil Groups

FIGURE 5

\\ghdnet.internal\ghd\AU\Perth\Projects\61\12516706\GIS\Maps\Working\12516706_MaterialCharacterisation\12516706_MaterialCharacterisation.aprx
Print date: 21 May 2021 - 10:56

Data source: SLIP: - accessed 20200729, GHD: Access Roads, Pond Layout - 20190927, Infrastructure Layout - 20190320, GHD: Channels, Proposed Main Access Road - 20200518 Landgate: Imagery - September 2013 to Jan 2018 (accessed - 20200518) WMS: . Created by: bjones2

Paper Size ISO A3

0 1 2 3 4

Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

N

GHD

K + S Salt Australia Pty Ltd
Ashburton Solar Salt Project
Phase 2 Site Investigation

Project No. **12516706**
Revision No. **2**
Date **21 May 2021**

Environmental Setting

FIGURE 6

\\ghdnet.internal\ghd\AU\Perth\Projects\61\12516706\GIS\Maps\Working\12516706_MaterialCharacterisation\12516706_MaterialCharacterisation.aprx
Print date: 21 May 2021 - 11:14

Data source: SLIP: GW-SW-ASS-Wetlands- accessed 20200729, GHD: Access Roads, Pond Layout - 20190927, Infrastructure Layout - 20190320, GHD: Channels, Proposed Main Access Road - 20200518
Landgate: Imagery - September 2013 to Jan 2018 (accessed - 20200518) SLIP_Public_Services/Soil_Risk_Map_WFS: SLIP / LANDGATE
WMS: . Created by: bjones2

Paper Size ISO A3

0 1 2 3 4

Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

N

GHD

K + S Salt Australia Pty Ltd
Ashburton Solar Salt Project
Phase 2 Site Investigation

Site investigation locations

Project No. **12516706**
Revision No. **0**
Date **24 May 2021**

FIGURE 7

\\ghdnet.internal\ghd\AU\Perth\Projects\61\12516706\GIS\Maps\Working\12516706_MaterialCharacterisation\12516706_MaterialCharacterisation.aprx
Print date: 24 May 2021 - 11:08

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Appendix

Appendix A – Borehole Logs

STANDPIPE PIEZOMETER LOG

Borehole No.: **BH01**

Sheet 1 of 4

Client: K + S Salt Australia Pty Ltd
Project: Ashburton Solar Salt Project
Phase 2 Site Investigation
Job No.: 12516706

Coordinates: **E** 269 887, **N** 7581 719
Ground Surface Elevation: +7.2m AHD **Total Depth:** 19.9m
Commenced: 24-Mar-20 **Completed:** 30-Mar-20
Contractor: J&S Drilling **Driller:** Alan

Rig Type : Jacro 350 drill rig on Mangrove Buggy **Inclination:** Vertical
Flushing Fluid: Water to 5 m, then Polymer
Hole Diameter (mm): 123

Logged:	SG	30-Mar-20
Processed:	WX	20-Oct-20
Checked:		

Depth Scale (m)	Daily Progress/ Observations: Date	Casing Depth (m)	Fluid Depth (m)	Drilling Method	Water	Depth (m)/ [Elev.]	Geological Unit	Graphic Log	Classification	Strata Description (type; colour; fines plasticity or particle characteristics; minor components; structure and/or origin)	Moisture Condition	Consistency/ Relative Density	Sample Type & Depth	Sample No.	Sample/ Test Records & Comments	Piezometer Components	Depth Scale (m)
						[+7.10]			SM	Topsoil - Carbonate Silty SAND Fine grained, sub-round to sub-angular; red-brown; non-plastic fines; with organics.	D	L				Above ground cover	
										Core loss: 0.1 to 1.0 m Inferred as Silty SAND						Grout	
1						1.0 [+6.20]			SM	Carbonate Silty SAND Fine to medium grained, angular, inferred salt; red-brown; non-plastic fines, trace broken shells, fine grained sand sized.		MD				Solid pipe Bentonite	1
													1.50	S	1.5 SPT: 5, 8, 11 [N=19]		
2						2.5 [+4.70]	Qe			Core loss: 2.5 to 3.0 m Inferred as Silty Sand.							2
3						3.0 [+4.20]			SM	Carbonate Silty SAND Fine to medium grained, sub-rounded to sub-angular, inferred quartz; red-brown; non-plastic fines, trace broken shells, fine grained sand sized.	D/M		3.00	S	3.0 SPT: 4, 5, 6 [N=11]		3
4						4.0 [+3.20]				Core loss: 4.0 to 4.5 m						Slotted pipe	4
						4.5 [+2.70]			SP	Carbonate SAND Fine to coarse grained, sub-rounded to sub-angular, inferred quartz; red-brown; trace silt.	M	MD	4.50	S	4.5 SPT: 3, 7, 11 [N=18]		
5				PQ Coring		5.0											5

GENERAL LOG 12516706 GINT.GPJ GHDLIB.GDT 20-10-20

STANDPIPE PIEZOMETER LOG

Borehole No.: **BH01**

Sheet 2 of 4

Client: K + S Salt Australia Pty Ltd
Project: Ashburton Solar Salt Project
Phase 2 Site Investigation
Job No.: 12516706

Coordinates: **E** 269 887, **N** 7581 719
Ground Surface Elevation: +7.2m AHD **Total Depth:** 19.9m
Commenced: 24-Mar-20 **Completed:** 30-Mar-20
Contractor: J&S Drilling **Driller:** Alan

Rig Type : Jacro 350 drill rig on Mangrove Buggy **Inclination:** Vertical
Flushing Fluid: Water to 5 m, then Polymer
Hole Diameter (mm): 123

Logged:	SG	30-Mar-20
Processed:	WX	20-Oct-20
Checked:		

Depth Scale (m)	Daily Progress/ Observations: Date	Casing Depth (m)	Fluid Depth (m)	Drilling Method	Water	Depth (m)/ [Elev.]	Geological Unit	Graphic Log	Classification	Strata Description (type; colour; fines plasticity or particle characteristics; minor components; structure and/or origin)	Moisture Condition	Consistency/ Relative Density	Sample Type & Depth	Sample No.	Sample/ Test Records & Comments	Piezometer Components	Depth Scale (m)
						[+2.10]			SP	Carbonate SAND	M	MD					
									SM	Fine to coarse grained, sub-rounded to sub-angular, inferred quartz; red-brown; trace silt.							
										Carbonate Silty SAND							
						5.6				Fine to medium grained; red-brown; non-plastic fines.							
						[+1.65]				Core loss: 5.55 to 6.0 m							
6						6.0											6
						[+1.20]			SM	Carbonate SAND	W	L	6.00	S	6.0 SPT: 3, 1, 5 [N=6]	Gravel	
										Fine to coarse grained, sub-round to sub-angular, quartz; red-brown; trace silt; trace fine shell gravel.							
						6.3			SM	Carbonate Sandy CLAY	W~PL	St					
						[+0.90]				Low to medium plasticity; red-brown; sand is fine to medium grained. 6.7 m: with Carbonate Silty SAND inclusions, pale orange.							
						6.8											
						[+0.40]				Core loss: 6.8 to 7.0 m							
7						7.0											7
						[+0.20]	Qe		GC	Carbonate Clayey Sandy GRAVEL	M	MD					
										Fine to coarse grained; sub-angular to angular; pale orange; sand is red-brown, fine to medium grained; clay is low plasticity.			7.50	S	7.5 SPT: 6, 6, 7 [N=13]		
				PQ Coring											From 8.0 m: strong HCL reaction.		
8						8.0											8
						[-0.80]			SM	Carbonate Silty Gravelly SAND							
										Fine to medium grained, sub-angular, inferred salt; red-brown; gravel is fine to coarse grained, sub-angular, of limestion; non-plastic fines. 8.3-8.5 m: increased gravel content.							
						8.9											
						[-1.70]			SM	Silty SAND		L	9.00	S	9.0 SPT: 3, 4, 4 [N=8] From 9.0 m: Minor HCL reaction.		
9										Fine to medium grained, sub-angular, inferred salt; red-brown; non-plastic fines; trace gravel of limestone. From 9.9 m: with gravel, fine to coarse grained, sub-angular of limestone; trace cobbles of limestone.							9
						10.0											
10																	10

STANDPIPE PIEZOMETER LOG

Borehole No.: **BH01**

Sheet 3 of 4

Client: K + S Salt Australia Pty Ltd
Project: Ashburton Solar Salt Project
Phase 2 Site Investigation
Job No.: 12516706

Coordinates: **E** 269 887, **N** 7581 719
Ground Surface Elevation: +7.2m AHD **Total Depth:** 19.9m
Commenced: 24-Mar-20 **Completed:** 30-Mar-20
Contractor: J&S Drilling **Driller:** Alan

Rig Type : Jacro 350 drill rig on Mangrove Buggy **Inclination:** Vertical
Flushing Fluid: Water to 5 m, then Polymer
Hole Diameter (mm): 123

Logged:	SG	30-Mar-20
Processed:	WX	20-Oct-20
Checked:		

Depth Scale (m)	Daily Progress/ Observations: Date	Casing Depth (m)	Fluid Depth (m)	Drilling Method	Water	Depth (m)/ [Elev.]	Geological Unit	Graphic Log	Classification	Strata Description (type; colour; fines plasticity or particle characteristics; minor components; structure and/or origin)	Moisture Condition	Consistency/ Relative Density	Sample Type & Depth	Sample No.	Sample/ Test Records & Comments	Piezometer Components	Depth Scale (m)
						[-2.90]			SM	Silty SAND	M	MD					
									GM	Fine to medium grained, sub-angular, inferred salt; red-brown; non-plastic fines; trace gravel of limestone. From 9.9 m: with gravel, fine to coarse grained, sub-angular of limestone; trace cobbles of limestone.							
						10.5 [-3.30]			SM	Silty Sandy GRAVEL Fine to medium grained, sub-angular to angular, limestone; pale orange gravel; red-brown sand fines; fine to medium grained angular salt sand; non-plastic fines.			10.50	S	10.5 SPT: 10, 13, 16 [N=29]		
11							Qe			Carbonate Silty Gravelly SAND Fine to medium grained, angular, salt; red-brown; gravel is pale orange, fine to coarse grained, sub-angular of limestone; non-plastic fines.						Backfill	11
12				PQ Coring								D	12.00	S	12.0 SPT: 11, 16, 15 [N=31]		12
						12.4 [-5.20]			CL	Sandy CLAY Low plasticity fines; red-brown; sand is fine to medium grained; angular, salt.	W~PL	VSt			From 12.45 m: No HCL reaction 12.4 to 12.8 m: Almost Clayey Sand.		
						12.8 [-5.60]				Core loss: 12.8 to 13.5 m							
13						13.5 [-6.30]			CL	Sandy CLAY Low plasticity fines; red-brown; sand is fine to medium grained; angular, salt; trace gravel, fine grained, sub-angular of limestone.	W<PL	H	13.50	S	13.5 SPT: 15, 21, 33 [N=54]		13
14							Qsed								13.5 to 15.0 m: Almost Clayey SAND		14
15						15.0											15

STANDPIPE PIEZOMETER LOG

Borehole No.: **BH01**

Sheet 4 of 4

Client: K + S Salt Australia Pty Ltd
Project: Ashburton Solar Salt Project
Phase 2 Site Investigation
Job No.: 12516706

Coordinates: **E** 269 887, **N** 7581 719
Ground Surface Elevation: +7.2m AHD **Total Depth:** 19.9m
Commenced: 24-Mar-20 **Completed:** 30-Mar-20
Contractor: J&S Drilling **Driller:** Alan

Rig Type : Jacro 350 drill rig on Mangrove Buggy **Inclination:** Vertical
Flushing Fluid: Water to 5 m, then Polymer
Hole Diameter (mm): 123

Logged:	SG	30-Mar-20
Processed:	WX	20-Oct-20
Checked:		

Depth Scale (m)	Daily Progress/ Observations: Date	Casing Depth (m)	Fluid Depth (m)	Drilling Method	Water	Depth (m)/ [Elev.]	Geological Unit	Graphic Log	Classification	Strata Description (type; colour; fines plasticity or particle characteristics; minor components; structure and/or origin)	Moisture Condition	Consistency/ Relative Density	Sample Type & Depth	Sample No.	Sample/ Test Records & Comments	Piezometer Components	Depth Scale (m)
						[-7.80]			CI	Sandy CLAY Medium plasticity; red-brown; sand is fine to medium grained, angular, salt.	W<PL	H	15.00	S	15.0 SPT: 14, 20, 31 [N=51]		
						15.5 [-8.30]			CL	Carbonate Sandy CLAY Low plasticity; red-brown; sand is fine to medium grained, angular.					15.5 to 17.0 m: Almost Clayey SAND		
16													16.50	S	16.5 SPT: 15, 24, 38 [N=62]		16
17						17.0 [-9.80]			SM	16.95 to 17.0 m: with gravel, fine grained, sub-rounded of haematite. Silty SAND Fine to medium grained, angular, salt; red-brown; non-plastic fines; trace gravel, fine to medium grained, sub-rounded of haematite.	D/M	VD			17.0 to 17.7 m: No HCl reaction 17.7 to 18.0 m: Almost Clayey SAND		17
				PQ Coring		17.8 [-10.60]	Qsed		CL	Sandy CLAY Low plasticity; red-brown; sand is fine to medium grained, angular, salt. From 18.0 m: clay is medium plasticity.	W<PL	H					
18									CI				18.00	S	18.0 SPT: 20, 48, * [R]		18
						18.3 [-11.10]			CL	From 18.3 m: clay is low plasticity; almost Clayey SAND.							
						18.7 [-11.50]			CI	Sandy CLAY Medium plasticity fines; red-brown, moltted pale grey; sand is fine to medium grained, angular, salt; with gravel, fine to medium grained, angular, cemented.							
19													19.50	S	19.5 SPT: 20, 44, 30/70 mm []		19
						19.9 [-12.67]				Termination Depth = 19.87m (Target Depth)							
20																	20

GENERAL LOG 12516706 GINT.GPJ GHDLIB.GDT 20-10-20

STANDPIPE PIEZOMETER LOG

Borehole No.: **BH02**

Sheet 1 of 4

Client: K + S Salt Australia Pty Ltd
Project: Ashburton Solar Salt Project
Phase 2 Site Investigation
Job No.: 12516706

Coordinates: **E** 272 595, **N** 7585 346
Ground Surface Elevation: +2.1m AHD **Total Depth:** 18.7m
Commenced: 30-Oct-19 **Completed:** 01-Nov-19
Contractor: J&S Drilling **Driller:** Brian

Rig Type : Jacro 350 drill rig on Mangrove Buggy **Inclination:** Vertical
Flushing Fluid: Water
Hole Diameter (mm): 180

Logged:	DO	01-Nov-19
Processed:	DO	20-Oct-20
Checked:		

Depth Scale (m)	Daily Progress/ Observations: Date	Casing Depth (m)	Fluid Depth (m)	Drilling Method	Water	Depth (m)/ [Elev.]	Geological Unit	Graphic Log	Classification	Strata Description (type; colour; fines plasticity or particle characteristics; minor components; structure and/or origin)	Moisture Condition	Consistency/ Relative Density	Sample Type & Depth	Sample No.	Sample/ Test Records & Comments	Piezometer Components	Depth Scale (m)
0	30-10			Hollow Stem Auger	Dipped at 2.79m on 1/11/19 at 7:50am	0.00	Czp		CH	Sandy CLAY High plasticity; brown; sand is fine grained sub-rounded; trace gravel, fine to medium grained, sub-angular (iron cemented?).	W<PL	VSt	0.00	S	0.0 SPT: 5, 7, 9 [N=16] 89% recovery	Above ground cover	0
						0.5 [+1.60]				Core loss: 0.5 to 0.85m Inferred as above							
1						0.9 [+1.25]			CI	Sandy CLAY Medium plasticity; brown; sand is fine grained, sub-rounded; high dry strength.	W~PL						1
						1.7 [+0.40]			CH	Carbonate Sandy CLAY High plasticity; brown; sand is fine to medium grained, sub-rounded of carbonate; with gravel, fine to coarse-grained, sub-angular to sub-rounded calcrete.							
2						2.6 [-0.45]			SC	Carbonate Clayey SAND Fine to medium grained; sub-rounded to sub-angular; pale brown; low plasticity fines; trace gravel, fine to medium grained, sub-angular to sub-rounded of calcrete; uncemented.	W	L-MD				Solid pipe	2
3	01-11		2.8										2.75	S	2.8 SPT: 7, 5, 5 [N=10] 100% recovery		3
						3.5 [-1.40]			SC-SW	Clayey Gravelly SAND Fine to medium grained, sub-rounded to sub-angular; pale brown; low plasticity fines; gravel, fine to coarse grained, sub-rounded to rounded of calcrete; uncemented.					Run 3.5 to 4.25m: Groundwater strike during drilling		
4						4.1 [-2.00]			SC	Clayey SAND Fine to medium grained, sub-rounded to sub-angular; brown; low plasticity fines; trace gravel, (locally with) fine to medium, sub-rounded of calcrete; uncemented.						Bentonite & grout mix	4
						4.7 [-2.60]				Core loss: 4.7 to 5.0m Inferred as below		L					
5						5.0											5

STANDPIPE PIEZOMETER LOG

Borehole No.: **BH02**

Sheet 2 of 4

Client: K + S Salt Australia Pty Ltd
Project: Ashburton Solar Salt Project
Phase 2 Site Investigation
Job No.: 12516706

Coordinates: **E** 272 595, **N** 7585 346
Ground Surface Elevation: +2.1m AHD **Total Depth:** 18.7m
Commenced: 30-Oct-19 **Completed:** 01-Nov-19
Contractor: J&S Drilling **Driller:** Brian

Rig Type : Jacro 350 drill rig on Mangrove Buggy **Inclination:** Vertical
Flushing Fluid: Water
Hole Diameter (mm): 180

Logged:	DO	01-Nov-19
Processed:	DO	20-Oct-20
Checked:		

Depth Scale (m)	Daily Progress/ Observations: Date	Casing Depth (m)	Fluid Depth (m)	Drilling Method	Water	Depth (m)/ [Elev.]	Geological Unit	Graphic Log	Classification	Strata Description (type; colour; fines plasticity or particle characteristics; minor components; structure and/or origin)	Moisture Condition	Consistency/ Relative Density	Sample Type & Depth	Sample No.	Sample/ Test Records & Comments	Piezometer Components	Depth Scale (m)
						[-2.90]			SC	Clayey SAND Fine to medium grained, sub-rounded to sub-angular sand; brown; medium plasticity clay; trace gravel, fine grained, sub-rounded to rounded of calcrete; uncemented.	W	L	5.00	S	5.0 SPT: 1, 2, 5 [N=7] 100% recovery		
6	30-10 31-10			Hollow Stem Auger			Czp								6.0m, hard material encountered. Switched to saw tooth drill bit to advance through this material.		6
										From 6.5m, gravel becomed sub-angular to sub-rounded.	M-W	MD	6.50	S	6.5 SPT: 7, 9, 14 [N=23] 100% recovery		
7															7.25 to 8.0m: Sample material fell out of inner rod during extraction. Retrieved this material by pulling the outer rod to 7.25m and redrilling to 8.0m. Run 7.25 to 8.0m: 100% recovery		7
8										From 8.0m, gravel becomes sub-rounded.		D	8.00	S	8.0 SPT: 9, 15, 21 [N=36] 73% recovery		8
										Between 8.65 and 8.75m: brown, mottled white (CaCO3 mottling); low to medium plasticity fines.							
9						9.3 [-7.20]			CI	Sandy CLAY Medium plasticity; brown; sand is fine grained, sub-rounded to sub-angular; trace gravel, fine to medium grained, sub-angular of calcrete.	W<PL	H	9.50	S	9.5 SPT: 16, 28, 43 [N=71] 73% recovery Clay becomes soft when saturated (tactile observation)	Bentonite	9
10						10.0											10

GENERAL LOG 12516706 GINT.GPJ GHDLIB.GDT 20-10-20

STANDPIPE PIEZOMETER LOG

Borehole No.: **BH02**

Sheet 3 of 4

Client: K + S Salt Australia Pty Ltd
Project: Ashburton Solar Salt Project
Phase 2 Site Investigation
Job No.: 12516706

Coordinates: **E** 272 595, **N** 7585 346
Ground Surface Elevation: +2.1m AHD **Total Depth:** 18.7m
Commenced: 30-Oct-19 **Completed:** 01-Nov-19
Contractor: J&S Drilling **Driller:** Brian

Rig Type : Jacro 350 drill rig on Mangrove Buggy **Inclination:** Vertical
Flushing Fluid: Water
Hole Diameter (mm): 180

Logged:	DO	01-Nov-19
Processed:	DO	20-Oct-20
Checked:		

Depth Scale (m)	Daily Progress/ Observations: Date	Casing Depth (m)	Fluid Depth (m)	Drilling Method	Water	Depth (m)/ [Elev.]	Geological Unit	Graphic Log	Classification	Strata Description (type; colour; fines plasticity or particle characteristics; minor components; structure and/or origin)	Moisture Condition	Consistency/ Relative Density	Sample Type & Depth	Sample No.	Sample/ Test Records & Comments	Piezometer Components	Depth Scale (m)
						[-7.90]			CI	Sandy CLAY Medium plasticity; brown; sand is fine grained, sub-rounded to sub-angular.	W<PL	H					
						10.7											
						[-8.55]				Core loss: 10.65 to 11.0m							
11						11.0											11
						[-8.90]			CH	Sandy CLAY High plasticity; brown; sand is fine grained, sub-rounded to sub-angular; trace gravel, white, fine to medium grained, sub-angular of calcrete.			11.00	S	11.0 SPT: 16, 23, 41 [N=64] 82% recovery 11.45 to 11.75m: PASS material characterisation samples taken 11.75 to 12.5m: Sample material fell out of inner rod during inner rod extraction. Retrieved this material by using a fingers catcher in the inner rod. Run 11.75 to 12.5m: 33% recovery		
						11.8					W>PL						
	31-10					[-9.65]			SC	Clayey SAND Fine to medium grained; brown; low plasticity.	W	VD					
	01-11					12.0										Gravel	
12						[-9.90]				Core loss: 12.0 to 12.5m Inferred as above							12
				Hollow Stem Auger		12.5	Czp										
						[-10.40]			CH	Sandy CLAY High plasticity; brown; sand is fine grained, sub-angular to sub-rounded.	W~PL	H	12.50	S	12.5 SPT: 15, 22, 39 [N=61] 100% recovery		
13						13.2											13
						[-11.10]			SC	Clayey SAND Fine to meduim grained, sub-angular to rounded; brown, stained pale grey; trace gravel, (locally with) fine to medium grained, sub-angular of calcrete; uncemented.	W	VD					
						14.0											
14						[-11.90]			CI-CH	Sandy CLAY Medium to high plasticity; brown; sand is fine to medium grained, sub-angular to sub-rounded; trace gravel, (locally with) fine to medium grained, sub-angular of calcrete.	W~PL	H	14.00	S	14.0 SPT: 18, 41, 30/70 mm [N=] 78% recovery		14
						14.5											
						[-12.40]				Core loss: 14.5 to 14.75m: Inferred as below.	W						
						14.8											
						[-12.65]			SC			VD					
15																	15

STANDPIPE PIEZOMETER LOG

Borehole No.: **BH02**

Sheet 4 of 4

Client: K + S Salt Australia Pty Ltd
Project: Ashburton Solar Salt Project
Phase 2 Site Investigation
Job No.: 12516706

Coordinates: **E** 272 595, **N** 7585 346
Ground Surface Elevation: +2.1m AHD **Total Depth:** 18.7m
Commenced: 30-Oct-19 **Completed:** 01-Nov-19
Contractor: J&S Drilling **Driller:** Brian

Rig Type : Jacro 350 drill rig on Mangrove Buggy **Inclination:** Vertical
Flushing Fluid: Water
Hole Diameter (mm): 180

Logged:	DO	01-Nov-19
Processed:	DO	20-Oct-20
Checked:		

Depth Scale (m)	Daily Progress/ Observations: Date	Casing Depth (m)	Fluid Depth (m)	Drilling Method	Water	Depth (m)/ [Elev.]	Geological Unit	Graphic Log	Classification	Strata Description (type; colour; fines plasticity or particle characteristics; minor components; structure and/or origin)	Moisture Condition	Consistency/ Relative Density	Sample Type & Depth	Sample No.	Sample/ Test Records & Comments	Piezometer Components	Depth Scale (m)
16				Hollow Stem Auger		15.3 [-13.15]	Czp		SC	Clayey SAND Fine to medium grained, sub-angular to rounded; brown; medium plasticity fines; trace gravel, fine to medium grained, sub-angular to sub-rounded of calcrete; uncemented.		VD				Slotted pipe	16
						15.5			SC CH	Core loss: 15.25 to 15.5m Inferred as above	W>PL	H	15.50	S	15.5 SPT: 15, 48, * [R] 100% recovery		
						[-13.55]			SC	Clayey SAND. As above.	M-W	VD					
						15.8 [-13.70]			GC	Sandy CLAY High plasticity; brown; sand is fine grained, sub-rounded; trace gravel, fine grained, sub-angular of calcrete and sandstone.					From 15.8m, hard drilling conditions (~40 to 60 min per m)		
						16.0 [-13.90]			SC								
						16.3 [-14.20]				Clayey SAND Fine to medium grained, sub-angular to sub-rounded; brown; low plasticity fines; trace gravel, fine to medium grained, sub-angular to sub-rounded of calcrete and sandstone; uncemented.							
						16.5 [-14.40]			SC								
						16.8 [-14.70]				Clayey Sandy GRAVEL Fine to coarse grained, sub-rounded of sandstone; brown; sand is fine to medium grained, sub-rounded; low plasticity fines; uncemented.							
17						17.0 [-14.90]			CI-CH		W<PL	H	17.00	S	17.0 SPT: 27, 30/70 mm, * [30/70 mm] 100% recovery		17
							Qsed			Clayey SAND (locally SAND in parts) Fine to medium grained, sub-angular to sub-rounded; brown; low to medium plasticity fines; uncemented.					17.45 to 17.8m: PASS material characterisation samples taken		
										Core loss: 16.3 to 16.5m Inferred as above							
										Clayey SAND (locally SAND in parts) Fine to medium grained, sub-angular to sub-rounded; brown; low to medium plasticity fines; uncemented.							
18										Core loss: 16.8 to 17.0m Inferred as above							18
										Sandy CLAY / CLAY Medium to high plasticity; brown, mottled grey; sand is fine to medium grained, sub-rounded. From 17.3m, grading to CLAY From 17.45m, trace gravel (locally with) fine, to medium grained, sub-angular to sub-rounded of calcrete and sandstone.			18.50	S	18.5 SPT: 26, 30/90 mm, * [30/90 mm]		
	01-11			SPT		18.7 [-16.64]				Termination Depth = 18.74m (Target Depth)							
19																	19
20																	20

STANDPIPE PIEZOMETER LOG

Borehole No.: **BH02A**

Sheet 1 of 1

Client: K + S Salt Australia Pty Ltd
Project: Ashburton Solar Salt Project
Phase 2 Site Investigation
Job No.: 12516706

Coordinates: **E** 272 595, **N** 7585 351
Ground Surface Elevation: +2.2m AHD **Total Depth:** 8.0m
Commenced: 02-Nov-19 **Completed:** 02-Nov-19
Contractor: J&S Drilling **Driller:** Brian

Rig Type : Jacro 350 drill rig on Mangrove Buggy **Inclination:** Vertical
Flushing Fluid: Water
Hole Diameter (mm): 180

Logged:	DO	02-Nov-19
Processed:	DO	20-Oct-20
Checked:		

Depth Scale (m)	Daily Progress/ Observations: Date	Casing Depth (m)	Fluid Depth (m)	Drilling Method	Water	Depth (m)/ [Elev.]	Geological Unit	Graphic Log	Classification	Strata Description (type; colour; fines plasticity or particle characteristics; minor components; structure and/or origin)	Moisture Condition	Consistency/ Relative Density	Sample Type & Depth	Sample No.	Sample/ Test Records & Comments	Piezometer Components	Depth Scale (m)
1				Solid Augering												Above ground cover; Solid pipe; Backfill	1
2																	2
3																Bentonite	3
4																	4
5																Gravel	5
6																	6
7																Slotted pipe	7
8						8.0 [-5.80]											8
9																	9
10																	10

STANDPIPE PIEZOMETER LOG

Borehole No.: **BH03**

Sheet 1 of 5

Client: K + S Salt Australia Pty Ltd
Project: Ashburton Solar Salt Project
Phase 2 Site Investigation
Job No.: 12516706

Coordinates: **E** 267 805, **N** 7587 157
Ground Surface Elevation: +1.6m AHD **Total Depth:** 20.5m
Commenced: 03-Nov-19 **Completed:** 04-Nov-19
Contractor: J&S Drilling **Driller:** Brian

Rig Type : Jacro 350 drill rig on Mangrove Buggy **Inclination:** Vertical
Flushing Fluid: Water
Hole Diameter (mm): 180

Logged:	DO	04-Nov-19
Processed:	DO	20-Oct-20
Checked:		

Depth Scale (m)	Daily Progress/ Observations: Date	Casing Depth (m)	Fluid Depth (m)	Drilling Method	Water	Depth (m)/ [Elev.]	Geological Unit	Graphic Log	Classification	Strata Description (type; colour; fines plasticity or particle characteristics; minor components; structure and/or origin)	Moisture Condition	Consistency/ Relative Density	Sample Type & Depth	Sample No.	Sample/ Test Records & Comments	Piezometer Components	Depth Scale (m)
0	03-11			Hollow Stem Auger	Dipped at 1.55m on 4/11/19 at 8am	0.4 [+1.20]	Qs		SP-SC	SAND Fine to medium grained, sub-angular to sub-rounded; brown; with fines; with plant root fibres to 0.1m depth; uncemented.	D	VL				Above ground cover	0
									SM	Carbonate Silty SAND Fine grained, sub-angular to sub-rounded of carbonate and quartz; brown; non-plastic fines; trace gravel, angular of claystone (?); uncemented.			0.50	S	0.5 SPT: 3, 1, 1 [N=2] 61% recovery		
1						1.3 [+0.30]			SM	Silty SAND Fine to medium grained, sub-rounded to sub-angular of quartz; grey mottled orange; low plasticity fines; uncemented.	M	MD			Run 1.25 to 2.0m: Groundwater strike during drilling		1
	04-11		1.6			1.6 [+0.00]			SP-SM	SAND Fine to medium grained, sub-rounded of quartz; grey; with fines.	W						
						1.8 [-0.20]				Core loss: 1.8 to 2.0m Inferred as above							
2						2.0 [-0.40]			SM	Silty SAND Fine to medium grained, sub-angular to sub-rounded; grey; low plasticity fines; trace coral and shell fragments (up to 25mm).			2.00	S	2.0 SPT: 4, 5, 6 [N=11] 100% recovery	Solid pipe	2
						2.8 [-1.15]			SP	SAND Fine to medium grained, sub-angular to sub-rounded of quartz; grey; trace coral and shell fragments (up to 10mm); trace fines; uncemented.		L			3.0 to 3.4m: Material characterisation samples taken From 3.5m, added water into inner tube to balance water pressures		
3						3.4 [-1.90]				Core loss: 3.4 to 3.5 m Inferred as above			3.50	S	3.5 SPT: 1, 3, 4 [N=7] 0% recovery		3
						3.8 [-2.20]			SP	Inferred as SAND below.							
4						4.3 [-2.65]			SP	SAND Fine to medium grained, sub-angular to sub-rounded of quartz; grey; trace fines; trace coral and shell fragments (up to 20mm). From 4.1m, becoming with coral and shell fragments.					ASS samples recovered at 0.25m, 0.5m, 0.75m, 1.0m, 1.25m, 1.5m, 1.75m, 2.0m, 2.25m, 2.5m, 2.75m, 3.0m, 3.25m, 3.4m, 3.8m and 4.25m QA01=BH03-3.0m	Bentonite & grout mix	4
										Core loss: 4.25 to 5.0 m							
5						5.0											5

GENERAL LOG 12516706 GINT.GPJ GHDLIB.GDT 20-10-20

STANDPIPE PIEZOMETER LOG

Borehole No.: **BH03**

Client: K + S Salt Australia Pty Ltd
Project: Ashburton Solar Salt Project
Phase 2 Site Investigation
Job No.: 12516706

Coordinates: **E** 267 805, **N** 7587 157
Ground Surface Elevation: +1.6m AHD **Total Depth:** 20.5m
Commenced: 03-Nov-19 **Completed:** 04-Nov-19
Contractor: J&S Drilling **Driller:** Brian

Rig Type : Jacro 350 drill rig on Mangrove Buggy **Inclination:** Vertical
Flushing Fluid: Water
Hole Diameter (mm): 180

Logged:	DO	04-Nov-19
Processed:	DO	20-Oct-20
Checked:		

Depth Scale (m)	Daily Progress/ Observations: Date	Casing Depth (m)	Fluid Depth (m)	Drilling Method	Water	Depth (m)/ [Elev.]	Geological Unit	Graphic Log	Classification	Strata Description (type; colour; fines plasticity or particle characteristics; minor components; structure and/or origin)	Moisture Condition	Consistency/ Relative Density	Sample Type & Depth	Sample No.	Sample/ Test Records & Comments	Piezometer Components	Depth Scale (m)
				Hollow Stem Auger		[-3.40]	Qs		SP	SAND Fine to medium grained, sub-angular to sub-rounded of quartz; grey; with shell and coral fragments (up to 10mm); uncemented.	W	VL	5.00	S	5.0 SPT: 1, 1, 2 [N=3] 29% recovery SPT sampler with finger catcher hammered to 5.7m to improve SPT sample recovery		
						5.5											
						[-3.90]				Core loss: 5.5 to 5.75 m Inferred as above							
						5.8											
						[-4.15]			SP	SAND Fine to medium grained, sub-angular to sub-rounded of quartz; grey; with shell and coral fragments (up to 10mm); uncemented.							
6						6.1											6
						[-4.50]				Core loss: 6.1 to 6.5 m Inferred as above							
						6.5											
						[-4.90]			SP	SAND Fine to medium grained, sub-angular to sub-rounded of quartz; grey; trace fines; trace shell fragments (up to 10mm); uncemented.		L	6.50	S	6.5 SPT: 3, 3, 4 [N=7] 51% recovery		
						6.8											
						[-5.20]			SC	Carbonate Clayey SAND Fine to medium grained, sub-angular to sub-rounded of carbonate and quartz; brown; low plasticity fines; trace gravel, fine to medium grained, sub-angular to sub-rounded of calcrete.							
7						7.3											7
						[-5.65]			SP-SC			MD					
						7.4											
						[-5.80]			GC	Carbonate SAND Fine to medium grained, sub-angular to sub-rounded of carbonate and quartz; brown; with fines; trace gravel, fine to medium grained, sub-angular of calcrete.							
						7.8											
						[-6.20]				Carbonate Clayey Sandy GRAVEL Fine to coarse grained, sub-angular to sub-rounded of calcrete, claystone and shell fragments; brown; sand is fine to medium grained, sub-angular to sub-rounded of carbonate; low plasticity fines. From 7.5 to 7.6 m: Silty SAND							
8						8.0							8.00				8
						[-6.50]	Czp		GC		M-W			S	8.0 SPT: 12, 13, 13 [N=26] 89% recovery		
									SC								
						8.5											
						[-6.85]				Core loss: 7.8 to 8.0 m							
						8.8				Carbonate Clayey Sandy GRAVEL As above							
						[-7.15]			SC	Carbonate Clayey SAND Fine to medium grained, sub-angular to sub-rounded of carbonate; brown; low plasticity fines; trace gravel, fine to medium grained, sub-angular to sub-rounded of calcrete.							
9										Core loss: 8.45 to 8.75m Inferred as above							9
										Carbonate Clayey SAND Fine to medium grained, sub-angular to sub-rounded; brown; low plasticity fines; trace gravel, fine grained, sub-angular to sub-rounded of calcrete and claystone.			9.50	S	9.5 SPT: 9, 12, 12 [N=24] 93% recovery		
10						10.0											10

STANDPIPE PIEZOMETER LOG

Borehole No.: **BH03**

Sheet 3 of 5

Client: K + S Salt Australia Pty Ltd
Project: Ashburton Solar Salt Project
Phase 2 Site Investigation
Job No.: 12516706

Coordinates: **E** 267 805, **N** 7587 157
Ground Surface Elevation: +1.6m AHD **Total Depth:** 20.5m
Commenced: 03-Nov-19 **Completed:** 04-Nov-19
Contractor: J&S Drilling **Driller:** Brian

Rig Type : Jacro 350 drill rig on Mangrove Buggy **Inclination:** Vertical
Flushing Fluid: Water
Hole Diameter (mm): 180

Logged:	DO	04-Nov-19
Processed:	DO	20-Oct-20
Checked:		

Depth Scale (m)	Daily Progress/ Observations: Date	Casing Depth (m)	Fluid Depth (m)	Drilling Method	Water	Depth (m)/ [Elev.]	Geological Unit	Graphic Log	Classification	Strata Description (type; colour; fines plasticity or particle characteristics; minor components; structure and/or origin)	Moisture Condition	Consistency/ Relative Density	Sample Type & Depth	Sample No.	Sample/ Test Records & Comments	Piezometer Components	Depth Scale (m)
11				Hollow Stem Auger		[-8.40]	Czp		SC	From 9.0 m: Clayey SAND Clayey SAND Fine to medium grained, sub-angular to sub-rounded; brown; low plasticity fines; trace gravel, fine grained, sub-rounded to sub-angular of calcrete.	M-W	MD	11.00	S	11.0 SPT: 5, 9, 16 [N=25] 100% recovery 11.45 to 11.75m: Material characterisation samples taken	Bentonite Gravel	11
12						12.4 [-10.80]			CI	Sandy CLAY Medium plasticity; brown; sand is fine grained, sub-angular to sub-rounded; trace gravel, fine, sub-angular to sub-rounded of calcrete.	W~PL	H	12.50	S	12.5 SPT: 10, 16, 22 [N=38] 89% recovery Run 13.25 to 14.0 m: 100% recovery. 160mm initially recovered. Remainder dropped in the hole after inner rod extraction. Pulled augers up to 13.25m, redrilled to 14.0m and recovered dropped material.	Slotted pipe	12
13						13.3 [-11.65]	Qsed		SP-SC	SAND Fine to coarse grained, sub-angular to sub-rounded of quartz (and some carbonate); brown; with fines non-plastic; trace gravel, fine to medium grained of quartz; uncemented.	W	VD					13
14	03-11 04-11					14.5 [-12.85] 14.6 [-12.95]			SP CI	14.3 m: With gravel, sub-rounded to rounded of quartz and claystone. Core loss Inferred as above	W~PL	H	14.00	S	14.0 SPT: 9, 26, 36 [N=62] 93% recovery 14.0 to 14.75m: Sample material dropped out of the inner rod during inner rod extraction. Some of this material was recovered in the next run.	Gravel Bentonite	14
15						15.0											15

STANDPIPE PIEZOMETER LOG

Borehole No.: **BH03**

Sheet 4 of 5

Client: K + S Salt Australia Pty Ltd
Project: Ashburton Solar Salt Project
Phase 2 Site Investigation
Job No.: 12516706

Coordinates: **E** 267 805, **N** 7587 157
Ground Surface Elevation: +1.6m AHD **Total Depth:** 20.5m
Commenced: 03-Nov-19 **Completed:** 04-Nov-19
Contractor: J&S Drilling **Driller:** Brian

Rig Type : Jacro 350 drill rig on Mangrove Buggy **Inclination:** Vertical
Flushing Fluid: Water
Hole Diameter (mm): 180

Logged:	DO	04-Nov-19
Processed:	DO	20-Oct-20
Checked:		

Depth Scale (m)	Daily Progress/ Observations: Date	Casing Depth (m)	Fluid Depth (m)	Drilling Method	Water	Depth (m)/ [Elev.]	Geological Unit	Graphic Log	Classification	Strata Description (type; colour; fines plasticity or particle characteristics; minor components; structure and/or origin)	Moisture Condition	Consistency/ Relative Density	Sample Type & Depth	Sample No.	Sample/ Test Records & Comments	Piezometer Components	Depth Scale (m)
						[-13.40]			CI-CH	Sandy CLAY Medium plasticity; brown; sand is fine to coarse grained, sub-angular to sub-rounded (some carbonate); trace gravel, fine to coarse grained, sub-rounded to rounded of quartz and calcrete. From 14.6 to 15.0m, moderately CaCO3 cemented.	W~PL W<PL				From 15.0m, hard drilling conditions (~40 min per m)		
						15.7 [-14.14]							15.50	S	15.5 SPT: 26, 30/90 mm, * [30/90 mm] 100% recovery		
						16.0 [-14.40]			CI-CH	Sandy CLAY Medium to high plasticity; brown; sand is fine grained, sub-angular to sub-rounded (some carbonate); trace gravel, fine to medium grained, sub-angular to rounded of calcrete, quartz and claystone.	W>PL				Run 15.25 to 15.5m: Sample material fell out of the inner rod durring extraction. This material was retrieved using the SPT sampler. Runs 16.0 to 16.25m and 16.25 to 16.5m: Sample material fell out of the inner rod during extraction. This material was recovered after drilling to 16.75m.		
										Core loss: 15.74 to 16.0m							
										Sandy CLAY Medium to high plasticity; brown; sand is fine grained, sub-angular to sub-rounded of quartz (some carbonate) ; trace gravel, fine to medium grained, sub-angular to rounded of calcrete, quartz and claystone.							
						16.8 [-15.15]			CH		W<PL						
										CLAY High plasticity; brown; with sand, fine grained, sub-angular to sub-rounded; trace gravel, fine grained, sub-rounded of calcrete.			17.00	S	17.0 SPT: 15, 23, 33 [N=56] 71% recovery	Gravel	
				Hollow Stem Auger			Qsed										
										From 18.5m, trace gravel, fine to medium grained, sub-rounded to sub-angular of calcrete.			18.50	S	18.5 SPT: 19, 28, 35 [N=63] 71% recovery		
						19.3 [-17.65]			CI	Sandy CLAY Medium plasticity; brown; sand is fine grained, sub-angular to sub-rounded; trace gravel, fine to medium grained, sub-rounded to sub-angular of calcrete.	W~PL						
						19.8 [-18.20]				Core loss: 19.8 to 20.0m							
						20.0											

STANDPIPE PIEZOMETER LOG

Borehole No.: **BH03**

Client: K + S Salt Australia Pty Ltd
Project: Ashburton Solar Salt Project
Phase 2 Site Investigation
Job No.: 12516706

Coordinates: **E** 267 805, **N** 7587 157
Ground Surface Elevation: +1.6m AHD **Total Depth:** 20.5m
Commenced: 03-Nov-19 **Completed:** 04-Nov-19
Contractor: J&S Drilling **Driller:** Brian

Rig Type : Jacro 350 drill rig on Mangrove Buggy **Inclination:** Vertical
Flushing Fluid: Water
Hole Diameter (mm): 180

Logged:	DO	04-Nov-19
Processed:	DO	20-Oct-20
Checked:		

Depth Scale (m)	Daily Progress/ Observations: Date	Casing Depth (m)	Fluid Depth (m)	Drilling Method	Water	Depth (m)/ [Elev.]	Geological Unit	Graphic Log	Classification	Strata Description (type; colour; fines plasticity or particle characteristics; minor components; structure and/or origin)	Moisture Condition	Consistency/ Relative Density	Sample Type & Depth	Sample No.	Sample/ Test Records & Comments	Piezometer Components	Depth Scale (m)
	04-11			SPT		[-18.40]	Qsed		Cl	Sandy CLAY Medium plasticity; brown; sand is fine grained, sub-angular to sub-rounded.	W~PL	H	20.00	S	20.0 SPT: 15, 22, 30 [N=52] 100% recovery		
						20.5 [-18.85]				Termination Depth = 20.45m (Target Depth)							
21																	21
22																	22
23																	23
24																	24
25																	25

STANDPIPE PIEZOMETER LOG

Borehole No.: **BH03A**

Sheet 1 of 2

Client: K + S Salt Australia Pty Ltd
Project: Ashburton Solar Salt Project
Phase 2 Site Investigation
Job No.: 12516706

Coordinates: **E** 267 803, **N** 7587 157
Ground Surface Elevation: +1.5m AHD **Total Depth:** 5.0m
Commenced: 04-Nov-19 **Completed:** 05-Nov-19
Contractor: J&S Drilling **Driller:** Brian

Rig Type : Jacro 350 drill rig on Mangrove Buggy **Inclination:** Vertical
Flushing Fluid: Water
Hole Diameter (mm): 180

Logged:	DO	05-Nov-19
Processed:	DO	20-Oct-20
Checked:		

Depth Scale (m)	Daily Progress/ Observations: Date	Casing Depth (m)	Fluid Depth (m)	Drilling Method	Water	Depth (m)/ [Elev.]	Geological Unit	Graphic Log	Classification	Strata Description (type; colour; fines plasticity or particle characteristics; minor components; structure and/or origin)	Moisture Condition	Consistency/ Relative Density	Sample Type & Depth	Sample No.	Sample/ Test Records & Comments	Piezometer Components	Depth Scale (m)
0				Solid Augering		5.0										Above ground cover; Bentonite & grout mix; Solid pipe; Bentonite; Gravel; Slotted pipe	0
1																	1
2																	2
3																	3
4																	4
5																	5

GENERAL LOG 12516706 GINT.GPJ GHDLIB.GDT 20-10-20

STANDPIPE PIEZOMETER LOG

Borehole No.: **BH03A**

Sheet 2 of 2

Client: K + S Salt Australia Pty Ltd
Project: Ashburton Solar Salt Project
Phase 2 Site Investigation
Job No.: 12516706

Coordinates: **E** 267 803, **N** 7587 157
Ground Surface Elevation: +1.5m AHD **Total Depth:** 5.0m
Commenced: 04-Nov-19 **Completed:** 05-Nov-19
Contractor: J&S Drilling **Driller:** Brian

Rig Type : Jacro 350 drill rig on Mangrove Buggy **Inclination:** Vertical
Flushing Fluid: Water
Hole Diameter (mm): 180

Logged:	DO	05-Nov-19
Processed:	DO	20-Oct-20
Checked:		

Depth Scale (m)	Daily Progress/ Observations: Date	Casing Depth (m)	Fluid Depth (m)	Drilling Method	Water	Depth (m)/ [Elev.]	Geological Unit	Graphic Log	Classification	Strata Description (type; colour; fines plasticity or particle characteristics; minor components; structure and/or origin)	Moisture Condition	Consistency/ Relative Density	Sample Type & Depth	Sample No.	Sample/ Test Records & Comments	Piezometer Components	Depth Scale (m)
						[-3.50]											
6																	6
7																	7
8																	8
9																	9
10																	10

STANDPIPE PIEZOMETER LOG

Borehole No.: **BH04**

Sheet 1 of 4

Client: K + S Salt Australia Pty Ltd
Project: Ashburton Solar Salt Project
Phase 2 Site Investigation
Job No.: 12516706

Coordinates: **E** 272 867, **N** 7580 738
Ground Surface Elevation: +3.4m AHD **Total Depth:** 15.0m
Commenced: 30-Mar-20 **Completed:** 31-Mar-20
Contractor: J&S Drilling **Driller:** Adrian

Rig Type : Jacro 350 drill rig on Mangrove Buggy **Inclination:** Vertical
Flushing Fluid: Seawater
Hole Diameter (mm): 123

Logged:	SD	31-Mar-20
Processed:	WR	20-Oct-20
Checked:		

Depth Scale (m)	Daily Progress/ Observations: Date	Casing Depth (m)	Fluid Depth (m)	Drilling Method	Water	Depth (m)/ [Elev.]	Geological Unit	Graphic Log	Classification	Strata Description (type; colour; fines plasticity or particle characteristics; minor components; structure and/or origin)	Moisture Condition	Consistency/ Relative Density	Sample Type & Depth	Sample No.	Sample/ Test Records & Comments	Piezometer Components	Depth Scale (m)
1	30-03			PQ Coring	Groundwater dipped at 2.5 m on 31/03/2020		Czp		CI	Silty CLAY Medium plasticity; brown; with sand, fine to coarse grained; calcerous.	W>PL	S			From surface, 'Prickly Pear' drill bit used. MC=Material Charactersation	Above ground cover Concrete	1
											W<PL	Fr			0.5-1.0m, MC: 2 x jar samples, 2 x disturbed bags		
											W>PL	S					
										1.0 to 1.5 m, locally becoming Sandy Silty CLAY.						Bentonite	
2									CH	From 1.5 m, loss of silt, clay is high plasticity.			1.50	SD01	1.5 SPT: 4, 4, 4 [N=8] 250/450 mm recovery, D01		2
						2.8 [+0.65]			GC	Clayey GRAVEL Fine grained; sub-rounded; of gypsum; brown; clay is high plasticity; with sand, fine to medium grained gypsum; calcerous.	M	MD				Gravel	
3						3.2 [+0.20]			CH	Sandy CLAY High plasticity; brown; sand, fine to medium grained, sub-angular to sub-rounded, of gypsum and quartz; trace gravel, sub-rounded of gypsum; calcerous. From 3.5 m, becoming non-calcareous.	W>PL	F-St	3.00	SD02	3.0 SPT: 7, 8, 8 [N=16] 420/450 mm recovery, D02		3
	30-03											St-VSt			Drilling rods pulled and drill bit changed to 'Surface Set' PQ bit.		
	31-03																
4										From 4.5 m, loss of gravel.		VSt	4.50	SD03	4.5 SPT: 9, 11, 17 [N=28] 400/450 mm recovery, D03		4
5						5.0											5

GENERAL LOG 12516706 GINT.GPJ GHDLIB.GDT 20-10-20

STANDPIPE PIEZOMETER LOG

Borehole No.: **BH04**

Client: K + S Salt Australia Pty Ltd
Project: Ashburton Solar Salt Project
Phase 2 Site Investigation
Job No.: 12516706

Coordinates: **E** 272 867, **N** 7580 738
Ground Surface Elevation: +3.4m AHD **Total Depth:** 15.0m
Commenced: 30-Mar-20 **Completed:** 31-Mar-20
Contractor: J&S Drilling **Driller:** Adrian

Rig Type : Jacro 350 drill rig on Mangrove Buggy **Inclination:** Vertical
Flushing Fluid: Seawater
Hole Diameter (mm): 123

Logged:	SD	31-Mar-20
Processed:	WR	20-Oct-20
Checked:		

Depth Scale (m)	Daily Progress/ Observations: Date	Casing Depth (m)	Fluid Depth (m)	Drilling Method	Water	Depth (m)/ [Elev.]	Geological Unit	Graphic Log	Classification	Strata Description (type; colour; fines plasticity or particle characteristics; minor components; structure and/or origin)	Moisture Condition	Consistency/ Relative Density	Sample Type & Depth	Sample No.	Sample/ Test Records & Comments	Piezometer Components	Depth Scale (m)
						[-1.60]			CH	Sandy CLAY High plasticity; brown; sand, fine to medium grained, sub-angular to sub-rounded, of quartz; trace gravel, sub-rounded of gypsum; trace gravel, fine grained, sub-rounded; calcerous.	W~PL	VSt				Slotted Pipe	
6						6.0 [-2.60]	Czp		CH	CLAY High plasticity; brown; with sand, fine grained; with local calcerous cementation as nodules up to 30 mm.		H	6.00	SD04	6.0 SPT: 13, 24, 39 [N=63] 300/450 mm recovery, D04		6
7				PQ Coring						From 7.0 m, trace local cemented nodules up to 150 mm.	W<PL				7.5 m, crystalline gypsum occurs in horizontal platey concentrations up to 2 mm thick.		7
										From 7.5 m, addition of trace gravel, fine grained, black, sub-rounded, of claystone, and crystalline of gypsum.			7.50	SD05	7.5 SPT: 16, 30, 12/50 mm [42/200 mm] 300/450 mm recovery, D05		
8							Qsed										8
																Bentonite	
9						9.2							9.00	SD06	9.0 SPT: 16, 20/95 mm, * [20/95 mm] 230/245 mm recovery, D06		9
										Start of coring at 9.245m. *Continued next sheet in Rock Core format.*							
10																	10

STANDPIPE PIEZOMETER LOG
*** ROCK CORE FORMAT ***

Borehole No.: **BH04**

Client: K + S Salt Australia Pty Ltd
Project: Ashburton Solar Salt Project
Phase 2 Site Investigation
Job No.: 12516706

Coordinates: **E** 272 867, **N** 7580 738
Ground Surface Elevation: +3.4m AHD **Total Depth:** 15.0m
Commenced: 30-Mar-20 **Completed:** 31-Mar-20
Contractor: J&S Drilling **Driller:** Adrian

Rig Type : Jacro 350 drill rig on Mangrove Buggy **Inclination:** Vertical
Drilling Fluid: Seawater
Core Diameter (mm): 85

Logged:	SD	31-Mar-20
Processed:	WR	20-Oct-20
Checked:		

Depth Scale (m)	Daily Progress/ Observations: Date	Casing Depth (m)	Fluid Depth (m)	Drilling Method	Water	Depth (m)/ [Elev.]	Geological Unit	Graphic Log	Strata Description (Rocktype; grain size; texture & structure; colour; strength; fracture condition; minor constituents)	Weathering/ Cementation	Estimated Rock Strength (VL L M H VH EH)	Rock Core Quality: TCR (%)	RQD (%)	F (fractures/m)	Defect Log	Drill Rate (min/m)	Defect Description & Comments	Piezometer Components	Depth Scale (m)
6																			6
7																			7
8																			8
9						9.2 [-5.85]			*Resuming in Core Log format 9.245m.*										9
10				PQ Coring		10.0	Qsed		Calcareous CLAYSTONE High plasticity; W-PL; brown; massive; with sand, fine to coarse grained, sub-angular to sub-rounded, of quartz and claystone, and coarse grained crystalline of gypsum; trace chart gravel (as below); local calcareous cementation nodules (as below); moist.	Fr		100 100	100 100	1 0		38 14	9.52 m, 45º, joint , medium scale, rough, planar, gypsum coating, 2 mm. 9.71 m, DB 9.78 m, DB		10

STANDPIPE PIEZOMETER LOG
*** ROCK CORE FORMAT ***

Borehole No.: **BH04**

Sheet 4 of 4

Client: K + S Salt Australia Pty Ltd
Project: Ashburton Solar Salt Project
Phase 2 Site Investigation
Job No.: 12516706

Coordinates: **E** 272 867, **N** 7580 738
Ground Surface Elevation: +3.4m AHD **Total Depth:** 15.0m
Commenced: 30-Mar-20 **Completed:** 31-Mar-20
Contractor: J&S Drilling **Driller:** Adrian

Rig Type : Jacro 350 drill rig on Mangrove Buggy **Inclination:** Vertical
Drilling Fluid: Seawater
Core Diameter (mm): 85

Logged:	SD	31-Mar-20
Processed:	WR	20-Oct-20
Checked:		

Depth Scale (m)	Daily Progress/ Observations: Date	Casing Depth (m)	Fluid Depth (m)	Drilling Method	Water	Depth (m)/ [Elev.]	Geological Unit	Graphic Log	Strata Description (Rocktype; grain size; texture & structure; colour; strength; fracture condition; minor constituents)	Weathering/ Cementation	Estimated Rock Strength (VL L M H VH EH)	Rock Core Quality: TCR (%)	RQD (%)	F (fractures/m)	Defect Log	Drill Rate (min/m)	Defect Description & Comments	Piezometer Components	Depth Scale (m)
						[-6.60]			From 9.8 m, becoming dry.	Fr							Change in drill bit.		
									Calcareous CLAYSTONE High plasticity; W-PL; brown; massive; with sand, fine to coarse grained, sub-angular to sub-rounded, of quartz and claystone, and coarse grained crystalline of gypsum; trace gravel, medium grained (20 mm), rounded of chert; local ca			100	100			14	9.85 m, DB 10.13 m, DB		
																	10.44 m, DB		
									From 10.1 m, sand is fine to medium grained.								10.54 m, DB		
11												85	100			20	11.23 m, DB		11
									From 11.5 m, increase in size of calcareous nodules up to 350 mm.								11.64 m, DB		
						11.8 [-8.38]			CORE LOSS 11.78 to 12.0 m Inferred as above										
12						12.0 [-8.60]			Calcareous CLAYSTONE High plasticity; W-PL; brown; massive; with sand, fine to coarse grained, sub-angular to sub-rounded, of quartz and claystone, and coarse grained crystalline of gypsum; local calcareous cementation as angular nodules, up to 15 mm; dry.								12.07 m, DB	Backfill	12
				PQ Coring			Qsed		From 12.57 m, Increase in sand content to Sandy CLAYSTONE.			75	58	0		9	12.56 m, DB 12.62 m, DB 12.69 m, DB		
13						13.1 [-9.73]			CORE LOSS 13.13 to 13.5 m Inferred as above								12.85 m, DB 12.94 m, DB		13
						13.5 [-10.10]			Calcareous Sandy CLAYSTONE High plasticity; W-PL; brown; massive; with sand, fine to coarse grained, sub-angular to sub-rounded, of quartz and claystone, and coarse grained crystalline of gypsum; local calcareous cementation as angular nodules, up to 15 mm; dry.								13.57 m, DB 13.72 m, DB		
14												100	100			17	14.04 m, DB 14.06 m, DB 14.08 m, DB 14.21 m, DB		14
																	14.38 m, DB		
																	14.70 m, DB		
15	31-03					15.0			Termination Depth = 15.00m								14.93 m, DB		15

COREHOLE 12516706 GINT.GPJ GHDLIB.GDT 20-10-20

STANDPIPE PIEZOMETER LOG

Borehole No.: **BH05**

Sheet 1 of 4

Client: K + S Salt Australia Pty Ltd
Project: Ashburton Solar Salt Project
Phase 2 Site Investigation
Job No.: 12516706

Coordinates: **E** 266 675, **N** 7578 586
Ground Surface Elevation: +0.7m AHD **Total Depth:** 15.0m
Commenced: 14-Jan-20 **Completed:** 17-Jan-20
Contractor: J&S Drilling **Driller:** Alan

Rig Type : Jacro 350 drill rig on Mangrove Buggy **Inclination:** Vertical
Flushing Fluid: Water to 10 m, then Polymer
Hole Diameter (mm): 180 Auger / 123 PQ

Logged:	SD	17-Jan-20
Processed:	DCH	20-Oct-20
Checked:		

Depth Scale (m)	Daily Progress/ Observations: Date	Casing Depth (m)	Fluid Depth (m)	Drilling Method	Water	Depth (m)/ [Elev.]	Geological Unit	Graphic Log	Classification	Strata Description (type; colour; fines plasticity or particle characteristics; minor components; structure and/or origin)	Moisture Condition	Consistency/ Relative Density	Sample Type & Depth	Sample No.	Sample/ Test Records & Comments	Piezometer Components	Depth Scale (m)
0	14-01			Hollow Stem Auger		[+0.66] 0.2 [+0.48]	Qt		CH	Crust Halite crystals up to 40 mm; white mottled brown; trace fines, non-plastic.	D W>PL	S	0.20	D	0.2 m: J01, J02, D05	Above ground cover	0
						0.5 [+0.20]				CLAY High plasticity; pale grey; trace sand is fine to medium grained, sub-angular, of quartz; non-calcareous.							
									GC		W	L	0.60	D	0.6 m: J03, J04, D06		
						0.8 [-0.07]				0.22-0.28 m: becoming grey-brown; with sand, fine to coarse-grained; with gravel, fine to medium; of angular gypsum crystals; uncemented.							
1						1.0 [-0.30]			GC	0.28-0.5 m: CORE LOSS							1
										Clayey GRAVEL Fine to medium grained, angular, of quartz; brown; clay is high plasticity, W>PL; with sand, fine to coarse-grained, angular, of gymsum and calcite; uncemented.			1.50	S	1.5 SPT: 1, 2, 3 [N=5] 1.5-2.05 m: disturbed sample D01 122% Recovery		
										0.77-1.0 m: CORE LOSS							
						2.0 [-1.30]				Clayey GRAVEL As above.							
2									CH	Sandy CLAY High plasticity; brown; sand is fine to medium-grained, sub-rounded, of quartz; calcareous.	W>PL	F					2
																Grout	
															At 2.8 m: switch to saw-tooth head on sampler		
3									CH	At 3.0 m: loss of sand.	W~PL	F - St	3.00	S	3.0 SPT: 10, 16, 18 [N=34] 3.0-3.46 m: disturbed sample D02 102 % Recovery		3
												S - F			3.5 m: J05, J06, D09 At 3.75 m: ASS quality assurance sample QA02		
											W>PL						
4						4.1 [-3.42]	Qsed			At 4.0 m: becoming slightly calcareous.					At 4.25 m: no ASS sample taken due to core loss		4
										4.12-4.5 m: CORE LOSS. Infered as above.							
						4.5 [-3.80]			CH	Sandy CLAY High plasticity; brown; sand is fine to medium-grained, sub-rounded, of quartz; calcareous.		St-VSt	4.50	S	4.5 SPT: 10, 12, 16 [N=28] 4.5-4.85 m: disturbed sample D03 78% Recovery		
5											W<PL						5
6																	6

GENERAL LOG 12516706 GINT.GPJ GHDLIB.GDT 20-10-20

STANDPIPE PIEZOMETER LOG

Borehole No.: **BH05**

Client: K + S Salt Australia Pty Ltd
Project: Ashburton Solar Salt Project
Phase 2 Site Investigation
Job No.: 12516706

Coordinates: **E** 266 675, **N** 7578 586
Ground Surface Elevation: +0.7m AHD **Total Depth:** 15.0m
Commenced: 14-Jan-20 **Completed:** 17-Jan-20
Contractor: J&S Drilling **Driller:** Alan

Rig Type : Jacro 350 drill rig on Mangrove Buggy **Inclination:** Vertical
Flushing Fluid: Water to 10 m, then Polymer
Hole Diameter (mm): 180 Auger / 123 PQ

Logged:	SD	17-Jan-20
Processed:	DCH	20-Oct-20
Checked:		

Depth Scale (m)	Daily Progress/ Observations: Date	Casing Depth (m)	Fluid Depth (m)	Drilling Method	Water	Depth (m)/ [Elev.]	Geological Unit	Graphic Log	Classification	Strata Description (type; colour; fines plasticity or particle characteristics; minor components; structure and/or origin)	Moisture Condition	Consistency/ Relative Density	Sample Type & Depth	Sample No.	Sample/ Test Records & Comments	Piezometer Components	Depth Scale (m)
7	14-01						Qsed		CH	Sandy CLAY High plasticity; brown; sand is fine to medium-grained, sub-rounded, of quartz; calcareous. From 6.1 m: with trace amounts of gravel, fine grained, angular, platy, of gypsum. From 6.5 m: with trace amounts of sand; coarse-grained, angular, platy, of gypsum. 6.8-7.0 m: bivalve shells, non-intact, up to 41x55 mm in size. At 7.0 m: non-calcareous.	W~PL	St-VSt VSt	6.00	S	6.0 SPT: 24, 43, 17/50 mm [] 6.0-6.3 m: disturbed sample D04 86% Recovery At 6.45 m: switch to PQ coring At 6.8 m, pause in run due to flush pipe blockage		7
8	16-01			PQ Coring						At 7.5 m: loss of gravel. Sand is fine to medium-grained.			7.50	S	At 7.4 m, driller notes 'softer zone' 7.5 SPT: 12, 16, 30 [N=46] 7.5-7.95 m: disturbed sample D07 100% Recovery	Grout	8
9										At 8.7 m: gain of trace local cementation of calcite, ~30% area, moderately cemented.		VSt - H H	9.00	S	At 8.6 m, change in drill bit from prickly pear to regular bit. 9.0 SPT: 20, 52, 8/20 mm [] 9.0-9.32 m: disturbed sample D08 100% Recovery		9
10						10.0				*Start of coring at 10m.* *Continued next sheet in Rock Core format.*							10
11																	11
12																	12

STANDPIPE PIEZOMETER LOG
*** ROCK CORE FORMAT ***

Borehole No.: **BH05**

Client: K + S Salt Australia Pty Ltd
Project: Ashburton Solar Salt Project
Phase 2 Site Investigation
Job No.: 12516706

Coordinates: **E** 266 675, **N** 7578 586
Ground Surface Elevation: +0.7m AHD **Total Depth:** 15.0m
Commenced: 14-Jan-20 **Completed:** 17-Jan-20
Contractor: J&S Drilling **Driller:** Alan

Rig Type : Jacro 350 drill rig on Mangrove Buggy **Inclination:** Vertical
Drilling Fluid: Various
Core Diameter (mm): 85

Logged:	SD	17-Jan-20
Processed:	DCH	20-Oct-20
Checked:		

Depth Scale (m)	Daily Progress/ Observations: Date	Casing Depth (m)	Fluid Depth (m)	Drilling Method	Water	Depth (m)/ [Elev.]	Geological Unit	Graphic Log	Strata Description (Rocktype; grain size; texture & structure; colour; strength; fracture condition; minor constituents)	Weathering/ Cementation	Estimated Rock Strength (VL L M H VH EH)	Rock Core Quality: TCR (%)	RQD (%)	F (fractures/m)	Defect Log	Drill Rate (min/m)	Defect Description & Comments	Piezometer Components	Depth Scale (m)
7																			7
8																			8
9																			9
10						10.0 [-9.30]			*Resuming in Core Log format 10m.*										10
11				PQ Coring			Qsed		Calcareous CLAYSTONE Brown; massively bedded; with 40% fine to medium grained sand, of quartz and salt (?) ; moderately well cemented; calcite veins, typically vertical, 20-30mm long, 5-20mm wide, <20% of area; moist.	Fr		100	100	0		11	10.09 m: DB 10.19 m: DB	Bentonite	11
												100	100	0		19	10.46 m: DB 10.65 m: DB 11.0 m: DB 11.35 m: DB	Gravel	
12																	11.9 m: DB		12

STANDPIPE PIEZOMETER LOG
*** ROCK CORE FORMAT ***

Borehole No.: **BH05**

Sheet 4 of 4

Client: K + S Salt Australia Pty Ltd
Project: Ashburton Solar Salt Project
Phase 2 Site Investigation
Job No.: 12516706

Coordinates: **E** 266 675, **N** 7578 586
Ground Surface Elevation: +0.7m AHD **Total Depth:** 15.0m
Commenced: 14-Jan-20 **Completed:** 17-Jan-20
Contractor: J&S Drilling **Driller:** Alan

Rig Type : Jacro 350 drill rig on Mangrove Buggy **Inclination:** Vertical
Drilling Fluid: Various
Core Diameter (mm): 85

Logged:	SD	17-Jan-20
Processed:	DCH	20-Oct-20
Checked:		

Depth Scale (m)	Daily Progress/ Observations: Date	Casing Depth (m)	Fluid Depth (m)	Drilling Method	Water	Depth (m)/ [Elev.]	Geological Unit	Graphic Log	Strata Description (Rocktype; grain size; texture & structure; colour; strength; fracture condition; minor constituents)	Weathering/ Cementation	Estimated Rock Strength (VL L M H VH EH)	Rock Core Quality: TCR (%)	RQD (%)	F (fractures/m)	Defect Log	Drill Rate (min/m)	Defect Description & Comments	Piezometer Components	Depth Scale (m)
13	16-01			PQ Coring			Qsed		At 11.95 m: 3 mm thick lamination, undulating, of crystalline gypsum. Calcareous CLAYSTONE Brown; massively bedded; with 40% fine to medium grained sand, of quartz and salt (?) ; moderately well cemented; calcite veins, typically vertical, 20-30mm long, 5-20mm wide, <20% of area; moist. At 12.21, 12.28, 12.42, 12.45, 12.69, 12.77, 13.25, 13.61, 14.28, 14.45 and 14.55 m: 1 mm thick laminations of gypsum, undulating, discontinuous, subhorizontal.	Fr		100	100	0		19	12.37 m: DB 12.56 m: DB 12.6 m: DB 13.0 m: DB 13.28 m: DB 13.4 m: DB	Slotted pipe Gravel	13
14	17-01											100	100	0		11	13.77 m: DB 14.43 m: DB 14.85 m: DB 14.96 m: DB		14
15	17-01					15.0 [-14.25] [-14.30]			SANDSTONE Fine to medium grained, angular, of quartz and iron oxides, brown; massively bedded; non-calcareous; moist. Termination Depth = 15.00m										15
16																			16
17																			17
18																			18

COREHOLE 12516706 GINT.GPJ GHDLIB.GDT 20-10-20

STANDPIPE PIEZOMETER LOG

Borehole No.: **BH05A**

Sheet 1 of 2

Client: K + S Salt Australia Pty Ltd
Project: Ashburton Solar Salt Project
Phase 2 Site Investigation
Job No.: 12516706

Coordinates: **E** 266 675, **N** 7578 587
Ground Surface Elevation: +0.7m AHD **Total Depth:** 5.0m
Commenced: 14-Jan-20 **Completed:** 17-Jan-20
Contractor: J&S Drilling **Driller:** Alan

Rig Type : Jacro 350 drill rig on Mangrove Buggy **Inclination:** Vertical
Flushing Fluid: Polymer
Hole Diameter (mm): 123

Logged:	SD	17-Jan-20
Processed:	DCH	20-Oct-20
Checked:		

Depth Scale (m)	Daily Progress/ Observations: Date	Casing Depth (m)	Fluid Depth (m)	Drilling Method	Water	Depth (m)/ [Elev.]	Geological Unit	Graphic Log	Classification	Strata Description (type; colour; fines plasticity or particle characteristics; minor components; structure and/or origin)	Moisture Condition	Consistency/ Relative Density	Sample Type & Depth	Sample No.	Sample/ Test Records & Comments	Piezometer Components	Depth Scale (m)
1				PQ Coring											Standpipe piezometer installed ~1 m away from BH05.	Above ground cover; Bentonite; Gravel; Slotted pipe	1
2																	2
3																Bentonite	3
4																	4
5						5.0											5

GENERAL LOG 12516706 GINT.GPJ GHDLIB.GDT 20-10-20

STANDPIPE PIEZOMETER LOG

Borehole No.: **BH05A**

Sheet 2 of 2

Client: K + S Salt Australia Pty Ltd
Project: Ashburton Solar Salt Project
Phase 2 Site Investigation
Job No.: 12516706

Coordinates: **E** 266 675, **N** 7578 587
Ground Surface Elevation: +0.7m AHD **Total Depth:** 5.0m
Commenced: 14-Jan-20 **Completed:** 17-Jan-20
Contractor: J&S Drilling **Driller:** Alan

Rig Type : Jacro 350 drill rig on Mangrove Buggy **Inclination:** Vertical
Flushing Fluid: Polymer
Hole Diameter (mm): 123

Logged:	SD	17-Jan-20
Processed:	DCH	20-Oct-20
Checked:		

Depth Scale (m)	Daily Progress/ Observations: Date	Casing Depth (m)	Fluid Depth (m)	Drilling Method	Water	Depth (m)/ [Elev.]	Geological Unit	Graphic Log	Classification	Strata Description (type; colour; fines plasticity or particle characteristics; minor components; structure and/or origin)	Moisture Condition	Consistency/ Relative Density	Sample Type & Depth	Sample No.	Sample/ Test Records & Comments	Piezometer Components	Depth Scale (m)
						[-4.30]											
6																	6
7																	7
8																	8
9																	9
10																	10

STANDPIPE PIEZOMETER LOG

Borehole No.: **BH05B**

Sheet 1 of 2

Client: K + S Salt Australia Pty Ltd
Project: Ashburton Solar Salt Project
Phase 2 Site Investigation
Job No.: 12516706

Coordinates: **E** 266 676, **N** 7578 588
Ground Surface Elevation: +0.7m AHD **Total Depth:** 16.0m
Commenced: 22-Mar-20 **Completed:** 22-Mar-20
Contractor: J&S Drilling **Driller:** Trevor

Rig Type : Jacro 350 drill rig on Mangrove Buggy **Inclination:** Vertical
Flushing Fluid: Bentonite
Hole Diameter (mm): 150

Logged:	SD	22-Mar-20
Processed:	WR	20-Oct-20
Checked:		

Depth Scale (m)	Daily Progress/ Observations: Date	Casing Depth (m)	Fluid Depth (m)	Drilling Method	Water	Depth (m)/ [Elev.]	Geological Unit	Graphic Log	Classification	Strata Description (type; colour; fines plasticity or particle characteristics; minor components; structure and/or origin)	Moisture Condition	Consistency/ Relative Density	Sample Type & Depth	Sample No.	Sample/ Test Records & Comments	Piezometer Components	Depth Scale (m)
1				Wash Boring												Above ground cover	1
2																Grout	2
3																Bentonite 100 mm PVC Pipe	3
4																Gravel	4
5																	5
6																Slotted Pipe	6
7																	7
8																	8
9																	9
10																	10

STANDPIPE PIEZOMETER LOG

Borehole No.: **BH05B**

Sheet 2 of 2

Client: K + S Salt Australia Pty Ltd
Project: Ashburton Solar Salt Project
Phase 2 Site Investigation
Job No.: 12516706

Coordinates: **E** 266 676, **N** 7578 588
Ground Surface Elevation: +0.7m AHD **Total Depth:** 16.0m
Commenced: 22-Mar-20 **Completed:** 22-Mar-20
Contractor: J&S Drilling **Driller:** Trevor

Rig Type : Jacro 350 drill rig on Mangrove Buggy **Inclination:** Vertical
Flushing Fluid: Bentonite
Hole Diameter (mm): 150

Logged:	SD	22-Mar-20
Processed:	WR	20-Oct-20
Checked:		

Depth Scale (m)	Daily Progress/ Observations: Date	Casing Depth (m)	Fluid Depth (m)	Drilling Method	Water	Depth (m)/ [Elev.]	Geological Unit	Graphic Log	Classification	Strata Description (type; colour; fines plasticity or particle characteristics; minor components; structure and/or origin)	Moisture Condition	Consistency/ Relative Density	Sample Type & Depth	Sample No.	Sample/ Test Records & Comments	Piezometer Components	Depth Scale (m)
11				Wash Boring													11
12																	12
13																	13
14																	14
15																Backfill	15
16						16.0 [-15.30]											16
17																	17
18																	18
19																	19
20																	20

STANDPIPE PIEZOMETER LOG

Borehole No.: **BH07**

Sheet 1 of 4

Client: K + S Salt Australia Pty Ltd
Project: Ashburton Solar Salt Project
Phase 2 Site Investigation
Job No.: 12516706

Coordinates: **E** 262 938, **N** 7573 345
Ground Surface Elevation: +1.8m AHD **Total Depth:** 16.5m
Commenced: 11-Mar-20 **Completed:** 14-Mar-20
Contractor: J&S Drilling **Driller:** Trevor

Rig Type : Jacro 350 drill rig on Mangrove Buggy **Inclination:** Vertical
Flushing Fluid: Water to 5 m, then Polymer
Hole Diameter (mm): 123

Logged:	SG	14-Mar-20
Processed:	WR	20-Oct-20
Checked:		

Depth Scale (m)	Daily Progress/ Observations: Date	Casing Depth (m)	Fluid Depth (m)	Drilling Method	Water	Depth (m)/ [Elev.]	Geological Unit	Graphic Log	Classification	Strata Description (type; colour; fines plasticity or particle characteristics; minor components; structure and/or origin)	Moisture Condition	Consistency/ Relative Density	Sample Type & Depth	Sample No.	Sample/ Test Records & Comments	Piezometer Components	Depth Scale (m)
0	11-03			PQ		0.0	Qt		SM	Carbonate Silty SAND Fine to coarse grained, sub-rounded to sub-angular, of quartz; pale brown; silt is non-plastic; trace clay; trace gravel, fine grained, angular of gypsum and shells.	D	L	0.00	S	0.0 SPT: 2, 3, 4 [N=7] 82% Recovery, D01 Strong HCl reaction MC: Material Characterisation	Above ground cover	0
										From 0.5 m: With medium grained gravel sized shell fragments.	M						
1						1.0 [+0.80]			SC	Carbonate Clayey SAND Fine to coarse grained, sub-rounded to sub-angular, of quartz; pale brown; non-plastic to low plasticity fines; with gravel and sand sized shell fragments.		MD-L			1.0 m: MC sample		1
						1.5 [+0.30]			SM	Carbonate Silty Gravelly SAND Fine to coarse grained, sub-rounded to sub-angular, of quartz; pale brown; gravel is fine to medium grained, angular, of calcarenite (weakly cemented); silt is non-plastic; with gravel sized shells.	W	MD	1.50	S	1.5 SPT: 6, 4, 5 [N=9] 100% Recovery, D02		
2						2.6 [-0.80]			SC/SM	Carbonate Clayey/Silty SAND Fine to medium grained, of carbonate; pale brown; clay/silt is low plasticity, red/brown; trace sand, coarse grained, of shell fragments; with gravel, of calcarenite (weakly cemented).	M				ASS samples recovered at 0.25m, 0.5m, 0.75m, 1.0m, 1.25m, 1.5m, 1.75m, 2.0m, 2.25m, 2.5m, 2.75m, 3.0m, 3.25m, 3.5m, 3.75m, 4.0m, 4.25m, 4.5m, 4.75m, 5.0m.	Solid Pipe	2
						3.0 [-1.20]			SC	Clayey SAND Fine to medium grained; red-brown; clay is low plastic; calcareous.			3.00	S	3.0 SPT: 4, 9, 10 [N=19] 93% Recovery, D03 Slight HCl reaction, almost sandy clay 3.5-4.0 m. 3.5 m: ASS QA sample	Grout	
3						3.5 [-1.70]			SM	Carbonate Silty SAND Fine to medium grained; red-brown; silt is non-plastic; with gravel, fine to medium grained, of calcarenite (weakly to moderately cemented).							3
4													4.50	S	4.5 SPT: 7, 10, 14 [N=24] 89% Recovery, D04		4
5						5.0											5

STANDPIPE PIEZOMETER LOG

Borehole No.: **BH07**

Client: K + S Salt Australia Pty Ltd
Project: Ashburton Solar Salt Project
Phase 2 Site Investigation
Job No.: 12516706

Coordinates: **E** 262 938, **N** 7573 345
Ground Surface Elevation: +1.8m AHD **Total Depth:** 16.5m
Commenced: 11-Mar-20 **Completed:** 14-Mar-20
Contractor: J&S Drilling **Driller:** Trevor

Rig Type : Jacro 350 drill rig on Mangrove Buggy **Inclination:** Vertical
Flushing Fluid: Water to 5 m, then Polymer
Hole Diameter (mm): 123

Logged:	SG	14-Mar-20
Processed:	WR	20-Oct-20
Checked:		

Depth Scale (m)	Daily Progress/ Observations: Date	Casing Depth (m)	Fluid Depth (m)	Drilling Method	Water	Depth (m)/ [Elev.]	Geological Unit	Graphic Log	Classification	Strata Description (type; colour; fines plasticity or particle characteristics; minor components; structure and/or origin)	Moisture Condition	Consistency/ Relative Density	Sample Type & Depth	Sample No.	Sample/ Test Records & Comments	Piezometer Components	Depth Scale (m)
6				PQ		[-3.20]	Qt		SM	Carbonate Silty SAND Fine to medium grained; red-brown; silt is non-plastic; with gravel, fine to medium grained, of calcarenite (weakly to moderately cemented); trace gravel, fine grained of non-intact shells.	M	MD	6.00	S	6.0 SPT: 6, 8, 8 [N=16] 100% Recovery, D05 From 6.5 m: Strong HCl reaction		6
7						7.7 [-5.90]	Qsed		Cl	Carbonate Sandy CLAY Medium plasticity; red-brown; sand is fine to medium grained. At 7.7m: 2mm thick layer of shells	W>PL	VSt-H	7.50	S	7.5 SPT: 9, 11, 19 [N=30] 93% Recovery, D06	Solid Pipe	7
8																Grout	8
9	11-03 12-03					9.0 [-7.20]			CH	Sandy CLAY High plasticity; red-brown; sand is fine to medium grained; calcareous.		VSt	9.00	S	9.0 m: MC sample 9.0 SPT: 8, 11, 16 [N=27] 87% Recovery, D07		9
10						9.5 [-7.70] 10.0			CL-Cl	Sandy CLAY Low to medium plasticity; red-brown; sand is fine to medium grained; with gravel; fine to medium grained, sub-rounded to sub-angular, weakly cemented gravel; calcareous.	W~PL	H				Bentonite	10

STANDPIPE PIEZOMETER LOG

Borehole No.: **BH07**

Sheet 3 of 4

Client: K + S Salt Australia Pty Ltd
Project: Ashburton Solar Salt Project
Phase 2 Site Investigation
Job No.: 12516706

Coordinates: **E** 262 938, **N** 7573 345
Ground Surface Elevation: +1.8m AHD **Total Depth:** 16.5m
Commenced: 11-Mar-20 **Completed:** 14-Mar-20
Contractor: J&S Drilling **Driller:** Trevor

Rig Type : Jacro 350 drill rig on Mangrove Buggy **Inclination:** Vertical
Flushing Fluid: Water to 5 m, then Polymer
Hole Diameter (mm): 123

Logged:	SG	14-Mar-20
Processed:	WR	20-Oct-20
Checked:		

Depth Scale (m)	Daily Progress/ Observations: Date	Casing Depth (m)	Fluid Depth (m)	Drilling Method	Water	Depth (m)/ [Elev.]	Geological Unit	Graphic Log	Classification	Strata Description (type; colour; fines plasticity or particle characteristics; minor components; structure and/or origin)	Moisture Condition	Consistency/ Relative Density	Sample Type & Depth	Sample No.	Sample/ Test Records & Comments	Piezometer Components	Depth Scale (m)
						[-8.20]			CL-Cl	Sandy CLAY Low to medium plasticity; red-brown; sand is fine to medium grained; with gravel; fine to medium grained, sub-rounded to sub-angular, weakly cemented gravel; calcareous.	W~PL	H			From 10.0 m: Slight HCl reaction	Solid Pipe	
													10.50	S	10.5 SPT: 16, 30, 47 [N=77] 58% recovery, D08	Gravel	
11						11.4											11
						[-9.60]			CL	Sandy Gravelly CLAY Low plasticity; red-brown; sand is fine to medium grained, sub-angular, gravel is fine grained, sub-angular, black.	W<PL						
12													12.00	S	12.0 SPT: 20, 48, 14/30 mm [N=R] 67% Recovery, D09 30 blows for >100mm peneration.	Slotted Pipe	12
				PQ			Qsed			12.5 to 13.0 m: Gravel is fine to medium grained, sub-rounded of quartz.							
13						13.3											13
						[-11.45]				Coreloss: 13.25 to 13.5 m.	-						
						13.5											
						[-11.70]			CL	Sandy Gravelly CLAY Low plasticity; red-brown; sand is fine to medium grained, sub-angular, gravel is fine grained, black, weakly cemented.	W<PL		13.50	S	13.5 SPT: 33, 30/90 mm, * [N=R] 104% Recovery 30 blows for >100mm peneration		
	12-03															Bentonite	
	14-03																
14																	14
																Gravel	
15						15.0											15

STANDPIPE PIEZOMETER LOG

Borehole No.: **BH07**

Sheet 4 of 4

Client: K + S Salt Australia Pty Ltd
Project: Ashburton Solar Salt Project
Phase 2 Site Investigation
Job No.: 12516706

Coordinates: **E** 262 938, **N** 7573 345
Ground Surface Elevation: +1.8m AHD **Total Depth:** 16.5m
Commenced: 11-Mar-20 **Completed:** 14-Mar-20
Contractor: J&S Drilling **Driller:** Trevor

Rig Type : Jacro 350 drill rig on Mangrove Buggy **Inclination:** Vertical
Flushing Fluid: Water to 5 m, then Polymer
Hole Diameter (mm): 123

Logged:	SG	14-Mar-20
Processed:	WR	20-Oct-20
Checked:		

Depth Scale (m)	Daily Progress/ Observations: Date	Casing Depth (m)	Fluid Depth (m)	Drilling Method	Water	Depth (m)/ [Elev.]	Geological Unit	Graphic Log	Classification	Strata Description (type; colour; fines plasticity or particle characteristics; minor components; structure and/or origin)	Moisture Condition	Consistency/ Relative Density	Sample Type & Depth	Sample No.	Sample/ Test Records & Comments	Piezometer Components	Depth Scale (m)
16				PQ		[-13.20]	Qsed		CL	Sandy Gravelly CLAY Low plasticity; red-brown; sand is fine to medium grained, sub-angular; gravel is fine grained, sub-angular, black, weakly cemented. From 15.5 m: Becoming red-brown with minor pale grey mottling.			15.00	S	15.0 SPT: 23, 44, 61 [N=105] 67% Recovery At 15.0 m: No HCl reaction	Gravel	16
	14-03					16.4 [-14.60]				Coreloss: 16.4 to 16.5 m.	-						
17						16.5 [-14.70]				Termination Depth = 16.50m (Target Depth)							17
18																	18
19																	19
20																	20

STANDPIPE PIEZOMETER LOG

Borehole No.: **BH07A**

Sheet 1 of 1

Client: K + S Salt Australia Pty Ltd
Project: Ashburton Solar Salt Project
Phase 2 Site Investigation
Job No.: 12516706

Coordinates: **E** 262 938, **N** 7573 346
Ground Surface Elevation: +1.8m AHD **Total Depth:** 7.7m
Commenced: 14-Mar-20 **Completed:** 14-Mar-20
Contractor: J&S Drilling **Driller:** Trevor

Rig Type : Jacro 350 drill rig on Mangrove Buggy **Inclination:** Vertical
Flushing Fluid: Polymer
Hole Diameter (mm): 123

Logged:	SG	14-Mar-20
Processed:	WR	20-Oct-20
Checked:		

Depth Scale (m)	Daily Progress/ Observations: Date	Casing Depth (m)	Fluid Depth (m)	Drilling Method	Water	Depth (m)/ [Elev.]	Geological Unit	Graphic Log	Classification	Strata Description (type; colour; fines plasticity or particle characteristics; minor components; structure and/or origin)	Moisture Condition	Consistency/ Relative Density	Sample Type & Depth	Sample No.	Sample/ Test Records & Comments	Piezometer Components	Depth Scale (m)
0	14-03			PQ Coring												Above ground cover	0
1																Solid Pipe Bentonite	1
2																	2
3																	3
4																Slotted Pipe Gravel	4
5																	5
6																Slotted Pipe	6
7																Gravel	7
	14-03					7.7 [-5.90]											
8																	8
9																	9
10																	10

GENERAL LOG 12516706 GINT.GPJ GHDLIB.GDT 20-10-20

STANDPIPE PIEZOMETER LOG

Borehole No.: **BH07B**

Sheet 1 of 1

Client: K + S Salt Australia Pty Ltd
Project: Ashburton Solar Salt Project
Phase 2 Site Investigation
Job No.: 12516706

Coordinates: **E** 262 938, **N** 7573 347
Ground Surface Elevation: +1.8m AHD **Total Depth:** 9.4m
Commenced: 15-Mar-20 **Completed:** 15-Mar-20
Contractor: J&S Drilling **Driller:** Trevor

Rig Type : Jacro 350 drill rig on Mangrove Buggy **Inclination:** Vertical
Flushing Fluid: Bentonite
Hole Diameter (mm): 150

Logged:	SG	15-Mar-20
Processed:	WR	20-Oct-20
Checked:		

Depth Scale (m)	Daily Progress/ Observations: Date	Casing Depth (m)	Fluid Depth (m)	Drilling Method	Water	Depth (m)/ [Elev.]	Geological Unit	Graphic Log	Classification	Strata Description (type; colour; fines plasticity or particle characteristics; minor components; structure and/or origin)	Moisture Condition	Consistency/ Relative Density	Sample Type & Depth	Sample No.	Sample/ Test Records & Comments	Piezometer Components	Depth Scale (m)
0	15-03			Wash Boring												Above ground cover	0
1																Grout	1
2																Solid Pipe	2
3																Bentonite	3
4																	4
5																	5
6																Slotted Pipe	6
7																	7
8																	8
9	15-03					9.4 [-7.60]										Solid Pipe	9
10																	10

STANDPIPE PIEZOMETER LOG

Borehole No.: **BH08**

Sheet 1 of 3

Client: K + S Salt Australia Pty Ltd
Project: Ashburton Solar Salt Project
Phase 2 Site Investigation
Job No.: 12516706

Coordinates: **E** 263 029, **N** 7573 316
Ground Surface Elevation: +5.5m AHD **Total Depth:** 15.0m
Commenced: 15-Mar-20 **Completed:** 17-Mar-20
Contractor: J&S Drilling **Driller:** Trevor

Rig Type : Jacro 350 drill rig on Mangrove Buggy **Inclination:** Vertical
Flushing Fluid: Water to 5 m, then Polymer
Hole Diameter (mm): 123

Logged:	SG	17-Mar-20
Processed:	WR	20-Oct-20
Checked:		

Depth Scale (m)	Daily Progress/ Observations: Date	Casing Depth (m)	Fluid Depth (m)	Drilling Method	Water	Depth (m)/ [Elev.]	Geological Unit	Graphic Log	Classification	Strata Description (type; colour; fines plasticity or particle characteristics; minor components; structure and/or origin)	Moisture Condition	Consistency/ Relative Density	Sample Type & Depth	Sample No.	Sample/ Test Records & Comments	Piezometer Components	Depth Scale (m)
0	15-03			PQ			Qe		SM	Carbonate Silty SAND Fine to medium grained, of carbonate; pale orange-brown; silt is non-plastic.	M	VL	0.00	S	0.0 SPT: 0, 2, 4 [N=6] SPT sunk under weight of hammers	Above ground cover Concrete	0
											D	L			0.0-0.2 m: With organics; strong HCl reaction 0.2-0.9 m: Trace organics.		
1											M						1
													1.50	S	1.5 SPT: 14, 19, 17 [N=36]	Grout	
2										From 2.1 m: Becoming gravelly, fine to medium grained, sub-angular of calcrete (weakly $CaCo_3$ cemented calcarenite).					ASS samples recovered at 0.25m, 0.5m, 0.75m, 1.0m, 1.25m, 1.5m, 1.75m, 2.0m, 2.25m, 2.5m, 2.75m, 3.0m, 3.25m, 3.5m, 3.75m, 4.0m, 4.25m, 4.5m, 4.75m, 5.0m.	Solid Pipe	2
						2.8 [+2.70]				Core loss: 2.8 to 3.0 m.	-						
3						3.0 [+2.50]			SM	Carbonate Silty SAND Fine to medium grained, of carbonate; pale orange-brown; silt is non-plastic.	M	L-MD	3.00	S	3.0 SPT: 4, 4, 6 [N=10]		3
	15-03																
	16-03															Bentonite	
4										From 4.0 m: With fine to medium gravel sized shells.							4
												MD	4.50	S	4.5 SPT: 7, 10, 8 [N=18]	Gravel	
5						5.0											5

STANDPIPE PIEZOMETER LOG

Borehole No.: **BH08**

Sheet 2 of 3

Client: K + S Salt Australia Pty Ltd
Project: Ashburton Solar Salt Project
Phase 2 Site Investigation
Job No.: 12516706

Coordinates: **E** 263 029, **N** 7573 316
Ground Surface Elevation: +5.5m AHD **Total Depth:** 15.0m
Commenced: 15-Mar-20 **Completed:** 17-Mar-20
Contractor: J&S Drilling **Driller:** Trevor

Rig Type : Jacro 350 drill rig on Mangrove Buggy **Inclination:** Vertical
Flushing Fluid: Water to 5 m, then Polymer
Hole Diameter (mm): 123

Logged:	SG	17-Mar-20
Processed:	WR	20-Oct-20
Checked:		

Depth Scale (m)	Daily Progress/ Observations: Date	Casing Depth (m)	Fluid Depth (m)	Drilling Method	Water	Depth (m)/ [Elev.]	Geological Unit	Graphic Log	Classification	Strata Description (type; colour; fines plasticity or particle characteristics; minor components; structure and/or origin)	Moisture Condition	Consistency/ Relative Density	Sample Type & Depth	Sample No.	Sample/ Test Records & Comments	Piezometer Components	Depth Scale (m)
6				PQ		[+0.50]	Qe		SM	Carbonate Silty SAND Fine to medium grained, of carbonate; pale orange-brown; silt is non-plastic; with gravel, fine to coarse grained, sub-angular of calcrete (weakly $CaCO_3$ cemented calcarenite).	M	L-MD					6
						6.5 [-1.00]				Core loss: 6.5 to 7.0 m Inferred as Silty SAND	-	VL	6.00	S	6.0 SPT: 2, 1, 1 [N=2] SPT material recovered in core 0% Recovery 6.5-6.95 m: Pushed sample tube and it returned empty.		
7						7.0 [-1.50]			SM	Carbonate Silty SAND Fine to medium grained, of carbonate; pale orange-brown; silt is non-plastic; with gravel, fine to coarse grained, sub-angular of calcrete (weakly CaCO3 cemented calcarenite).	M	MD					7
						7.5 [-2.00]			SC	From 7.3 m: Becoming red/brown with thin white bands. Carbonate Clayey SAND Fine to medium grained, of carbonate; red-brown; clay has low plasticity; trace gravel, fine grained.			7.50	S	7.5 SPT: 9, 8, 10 [N=18]	Gravel	
8										From 8.3m: Loss of gravel.						Slotted Pipe	8
9													9.00	S	9.0 SPT: 8, 11, 9 [N=20]		9
10						10.0				From 9.5 m: Increasing sand content.							10

STANDPIPE PIEZOMETER LOG

Borehole No.: **BH08**

Sheet 3 of 3

Client: K + S Salt Australia Pty Ltd
Project: Ashburton Solar Salt Project
Phase 2 Site Investigation
Job No.: 12516706

Coordinates: **E** 263 029, **N** 7573 316
Ground Surface Elevation: +5.5m AHD **Total Depth:** 15.0m
Commenced: 15-Mar-20 **Completed:** 17-Mar-20
Contractor: J&S Drilling **Driller:** Trevor

Rig Type : Jacro 350 drill rig on Mangrove Buggy **Inclination:** Vertical
Flushing Fluid: Water to 5 m, then Polymer
Hole Diameter (mm): 123

Logged:	SG	17-Mar-20
Processed:	WR	20-Oct-20
Checked:		

Depth Scale (m)	Daily Progress/ Observations: Date	Casing Depth (m)	Fluid Depth (m)	Drilling Method	Water	Depth (m)/ [Elev.]	Geological Unit	Graphic Log	Classification	Strata Description (type; colour; fines plasticity or particle characteristics; minor components; structure and/or origin)	Moisture Condition	Consistency/ Relative Density	Sample Type & Depth	Sample No.	Sample/ Test Records & Comments	Piezometer Components	Depth Scale (m)
						[-4.50]			SC	Carbonate Clayey SAND Fine to medium grained, of carbonate; red-brown; clay has low plasticity.						Bentonite	
						10.4	Qe										
						[-4.90]			CL	Sandy CLAY Low plasticity; red-brown; sand is fine to medium grained, of carbonate.	W<PL	H	10.50	S	10.5 SPT: 16, 27, 33 [N=60] Swapped drill bit.		
11						11.3											11
						[-5.80]			SC	Carbonate Clayer SAND Fine to medium grained, of carbonate; red-brown; clay is non-plastic; weakly cemented.	D-M	D					
						11.8											
						[-6.30]			GC	Clayey Sandy GRAVEL Fine to coarse grained, rounded, mixed lithology of quartz, Banded Iron Formation & chert; sand is fine to medium grained; clay has low plasticity.	M		12.00	S	12.0 SPT: 14, 20, 23 [N=43]		
12																	12
				PQ			Qsed									Gravel	
	16-03														12.45-13.25 m: Fines grained sand washing out, returning as gravel. Inferred Clayey Sandy GRAVEL		
13	17-03					13.3											13
						[-7.75]				Core loss: 13.25 to 13.5 m	-						
						13.5											
						[-8.00]			GP	Sandy GRAVEL Fine to medium grained, rounded mixed lithology, sand is medium to coarse grained (red-brown-black to white gravel) with fines.	M	VD	13.50	S	13.5 SPT: 10, 45, 22 [N=67]		
						13.8											
						[-8.30]			CL-CI	Sandy CLAY Low to medium plasticity; red-brown; sand is fine to medium grained.	W<PL	H					
14						14.0											14
						[-8.50]				Core loss: 14.0 to 14.5 m Inferred as Sandy CLAY.							
						14.5											
						[-9.00]			CI	Sandy CLAY Medium plasticity; red/brown; sand is fine to medium grained; with gravel, fine grained, sub-rounded.	W~PL		14.50	S	14.5 SPT: 10, 30, 43 [N=73]		
	17-03					15.0											
15						[-9.45]				Termination Depth = 14.95m (Target Depth)							15

BOREHOLE LOG

Borehole No.: **BH09**

Sheet 1 of 5

Client: K + S Salt Australia Pty Ltd
Project: Ashburton Solar Salt Project
Phase 2 Site Investigation
Job No.: 12516706

Coordinates: **E** 268 003, **N** 7572 193
Ground Surface Elevation: +3.5m AHD **Total Depth:** 20.3m
Commenced: 20-Jan-20 **Completed:** 23-Jan-20
Contractor: J&S Drilling **Driller:** Brian

Rig Type : Jacro 350 drill rig on Mangrove Buggy **Inclination:** Vertical
Flushing Fluid: Water
Hole Diameter (mm): 180

Logged:	SD/DO	23-Jan-20
Processed:	DCH	20-Oct-20
Checked:		

Depth Scale (m)	Daily Progress/ Observations: Date	Casing Depth (m)	Fluid Depth (m)	Drilling Method	Water	Depth (m)/ [Elev.]	Geological Unit	Graphic Log	Classification	Strata Description (type; colour; fines plasticity or particle characteristics; minor components; structure and/or origin)	Moisture Condition	Consistency/ Relative Density	Sample Type & Depth	Sample No.	Sample/ Test Records & Comments
0	20-01			Hollow Stem Auger			Qe		SP-SC	SAND Fine to medium grained, sub-angular to sub-rounded, of quartz; red-brown; with clay, non-plastic; calcareous; very weakly cemented.	D	L			Monitoring well BH09A installed approximately 4 m north of BH09 location.
						0.8 [+2.70]			CH	At 0.75 m, nodules up to 10 mm, moderately cemented.	W>PL	S-F			
1						1.0 [+2.50]				Sandy CLAY High plasticity; brown; sand is fine to medium-grained, sub-angular to sub-rounded, of quartz; trace gravel, fine grained, sub-angular of calcrete; Calcareous.					1.25 m: quality assurance sample (QA03).
						1.5 [+2.00]				1.0-1.5 m: CORE LOSS Inferred as above.					
									CH	Sandy CLAY High plasticity; brown; sand is fine to medium-grained, sub-angular to sub-rounded, of quartz; trace gravel, fine grained, sub-angular of calcrete; moderately cemented Calcareous.		VS	1.50	S	1.5 SPT: 1, 0, 2 [N=2] D01 100% Recovery
2										2.0 m, becoming CLAY with sand.		S-F			
										2.25 m, loss of gravel, only slight calcareous reaction.					Calcrete is of calcareously moderately cemented mudstone.
							Czp					F			
3										3.0 m, becoming Sandy CLAY.			3.00	S	3.0 SPT: 3, 5, 6 [N=11] D02 100% Recovery
						4.0 [-0.50]				4.0-4.5 m: CORE LOSS Inferred as above.					
4						4.5 [-1.00]			CH	Sandy CLAY, as above.			4.50	S	4.5 SPT: 6, 5, 8 [N=13] D03 100% Recovery At 4.5 m: water added to auger drilling method.
5						5.0									

BOREHOLE LOG

Borehole No.: **BH09**

Sheet 2 of 5

Client: K + S Salt Australia Pty Ltd
Project: Ashburton Solar Salt Project
Phase 2 Site Investigation
Job No.: 12516706

Coordinates: **E** 268 003, **N** 7572 193
Ground Surface Elevation: +3.5m AHD **Total Depth:** 20.3m
Commenced: 20-Jan-20 **Completed:** 23-Jan-20
Contractor: J&S Drilling **Driller:** Brian

Rig Type : Jacro 350 drill rig on Mangrove Buggy **Inclination:** Vertical
Flushing Fluid: Water
Hole Diameter (mm): 180

Logged:	SD/DO	23-Jan-20
Processed:	DCH	20-Oct-20
Checked:		

Depth Scale (m)	Daily Progress/ Observations: Date	Casing Depth (m)	Fluid Depth (m)	Drilling Method	Water	Depth (m)/ [Elev.]	Geological Unit	Graphic Log	Classification	Strata Description (type; colour; fines plasticity or particle characteristics; minor components; structure and/or origin)	Moisture Condition	Consistency/ Relative Density	Sample Type & Depth	Sample No.	Sample/ Test Records & Comments	Depth Scale (m)
6				Hollow Stem Auger		[-1.50]	Czp		CH	Sandy CLAY High plasticity; brown; sand is fine to medium-grained, sub-angular to sub-rounded, of quartz; trace gravel, fine grained, sub-angular of calcrete; moderately cemented; calcareous.	W>PL		6.00	S	6.0 SPT: 6, 7, 10 [N=17] D04 89% Recovery At 6.0 m, driller notes stiff material at depth	6
						6.5 [-2.95]				6.45-6.75 m: CORE LOSS Inferred as above.						
						6.8 [-3.25]			CH	Sandy CLAY High plasticity; brown; sand is fine to medium-grained, sub-angular to sub-rounded, of quartz; trace gravel, fine grained, sub-angular of calcrete; moderately cemented; calcareous. 7.0 m, non-calcareous.	W~PL W>PL					
7										7.4-7.5 m, trace gravel, medium grained, rounded, of quartz. 7.5 m, becoming CLAY with Sand.	W<PL W>PL	St F	7.50	S	7.5 SPT: 9, 10, 14 [N=24] D05 100% Recovery	7
8										8.0-8.1 m, calcareous, trace gravel, fine grained of calcrete; moderately cemented.	W~PL W>PL W~PL	F-St				8
9						9.5 [-5.95]			CH	8.9 m, becoming CLAY; trace sand.	W<PL	St	9.00	S	9.0 SPT: 10, 14, 21 [N=35] D06 100% Recovery	9
	20-01 21-01						Qsed		CI	Sandy CLAY Medium plasticity; brown; sand is fine to medium-grained, sub-angular to sub-rounded.	W<PL	H	9.75	S	9.8 SPT: 14, 17, 27 [N=44] 91% Recovery, D07	
10																10

BOREHOLE LOG

Borehole No.: **BH09**

Sheet 3 of 5

Client: K + S Salt Australia Pty Ltd
Project: Ashburton Solar Salt Project
Phase 2 Site Investigation
Job No.: 12516706

Coordinates: **E** 268 003, **N** 7572 193
Ground Surface Elevation: +3.5m AHD **Total Depth:** 20.3m
Commenced: 20-Jan-20 **Completed:** 23-Jan-20
Contractor: J&S Drilling **Driller:** Brian

Rig Type : Jacro 350 drill rig on Mangrove Buggy **Inclination:** Vertical
Flushing Fluid: Water
Hole Diameter (mm): 180

Logged:	SD/DO	23-Jan-20
Processed:	DCH	20-Oct-20
Checked:		

Depth Scale (m)	Daily Progress/ Observations: Date	Casing Depth (m)	Fluid Depth (m)	Drilling Method	Water	Depth (m)/ [Elev.]	Geological Unit	Graphic Log	Classification	Strata Description (type; colour; fines plasticity or particle characteristics; minor components; structure and/or origin)	Moisture Condition	Consistency/ Relative Density	Sample Type & Depth	Sample No.	Sample/ Test Records & Comments
									CI	Sandy CLAY Medium plasticity; brown; sand is fine to medium-grained, sub-angular to sub-rounded.	W<PL	H	9.75	S	9.8 SPT: 14, 17, 27 [N=44] 91% Recovery, D07
									CI-CH	10.5 m: fines becoming medium to high plasticity.					
11						11.0 [-7.50]			SC	Clayey SAND Fine to medium grained, sub-angular to sub-rounded; brown; low plasticity fines; non-calcareous; uncemented.	M-W	D	11.00	S	11.0 SPT: 14, 19, 22 [N=41] 100% Recovery, D08
12				Hollow Stem Auger		12.2 [-8.65]	Qsed			12.15-12.5 m: CORE LOSS Inferred as above.					
						12.5 [-9.00]			SC	Clayey SAND Fine to medium grained, sub-angular to sub-rounded; brown; low plasticity fines; non-calcareous; uncemented.			12.50	S	12.5 SPT: 8, 13, 21 [N=34] 100% Recovery, D09
13										13.0 m: fines becoming medium plasticity.					
						13.3 [-9.75]			SP-SC	13.2 m: with gravel, coarse grained, sub-rounded of calcrete. SAND Fine to medium grained, sub-angular to sub-rounded; brown; with clay, non-plastic; non-calcareous; uncemented.	W				13.25-14.5 m: PASS material characterisation samples taken (2 jars and 2 bags)
						13.8 [-10.30]				13.8-14.0 m: CORE LOSS Inferred as above.					
14						14.0 [-10.50]			SP-SC	SAND Fine to medium grained, sub-angular to sub-rounded; brown; with clay, non-plastic; trace gravel, fine to coarse grained, sub-angular of calcrete; uncemented.		VD	14.00	S	14.0 SPT: 8, 50/125 mm, * [] 100% Recovery, D10
						14.6 [-11.05]				14.55-14.75 m: CORE LOSS					
						14.8 [-11.25]			SP-SC	SAND, as above.					At 14.75 m, core jammed in the rods. All rods were extracted from the ground to remove the core.
15						15.0									

GENERAL LOG 12516706 GINT.GPJ GHDLIB.GDT 20-10-20

BOREHOLE LOG

Borehole No.: **BH09**

Sheet 4 of 5

Client: K + S Salt Australia Pty Ltd
Project: Ashburton Solar Salt Project
Phase 2 Site Investigation
Job No.: 12516706

Coordinates: **E** 268 003, **N** 7572 193
Ground Surface Elevation: +3.5m AHD **Total Depth:** 20.3m
Commenced: 20-Jan-20 **Completed:** 23-Jan-20
Contractor: J&S Drilling **Driller:** Brian

Rig Type : Jacro 350 drill rig on Mangrove Buggy **Inclination:** Vertical
Flushing Fluid: Water
Hole Diameter (mm): 180

Logged:	SD/DO	23-Jan-20
Processed:	DCH	20-Oct-20
Checked:		

Depth Scale (m)	Daily Progress/ Observations: Date	Casing Depth (m)	Fluid Depth (m)	Drilling Method	Water	Depth (m)/ [Elev.]	Geological Unit	Graphic Log	Classification	Strata Description (type; colour; fines plasticity or particle characteristics; minor components; structure and/or origin)	Moisture Condition	Consistency/ Relative Density	Sample Type & Depth	Sample No.	Sample/ Test Records & Comments	Depth Scale (m)
						[-11.50]			SC	Clayey SAND Fine to medium grained, sub-angular to sub-rounded; brown; low to medium plasticity fines; trace gravel, fine to coarse grained, sub-angular of calcrete.	W	VD				
						15.4										
						[-11.85]				15.35-15.5 m: CORE LOSS						
						15.5							15.50			
						[-12.00]			SC	Clayey SAND Fine to medium grained, sub-angular to sub-rounded; brown; low to medium plasticity fines; trace gravel, fine to coarse grained, sub-angular to sub-rounded of calcrete; locally calcium carbonate stained white.				S	15.5 SPT: 22, 30/110 mm + 15/10 mm, * [] 100% Recovery, D11	
						15.8					W>PL	H				
16						[-12.27]			CI	Sandy CLAY Medium plasticity; brown; sand is fine grained; trace gravel, fine to medium grained, sub-angular of calcrete; locally calcium carbonate stained pale grey.					15.5-16.25 m: core sample fell out of the tube during extraction. Retrieved again by re-drilling over.	16
															15.77-16.7 m: PASS material characterisation samples taken (2 jars and 2 bags)	
											W<PL					
						16.7									16.7-17.0 m, material was washed away due to core plugging the tube sampler.	
						[-13.20]				16.7-17.0 m: CORE LOSS						
17						17.0										17
						[-13.50]			CI	Sandy CLAY Medium plasticity; brown; sand is fine grained; trace gravel, fine to medium grained, sub-angular of calcrete; locally calcium carbonate stained pale grey.			17.00	S	17.0 SPT: 26, 39/90 mm, * [] 100% Recovery, D12	
						17.4									17.4-17.75 and 17.75-18.2 m, core fell out of catcher and was washed away in the next run.	
						[-13.90]	Qsed			17.4-18.2 m: CORE LOSS Inferred as below.						
18						18.2										18
						[-14.70]			CI-CH	Sandy CLAY Medium to high plasticity; brown; sand is fine grained, locally calcium carbonate stained pale grey.			18.50	S	18.5 SPT: 36, 30/60 mm, * [] 100% Recovery, D13	
											W~PL					
19																19
20						20.0										20

GENERAL LOG 12516706 GINT.GPJ GHDLIB.GDT 20-10-20

BOREHOLE LOG

Borehole No.: **BH09**

Sheet 5 of 5

Client: K + S Salt Australia Pty Ltd
Project: Ashburton Solar Salt Project
Phase 2 Site Investigation
Job No.: 12516706

Coordinates: **E** 268 003, **N** 7572 193
Ground Surface Elevation: +3.5m AHD **Total Depth:** 20.3m
Commenced: 20-Jan-20 **Completed:** 23-Jan-20
Contractor: J&S Drilling **Driller:** Brian

Rig Type : Jacro 350 drill rig on Mangrove Buggy **Inclination:** Vertical
Flushing Fluid: Water
Hole Diameter (mm): 180

Logged:	SD/DO	23-Jan-20
Processed:	DCH	20-Oct-20
Checked:		

Depth Scale (m)	Daily Progress/ Observations: Date	Casing Depth (m)	Fluid Depth (m)	Drilling Method	Water	Depth (m)/ [Elev.]	Geological Unit	Graphic Log	Classification	Strata Description (type; colour; fines plasticity or particle characteristics; minor components; structure and/or origin)	Moisture Condition	Consistency/ Relative Density	Sample Type & Depth	Sample No.	Sample/ Test Records & Comments	Depth Scale (m)
	21-01					[-16.50] 20.3 [-16.75]	Qsed		CH	Sandy CLAY, as above.	W~PL	H	20.00	S	20.0 SPT: 29, 30/100 mm, * []	
										Termination Depth = 20.25m (Target Depth)						
21																21
22																22
23																23
24																24
25																25

GENERAL LOG 12516706 GINT.GPJ GHDLIB.GDT 20-10-20

STANDPIPE PIEZOMETER LOG

Borehole No.: **BH09A**

Sheet 1 of 1

Client: K + S Salt Australia Pty Ltd
Project: Ashburton Solar Salt Project
Phase 2 Site Investigation
Job No.: 12516706

Coordinates: **E** 268 003, **N** 7572 195
Ground Surface Elevation: +3.5m AHD **Total Depth:** 9.0m
Commenced: 23-Jan-20 **Completed:** 23-Jan-20
Contractor: J&S Drilling **Driller:** Brian

Rig Type : Jacro 350 drill rig on Mangrove Buggy **Inclination:** Vertical
Flushing Fluid: Water
Hole Diameter (mm): 180

Logged:	DO	23-Jan-20
Processed:	DCH	20-Oct-20
Checked:		

Depth Scale (m)	Daily Progress/ Observations: Date	Casing Depth (m)	Fluid Depth (m)	Drilling Method	Water	Depth (m)/ [Elev.]	Geological Unit	Graphic Log	Classification	Strata Description (type; colour; fines plasticity or particle characteristics; minor components; structure and/or origin)	Moisture Condition	Consistency/ Relative Density	Sample Type & Depth	Sample No.	Sample/ Test Records & Comments	Piezometer Components	Depth Scale (m)
1				Solid Augering											1.5-2.5 m: material characterisation samples taken (2 jars and 2 bags).	Above ground cover	1
2																Solid pipe	2
3															ASS samples recovered at 0.25m, 0.5m, 0.75m, 1.25m, 1.5m, 1.75m, 2.0m, 2.25m, 2.5m, 2.75m, 3m, 3.5m, 3.75m, 4.0m, 4.25m, 4.5m, 4.75m, 5.0m. ASS samples missed due to no core recovery at 1.0 m and 3.25 m.	Grout	3
4																Bentonite	4
5																Gravel	5
6																	6
7																Slotted pipe	7
8																	8
9						9.0 [-5.50]											9
10																	10

GENERAL LOG 12516706 GINT.GPJ GHDLIB.GDT 20-10-20

STANDPIPE PIEZOMETER LOG

Borehole No.: **BH09B**

Sheet 1 of 1

Client: K + S Salt Australia Pty Ltd
Project: Ashburton Solar Salt Project
Phase 2 Site Investigation
Job No.: 12516706

Coordinates: **E** 268 003, **N** 7572 197
Ground Surface Elevation: +3.5m AHD **Total Depth:** 3.0m
Commenced: 23-Jan-20 **Completed:** 23-Jan-20
Contractor: J&S Drilling **Driller:** Brian

Rig Type : Jacro 350 drill rig on Mangrove Buggy **Inclination:** Vertical
Flushing Fluid: Water
Hole Diameter (mm): 180

Logged:	DO	23-Jan-20
Processed:	ZW	20-Oct-20
Checked:		

Depth Scale (m)	Daily Progress/ Observations: Date	Casing Depth (m)	Fluid Depth (m)	Drilling Method	Water	Depth (m)/ [Elev.]	Geological Unit	Graphic Log	Classification	Strata Description (type; colour; fines plasticity or particle characteristics; minor components; structure and/or origin)	Moisture Condition	Consistency/ Relative Density	Sample Type & Depth	Sample No.	Sample/ Test Records & Comments	Piezometer Components	Depth Scale (m)
1				Solid Augering												Above ground cover; Solid Pipe; Bentonite	1
2																Gravel; Slotted Pipe	2
3						3.0 [+0.50]											3
4																	4
5																	5

GENERAL LOG 12516706 GINT.GPJ GHDLIB.GDT 20-10-20

STANDPIPE PIEZOMETER LOG

Borehole No.: **BH10**

Sheet 1 of 5

Client: K + S Salt Australia Pty Ltd
Project: Ashburton Solar Salt Project
Phase 2 Site Investigation
Job No.: 12516706

Coordinates: **E** 266 494, **N** 7572 270
Ground Surface Elevation: +0.9m AHD **Total Depth:** 20.0m
Commenced: 25-Jan-20 **Completed:** 29-Jan-20
Contractor: J&S Drilling **Driller:** Brian

Rig Type : Jacro 350 drill rig on Mangrove Buggy **Inclination:** Vertical
Flushing Fluid: Water to 14 m, then Polymer
Hole Diameter (mm): 180 Auger / 123 PQ

Logged:	DO	29-Jan-20
Processed:	AT	20-Oct-20
Checked:		

Depth Scale (m)	Daily Progress/ Observations: Date	Casing Depth (m)	Fluid Depth (m)	Drilling Method	Water	Depth (m)/ [Elev.]	Geological Unit	Graphic Log	Classification	Strata Description (type; colour; fines plasticity or particle characteristics; minor components; structure and/or origin)	Moisture Condition	Consistency/ Relative Density	Sample Type & Depth	Sample No.	Sample/ Test Records & Comments	Piezometer Components	Depth Scale (m)
0	25-01			Hollow Stem Auger		0.9 [+0.05]	Qt		Cl	Sandy CLAY Medium plasticity; brown; sand is fine to medium grained, sub-angular to sub-rounded of quartz and some carbonate; trace gravel, fine to medium grained, sub-angular to sub-rounded of calcrete; moderately well cemented; Calcareous. From 0.5 m, Sandy CLAY.	W~PL	St	0.00	S	0.0 SPT: 1, 3, 6 [N=9] 73% Recovery U60 tube pushed from 0.0-0.5 m at a location approximately 2 m north of BH10. 62% Recovery.	Above ground cover Concrete	0
1						1.3 [-0.35]				0.85-1.25 m: CORE LOSS							1
						1.6 [-0.70]			Cl	Sandy CLAY Medium plasticity; brown; sand is fine to medium grained, sub-angular to sub-rounded; trace gravel pale brown, fine to medium grained, sub-angular to sub-rounded of calcrete.	W>PL				Shallow well BH10A installed ~2 m north of BH10 location.		
									SC	Clayey SAND Fine to medium grained, sub-angular to sub-rounded; brown; clay has low plasticity; non-calcareous; uncemented.	M-W	MD					
2						1.9 [-1.00]			Cl	Sandy CLAY Medium plasticity; brown; sand is fine to medium grained, sub-angular to sub-rounded of quartz; trace gravel, pale brown, fine to medium grained, sub-angular to sub-rounded of calcrete.	W>PL	VSt	2.00	S	2.0 SPT: 7, 8, 10 [N=18] 91% Recovery 2.5 m: pass quality assurance sample (QA05).		2
3							Qsed									Bentonite & grout mix	3
										From 3.4 m, trace gravel, becoming grey, fine to coarse grained, angular, tabular of quartz (?).			3.50	S	3.5 SPT: 9, 10, 11 [N=21] 100% Recovery		
4															4.1-5.0 m: PASS material characterisation sample taken (2 jars and 2 bags)	Solid Pipe	4
											W<PL						
5						5.0											5

STANDPIPE PIEZOMETER LOG

Borehole No.: **BH10**

Sheet 2 of 5

Client: K + S Salt Australia Pty Ltd
Project: Ashburton Solar Salt Project
Phase 2 Site Investigation
Job No.: 12516706

Coordinates: **E** 266 494, **N** 7572 270
Ground Surface Elevation: +0.9m AHD **Total Depth:** 20.0m
Commenced: 25-Jan-20 **Completed:** 29-Jan-20
Contractor: J&S Drilling **Driller:** Brian

Rig Type : Jacro 350 drill rig on Mangrove Buggy **Inclination:** Vertical
Flushing Fluid: Water to 14 m, then Polymer
Hole Diameter (mm): 180 Auger / 123 PQ

Logged:	DO	29-Jan-20
Processed:	AT	20-Oct-20
Checked:		

Depth Scale (m)	Daily Progress/ Observations: Date	Casing Depth (m)	Fluid Depth (m)	Drilling Method	Water	Depth (m)/ [Elev.]	Geological Unit	Graphic Log	Classification	Strata Description (type; colour; fines plasticity or particle characteristics; minor components; structure and/or origin)	Moisture Condition	Consistency/ Relative Density	Sample Type & Depth	Sample No.	Sample/ Test Records & Comments	Piezometer Components	Depth Scale (m)
						[-4.10]			CI	Sandy CLAY Medium plasticity; brown; sand is fine grained, sub-angular to sub-rounded; trace gravel, pale brown, fine to medium grained, sub-angular to sub-rounded of calcrete.		H	5.00	S	5.0 SPT: 10, 18, 29 [N=47] 80% Recovery		
						5.5										Solid Pipe	
						[-4.60]			CH	CLAY High plasticity; brown; with sand, fine to medium grained; trace gravel, fine to coarse grained, sub-angular to sub-rounded of calcrete.	W~PL						
	25-01																
	27-01																
6																	6
						6.4											
						[-5.45]				6.35-6.5 m: CORE LOSS							
						6.5											
						[-5.60]			CH	CLAY High plasticity; brown; with sand, fine to medium grained; trace gravel, fine to coarse grained, sub-angular to sub-rounded of calcrete.			6.50	S	6.5 SPT: 10, 17, 31 [N=48] 73% Recovery		
7										From 7.0 m, trace fine to medium grained sand.	W>PL					Bentonite	7
										From 7.4 to 7.6 m: Sandy CLAY bed.							
											W~PL						
						7.7											
						[-6.80]				7.7-8.0 m: CORE LOSS							
						8.0											
8						[-7.10]			CH	CLAY High plasticity; brown; with sand, fine grained; trace gravel, pale grey and pale brown, fine to coarse grained, sub-angular to sub-rounded of calcrete.			8.00	S	8.0 SPT: 22, 38, 30/80 mm [] 42% Recovery	Gravel	8
											W>PL				8.75-9.5 m: majority of material dropped during extraction. Unsuccessfully attempted to recover dropped core.		
										From 8.75 m, grading to Sandy CLAY.	W~PL						
						8.9											
						[-8.00]				8.9-9.5 m: CORE LOSS	M	VD				Slotted Pipe	
9																	9
						9.5											
						[-8.60]			SC	Clayey SAND Fine to medium grained, sub-angular to sub-rounded; brown; low plasticity fines; trace gravel, fine to medium grained, sub-angular to sub-rounded of calcrete.			9.50	S	9.5 SPT: 19, 41, 30/65 mm [] 100% Recovery		
						10.0											
10																	10

Hollow Stem Auger

Qsed

GENERAL LOG 12516706 GINT.GPJ GHDLIB.GDT 20-10-20

STANDPIPE PIEZOMETER LOG

Borehole No.: **BH10**

Sheet 3 of 5

Client: K + S Salt Australia Pty Ltd
Project: Ashburton Solar Salt Project
Phase 2 Site Investigation
Job No.: 12516706

Coordinates: **E** 266 494, **N** 7572 270
Ground Surface Elevation: +0.9m AHD **Total Depth:** 20.0m
Commenced: 25-Jan-20 **Completed:** 29-Jan-20
Contractor: J&S Drilling **Driller:** Brian

Rig Type : Jacro 350 drill rig on Mangrove Buggy **Inclination:** Vertical
Flushing Fluid: Water to 14 m, then Polymer
Hole Diameter (mm): 180 Auger / 123 PQ

Logged:	DO	29-Jan-20
Processed:	AT	20-Oct-20
Checked:		

Depth Scale (m)	Daily Progress/ Observations: Date	Casing Depth (m)	Fluid Depth (m)	Drilling Method	Water	Depth (m)/ [Elev.]	Geological Unit	Graphic Log	Classification	Strata Description (type; colour; fines plasticity or particle characteristics; minor components; structure and/or origin)	Moisture Condition	Consistency/ Relative Density	Sample Type & Depth	Sample No.	Sample/ Test Records & Comments	Piezometer Components	Depth Scale (m)
11				Hollow Stem Auger		[-9.10] 10.4			SC	Clayey SAND Fine to medium-grained, sub-angular to sub-rounded; brown; low to medium plasticity fines; trace gravel, fine to medium grained, sub-angular to sub-rounded of calcrete, well-cemented.	M-W	VD					11
						[-9.50] 10.7			Cl	Sandy CLAY Medium plasticity; brown; sand is fine to medium grained; trace gravel, pale brown, fine to medium grained, sub-angular to sub-rounded of calcrete, well-cemented.	W>PL	H					
						[-9.80] 11.0				10.7-11.0 m: CORE LOSS	M	VD					
						[-10.10] 11.5			SC	Clayey SAND Fine to medium grained; brown; sub-angular to sub-rounded; clay has low to medium plasticity; with gravel, pale brown and pale grey, fine to coarse grained, sub-angular to sub-rounded of calcrete.			11.00	S	11.0 SPT: 36, 30/100 mm, * [] 100% Recovery	Slotted Pipe	
12						[-10.60] 12.2			Cl-CH	From 11.25 to 11.4 m, Sandy CLAY	W>PL	H				Gravel	12
										Sandy CLAY Medium to high plasticity; brown; sand is fine to medium grained; trace gravel, pale grey, fine to medium grained, sub-angular to sub-rounded of quartz and calcrete.							
						[-11.30] 12.5	Qsed			12.2-12.5 m: CORE LOSS. Inferred as below	M-W	VD					
						[-11.60] 13.0			SC	Clayey SAND Fine to medium grained, sub-angular to sub-rounded; brown, locally mottled pale grey; clay has low plasticity; trace gravel, fine to medium grained, sub-rounded of quartz.			12.50	S	12.5 SPT: 18, 31, 30/70 mm [] 100% Recovery	Bentonite	
13						[-12.10] 13.9			Cl	Sandy CLAY (locally Clayey SAND) Medium plasticity; brown; sand is fine to medium grained; trace fine to medium grained, sub-rounded of quartz and calcrete.	W>PL	H					13
										13.9-14.0 m: CORE LOSS. Inferred as below.	M-W	VD					
14				PQ Coring		[-13.10] 14.8			SC	Clayey SAND Fine to medium grained, sub-angular to sub-rounded; brown; clay has low plasticity; trace gravel, fine to medium grained of calcrete and rounded, black claystone gravel. From 14.6 m, with sandstone cobbles.			14.00	S	14.0 SPT: 11, 25, 40 [N=65] 96% Recovery	Gravel	14
	27-01 29-01					[-13.85] 15.0				14.75-15.0 m: CORE LOSS. Inferred as above.							
15																	15

STANDPIPE PIEZOMETER LOG

Borehole No.: **BH10**

Client: K + S Salt Australia Pty Ltd
Project: Ashburton Solar Salt Project
Phase 2 Site Investigation
Job No.: 12516706

Coordinates: **E** 266 494, **N** 7572 270
Ground Surface Elevation: +0.9m AHD **Total Depth:** 20.0m
Commenced: 25-Jan-20 **Completed:** 29-Jan-20
Contractor: J&S Drilling **Driller:** Brian

Rig Type : Jacro 350 drill rig on Mangrove Buggy **Inclination:** Vertical
Flushing Fluid: Water to 14 m, then Polymer
Hole Diameter (mm): 180 Auger / 123 PQ

Logged:	DO	29-Jan-20
Processed:	AT	20-Oct-20
Checked:		

Depth Scale (m)	Daily Progress/ Observations: Date	Casing Depth (m)	Fluid Depth (m)	Drilling Method	Water	Depth (m)/ [Elev.]	Geological Unit	Graphic Log	Classification	Strata Description (type; colour; fines plasticity or particle characteristics; minor components; structure and/or origin)	Moisture Condition	Consistency/ Relative Density	Sample Type & Depth	Sample No.	Sample/ Test Records & Comments	Piezometer Components	Depth Scale (m)
						[-14.10]				14.75-15.0 m: CORE LOSS. Inferred as below.	M-W	VD			14.0-15.5m, 50% recovery due to cobbles plugging the core catcher during drilling.		
						15.5 [-14.60]			SC	Clayey SAND Fine to medium grained, sub-angular to sub-rounded; brown, locally mottled pale grey; low plasticity fines; trace gravel, fine to medium grained, sub-angular of carbonate, well cemented. 15.9 m: Sandstone cobble intersected.			15.50	S	15.5 SPT: 16, 41, 19/50 mm [14/50 mm + 5 HB] 100% Recovery		
16						16.0 [-15.10]	Qsed			16.0-17.0 m: CORE LOSS. Inferred as above.					15.5-17.0 m, 33% recovery due to plugging of the core catcher during drilling.		16
17				PQ Coring		17.0 [-16.10]			SC	Clayey SAND Fine to medium grained, sub-angular to sub-rounded; brown; low plasticity fines; with sandstone cobbles; trace gravel, fine to medium grained, sub-rounded of quartz, claystone and carbonate.			17.00	S	17.0 SPT: 17, 29, 38 [N=67] 100% Recovery	Hole collapse	17
18						17.9				*Start of coring at 17.9m.* *Continued next sheet in Rock Core format.*							18
19																	19
20																	20

STANDPIPE PIEZOMETER LOG
*** ROCK CORE FORMAT ***

Borehole No.: **BH10**

Sheet 5 of 5

Client: K + S Salt Australia Pty Ltd
Project: Ashburton Solar Salt Project
Phase 2 Site Investigation
Job No.: 12516706

Coordinates: **E** 266 494, **N** 7572 270
Ground Surface Elevation: +0.9m AHD **Total Depth:** 20.0m
Commenced: 25-Jan-20 **Completed:** 29-Jan-20
Contractor: J&S Drilling **Driller:** Brian

Rig Type : Jacro 350 drill rig on Mangrove Buggy **Inclination:** Vertical
Drilling Fluid: Polymer
Core Diameter (mm): 85

Logged:	DO	29-Jan-20
Processed:	AT	20-Oct-20
Checked:		

Depth Scale (m)	Daily Progress/ Observations: Date	Casing Depth (m)	Fluid Depth (m)	Drilling Method	Water	Depth (m)/ [Elev.]	Geological Unit	Graphic Log	Strata Description (Rocktype; grain size; texture & structure; colour; strength; fracture condition; minor constituents)	Weathering/ Cementation	Estimated Rock Strength (VL L M H VH EH)	Rock Core Quality: TCR (%)	RQD (%)	F (fractures/m)	Defect Log	Drill Rate (min/m)	Defect Description & Comments	Piezometer Components	Depth Scale (m)
16																			16
17																			17
						17.9 [-17.00]			*Resuming in Core Log format 17.9m.*										
18				PQ Coring			Qsed		SILTSTONE Grey, stained brown, predominantly fine-grained, with some medium grains; non-calcareous.	We		100	100	0			18.0 m: DB 18.08 m: DB		18
												100	100				18.22 m: DB 18.27 m: DB 18.31 m: DB 18.41 m: DB		
19									From 18.5 m, brown, stained grey.								18.5 m: DB 18.57 m: JT, 45°, irregular, smooth. 18.59 m: DB 18.73 m: DB 19 m: DB		19
									From 19.35 to 19.40, weakly cemented Sandy CLAY.	Wk-We		100	83						
20	29-01					20.0			From 19.8 m, weakly cemented Sandy CLAY.	Wk				N/A			19.8 m: DB		20
									Termination Depth = 20.00m										

STANDPIPE PIEZOMETER LOG

Borehole No.: **BH10A**

Sheet 1 of 2

Client: K + S Salt Australia Pty Ltd
Project: Ashburton Solar Salt Project
Phase 2 Site Investigation
Job No.: 12516706

Coordinates: **E** 266 494, **N** 7572 272
Ground Surface Elevation: +0.9m AHD **Total Depth:** 5.0m
Commenced: 25-Jan-20 **Completed:** 29-Jan-20
Contractor: J&S Drilling **Driller:** Alan

Rig Type : Jacro 350 drill rig on Mangrove Buggy **Inclination:** Vertical
Flushing Fluid: Water
Hole Diameter (mm): 180

Logged:	DO	29-Jan-20
Processed:	ZW	20-Oct-20
Checked:		

Depth Scale (m)	Daily Progress/ Observations: Date	Casing Depth (m)	Fluid Depth (m)	Drilling Method	Water	Depth (m)/ [Elev.]	Geological Unit	Graphic Log	Classification	Strata Description (type; colour; fines plasticity or particle characteristics; minor components; structure and/or origin)	Moisture Condition	Consistency/ Relative Density	Sample Type & Depth	Sample No.	Sample/ Test Records & Comments	Piezometer Components	Depth Scale (m)
1				Solid Augering												Above ground cover Concrete; Bentonite; Solid Pipe	1
2																	2
3																Slotted Pipe	3
4																	4
5						5.0											5

GENERAL LOG 12516706 GINT.GPJ GHDLIB.GDT 20-10-20

STANDPIPE PIEZOMETER LOG

Borehole No.: **BH10A**

Sheet 2 of 2

Client: K + S Salt Australia Pty Ltd
Project: Ashburton Solar Salt Project
Phase 2 Site Investigation
Job No.: 12516706

Coordinates: **E** 266 494, **N** 7572 272
Ground Surface Elevation: +0.9m AHD **Total Depth:** 5.0m
Commenced: 25-Jan-20 **Completed:** 29-Jan-20
Contractor: J&S Drilling **Driller:** Alan

Rig Type : Jacro 350 drill rig on Mangrove Buggy **Inclination:** Vertical
Flushing Fluid: Water
Hole Diameter (mm): 180

Logged:	DO	29-Jan-20
Processed:	ZW	20-Oct-20
Checked:		

Depth Scale (m)	Daily Progress/ Observations: Date	Casing Depth (m)	Fluid Depth (m)	Drilling Method	Water	Depth (m)/ [Elev.]	Geological Unit	Graphic Log	Classification	Strata Description (type; colour; fines plasticity or particle characteristics; minor components; structure and/or origin)	Moisture Condition	Consistency/ Relative Density	Sample Type & Depth	Sample No.	Sample/ Test Records & Comments	Piezometer Components	Depth Scale (m)
						[-4.10]											
6																	6
7																	7
8																	8
9																	9
10																	10

STANDPIPE PIEZOMETER LOG

Borehole No.: **BH10B**

Sheet 1 of 2

Client: K + S Salt Australia Pty Ltd
Project: Ashburton Solar Salt Project
Phase 2 Site Investigation
Job No.: 12516706

Coordinates: **E** 266 494, **N** 7572 273
Ground Surface Elevation: +0.9m AHD **Total Depth:** 17.0m
Commenced: 19-Mar-20 **Completed:** 20-Mar-20
Contractor: J&S Drilling **Driller:** Alan

Rig Type : Jacro 350 drill rig on Mangrove Buggy **Inclination:** Vertical
Flushing Fluid: Bentonite
Hole Diameter (mm): 150

Logged:	SD	20-Mar-20
Processed:	WR	20-Oct-20
Checked:		

Depth Scale (m)	Daily Progress/ Observations: Date	Casing Depth (m)	Fluid Depth (m)	Drilling Method	Water	Depth (m)/ [Elev.]	Geological Unit	Graphic Log	Classification	Strata Description (type; colour; fines plasticity or particle characteristics; minor components; structure and/or origin)	Moisture Condition	Consistency/ Relative Density	Sample Type & Depth	Sample No.	Sample/ Test Records & Comments	Piezometer Components	Depth Scale (m)
1				Wash Boring												Above ground cover	1
2																Grout	2
3																Bentonite	3
4																Gravel	4
5																	5
6																	6
7																	7
8																	8
9																100 mm Slotted PVC Pipe	9
10																	10

GENERAL LOG 12516706 GINT.GPJ GHDLIB.GDT 20-10-20

STANDPIPE PIEZOMETER LOG

Borehole No.: **BH10B**

Sheet 2 of 2

Client: K + S Salt Australia Pty Ltd
Project: Ashburton Solar Salt Project
Phase 2 Site Investigation
Job No.: 12516706

Coordinates: **E** 266 494, **N** 7572 273
Ground Surface Elevation: +0.9m AHD **Total Depth:** 17.0m
Commenced: 19-Mar-20 **Completed:** 20-Mar-20
Contractor: J&S Drilling **Driller:** Alan

Rig Type : Jacro 350 drill rig on Mangrove Buggy **Inclination:** Vertical
Flushing Fluid: Bentonite
Hole Diameter (mm): 150

Logged:	SD	20-Mar-20
Processed:	WR	20-Oct-20
Checked:		

Depth Scale (m)	Daily Progress/ Observations: Date	Casing Depth (m)	Fluid Depth (m)	Drilling Method	Water	Depth (m)/ [Elev.]	Geological Unit	Graphic Log	Classification	Strata Description (type; colour; fines plasticity or particle characteristics; minor components; structure and/or origin)	Moisture Condition	Consistency/ Relative Density	Sample Type & Depth	Sample No.	Sample/ Test Records & Comments	Piezometer Components	Depth Scale (m)
11				Wash Boring													11
12																	12
13																	13
14																	14
15																	15
16																Backfill	16
17						17.0 [-16.10]											17
18																	18
19																	19
20																	20

STANDPIPE PIEZOMETER LOG

Borehole No.: **BH11**

Sheet 1 of 5

Client: K + S Salt Australia Pty Ltd
Project: Ashburton Solar Salt Project
Phase 2 Site Investigation
Job No.: 12516706

Coordinates: **E** 260 260, **N** 7569 715
Ground Surface Elevation: +1.2m AHD **Total Depth:** 19.5m
Commenced: 07-Mar-20 **Completed:** 08-Mar-20
Contractor: J&S Drilling **Driller:** Daniel

Rig Type : Jacro 350 drill rig on Mangrove Buggy **Inclination:** Vertical
Flushing Fluid: Water to 5 m, then Polymer
Hole Diameter (mm): 123

Logged:	DO	08-Mar-20
Processed:	ZW	20-Oct-20
Checked:		

Depth Scale (m)	Daily Progress/ Observations: Date	Casing Depth (m)	Fluid Depth (m)	Drilling Method	Water	Depth (m)/ [Elev.]	Geological Unit	Graphic Log	Classification	Strata Description (type; colour; fines plasticity or particle characteristics; minor components; structure and/or origin)	Moisture Condition	Consistency/ Relative Density	Sample Type & Depth	Sample No.	Sample/ Test Records & Comments	Piezometer Components	Depth Scale (m)
0	07-03			PQ Coring		[+1.10]			SP-SM Cl	SAND Fine to medium grained, sub-angular to sub-rounded of quartz; pale brown; with silt.	M W>PL	L F	0.00	S	0.0 SPT: 2, 3, 3 [N=6] Recovery= 350/450 mm MC: Material Characterisation From 0.0 m, drilled using "prickly pear" drill bit.		0
										Sandy CLAY (borderline Clayey SAND) Medium plasticity; brown; sand is fine to medium grained, sub-angular to sub-rounded of quartz; trace fine to medium grained, sub-rounded of calcrete (moderately to well $CaCO_3$ cemented sandstone).			1.00	D	MC Sample: 2 x Jar Samples , 2 x Sample Bags		
1						1.6 [-0.40]	Qt		SC	Clayey Gravelly SAND Fine to coarse grained, sub-angular to sub-rounded of carbonate and quartz; pale brown; gravel is fine to coarse grained, sub-angular to sub-rounded of calcrete (well $CaCO_3$ cemented sandstone); trace fines; trace shell fragments (gravel sized).	W	MD	1.50	S	1.5 SPT: 9, 12, 8 [N=20] Recovery= 260/450 mm		1
													2.00	D	MC Sample: 2 x Jar Samples , 2 x Sample Bags	Grout	
2																	2
													3.00	S	3.0 SPT: 4, 8, 6 [N=14] 100% Recovery	50 mm Solid PVC Pipe	
3						3.8 [-2.60]	Qsed		Cl	Sandy CLAY Medium plasticity; brown; sand is fine to medium grained, sub-angular to sub-rounded of quartz; trace gravel, fine to coarse grained, sub-rounded to rounded of calcrete (well $CaCO_3$ cemented sandstone).	W~PL	H	3.80	D	MC Sample: 2 x Jar Samples , 2 x Sample Bags		3
													4.50	S	4.5 SPT: 9, 15, 19 [N=34] Recovery= 310/450 mm	Bentonite	
4																	4
5						5.0											5

GENERAL LOG 12516706 GINT.GPJ GHDLIB.GDT 20-10-20

STANDPIPE PIEZOMETER LOG

Borehole No.: **BH11**

Sheet 2 of 5

Client: K + S Salt Australia Pty Ltd
Project: Ashburton Solar Salt Project
Phase 2 Site Investigation
Job No.: 12516706

Coordinates: **E** 260 260, **N** 7569 715
Ground Surface Elevation: +1.2m AHD **Total Depth:** 19.5m
Commenced: 07-Mar-20 **Completed:** 08-Mar-20
Contractor: J&S Drilling **Driller:** Daniel

Rig Type : Jacro 350 drill rig on Mangrove Buggy **Inclination:** Vertical
Flushing Fluid: Water to 5 m, then Polymer
Hole Diameter (mm): 123

Logged:	DO	08-Mar-20
Processed:	ZW	20-Oct-20
Checked:		

Depth Scale (m)	Daily Progress/ Observations: Date	Casing Depth (m)	Fluid Depth (m)	Drilling Method	Water	Depth (m)/ [Elev.]	Geological Unit	Graphic Log	Classification	Strata Description (type; colour; fines plasticity or particle characteristics; minor components; structure and/or origin)	Moisture Condition	Consistency/ Relative Density	Sample Type & Depth	Sample No.	Sample/ Test Records & Comments	Piezometer Components	Depth Scale (m)
6				PQ Coring		[-3.80]	Qsed		Cl-CH	Sandy CLAY Medium to high plasticity; brown, locally mottled grey; sand is fine grained of quartz; trace gravel, fine to medium grained, sub-angular to sub-rounded, of black iron cemented claystone and calcrete.	W<PL	H			From 5.0m, switched drill bit to "surface set"	Gravel	6
											W~PL	VSt	6.00	S	6.0 SPT: 8, 11, 16 [N=27] Recovery= 270/450 mm		
7						6.5 [-5.30]			SC	Clayey SAND Fine to medium grained, sub-angular to sub-rounded of quartz; brown; low plasticity fines; trace gravel, fine to medium grained, sub-angular to rounded of gypsum, iron cemented and calcrete.	M-W	MD-D			6.5-7.3m, assumed medium dense to dense.		7
						7.3 [-6.10]			Cl-CH	Sandy CLAY as below.	W~PL	H					
						7.4 [-6.30]			Cl-CH	7.4 m to 7.5 m: CORE LOSS. Inferred as below.			7.50	S	7.5 SPT: 10, 19, 31 [N=50] Recovery= 380/450 mm	Slotted PVC Pipe	
8									Cl-CH	Sandy CLAY Medium to high plasticity; brown; sand is fine grained of quartz; trace gravel, fine to medium grained, of gypsum, black iron cemented claystone and calcrete. From 8.0 m, clay, with fine grained sand; trace gravel, fine to medium grained, sub-angular to sub-rounded of gypsum claystone, iron cemented and calcrete.							8
									CH		W<PL						
9													9.00	S	9.0 SPT: 15, 25, 32 [N=57] Recovery= 250/450 mm	Bentonite	9
	07-03																
	08-03																
10						10.0											10

STANDPIPE PIEZOMETER LOG

Borehole No.: **BH11**

Client: K + S Salt Australia Pty Ltd
Project: Ashburton Solar Salt Project
Phase 2 Site Investigation
Job No.: 12516706

Coordinates: **E** 260 260, **N** 7569 715
Ground Surface Elevation: +1.2m AHD **Total Depth:** 19.5m
Commenced: 07-Mar-20 **Completed:** 08-Mar-20
Contractor: J&S Drilling **Driller:** Daniel

Rig Type : Jacro 350 drill rig on Mangrove Buggy **Inclination:** Vertical
Flushing Fluid: Water to 5 m, then Polymer
Hole Diameter (mm): 123

Logged:	DO	08-Mar-20
Processed:	ZW	20-Oct-20
Checked:		

Depth Scale (m)	Daily Progress/ Observations: Date	Casing Depth (m)	Fluid Depth (m)	Drilling Method	Water	Depth (m)/ [Elev.]	Geological Unit	Graphic Log	Classification	Strata Description (type; colour; fines plasticity or particle characteristics; minor components; structure and/or origin)	Moisture Condition	Consistency/ Relative Density	Sample Type & Depth	Sample No.	Sample/ Test Records & Comments	Piezometer Components	Depth Scale (m)
11				PQ Coring		[-8.80] 10.3 [-9.10] 10.5 [-9.30] 11.1 [-9.90] 13.0	Qsed		CI-CH CI-CH CI	CLAY Medium to high plasticity; brown; with sand, fine grained; trace gravel, fine to medium grained, sub-angular to sub-rounded of calcrete, iron cemented, claystone and quartz. 10.3 m to 10.5 m: CORE LOSS. Inferred as below. CLAY Medium to high plasticity; brown; with sand, fine grained; trace gravel, fine to medium grained, sub-angular to sub-rounded of calcrete, iron cemented, claystone and quartz. Sandy CLAY Medium plasticity; brown; sand is fine to medium grained, sub-angular to sub-rounded of quartz; with gravel, fine to medium grained, sub-angular to rounded of calcrete, iron cemented and claystone.			10.50 12.00	S S	10.5 SPT: 7, 12, 21 [N=33] Recovery= 350/450 mm 12.0 SPT: 19, 34, 30/95 mm [N=R] Recovery= 250/395 mm		11 12
13										*Start of coring at 13m.* *Continued next sheet in Rock Core format.*							13
14																	14
15																	15

STANDPIPE PIEZOMETER LOG
*** ROCK CORE FORMAT ***

Borehole No.: **BH11**

Client: K + S Salt Australia Pty Ltd
Project: Ashburton Solar Salt Project
Phase 2 Site Investigation
Job No.: 12516706

Coordinates: **E** 260 260, **N** 7569 715
Ground Surface Elevation: +1.2m AHD **Total Depth:** 19.5m
Commenced: 07-Mar-20 **Completed:** 08-Mar-20
Contractor: J&S Drilling **Driller:** Daniel

Rig Type : Jacro 350 drill rig on Mangrove Buggy **Inclination:** Vertical
Drilling Fluid: Polymer
Core Diameter (mm): 85

Logged:	DO	08-Mar-20
Processed:	ZW	20-Oct-20
Checked:		

Depth Scale (m)	Daily Progress/ Observations: Date	Casing Depth (m)	Fluid Depth (m)	Drilling Method	Water	Depth (m)/ [Elev.]	Geological Unit	Graphic Log	Strata Description (Rocktype; grain size; texture & structure; colour; strength; fracture condition; minor constituents)	Weathering/ Cementation	Estimated Rock Strength (VL L M H VH EH)	Rock Core Quality: TCR (%)	RQD (%)	F (fractures/m)	Defect Log	Drill Rate (min/m)	Defect Description & Comments	Piezometer Components	Depth Scale (m)
11																			11
12																			12
13						13.0 [-11.80]			*Resuming in Core Log format 13m.*										13
14				PQ Coring			Qsed		MUDSTONE Fine grained; Brown, locally mottled grey; trace fine to coarse grained, sub-angular to sub-rounded of calcrete and iron cemented nodules. Borderline soil strength.	Mo-We		100 100	100 100	0			13.45 m: DB 13.5 SPT: 18, 36, 17/55 [N=R] [12/55mm + 5 HB] Recovery= 290mm 13.86-14.0 m: DB 14.1 m: DB 14.2 m: DB	Gravel Backfill	14
15						15.0											14.94 m: DB		15

STANDPIPE PIEZOMETER LOG
*** ROCK CORE FORMAT ***

Borehole No.: **BH11**

Sheet 5 of 5

Client: K + S Salt Australia Pty Ltd
Project: Ashburton Solar Salt Project
Phase 2 Site Investigation
Job No.: 12516706

Coordinates: **E** 260 260, **N** 7569 715
Ground Surface Elevation: +1.2m AHD **Total Depth:** 19.5m
Commenced: 07-Mar-20 **Completed:** 08-Mar-20
Contractor: J&S Drilling **Driller:** Daniel

Rig Type : Jacro 350 drill rig on Mangrove Buggy **Inclination:** Vertical
Drilling Fluid: Polymer
Core Diameter (mm): 85

Logged:	DO	08-Mar-20
Processed:	ZW	20-Oct-20
Checked:		

Depth Scale (m)	Daily Progress/ Observations: Date	Casing Depth (m)	Fluid Depth (m)	Drilling Method	Water	Depth (m)/ [Elev.]	Geological Unit	Graphic Log	Strata Description (Rocktype; grain size; texture & structure; colour; strength; fracture condition; minor constituents)	Weathering/ Cementation	Estimated Rock Strength (VL L M H VH EH)	Rock Core Quality: TCR (%)	RQD (%)	F (fractures/m)	Defect Log	Drill Rate (min/m)	Defect Description & Comments	Piezometer Components	Depth Scale (m)
						[-13.80]			Sandy CLAY Medium to high plasticity; brown, locally mottled grey; sand is fine to medium grained of quartz, W>PL.	Mo							15.0 m: DB 15.0 SPT: 17, 30, 32/125mm [N=R] [27/125mm + 5 HB] Recovery= 400mm 15.45 m: DB		
						15.5 [-14.30]			SANDSTONE Fine to medium grained; brown, locally mottled grey.	Mo-We		100	100						
16									From 16.0 m, locally stained white.								15.95 m: DB 16.14 m: DB 16.24 m: DB 16.36-16.4 m: DB		16
17				PQ Coring			Qsed					100	100	0			16.82 m: DB 17.0 m: DB 17.14 m: DB 17.24 m: DB 17.28 m: DB 17.46 m: DB 17.69 m: DB		17
18									From 18.0 m, with white/pale grey (non-$CaCO_3$) cemented clay veins / localised mottling.								18.0 m: DB		18
19	08-03					19.5			From 18.5 m, trace gravel, fine grained, rounded, dark brown.			100	100						19
						[-18.30]			Termination Depth = 19.50m										
20																			20

COREHOLE 12516706 GINT.GPJ GHDLIB.GDT 20-10-20

STANDPIPE PIEZOMETER LOG

Borehole No.: **BH11A**

Sheet 1 of 1

Client: K + S Salt Australia Pty Ltd
Project: Ashburton Solar Salt Project
Phase 2 Site Investigation
Job No.: 12516706

Coordinates: **E** 260 263, **N** 7569 718
Ground Surface Elevation: +1.2m AHD **Total Depth:** 4.6m
Commenced: 09-Mar-20 **Completed:** 10-Mar-20
Contractor: J&S Drilling **Driller:** Daniel

Rig Type : Jacro 350 drill rig on Mangrove Buggy **Inclination:** Vertical
Flushing Fluid: Polymer
Hole Diameter (mm): 123

Logged:	DO	10-Mar-20
Processed:	WR	20-Oct-20
Checked:		

Depth Scale (m)	Daily Progress/ Observations: Date	Casing Depth (m)	Fluid Depth (m)	Drilling Method	Water	Depth (m)/ [Elev.]	Geological Unit	Graphic Log	Classification	Strata Description (type; colour; fines plasticity or particle characteristics; minor components; structure and/or origin)	Moisture Condition	Consistency/ Relative Density	Sample Type & Depth	Sample No.	Sample/ Test Records & Comments	Piezometer Components	Depth Scale (m)
0				PQ Coring		4.6 [-3.40]										Bentonite	0
1																Solid Pipe Gravel	1
2																	2
3																Slotted Pipe	3
4																	4
5																	5

GENERAL LOG 12516706 GINT.GPJ GHDLIB.GDT 20-10-20

STANDPIPE PIEZOMETER LOG

Borehole No.: **BH12**

Sheet 1 of 4

Client: K + S Salt Australia Pty Ltd
Project: Ashburton Solar Salt Project
Phase 2 Site Investigation
Job No.: 12516706

Coordinates: **E** 260 263, **N** 7569 718
Ground Surface Elevation: +8.7m AHD **Total Depth:** 19.3m
Commenced: 14-Feb-20 **Completed:** 28-Feb-20
Contractor: J&S Drilling **Driller:** Daniel

Rig Type : Jacro 350 drill rig on Mangrove Buggy **Inclination:** Vertical
Flushing Fluid: Water to 5 m, then Polymer
Hole Diameter (mm): 123

Logged:	DO	28-Feb-20
Processed:	ZW	20-Oct-20
Checked:		

Depth Scale (m)	Daily Progress/ Observations: Date	Casing Depth (m)	Fluid Depth (m)	Drilling Method	Water	Depth (m)/ [Elev.]	Geological Unit	Graphic Log	Classification	Strata Description (type; colour; fines plasticity or particle characteristics; minor components; structure and/or origin)	Moisture Condition	Consistency/ Relative Density	Sample Type & Depth	Sample No.	Sample/ Test Records & Comments	Piezometer Components	Depth Scale (m)
0	14-02			PQ Coring		[+8.60]	Qe		SM	Topsoil - Silty SAND Fine to medium grained; red-brown; silt is non-plastic; non-calcareous.	D	MD	0.00	U(63)	SP 0.0-0.1m U63 tube pushed from 0.0-0.5m ASS samples recovered at 0.25m, 0.5m, 1.35m, 1.5m, 1.75m, 3.0m, 3.25m, 4.0m, 4.25m, 4.5m, 4.75m, 5.0m MC: Material Characterisation	Above ground cover Concrete	0
						0.5 [+8.25]			SM	Silty SAND Fine to medium grained; red-brown; silt is non-plastic; non-calcareous; uncemented.							
1						1.2				0.45 m to 1.2 m: CORE LOSS. Inferred as above.							1
						[+7.50]			SM	Silty SAND Fine to medium grained; red-brown; silt is non-plastic; non-calcareous; uncemented.	M		1.20	D	1.2-1.5m: MC sample	Backfill	
													1.50	S	1.5 SPT: 2, 11, 21 [N=32] 93% Recovery		
2						2.0 [+6.75]				1.95 m to 3.0 m: CORE LOSS. Inferred as below.							2
						3.0 [+5.70]			SM	Silty SAND Fine to medium grained; red-brown; silt is non-plastic; non-calcareous; uncemented.			3.00	S	3.0 SPT: 2, 5, 15 [N=20] 89% Recovery	Solid Pipe Bentonite	
3						3.5 [+5.25]				3.45 m to 4.0 m: CORELOSS. Inferred as below.	W	L					3
	14-02					4.0									4.0m, Drilling suspended for 10 days due to weather.		
4	25-02					[+4.60]			SM	Silty SAND. As above.							4
									SP-SM	Carbonate SAND (borderline Silty SAND) Fine to medium grained, sub-angular to sub-rounded of carbonate; brown; with silt; trace gravel, fine to medium grained, sub-rounded to rounded calcrete (weakly to moderately, $CaCO_3$ cemented sandstone).	W	L			Sample QA12 at 4.25 m		
													4.50	S	4.5 SPT: 2, 4, 5 [N=9] 80% Recovery		
5																	5

GENERAL LOG 12516706 GINT.GPJ GHDLIB.GDT 20-10-20

STANDPIPE PIEZOMETER LOG

Borehole No.: **BH12**

Sheet 2 of 4

Client: K + S Salt Australia Pty Ltd
Project: Ashburton Solar Salt Project
Phase 2 Site Investigation
Job No.: 12516706

Coordinates: **E** 260 263, **N** 7569 718
Ground Surface Elevation: +8.7m AHD **Total Depth:** 19.3m
Commenced: 14-Feb-20 **Completed:** 28-Feb-20
Contractor: J&S Drilling **Driller:** Daniel

Rig Type : Jacro 350 drill rig on Mangrove Buggy **Inclination:** Vertical
Flushing Fluid: Water to 5 m, then Polymer
Hole Diameter (mm): 123

Logged:	DO	28-Feb-20
Processed:	ZW	20-Oct-20
Checked:		

Depth Scale (m)	Daily Progress/ Observations: Date	Casing Depth (m)	Fluid Depth (m)	Drilling Method	Water	Depth (m)/ [Elev.]	Geological Unit	Graphic Log	Classification	Strata Description (type; colour; fines plasticity or particle characteristics; minor components; structure and/or origin)	Moisture Condition	Consistency/ Relative Density	Sample Type & Depth	Sample No.	Sample/ Test Records & Comments	Piezometer Components	Depth Scale (m)
									SP-SM		W	L					
						5.3 [+3.40]			SP-SM	Carbonate Gravelly SAND Fine to medium grained, sub-angular to sub-rounded of carbonate; brown; gravel is fine to medium grained, sub-angular to sub-rounded of calcrete (weakly to strongly $CaCO_3$ cemented sandstone); with silt, non-plastic.	W	L					
						5.9				5.9 m to 6.0 m: CORE LOSS.							
6						[+2.70]			SM	Carbonate Silty SAND (borderline SAND) Fine to medium grained, sub-angular to sub-rounded of carbonate; brown; non-plastic fines; with gravel, fine to medium grained, sub-angular to sub-rounded of concrete (moderately to strongly $CaCO_3$ cemented sandstone) 6.45 m to 6.75 m: Gravelly Silty SAND.			6.00	S	6.0 SPT: 2, 3, 4 [N=7] 93% Recovery	Gravel	6
	25-02 27-02			PQ Coring									6.50	D	MC Sample: 2 x Jar Samples , 2 x Sample Bags		
7						7.2 [+1.50]	Qe		SM	Silty SAND Fine to medium grained, sub-angular to sub-rounded of quartz and carbonate; brown; silt is non-plastic to low plasticity; trace shell fragments, gravel sized, fine grained; calcareous.		MD	7.50	S	7.5 SPT: 4, 6, 7 [N=13] 73% Recovery	Slotted Pipe	7
8										From 8.1 m, trace gravel, fine to medium grained, sub-angular to sub-rounded of sandstone and calcrete (moderately to strongly $CaCO_3$ cemented sandstone).							8
9													9.00	S	9.0 SPT: 8, 8, 8 [N=16] 76% Recovery		9
10						10.0											10

STANDPIPE PIEZOMETER LOG

Borehole No.: **BH12**

Sheet 3 of 4

Client: K + S Salt Australia Pty Ltd
Project: Ashburton Solar Salt Project
Phase 2 Site Investigation
Job No.: 12516706

Coordinates: **E** 260 263, **N** 7569 718
Ground Surface Elevation: +8.7m AHD **Total Depth:** 19.3m
Commenced: 14-Feb-20 **Completed:** 28-Feb-20
Contractor: J&S Drilling **Driller:** Daniel

Rig Type : Jacro 350 drill rig on Mangrove Buggy **Inclination:** Vertical
Flushing Fluid: Water to 5 m, then Polymer
Hole Diameter (mm): 123

Logged:	DO	28-Feb-20
Processed:	ZW	20-Oct-20
Checked:		

Depth Scale (m)	Daily Progress/ Observations: Date	Casing Depth (m)	Fluid Depth (m)	Drilling Method	Water	Depth (m)/ [Elev.]	Geological Unit	Graphic Log	Classification	Strata Description (type; colour; fines plasticity or particle characteristics; minor components; structure and/or origin)	Moisture Condition	Consistency/ Relative Density	Sample Type & Depth	Sample No.	Sample/ Test Records & Comments	Piezometer Components	Depth Scale (m)
						[-1.30]			SM	Silty SAND Fine to medium grained, sub-angular to sub-rounded of quartz; brown; silt has low plasticity.	M-W	MD				Gravel	
																Bentonite	
													10.50	S	10.5 SPT: 7, 8, 10 [N=18] 93% Recovery		
11																	11
										From 11.8 m, trace gravel, black, fine to coarse grained, sub-rounded of claystone; and trace gravel, fine to medium grained, sub-rounded to rounded of quartz and gypsum.	M	D	12.00	S	12.0 SPT: 7, 14, 20 [N=34] 91% Recovery		
12																	12
				PQ Coring			Qe						12.50	D	12.5-13.0m: MC Sample : 2 x Jar Samples, 2 x Sample Bags)		
13																	13
						13.4 [-4.70]			CI	Sandy CLAY Medium plasticity; brown; sand is fine grained, sub-angular to sub-rounded of quartz; trace gravel, black, fine to medium grained, sub-rounded of claystone.	W~PL	VSt	13.50	S	13.5 SPT: 8, 10, 10 [N=20] 91% Recovery		
14	27-02 28-02								SP-SM CH	Between 14.15 m and 14.3 m, bed of sand, with silt. From 14.3 m, increasing clay content.						Gravel	14
15						15.0											15

GENERAL LOG 12516706 GINT.GPJ GHDLIB.GDT 20-10-20

STANDPIPE PIEZOMETER LOG

Borehole No.: **BH12**

Sheet 4 of 4

Client: K + S Salt Australia Pty Ltd
Project: Ashburton Solar Salt Project
Phase 2 Site Investigation
Job No.: 12516706

Coordinates: **E** 260 263, **N** 7569 718
Ground Surface Elevation: +8.7m AHD **Total Depth:** 19.3m
Commenced: 14-Feb-20 **Completed:** 28-Feb-20
Contractor: J&S Drilling **Driller:** Daniel

Rig Type : Jacro 350 drill rig on Mangrove Buggy **Inclination:** Vertical
Flushing Fluid: Water to 5 m, then Polymer
Hole Diameter (mm): 123

Logged:	DO	28-Feb-20
Processed:	ZW	20-Oct-20
Checked:		

Depth Scale (m)	Daily Progress/ Observations: Date	Casing Depth (m)	Fluid Depth (m)	Drilling Method	Water	Depth (m)/ [Elev.]	Geological Unit	Graphic Log	Classification	Strata Description (type; colour; fines plasticity or particle characteristics; minor components; structure and/or origin)	Moisture Condition	Consistency/ Relative Density	Sample Type & Depth	Sample No.	Sample/ Test Records & Comments	Piezometer Components	Depth Scale (m)
16				PQ Coring		[-6.30]	Qe		CH	Sandy CLAY High plasticity; brown; sand is fine grained, sub-angular to sub-rounded of quartz; trace gravel, black, fine to medium grained, sub-rounded of claystone; with dry clasts of sandy clay.	W~PL	VSt	15.00	S	15.0 SPT: 6, 9, 12 [N=21] 98% Recovery		16
						16.5									16.2 m, switched drill bit from 'pickelly pear' to 'surface set' due to difficult drilling conditions		
17						[-7.80] 16.7			SM	Silty Gravelly SAND Fine to medium grained, sub-angular to sub-rounded of quartz; brown; silt has low to medium plasticity; gravel is fine to coarse grained, sub-rounded to rounded of claystone and quartz.	W	VD	16.50	S	16.5 SPT: 42, 30/90 mm, * [N=R] 96% Recovery		17
						[-8.04]	Qsed			16.74 m to 18.0 m: CORE LOSS. Recoved as gravel, medium to coarse grained, sub-rounded to rounded of quartz and claystone. Inferred as above.							
18						18.0 [-9.30]			SM	Silty Gravelly SAND. As above.			18.00	S	18.0 SPT: 29, 38, 20/50 mm [N=R] [15/50 mm + 5 HB] 86% Recovery	Hole collapse	18
						18.2 [-9.50]			Cl	Gravelly CLAY Medium plasticity; brown; gravel is fine to medium grained, sub-angular to sub-rounded of quartz and calcrete (strongly $CaCO_3$ cemented Sandstone).	W~PL	H					
						18.4 [-9.70]			Cl-CH	Sandy CLAY Medium to high plasticity; brown mottled black (iron); sand is fine grained; trace gravel, white, fine to medium grained, sub-angular of calcrete.							
19	28-02					19.3							19.00	S	19.0 SPT: 29, 30/100mm, * [] Recovery= 100%		19
						[-10.55]				Termination Depth = 19.25m (Target Depth)							
20																	20

BOREHOLE LOG

Borehole No.: **BH12A**

Sheet 1 of 1

Client: K + S Salt Australia Pty Ltd
Project: Ashburton Solar Salt Project
Phase 2 Site Investigation
Job No.: 12516706

Coordinates: **E** 261 195, **N** 7565 602
Ground Surface Elevation: +8.7m AHD **Total Depth:** 4.0m
Commenced: 29-Feb-20 **Completed:** 29-Feb-20
Contractor: J&S Drilling **Driller:** Daniel

Rig Type : Jacro 350 drill rig on Mangrove Buggy **Inclination:** Vertical
Flushing Fluid: Water
Hole Diameter (mm): 123

Logged:	DO	29-Feb-20
Processed:	ZW	20-Oct-20
Checked:		

Depth Scale (m)	Daily Progress/ Observations: Date	Casing Depth (m)	Fluid Depth (m)	Drilling Method	Water	Depth (m)/ [Elev.]	Geological Unit	Graphic Log	Classification	Strata Description (type; colour; fines plasticity or particle characteristics; minor components; structure and/or origin)	Moisture Condition	Consistency/ Relative Density	Sample Type & Depth	Sample No.	Sample/ Test Records & Comments	Depth Scale (m)
0				HA		[+8.60]	Qe		SM	Topsoil - Silty SAND Fine to medium grained, brown, sub-angular to sub-rounded of quartz; silt is non-plastic; with plant rootlets.	D	MD			HA: Hand excavation to 0.4 m.	0
									SM	Silty SAND Fine to medium grained, brown, sub-angular to sub-rounded of quartz; silt is non-plastic.	M		0.70	ASS	0.7 m: ASS sample	
1										0.9 to 1.1 m, increased fines content, low plasticity; sand is fine grained.	D		1.00	ASS	1.0 m: ASS sample	1
											M					
2				PQ Coring									2.00	ASS	2.0 m: ASS sample	2
													2.25	ASS	2.25 m: ASS sample	
													2.50	ASS	2.5 m: ASS sample	
											D		2.75	ASS	2.75 m: ASS sample	
3											M					3
															3.35-4.0m: Driller pulled rods up and down during this run due to drilling difficulties.	
4						4.0 [+4.70]				Termination Depth = 4.00m (Target Depth)						4
5																5

STANDPIPE PIEZOMETER LOG

Borehole No.: **BH13**

Sheet 1 of 5

Client: K + S Salt Australia Pty Ltd
Project: Ashburton Solar Salt Project
Phase 2 Site Investigation
Job No.: 12516706

Coordinates: **E** 271 735, **N** 7563 998
Ground Surface Elevation: +6.2m AHD **Total Depth:** 16.5m
Commenced: 10-Feb-20 **Completed:** 11-Feb-20
Contractor: J&S Drilling **Driller:** Alan

Rig Type : Jacro 350 drill rig on Mangrove Buggy **Inclination:** Vertical
Flushing Fluid: Water to 5 m, then Polymer
Hole Diameter (mm): 123

Logged:	SG	11-Feb-20
Processed:	WR	20-Oct-20
Checked:		

Depth Scale (m)	Daily Progress/ Observations: Date	Casing Depth (m)	Fluid Depth (m)	Drilling Method	Water	Depth (m)/ [Elev.]	Geological Unit	Graphic Log	Classification	Strata Description (type; colour; fines plasticity or particle characteristics; minor components; structure and/or origin)	Moisture Condition	Consistency/ Relative Density	Sample Type & Depth	Sample No.	Sample/ Test Records & Comments	Piezometer Components	Depth Scale (m)
	10-02			PQ	Groundwater dipped at 3.86 m on 13/02/2020					0.0 to 0.65 m: CORE LOSS. Inferred as SILT.	-	-			Water return lost from 0.0 to 0.7 m	Above ground cover; Backfill Clay 0.0-0.5m	
						0.7 [+5.55]			ML	Sandy SILT Low plasticity; red-brown with minor black mottling; sand is fine to medium grained; weakly cemented.	W<PL	VSt			Water return gained at ~0.7 m, and drilling becomes harder		
1															1.3 to 1.5m: Material characterisation samples taken	Bentonite 0.5-2.0m	1
													1.50	S	1.5 SPT: 7, 11, 15 [N=26] 100% recovery		
2																Top of Gravel 2m	2
						3.0 [+3.20]			CL	Sandy CLAY Low plasticity; red-brown; sand is fine to medium grained; non-calcareous.			3.00	S	3.0 SPT: 5, 11, 16 [N=27] 100% recovery		
3															3.3 to 3.5m: Material characterisation samples taken		3
						3.7 [+2.50]			SM	Silty SAND Fine to medium grained; red-brown; silt is non-plastic; calcareous.	M	MD			From 3.8 m: Weak HCl reaction		
4															4.0 to 4.2m: Material characterisation samples taken		4
						4.2 [+2.00]				4.2 to 4.5 m: CORE LOSS.							
						4.5 [+1.70]			SM	Silty SAND Fine to medium grained; red-brown; silt is non-plastic; calcareous.			4.50	S	4.5 SPT: 4, 9, 12 [N=21] 89% recovery	Screen 3-6m	
5																	5

STANDPIPE PIEZOMETER LOG

Borehole No.: **BH13**

Sheet 2 of 5

Client: K + S Salt Australia Pty Ltd
Project: Ashburton Solar Salt Project
Phase 2 Site Investigation
Job No.: 12516706

Coordinates: **E** 271 735, **N** 7563 998
Ground Surface Elevation: +6.2m AHD **Total Depth:** 16.5m
Commenced: 10-Feb-20 **Completed:** 11-Feb-20
Contractor: J&S Drilling **Driller:** Alan

Rig Type : Jacro 350 drill rig on Mangrove Buggy **Inclination:** Vertical
Flushing Fluid: Water to 5 m, then Polymer
Hole Diameter (mm): 123

Logged:	SG	11-Feb-20
Processed:	WR	20-Oct-20
Checked:		

Depth Scale (m)	Daily Progress/ Observations: Date	Casing Depth (m)	Fluid Depth (m)	Drilling Method	Water	Depth (m)/ [Elev.]	Geological Unit	Graphic Log	Classification	Strata Description (type; colour; fines plasticity or particle characteristics; minor components; structure and/or origin)	Moisture Condition	Consistency/ Relative Density	Sample Type & Depth	Sample No.	Sample/ Test Records & Comments	Piezometer Components	Depth Scale (m)
						5.4 [+0.80]			SM	Silty SAND Fine to medium grained; red-brown; silt is non-plastic; calcareous.					Drilling fluid changed from water to polymer at 5.0 m		
									CL	Sandy CLAY Low plasticity; red-brown; sand is fine to medium grained. 5.7m: with gravel, coarse grained of concrete (weakly to strongly CaCO3 cemented claystone) From 5.7 m: With gravel, coarse grained of calcrete (weakly to strongly $CaCO_3$ cemented claystone).	W<PL	H					
6						6.0 [+0.20]			CI	CLAY Medium plasticity; red-brown; with sand, fine to medium grained; with gravel, of weakly $CaCO_3$ cemented claystone.			6.00	S	6.0 SPT: 11, 21, 29 [N=50] 56% recovery		6
	10-02 11-02					6.5 [-0.30]	Czp		CL	Carbonate Gravelly Sandy CLAY Low plasticity clay; red-brown; sand is fine to medium grained; angular, of quartz, weakly cemented; gravel is fine to coarse grained, of calcarenite (weakly to moderately cemented).						Base of Gravel 6.5m Bentonite Seal 6.5-6.7m	
7				PQ		7.5 [-1.30]			CI	Carbonate Sandy CLAY Medium plasticity; red-brown mottled white; sand is fine grained, angular of quartz; with gravel of calcarenite (weakly cemented).			7.50	S	7.5 SPT: 15, 33, 30/50 mm [63/200 mm] 78% recovery		7
						7.8 [-1.60]			GC	Sandy Clayey GRAVEL Medium to coarse grained; sub-angular; of weakly to moderately cemeted calcarenite; red-brown mottled white; clay has low plasticity; sand is fine to medium grained.	-	-					
8						8.1				*Start of coring at 8.1m.* *Continued next sheet in Rock Core format.*							8
9																	9
10																	10

STANDPIPE PIEZOMETER LOG
*** ROCK CORE FORMAT ***

Borehole No.: **BH13**

Client: K + S Salt Australia Pty Ltd
Project: Ashburton Solar Salt Project
Phase 2 Site Investigation
Job No.: 12516706

Coordinates: **E** 271 735, **N** 7563 998
Ground Surface Elevation: +6.2m AHD **Total Depth:** 16.5m
Commenced: 10-Feb-20 **Completed:** 11-Feb-20
Contractor: J&S Drilling **Driller:** Alan

Rig Type : Jacro 350 drill rig on Mangrove Buggy **Inclination:** Vertical
Drilling Fluid: Polymer
Core Diameter (mm): 85

Logged:	SG	11-Feb-20
Processed:	WR	20-Oct-20
Checked:		

Depth Scale (m)	Daily Progress/ Observations: Date	Casing Depth (m)	Fluid Depth (m)	Drilling Method	Water	Depth (m)/ [Elev.]	Geological Unit	Graphic Log	Strata Description (Rocktype; grain size; texture & structure; colour; strength; fracture condition; minor constituents)	Weathering/ Cementation	Estimated Rock Strength (VL L M H VH EH)	Rock Core Quality: TCR (%)	RQD (%)	F (fractures/m)	Defect Log	Drill Rate (min/m)	Defect Description & Comments	Piezometer Components	Depth Scale (m)
6																			6
7																			7
8						8.1 [-1.90]			*Resuming in Core Log format 8.1m.*										8
9				PQ			Qsed		Calcareous Silty SANDSTONE Fine grained; red-brown mottled white; locally calcarenite.	Wk-Mo		100	100	0			HCl does not react on silty sandstone, but does on calcarenite.		9
										Wk-VWk							8.8 m, DB 8.95 m, DB 9.0 SPT: 22, 35, 29 [N=64] Recovery= 100%		
									9.5 to 10.15 m: Zones of very weakly cemented material with no rock strength.	Wk-Mo		77	33	20			Material is readily peeled with knife and can be broken by hand.		
10						10.0													10

STANDPIPE PIEZOMETER LOG
*** ROCK CORE FORMAT ***

Borehole No.: **BH13**

Sheet 4 of 5

Client: K + S Salt Australia Pty Ltd
Project: Ashburton Solar Salt Project
Phase 2 Site Investigation
Job No.: 12516706

Coordinates: **E** 271 735, **N** 7563 998
Ground Surface Elevation: +6.2m AHD **Total Depth:** 16.5m
Commenced: 10-Feb-20 **Completed:** 11-Feb-20
Contractor: J&S Drilling **Driller:** Alan

Rig Type : Jacro 350 drill rig on Mangrove Buggy **Inclination:** Vertical
Drilling Fluid: Polymer
Core Diameter (mm): 85

Logged:	SG	11-Feb-20
Processed:	WR	20-Oct-20
Checked:		

Depth Scale (m)	Daily Progress/ Observations: Date	Casing Depth (m)	Fluid Depth (m)	Drilling Method	Water	Depth (m)/ [Elev.]	Geological Unit	Graphic Log	Strata Description (Rocktype; grain size; texture & structure; colour; strength; fracture condition; minor constituents)	Weathering/ Cementation	Estimated Rock Strength (VL L M H VH EH)	Rock Core Quality: TCR (%)	RQD (%)	F (fractures/m)	Defect Log	Drill Rate (min/m)	Defect Description & Comments	Piezometer Components	Depth Scale (m)
						[-3.80] 10.2 [-3.95]			Calcareous Silty SANDSTONE Fine grained; red-brown mottled white; locally calcarenite.								Broken zone 10.0-10.15m.		
									10.15 to 10.5 m: CORE LOSS.			77	33						
						10.5 [-4.30]			Calcareous Silty SANDSTONE Fine grained; red-brown mottled white; locally calcarenite; with mica sand.	Wk-Mo							10.5 SPT: 10, 23, 30/70mm [N=53/220mm] Recovery= 82%		
11												100	75	0					11
									From 11.8 m: Trace gravel, coarse grained, rounded, of quartz.									Gravel Backfill 6.7-16.5m	
12						12.0 [-5.80]			Sandy Clayey GRAVEL Fine to coarse grained; rounded; of mixed lithology including quartz and Banded Iron Formation; clay has low plasticity; sand is fine to medium grained.	Wk							12.0 SPT: 23/80mm Recovery= 4% with 5 consecutive blows with no penetration.		12
						12.2 [-6.00]				Mo									
				PQ			Qsed		Carbonate Sandy CLAY Medium to high plasticity; red-brown mottled pale grey; sand is fine to coarse grained; trace gravel and cobbles of calcrete (with $CaCO_3$ cemented of claystone); moist; with calcareous veins, 1 mm thick.								12.0m: Lost water return. 12.5m: Water returned and is salty.		
13																			13
																	13.5 SPT: 27, 30/100mm [N=30/100mm] Recovery= 51%		
14																			14
15																			15

STANDPIPE PIEZOMETER LOG
*** ROCK CORE FORMAT ***

Borehole No.: **BH13**

Sheet 5 of 5

Client: K + S Salt Australia Pty Ltd
Project: Ashburton Solar Salt Project
Phase 2 Site Investigation
Job No.: 12516706

Coordinates: **E** 271 735, **N** 7563 998
Ground Surface Elevation: +6.2m AHD **Total Depth:** 16.5m
Commenced: 10-Feb-20 **Completed:** 11-Feb-20
Contractor: J&S Drilling **Driller:** Alan

Rig Type : Jacro 350 drill rig on Mangrove Buggy **Inclination:** Vertical
Drilling Fluid: Polymer
Core Diameter (mm): 85

Logged:	SG	11-Feb-20
Processed:	WR	20-Oct-20
Checked:		

Depth Scale (m)	Daily Progress/ Observations: Date	Casing Depth (m)	Fluid Depth (m)	Drilling Method	Water	Depth (m)/ [Elev.]	Geological Unit	Graphic Log	Strata Description (Rocktype; grain size; texture & structure; colour; strength; fracture condition; minor constituents)	Weathering/ Cementation	Estimated Rock Strength (VL L M H VH EH)	Rock Core Quality: TCR (%)	RQD (%)	F (fractures/m)	Defect Log	Drill Rate (min/m)	Defect Description & Comments	Piezometer Components	Depth Scale (m)
16				PQ			Qsed		Carbonate Sandy CLAY Medium to high plasticity; red-brown mottled pale grey; sand is fine to coarse grained; trace gravel and cobbles of calcrete (with $CaCO_3$ cemented of claystone); moist; with calcareous veins, 1 mm thick. From 15.0 m: Increasing sand content.	Mo							15.0 SPT: 29, 50/150mm [N=50/150mm] Recovery= 67% (ie 30 blows for less than 100mm penetration)		16
						16.5 [-10.30]			Termination Depth = 16.50m									Base of Hole 16.5m	
17																			17
18																			18
19																			19
20																			20

STANDPIPE PIEZOMETER LOG

Borehole No.: **BH14**

Sheet 1 of 5

Client: K + S Salt Australia Pty Ltd
Project: Ashburton Solar Salt Project
Phase 2 Site Investigation
Job No.: 12516706

Coordinates: **E** 259 892, **N** 7565 531
Ground Surface Elevation: +1.0m AHD **Total Depth:** 20.0m
Commenced: 01-Mar-20 **Completed:** 03-Mar-20
Contractor: J&S Drilling **Driller:** Daniel

Rig Type : Jacro 350 drill rig on Mangrove Buggy **Inclination:** Vertical
Flushing Fluid: Water to 5 m, then Polymer
Hole Diameter (mm): 123

Logged:	DO	03-Mar-20
Processed:	ZW	20-Oct-20
Checked:		

Depth Scale (m)	Daily Progress/ Observations: Date	Casing Depth (m)	Fluid Depth (m)	Drilling Method	Water	Depth (m)/ [Elev.]	Geological Unit	Graphic Log	Classification	Strata Description (type; colour; fines plasticity or particle characteristics; minor components; structure and/or origin)	Moisture Condition	Consistency/ Relative Density	Sample Type & Depth	Sample No.	Sample/ Test Records & Comments	Piezometer Components	Depth Scale (m)
0	01-03			PQ Coring		0.7 [+0.30]	Qt		SC	Clayey SAND (borderline Sandy CLAY) Fine to medium grained, sub-angular to sub-rounded of quartz; brown; clay has low to medium plasticity.	M-W	VL/S	0.00	S	MC: Material Characterisation 0.0 SPT: 1, 2, 1 [N=3] 80% Recovery From surface, hole drilled using a prickly pear drill bit.	Above ground cover	0
											W						
						1.0 [+0.00]			SP-SM	SAND Fine to medium grained, sub-angular to sub-rounded of quartz; brown; with silt.		VL					
1									SC	Clayey SAND Fine to medium grained, sub-angular to sub-rounded of quartz; grey-brown; clay has low to medium plasticity.			1.00	D	Run 1 to 1.25 m: push rods into ground. MC Sample : 2 x Jar Samples and 2 x Sample Bags		1
												L-MD	1.50	S	1.5 SPT: 4, 4, 6 [N=10] 89% Recovery		
2																Grout	2
						2.9 [-1.90]			SM	Silty SAND Fine to medium grained, sub-angular to sub-rounded of quartz; grey-brown; silt has low plasticity; trace gravel, pale brown, fine to medium grained, sub-angular to sub-rounded of calcrete (weakly to strongly $CaCO_3$ cemented sandstone).		MD			ASS samples recovered at 0.25m, 0.5m, 0.75m, 1.0m, 1.25m, 1.5m, 1.75m, 2.0m, 2.25m, 2.5m, 2.75m, 3.0m, 3.25m, 3.5m, 3.75m, 4.0m, 4.25m, 4.5m, 4.75m, 5.0m		
3													3.00	S	3.0 SPT: 3, 5, 7 [N=12] 82% Recovery	Solid Pipe	3
4									SP/SM	From 4.0 m, sand/silty sand, of quartz and some carbonate sand.					Pass sample QA14 at 4.25 m		4
						4.6 [-3.60]			SC	Gravelly Clayey SAND Fine to medium grained, sub-angular to sub-rounded of quartz; brown; clay and gravel as below.			4.50	S	4.5 SPT: 7, 12, 16 [N=28] 87% Recovery		
5	01-03					5.0											5

GENERAL LOG 12516706 GINT.GPJ GHDLIB.GDT 20-10-20

STANDPIPE PIEZOMETER LOG

Borehole No.: **BH14**

Sheet 2 of 5

Client: K + S Salt Australia Pty Ltd
Project: Ashburton Solar Salt Project
Phase 2 Site Investigation
Job No.: 12516706

Coordinates: **E** 259 892, **N** 7565 531
Ground Surface Elevation: +1.0m AHD **Total Depth:** 20.0m
Commenced: 01-Mar-20 **Completed:** 03-Mar-20
Contractor: J&S Drilling **Driller:** Daniel

Rig Type : Jacro 350 drill rig on Mangrove Buggy **Inclination:** Vertical
Flushing Fluid: Water to 5 m, then Polymer
Hole Diameter (mm): 123

Logged:	DO	03-Mar-20
Processed:	ZW	20-Oct-20
Checked:		

Depth Scale (m)	Daily Progress/ Observations: Date	Casing Depth (m)	Fluid Depth (m)	Drilling Method	Water	Depth (m)/ [Elev.]	Geological Unit	Graphic Log	Classification	Strata Description (type; colour; fines plasticity or particle characteristics; minor components; structure and/or origin)	Moisture Condition	Consistency/ Relative Density	Sample Type & Depth	Sample No.	Sample/ Test Records & Comments	Piezometer Components	Depth Scale (m)
	02-03			PQ Coring		[-4.00]	Qt		SC	Gravelly Clayey SAND Fine to medium grained, sub-angular to sub-rounded quartz; brown; clay has low plasticity; gravel is fine to medium grained, sub-angular (clasts of clayey sand/sandy clay and trace calcrete).	W	MD	5.00	D	5.0-5.5 m,MC Sample : 2 x Jar Samples and 2 x Sample Bags		
6						6.0 [-5.00]			CH	CLAY High plasticity; brown; trace fine grained sand; trace gravel, fine to medium grained, sub-angular of calcrete (strongly $CaCO_3$ cemented sandstone).	W<PL	H	6.00	S	6.0 SPT: 11, 21, 39 [N=60] 60% Recovery		6
7						7.3 [-6.30]	Qsed		Cl-CH	Sandy CLAY Medium to high plasticity; brown, locally stained pale grey; sand is fine grained; with gravel, fine to medium grained, sub-angular to sub-rounded of calcrete and sandstone (strongly $CaCO_3$ cemented sandstone).		VSt	7.50	S	7.5 SPT: 10, 11, 16 [N=27] 96% Recovery		7
8										From 8.0 m, brown, locally stained pale grey and locally spotted black (iron).			8.00	D	8.0-8.5m, MC Sample : 2 x Jar Samples and 2 x Sample Bags		8
9												H	9.00	S	9.0 SPT: 9, 14, 21 [N=35] 91% Recovery	Bentonite	9
10						10.0											10

GENERAL LOG 12516706 GINT.GPJ GHDLIB.GDT 20-10-20

STANDPIPE PIEZOMETER LOG

Borehole No.: **BH14**

Client: K + S Salt Australia Pty Ltd
Project: Ashburton Solar Salt Project
Phase 2 Site Investigation
Job No.: 12516706

Coordinates: **E** 259 892, **N** 7565 531
Ground Surface Elevation: +1.0m AHD **Total Depth:** 20.0m
Commenced: 01-Mar-20 **Completed:** 03-Mar-20
Contractor: J&S Drilling **Driller:** Daniel

Rig Type : Jacro 350 drill rig on Mangrove Buggy **Inclination:** Vertical
Flushing Fluid: Water to 5 m, then Polymer
Hole Diameter (mm): 123

Logged:	DO	03-Mar-20
Processed:	ZW	20-Oct-20
Checked:		

Depth Scale (m)	Daily Progress/ Observations: Date	Casing Depth (m)	Fluid Depth (m)	Drilling Method	Water	Depth (m)/ [Elev.]	Geological Unit	Graphic Log	Classification	Strata Description (type; colour; fines plasticity or particle characteristics; minor components; structure and/or origin)	Moisture Condition	Consistency/ Relative Density	Sample Type & Depth	Sample No.	Sample/ Test Records & Comments	Piezometer Components	Depth Scale (m)
11						[-9.00]			CI-CH	Sandy CLAY Medium to high plasticity; brown, locally stained pale grey and locally spotted black (iron); sand is fine grained; with gravel, fine to medium grained, sub-angular to sub-rounded of calcrete and sandstone (strongly $CaCO_3$ cemented sandstone).	W<PL	H	10.50	S	10.5 SPT: 12, 21, 32 [N=53] 80% Recovery	Gravel	11
						11.1				*Start of coring at 11.1m.* *Continued next sheet in Rock Core format.*							
12																	12
13																	13
14																	14
15																	15

STANDPIPE PIEZOMETER LOG
*** ROCK CORE FORMAT ***

Borehole No.: **BH14**

Client: K + S Salt Australia Pty Ltd
Project: Ashburton Solar Salt Project
Phase 2 Site Investigation
Job No.: 12516706

Coordinates: **E** 259 892, **N** 7565 531
Ground Surface Elevation: +1.0m AHD **Total Depth:** 20.0m
Commenced: 01-Mar-20 **Completed:** 03-Mar-20
Contractor: J&S Drilling **Driller:** Daniel

Rig Type : Jacro 350 drill rig on Mangrove Buggy **Inclination:** Vertical
Drilling Fluid: Polymer
Core Diameter (mm): 85

Logged:	DO	03-Mar-20
Processed:	ZW	20-Oct-20
Checked:		

Depth Scale (m)	Daily Progress/ Observations: Date	Casing Depth (m)	Fluid Depth (m)	Drilling Method	Water	Depth (m)/ [Elev.]	Geological Unit	Graphic Log	Strata Description (Rocktype; grain size; texture & structure; colour; strength; fracture condition; minor constituents)	Weathering/ Cementation	Estimated Rock Strength (VL L M H VH EH)	Rock Core Quality: TCR (%)	RQD (%)	F (fractures/m)	Defect Log	Drill Rate (min/m)	Defect Description & Comments	Piezometer Components	Depth Scale (m)
11						11.1 [-10.10]			*Resuming in Core Log format 11.1m.*										11
12				PQ Coring			Qsed		SANDSTONE Fine to medium grained; brown, stained pale grey, locally stained white ($CaCO_3$) and black (iron); locally $CaCO_3$ cemented. From 11.5 m to 11.55 m, well iron cemented band. From 12.25 m, brown, loss of $CaCO_3$ cementation; addition of trace gravel, fine grained, black, rounded, of claystone.	Mo-We		100	100	0			11.18 m: DB 11.33 m: DB 11.58 m: DB 11.67 m: DB 11.78 m: DB 11.88 m: DB 11.93-12.0 m: DB 12.0 SPT: 20, 45/140mm, * [N=R] 100% Recovery From 12.35-12.5m, void infilled with pale grey sandy clay, 10mm thick. 12.45 m: DB 12.65 m: DB 12.76 m: DB	Slotted Pipe	12
13						13.5 [-12.50]			CLAY Medium to high plasticity; brown, stained pale grey; with fine grained sand; with gravel, fine to medium grained, sub-angular to sub-rounded, of white gypsum, black iron cemented and pale grey mudstone.	Mo Mo-We Mo Mo-We Mo		100	33				13.27 m: DB 13.39 m: DB 13.47 m: DB 13.5 m: DB 13.8-13.85 m: DB 13.95 m: DB 14.2-14.5 m: DB	Hole collapse	13
14																			14
15						15.0													15

STANDPIPE PIEZOMETER LOG
*** ROCK CORE FORMAT ***

Borehole No.: **BH14**

Sheet 5 of 5

Client: K + S Salt Australia Pty Ltd
Project: Ashburton Solar Salt Project
Phase 2 Site Investigation
Job No.: 12516706

Coordinates: **E** 259 892, **N** 7565 531
Ground Surface Elevation: +1.0m AHD **Total Depth:** 20.0m
Commenced: 01-Mar-20 **Completed:** 03-Mar-20
Contractor: J&S Drilling **Driller:** Daniel

Rig Type : Jacro 350 drill rig on Mangrove Buggy **Inclination:** Vertical
Drilling Fluid: Polymer
Core Diameter (mm): 85

Logged:	DO	03-Mar-20
Processed:	ZW	20-Oct-20
Checked:		

Depth Scale (m)	Daily Progress/ Observations: Date	Casing Depth (m)	Fluid Depth (m)	Drilling Method	Water	Depth (m)/ [Elev.]	Geological Unit	Graphic Log	Strata Description (Rocktype; grain size; texture & structure; colour; strength; fracture condition; minor constituents)	Weathering/ Cementation	Estimated Rock Strength (VL L M H VH EH)	Rock Core Quality: TCR (%)	RQD (%)	F (fractures/m)	Defect Log	Drill Rate (min/m)	Defect Description & Comments	Piezometer Components	Depth Scale (m)
16	02-03			PQ Coring		[-14.00]	Qsed		CLAY Medium to high plasticity; brown, stained pale grey; with fine grained sand; with gravel, fine to medium grained, sub-angular to sub-rounded, of white gypsum, black iron cemented and pale grey mudstone.	Mo		100	33				15.0 SPT: 12, 18, 32 [N=50] 80% Recovery		16
	03-03					16.0 [-15.00]			MUDSTONE Fine grained; brown, stained pale grey, locally iron stained orange and red; trace gravel, fine to coarse grained, black iron cemented and white gypsum.	Mo-We							16.0-16.05 m: DB 16.25 m: DB 16.35 m: DB 16.5 SPT: 14, 42, 30/90mm [N=R] 67% Recovery 16.5 m: DB		
17												100	100	0			17 m: DB	Gravel and hole collapse	17
																	17.45 m: DB 17.67 m: DB 17.87 m: DB 17.91 m: DB 17.96 m: DB 18.0 m: DB		
18										We									18
										Mo-We							18.21 m: DB		
																	18.65 m: DB 18.78 m: DB		
19						19.0 [-18.00]			CLAY Medium to high plasticity; brown, stained grey; with fine grained sand; with gravel, fine to medium grained, sub-angular to sub-rounded, of mudstone and some black iron cemented and white calcrete.	Mo		100	100						19
	03-03					20.0 [-18.95]						100					19.5 SPT: 9, 21, 28 [N=49] 76% Recovery		
20									Termination Depth = 19.95m										20

STANDPIPE PIEZOMETER LOG

Borehole No.: **BH14A**

Sheet 1 of 1

Client: K + S Salt Australia Pty Ltd
Project: Ashburton Solar Salt Project
Phase 2 Site Investigation
Job No.: 12516706

Coordinates: **E** 259 892, **N** 7565 533
Ground Surface Elevation: +1.0m AHD **Total Depth:** 6.0m
Commenced: 04-Mar-20 **Completed:** 04-Mar-20
Contractor: J&S Drilling **Driller:** Daniel

Rig Type : Jacro 350 drill rig on Mangrove Buggy **Inclination:** Vertical
Flushing Fluid: Polymer
Hole Diameter (mm): 123

Logged:	DO	04-Mar-20
Processed:	ZW	20-Oct-20
Checked:		

Depth Scale (m)	Daily Progress/ Observations: Date	Casing Depth (m)	Fluid Depth (m)	Drilling Method	Water	Depth (m)/ [Elev.]	Geological Unit	Graphic Log	Classification	Strata Description (type; colour; fines plasticity or particle characteristics; minor components; structure and/or origin)	Moisture Condition	Consistency/ Relative Density	Sample Type & Depth	Sample No.	Sample/ Test Records & Comments	Piezometer Components	Depth Scale (m)
0				PQ Coring									0.00	U(63)	U63 tube pushed from 0.0-0.5m and recovered 400mm.	Above ground cover Concrete	0
1																Backfill	1
																Solid Pipe	
																Bentonite	
2																	2
3																	3
4																Gravel	4
																Slotted Pipe	
5																	5
6						6.0 [-5.00]											6
7																	7
8																	8
9																	9
10																	10

STANDPIPE PIEZOMETER LOG

Borehole No.: **BH15**

Sheet 1 of 5

Client: K + S Salt Australia Pty Ltd
Project: Ashburton Solar Salt Project
Phase 2 Site Investigation
Job No.: 12516706

Coordinates: **E** 265 126, **N** 7565 578
Ground Surface Elevation: +1.6m AHD **Total Depth:** 20.0m
Commenced: 31-Jan-20 **Completed:** 02-Feb-20
Contractor: J&S Drilling **Driller:** Alan

Rig Type : Jacro 350 drill rig on Mangrove Buggy **Inclination:** Vertical
Flushing Fluid: Water to 5 m, then Polymer
Hole Diameter (mm): 180 Auger / 123 PQ

Logged:	DO	02-Feb-20
Processed:	AT	20-Oct-20
Checked:		

Depth Scale (m)	Daily Progress/ Observations: Date	Casing Depth (m)	Fluid Depth (m)	Drilling Method	Water	Depth (m)/ [Elev.]	Geological Unit	Graphic Log	Classification	Strata Description (type; colour; fines plasticity or particle characteristics; minor components; structure and/or origin)	Moisture Condition	Consistency/ Relative Density	Sample Type & Depth	Sample No.	Sample/ Test Records & Comments	Piezometer Components	Depth Scale (m)
1	31-01			Hollow Stem Auger		0.00	Qe		SM	Silty SAND (borderline SAND) Fine to medium grained, sub-angular to sub-rounded; brown; silt is non-plastic.	D	MD	0.00	U(63)	MC=Material Charactersation U63 tube pushed from 0.0 to 0.45 m	Above ground cover Concrete	1
													0.45	S/ ASS	0.5 SPT: 3, 5, 7 [N=12] 100% Recovery, ASS Sample at 0.5 m ASS samples recovered at 0.25 m, 1.0 m, 1.25 m, 1.5 m, 4.0 m, 4.25 m, 4.5 m		
2						1.2 [+0.40]			CI-CH	Sandy CLAY / CLAY Medium to high plasticity; brown; sand is fine to medium grained, sub-angular to sub-rounded; trace gravel, fine to medium grained, sub-angular of calcrete.	W<PL	St					2
												VSt	2.00	S/ ASS	2.0 SPT: 9, 14, 15 [N=29] 78% Recovery, ASS Sample at 2.0 m and 2.25 m	Solid Pipe	
3						2.8 [-1.20]	Czp		CI	Sandy CLAY Medium plasticity; brown; sand is fine to medium grained, sub-angular to sub-rounded; trace gravel, fine to medium grained, sub-angular to sub-rounded of calcrete. Between 3.05 and 3.1 m, weakly $CaCO_3$ cemented. Between 3.4 and 3.5 m, weakly $CaCO_3$ cemented. From 3.5 m, trace gravel, fine to medium grained, angular, elongated, of gypsum .			2.50	D/ ASS	2.5 to 3.5 m, MC: 2 x jar samples, 2 x sample bags 3.25 m, PASS QA10 sample, ASS Samples at 2.5 m and 3.0 m	Grout/Bentonite Mix	3
											W~PL	H	3.50	S/ ASS	3.5 SPT: 9, 17, 26 [N=43] 67% Recovery, ASS Sample at 3.5 m		
4										At 4.23 m, 20 mm of halite.	W>PL						4
						4.7 [-3.10]				4.7 to 5.0 m: CORE LOSS. Inferred as below.							
5						5.0											5

STANDPIPE PIEZOMETER LOG

Borehole No.: **BH15**

Sheet 2 of 5

Client: K + S Salt Australia Pty Ltd
Project: Ashburton Solar Salt Project
Phase 2 Site Investigation
Job No.: 12516706

Coordinates: **E** 265 126, **N** 7565 578
Ground Surface Elevation: +1.6m AHD **Total Depth:** 20.0m
Commenced: 31-Jan-20 **Completed:** 02-Feb-20
Contractor: J&S Drilling **Driller:** Alan

Rig Type : Jacro 350 drill rig on Mangrove Buggy **Inclination:** Vertical
Flushing Fluid: Water to 5 m, then Polymer
Hole Diameter (mm): 180 Auger / 123 PQ

Logged:	DO	02-Feb-20
Processed:	AT	20-Oct-20
Checked:		

Depth Scale (m)	Daily Progress/ Observations: Date	Casing Depth (m)	Fluid Depth (m)	Drilling Method	Water	Depth (m)/ [Elev.]	Geological Unit	Graphic Log	Classification	Strata Description (type; colour; fines plasticity or particle characteristics; minor components; structure and/or origin)	Moisture Condition	Consistency/ Relative Density	Sample Type & Depth	Sample No.	Sample/ Test Records & Comments	Piezometer Components	Depth Scale (m)
						[-3.40]			CI	Sandy CLAY Medium plasticity; brown; sand is fine to medium grained, sub-angular to sub-rounded; trace gravel, black, fine to medium grained, angular, gypsum and claystone.	W>PL	H	5.00	S	5.0 SPT: 8, 13, 19 [N=32] 71% Recovery		
									CH	Between 5.5 and 5.8 m, becoming high plasticity CLAY; with sand.	W<PL						
									CI						5.9 m, change in drill bit.		
6																	6
							Czp						6.50	S	6.5 SPT: 11, 16, 28 [N=44] 78% Recovery		
7									CI-CH	From 7.0 m, becoming medium to high plasticity; brown stained pale grey-brown, spotted black; with gravel, fine to coarse grained, angular to sub-angular of calcrete and laminated gypsum; locally weakly $CaCO_3$ cemented.						Bentonite	7
8	31-01 01-02			PQ Coring		8.4							8.00	S	8.0 SPT: 21, 45/145 mm, * [] 51% Recovery		8
										Start of coring at 8.4m. *Continued next sheet in Rock Core format.*							
9																	9
10																	10

STANDPIPE PIEZOMETER LOG
*** ROCK CORE FORMAT ***

Borehole No.: **BH15**

Client: K + S Salt Australia Pty Ltd
Project: Ashburton Solar Salt Project
Phase 2 Site Investigation
Job No.: 12516706

Coordinates: **E** 265 126, **N** 7565 578
Ground Surface Elevation: +1.6m AHD **Total Depth:** 20.0m
Commenced: 31-Jan-20 **Completed:** 02-Feb-20
Contractor: J&S Drilling **Driller:** Alan

Rig Type : Jacro 350 drill rig on Mangrove Buggy **Inclination:** Vertical
Drilling Fluid: Polymer
Core Diameter (mm): 85

Logged:	DO	02-Feb-20
Processed:	AT	20-Oct-20
Checked:		

Depth Scale (m)	Daily Progress/ Observations: Date	Casing Depth (m)	Fluid Depth (m)	Drilling Method	Water	Depth (m)/ [Elev.]	Geological Unit	Graphic Log	Strata Description (Rocktype; grain size; texture & structure; colour; strength; fracture condition; minor constituents)	Weathering/ Cementation	Estimated Rock Strength (VL L M H VH EH)	Rock Core Quality: TCR (%)	RQD (%)	F (fractures/m)	Defect Log	Drill Rate (min/m)	Defect Description & Comments	Piezometer Components	Depth Scale (m)
6																			6
7																			7
8																			8
						8.4 [-6.80]			*Resuming in Core Log format 8.4m.*										
9				PQ Coring			Qsed		SANDSTONE Fine to medium grained; brown patched pale grey and pale brown, locally spotted black; trace gravel, fine to coarse grained, angular, of gypsum. Borderline soil strength.	Wk		100 100	100 100	0			9.35-9.50 m, DB's 9.5m, SPT: N: 16/31, 30/80mm 79% recovery 9.88-10.0 m, DB's		9
10						10.0													10

STANDPIPE PIEZOMETER LOG
*** ROCK CORE FORMAT ***

Borehole No.: **BH15**

Sheet 4 of 5

Client: K + S Salt Australia Pty Ltd
Project: Ashburton Solar Salt Project
Phase 2 Site Investigation
Job No.: 12516706

Coordinates: **E** 265 126, **N** 7565 578
Ground Surface Elevation: +1.6m AHD **Total Depth:** 20.0m
Commenced: 31-Jan-20 **Completed:** 02-Feb-20
Contractor: J&S Drilling **Driller:** Alan

Rig Type : Jacro 350 drill rig on Mangrove Buggy **Inclination:** Vertical
Drilling Fluid: Polymer
Core Diameter (mm): 85

Logged:	DO	02-Feb-20
Processed:	AT	20-Oct-20
Checked:		

Depth Scale (m)	Daily Progress/ Observations: Date	Casing Depth (m)	Fluid Depth (m)	Drilling Method	Water	Depth (m)/ [Elev.]	Geological Unit	Graphic Log	Strata Description (Rocktype; grain size; texture & structure; colour; strength; fracture condition; minor constituents)	Weathering/ Cementation	Estimated Rock Strength (VL L M H VH EH)	Rock Core Quality: TCR (%)	RQD (%)	F (fractures/m)	Defect Log	Drill Rate (min/m)	Defect Description & Comments	Piezometer Components	Depth Scale (m)
11				PQ Coring		[-8.40]	Qsed		SANDSTONE Fine to medium grained; brown patched pale grey and pale brown, locally spotted black; trace gravel, fine to coarse grained, angular, of gypsum; trace thin (<5 mm) gypsum seams, with occasional thin clayey sand layers (<0.3 m). Borderline soil strength to 14.1 m.	Wk-Mo		100	100				10.34 m, DB 10.47 m, DB 10.87 m, DB 10.96 m, DB 11.0 m, SPT=23, 30/90 mm 100% recovery	Gravel Slotted Pipe	11
									11.0 to 11.3 m, Clayey SAND.	Wk									
										Wk-Mo									
12									From 11.6 m, loss of gypsum seams, becoming brown patched pale grey and pale brown.			100	80	0			11.63 m, DB 11.70 m, DB 11.80 m, DB 12.13 m, DB 12.20 m, DB 12.24 m, DB 12.35 m, DB 12.42 m, DB 12.50 m, DB	Bentonite	12
									12.55 to 12.75 m, Clayey SAND.	Wk									
										Wk-Mo									
13									13.30 to 13.35 m, Clayey SAND.			100	83				13.44 m, DB 13.50 m, DB 13.59 m, DB 13.70 m, DB 13.82 m to 14.0 m, DB's		13
14	01-02 02-02																14.12 m, DB 14.29 m, DB		14
												100	100						
15						15.0											14.66 m, DB		15

STANDPIPE PIEZOMETER LOG
*** ROCK CORE FORMAT ***

Borehole No.: **BH15**

Sheet 5 of 5

Client: K + S Salt Australia Pty Ltd
Project: Ashburton Solar Salt Project
Phase 2 Site Investigation
Job No.: 12516706

Coordinates: **E** 265 126, **N** 7565 578
Ground Surface Elevation: +1.6m AHD **Total Depth:** 20.0m
Commenced: 31-Jan-20 **Completed:** 02-Feb-20
Contractor: J&S Drilling **Driller:** Alan

Rig Type : Jacro 350 drill rig on Mangrove Buggy **Inclination:** Vertical
Drilling Fluid: Polymer
Core Diameter (mm): 85

Logged:	DO	02-Feb-20
Processed:	AT	20-Oct-20
Checked:		

Depth Scale (m)	Daily Progress/ Observations: Date	Casing Depth (m)	Fluid Depth (m)	Drilling Method	Water	Depth (m)/ [Elev.]	Geological Unit	Graphic Log	Strata Description (Rocktype; grain size; texture & structure; colour; strength; fracture condition; minor constituents)	Weathering/ Cementation	Estimated Rock Strength (VL L M H VH EH)	Rock Core Quality: TCR (%)	RQD (%)	F (fractures/m)	Defect Log	Drill Rate (min/m)	Defect Description & Comments	Piezometer Components	Depth Scale (m)
16				PQ Coring		[-13.40]	Qsed		SANDSTONE Fine to medium grained; brown patched pale grey and pale brown. 15.80 m, 20 mm thick Clayey SAND layer. From 17.5 m, brown streaked pale brown and locally spotted black. From 19.3 m, trace gravel, dark grey, fine to medium grained, sub-rounded of claystone.	Wk-Mo		100 100 100 100 100	100 99 100 100	0			15.00 m, DB 15.23 m, DB 15.36 m to 15.50 m, DB 15.60 m, DB 15.69 m, DB 15.89 m, DB 16.43 m, DB 16.58 m, DB 16.70 m, DB 16.84 m, DB 17.00 m, DB 17.09 m, DB 17.13 m, DB 17.34 m, DB 17.51 m, DB 17.70 m, DB 17.93 m, DB 18.00 m, DB 18.35 m, DB 18.50 m, DB 18.58 m, DB 18.97 m, DB 19.00 m, DB 19.09 m, DB 19.15 m, DB 19.49 m, DB 19.73 m, DB	Gravel	16
17																			17
18																			18
19																			19
20	02-02					20.0			Termination Depth = 20.00m										20

STANDPIPE PIEZOMETER LOG

Borehole No.: **BH15A**

Sheet 1 of 1

Client: K + S Salt Australia Pty Ltd
Project: Ashburton Solar Salt Project
Phase 2 Site Investigation
Job No.: 12516706

Coordinates: **E** 265 126, **N** 7565 580
Ground Surface Elevation: +1.6m AHD **Total Depth:** 5.0m
Commenced: 31-Jan-20 **Completed:** 02-Feb-20
Contractor: J&S Drilling **Driller:** Alan

Rig Type : Jacro 350 drill rig on Mangrove Buggy **Inclination:** Vertical
Flushing Fluid: Polymer
Hole Diameter (mm): 123

Logged:	DO	02-Feb-20
Processed:	ZW	20-Oct-20
Checked:		

Depth Scale (m)	Daily Progress/ Observations: Date	Casing Depth (m)	Fluid Depth (m)	Drilling Method	Water	Depth (m)/ [Elev.]	Geological Unit	Graphic Log	Classification	Strata Description (type; colour; fines plasticity or particle characteristics; minor components; structure and/or origin)	Moisture Condition	Consistency/ Relative Density	Sample Type & Depth	Sample No.	Sample/ Test Records & Comments	Piezometer Components	Depth Scale (m)
1				PQ Coring												Above ground cover Concrete; Bentonite; Solid Pipe	1
2																	2
3																Slotted Pipe; Gravel	3
4																	4
5						5.0 [-3.40]											5

GENERAL LOG 12516706 GINT.GPJ GHDLIB.GDT 20-10-20

Appendix B – Laboratory Results

Appendix B
Table 1
Initial Material Characterisation Results

									NAG and NAPP						
				pH (aqueous extract)	Electrical conductivity (lab)	CEC	Exchangeable Sodium Percent	Total Soluble Salts	Moisture Content (%)	Net Acid Generation: NAG (initial to pH 4.5)	Net Acid Generation: NAG (pH 4.5 - pH 7.0)	pH After Oxidation (pH NAG)*	Maximum Potential Acidity (MPA)	Net Acid Producing Potential (NAPP)	Acid Neutralising Capacity (ANC)
				pH Units	µS/cm	meq/100g	%	mg/kg	%	Kg H2SO4/t	Kg H2SO4/t	PH UNITS	Kg H2SO4/t	Kg H2SO4/t	Kg H2SO4/t
LOR				0.1	10	0.05	0.1		1	0.1	0.1	0.1	0.005	0.1	0.5
Sample ID	**Location ID**	**Sample depth**	**Sample date**												
AU03_0.75	AU03	0.75	15/01/2020	8.4	12,000	210	0.4	10,000	22	< 0.1	< 0.1	8.3	0.15	(-)27.3353	27
BH01_1.0	BH01	1	24/03/2020	8.4	4000	40	0.9	3100	17	< 0.1	< 0.1	10	< 0.15	(-)58.0074	58
BH01_6.5	BH01	6.5	24/03/2020	8.6	2100	20	3.2	1600	11	< 0.1	< 0.1	7.5	< 0.15	(-)16.0845	16
BH03_3.4	BH03	3.4	23/01/2020	-	-	-	-	-	-	< 0.1	< 0.1	11	0.71	(-)55.8181	57
BH05_0.2	BH05	0.2	14/01/2020	-	17,000	3.9	5.9	-	21	-	-	-	-	-	-
BH05_0.6	BH05	0.6	14/01/2020	-	19,000	16	9.3	-	21	-	-	-	-	-	-
BH05_0.6	BH05	0.6	15/01/2020	9	9600	29	1.6	7000	12	< 0.1	< 0.1	11	0.18	(-)413.0621	410
BH05_3.5	BH05	3.5	14/01/2020	-	10,000	59	1.3	-	14	-	-	-	-	-	-
BH07_0.75	BH07	0.75	11/03/2020	8.8	6200	32	1.6	510	21	< 0.1	< 0.1	11	< 0.15	(-)521.7809	520
BH07_1.75	BH07	1.75	11/03/2020	9	9300	31	1.2	7300	18	< 0.1	< 0.1	11	< 0.15	(-)476.3163	480
BH09_1.5-2.5	BH09	1.5-2.5	23/01/2020	-	-	-	-	-	14	-	-	-	-	-	-
BH10_4.1_5.0	BH10	4.1	15/01/2020	8.1	17,000	17	7.6	15,000	25	< 0.1	< 0.1	8.7	< 0.15	(-)10.9702	11
BH10_4.1_5.0	BH10	4.1	11/03/2020	8.5	16,000	21	5.6	13,000	25	< 0.1	< 0.1	8.3	< 0.15	(-)10.9395	11
BH11_1.0_1.5	BH11	1	17/03/2020	8.7	12,000	36	4.8	9100	14	< 0.1	< 0.1	8.8	< 0.15	(-)160.1326	160
BH12_1.2-1.5	BH12	1.2-1.5	10/02/2020	-	-	-	-	-	15	-	-	-	-	-	-
BH13_1.3-1.5	BH13	1.3-1.5	10/02/2020	-	-	-	-	-	10	-	-	-	-	-	-
BH13_3.3-3.5	BH13	3.3-3.5	10/02/2020	-	-	-	-	-	17	-	-	-	-	-	-
BH13_4.0-4.2	BH13	4-4.2	10/02/2020	-	-	-	-	-	15	-	-	-	-	-	-
BH14_1.0_1.5	BH14	1	17/03/2020	8.3	11,000	7.4	16	8100	11	< 0.1	< 0.1	9.1	< 0.15	(-)49.5164	50
BH14_5.0_5.5	BH14	5	17/03/2020	8.3	13,000	16	28	10,000	18	< 0.1	< 0.1	7.2	< 0.15	(-)11.0772	11
BH14_8.0_8.5	BH14	8	17/03/2020	8.3	12,000	24	22	9300	16	< 0.1	< 0.1	9.2	< 0.15	(-)28.9825	29

Appendix A
Table 1
Initial Material Characterisation Results

				Metals and Metalloids												
				Arsenic	Beryllium	Boron	Cadmium	Cobalt	Copper	Lead	Manganese	Mercury	Nickel	Selenium	Zinc	Chromium (hexavalent)
				mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
LOR				2	2	10	0.4	5	5	5	5	0.1	5	2	5	1
Sample ID	**Location ID**	**Sample depth**	**Sample date**													
AU03_0.75	AU03	0.75	15/01/2020	-	-	-	-	-	-	-	-	-	-	-	-	-
BH01_1.0	BH01	1	24/03/2020	-	-	-	-	-	-	-	-	-	-	-	-	-
BH01_6.5	BH01	6.5	24/03/2020	-	-	-	-	-	-	-	-	-	-	-	-	-
BH03_3.4	BH03	3.4	23/01/2020	-	-	-	-	-	-	-	-	-	-	-	-	-
BH05_0.2	BH05	0.2	14/01/2020	14	<2	56	<0.4	<5	13	<5	14	<0.1	<5	<2	<5	<1
BH05_0.6	BH05	0.6	14/01/2020	15	<2	110	<0.4	8.4	15	7.6	590	<0.1	18	<2	29	<1
BH05_0.6	BH05	0.6	15/01/2020	-	-	-	-	-	-	-	-	-	-	-	-	-
BH05_3.5	BH05	3.5	14/01/2020	14	<2	41	<0.4	7.5	17	8.7	120	<0.1	20	<2	27	<1
BH07_0.75	BH07	0.75	11/03/2020	-	-	-	-	-	-	-	-	-	-	-	-	-
BH07_1.75	BH07	1.75	11/03/2020	-	-	-	-	-	-	-	-	-	-	-	-	-
BH09_1.5-2.5	BH09	1.5-2.5	23/01/2020	10	<2	13	<0.4	5.8	13	5.7	230	<0.1	12	<2	15	-
BH10_4.1_5.0	BH10	4.1	15/01/2020	-	-	-	-	-	-	-	-	-	-	-	-	-
BH10_4.1_5.0	BH10	4.1	11/03/2020	-	-	-	-	-	-	-	-	-	-	-	-	-
BH11_1.0_1.5	BH11	1	17/03/2020	-	-	-	-	-	-	-	-	-	-	-	-	-
BH12_1.2-1.5	BH12	1.2-1.5	10/02/2020	5.9	<2	<10	<0.4	<5	7.3	<5	100	<0.1	9.7	<2	13	-
BH13_1.3-1.5	BH13	1.3-1.5	10/02/2020	7	<2	<10	<0.4	20	33	12	880	<0.1	32	<2	54	-
BH13_3.3-3.5	BH13	3.3-3.5	10/02/2020	7.6	<2	<10	<0.4	14	31	11	520	<0.1	28	<2	46	-
BH13_4.0-4.2	BH13	4-4.2	10/02/2020	5.2	<2	<10	<0.4	6.2	15	6.6	250	<0.1	15	<2	22	-
BH14_1.0_1.5	BH14	1	17/03/2020	-	-	-	-	-	-	-	-	-	-	-	-	-
BH14_5.0_5.5	BH14	5	17/03/2020	-	-	-	-	-	-	-	-	-	-	-	-	-
BH14_8.0_8.5	BH14	8	17/03/2020	-	-	-	-	-	-	-	-	-	-	-	-	-

Appendix C – Laboratory Certificates

GHD Pty Ltd WA
999 Hay Street Perth
Perth
WA 6004

NATA Accredited
Accreditation Number 1261
Site Number 23736

Accredited for compliance with ISO/IEC 17025 – Testing
The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards.

Attention: **Louise Cockerton**

Report **730742-S**
Project name K + S SALT
Project ID 12516706
Received Date Jun 27, 2020

Client Sample ID			**BH01_1.0**	**BH01_6.5**	**BH07_0.75**	**BH07_1.75**
Sample Matrix			**Soil**	**Soil**	**Soil**	**Soil**
Eurofins Sample No.			**P20-JI16055**	**P20-JI16056**	**P20-JI16057**	**P20-JI16058**
Date Sampled			**Mar 24, 2020**	**Mar 24, 2020**	**Mar 11, 2020**	**Mar 11, 2020**
Test/Reference	LOR	Unit				
Conductivity (1:5 aqueous extract at 25°C as rec.)	10	uS/cm	4000	2100	6200	9300
pH (1:5 Aqueous extract at 25°C as rec.)	0.1	pH Units	8.4	8.6	8.8	9.0
Total Soluble Salts*		mg/kg	3100	1600	510	7300
Exchangeable Sodium Percentage (ESP)	0.1	%	0.9	3.2	1.6	1.2
% Moisture	1	%	17	11	21	18
XRD Analysis			see attached	see attached	see attached	see attached
Cation Exchange Capacity						
Cation Exchange Capacity	0.05	meq/100g	40	20	32	31
Net Acid Production Potential (by CRS)						
Acid Neutralising Capacity (as CaCO3)*	0.1	% CaCO3	5.9	1.6	53	49
Acid Neutralising Capacity (as H2SO4/t)*	0.5	kgH2SO4/t	58	16	520	480
Acid Production Potential (by CRS)	0.15	kgH2SO4/t	< 0.15	< 0.15	< 0.15	< 0.15
Chromium Reducible Sulfur^{S04}	0.005	% S	< 0.005	< 0.005	< 0.005	< 0.005
Net Acid Production Potential (NAPP) by CRS*	0.1	kgH2SO4/t	(-)58.0074	(-)16.0845	(-)521.7809	(-)476.3163
Net Acid Generation						
Net Acid Generation: NAG (initial to pH 4.5)*	0.1	kgH2SO4/t	< 0.1	< 0.1	< 0.1	< 0.1
Net Acid Generation: NAG (pH 4.5 - pH 7.0)*	0.1	kgH2SO4/t	< 0.1	< 0.1	< 0.1	< 0.1
pH After Oxidation (pH NAG)*	0.1	pH Units	10	7.5	11	11

Client Sample ID			**BH10_4.1_5.0**	**BH11_1.0_1.5**	**BH14_1.0_1.5**	**BH14_5.0_5.5**
Sample Matrix			**Soil**	**Soil**	**Soil**	**Soil**
Eurofins Sample No.			**P20-JI16059**	**P20-JI16060**	**P20-JI16061**	**P20-JI16062**
Date Sampled			**Mar 11, 2020**	**Mar 17, 2020**	**Mar 17, 2020**	**Mar 17, 2020**
Test/Reference	LOR	Unit				
Conductivity (1:5 aqueous extract at 25°C as rec.)	10	uS/cm	16000	12000	11000	13000
pH (1:5 Aqueous extract at 25°C as rec.)	0.1	pH Units	8.5	8.7	8.3	8.3
Total Soluble Salts*		mg/kg	13000	9100	8100	10000
Exchangeable Sodium Percentage (ESP)	0.1	%	5.6	4.8	16	28
% Moisture	1	%	25	14	11	18
XRD Analysis			see attached	see attached	-	-
Cation Exchange Capacity						
Cation Exchange Capacity	0.05	meq/100g	21	36	7.4	16

Client Sample ID			BH10_4.1_5.0	BH11_1.0_1.5	BH14_1.0_1.5	BH14_5.0_5.5
Sample Matrix			Soil	Soil	Soil	Soil
Eurofins Sample No.			P20-JI16059	P20-JI16060	P20-JI16061	P20-JI16062
Date Sampled			Mar 11, 2020	Mar 17, 2020	Mar 17, 2020	Mar 17, 2020
Test/Reference	LOR	Unit				
Net Acid Production Potential (by CRS)						
Acid Neutralising Capacity (as CaCO3)*	0.1	% CaCO3	1.1	16	5.1	1.1
Acid Neutralising Capacity (as H2SO4/t)*	0.5	kgH2SO4/t	11	160	50	11
Acid Production Potential (by CRS)	0.15	kgH2SO4/t	< 0.15	< 0.15	< 0.15	< 0.15
Chromium Reducible Sulfur^{S04}	0.005	% S	< 0.005	< 0.005	< 0.005	< 0.005
Net Acid Production Potential (NAPP) by CRS*	0.1	kgH2SO4/t	(-)10.9395	(-)160.1326	(-)49.5164	(-)11.0772
Net Acid Generation						
Net Acid Generation: NAG (initial to pH 4.5)*	0.1	kgH2SO4/t	< 0.1	< 0.1	< 0.1	< 0.1
Net Acid Generation: NAG (pH 4.5 - pH 7.0)*	0.1	kgH2SO4/t	< 0.1	< 0.1	< 0.1	< 0.1
pH After Oxidation (pH NAG)*	0.1	pH Units	8.3	8.8	9.1	7.2

Client Sample ID			BH14_8.0_8.5	AU03_0.75	BH03_3.4	BH10_4.1_5.0
Sample Matrix			Soil	Soil	Soil	Soil
Eurofins Sample No.			P20-JI16063	P20-JI19020	P20-JI19021	P20-JI19022
Date Sampled			Mar 17, 2020	Jan 15, 2020	Jan 23, 2020	Jan 15, 2020
Test/Reference	LOR	Unit				
Conductivity (1:5 aqueous extract at 25°C as rec.)	10	uS/cm	12000	12000	-	17000
pH (1:5 Aqueous extract at 25°C as rec.)	0.1	pH Units	8.3	8.4	-	8.1
Total Soluble Salts*		mg/kg	9300	10000	-	15000
Exchangeable Sodium Percentage (ESP)	0.1	%	22	0.4	-	7.6
% Moisture	1	%	16	22	-	25
XRD Analysis			-	see attached	see attached	see attached
Cation Exchange Capacity						
Cation Exchange Capacity	0.05	meq/100g	24	210	-	17
Net Acid Production Potential (by CRS)						
Acid Neutralising Capacity (as CaCO3)*	0.1	% CaCO3	3.0	2.8	5.8	1.1
Acid Neutralising Capacity (as H2SO4/t)*	0.5	kgH2SO4/t	29	27	57	11
Acid Production Potential (by CRS)	0.15	kgH2SO4/t	< 0.15	< 0.15	0.71	< 0.15
Chromium Reducible Sulfur^{S04}	0.005	% S	< 0.005	< 0.005	0.023	< 0.005
Net Acid Production Potential (NAPP) by CRS*	0.1	kgH2SO4/t	(-)28.9825	(-)27.3353	(-)55.8181	(-)10.9702
Net Acid Generation						
Net Acid Generation: NAG (initial to pH 4.5)*	0.1	kgH2SO4/t	< 0.1	< 0.1	< 0.1	< 0.1
Net Acid Generation: NAG (pH 4.5 - pH 7.0)*	0.1	kgH2SO4/t	< 0.1	< 0.1	< 0.1	< 0.1
pH After Oxidation (pH NAG)*	0.1	pH Units	9.2	8.3	11	8.7

Client Sample ID			BH05_0.6
Sample Matrix			Soil
Eurofins Sample No.			P20-JI19023
Date Sampled			Jan 15, 2020
Test/Reference	LOR	Unit	
Conductivity (1:5 aqueous extract at 25°C as rec.)	10	uS/cm	9600
pH (1:5 Aqueous extract at 25°C as rec.)	0.1	pH Units	9.0
Total Soluble Salts*		mg/kg	7000
Exchangeable Sodium Percentage (ESP)	0.1	%	1.6
% Moisture	1	%	12
XRD Analysis			see attached

Client Sample ID			BH05_0.6
Sample Matrix			Soil
Eurofins Sample No.			P20-JI19023
Date Sampled			Jan 15, 2020
Test/Reference	LOR	Unit	
Cation Exchange Capacity			
Cation Exchange Capacity	0.05	meq/100g	29
Net Acid Production Potential (by CRS)			
Acid Neutralising Capacity (as CaCO3)*	0.1	% CaCO3	42
Acid Neutralising Capacity (as H2SO4/t)*	0.5	kgH2SO4/t	410
Acid Production Potential (by CRS)	0.15	kgH2SO4/t	0.18
Chromium Reducible Sulfur^{S04}	0.005	% S	0.006
Net Acid Production Potential (NAPP) by CRS*	0.1	kgH2SO4/t	(-)413.0621
Net Acid Generation			
Net Acid Generation: NAG (initial to pH 4.5)*	0.1	kgH2SO4/t	< 0.1
Net Acid Generation: NAG (pH 4.5 - pH 7.0)*	0.1	kgH2SO4/t	< 0.1
pH After Oxidation (pH NAG)*	0.1	pH Units	11

Sample History

Where samples are submitted/analysed over several days, the last date of extraction and analysis is reported.
A recent review of our LIMS has resulted in the correction or clarification of some method identifications. Due to this, some of the method reference information on reports has changed. However, no substantive change has been made to our laboratory methods, and as such there is no change in the validity of current or previous results.

If the date and time of sampling are not provided, the Laboratory will not be responsible for compromised results should testing be performed outside the recommended holding time.

Description	Testing Site	Extracted	Holding Time
Conductivity (1:5 aqueous extract at 25°C as rec.)	Melbourne	Jul 14, 2020	7 Days
- Method: LTM-INO-4030 Conductivity			
Cation Exchange Capacity	Melbourne	Jul 15, 2020	180 Days
- Method: LTM-MET-3060 Cation Exchange Capacity by bases & Exchangeable Sodium Percentage			
pH (1:5 Aqueous extract at 25°C as rec.)	Melbourne	Jul 14, 2020	7 Days
- Method: LTM-GEN-7090 pH in soil by ISE			
Total Soluble Salts*	Perth	Jul 16, 2020	0 Day
- Method:			
Exchangeable Sodium Percentage (ESP)	Melbourne	Jul 15, 2020	28 Days
- Method: LTM-MET-3060 - Cation Exchange Capacity (CEC) & Exchangeable Sodium Percentage (ESP)			
Net Acid Production Potential (by CRS)			
Acid Neutralising Capacity (as CaCO3)*	Brisbane	Jul 14, 2020	6 Week
- Method: Net Acid Production Potential (by CRS)			
Acid Production Potential (by CRS)	Brisbane	Jul 14, 2020	6 Week
- Method: Net Acid Production Potential (by CRS)			
Chromium Reducible Sulfur	Brisbane	Jul 14, 2020	0 Days
- Method: Net Acid Production Potential (by CRS)			
Net Acid Generation	Brisbane	Jul 14, 2020	6 Week
- Method: Miller S.D (1998)			
% Moisture	Melbourne	Jul 10, 2020	14 Days
- Method: LTM-GEN-7080 Moisture			

eurofins | Environment Testing

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Address: 999 Hay Street Perth
Perth
WA 6004

Project Name: K + S SALT
Project ID: 12516706

Order No.:
Report #: 730742
Phone: 08 6222 8222
Fax: 08 9429 6555

Received: Jun 27, 2020 11:23 AM
Due: Jul 13, 2020
Priority: 10 Day
Contact Name: Louise Cockerton

Eurofins Analytical Services Manager : Robert Johnston

Sample Detail						Exchangeable Sodium Percentage (ESP)	pH (1:5 Aqueous extract at 25°C as rec.)	Total Soluble Salts*	XRD Analysis	Moisture Set	Cation Exchange Capacity	Net Acid Production Potential (by CRS)	Net Acid Generation
Melbourne Laboratory - NATA Site # 1254 & 14271						X	X			X	X		
Sydney Laboratory - NATA Site # 18217													
Brisbane Laboratory - NATA Site # 20794												X	X
Perth Laboratory - NATA Site # 23736								X					
External Laboratory									X				
No	**Sample ID**	**Sample Date**	**Sampling Time**	**Matrix**	**LAB ID**								
1	BH01_1.0	Mar 24, 2020		Soil	P20-JI16055	X	X	X	X	X	X	X	X
2	BH01_6.5	Mar 24, 2020		Soil	P20-JI16056	X	X	X	X	X	X	X	X
3	BH07_0.75	Mar 11, 2020		Soil	P20-JI16057	X	X	X	X	X	X	X	X
4	BH07_1.75	Mar 11, 2020		Soil	P20-JI16058	X	X	X	X	X	X	X	X
5	BH10_4.1_5.0	Mar 11, 2020		Soil	P20-JI16059	X	X	X	X	X	X	X	X
6	BH11_1.0_1.5	Mar 17, 2020		Soil	P20-JI16060	X	X	X	X	X	X	X	X
7	BH14_1.0_1.5	Mar 17, 2020		Soil	P20-JI16061	X	X	X		X	X	X	X
8	BH14_5.0_5.5	Mar 17, 2020		Soil	P20-JI16062	X	X	X		X	X	X	X
9	BH14_8.0_8.5	Mar 17, 2020		Soil	P20-JI16063	X	X	X		X	X	X	X
10	AU03_0.75	Jan 15, 2020		Soil	P20-JI19020	X	X	X	X	X	X	X	X

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IANZ # 1290

Company Name: GHD Pty Ltd WA
Address: 999 Hay Street Perth
Perth
WA 6004

Project Name: K + S SALT
Project ID: 12516706

Order No.:
Report #: 730742
Phone: 08 6222 8222
Fax: 08 9429 6555

Received: Jun 27, 2020 11:23 AM
Due: Jul 13, 2020
Priority: 10 Day
Contact Name: Louise Cockerton

Eurofins Analytical Services Manager : Robert Johnston

Sample Detail						Exchangeable Sodium Percentage (ESP)	pH (1:5 Aqueous extract at 25°C as rec.)	Total Soluble Salts*	XRD Analysis	Moisture Set	Cation Exchange Capacity	Net Acid Production Potential (by CRS)	Net Acid Generation
Melbourne Laboratory - NATA Site # 1254 & 14271						X	X			X	X		
Sydney Laboratory - NATA Site # 18217													
Brisbane Laboratory - NATA Site # 20794												X	X
Perth Laboratory - NATA Site # 23736								X					
11	BH03_3.4	Jan 23, 2020		Soil	P20-Jl19021				X			X	X
12	BH10_4.1_5.0	Jan 15, 2020		Soil	P20-Jl19022	X	X	X	X	X	X	X	X
13	BH05_0.6	Jan 15, 2020		Soil	P20-Jl19023	X	X	X	X	X	X	X	X
Test Counts						12	12	12	10	12	12	13	13

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Internal Quality Control Review and Glossary

General

1. Laboratory QC results for Method Blanks, Duplicates, Matrix Spikes, and Laboratory Control Samples follows guidelines delineated in the National Environment Protection (Assessment of Site Contamination) Measure 1999, as amended May 2013 and are included in this QC report where applicable. Additional QC data may be available on request.
2. All soil/sediment/solid results are reported on a dry basis, unless otherwise stated.
3. All biota/food results are reported on a wet weight basis on the edible portion, unless otherwise stated.
4. Actual LORs are matrix dependant. Quoted LORs may be raised where sample extracts are diluted due to interferences.
5. Results are uncorrected for matrix spikes or surrogate recoveries except for PFAS compounds.
6. SVOC analysis on waters are performed on homogenised, unfiltered samples, unless noted otherwise.
7. Samples were analysed on an 'as received' basis.
8. Information identified on this report with blue colour, indicates data provided by customer, that may have an impact on the results.
9. This report replaces any interim results previously issued.

Holding Times

Please refer to 'Sample Preservation and Container Guide' for holding times (QS3001).

For samples received on the last day of holding time, notification of testing requirements should have been received at least 6 hours prior to sample receipt deadlines as stated on the SRA.

If the Laboratory did not receive the information in the required timeframe, and regardless of any other integrity issues, suitably qualified results may still be reported.

Holding times apply from the date of sampling, therefore compliance to these may be outside the laboratory's control.

For VOCs containing vinyl chloride, styrene and 2-chloroethyl vinyl ether the holding time is 7 days however for all other VOCs such as BTEX or C6-10 TRH then the holding time is 14 days.

****NOTE:** pH duplicates are reported as a range NOT as RPD

Units

mg/kg: milligrams per kilogram | **mg/L:** milligrams per litre | **ug/L:** micrograms per litre

ppm: Parts per million | **ppb:** Parts per billion | **%:** Percentage

org/100mL: Organisms per 100 millilitres | **NTU:** Nephelometric Turbidity Units | **MPN/100mL:** Most Probable Number of organisms per 100 millilitres

Terms

Dry	Where a moisture has been determined on a solid sample the result is expressed on a dry basis.
LOR	Limit of Reporting.
SPIKE	Addition of the analyte to the sample and reported as percentage recovery.
RPD	Relative Percent Difference between two Duplicate pieces of analysis.
LCS	Laboratory Control Sample - reported as percent recovery.
CRM	Certified Reference Material - reported as percent recovery.
Method Blank	In the case of solid samples these are performed on laboratory certified clean sands and in the case of water samples these are performed on de-ionised water.
Surr - Surrogate	The addition of a like compound to the analyte target and reported as percentage recovery.
Duplicate	A second piece of analysis from the same sample and reported in the same units as the result to show comparison.
USEPA	United States Environmental Protection Agency
APHA	American Public Health Association
TCLP	Toxicity Characteristic Leaching Procedure
COC	Chain of Custody
SRA	Sample Receipt Advice
QSM	US Department of Defense Quality Systems Manual Version 5.3
CP	Client Parent - QC was performed on samples pertaining to this report
NCP	Non-Client Parent - QC performed on samples not pertaining to this report, QC is representative of the sequence or batch that client samples were analysed within.
TEQ	Toxic Equivalency Quotient

QC - Acceptance Criteria

RPD Duplicates: Global RPD Duplicates Acceptance Criteria is 30% however the following acceptance guidelines are equally applicable:

Results <10 times the LOR : No Limit

Results between 10-20 times the LOR : RPD must lie between 0-50%

Results >20 times the LOR : RPD must lie between 0-30%

Surrogate Recoveries: Recoveries must lie between 20-130% Phenols & 50-150% PFASs

PFAS field samples that contain surrogate recoveries in excess of the QC limit designated in QSM 5.3 where no positive PFAS results have been reported have been reviewed and no data was affected.

WA DWER (n=10): PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFBS, PFHxS, PFOS, 6:2 FTSA, 8:2 FTSA

QC Data General Comments

1. Where a result is reported as a less than (<), higher than the nominated LOR, this is due to either matrix interference, extract dilution required due to interferences or contaminant levels within the sample, high moisture content or insufficient sample provided.
2. Duplicate data shown within this report that states the word "BATCH" is a Batch Duplicate from outside of your sample batch, but within the laboratory sample batch at a 1:10 ratio. The Parent and Duplicate data shown is not data from your samples.
3. Organochlorine Pesticide analysis - where reporting LCS data, Toxaphene & Chlordane are not added to the LCS.
4. Organochlorine Pesticide analysis - where reporting Spike data, Toxaphene is not added to the Spike.
5. Total Recoverable Hydrocarbons - where reporting Spike & LCS data, a single spike of commercial Hydrocarbon products in the range of C12-C30 is added and it's Total Recovery is reported in the C10-C14 cell of the Report.
6. pH and Free Chlorine analysed in the laboratory - Analysis on this test must begin within 30 minutes of sampling.Therefore laboratory analysis is unlikely to be completed within holding time. Analysis will begin as soon as possible after sample receipt.
7. Recovery Data (Spikes & Surrogates) - where chromatographic interference does not allow the determination of Recovery the term "INT" appears against that analyte.
8. Polychlorinated Biphenyls are spiked only using Aroclor 1260 in Matrix Spikes and LCS.
9. For Matrix Spikes and LCS results a dash " -" in the report means that the specific analyte was not added to the QC sample.
10. Duplicate RPDs are calculated from raw analytical data thus it is possible to have two sets of data.

Quality Control Results

Test	Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Code
Method Blank							
Conductivity (1:5 aqueous extract at 25°C as rec.)	uS/cm	< 10			10	Pass	
LCS - % Recovery							
Net Acid Production Potential (by CRS)							
Acid Neutralising Capacity (as CaCO3)*	%	99			70-130	Pass	
Chromium Reducible Sulfur	%	97			80-120	Pass	

Test	Lab Sample ID	QA Source	Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Code
Duplicate									
				Result 1	Result 2	RPD			
% Moisture	P20-Jl16055	CP	%	17	16	2.0	30%	Pass	
Duplicate									
Net Acid Production Potential (by CRS)				Result 1	Result 2	RPD			
Acid Production Potential (by CRS)	P20-Jl16055	CP	kgH2SO4/t	< 0.15	< 0.15	<1	30%	Pass	
Chromium Reducible Sulfur	P20-Jl16055	CP	% S	< 0.005	< 0.005	<1	30%	Pass	
Duplicate									
Net Acid Generation				Result 1	Result 2	RPD			
Net Acid Generation: NAG (initial to pH 4.5)*	P20-Jl16055	CP	kgH2SO4/t	< 0.1	< 0.1	<1	30%	Pass	
Net Acid Generation: NAG (pH 4.5 - pH 7.0)*	P20-Jl16055	CP	kgH2SO4/t	< 0.1	< 0.1	<1	30%	Pass	
pH After Oxidation (pH NAG)*	P20-Jl16055	CP	pH Units	10	10	<1	30%	Pass	
Duplicate									
				Result 1	Result 2	RPD			
Conductivity (1:5 aqueous extract at 25°C as rec.)	P20-Jl16060	CP	uS/cm	12000	11000	13	30%	Pass	
pH (1:5 Aqueous extract at 25°C as rec.)	P20-Jl16060	CP	pH Units	8.7	8.7	pass	30%	Pass	
Duplicate									
Net Acid Production Potential (by CRS)				Result 1	Result 2	RPD			
Acid Production Potential (by CRS)	P20-Jl19021	CP	kgH2SO4/t	0.71	0.71	1.0	30%	Pass	
Chromium Reducible Sulfur	P20-Jl19021	CP	% S	0.023	0.023	1.0	30%	Pass	
Duplicate									
Net Acid Generation				Result 1	Result 2	RPD			
Net Acid Generation: NAG (initial to pH 4.5)*	P20-Jl19021	CP	kgH2SO4/t	< 0.1	< 0.1	<1	30%	Pass	
Net Acid Generation: NAG (pH 4.5 - pH 7.0)*	P20-Jl19021	CP	kgH2SO4/t	< 0.1	< 0.1	<1	30%	Pass	
pH After Oxidation (pH NAG)*	P20-Jl19021	CP	pH Units	11	11	<1	30%	Pass	
Duplicate									
				Result 1	Result 2	RPD			
% Moisture	P20-Jl19022	CP	%	25	25	<1	30%	Pass	

Comments

XRD analysed by: Intertek Testing Services, report references 2004.00/2012205, 2004.00/2012355

Sample Integrity

Custody Seals Intact (if used)	N/A
Attempt to Chill was evident	Yes
Sample correctly preserved	Yes
Appropriate sample containers have been used	Yes
Sample containers for volatile analysis received with minimal headspace	N/A
Samples received within HoldingTime	Yes
Some samples have been subcontracted	Yes

Qualifier Codes/Comments

Code	Description
S04	Acid Sulfate Soil Samples have a 24 hour holding time unless frozen or dried within that period

Authorised By

Robert Johnston	Analytical Services Manager
Emily Rosenberg	Senior Analyst-Metal (VIC)
Myles Clark	Senior Analyst-SPOCAS (QLD)
Rhys Thomas	Senior Analyst-Inorganic (WA)
Scott Beddoes	Senior Analyst-Inorganic (VIC)

Glenn Jackson
General Manager

Final report - this Report replaces any previously issued Report

- Indicates Not Requested

* Indicates NATA accreditation does not cover the performance of this service

Measurement uncertainty of test data is available on request or please click here.

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QUANTITATIVE X-RAY DIFFRACTION ANALYSIS

REPORT PREPARED FOR	EUROFINS ENVIRONMENT TESTING AUSTRALIA PTY LTD C.GIBSON
CLIENT CODE	2004.00
JOB CODE	2012205
No. of SAMPLES	6
CLIENT O/N	20-D29148 730742
SAMPLE SUBMISSION No.	12516706
PROJECT	K+S
STATE	PULPS
DATE RECEIVED	17/07/2020
DATE COMPLETED	30/07/2020
DATE WRITTEN	30/07/2020
WRITTEN BY	Dr Sharon Ness
ANALYSING LABORATORY	Perth

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SAMPLE DETAILS

DISCLAIMER

This report relates specifically to the sample(s) that were drawn and/or provided by the client or their nominated third party. The reported results(s) provide no warranty or verification on the sample(s) representing any specific goods and/or shipment and only relate to the sample(s) as received and tested. This report is prepared solely for the use of the client named in this report. Intertek accepts no responsibility for any loss, damage or laibility suffered by a third party as a result of any reliance upon or use of this report.

The results provided are not intended for commercial settlement purposes.

SIGNIFICANT FIGURES

The method detection limit is approximately 1 wt% for most phases.

Uncertainty in the analysis should reflect errors (absolute) of no greater than: +/- 10% for phases 50-95%, +/- 5% for phases 10-50% and +/- 2% for phases 3-10%. Phases of < 3% are approaching detection limit and normally no refinements are made on these.

Please note that results are rounded off to integer values

LEGEND

ND	Not Detected
EMPTY CELL	Phase not included in refinement

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JOB INFORMATION

PREPARATION

XRD16 (dry 50C, mill < 60um, micronised)

ANALYTICAL METHOD

XRDQUANT01 - Quantitative analysis, crystalline and amorphous content

SAMPLING

Sample(s) coned and quartered, then grab(s) taken

AMORPHOUS CONTENT DETERMINATION

Internal standard single scan

ADDITIONS

Internal standard CaF2 (fluorite)

SAMPLE PRESENTATION

Sample(s) packed and presented as unoriented powder mount(s) of the total sample

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JOB INFORMATION

INSTRUMENTATION AND PARAMETERS

INSTRUMENT:

PANalytical Cubix^3 XRD
Copper radiation (operating at 45 kV and 40 mA)
Graphite monochromator (diffracted beam)

PARAMETERS:

Parameter	Setting
Start angle (deg 2θ)	4
End angle (deg 2θ)	65
Step size (deg 2θ)	0.02
Time/active length (secs)	150
Active length (deg 2θ)	4.01

SOFTWARE:

Qualitative analysis:

Bruker Diffrac.EVA 4.2 Search/Match
ICDD PDF-2 (2015) database

Quantitative analysis:

SIROQUANT Version 4
ICSD (2020) database

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RESULTS

The quantitative analysis of the crystalline and amorphous content of each sample is given in the file, **2004.00_2012205 XRD RESULTS.xlsx**, attached to the report email.

Calculation of the phase abundances has been based on the Brindley contrast corrections using a particle diameter of 4 µm.

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NOTES

1

The amorphous content may contain some of the more poorly crystalline clay phases and conversely the clay phase content may contain some poorly crystalline or amorphous material. Where there is a significant presence of clay material, the distinction between poorly crystalline material and amorphous content can be imprecise.

2

For confirmation of the clay mineralogy, a clay separation followed by analysis of oriented clay mounts (glycol and heat treated) would be required.

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QUALITY CONTROL

NIST STANDARD REFERENCE MATERIAL (SRM) 656

This standard is used for quality control on the instrument and software.

The standard reference material is a powder which consists of sub-micrometer, equi-axial, non-aggregated grains that do not display the effects of absorption contrast, extinction or preferred orientation.

An aliquot of this SRM, spiked with 10% Al2O3 (SRM 676a) for the amorphous content determination, was prepared as un-oriented powder mount of the total sample and the pattern analysed with SIROQUANT™

Sample ID **α 656 (High α Phase Powder)**

		2012205	method std dev	SRM certified	SRM uncert
Phase	**Formula**	**wt%**	**wt%**	**wt%**	**wt%**
Amorphous content		9.6	0.5	9.5	0.61
Si3N4, alpha	Si3N4	87.5	0.5	87.5	0.59
Si3N4, beta	Si3N4	2.9	0.1	3.0	0.05

Each interval defined by the certified value and its uncertainty is a 95% confidence interval for the true value of the mean in the absence of systematic error.

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METHOD DESCRIPTION

Quantification is determined from the chosen software package: this uses the full-profile Rietveld method of refining the profile of the calculated XRD pattern against the profile of the measured XRD pattern. The total calculated pattern is the sum of the calculated patterns of the individual phases.

Results are given as weight % of the total crystalline phases and amorphous content.

The amorphous content quantifies the amorphous material and unknown minerals or known minerals for which there is not a suitable crystal structure.

Corrections are incorporated into the process that allows for a more accurate description of the mineral's contribution to the measured pattern and to allow for variation due to atomic substitution, layer disordering, preferred orientation, and other factors that affect the acquisition of the XRD scan.

The limitations of qualitative XRD analysis are as follows:

There is a limit of detection of approximately 1 wt% on the crystalline phases.
The detection of a phase may be dependent on its crystallinity.
Where there exist multiple phases, overlap of diffracted reflections can occur, thus rendering some ambiguity into the interpretation.
Overlapping reflections of a major phase can mask the presence of minor or trace phases.

Some phases cannot be unambiguously identified as they are present in minor or trace amounts.

The limitations of quantitative XRD analysis by a full-profile Rietveld method are as follows:

The limitations for qualitative XRD analysis apply.
The method as described is standardless: it relies solely on the published crystallographic data available for each phase. Some data may not exactly describe the phases present.

Particle size is important with respect to the absorption of the X-rays by the sample. Micronising reduces the particle size to that more suitable for quantitative analysis.

The accuracy of the analysis is dependent on sampling and sample preparation in addition to the calculated profiles being exactly representative of the chemistry of the component phases and their crystallinity. Some preferred orientation effects and reflection overlaps may occur which cannot be adequately resolved.

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AMORPHOUS CONTENT

INTERNAL STANDARD METHOD

Single scan (SIROQUANT™ and TOPAS)

The amorphous content is determined from the addition of a known spike of a well-crystalline internal standard to each sample.

When amorphous material is present, the weight percentage of the spike found is larger than actually weighed out. The amount of amorphous material that causes the difference in the spike weight percentages is then calculated and all weight percentages are normalised to include the amorphous content.

Double scan (SIROQUANT only)

SIROQUANT™ also allows the choice of using the spiked pattern completely, or combining the run with a previous unspiked pattern result. This choice is given because the weight percentages from an unspiked pattern are more accurate since the intensities are not diluted by the spike addition. The percentages from the unspiked sample are normalised to the amorphous content calculated from the spiked sample pattern.

EXTERNAL STANDARD METHOD (SIROQUANT™ and TOPAS)

The amorphous content is determined from the external standard method[1].

The normalisation constant is determined from the external standard which allows the calculated weight fractions to be placed on an absolute scale.

Reference:

1. O'Connor, B.H., and Raven, M.D., "Application of the Rietveld refinement procedure in assaying powdered mixtures", Powder Diffraction 3(1), (1988), 2-6.

Modelling

A pattern representing a poorly crystalline form of silica is used in the SIROQUANT program.[2]

Reference:

2. Ward, C.R. and French, D., "Determination of glass content and estimation of glass composition in fly ash using quantitative X-ray diffractometry." Fuel 85 (2006), 2268-2277.

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b) the cost of having those services supplied again.

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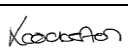
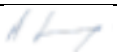
Document Status

Revision	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
A	S.Isbister	L.Cockerton P. Hamer				
B	S.Isbister	L.Cockerton P. Hamer		A. Jennings		27.11.20
0	L.Cockerton	P.Baker		A. Jennings		24.05.21
1	L.Cockerton	P.Baker		A. Jennings		26.05.21
2	L.Cockerton	P.Baker		A. Jennings		31.05.21

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