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Site Characterisation - Technical Report
LYNDHURST

NATIONAL RADIOACTIVE WASTE MANAGEMENT FACILITY

Site Characterisation Technical Report - Lyndhurst

Client: Commonwealth Department of Industry, Innovation and Science

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Limitations Statement

Limitations Statement

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It is based on generally accepted practices and standards at the time it was prepared. No other warranty, expressed or implied, is made as to the professional advice included in this Report.

It is prepared in accordance with the scope of work and for the purpose outlined in the contract dated 31 January 2018.

The methodology adopted and sources of information used by AECOM are outlined in this the Report.

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This Report was prepared between February and July 2018, and is based on the conditions encountered and information reviewed at the time of preparation. AECOM disclaims responsibility for any changes that may have occurred after this time.

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This report contains information obtained by inspection, sampling, testing or other means of investigation. This information is directly relevant only to the points in the ground where they were obtained at the time of the assessment. The seismic or borehole logs reviewed indicate the inferred ground conditions only at the specific locations tested. The precision with which conditions are indicated depends largely on the uniformity of conditions and on the frequency and method of sampling. The behaviour of groundwater and some aspects of chemicals in soil and groundwater are complex. Our assessment is based upon the data presented in this report and our experience. Future advances in regard to the understanding of chemicals and their behaviour, and changes in regulations affecting their management, could impact on our conclusions and recommendations regarding their potential presence on this site.

Where conditions encountered at the site are subsequently found to differ significantly from those anticipated in this report, AECOM must be notified of any such findings and be provided with an opportunity to review the recommendations of this report.

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Any estimates of potential costs which have been provided are presented as estimates only as at the date of the Report. Any cost estimates that have been provided may therefore vary from actual costs at the time of expenditure.

Executive Summary

Executive Summary

The Australian Government is committed to identifying a site for the National Radioactive Waste Management Facility (NRWMF) that will permanently dispose of Australia's low level radioactive waste and temporarily store intermediate level radioactive waste. Sites being considered have been identified through a voluntary community nomination process.

The Department of Industry, Innovation and Science ('the Department') established a NRWMF Task Force to lead a site nomination and selection process in accordance with the requirements of the *National Radioactive Waste Management Act (2012).* Three sites were shortlisted for Site Characterisation for the purpose of assessing their technical suitability for siting the NRWMF including the Lyndhurst and Napandee sites near Kimba, South Australia and the Wallerberdina site near Hawker, South Australia.

AECOM Australia Pty Ltd (AECOM) has been engaged by the Department to conduct Site Characterisation studies at the three shortlisted sites. The studies are focused on characterising the surface and subsurface environments within and surrounding the nominated 100 hectare study areas being considered for siting of the NRWMF. The studies also comprise a preliminary assessment of constraints and options for the enabling infrastructure that would be required to develop and operate the NRWMF. This Technical Report outlines the methods and results for the Site Characterisation studies at the Lyndhurst site.

A range of key site characteristics or criteria were developed with reference to Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) and International Atomic Energy Agency (IAEA) guidelines relating to the selection and evaluation of sites being considered for the siting of radioactive waste facilities.

In Australia, the siting and licensing of controlled facilities such as the proposed NRWMF are governed by the *Australian National Radioactive Waste Management Act (2012), Australian Radiation Protection and Nuclear Safety Act (1998)* and Australian Radiation Protection and Nuclear Safety Regulations (1999). The ARPANSA Regulatory Guide 'Siting of Controlled Facilities' (2014) outlines criteria which should be taken into account when screening potential sites for controlled facilities. Similarly, the International Atomic Agency (IAEA) Safety Standard 'Site Survey and Site Selection for Nuclear Installations' provides clear guidance on site characteristics to be considered for facilities such as the NRWMF. The requirements of these pieces of legislation and guidelines have been taken into account in developing the site characteristic criteria used in the Site Characterisation studies which are shown in the table below. As the abovementioned legislation and guidelines are all encompassing and are relevant to all site selection characteristics, they are not specifically referenced in the table.

Table 1 Summary of Site Assessment for Lyndhurst

Site Characteristic	Objective of Assessment	Key Legislation, Standards and Guidelines	Preferred Site Characteristics	Assessment Findings
Flora & Fauna	To characterise the flora and fauna present on and adjacent to the site and identify any significant or threatened species and supporting habitats which could preclude use of the site for the proposed NRWMF.	*Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). *Native Vegetation Act 1991* (SA) *National Parks and Wildlife Act 1972* (SA)	Absence of Commonwealth or State threatened species and supporting habitat, minimal requirement for vegetation clearance.	The Lyndhurst site has no threatened ecological communities and only around 5% of the area is vegetated comprising low quality habitat. There is high quality habitat within vegetated areas nearby to the site. There are Commonwealth and State listed flora and fauna species with potential of occurrence, for which some have been recorded within 10 km of the site. Further field surveys will be required to determine the likelihood of occurrence and significance of any potential impacts on the listed species.
Conservation and special use areas	To identify any Conservation or Recreational Parks in close proximity to the site and Aboriginal heritage or State and Local listed heritage sites which could preclude use of the site for the proposed NRWMF.	*National Parks and Wildlife Act 1972* (SA) *Heritage Places Act 1993* (SA)	Absence of Parks (National Parks, Conservation Parks, Conservation Reserves, Recreational Parks, Wilderness Protected Areas and native vegetation Heritage Agreements) and Aboriginal or State and Local heritage sites on or adjacent to the site	The Lyndhurst site has no Aboriginal heritage sites or State or Local heritage sites within the site and its surrounds. Five areas of native vegetation conserved under heritage agreements are present either directly or the local vicinity of the site and Lake Gilles Conservation Park is 2 km from the site.
Radiation, background and risks	Establish a baseline for future environmental monitoring and identify potential elevated background conditions that could affect safety of personnel	IAEA-TECDOC-1363 Guidelines for radioelement mapping using gamma ray spectrometry data. IAEA NS-R-3 (Rev.1) Site Evaluations for Nuclear Installations.	Background radiation levels within the ARPANSA Action Levels for workplaces and not sufficiently elevated to impact on environmental monitoring	Results from published historical data and a subsequent targeted intensive aerial radiometric survey do not indicate the presence of elevated background radiation conditions that could affect safety of personnel or impact future environmental monitoring.

Site Characteristic	Objective of Assessment	Key Legislation, Standards and Guidelines	Preferred Site Characteristics	Assessment Findings
Climate change and long term environmental scenarios	Establish existing climatic conditions for the site based on historic average and identify likely changes to climate based on projections and identify resultant key hazards that could impact on the future NRWMF and workers	AS5534-2013 Climate change adaptation for settlement and infrastructure – A risk based approach. IAEA SSG-18 Specific Safety Guide Meteorological and Hydrological Hazards in Site Evaluation for Nuclear Installations.	Future climate change conditions where the frequency and intensity of climatic events have minimal impacts or where design measures can mitigate risks	Potential climate change impacts include higher intensity rainfall events, extreme heat and fire weather. These events have the potential to impact on variables including worker safety, infrastructure damage, waste transport, flooding, power supply and maintenance costs amongst others. Potential climate change impacts should be used to inform design and operation of the NRWMF.
Bushfire Risks	Characterise bushfire threat from factors including vegetation/ fuel hazard at local and landscape level, site slopes, bushfire weather frequency/ severity and assess the likelihood and nature of bushfire impact based on potential for ignition, development and approach in the landscape.	AS 3959-2009 Construction of Buildings in Bushfire Prone Areas. Department of Environment, Water and Natural Resources, 2012. Overall Fuel Hazard Guide for South Australia	Combination of climatic conditions, fuel loadings, topography and ability to create buffers which minimises the risk and potential severity of bushfires	The site is not unduly impacted by bushfire hazards (fuel load from vegetation including Mallee woodland directly to the northwest), site slopes, bushfire weather conditions, potential for ignition and fire development in local area) if appropriate low threat setbacks (i.e. areas of cleared vegetation) are established around assets commensurate with their vulnerability to bushfire attack and provision of fire fighting infrastructure.

Site Characteristic	Objective of Assessment	Key Legislation, Standards and Guidelines	Preferred Site Characteristics	Assessment Findings
Hydrology and Flood Risks	Assess potential localised flooding (water logging or extreme rainfall) or episodic major flooding or avulsion potential from upstream catchments now, and as a result of climate change, that could impact operations and site access without mitigation	IAEA SSG-18 Meteorological and Hydrological Hazards in Site Evaluation for Nuclear Installations. Ball J, et al.2016, Australian Rainfall and Runoff (ARR): A Guide to Flood Estimation	Minimal catchment areas and watercourses draining into the site, an absence of 'hydrophobic' soils, high soil conductivity rates and lower intensity rainfall events	There are no creek lines in the local area. Drainage lines exist through the site and there is anecdotal evidence of periodic waterlogging. Hydrological and hydraulic modelling to quantify the potential for and if relevant risks of flooding from Lake Gilles and a nearby non-perennial drainage depression with approx. 540 km^2 catchment will require assessment. Climate change predictions for the area suggest a future increase in rainfall intensity resulting in a potential increase in the magnitude of floods and infrastructure impacts such as road closures.
Impacts of Nearby Human Activities and Land Use Planning	Identify existing and potential future land uses on, or in proximity to the site, (sensitive land uses, extractive or hazardous activities) that may adversely impact on the site or be impacted by the NRWMF	IAEA Safety Requirements NS-R-3 (Rev.1) Site Evaluations for Nuclear Installations. Kimba Council Development Plan; consolidated 25 October 2012	Minimal sensitive land uses (e.g. residences, community facilities) on or proximal to the site, suitable buffer distances from nearest sensitive land uses. Minimal land uses (e.g. mining tenements, hazardous facilities, airfields) on or close to the site which could adversely impact on the NRWMF	The site is well separated from adversely affecting development and sensitive land uses. The land zoning, together with the physical characteristic of land within the locality and declining population trend, suggests that the likelihood of adversely affecting and intensive residential or urban development being developed in proximity of the site in the future would be low. A key consideration is the existence of a number of mineral tenements over and within close proximity to the site. If these tenements proceed to production, the associated activities may have the potential to impact the NRWF or its enabling infrastructure and will require further assessment if Lyndhurst is given further consideration.

Site Characteristic	Objective of Assessment	Key Legislation, Standards and Guidelines	Preferred Site Characteristics	Assessment Findings
Geology, hydrogeology, geochemistry, geotechnical and soils	Characterise the site sub-surface environment to determine geological, hydrogeological and geochemical characteristics	AS1726 – 2017 Australian Standard Geotechnical Site Investigations. AS1289 series Australian Standard Method of testing soils for engineering purposes. AS/NZS 5667.1 Water quality – Sampling Guidance on the design of sampling programs, sampling techniques and preservation and handling of samples NUDLC, 2012 *Minimum Construction Requirements for Water Bores in Australia V3* developed by the National Uniform Drillers Licensing Committee, Third Edition, February 2012	Deep watertable, low potential for vertical or horizontal migration of water through underlying soil, poor quality groundwater, presence of subsurface material with chemical attenuation properties, limited or no groundwater users, absence of geotechnical hazards (potential for slope instability, soil liquefaction, collapsing or expansive soils, subsidence due to ground features, long-term settlement, soil scour and erodibility).	The geological, hydrogeological, soil and geotechnical conditions at the site do not present hazards or constraints that would not be manageable through appropriate design and operational protocols. Groundwater in the watertable aquifer was found to be present at depths generally >10 m below ground surface, be of very limited beneficial use due to its high salinity and low yield observed during bore development and sampling. The relative high vertical difference over a short distance suggests there is poor hydraulic connection between the watertable and deeper aquifers (also saline), which is consistent with the assumed relative low permeability of the kaolin (clay) weathered bedrock profile. The subsurface clays and kaolin exhibit chemical attenuation properties. These subsurface clays however if exposed or used as fill may have due to their sodicity and potential for dispersion lead to surface hardening/ crusting and waterlogging, and be limiting to plant growth. Geohazards are unlikely to be present at the site, with the exception of soils of low expansive potential at surface increasing to medium at 6 m depth, which can be mitigated via design standards (AS2870). This assessment is based on current data but further investigations would be

Site Characteristic	Objective of Assessment	Key Legislation, Standards and Guidelines	Preferred Site Characteristics	Assessment Findings
				required for site specific aspects such as design of footings and structures.
Landform stability	Identify geomorphological processes (including fluvial, aeolian, slope/ mass movement) with potential to impact on long term site stability	No recognised applicable standards or guidelines	Stable landform, minimal potential for slope or mass movement processes	The Lyndhurst study site is situated on Quaternary dunes, which appear to be relics from a period of greater aeolian activity but remain potentially susceptible to aeolian processes, particularly if the vegetation cover is disturbed. The potential for slope and mass movement processes need to be considered, particularly at times of high rainfall and in relation to seismic activity. The north-western edge of the study site abuts a low-lying area that requires modelling to determine whether it may be inundated when Lake Gilles is also in flood, exposing the site to lake-shore processes.
Seismic activity	Characterise potential seismic hazards with emphasis on active faults beneath or near the site, near surface faults and the presence of ridge crests in the site vicinity	IAEA SSG-9 Seismic Hazards in Site Evaluation for Nuclear Installations, relevant peer-reviewed technical information listed in our methodology and scope and other referenced IAEA documents	Absence of potentially active faults that could cause surface faulting through the NRWMF, near-surface faults that could cause folding or other deformation within the NRWMF, nearby faults that could cause hanging wall or rupture directivity effects which amplify ground motions and ridge crests which amplify ground motions	The seismic hazard level of the Lyndhurst site is assessed with a high level of confidence to be low based on the review and interpretation of seismic data indicating the absence of potentially active faults in the foundation, near-surface faults beneath or near the foundation, and faults in the nearby area (excluding the possibility of one-off faulting).

Site Characteristic	Objective of Assessment	Key Legislation, Standards and Guidelines	Preferred Site Characteristics	Assessment Findings
Transport considerations	Assess proximity of the site to waste sources and characterise the national, regional and local transport networks (including multi-modal) to enable safe site access and egress	ARPANSA, 2014. The Code for the Safe Transport of Radioactive Material ARPANSA (2008) Code of Practice for the Safe Transport of Radioactive Materials Austroads Guide to Road Design National Heavy Vehicle Regulator, 2017. Performance-Based Standards Scheme – Network Classification Guidelines National Heavy Vehicle Regulator, 2017. Performance-Based Standards Scheme – Vehicle Certification Rules	Major highway access from waste sources around Australia, good local access road network with minimal upgrade requirements and potential for multi-modal transport options	The Lyndhurst site is well served by major road networks with several local site access options which would require both road upgrades and sealing (up to 21 kilometres) to accommodate frequent B-double movements and infrequency ODOM movements. A detailed survey of local road network to determine its condition, width, formation, traffic volumes, presence and significance of roadside vegetation habitat is required for the preferred option(s). .
Capacity to deal with NRWMF wastes and emissions	Assess availability and proximity of facilities to treat, recycle or dispose of all generated waste streams and consider the potential for on-site treatment, recycling and disposal	Applicable waste classification, treatment and disposal criteria and guidelines	Proximity to suitable waste management facilities and site attributes that can accommodate potential onsite waste management options	Given the site's location (15 km from Kimba), there are a number of waste and recycling depots capable of receiving and/or accepting waste generated from the Project. However, certain waste types (e.g. hazardous and/or Listed Waste) may need to be managed on-site then sent off-site further afield outside the region. Further definition of waste streams and volumes as the facility design progresses is required to refine the assessment.

Site Characteristic	Objective of Assessment	Key Legislation, Standards and Guidelines	Preferred Site Characteristics	Assessment Findings
Utilities, energy and infrastructure	Assess the proximity to, and capacity of, key services and utilities at and near the site (power, water, wastewater, gas telecommunications, storm water)	Relevant Australian Standards to apply at detailed design phase	Close proximity to all required services and utilities with minimal upgrade and connection requirements	There is an absence of services and utilities in the vicinity of the site (power, water, wastewater, gas, telecommunications and stormwater). The site is 55km from the closest transmission substation and 45km from any transmission line. Connection can be made to a local 90mm diameter potable water at the edge of the site initially during construction, whilst permanent connection is made to the existing 375 mm diameter main 6.3 km to the south (along with establishment of booster pumping stations along the route). The existing communications network in the region is inadequate. Mobile coverage and data may be provided via a tower to connect to the Sky Muster satellite, or a tower for mobile coverage plus fixed fibre optic cable from Kimba once the NBN is available in town.

Site Characteristic	Objective of Assessment	Key Legislation, Standards and Guidelines	Preferred Site Characteristics	Assessment Findings
Renewable or non-renewable natural resources and the site potential to use renewable resources	Assess availability of renewable resources in the site area to provide power to the site and offset grid supplied energy.	Relevant Australian Standards to apply at detailed design phase	Location which has high potential to generate renewable energy, particularly solar and wind resources, which can be harnessed by technology in a manner which will increase the (network) reliability of power supply to the site.	The Lyndhurst site is located in an area of moderate / high solar exposure and is a moderate wind resource area. The site requires extensive distribution lines to be constructed for connection to the power transmission network. The inclusion of renewable energy for generation on site, as well as supporting energy storage technologies such as batteries (short term) and diesel (long term) should be further considered and could provide both commercial and power reliability benefits to the project. Consideration of the grid constraints, reliability, and potential connection points are key considerations for determining the amount of solar PV (the most suitable technology for the site) and storage required

There are a number of potential environmental constraints identified at Lyndhurst that would likely require mitigation or management should the proposed NRWMF be further considered at the site. These include bushfire within in the landscape, localised or episodic catchment flooding, and wind erosion, slope erosion or mass movement of sands from longitudinal dunes.

Groundwater in the water table aquifer is present at depths generally exceeding 10 m below ground surface across the site which would provide good separation between the base of any proposed NRWMF and groundwater. Water quality in the bedrock aquifers is highly saline (similar to that of seawater) and is not considered suitable for any realistic beneficial use.

The seismic hazard level of the Lyndhurst site is low based on review and interpretation of seismic data indicating with a high-level confidence that potentially active faults in the foundation, near-surface faults beneath or near the foundation, and faults in the nearby area are not present (excluding the possibility of one-off faulting). The site is not expected to be subject to near-fault ground motions, so no special design issues or mitigation measures are expected to be necessary. Australian Standard AS1170.4 specifies design procedures that are appropriate for this site.

There are no threatened ecological communities within the Lyndhurst site and surrounds. Fragmented patches of native vegetation within the site (approximately 5% of the area) were found to be in good condition, with linear corridors of Mallee trees in degraded condition. An area of native vegetation in excellent condition that is conserved via a heritage agreement is located adjacent to the north-west boundary of the site. If vegetation clearance is required for development of the NRWMF, then it will be important to conduct further targeted field surveys to determine likelihood and significance of any impacts on individual Commonwealth and State listed flora and fauna species that have the potential for occurrence in the local area.

The site is well served by major road networks with several local unsealed road access options. There is an absence of utilities, including potable water, power and communications, of appropriate capacity in the near vicinity of the site. Potable water and power will require pipelines and distribution lines, respectively, to be installed over large distances to connect with existing networks. Communications towers and possibly an in-ground fibre optic NBN cable from Kimba (once rolled out) would need to be constructed to connect to mobile phone and data communications. The inclusion of renewable energy for generation on site, as well as supporting energy storage technologies such as batteries (short term) and diesel (long term), would provide both commercial and power reliability benefits to the project.

The site is well separated from adversely affecting development and sensitive land uses. There are a number of mineral tenements in the local area, the closest being around 4 km from the site. If these tenements proceeded to a development phase, they could have a potential impact on the NRWMF and its enabling infrastructure and will need to be further assessed.

In summary, there are no significant constraints identified to date which would preclude siting of the NRWMF at the Lyndhurst site.

Potential design issues and mitigation measures that could be employed have been identified to address enabling infrastructure constraints and environmental constraints, or to protect environmental values.

The Site Characterisation and NRWMF design are running in parallel and each will inform the other as the site selection process progresses.

A second stage of more detailed Site Characterisation studies will be conducted once a preferred site is selected by the responsible Minister.

Data gaps and recommendations for additional work scope items to fill such gaps have been provided for the proposed second stage. The development of a robust conceptual site model and environmental dataset will support the development of a safety case for the NRWMF and applications for licensing and environmental approvals. Baseline conditions must also be established to enable future surveillance and monitoring during construction and operation of the NRWMF.

1.0

Introduction

1.0 Introduction

Background

The Australian Government is committed to identifying a site for the National Radioactive Waste Management Facility (NRWMF) that will permanently dispose of Australia's low level radioactive waste and temporarily store intermediate level radioactive waste. Sites being considered have been identified through a voluntary community nomination process.

There is currently no disposal facility for low level radioactive waste in Australia. Waste is stored at more than 100 locations around the country. Many are running out of storage capacity or were never engineered for the storage of such waste. The NRWMF will provide a safe and secure facility for the consolidation and management of Australia's current and future radioactive waste in a sustainable manner that safeguards the environment. All radioactive waste will be received at the facility in a solid form and packaged in a manner that meets the Waste Acceptance Criteria.

Low level radioactive waste to be permanently disposed of at the new facility includes protective clothing and equipment from medical procedures, laboratory wastes such as paper, glassware and plastic, contaminated soil and discarded smoke detectors and emergency exit signs. Low level waste emits radiation at levels which generally require minimal shielding during transport, storage and handling.

Intermediate level waste to be temporarily stored at the new facility contains radioactive material at a concentration that requires shielding for safe handling and transport and includes waste from the production of radiopharmaceuticals, waste generated by the reprocessing of spent research reactor fuel and disused radioactive sources from industry and medicine. In line with international best practice, Australia's intermediate level waste is stored in individually manufactured, tested and quality assured shielded containers that are physically secure and shielding of the radiation.

The engineering design of the proposed NRWMF is occurring in parallel with the Site Characterisation studies and Cultural Heritage Assessments of the sites.

NRWMF Site Characterisation Study

The Commonwealth Department of Industry, Innovation and Science ('the Department') established a NRWMF Task Force to lead a site nomination and selection process in accordance with the requirements of the *National Radioactive Waste Management Act (2012).* Three sites were shortlisted for Site Characterisation for the purpose of assessing their technical suitability for siting the NRWMF including the Lyndhurst and Napandee sites near Kimba, South Australia and the Wallerberdina site near Hawker, South Australia.

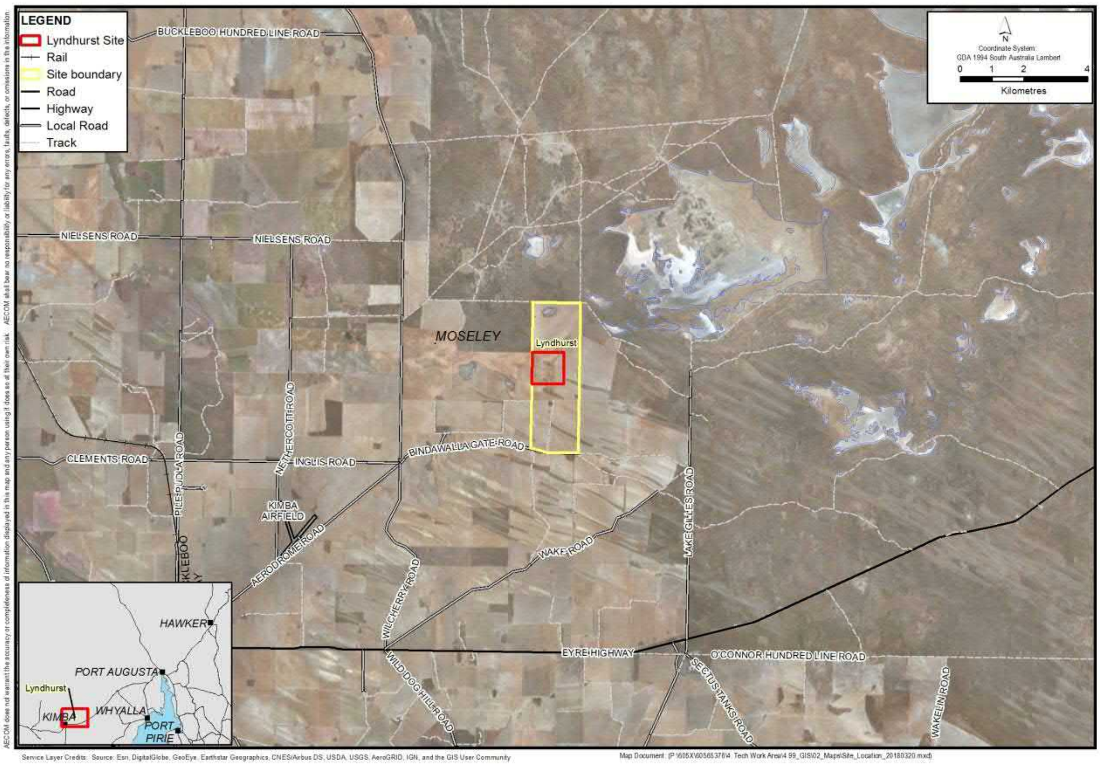
The Department has a comprehensive and ongoing stakeholder communications and engagement program underway within each local community.

AECOM Australia Pty Ltd (AECOM) was commissioned by the Department to conduct Site Characterisation studies at the three shortlisted sites. The works are focused on characterising the surface and subsurface environments within and surrounding nominated 100 hectare study area being considered for potential siting of the NRWMF. The works also comprise a preliminary assessment of constraints and options for enabling infrastructure that would be required to develop and operate the NRWMF. This report outlines the methods used and results of the Site Characterisation studies undertaken at the Lyndhurst site. The location of the site and study area contained within the site is displayed in Figure 1 below and described in Table 2 below. The study area hereafter referred to as 'the site'.

Table 2 Site Identification Details

Site Name	Lyndhurst
Site Description	143 Bindawalla Gate Road, Hundred of Moseley Country of Buxton District Council of Kimba
Land Parcel	1 Parcel described as: Hundred Plan 500700, Parcel 38 (Part of Certificate of Title Volume 5925 Folio 858) Total approximate nominated site area is 700 ha

Figure 1 Site Location Plan



The general site setting can be summarised as follows:

- The site is located approximately 15 km north-east of the township of Kimba;
- The site is located within an semi-arid area, in a warm temperate climate zone characterised by hot summers with moderate humidity and low annual rainfalls predominantly during the winter and spring months;
- Land in the local and regional area is predominantly used for broad acre cropping;
- The landscape is characterised by Quaternary longitudinal dunes which have historically been extensive cleared for cropping, with a low lying saline playa lake, Lake Gilles, which is part of a conservation park located 2 km east of the site which would only be filled during infrequent episodic flooding;
- There are no surface water features such as creeks or lakes in the local area; surface waters under flood conditions are expected to flow locally with the topography in the swales between dunes;

- To the north of the property boundary is a pastoral property in which the native vegetation is used for dryland grazing. The owner of the nominated site also owns the land to the west of the site from a point north of Bindawalla Gate Road;
- There are a number of areas of native vegetation conserved under heritage agreements in the local area including an area directly adjacent the north-western corner of the site on property held by the owner of the nominated site which is in excellent condition vegetation. Fragmented patches of native vegetation within the site were of good condition, with linear corridors of Mallee trees in degraded condition;
- The site can be accessed via a number of existing formed unsealed roads from Kimba/ Eyre Highway including Aerodrome Road, Wilcherry Road and Lake Gilles Road;
- The site is well separated from adversely affecting development and sensitive land uses; and
- The nearest dwelling is understood to be located approximately 2.6 km from the site.

Site Characterisation studies have been undertaken for the purpose of providing a technical assessment to determine whether any environmental hazards and values, or enabling infrastructure constraints exist that are considered to present ‘fatal flaws’ that would preclude further consideration of siting of the NRWMF at the Lyndhurst site.

A review of available published information, field observations and survey data pertaining to the surface and subsurface environment and enabling infrastructure considerations has been prepared for assessment against key site characteristic criteria. The criteria were established with reference to Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) and International Atomic Energy Agency (IAEA) guidelines relating to the selection, evaluation and environmental safety case of sites being considered for the siting of radioactive waste facilities.

Site characteristic values and hazards, or infrastructure constraints can often be mitigated by the facility design. Potential design issues and mitigation measures that could be employed to address them have been identified but will require further refinement throughout the design process. The Site Characterisation and facility design are running in parallel and will inform the other as the site selection process progresses.

A second stage of more detailed Site Characterisation works will be conducted once a preferred site is selected by the responsible Minister.

Assessment data gaps and recommendations for additional work scope items to fill such gaps have been provided for this second stage. The development of a robust conceptual site model and environmental dataset will support the development of a safety case for the NRWMF and applications for licensing and environmental approvals. Baseline conditions must also be established to enable future surveillance and monitoring during construction and operation of the NRWMF.

2.0

Surface Environment

2.0 Surface Environment

A desktop and selective field assessment of the surface environmental conditions within the site and surrounds is outlined below. The characteristics of the surface environment covered in this assessment include flora, fauna, conservation values, and hazards associated with climate, bushfire, background radiation, flooding and nearby human activities under current and future potential land uses.

Site characteristic assessment criteria that have the potential, either alone or in combination with other criteria, to impact on siting of the facility were developed. Published and anecdotal information relevant to the site and the local and regional area was reviewed. A site inspection, an ecological field survey, and an aerial survey to digitally map the terrain/ topography (using LiDAR) and background radiation at ground surface (using radiometrics) of the site and immediate surrounds were also undertaken. The desktop and field data of the surface environment was interpreted for assessment against the site characteristic criteria.

Site characteristic values and hazards can often be mitigated by the facility design. Potential design issues and mitigation measures that could be employed to address them have been identified. The Site Characterisation and facility design are running in parallel and will inform the other as the site selection process progresses.

Assessment data gaps and recommendations for additional work scope items to fill such gaps in a more detailed second stage of the Site Characterisation studies are provided for each of surface environmental characteristics.

2.1 Flora, Fauna and Conservation

2.1.1 Methodology and Results

2.1.1.1 Site Characteristic Criteria

The key site characteristic criteria relevant to flora, fauna and conservation include:

Flora and Fauna

- presence and condition of native vegetation;
- presence of Commonwealth listed threatened species and habitat; and
- presence of State listed threatened species.

For assessment purposes two of the above key criteria have been broken up into sub criteria as follows:

- presence of Commonwealth listed threatened species and habitat
  - presence of Threatened Ecological Communities
  - presence of threatened flora species
  - presence of threatened fauna species
  - presence of threatened fauna habitat
  - presence of Migratory species
- presence of State listed threatened species and habitat
  - presence of threatened flora species
  - presence of threatened fauna species.

Conservation

- proximity and value of Parks (National Parks, Conservation Parks, Conservation Reserves, Recreational Parks, Wilderness Protected areas and native vegetation Heritage Agreements);
- proximity of Aboriginal heritage sites; and
- proximity of Commonwealth, state and local heritage sites.

2.1.1.2 Desktop Methods and Results

Legislative Context

The Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) is the main piece of Federal legislation protecting biodiversity in Australia. All Matters of National Environmental Significance (MNES) are listed under the EPBC Act. These include:

- listed threatened species and ecological communities;
- migratory species protected under international agreements;
- Ramsar wetlands of international importance;
- the Commonwealth marine environment;
- world Heritage properties;
- national Heritage places;
- Great Barrier Reef Marine Park;
- a water resource, in relation to coal seam gas development and large coal mining development; and
- nuclear actions.

If an action is likely to have a significant impact on a MNES this action must be referred to the Minister for the Environment for a decision on whether assessment and approval is required under the EPBC Act.

The EPBC Act provides the legal framework and categories for the protection of flora and fauna species. Species can be listed as threatened, migratory or marine under the EPBC Act. Species at risk of extinction are recognised at a Commonwealth level under section 179 of the EPBC Act and are categorised in one of six categories as outlined in Table 3. Species may be listed as Marine under section 248 of the EPBC Act.

Migratory species are animals that migrate to Australia and its external territories or pass over Australian waters during annual migrations. Listed migratory species include those listed in the:

- Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention);
- China-Australia Migratory Bird Agreement (CAMBA);
- Japan-Australia Migratory Bird Agreement (JAMBA); and
- Republic of Korea-Australia Migratory Bird Agreement (ROKAMBA).

Table 3 Categories of Species Listed under Schedule 179 of the EPBC Act

Conservation	Code Category
Ex	**Extinct Taxa** which at a particular time if, at that time, there is no reasonable doubt that the last member of the species has died.
ExW	**Extinct in the Wild** Taxa which is known only to survive in cultivation, in captivity or as a naturalised population well outside its past range; or it has not been recorded in its known and/or expected habitat, at appropriate seasons, anywhere in its past range, despite exhaustive surveys over a time frame appropriate to its life cycle and form.
CE	**Critically Endangered** Taxa which at a particular time if, at that time, it is facing an extremely high risk of extinction in the wild in the immediate future, as determined in accordance with the prescribed criteria.
E	**Endangered** Taxa which is not critically endangered and it is facing a very high risk of extinction in the wild in the immediate or near future, as determined in accordance with the prescribed criteria.
V	**Vulnerable** Taxa which is not critically endangered or endangered and is facing a high risk of extinction in the wild in the medium-term future, as determined in accordance with the prescribed criteria.
CD	**Conservation Dependent** Taxa which at a particular time if, at that time: the species is the focus of a specific conservation program the cessation of which would result in the species becoming vulnerable, endangered or critically endangered.

Communities can be classified as Threatened Ecological Communities (TECs) under the EPBC Act. The EPBC Act protects Australia's ecological communities by providing for:

- identification and listing of ecological communities as threatened;
- development of conservation advice and recovery plans for listed ecological communities;
- recognition of key threatening processes; and
- reduction of the impact of these processes through threat abatement plans.

Categories of federally listed TECs are described in the table below.

Table 4 Categories of TECs listed under the EPBC Act

Code	Category
CE	**Critically Endangered** If, at that time, it is facing an extremely high risk of extinction in the wild in the immediate future.
E	**Endangered** If, at that time, it is not critically endangered and is facing a very high risk of extinction in the wild in the near future.
V	**Vulnerable** If, at that time, it is not critically endangered or endangered, and is facing a high risk of extinction in the wild in the medium-term future.

In South Australia, the Department of Environment, Water and Natural Resources (DEWNR) works with Natural Resource Management Boards to implement State environment legislation across eight natural resource management regions in South Australia. A number of pieces of legislation provide provision for the management natural resources, including:

- National Parks, Conservation Parks, Conservation Reserves, Recreational Parks, Wilderness Protected areas the *National Parks and Wildlife Act 1972* (NPW Act), *Crown Land Management Act 2009* (CLM Act) or the *Wilderness Protection Act 1992* (WP Act);
- Non-Aboriginal heritage sites of significance and Aboriginal heritage sites;
- Local Heritage places in South Australia;
- Native vegetation (for conservation, to control the clearance of native vegetation and to outline the mechanisms for Heritage Agreements (i.e. a conservation area on private land, which is ongoing or perpetual);
- Wildlife (for conservation and management of threatened species under the *National Parks and Wildlife NPW Act*); and
- Natural resources (protection, pest management, etc.).

Table 5 Categories of Threatened Species under the NPW Act

Code	Category
Endangered	Listed under Schedule 7. A taxon is Endangered when the best available evidence indicates that it meets any of the criteria A to E (defined in Section V IUCN, 2001), for Endangered and it is therefore considered to be facing a very high risk of extinction in the wild.
Vulnerable	Listed under Schedule 8. A taxon is Vulnerable when the best available evidence indicates that it meets any of the criteria A to E for Vulnerable (defined in Section V IUCN, 2001), and it is therefore considered to be facing a high risk of extinction in the wild.
Rare	Listed under Schedule 9. A taxon is considered rare if it is in decline and those that naturally have limited presence. This category does not follow the IUCN Red List.

Desktop Methods

Flora and fauna comprises of vegetation and ecological communities (native and invasive), and fauna and habitat (including habitat corridors). Conservation comprises of conservation and special use areas. A review of publicly available literature to describe the existing environment, and relevant database searches was undertaken to identify potential occurrence of significant flora, vegetation and fauna species. A 10 km buffer around Lyndhurst was covered by the desktop assessment. This ensured that contextual information was considered during the assessment. Following this, an assessment of likelihood of occurrence was undertaken based on information gathered during this exercise.

The following databases were utilised to inform the desktop review:

- Department of the Environment and Energy (DoEE, 2018) *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) Protected Matters Search Tool. Accessed 15/02/2018 at http://www.environment.gov.au/webgis-framework/apps/pmst/pmst.jsf;
- South Australian Department of Environment, Water and Natural Resources (DEWNR) Biological Database of South Australia (BDBSA) for threatened flora and fauna species listed under the South Australian *National Parks and Wildlife Act 1972* (NPW Act). Data request sent to DEWNR on 15/02/2018 through http://www.environment.sa.gov.au/Science/Information_data/Biological_databases_of_South_Australia. Received data from DEWNR on the 20/02/2018;
- NatureMaps vegetation mapping administered by DEWNR. Accessed 15/02/2018 at http://spatialwebapps.environment.sa.gov.au/naturemaps/?locale=en-us&viewer=naturemaps;
- Aerial imagery;
- The South Australian Department of State Development (DSD), Register of Aboriginal Sites and Objects. Data request sent to DSD on 19/02/18. Received data on 2 March 2018;
- Park resources provided on the DEWNR website including a report and map of Protected Areas of South Australia (December 2016 edition), accessed at http://www.environment.sa.gov.au/managing-natural-resources/park-management/parks-boundaries; and
- SA Heritage Places Database, accessed at http://maps.sa.gov.au/heritagesearch/HeritageSearchLocation.aspx.

Likelihood of Occurrence

A likelihood of occurrence assessment was completed for all conservation significant species and communities that were identified from the desktop review. The likelihood of occurrence assessment considered both the Lyndhurst site and Buffer Zone. This ensured that indirect impacts on conservation significant species and communities may be considered in the planning phase of the Project. Individual conservation significant species are tabulated in the field methods and results section.

The likelihood assessment considers the presence of suitable habitat, number of records, date of records, and proximity of known records in relation to the Lyndhurst site and the Buffer Zone and within the expanded Study Area. The year of records and number of records were also taken into account to verify the accuracy of location data and the commonality of the species.

Five categories are used for the assessment, including:

- **Unlikely**: No preferred/suitable habitat present. Species unlikely to be present on the site at any time or during any season. No records of species/community in expanded Study Area.
- **Low**: Potentially suitable habitat present lacking condition, specific floristic or complexity data. Species may visit or fly over however habitat is unlikely to be considered critical to the survival of the species. No recent records of species/community in expanded Study Area.

- **Moderate**: Preferred habitat (or parts thereof) present and is of size suitable for supporting species (individual or population). One or more recent records of species/community in expanded Study Area.
- **High**: Suitable habitat is present. Several recent records of species/community in expanded Study Area.
- **Present**: Species known to be present, confirmed records in Sites and suitable habitat is present.

Desktop Results – Commonwealth Listed Species

The search for the Lyndhurst site identified 12 threatened species and 13 Marine and/or Migratory species protected under the EPBC Act that may potentially occur. This includes four threatened flora species, seven threatened bird species, one threatened mammal and 13 Marine and/or Migratory bird species. The Protected Matters Search Tool (PMST) report is provided in its entirety in Appendix A.

There were no TECs identified as potentially occurring within the expanded Study Area, Buffer Zone or Lyndhurst site. It can therefore be confidently assumed that no TECs occur within the Lyndhurst site or the Buffer Zone.

Four flora species listed as threatened under the EPBC Act were identified in the PMST. None of these species are considered Known, Likely, or to have a Moderate likelihood of occurrence within the Lyndhurst Site. Two flora species have been recorded within the Buffer Zone. *Acacia rhetinocarpa* was recorded in 1989 in an area currently cleared for agriculture. The location may be incorrect due to the time elapsed since the record was made. Species habitat includes calcerous sands and loamy earths which may be present in the Buffer Zone. *Caladenia tensa* was recorded in the expanded Study Area in 2000 in an area shown as cleared on aerial imagery. It is associated with woodlands and has a Moderate likelihood of occurrence within the Buffer Zone.

Intact native vegetation associated with Lake Gilles Conservation Park provides suitable habitat for the four threatened flora species, in particular for the two species that are known to occur within the expanded Study Area.

Eight fauna species listed as threatened under the EPBC Act were identified during the desktop assessment. Of these, seven were listed in the PMST including six bird species and one mammal species. The BDBSA search identified one additional bird species listed as Vulnerable which has been recorded within the buffer area. No threatened fauna listed under the EPBC Act are known or considered likely to occur within the Lyndhurst site or Buffer Zone. Within the Buffer Zone, the Malleefowl is considered to have a Moderate likelihood of occurrence. The Sandhill Dunnart is also considered to have a Moderate likelihood of occurrence within the Buffer Zone. However, there are no records of the species within 10 km of the site as the species is highly cryptic and detection rates would be anticipated to be low. Whilst historically recorded in the expanded Study Area, there is no preferred habitat for the Painted Button Quail present within Lyndhurst site or the Buffer Zone. As such the species is considered Unlikely to occur.

The PMST identified ten fauna species listed as Migratory under the EPBC Act. Of these, two are also listed as Critically Endangered and are therefore not discussed further in this section. The BDBSA search identified one additional bird species (Satin Flycatcher) listed as Marine and Migratory which has been recorded within the expanded Study Area. The remaining nine species are all bird species listed as Marine and Migratory. The PMST identified four bird species listed as Marine under the EPBC Act. Migratory and Marine species identified are typically associated with wetland type habitats. Such habitat is not identified within the site or the Buffer Zone and as such these species are considered to have a low to unlikely likelihood of occurrence.

Desktop Results – State Ecological Values

There are two patches of native vegetation and a linear corridor of mallee trees present within the Lyndhurst site. Within the Buffer Zone there are numerous discreet patches of native vegetation. Vegetation within the vicinity of the Lyndhurst site comprises of Mallee Woodland and Shrubland, Chenopod Shrub, Samphire Shrub and Forbland, Casuarina Forest and Woodland, and Acacia Forest and Woodlands (DEWNR, 2018b).

The BDBSA search identified seven State listed threatened flora species that have been recorded in the Buffer Zone. Four of the listed species are associated with salt lakes and gypseous and duplex soils. Their presence within the Buffer Zone is associated with Lake Gilles, located approximately 3 km northeast of the Lyndhurst site. One species, *Daviesia devito* has a Moderate likelihood of occurrence within the Lyndhurst site and Buffer Zone. This species is listed as Rare under the NPW Act and prefers sandy, loamy or calcerous soils. The remaining three species are considered to have a Low to Unlikely likelihood of occurrence.

The desktop review identified 18 fauna species listed as threatened under the NPW Act including ten identified in the BDBSA search and another eight species identified in the PMST search. Species previously discussed (11 species total) that are listed under the EPBC Act are not further discussed in this section. The remaining seven fauna species are listed as Rare under the NPW Act and are all bird species. Of these, none are Known or considered Likely to occur within the Lyndhurst site or Buffer Zone. One species, the Restless Flycatcher (*Myiagra inquieta*) is considered to have a Moderate likelihood of occurrence within the Lyndhurst Site and Buffer Zone. This species has been recorded six times in the expanded Study Area as recent as 2008. The species is commonly observed in farmland in proximity to woodland habitats. Six of the State listed species have a Moderate likelihood of occurrence within the Buffer Zone.

Lyndhurst Site Linear Corridor of Native Vegetation (Mallee trees) Along Eastern Property Boundary

Lyndhurst Site Native Vegetation (Mallee trees) on Sand Ridges

The BDBSA search identified two weed species declared under the NRM Act that have been recorded in the expanded Study Area. This includes Salvation Jane/Paterson's Curse (**Echium plantagineum*) and Horehound (**Marrubium vulgare*).

Conservation and Special Use Areas

Two Parks were identified in the expanded Study Area including Lake Gilles Conservation Park and Mootra Conservation Reserve (Figure 2). Lake Gilles Conservation Park is located approximately 2 km east of Lyndhurst site and extends for 65,528 ha. The Park comprises sparse and semi-arid Mallee landscape with a saline lake surrounded by low sandy rises, gypsum dunes and isolated stony hills (DEWNR, 2016). The Mootra Conservation Reserve is located approximately 10 km west of Lyndhurst site and extends for 949 ha.

The desktop review did not identify any State Heritage sites listed under the HP Act or Local Heritage Places listed in Development Plans within the expanded Study Area. The closest sites according to the SA Heritage database are more than 15 km away, including:

- Stables, Shed & Yards near Wirrigenda Hill in Kimba (State heritage place:14223);
- Cunyarie Rocks (Emu Rocks) Water Supply Structure near Cunyarie via Kimba (State heritage place: 14224); and
- Refuge Rockholes Historic Reserve (Secret Rocks) at Whyalla Road, Kimba (State heritage place: 14251).

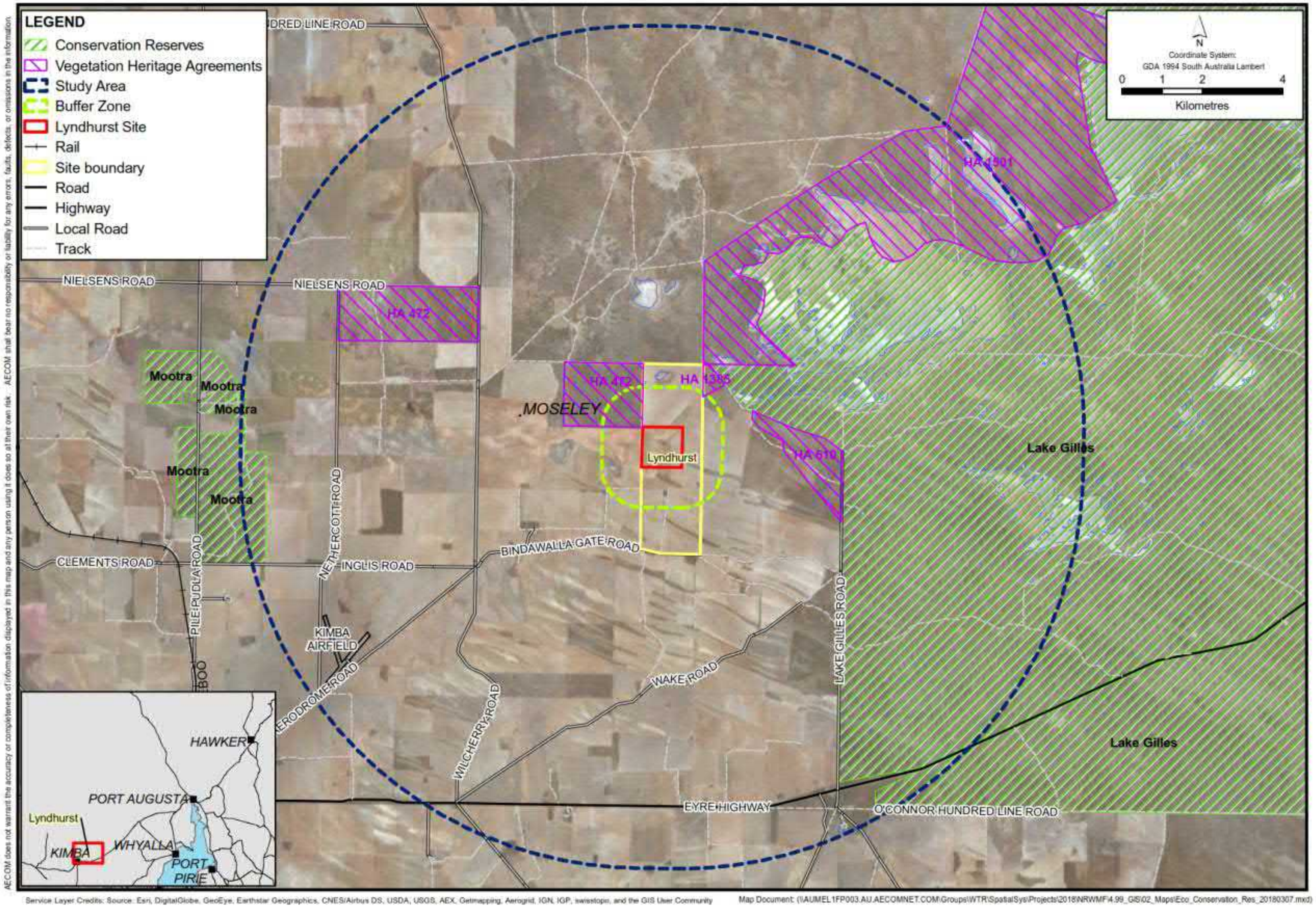
The desktop review identified five Heritage Agreements (native vegetation) within 5 km of the Lyndhurst site (Figure 2):

- Heritage Agreement Number: 472, Registered: 05/03/1991, File number: 1990/1131, located directly north-west of the Lyndhurst Site on the adjacent property (CT/6052/777) to the west.
- Heritage Agreement Number: 472, Registered: 05/03/1991, File number: 1990/1131, located approximately 4.5 km north-west of the Lyndhurst Site on property (CT/5941/842) to the west.
- Heritage Agreement Number: 1385, Registered: 24/01/2007, File number: 2004/1093, located approximately 1 km north-east on the adjacent property (CT/5941/842) to the east.
- Heritage Agreement Number: 1501, Registered: 30/11/2010, File number: 2007/1023, located approximately 1.5 km north-east on the adjacent property (CL/1290/4) to the north.

- Heritage Agreement Number: 610, Registered: 31/3/1992, File number: 1991/1058, located approximately 2.5 km north-east on the adjacent property (CT/5941/842) to the east

Native Vegetation associated with Heritage Agreement 472, CT/6052/777

Figure 2 Parks and Heritage Agreements



There are no Aboriginal Sites protected under the AH Act within the Buffer Area (DSD, 2018). The Lyndhurst site is located within the Barngarla native title area. The Barngarla Determination Aboriginal Corporation may have an interest in any potential developments in the area.

2.1.1.3 Field Methods and Results

The large area of remnant native vegetation in the northwest corner of the survey area is classified as being in Excellent condition as per the definition in Table 6 below. There is no evidence of historical clearing or grazing. The condition was evident in the higher biodiversity and stability of soil surface from cryptograms and litter.

Vegetation condition is mapped in Figure 3.

Figure 3 Vegetation types and condition

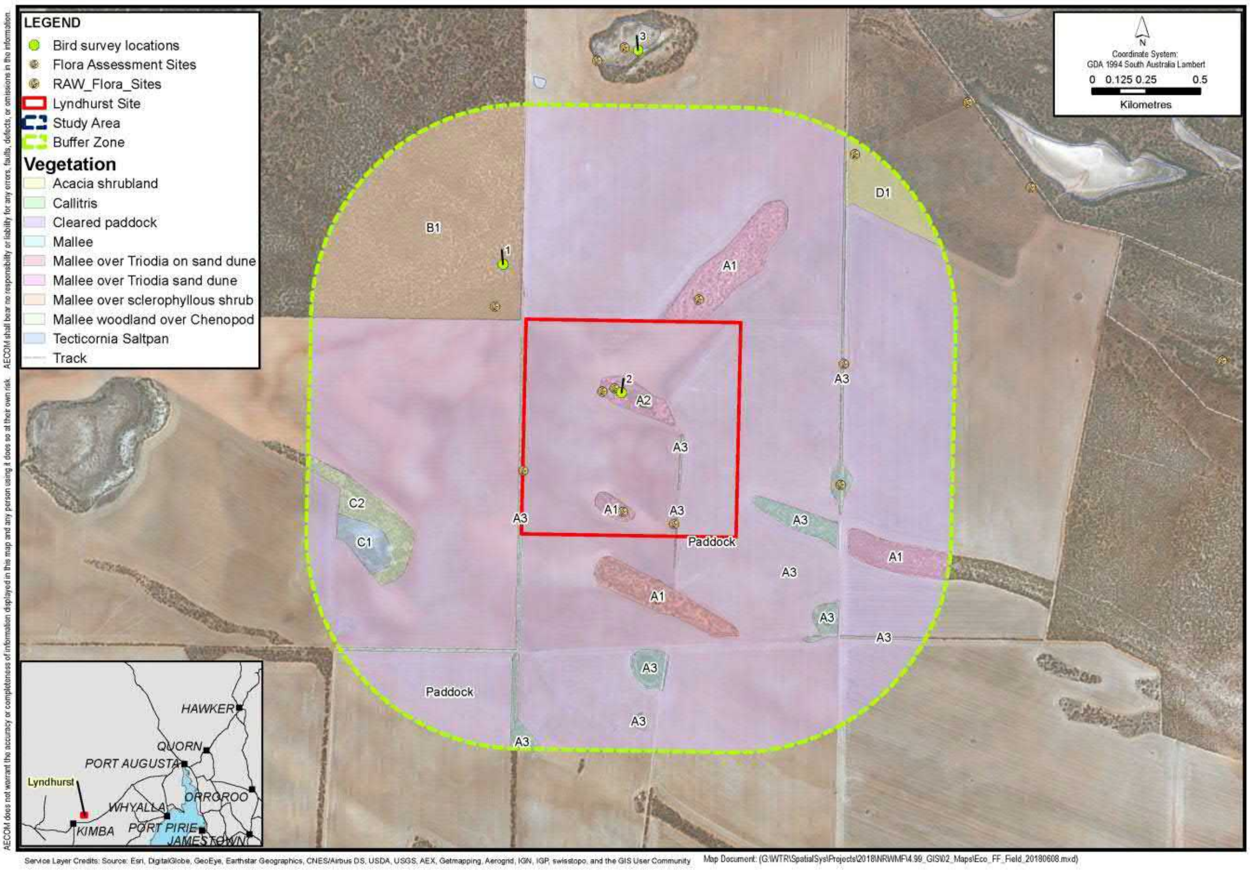


Table 6 Vegetation condition scale (Trudgen, 1991)

Vegetation Condition	Description
Excellent	Pristine or nearly so, no obvious signs of damage caused by human activities since European settlement.
Very Good	Some relatively slight signs of damage caused by human activities since European settlement. For example, some signs of damage to tree trunks caused by repeated fire, the presence of some relatively non-aggressive weeds, or occasional vehicle tracks.
Good	More obvious signs of damage caused by human activity since European settlement, including some obvious impact on the vegetation structure such as that caused by low levels of grazing or slightly aggressive weeds.
Poor	Still retains basic vegetation structure or ability to regenerate it after very obvious impacts of human activities since European settlement, such as grazing, partial clearing, frequent fires, or aggressive weeds.
Degraded	Severely impacted by grazing, very frequent fires, clearing or a combination of these activities. Scope for some regeneration but not to a state approaching good condition without intensive management. Usually with a number of weed species present including very aggressive species.
Completely Degraded	Areas that are completely or almost completely without native species in the structure of their vegetation; i.e. areas that are cleared or 'parkland cleared' with their flora comprising weed or crop species with isolated native trees or shrubs.

Threatened flora

Nine conservation significant flora species were identified during the desktop assessment including four species listed under the *Environment, Protection and Biodiversity Conservation Act 1999* (EPBC Act) and five species listed under the *National Parks and Wildlife Act 1972* Act (Table 7).

Seven flora species have been recorded within the Study Area (Figure 4). Of these, six are considered to have a low or moderate likelihood of occurrence within the survey area as indicated in Table 7. Suitable habitat was recorded and there are historical records from the vicinity of the site. The suitable habitat is predominantly located within the large area of remnant native vegetation situated in the northwest corner of the survey area, and linear corridors of mallee woodland.

The likelihood of *Acacia rhetinocarpa* occurring was reduced from High to Unlikely following the field survey. The species was historically recorded in the region however suitable habitat was not observed within the survey area.

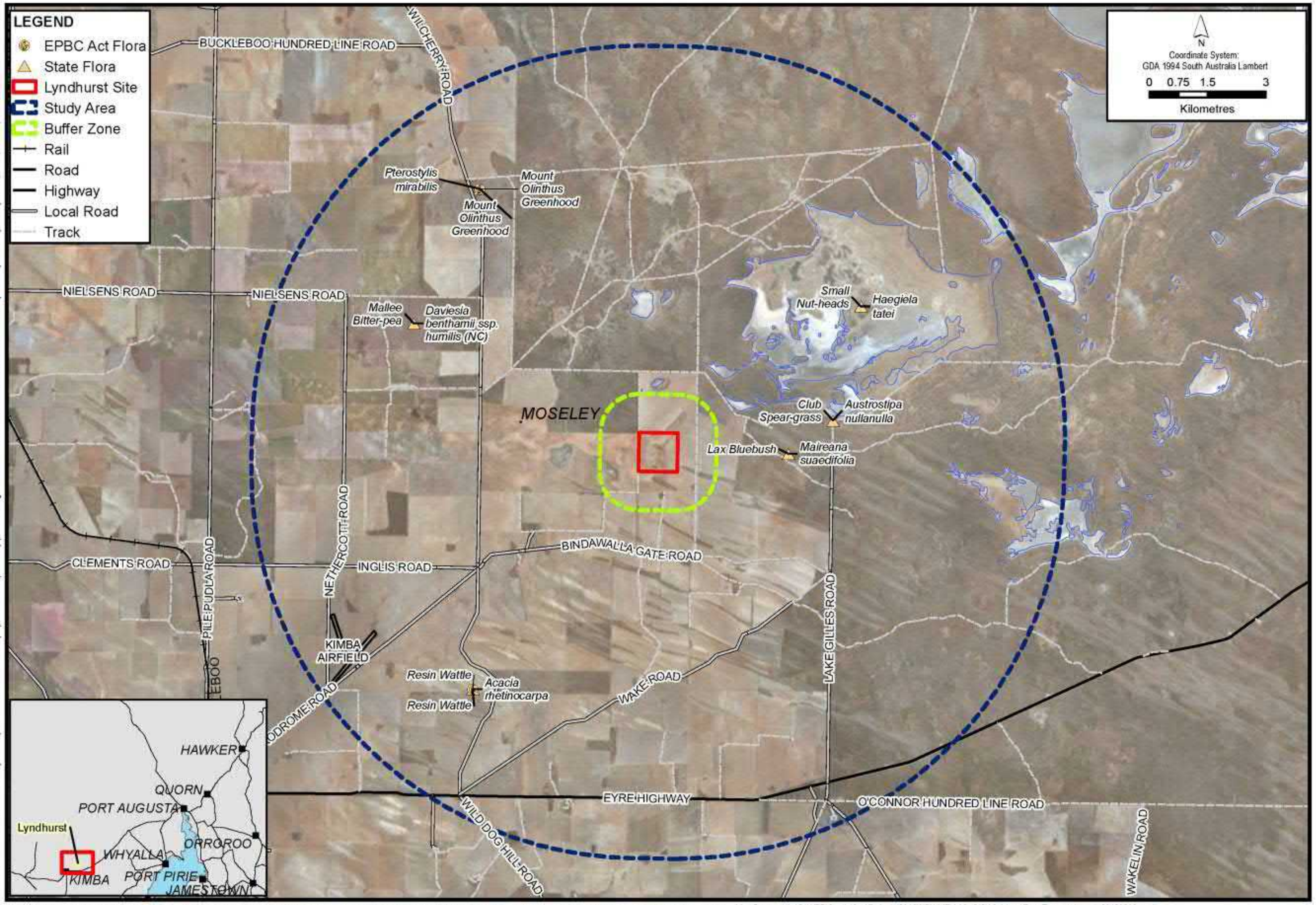
Table 7 Threatened Flora Species Including EPBC Act Status, Habitat and Likelihood of Occurrence

Taxon	EPBC Act[1]	NPW Act[1]	Habitat	Desktop Assessment	Field Survey Assessment
Acacia rhetinocarpa Neat Wattle	VU	VU	The Neat Wattle usually grows in open scrub on calcareous sand, sandy loam, red shallow porous loam or grey-brown calcareous loamy earths.	High	Unlikely
Caladenia tensa Greencomb Spider-orchid	EN		Grows in Cypress-pine/Yellow Gum Woodland, Heathy Woodland and Mallee on sands and sandy loams derived from aeolian sand deposits	Moderate	Low
Pterostylis mirabilis Nodding Rufoushood	VU	V	The orchid grows mostly in stony brown loam soils, among rocks on hilly slopes in scrublands of Broombush (*Melaleuca uncinata*). The Nodding Rufoushood is also	Unlikely	Moderate

Taxon	EPBC Act[1]	NPW Act[1]	Habitat	Desktop Assessment	Field Survey Assessment
			known from *Callitris* and *Eucalypt* woodland		
Swainsona pyrophila Yellow Swainson-pea	VU	R	Grows in mallee scrub on sandy or loamy soil, usually found only after fire. Sites include cleared and burnt mallee scrub on red loam to sand, previously burnt *Eucalyptus dumosa* mallee, disturbed woodland in sheltered aspects, a bulldozed firebreak adjacent to wheat paddocks, roadsides, claypans and at the edge of fire ash.	Unlikely	Low
Acacia rhigiophylla Dagger-leaf Wattle		R	Small occurrence on Eyre Peninsula and Murray region in open scrub associated with *Eucalyptus socialis* and *E. gracilis,* in hard alkaline red duplex or grey-brown calcareous loam soil.	Low	Moderate
Austrostipa nullanulla Club Spear-grass		VU	Club Spear-grass occurs on crests, slopes and spurs often on the western to north-western side of large lunettes of flour gypsum (Kopi), or in sandy loam soils, and most often around salt lakes.	Unlikely	Unlikely
Daviesia devito (historically known as *Daviesia benthamii* subsp. *humilis*) Mallee Bitter-pea		R	Found in the southern part of South Australia, from the southern Eyre Peninsula to the South-east, growing in mallee on sandy or loamy, usually calcareous soils.	Moderate	Moderate
Haegiela tatei Small Nut-heads		R	Found along the coast from Fowlers Bay to the Coorong in South Australia, growing in saline, often gypseous habitats and often growing in samphire flats or low chenopod shrubland.	Unlikely	Unlikely
Maireana suaedifolia Lax Bluebush		R	Found on loam and sandy soils alongside salt lakes and alluvial plains.	Unlikely	Moderate

1. EN Endangered, VU Vulnerable, R Rare

Figure 4 Threatened flora records within the study area



Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community Map Document: (G:\WTR\SpatialSys\Projects\2018\NRWMF\4.99_GIS\02_Maps\Eco_Flora_state_nat_20180608.mxd)

Flora and Vegetation

A field survey was undertaken by AECOM using personnel experienced in undertaking field surveys in South Australia and Western Australia. The Lyndhurst Site and a 1 km buffer, referred to as the Survey Area, were traversed on foot and by vehicle on 17 April, 2018.

Methods described in the Native Vegetation Council Bushland Assessment Manual (2017) were used to collect floristic data within areas of remnant native vegetation. Representative 1 hectare (ha) unbounded quadrats were used where possible. The survey area was characterised by multiple small sites located within close proximity to one another. One quadrat was used to include multiple discreet areas if they were observed to represent similar vegetation types. As a preliminary assessment, methods outlined for a 'small site field' were used.

Quadrats were given a unique site name and the following collected:

- Species list (including height and foliage cover) of dominant species only;
- Photograph;
- Waypoint;
- Site observations;
- Weed cover rating;
- Regeneration;
- Level of impact;
- Litter cover;
- Hollow-bearing trees (presence); and
- Tree health.

Data collected from quadrats were used to determine the condition of the site and can be used as an out-of-season baseline dataset for future monitoring or guiding targeted surveys where required.

Vegetation Types

No Threatened Ecological Communities were identified as potentially occurring in the expanded Study Area and none were recorded during the field survey.

Seven vegetation types were recorded during the field survey extending 148.92 ha. These included:

- five mallee woodlands including three scattered throughout paddocks, one representing excellent condition vegetation, and one acting as a buffer/ecotone of the Tecticornia saltpan;
- a Tecticornia saltpan; and
- degraded Acacia shrubland.

Descriptions and photographs are presented in Table 8 and mapped in Figure 3 supported by site data presented in Appendix A.

Table 8 Vegetation types Lyndhurst recorded within the survey area including code, description and photograph

Code	Vegetation Description	Photograph
A1	Open mallee woodland over Triodia Open mallee of *Eucalyptus socialis* subsp. *viridans* over *Melaleuca lanceolata, Acacia hakeoides* and *Eremophila deserti* tall open shrubland over *Olearia muelleri, Lomandra leucocephala* subsp. *robusta* and *Triodia irritans* low shrubs and hummock grassland. Recorded on sandy soils on dune systems. Diversity of native species varied as a result of historical impacts of grazing and isolation. Vegetation type represented by Lyn 1, 2, and 3.	
A2	Low Woodland *Callitris gracilis* over Chenopods Low woodland *Callitris gracilis* and *Eucalyptus incrassata* over *Enchylaena tomentosa* var. *tomentosa*, *Rhagodia spinescens, Dianella revoluta* and sparse grasses. Disturbed sandy patch of Callitris with evidence of dieback in trees. Understorey appears more susceptible to impacts from grazing. Vegetation type represented by Lyn 6.	
A3	Mallee Mallee woodland of *Eucalyptus socialis* over mixed shrubs including *Enchylaena tomentosa, Cratystylis conocephala, Maireana* sp., and *Atriplex* sp. Vegetation in linear corridors varying in condition due to extensive clearing. Likely weed invasion present following rain. Vegetation type described from observations only.	

Code	Vegetation Description	Photograph
B1	Mallee woodland over sclerophyllous shrubs Low mallee woodland of *Eucalyptus socialis, Eucalyptus gracilis, Eucalyptus porosa* and *Eucalyptus brachycalyx* over *Eremophila scoparia* and *Olearia muelleri, Westringia rigida* mid shrubland. Excellent condition vegetation in large block of native remnant vegetation on undulating flats. Vegetation type represented by Lyn 4.	
C1	Tecticornia saltpan Low open shrubland of *Tecticornia indica* and *Tecticornia halocnemoides* with isolated *Maireana Astrotricha* and *Tecticornia pergranulata*. Located on clay soils with salt residue on surface. Isolated dead trees throughout. Vegetation type represented by Lyn 7.	
C2	Mallee woodland over Chenopods Open mallee woodland of *Eucalyptus incrassata over Enchylaena tomentosa* var. *tomentosa*, *Rhagodia spinescens* low open shrubland with sparse dead grasses. Ecotone community represents the edge of the Tecticornia saltpan. Patches of dead trees and further characterised by sparse understorey. Vegetation type represented by Lyn 5.	

Code	Vegetation Description	Photograph
D1	*Acacia* shrubland Mid shrubland of *Acacia* and *Eremophila* over sterile grasses. Isolated to one occurrence, this community appears to represent potential rehabilitation or restoration of the area as evident by lack of mallee trees and age of species. Isolated to corner of survey area.	
Paddock	Open farmland of undulating terrain supporting introduced grass and herb species.	

Vegetation Condition

Vegetation condition mapping was based on a popular method applied in the Eremaean Botanical Province in Western Australia. The condition scale refers to the impact of disturbance and the ability of the community to regenerate.

Vegetation condition varied from Excellent to Degraded. The small patches of native vegetation within paddocks were mapped in Good condition. These patches would be able to regenerate to a stable ecosystem representing all pre-impact strata if impacts such as grazing were removed. Their isolation from other patches has also likely reduced their biodiversity.

Linear corridors of mallee trees were considered Degraded. The edge effects within these communities are present throughout, with reduced biodiversity in all strata evident.

<u>Fauna and Fauna Habitat</u>

A field survey was undertaken by an AECOM Zoologist experienced in surveys in similar environments. Fauna surveys occurred concurrently with the aforementioned flora surveys. As per the flora survey, the survey area was traversed by foot and vehicle

Detailed notes were collected on the habitat attributes of the survey area such as waterways, woodlands, shrub-lands and the presence of rocky outcrops. Habitat assessments focused on the identification of preferred habitat for threatened fauna species as identified as having potential to occur during the desktop investigations.

Whilst traversing the site, habitat features such as fallen woody debris were actively searched and incidental observations of fauna recorded. The presence of scats, tracks and other traces were also recorded particularly those that may indicate use of the habitat by Mallee Fowl.

Additionally, a 20 minute bird census was completed at three locations. Locations subject to bird survey included Mallee Vegetation just beyond the South West corner of the site, dune vegetation in the buffer area within agricultural land to the west of the site and a roving survey around the perimeter of the paddock in which the site lies.

Fauna habitats

A number of fauna habitat types were identified within the site and buffer zone. Habitat types consisted of open farmland, disturbed Mallee Woodland, high value Mallee Woodland, dune shrubland and *Tecticornia* saltpan surrounded by Mallee Woodland with sclerophyllous shrubs.

Open farmland was the dominant habitat type within the proposed site footprint and much of the adjoining paddocks. This area was almost entirely denuded of living vegetation and was dominated by a mixture of bare ground and crop stubble (dead organic matter). No current cropping activities were apparent though sheep grazing was noted within the southern of the paddocks in which the site footprint is situated. Open farmland is considered of negligible habitat value.

Open farmland within Lyndhurst Site

Also, two discrete isolated patches of Mallee Woodland occur within the site footprint (as described in Table 8 as A1 and A3. This habitat aligns with vegetation type A1. The northern and largest of these two patches consisted of open Mallee Woodland above small tussocks of hummock grass. At the woodlands centre was a small stand of Buloke. Organic debris and soil crust was sparse however wood debris and greater habitat complexity was present toward the patches centre. The second, and smaller of the two patches, was located toward the southern portion of the site footprint. Habitat composition was similar however it had less cover of hummock grass and less woody debris. Buloke was absent. Both patches may provide low quality habitat for ground dwelling fauna and dispersal and occasional habitat for woodland birds. Both patches show evidence of recent grazing pressure with a small flock of sheep observed in the smaller of the two patches and likely to be adversely impacting ground cover. A further third patch of habitat of similar composition was also identified beyond the Lyndhurst sites southern boundary.

Mallee woodland in site boundary large patch left and small patch right.

Within the buffer zone, high quality Mallee Woodland habitat was present within an area of woodland reserve and to north east of the site boundary. This habitat type aligns with vegetation code B1. Habitat within this area consisted of dense Mallee overstorey with an acacia mid storey and ground cover consisting of saltbush and occasional hummock grass. This area contained a significant amount of woody debris had greater habitat complexity than Mallee within the site footprint. Vegetation provided good habitat for small to large ground dwelling fauna and woodland birds. Bird activity and diversity was noted to be high at this location.

High value Mallee woodland

To the direct north of the site boundary and within the buffer zone was an isolated patch of acacia shrubland with a sparse Mallee overstorey. This shrubland which is mapped as vegetation code A1 contained a sparse ground cover of small hummock grass tussocks had sparse organic and woody debris and was more closed than the remnants within the site boundary. Habitat is likely to be of moderate suitability for ground dwelling fauna.

Dune shrubland

Further north, and just beyond the boundary of the buffer zone, was an area of low open shrub-land and saltbush ringed by Mallee with an acacia midstorey. This habitat type, possibly a remnant of Lake Gilles system was assessed as it likely to be subject to inundation following rainfall and thus provides habitat not otherwise identified within the paddocks assessed. Due to its complexity and areas of extensive woody debris and proximity close to the Lake Gilles Conservation Reserve this habitat is likely to support a diversity of fauna species. The significance of observations within this area is further expanded on below. Vegetation showed signs of grazing, however, at lower intensity than habitat within the site boundary. This habitat was located in a separate paddock to the site boundary and no livestock was present within the paddock at the time of assessment.

Tall Mallee Woodland surrounding saltbush

Fauna diversity

A total of 27 fauna species were recorded across the Lyndurst site and its buffer zone. Fauna species detected included an indirect observation of Malleefowl *Leipoa ocellata*. This observation is detailed further below. All other species observed are considered common species. Species observed include Ring Necked Parrot *Barnardius zonarius*, Red Capped Robin *Petroica goodenovii*, Dusky Woodswallow *Artamus cyanopterus*, Spotted Pardalote *Pardalotus punctatus* and Weebill *Smicrornis brevirostris. A* full list of observed fauna is presented in Table 9, the location of bird surveys are presented in Figure 5*.* A wedge-tailed Eagle *Aquila audax* and Singing Honeyeater *Gavicalis virescens* observed on the site are shown below.

Wedge-tailed Eagle (left), Singing Honeyeater (right)

Tracks believed to be consistent with Malleefowl where identified in habitat to the north of the buffer zone. The observed footprints were approximately 12 cm in length and are consistent with guidance within the National Manual for the Mallee Fowl Monitoring system (NHT, 2008). A search of connected habitat failed to detect any birds or breeding mounds. Based on available evidence, it is thought that the species is likely to use the area as part of its foraging habitat. The habitat in question is within 300 m of large areas of vegetation continuous with Lake Gilles Conservation Reserve which known to support Malleefowl. This area was less grazed than that within the site boundary and typically in better condition than habitat assessed in the buffer area with the exception of Mallee vegetation to the northwest of the site.

Footprints' believed to be Mallee fowl

Table 9 Observed fauna

Common Name	Scientific Name	EPBC	NPW	Location
Birds				
Australian Magpie	*Gymnorhina tibicen*			1, 2, 3
Australian Raven	*Corvus coronoides*			1, 2, 3
Common Bronzewing	*Phaps chalcoptera*			2
Crested pigeon	*Ocyphaps lophotes*			1, 2
Dusky Woodswallow	*Artamus cyanopterus*			3
Emu	*Dromaius novaehollandiae*			
European Starling	*Sturnus vulgaris*			1
Galah	*Eolophus roseicapilla*			1, 2
Grey Butcherbird	*Cracticus torquatus*			
Grey-fantail	*Rhipidura albiscapa*			1
Mulga Parrot	*Psephotus varius*			3
Malleefowl*	*Leipoa ocellata*	Vulnerable	Vulnerable	3
Red Capped Robin	*Petroica goodenovii*			1
Red Wattle Bird	*Anthochaera carunculata*			3
Ring-necked parrot	*Barnardius zonarius*			1, 3
Silvereye	*Zosterops lateralis*			1
Singing Honeyeater	*Gavicalis virescens*			1,2
Spotted Pardalote	*Pardalotus punctatus*			1
Wedge-tailed Eagle	*Aquila audax*			
Weebill	*Smicrornis brevirostris*			1
Willie Wagtail	*Rhipidura leucophrys*			1, 2, 3
Yellow-rumped Thornbill	*Acanthiza chrysorrhoa*			1, 3
Yellow-throated Miner	*Manorina flavigula*			1,2, 3
Zebra Finch	*Taeniopygia guttata*			3
Mammals				
Feral Cat	*Felis catus*			
Sheep	*Ovis aries*			
Western Grey Kangaroo	*Macropus fuliginosus*			

Threatened fauna

Threatened fauna identified during the desktop assessment included eight species listed as threatened under the EPBC act, ten fauna listed as migratory and marine and four listed as marine under the EPBC Act and sixteen species listed under the NPW Act. In total, ten species have been recorded in the expanded Study Area (Refer Figure 5). Only one species Restless Flycatcher *Myiagra inquieta* has been recorded in the buffer zone. This species is commonly observed in farmland in proximity to woodland habitats. Other threatened fauna recorded in the expanded Study Area include Malleefowl, Thick-billed Grasswren *Amytornis modestus* and Purple-gaped Honeyeater *Lichenostomus cratitius occidentalis*

The likelihood of threatened fauna species occurring was reassessed following the completion of the field survey. Within the site boundary itself, habitat values for threatened fauna were notably low. The site predominately consisted of open farmland and was devoid of vegetation which was of negligible habitat value. Within the site boundary however, small isolated areas of native vegetation occur. These areas whilst containing some opportunities were heavily grazed and modified. While the presence of certain species cannot be ruled out, these areas are unlikely to form core habitat for any of the threatened species identified. As such, no threatened species have been assigned a greater than low likelihood of occurrence in the site footprint.

Within the buffer zone, habitat values were notably higher particularly within the Mallee Woodland reserve. This area is considered to provide significant habitat for threatened birds and small mammals. Given the linkages of this area to the Lake Gillies Conservation Reserve, this area is likely to support threatened species at least on an intermittent basis. Species considered likely to occur here include Mallefowl, Sanhill Dunnart *Sminthopsis psammophila* and a number of woodland bird species.

Beyond the buffer zone, toward the northern boundary of the northern paddock and along eastern boundary, habitat of significant value to threatened species exists. Habitat values were particularly high to the east where proposed access tracks interface with the Lake Gilles Reserve. It is recommended that any impact to these areas be avoided. Significant environmental controls to mitigate impacts to threatened fauna would be required to facilitate the project should impacts to this area be proposed with the matter likely to require referral under the EPBC Act. The basis of this referral would be required primarily due to the potential to impact habitat for the EPBC Act listed Malleefowl and Sandhill Dunnart.

As previously discussed Malleefowl is known to occur in Lake Gilles Conservation reserve Although a review of the recovery plan for the species (Benshemesh, 2007) does not discuss the importance of Lake Gilles in particular, the map of records shows a cluster of recent records within the reserve and the site’s vicinity (within the period of 2000-2005 noting the recovery plan was published in 2007). To AECOM’s knowledge, no confirmed records of Sandhill Dunnart occur in the Lake Gilles Conservation Reserve. However, the national recovery plan does identify the area as potential habitat and notes that further surveys are required to confirm the species status (Churchill, 2001). The national recovery plan for Sandhill dunnart is notably dated and was published in 2001. Consultation with Ecological Horizons Pty Ltd, revealed that Sandhill Dunnart has been recorded in Secret Rocks which is located approximately 39km to the south -east of the proposed site footprint. Given documented habitat values, targeted surveys would be required to confirm the status of Sandhill Dunnart within the site footprint and the buffered extent. Habitat most likely to support the species is present within to the north east of the site footprint. Grazing pressure and a lack of groundcover is likely to have reduced habitat suitability of remnant vegetation within the site footprint but given the understudied nature of the species, targeted assessment should be considered under a precautionary approach.

In addition to the aforementioned species, a number of woodland birds such as the Thick-billed Grass Wren and Purple-gaped Honeyeater are also considered to have a likelihood of occurrence either within the site footprint and or buffer zone. Habitat in the site footprint is unlikely to represent core habitat for any of these species but rather to provide low quality foraging and perching areas when moving between large continuous areas of vegetation / habitat within the buffer zone and broader area.

Table 10. Threatened Fauna Species Likelihood of Occurrence

Taxon	EPBC Status	NPW Status	Habitat Type	Within Site	Within Buffer
Acanthiza iredalei iredalei Slender-billed Thornbill (western)		VU	The Slender-billed Thornbill (western) usually occurs in chenopod shrublands that are dominated by samphire or *Maireana* and *Atriplex* associations.	Low	Moderate
Actitis hypoleucos Common Sandpiper	Mi, Ma		Edges of saltwater to fresh waterbodies and wetlands, including estuaries, lakes, drainage lines, tidal watercourses and mudflats; occasionally beaches and rocky headlands; mainly spring-summer non-breeding migrant.	Unlikely	Unlikely
Amytornis textilis myall Western Grasswren	VU		Occurs in open chenopod shrublands, often where dense stands of Dead Finish *Acacia tetragonophylla* or Blackbush *Maireana pyramidata* surround drainage lines. It also occurs in saltbush *Atriplex* spp. and bluebush *Maireana* spp. shrublands with a sparse or open overstorey of low trees or shrubs, such as Western Myall *Acacia papyrocarpa*, Black Oak *Casuarina cristata pauper*, Australian Boxthorn *Lycium australe*, Bullock Bush *Alectryon oleaefolium* and Sugarwood *Myoporum platycarpum.*	Low	Low
Apus pacificus Fork-tailed Swift	Mi, Ma		Aerial over a wide range of habitats, from inland to coast; spring-summer non-breeding migrant.	Low	Low
Ardea alba Great Egret	Ma		Freshwater and brackish wetlands and watercourses, intertidal mudflats, inland lakes, swamps and rivers; also farm dams, irrigation drainages and artificial wetlands.	Unlikely	Unlikely
Ardea ibis Cattle Egret	Ma	R	Freshwater wetlands and watercourses, pastures and croplands, especially where drainage is poor. Occasionally also tidal flats and estuaries.	Unlikely	Unlikely
Calamanthus (Hylacola) cautus Shy Heathwren		R	They inhabit mostly mallee woodland that has relatively dense shrub and heath understorey.	Low	Moderate

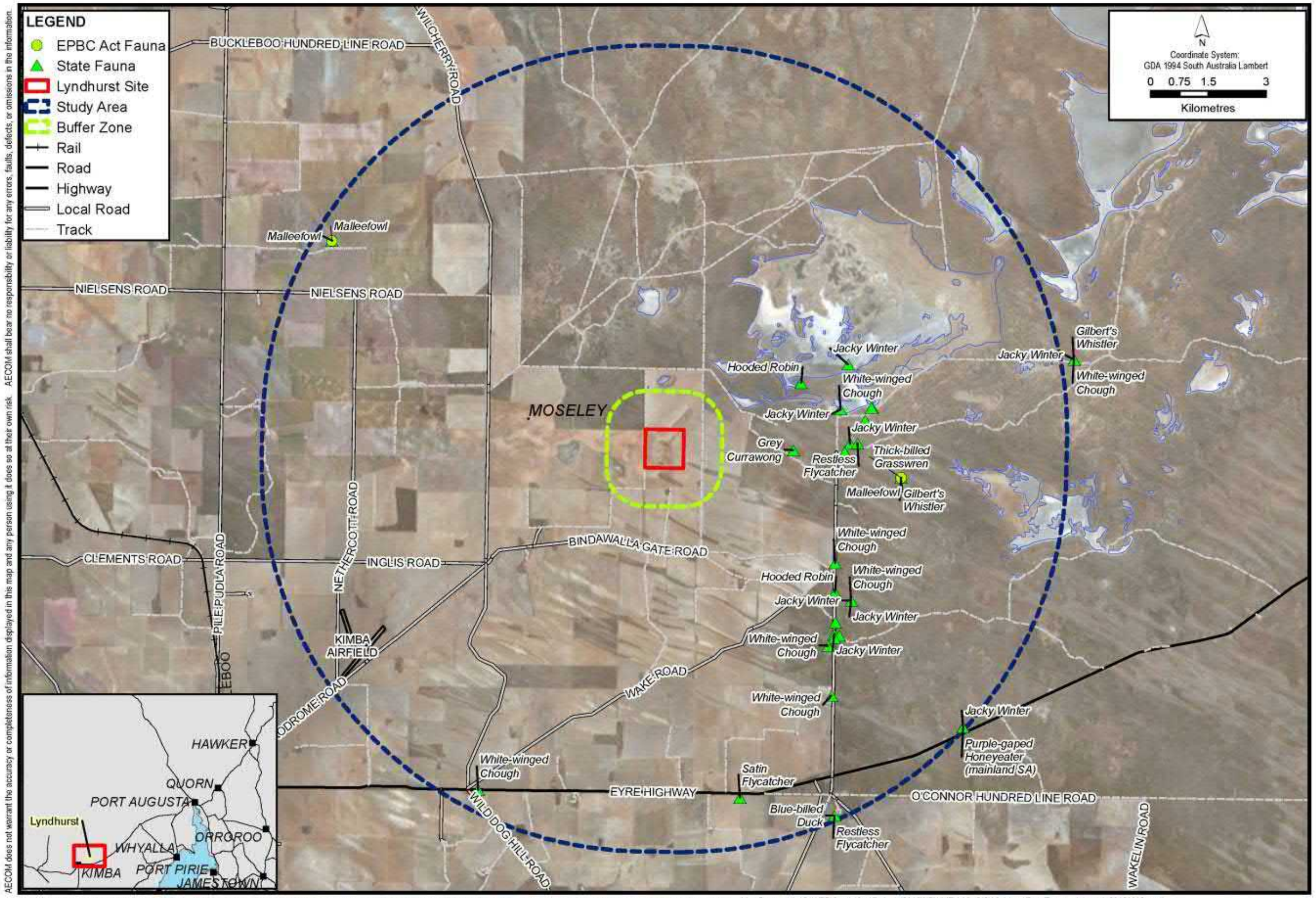
Taxon	EPBC Status	NPW Status	Habitat Type	Within Site	Within Buffer
Calidris acuminate Sharp-tailed Sandpiper	Mi, Ma		Prefers the grassy edges of shallow inland freshwater wetlands. It is also found around sewage farms, flooded fields, mudflats, mangroves, rocky shores and beaches.	Unlikely	Unlikely
Calidris ferruginea Curlew Sandpiper	CR, Mi Ma		Coastal estuaries, bays and shallow wetlands, tidal mudflats and sandflats; mainly spring-summer non-breeding migrant.	Unlikely	Unlikely
Calidris melanotos Pectoral Sandpiper	Mi, Ma		Shallow freshwater or brackish wetlands, including swamps, flooded grasslands, sewage ponds, occasionally tidal flats and saltmarshes.	Unlikely	Unlikely
Charadrius veredus Oriental Plover	Mi, Ma		Immediately after arriving in non-breeding grounds in northern Australia, Oriental Plovers spend a few weeks in coastal habitats such as estuarine mudflats and sandbanks, on sandy or rocky ocean beaches or nearby reefs, or in near-coastal grasslands, before dispersing further inland. Thereafter they usually inhabit flat, open, semi-arid or arid grasslands, where the grass is short and sparse, and interspersed with hard, bare ground, such as claypans, dry paddocks, playing fields, lawns and cattle camps.	Low	Low
Corcorax melanorhamphos White-winged Chough		R	White-winged Choughs are found in open forests and woodlands. They tend to prefer the wetter areas, with lots of leaf-litter, for feeding, and available mud for nest building.	Low	Moderate
Gallinago hardwickii Latham's Snipe	Mi, Ma	R	Wet grasslands and pastures, open and wooded swamps; spring-summer non-breeding migrant.	Unlikely	Unlikely
Haliaeetus leucogaster White-bellied Sea-Eagle	Ma	EN	Occupies all coastal areas extending inland through main waterways, coastal islands, coastal lakes and along some inland rivers. It forages primarily for fish over large areas of open water.	Unlikely	Unlikely
Leipoa ocellata Malleefowl	VU	VU	Mallee woodlands, scrubland and heathlands, often with sandy substrate. Breed in areas with good leaf litter layer. Occasional forage in open	Low	Present

Taxon	EPBC Status	NPW Status	Habitat Type	Within Site	Within Buffer
			areas, including farmland and clearing amongst mallee.		
Lichenostomus cratitius occidentalis Purple-gaped Honeyeater		R	Inhabits deserts and Xeric Shrublands, Mediterranean Forests, woodlands and scrubs, Temperate Grasslands, Savannas, and Shrublands.	Low	Moderate
Merops ornatus Rainbow Bee-eater	Ma		Spring-summer migrants to Victoria where they occur in many wooded habitats with an annual rainfall of less than 800mm, especially north of the Great Divide; often along vegetated watercourses and cuttings or banks along watercourses.	Unlikely	Unlikely
Motacilla cinerea Grey Wagtail	Mi, Ma		The grey wagtail is found around fast-flowing mountain streams, often in forested areas, as well as lowland watercourses such as canals and rivers.	Unlikely	Unlikely
Motacilla flava Yellow Wagtail	Mi, Ma		The yellow wagtail occurs in a variety of damp or wet habitats with low vegetation, from rushy pastures, meadows, hay fields and marshes to damp steppe and grassy tundra.	Unlikely	Unlikely
Myiagra cyanoleuca Satin Flycatcher	Mi, Ma	EN	Mainly in wet forests and dense woodlands, particularly with tall canopy of eucalypts with an understorey of tea-trees and wattles along streams. Seasonal visitor (mainly spring) to drier inland woodlands, coastal areas and occasionally gardens.	Low	Low
Myiagra inquieta Restless Flycatcher		R	The Restless Flycatcher is found in open forests and woodlands and is frequently seen in farmland.	Moderat e	Moderate
Numenius madagascariensis Eastern Curlew	CR, Mi Ma	EN	Coastal lakes, estuaries, tidal mudflats and sandflats, mangroves and saltmarshes; occasionally fresh or brackish lakes near coast; mainly spring-summer non-breeding migrant	Unlikely	Unlikely
Oxyura australis Blue-billed Duck		R	The Blue-billed Duck is almost wholly aquatic, and is seldom seen on land. Non-breeding flocks, often with several hundred individuals, congregate on large, deep open freshwater dams and lakes in autumn. The daylight hours are spent alone	Unlikely	Unlikely

Taxon	EPBC Status	NPW Status	Habitat Type	Within Site	Within Buffer
			in small concealed bays within vegetation or communally in large exposed rafts far from the shore.		
Pachycephala inornata Gilbert's Whistler		R	It is widely recorded in mallee shrublands, but also occurs in box-ironbark woodlands, Cypress Pine and Belah woodlands and River Red Gum forests.	Low	Moderate
Pedionomus torquatus Plains-wanderer	CR	EN	Low, open native grasslands, typically with sward less than 1m high, with extensive inter-tussock spaces and high diversity of small herbs; sometimes in unimproved pastures or crops.	Low	Low
Pezoporus occidentalis Night Parrot	EN	EN	Extinct in south-eastern Australia; historical records from arid and semi-arid chenopod shrublands, spinifex (Triodia) on stony rises, flats around salt lakes and flooded claypans	Unlikely	Unlikely
Sminthopsis psammophila Sandhill Dunnart	EN	VU	On the Eyre Peninsula, the sandhill dunnart occupies sand ridges covered by hummock grassland and mallee-broombush shrub. Preferred habitat for this species is poorly described and is distribution is poorly understood.	Moderate	High
Turnix varius Painted Buttonquail	VU		Temperate and eastern tropical forests and woodlands form the habitats of this species. They appear to prefer closed canopies with some understory and deep leaf litter on the ground.	Unlikely	Unlikely

CR Critically endangered, EN Endangered, VU Vulnerable, R Rare, Mi Migratory, Ma Marine

Figure 5 Threatened fauna records within Study Area.



Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community Map Document: (G:\WTR\SpatialSys\Projects\2018\NRWMF\4.99_GIS\02_Maps\Eco_Fauna_state_nat_20180608.mxd)

2.1.2 Assessment Against Criteria

An assessment against suitability criteria has been undertaken following the desktop review and field investigations (Table 11).

Table 11 Assessment of Suitability against Criteria

Key Criteria	Site Conditions	Constraints / hazards
Presence and condition of native vegetation 5.75 ha of native vegetation in condition ranging between completely degraded to good.		
Presence and condition of native vegetation	5.72 ha of survey area comprise native vegetation in Excellent to Degraded condition.	The need to remove remnant vegetation
Presence of Commonwealth listed threatened species and habitat No Threatened Ecological Communities (TECs). Three threatened flora and two threatened fauna species may be present. Targeted surveys are required to verify presence/absence of species if site is considered further.		
Presence of Threatened Ecological Communities	No TECs identified.	None identified.
Presence of threatened flora species	Three threatened flora species may occur within the Site or directly adjacent (within 1 km). Targeted surveys during ideal detection periods for species would be required to ascertain presence/absence of species.	Potential for species to be present. Clearing of native vegetation may be considered significant and require referral under EPBC Act.
Presence of threatened fauna species	Malleefowl confirmed to utilise habitat in area. Sandhill Dunnart presence requires verification from additional surveys.	Clearing of native vegetation may be considered 'significant' and require referral under EPBC Act.
Presence of threatened fauna habitat	Low quality habitat within site footprint. High habitat values identified in the buffered zone and broader area.	Impacts to fauna would need to be mitigated.
Presence of Migratory species	No suitable habitat present.	None identified
Presence of State listed threatened species and habitat Five flora species and ten fauna species recorded in expanded Study Area including three flora and one fauna species considered to have a Moderate likelihood of occurrence. Majority are associated with adjacent Conservation Reserve and Lake Gilles.		
Presence of threatened flora species	Three threatened flora species considered to have a moderate likelihood of occurring within survey area. Targeted surveys required to ascertain presence/absence.	State-listed species may be present and require appropriate management.
Presence of threatened fauna species	Low quality habitat for threatened species in the site footprint and moderate to high quality habitat in the buffered extent and broader study area.	Impacts to fauna would need to be mitigated.

Key Criteria	Site Conditions	Constraints / hazards
Proximity and value of Parks (National Parks, Conservation Parks, Conservation Reserves, Recreational Parks and Wilderness Protected areas) Lake Gilles Conservation Park and Mootra Conservation Reserve present within expanded Study Area.		
Proximity and value of Parks	None within Site, Lake Gilles Conservation Park present within expanded Study Area. No Native Vegetation Heritage Agreements present within Site, five are present within the expanded Study Area.	Suitable with appropriate management.
Proximity of Aboriginal heritage sites There are no known Aboriginal Heritage Sites located within the expanded Study Area.		
Proximity of Aboriginal heritage sites	No Aboriginal Heritage Sites located within the expanded Study Area.	Suitable with appropriate management.
Proximity of Commonwealth, state and local heritage sites No such sites present		
State and Local Heritage Sites	No Commonwealth, state or local heritage sites.	None

2.1.3 Design Issues and Mitigation Measures

The Lyndhurst site includes 5.72 ha of native vegetation. Two patches are isolated to sandy hills and one linear corridor presents an historical wind barrier. Clearing of native vegetation should be avoided where possible.

The site is adjacent to an area of Excellent condition native mallee woodland (northwest corner). This area is considered to be of high environmental value and likely to provide habitat for threatened flora and fauna species. As such, mitigation and management of indirect impacts would be required to protect this area should Lyndhurst be further considered.

Access to the site will require widening of existing tracks where present. Clearing of native vegetation, in particular the linear corridors, should be avoided as they provide important fauna habitat corridors and wind barriers.

2.1.4 Data Gaps and Recommendations for Stage 2 Work Program

Three EPBC Act listed flora species may be present within the Site. The likelihood of occurrence is low and moderate. The presence of these species may have implications on clearing of native vegetation, and the management of indirect impacts. Targeted surveys would be required to obtain more certainty on the presence of these species.

Status of the Sandhill Dunnart is unknown. Targeted surveys for the species are recommended. Whilst a number of woodland bird species have also been identified as potentially occurring within the site and/ or buffer zone, targeted surveys for such species are not recommended. Given the degraded and fragmented nature of habitat within the site footprint and the dispersal abilities of these species, they are unlikely to be impacted by vegetation clearance and the loss of a small area of foraging habitat is likely to have a negligible impact on their ability to persist in the region.

The flora and vegetation surveys were completed on 17 to 19 April 2018 following several dry summer months. Lack of rainfall for months leading up to the survey has excluded the majority of annual species and prevented species identification due to lack of suitable material. In particular, weed species presence was insignificant. This may differ from post-wet conditions when annual weeds including daisies and grasses emerge. The implications of excluding this data would impact on the assessment of native vegetation significance and potential to provide habitat for threatened flora and fauna species.

The Native Vegetation Council has developed a quantitative and scientifically robust method for assessing vegetation community condition. These assessments are based on comprehensive field surveys and benchmark sites. Given the preliminary nature of this assessment, no comprehensive analysis against benchmarks was undertaken. For this to occur, surveys would need to be undertaken in the ideal survey season, two to four weeks following significant rainfall events. Lacking this level of detail would prevent the native vegetation condition from being assessed against larger datasets to determine significance. This may or may not present a potential risk for the project at this time.

To a similar extent, the long dry summer and lack of rainfall for months leading up to the survey is likely to have compromised resident fauna assemblages. As such, there is the potential that the site provides habitat for additional fauna species not identified during this assessment.

It is recommended that targeted surveys be completed for species that have been identified as potentially occurring within the Site. This includes three EPBC Act listed flora species and the Sandhill Dunnart. There are several methods prescribed for the Sandhill Dunnart in the National Survey Guidelines for Australia's Threatened Mammals (DSEWPaC, 2011). These methods include pitfall trapping, Elliot trapping, hair sampling and the use of infrared Camera traps. Outcomes of these surveys would further inform legislative implications as they pertain to the project. The targeted flora species would require walking transects through the native vegetation during their ideal detection period to determine their presence.

2.2 Radiation, Background and Risks

2.2.1 Methodology and Results

2.2.1.1 Site Characteristic Criteria

This assessment of radiation, background and risks, address the key site suitability criteria:

Elevated background radiation conditions that could affect safety of personnel or impact future environmental monitoring

This criteria has been developed with reference to ARPANSA guidelines (2014) and IAEA standards (2011, 2016) which outline the need to establish the radiological baseline/ background radiation conditions during site characterisation and prior to submitting a license application for a radioactive waste facility.

For context, it is noted that construction and operational workers could be exposed to natural background radiation either through the ingestion of dust, direct contact with site material, or the inhalation of radon gas (which has intruded into buildings) from the decay of uranium and thorium.

Effective background radiation conditions must be established at the site, to enable environmental monitoring and surveillance to occur at an operational facility against a well-defined baseline.

2.2.1.2 Desktop Methods and Results

A desktop review of available background radiation survey data was undertaken. Data sources included the Geosciences Australia Geophysical Archive Data Delivery System (GADDS) for radiometrics which has a resolution of 100 metres and ARPNSA's 1990 Radon mapping.

It is also understood that the SA Government has recently commissioned geophysical fly-overs of the whole state doing a radiometric survey on a 200 m resolution however; this data has been delayed in publication (now expected in late 2018).

The Eyre Peninsula region is also noted by ARPNSA "Radon" Map of Australia (1990) to have a background level of 10 to15 Bq/m^3. These levels are around 1% of the ARPNSA Action levels for workplaces (i.e. 1000Bq/m^3).

The 1991 Lake Gilles Radiometric Survey (accessed from GADS) concluded:

- Potassium signatures dominated the region with a relatively uniform distribution, although, as expected, Moornaba Sands (aeolian quartz sands and carbonates) were associated with lower potassium responses.
- Uranium detections were relatively high, coinciding with the Lake Gilles Formation, with the extent of surface sediments reporting a relatively uniform uranium signature.

A 1988 survey of the radiation background levels conducted across three areas including Kimba (Geosciences Australia database – 200 metres grid) concluded that the levels are 10 Bq/m^3.

Based on this information there was considered to be the potential for slightly elevated background radiation levels, above those of associated with terrestrial sources in the Lyndhurst site, associated with elevated background uranium levels that appear to be associated with Lake Gilles and the Flinders Ranges.

2.2.1.3 Field Methods and Results

An aerial radiometric survey over the site and its surrounds was carried out in April 2018 by geophysics contractor Daishsat to supplement the existing publically available data.

The light aircraft was fitted with a tail-mounted boom assembly ("stinger") with on-board Geometrics and Billingsley magnetometers and Radiation Solutions integrated gamma detector and spectrometer. Location (including detector height) was precisely measured by a combination of radar altimeter and Novatel GPS Receiver. Magnetic signal was acquired to a resolution of 1 fiducials at a rate of 20 Hz (approximately 2.1 metres horizontal interval) and spectrometric signal data to a resolution of 0.5 fiducials was acquired at 1 second intervals (approximately 42 metres). Data terrain modelling was composed with a resolution of -2 fiducials. Magnetometer and spectral data collection were synchronised to spatial data to ensure the spatial integrity of the information gathered.

The aircraft (with a cruising speed of about 260 kph) gathered data on 50 m line spacing from a north-south survey height of around 50 m running survey lines spacing of 50 m (tied on an east-west basis at 500 m). Radiometric data was processed using standard radiometric correction procedures including background radon correction using Minty's Method (Minty 1996), height correction and subsequent data presentation using the Noise Adjusted Singular Value Decomposition (NASVD) Method.

Results for the entire aerial survey area of 16 square kilometres were interpreted on 10 m by 10m grid basis for radiometric data (potassium, uranium and thorium) in disintegrations per second and magnetics were reported in nanoTesla (nT). The study area of 1 square kilometre was subsequently sub-sampled. The techniques were consistent with current industry practice for these kinds of investigations. Quality control and quality assurance protocols confirmed that the data was of adequate quality for baseline interpretation purposes.

The aerial radiometric field survey data aligns with the historical published datasets. Slightly elevated background radiation levels are present, above those of associated with terrestrial sources in the Lyndhurst Study Area, which appears to be associated with elevated background uranium levels that arise from Lake Gilles and in Flinders Ranges Study Area.

Further details of the radiometric aerial survey and data interpretation by geophysics contractor Daishsat are contained within a report in Appendix C.

2.2.2 Assessment Against Criteria

Results from published historical data and subsequent targeted intensive aerial radiometric field data does not indicate the presence of elevated background radiation conditions exist that could affect safety of personnel or impact future environmental monitoring.

2.2.3 Design Issues and Mitigation Measures

Based on the above assessment no mitigation measures are required to protect worker safety during construction of the facility, nor require detailed mapping and material testing to establish the baseline conditions prior to construction and operation of the facility.

2.2.4 Data Gaps and Recommendations for Stage 2 Work Program

Due to the coarse nature of the available data for background radiation, a "ground truthing" exercise is recommended. A ground based survey should comprise traverses across the site and immediate surrounds using gamma ray spectrometers to map the background radiation. The observed data will be interpreted with reference to changes environmental features such as the topography, geology and soil types and with comparison against aerial radiometric data.

Detail of the scope and methodology for this survey shall be provided under a separate cover prepared with reference to IAEA (2003) Guidelines for Radioelement Mapping Using Gamma Ray Spectrometry Data, IAEA-TECDOC-1363. These guidelines noted that that while many naturally occurring elements have radioactive isotopes, only potassium, and the uranium and thorium decay series, have radioisotopes that produce gamma rays of sufficient energy and intensity to be measured by gamma ray spectrometry.

Radioelement concentrations in surface and subsurface soils, rock and groundwater shall be also analysed to establish baseline conditions across the site and any potential risk to site workers from use of or contact with these materials.

2.3 Climatic Conditions and Climate Change

Extreme weather events and longer term changes in climate may impact operation of the future NRWMF. This report presents the outcomes of the Stage 1 Desktop Assessment, providing a summary of the potential material climate change related impacts to the site and future facility.

More detailed consideration and assessment of these material impacts is required in order to determine the significance of the impacts, resulting design issues and the need for mitigation measures. Extreme weather events related to rainfall, heat, and fire weather are likely to pose the greatest number of impacts. These potential impacts include damaging assets, disrupting power supply to the site, disrupting transport networks and affecting the health and safety risks to operators. Potential impacts to the site are summarised in Table 12.

Historic climate data and future climate projections are provided in this report to support the other site characterisation investigations being undertaken, or more detailed assessments of risk in later stages of the project. In summary, the site is located in a warm temperate climate zone characterised by hot summers, with moderate humidity and low annual rainfall, predominately during the winter and spring months. A hotter and drier future climate is projected with an increased intensity of heavy rainfall events.

The projected changes in climate and identified impacts are not reasons to preclude the site from further consideration. However, it is acknowledged that the projected changes in climate will influence the site characterisation impacts assessed by other studies in this report and that the identified impacts should be considered in the assessment of the site and the design of the future facility and development of operational management practices.

No additional data requirements are requested from the Stage 2 Field Program to support the climate change assessment. However, it is recommended that more detailed assessment of the impacts identified in this report be undertaken to inform the detailed design.

2.3.1 Methodology

The desktop assessment identified the historic and projected future climate conditions and associated hazards relevant to the site and the future facility.

To identify the climate conditions and hazards relevant to the site, the following steps were undertaken:

- Identification of the closest weather station and collation of historical climate data from the Bureau of Meteorology.
- Identification of the relevant Natural Resource Management (NRM) sub-cluster through geographic information system (GIS) analysis of site location and NRM boundary.
- Identification of the relevant climate hazards based on a review of the International Atomic Energy Agency (IAEA) Specific Safety Guide No. SSG-18 (2011): Metrological and Hydrological Hazards in Site Evaluation for Nuclear Installations.
- Collation of climate projections from the *Climate Change in Australia Technical Report* (2015) and NRM cluster reports.

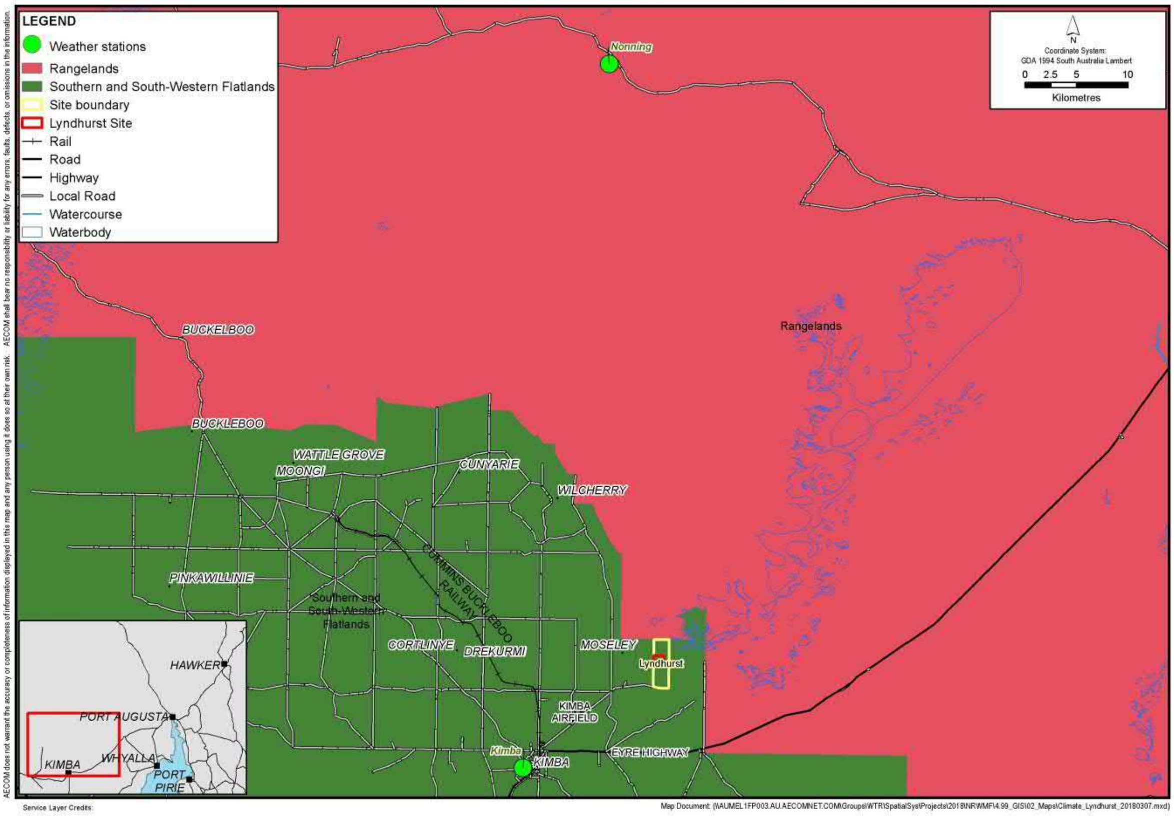
To determine potential impacts to the site and the future facility arising from those hazards, the project team drew on its experience in undertaking climate change risk assessments for infrastructure projects and communities. The potential impacts arising from hazards were then discussed with specialists addressing other site suitability characteristics to confirm if the impacts are likely to be material and could be managed through design or operational management practices.

2.3.1.1 Data used in Desktop Assessment

Historical climate data was required to provide context for the changes in climate conditions indicated by the climate projections (refer to Appendix B). Historical climate data was obtained from the Bureau of Meteorology for the closest weather station, Kimba (refer to Figure 6). Data was collected for the following climate variables, mean maximum and minimum temperature, hottest day recorded, annual rainfall, mean 9am and 3pm humidity and wind speed. Additional data on the historical average number of hottest days over 35 ^{o}C, frosts and severe fire days were obtained from the 2015 CSIRO and the Australian Bureau of Metrology (BoM) Technical Report (CSIRO & BOM 2015).

Climate projections for the site were obtained from the 2015 CSIRO and BoM Climate Change in Australia *Southern and South Western Flatlands Cluster Report* and the *Rangelands Cluster Report*. The cluster is one of eight Natural Resource Management (NRM) clusters used to develop climate projections across Australia. The clusters correspond to the broad-scale climate and biophysical regions of Australia. Each cluster is broken down into sub clusters. The Lyndhurst site is located in the Eastern Sub - Cluster as seen in Figure 6.

Figure 6 Location of the Lyndhurst site, relevant weather stations and Natural Resource Management Clusters used to determine climate projections.



Given the site's proximity to the border of the Southern and South Western Flatlands NRM cluster, the climate projections for the Rangelands NRM cluster to the north are also presented. The Rangelands projections are provided alongside historical climate data from the Nonning weather station which is located approximately 55km to the north of the site.

Given the anticipated long life of the proposed asset, climate projections are provided for two timeframes (2030 and 2090) and two Representative Concentration Pathways (RCPs[1]) (RCP 4.5 (lower emissions) and RCP 8.5 (high emissions)) A summary of these projections is outlined in Table 13, a detailed table of climate projections are available in Appendix B.

For 2030, projections for RCP 8.5 are provided as for the last ten years global concentrations of greenhouse gasses have tracked along this emissions pathway (DELWP, 2015). For 2090, projections are provided for RCP 4.5 and RCP 8.5 to provide an upper and lower range for how the climate may change.

Due to the inherent uncertainties involved in developing climate projections, the CSIRO & BOM (2015) assign statements of confidence. These statements either relate to:

- <u>the level of confidence in specific, absolute or percentage changes in climate variables</u>. These statements refer to a level of agreement in the results produced by the climate models, with the higher level of agreement across models increasing the level of confidence. In the Rangelands

[1] Representative Concentration Pathways (RCP) are a set of greenhouse gas concentration and emission pathways that are used to support research on impacts and potential policy responses to climate change.

Cluster report (Watterson, I. et al. 2015, p44), the levels of agreement are defined as "…'medium' being more than 60% of models, 'high ' more than 75%, 'very high ' more than 90%, and 'substantial' agreement on a change outside the 10th to 90th percentile range of model natural variability". A definition for 'low' is not provided.

- the level of confidence in the trend of change where specific projections are not available (e.g. for changes in extreme rainfall and changes in extreme heat). These statements are more general in nature and do not have a quantitative definition. The following five levels of confidence are used: *very low, low, medium, high and very high.*
- The confidence levels associated with climate projections are summarised in Table 14 and detailed in Appendix B. Separate tables are provided for the two NRM clusters relevant to the site.

2.3.1.2 Site Characteristic Criteria

The site characteristic criteria relevant to assessing climate change impacts are:

- Key hazards that could impact the future facility and workers: identification of the hazards, their impact and the site characteristics and enabling infrastructure elements they relate to.
- Change in frequency or intensity of climate hazards: The projected change in climate hazards that may affect the site or future facility. This also includes the degree of confidence in the projections.

2.3.2 Assessment Against Criteria

2.3.2.1 Assessment Criteria 1 - Key hazards that could impact the future facility and workers

Table 12 outlines the potential impacts to the site and future facility and the associated hazards. The hazards that are associated with the most number of identified impacts include extreme rainfall, extreme heat and fire weather. The identified impacts are not a reason to preclude the site from further consideration, however, the impacts will need to be considered in the design of the future facility and development of operational management practices.

Table 12 Impacts arising from climate hazards and relevant assessment areas

Impact	Climate Hazard/s	Significance and Potential Ability to Manage the Impact	Relevant Site Characterisation Assessment Areas
Increased electricity demand for onsite cooling (e.g. air conditioning, cooling for power generation or energy storage)	Extreme Heat	Material concern to the safe operation of the facility Impact can be managed through the design	- Utilities, energy and infrastructure
OHS risks to staff and personnel during construction and operation	Extreme Heat Extreme Rainfall Extreme Wind Fire Weather Hail Lightning	Material concern to the safe operation of the facility. Impact can be managed through the design	- Water - Risks from the surrounding environments (e.g. bushfires). - Climatic conditions (Wind & flood) - Site characteristics which have the potential to impact on site safety

Impact	Climate Hazard/s	Significance and Potential Ability to Manage the Impact	Relevant Site Characterisation Assessment Areas
Increased degradation, damage or failure of assets and supporting infrastructure (e.g. road surfaces, monitoring systems, cooling systems, electrical equipment, monitoring and communication systems, concrete and concrete joints, steel, asphalt, protective cladding, coatings, sealants, timber, masonry, pipework, transmission cables, earthen bunds, solar panels)	Extreme Heat Extreme Rainfall Extreme Wind Fire Weather Hail Lightning Increased Average Temperature Solar Radiation Frost	Material concern to the safe operation of the facility Impact can be managed through the design and operational management practices	- Vegetation and Ecological Communities - Risks from the surrounding environments (e.g. bushfires) - Climatic conditions – Wind and Flood - Site characteristics which have the potential to impact on site safety - Renewable or non-renewable natural resources and the potential to use renewable resources - Transport considerations - Utilities, energy and infrastructure
Disruption of power supply to the site as a result of impacts to the electricity transmission and distribution network	Extreme Heat Extreme Rainfall Extreme Wind Fire Weather Lightning	Material concern to the safe operation of the facility Impact can be managed through the design	- Risks from the surrounding environments (e.g. bushfires) - Climatic conditions – Wind and Flood - Utilities, energy and infrastructure

Impact	Climate Hazard/s	Significance and Potential Ability to Manage the Impact	Relevant Site Characterisation Assessment Areas
Erosion of landscape and vegetation	Extreme Rainfall	Material concern to the safe operation of the facility Impact can be managed operational management practices	- Vegetation and Ecological Communities - Soil and other substrates - Water - Conservation and special use area - Climatic conditions – Wind and Flood
Disruption to construction and operations as a result of inundation, or fire, in close proximity to facilities or transport networks	Extreme Rainfall Fire Weather	Material concern to the safe operation of the facility Impact can be managed through the design and operational management practices	- Risks from the surrounding environments (e.g. bushfires) - Climatic conditions – Wind and Flood - Site characteristics which have the potential to impact on site safety - Transport considerations
Damage to, or failure of, off-site storage or disposal facilities	Extreme Rainfall Extreme Wind Fire Weather Hail	Material concern to the safe operation of the facility Impact can be managed operational management practices	- Water - Capacity to deal with facility wastes and emissions (impacts to off-site facilities) - Risks from the surrounding environments (e.g. bushfires) - Climatic conditions – Wind and Flood - Transport considerations

Impact	Climate Hazard/s	Significance and Potential Ability to Manage the Impact	Relevant Site Characterisation Assessment Areas
Reduced capacity or shutdown of onsite renewable energy generation (e.g. wind, solar, geothermal)	Wind Fire Weather Reduced Average Rainfall Increased Average Temperature Hail Extreme Heat	Material concern to the safe operation of the facility Impact can be managed through the design and operational management practices	- Climatic conditions – Wind and Flood - Renewable or non-renewable natural resources and the potential to use renewable resources - Utilities, energy and infrastructure
Reduced availability and quality of water supply	Extreme Rainfall Fire Weather Increased Average Temperature Reduced Average Rainfall	Material concern to the safe operation of the facility Impact can be managed through the design and operational management practices	- Geology and geotechnical characteristics (incl. groundwater) - Water - Risks from the surrounding environments (e.g. bushfires) - Site characteristics which have the potential to impact on site safety - Utilities, energy and infrastructure

Impact	Climate Hazard/s	Significance and Potential Ability to Manage the Impact	Relevant Site Characterisation Assessment Areas
Increased maintenance costs of facility and supporting infrastructure (roads, pavements) as materials need to be replaced more often and/or with more resilient materials	Increased Average Temperature Extreme Heat Extreme Rainfall Extreme Wind Fire Weather Hail Solar Radiation Frost	Material concern to the safe operation of the facility Impact can be managed through the design and operational management practices	- Transport considerations
Damage to infrastructure foundations and buried assets due to ground movement as a result of drying soils, changed soil composition, freeze / thaw cycle and potential changes in groundwater levels	Reduced Average Rainfall Soil Moisture Evapotranspiration Extreme Rainfall Frosts	Material concern to the safe operation of the facility Impact can be managed through the design	- Geology and geotechnical characteristics (incl. groundwater) - Soil and other substrates - Water - Site characteristics which have the potential to impact on site safety - Utilities, energy and infrastructure

Impact	Climate Hazard/s	Significance and Potential Ability to Manage the Impact	Relevant Site Characterisation Assessment Areas
Increased potential for dust storms which may create health and safety risks and impact operations, including efficiency of solar panels	Soil Moisture Reduced Average Rainfall	Material concern to the safe operation of the facility. Impact can be managed through the design and operational management practices	- Soil and other substrates - Site characteristics which have the potential to impact on site safety - Renewable or non-renewable natural resources and the potential to use renewable resources

2.3.2.2 Assessment Criteria 2 – Climate change projections for the site

The site is located in a warm temperate climate zone characterised by hot summers, with moderate humidity and low annual rainfall (250 – 350 mm per year at Kimba SA) (BoM, 2018a). Rainfall occurs predominately during the winter and spring months.

The average diurnal temperature range is approximately 15 °C each month, with an annual mean maximum temperature of 23.6 °C and a mean minimum of 10.3 °C. The highest temperature recorded at the site was 46°C in January 2013. A mean number of eight days below 2 °C occur per annum indicating potential frost days. Based on measurements from 1967 to 2010 mean wind speeds have been recorded as 8.4 km/h at 9am and 11.6 km/h at 3pm (BoM, 2018a).

The long term (2090) climate projections for RCP 8.5 indicate that across both NRM sub-clusters there will be a hotter and drier future climate in the region, due to overall decrease in the amount of annual rainfall, increase in average temperature and annual number of days above 35 °C. Across both clusters, evapotranspiration rates are projected to increase, alongside a reduction in soil moisture and relative humidity. The intensity of heavy rainfall events are also projected to increase.

Table 13 provides a summary of the historic climate data and projected changes for 2090. Additional detail on the source of the projections, as well as projections for 2030, are provided in Appendix B. As outlined in Table 14, no projections are available for changes in lightning or hail.

Differences between the NRM clusters are observed for the projected number of severe fire days, solar radiation and average wind. In the SSW Flatlands cluster, severe fire days are projected to increase with high confidence, while in the Rangelands Cluster there is low confidence in the projected changes to future fire weather, however, if and when bushfire does occur in future climates for this area it can be expected to exhibit more extreme behaviour (Watterson et al. 2015).

Solar radiation in the SSW Flatlands cluster is projected to increase substantially, while in the Rangelands there is medium model agreement on little change Average wind in the SSW Flatlands is projected, with medium model agreement, to substantially decrease, while in the Rangelands there is medium model agreement on an increase in average wind.

The projected changes in climate are not a reason to preclude the site from further consideration, however, it is acknowledged that the projected changes in climate will influence the impacts assessed by other site characterisation studies.

Table 13 Historic climate and climate change projections

Climate Variable	Historic Climate (Kimba weather station)	2090 RCP 8.5 – Southern & South Western Flatlands	2090 RCP 8.5 Rangelands
Mean maximum Temperature (°C)	23.6	+3.3 (+2.6 to +4.1)	+4.3 (+2.8 to +5.2)
Days over 35 (°C)[4]	20 (1995 baseline)	47 (38 to 57)	
Frost (days with min. temp. <2 °C)	1.1 / 3.3 (1981-2010 baseline)	0.0 (0.0 to 0.0) /2.1 (6.0 to 0.8) (Adelaide / Alice Springs)	
Severe fire danger days per year (FFDI > 50) (Ceduna)	11.1 (1995 baseline)	12.1 to 15.6	21.1 to 37.9
Rainfall (mm)	348.3	-9 (-37 to +6)	-4 (-29 to +13)
Rainfall Intensity	N/A	There is high confidence that the intensity of heavy rainfall extremes will increase in both clusters, but there is low confidence in the magnitude of this change.	
Evapotranspiration (%)	N/A	+10.2 (+7.4 to +15.7)	+10.5 (+6.4 to +14.5)
Relative humidity (%)	Mean at 9am: 55 Mean at 3pm: 30	-1.6 (-3.2 to -0.3)	-2.6 (-5.1 to +0.4)
Average wind speed	Mean at 9am: 20.3 Mean at 3pm:12.8	-1.8 (-4.4 to 0)	+0.7 (-2.4 to +2)
Solar radiation (%)	N/A	+1.5 (-0.1 to +3.6)	-0.3 (-1.8 to +1.4)
Soil moisture	N/A	-4.4 (-8.7 to -0.9)	-1.7 (-5.9 to -0.5)

2.3.3 Design Issues and Mitigation Measures

The risks associated with climate change can typically be managed through a combination of design solutions and operational management approaches. Table 12 summarises the potential impacts to the site and future facility to be considered in the design and operational phases. The table identifies the site characterisation assessment areas that each impact relates to, whether the impacts are likely to be material and if they can be managed through design or operational management practices. More detailed consideration and assessment of these impacts is required by the relevant site characteristics and enabling infrastructure elements in order to determine the most appropriate design and operational management solutions.

When considering the impacts in the design phase it will be important to consider how the frequency or intensity of impacts is likely to change over the operational lifespan of the future facility, rather than just considering historical climate data.

2.3.4 Data Gaps and Recommendations for Stage 2 Work Program

2.3.4.1 Data Gaps and Limitations

Climate projections are inherently uncertain due to limits in the theoretical understanding of the Earth's climate, in the numerical modelling of the climate and in the emission scenarios used to inform climate modelling. These uncertainties are reflected in the 'confidence' statements included with each of the climate projections (as shown in Appendix B). Providing projections for multiple RCPs also assists in addressing the issue of uncertainties with projections by providing a range of potential changes.

A summary of the statements of confidence is presented in Table 14. The projections included in this report are limited to the end of the century. The lifespan of the future facility and closure requirements (e.g. capping) may extend beyond this period.

Table 14 Summary of level of confidence assigned to climate projections.

Climate Hazard	Summary of level of confidence in projected change in frequency / trend for both SSW Flatlands & Rangelands NRM unless noted. 2030 and 2090 (RCP8.5)
Extreme Heat	Very high confidence
Extreme Rainfall	High confidence in the direction of change, but low confidence in the magnitude of change
Fire weather	High confidence in SSW Flatlands Low confidence in the Rangelands
Frost	High confidence
Wind speed	High model agreement in the SSW Flatlands in 2030 and Medium model agreement in 2090 Medium model agreement in Rangelands
Hail	No projections available. "Climate models do not yet simulate the dynamics of the climate system well enough at small scales to predict changes in hail, thunderstorms and tornadoes"(CCA Ltd 2016, p19)
Lightning	
Average Temperature	Very high model agreement
Evapotranspiration	Very high model agreement
Solar Radiation	Medium model agreement in the SSW Flatlands High model agreement in the Rangelands in 2030. Medium model agreement in the Rangelands in 2090
Soil Moisture	Medium model agreement in the Rangelands in 2030 and 2090 and SSW Flatlands in 2030 High model agreement in the SSW Flatlands in 2090

2.3.4.2 Recommendations for Stage 2 Work Program

Stage 2 of the study seeks to collect data via a program of field works. No additional data requirements are requested from the Stage 2 Field Program to support the climate change desktop assessment. However, it is recommended that the relevant site characterisation assessment areas identified in this report as being impacted by climate hazards consider their data requirements to enable a more detailed assessment of the significance of the identified impacts.

2.3.4.3 Recommended Process for Undertaking a More Detailed Assessment

To support the design process it is recommended that a more detailed assessment of the impacts identified in this report be undertaken. This section outlines the recommended process for undertaking a more detailed assessment which should be used to inform the design process.

Initial risk identification and rating

The information contained in this report should be used to inform an initial climate risk assessment. The risk assessment will identify and rate the risks that extreme weather events and longer term changes in climate may pose to the achievement of the project objectives. A risk management framework will need to be established including likelihood and consequence definitions and ratings. The framework should be aligned with the project's risk framework and *AS5334 – Climate Change Adaptation for Settlements and Infrastructure – A Risk Based Approach*.

Validating at a design workshop

The findings of the initial risk assessment should be confirmed and evaluated as a part of a Design Workshop with key technical specialists. The workshop should also be used to identify adaptation actions, or risk control measures that need to be incorporated into the design, or future operational procedures.

Climate change impact assessment report

Following the workshop, a climate change impact assessment report should be developed to document the findings of the risk assessment process and the recommended adaptation responses. Guidance will also be presented on the key considerations that need to be integrated into design. For example specific recommendations on how consideration of changes extreme rainfall should be integrated into the work undertaken by the hydrological, hydrogeological, and geotechnical specialists.

2.4 Bushfire Risks

2.4.1 Methodology and Results

The site is located within the Eastern Eyre Peninsula Fire Ban District, for which the current applicable 2017/2018 fire danger season period runs from 1 November 2017 to 15 April 2018. The site is not located within a bushfire protection area.

Bushfire management consultant Terramatrix Pty Ltd has undertaken a desktop-based assessment of the following key characteristics contributing to the bushfire hazard at the site:

- Topography (slope and aspect);
- Vegetation (distribution and nature of the fuel hazard);
- Climate and weather (temperature, wind, relative humidity and frequency of elevated fire danger days); and
- Bushfire characteristics (likelihood of ignition and development of a bushfire with potential to impact the site, credible scenarios, flame lengths and rates of spread).

The assessment focuses on the nature of the bushfire hazard at the site, rather than the likelihood or consequence of loss or damage by bushfire (risk) to a potential facility, which would require a more detailed analysis of the vulnerability of assets and infrastructure that may be developed at the site, and which, it is assumed will be the same regardless of the location.

2.4.1.1 Site Characteristic Criteria

AS 3959-2009 compliance is invoked by the National Construction Code (NCC) as a deemed-to-satisfy pathway for meeting the bushfire protection requirements of the Building Code of Australia (BCA)[2] (ABCB, 2016). The AS 3959-2009 site assessment methodology requires an assessment of the vegetation and topography within 100m of a site or building, to determine the applicable Bushfire Attack Level (BAL) construction standard for the building based on the nature of the anticipated bushfire attack[3] (for an explanation of BALs see Table 24. For the purposes of this study, as a precaution, the site assessment zone was extended to 200m i.e. 200m around the 100ha site area (see Figure 7).

The site characteristic criteria relevant to determining bushfire hazards at a site comprise:

Vegetation

- The extent and nature of the fuel hazard posed by the vegetation at and immediately surrounding the site (within 200 of the site) and at the wider landscape level (within 1km, and extending up to 20km, around the site)

Topography

- Effective and site slopes that may influence bushfire behaviour and impacts, at the site and landscape scale.

Weather

- Frequency and severity of bushfire weather conditions that will influence fire behaviours

Such conditions may be experienced, based on climatic factors including relative humidity (%), temperature (C˚), wind speed (km/h) and direction, and the return interval (frequency) of days of elevated fire danger.

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[2] The BCA comprises Volumes 1 and 2 of the National Construction Code (NCC).
[3] A determination of the applicability, or otherwise, of the NCC to the proposed NRWMF is beyond the scope of this study and has not been undertaken. The AS 3959-2009 methodology has been applied, due to the common acceptance of the methodology (or a variation of it) in building and planning jurisdictions across Australia, as a benchmark for determining a building's level of exposure to a bushfire hazard and the commensurate BAL construction standard.

Bushfire scenarios and impacts

- Likelihood and nature of bushfire impacts that may be experienced based on potential for ignition and development in the surrounding landscape and factors such as the approach, spread, and flux (of a fire)

2.4.1.2 Desktop Methods and Results

2.4.1.2.1 AECOM data

AECOM generated data used in the assessment comprised the following:

- Spatial files with a geographic extent of approximately 3km around the site, comprising cadastre, roads, site boundaries, 1 m contours (generated from LiDAR aerial data with a vertical accuracy of 0.1 m), and surface water features and drainage lines.
- Spatial files with vegetation type mapping prepared based on field surveys by AECOM with a geographic extent of at least 1 km around the site.

All other layers and data shown in maps or referred to in this report were obtained, or generated by Terramatrix.

2.4.1.2.2 Vegetation

The extent of vegetation and vegetation types on and around the site was identified based on:

- AECOM vegetation type mapping prepared based on field surveys by AECOM
- Google Earth imagery

The fuel hazard posed by, and bushfire characteristics associated with, the vegetation was determined according to:

- Classification as per AS 3959-2009 vegetation groups and types (Standards Australia, 2011);
- Major Vegetation Group (MVG) and Major Vegetation Subgroup (MVS) descriptors for the Native Vegetation Information System (NVIS) (Keith and Pellow, 2015);
- South Australian prescribed burning guide (DENR, 2011); and
- Other published literature (e.g. Cruz *et al.*, 2010; Cruz *et al.*, 2013).

2.4.1.2.3 Topography

The topography was assessed based on elevation model of the site and surrounds to more than 3 km was created by AECOM with 1 m contours from LiDAR aerial survey data collected with a vertical accuracy of 0.1 m. Slopes were determined by rise over run calculations using the 1m contour data.

2.4.1.2.4 Weather

Terramatrix obtained synoptic weather data for the Bureau of Meteorology (BOM) weather station at Kimba, closest to the site which is considered representative of weather that could be experienced. The data was sorted and refined, and selected records analysed to generate a record of relative humidity, temperature, wind (speed and direction). The return period (frequency) of days of elevated fire danger was calculated following the Generalised Extreme Value (GEV) analysis method (Douglas, 2013; Douglas *et al.*, 2015).

2.4.1.2.5 Bushfire scenarios and impacts

Credible bushfire scenarios, and the hazard posed by them, were determined based on the analysis of vegetation, topography and fire weather conditions. The assessment was further informed by:

- Analysis of incident data from 1 May 2009 to 30 June 2015, for South Australian Country Fire Service (CFS) brigades located within approximately 30km of each site (Data SA, 2018);
- Fire history records (*ibid.*);

- Development Plan and Bushfire Protection Area[4] mapping (Location SA Map Viewer, 2018);
- Population density data (*ibid.*); and
- Rate of spread, flame length and Radiant Heat Flux (RHF) calculations using the detailed 'Method 2' procedure of AS 3959-2009 (Standards Australia, 2011).

2.4.1.3 Field Methods and Results

No site inspections were undertaken by Terramatrix in the conduct of this assessment.

However, field survey data was obtained by AECOM which was used to update the initial assessment, including:

- digital map of the topography obtained using LiDAR from an aerial survey; and
- a map of the vegetation types developed on the basis of on-ground survey (reported herein).

2.4.2 Assessment Against Criteria

2.4.2.1 Vegetation

Figure 7 shows the extent of potentially classifiable vegetation, within the 200m assessment zone around the Lyndhurst site. Classified vegetation is vegetation that is deemed hazardous from a bushfire perspective according to the AS 3959-2009 methodology.

The classification system uses a generalised description of vegetation based on the AUSLIG (Australian Natural Resources Atlas: No. 7 - Native Vegetation) classification system. The classification should be based on the mature (long-term) state of the vegetation and the likely fire behaviour that it will generate.

2.4.2.1.1 Mallee-Mulga

Based on the AECOM vegetation mapping, descriptions and photographs (see Figure 7), it is considered that most, if not all, the tree and shrub vegetation best accords with the Mallee-Mulga (Group E) classification under AS 3959-2009. This is the Tall shrub vegetation type, described as *'Vegetation dominated by shrubs (especially eucalypts and acacias) with a multi-stemmed habit; usually greater than 2m in height; <30% foliage cover. Understorey of widespread to dense low shrubs (acacias) or sparse grasses'* (Standards Australia, 2011).

It also accords with SA native vegetation mapping, which identifies almost the entire tree and shrub vegetation as MVG 14 Mallee Woodlands and Shrublands (NatureMaps, 2018; Location SA Map Viewer, 2018). The structure of MVG 14 is described as:

- 'Woodlands and shrublands dominated by low, multi-stemmed, sclerophyllous eucalypts and occasionally co-dominated by small trees from other genera with a sparse to dense understorey.
- Height of eucalypt canopy rarely exceeds 6 m.
- Tree canopy cover varies with rainfall, topographic position, soil characteristics and particularly fire history, but projective foliage cover is notionally within the range 10 – 30 per cent and crown cover 20 – 50 per cent.
- Understorey structure also varies with rainfall, topographic position, soil characteristics and particularly fire history, and may be dominated by shrubs, hummock grasses, chenopods or tussock grasses. In drought the ground layer is sparse, while following heavy rainfall a prominent cover of ephemeral herbs with tussock grasses occurs' *(DEE, 2017a)*.

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[4] Designated bushfire protection areas in South Australia are subject to bushfire related planning and building requirements based on the level of bushfire risk determined for the site. Bushfire planning policies for bushfire protection areas can be found in local Development Plans (Government of South Australia, 2012).

Figure 7 Lyndhurst – site assessment zone for bushfire hazard assessment.

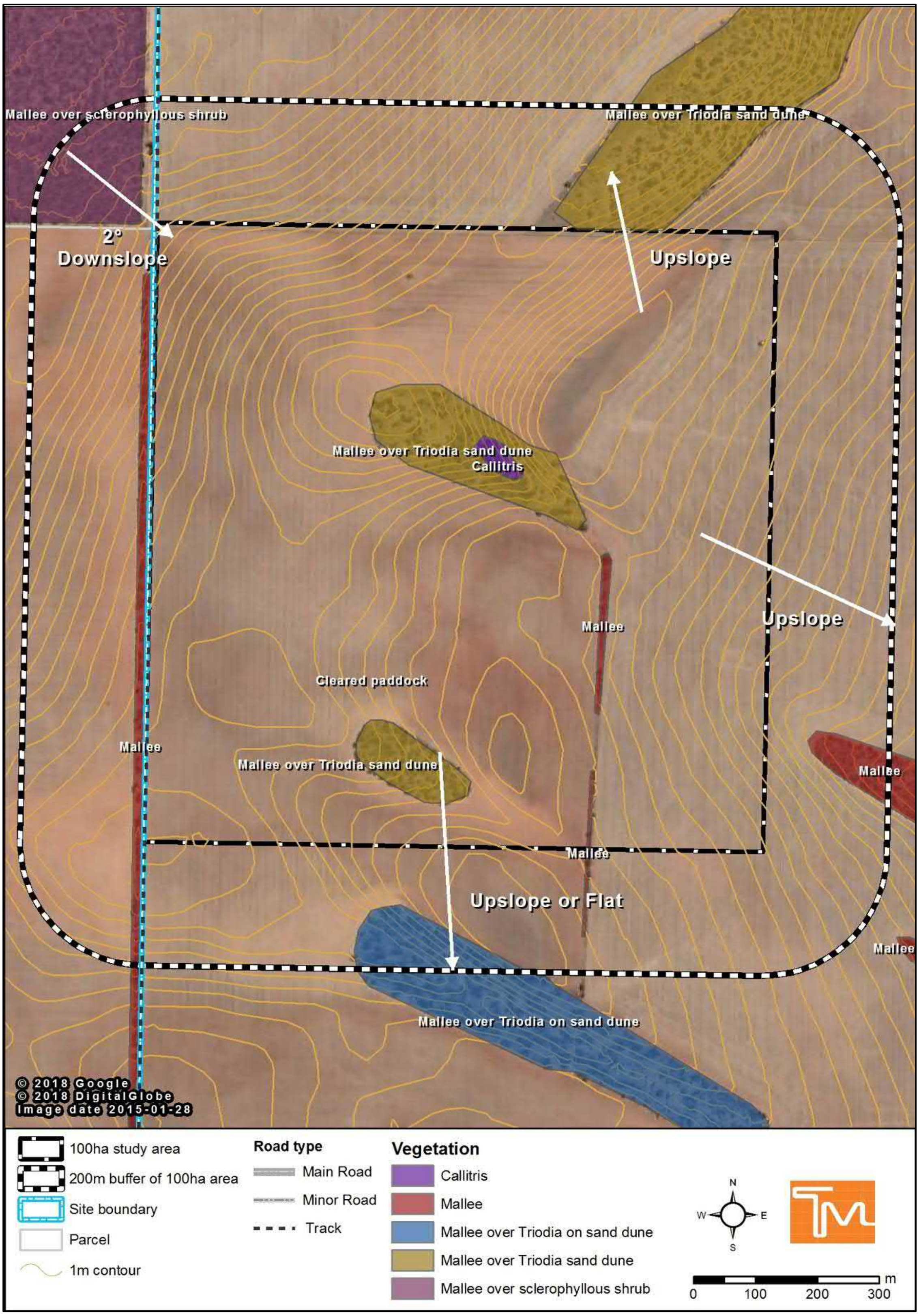


Figure 8 Lyndhurst landscape assessment to 3km.

The South Australian prescribed burning guide identifies that semi-arid Mallee vegetation occurs across large areas of the central to northern Eyre Peninsula and describes this vegetation as '*Low open eucalypt dominated vegetation with an understorey of smaller shrubs, grasses and herbs. The fuel array is typically highly discontinuous'* (DENR, 2011). AECOM provided photos and descriptions of vegetation on and round the site (MacDonnell, 2018; AECOM, 2018a) that match this descriptor and accord best with a Mallee-Mulga classification under AS 3959-2009.

The major vegetation subgroup (MVS) Mallee heath and shrublands is identified as a component of MVG 14 where it occurs on and around the site (Location SA Map Viewer, 2018).

The southernmost patch of tree and shrub vegetation within the 200m assessment zone is identified as MVG 8 Casuarina Forest and Woodland, MVS Casuarina and Allocasuarina forests and woodlands (Location SA Map Viewer, 2018). The vegetation structure for this vegetation type is described as a low woodland. The MVG description includes:

'Trees are typically around 12 m tall with crown cover >20 per cent, foliage projective cover >10 per cent, and the understorey includes an open layer chenopod or other shrubs' (DEE, 2017b).

Based on the available data this small patch is likely to also likely to be classifiable as Mallee-Mulga.

The large areas of tree and shrub vegetation in the landscape to the northwest, north, northeast and east of the site (see Figure 8), are also mapped as MVG 14 Mallee Woodlands and Shrublands (NatureMaps, 2018; Location SA Map Viewer, 2018). They include extensive tracts of native vegetation associated with the Lake Gilles Conservation Park to the northeast of the site and other abutting land.

Mallee woodlands and shrublands are recognised as the most fire prone and highly flammable of all plant communities in semi-arid and arid zones. There is potential for bushfire to burn large areas and be fast moving and intense under even moderate conditions (DEE, 2017; Cruz *et al.*, 2013; Cruz *et al.*, 2015). There is however, no record of fire in the publically available fire history data available for the site and surrounding 3km area.

The rest of the surrounding landscape to the west and south, is not densely settled and appears to be pastoral, associated with cropping and/or grazing, and is considered relatively low threat.

2.4.2.1.2 Shrubland

Any areas of denser shrub and heath vegetation, without a Mallee eucalypt component, that on average do not exceed to 2m in height may be classified as Low Shrubland, under the Shrubland group in AS 3959-2009. This is defined as *'Shrubs <2 m high; greater than 30% foliage cover. Understoreys may contain grasses. Acacia and Casuarina often dominant in the arid and semi-arid zones*' (Standards Australia, 2011).

If any Shrubland is present, a distinction between it and the Mallee-Mulga vegetation will be required to determine asset setback distances from vegetation (Asset Protection Zones (APZs)) for future development. The distinction should be based on the nature of the fuel hazard of the vegetation, specifically the average height of the vegetation and the amount and arrangement of fine fuels.

Although Mallee-Mulga vegetation may be taller than Shrubland, it should be noted that slightly larger APZs are required for Shrubland than Mallee-Mulga, due to the higher overall fine fuel load presumed for Shrubland. AS 3959-2009 presumes a fuel load of 8t/ha for Mallee-Mulga vegetation, whilst Shrubland is assigned an overall fuel load of 15t/ha. The same fire behaviour model and equations are used in AS 3959-2009 to calculate forwards rate of spread and flame length (and hence APZ distances) for both vegetation types (Standards Australia, 2011).

In a study of fire behaviour in semi-arid mallee-heath shrublands of South Australia, Cruz *et al*. (2010) found a range for overall fine fuel loads from 3.8t/ha to 10t/ha with an average of 9.2t/ha in vegetation where fire spread was sustained. This study developed fire spread models used in the South Australian prescribed burning guide.

The South Australian prescribed burning guide identifies that semi-arid Mallee-heath vegetation occurs across large areas of the central to northern Eyre Peninsula and describes it as '*Heathy-shrub dominated vegetation under patches of overstorey mallee. The near surface fuel array is typically discontinuous* (DENR, 2011).

2.4.2.1.3 Grassland

Grassland areas are not specifically differentiated in Figure 7 but they are apparent on the aerial imagery. All areas of pasture or grassy vegetation will meet the AS 3959-2009 classification of Grassland where there is an overstorey foliage cover of less than 10%. They can be excluded from classification, as non-hazardous vegetation, if they are grazed or cropped to less than 100mm high, in accordance with the criteria in AS 3959-2009 (see exclusion criteria below).

The grassland in the imagery and AECOM site photographs appears to be grazed or cropped, however, any grain or legume crops on, or around the site, could be up to 1m high before harvesting in December /January.

It should be noted that fire can still spread across grasslands even if they are managed, cropped or grazed to comprise non-hazardous vegetation less than 100m high.

Figure 9 The landscape surrounding the Lyndhurst 100ha site and expanded Study Area (show in red fill)

A 10km buffer of the site is shown in blue outline and a 20km buffer is shown in white outline. The yellow circle shows the location of the BOM weather station from which weather data was obtained and analysed (see Section2.4.2.3). Green circles identify the locations of the nearest CFS brigades (see Section2.4.2.4.4).

2.4.2.1.4 Non-hazardous vegetation

Due to their limited size and connectivity, some of the patches of tree and shrub vegetation may meet one or more of the exclusion criteria in AS 3959-2009, depending on their distance and orientation to any future buildings.

Exclusion from classification is provided for in AS 3959-2009 when the size, configuration and nature of the fuel hazard in vegetation is not likely to generate a bushfire of sufficient size and intensity to justify a building response. Excluded vegetation is deemed to be non-hazardous and therefore excluded from classification according to the following criteria:

i. *'Vegetation of any type that is more than 100m from the site;*
ii. *Single areas of vegetation less than 1ha in area and not within 100m of other areas of vegetation being classified;*

iii. *Multiple areas of vegetation less than 0.25ha in area and not within 20m of the site or each other;*

iv. *Strips of vegetation less than 20m in width (measured perpendicular to the elevation exposed to the strip of vegetation) regardless of length and not within 20m of the site or each other, or other areas of vegetation being classified;*

v. *Non-vegetated areas, including waterways, roads, footpaths, buildings and rocky outcrops; and*

vi. *Low threat vegetation including grassland managed in a minimal fuel condition, maintained lawns, golf courses, maintained public reserves and parklands, vineyards, orchards, cultivated gardens, commercial nurseries, nature strips and windbreaks. Note: Minimal fuel condition means there is insufficient fuel available to significantly increase the severity of the bushfire attack (recognizable as short-cropped grass for example, to a nominal height of 100mm)*' (Standards Australia, 2011).

Excluded vegetation is likely to include the narrow bands of vegetation running north-south through the site and north-south along the western boundary, if they are sufficiently distant from future buildings (i.e. >20m). They are unlikely to generate significant fire behaviour that would pose an appreciable hazard, due to their small size and general lack of connectivity with other larger patches of classifiable vegetation.

The two larger patches of tree and shrub vegetation within the 100ha site are over 1ha in size and development should aim to be at least 100m from them (and any vegetation outside the site) so that they can be considered low threat.

2.4.2.1.5 Summary of Assessment of Extent and Nature of Fuel Hazard from Vegetation at Local and Landscape Scales

Most, if not all, of the tree and shrub vegetation on and around Lyndhurst, likely best accords with the Mallee-Mulga (Group E) classification under AS 3959-2009.

Areas of denser shrub and heath vegetation, without a Mallee eucalypt component, that on average do not exceed to 2m in height, may be classified as Shrubland. If any shrubland is present a distinction between it and the Mallee-Mulga vegetation will be required to determine asset setback distances from vegetation APZs for future development. Slightly larger APZs are required for Shrubland than Mallee-Mulga, due to the higher overall fine fuel load presumed for Shrubland.

All areas of pasture or grassy vegetation will meet the AS 3959-2009 classification of Grassland where there is an overstorey foliage cover of less than 10%. They can be excluded from classification, as low threat (non-hazardous) vegetation, if they are grazed, slashed or cropped to less than 100mm high, but could still contribute to fire spread.

Excluded vegetation is likely to include the narrow bands of vegetation running north-south through the site and north-south along the western boundary, if they are sufficiently distant from future buildings (i.e. >20m). They are unlikely to generate significant fire behaviour that would pose an appreciable hazard, due to their small size and general lack of connectivity with other larger patches of classifiable vegetation.

The two larger patches of tree and shrub vegetation within the 100ha site are over 1ha in size and development should aim to be at least 100m from them (and any vegetation outside the site) so that this vegetation can be considered low threat.

The Lyndhurst site could be exposed to a large and intense and fast moving fire in the Mallee-woodland vegetation that abuts the 100ha site to the northwest. Consequently, siting of a NRWMF at this location should aim to maximise the setbacks from the northwest, or at least achieve the minimum 100m setback required under AS 3959-2009 for this vegetation to be deemed low threat.

100m setbacks from the two larger patches of Mallee-Woodland within the site are also desirable. The setbacks will need to be commensurate with the desired radiant heat flux safety thresholds for, and construction standards of, assets and buildings. The exposure of the facility to a bushfire on this site should not pose an unacceptable risk if appropriate bushfire protection measures are provided commensurate with the vulnerability of the facility.

2.4.2.2 Topography

The AS 3959-2009 methodology requires that the 'effective slope' be identified to determine applicable setback distances for buildings from hazardous vegetation. This is the slope of land under the classified vegetation that will most significantly influence the bushfire attack on a building. Two broad types apply:

- Flat and/or Upslope - land that is flat or on which a bushfire will be burning downhill in relation to the development. Fires burning downhill (i.e. on an upslope) will generally be moving more slowly with a reduced intensity.
- Downslope - land under the classified vegetation on which a bushfire will be burning uphill in relation to the development. As the rate of spread of a bushfire burning on a downslope (i.e. burning uphill towards a development) is significantly influenced by increases in slope, downslopes are grouped into five classes in 5˚ increments from 0˚ up to 20˚.

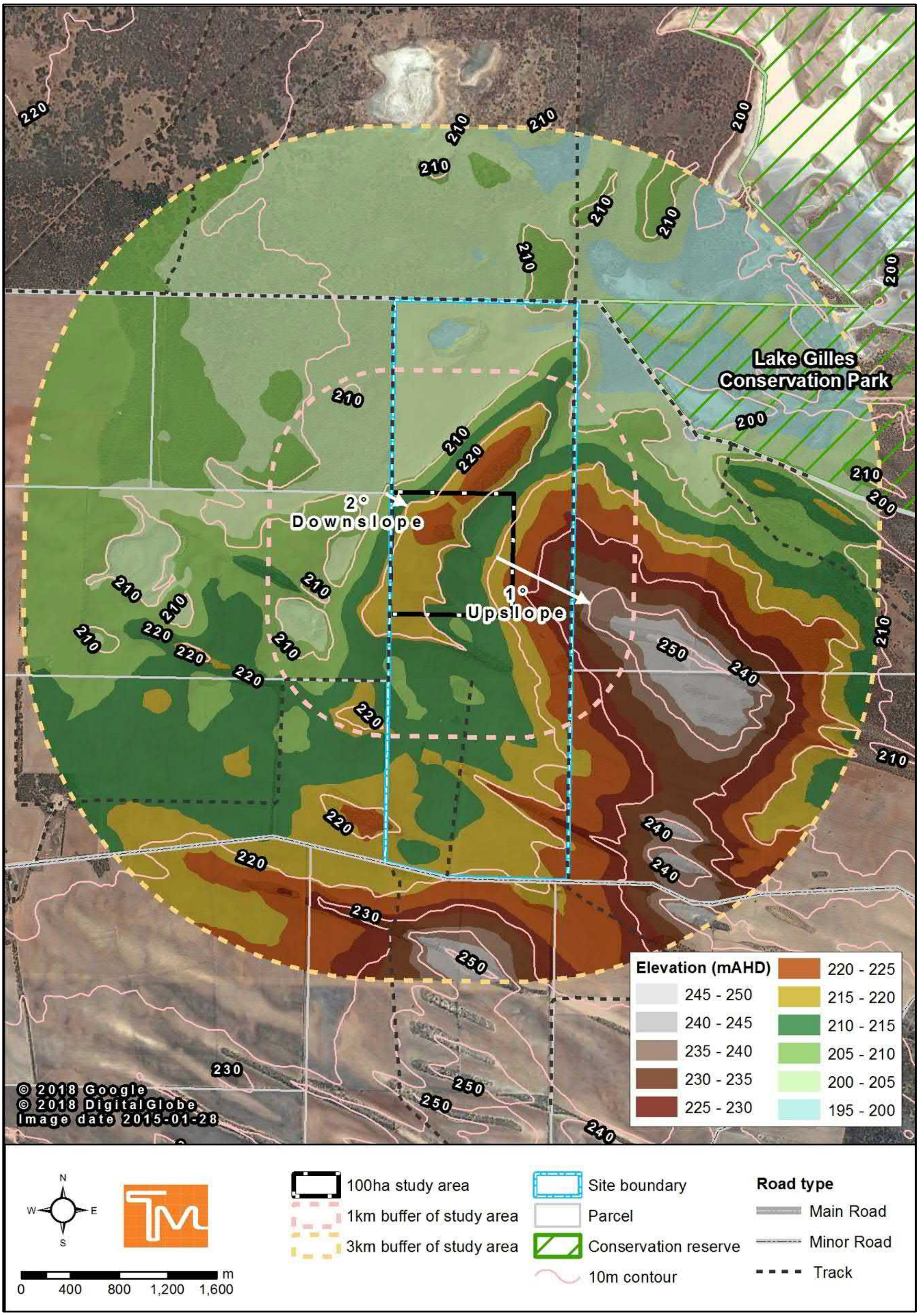
Figure 7 and Figure 10 show that a slight downslope of up to 2˚ occurs from the northwest to the southeast. This slight slope will not significantly influence bushfire behaviour. Figure 10 shows the elevation of the land across the site and for 3km around it.

Whilst fire spread and flame lengths might surge slightly if a fire burns up the occasional dune crest and ridge, overall the land is flat with a benign topography that is not an appreciable influence on the bushfire hazard or risk at this site.

Depending on where the facility is located with the site, a 0˚ slope gradient (applied to flat land and all upslopes) would likely be applicable for determining asset setback distances/APZs at the site.

The topography is not conducive to severe fire behaviour and is not an appreciable influence on the bushfire hazard or risk at Lyndhurst.

Figure 10 Elevation map for Lyndhurst based on 1m contours.



2.4.2.3 Weather

The Forest Fire Danger Index (FFDI) and the Grassland Fire Danger Index (GFDI) are typically used to represent both the level of bushfire threat and difficulty of suppression on a given day, based on weather (and fuel) conditions. The indices are used for predicting fire behaviour including the difficulty of suppression, forecasting Fire Danger Ratings (FDRs) and determining an appropriate level of preparedness for emergency services. Table 15 displays the FDRs, their FFDI range and the description of conditions for each FDR.

Table 15 Fire Danger Ratings (AFAC, 2009, CFS, 2017)

Forest Fire Danger Index	Fire Danger Rating (FDR)	Total Fire Ban	Description of conditions
100+	Catastrophic (Code Red)	Yes	The worst conditions for a bush or grass fire. If a fire starts and takes hold, it will be extremely difficult to control. It will take significant firefighting resources and cooler conditions to bring it under control. Spot fires will start well ahead of the main fire and cause rapid spread of the fire. Embers will come from many directions. Homes are not designed or constructed to withstand fires in these conditions. The safest place to be is away from bushfire prone areas.
75-99	Extreme	Yes	Fires will be uncontrollable, unpredictable and fast moving – flames will be higher than roof tops. People will die and be injured. Hundreds of homes and businesses will be destroyed. Only well prepared, well-constructed and actively defended houses are likely to offer safety during a fire. Thousands of embers will be blown around. Spot fires will move quickly and come from many directions, up to 6 km ahead of the fire.
50-74	Severe	Yes	Fires will be uncontrollable and move quickly– flames may be higher than roof tops. There is a chance people may die and be injured. Some homes and businesses will be destroyed. Well prepared and actively defended houses can offer safety during a fire. Expect embers to be blown around. Spot fires may occur up to 4 km ahead of the fire
25-49	Very High	May be declared.	Fires can be difficult to control – flames may burn into the tree tops. There is a low chance people may die or be injured. Some homes and businesses may be damaged or destroyed. Well prepared and actively defended houses can offer safety during a fire. Embers may be blown ahead of the fire. Spot fires may occur up to 2 km ahead of the fire.
12-24	High	No	Fires can be controlled. Loss of life is highly unlikely and damage to property will be limited. Well prepared and actively defended houses can offer safety during a fire. Embers may be blown ahead of the fire. Spot fires can occur close to the main fire.
0-11	Low – Moderate	No	Fires can be easily controlled. Little to no risk to life and property.

2.4.2.3.1 Grass Fire Danger Index analysis

Analysis of weather data has been undertaken to calculate a 'historical' fire danger index representative of the hazard associated with weather conditions during elevated FDRs at a BOM station location selected to be representative of conditions at each site. Analysis was undertaken for each day during the fire season period (October-April) that the required weather data inputs were available.

The two closest BOM station at Kimba was selected as being most representative of fire weather that may be experienced. Table 16 summarises the attributes of the stations.

Table 16 Summary of BOM station attributes

Attribute	Kimba
Distance and direction from Lyndhurst	16km to southwest
Elevation	280m
BOM Station No.	018040
BOM district name	Western Agricultural
Opened	1 Jan 1920
Data available	Synoptic
Date of oldest 3pm record with all inputs*	1st March 1972
Date of most recent 3pm record with all inputs*	30th April 2015
% of 3pm records with all inputs*	64%
No. of years with 3pm records with all inputs*	36

Record with all inputs= 3pm data available for all three attributes for calculating GFDI i.e. relative humidity, temperature and wind speed.

Synoptic (3 hourly) data were available for both stations. The data were sorted to select only those records for which there were complete inputs available to calculate the fire danger index i.e. relative humidity (%), temperature (˚C) and wind speed (km/h). Only 3pm synoptic data was used, based on the assumption that 3pm records were the most likely of the synoptic data to be representative of the peak fire danger for each day. Cruz *et al.* (2013) identify that 3pm is the mid-point of the daily time period when fire weather conditions peak and shrub and heath fires are more than 50% likely to be sustained and will spread). Only those 3pm records for days during the fire season period (i.e. 1st October – 30th April) were used.

It was considered that the GFDI was more applicable to the fire conditions at the three sites than the FFD). This is due to the prevalence of grassland and other fuels in the landscape in which fire behaviour is influenced more by wind speed, for which the GFDI is the more sensitive index at higher winds than the FFDI (Yeo *et al.*, 2014). Accordingly, an estimate of the GFDI was calculated from each daily 3pm record for which the inputs were available.

It should be noted that GFDI requires an estimate of the degree of grass curing[5] as a key input. As this input was not available or able to be calculated, it was assumed to be 100% for all records in the GFDI calculations. This will likely result in a conservative, over-estimate of the GFDI, especially during spring and early summer when grass may not be fully cured[6]. Note that the GFDI analysis has been undertaken for comparative purposes only, to assist in comparing the three sites and assessing the appropriateness of design fire inputs. It does not necessarily equal the actual GFDI or fire weather conditions that may have occurred at a site[7].

[5] Curing is defined as the process by which grasses senesce i.e. become dormant or die and dry out, and is measured as the percentage of dead material present (CFA, 2014).
[6] Note that in pastoral landscapes in southern Australia, grasslands and crops will comprises a mosaic of fuel conditions (Cruz *et al.*, 2015).
[7] Uncertainty values for calculated FDIs, especially GFDIs, resulting from the imprecision of the input values, are very significant and may cross a number of FDR classes (Yeo *et al.*, 2014).

For consistency with AS 3959-2009, the GFDI calculation used the equation for the McArthur Mark 4 Grassland Fire Danger Meter (Purton 1982; Yeo *et al.*, 2014). Following GFDI analysis, the GEV method was then used to determine the return period (recurrence) of annual maximum GFDI values for each station.

Table 17 Record of the six years with the highest GFDI for Kimba

Year	Month	Day	Temperature (˚C)	Relative humidity (%)	Wind speed (km/h)	GFDI
1990	11	6	36.5	9	50	136
2009	12	23	39.6	8	46.4	130
2013	10	9	33.5	7	46.4	114
2002	10	7	20.4	24	64.8	107
2005	4	9	36.2	24	48.2	81
2004	10	12	39	8	37.1	80

Table 18 GEV recurrence intervals for various GFDI/FDR thresholds

Fire weather threshold (FFDI)	Equivalent GFDI[8]	Recurrence Interval (yrs)
		Kimba
Severe fire danger (FFDI 50)	70	4.0
AS 3959-2009 (FFDI 80)[9]	110	18.7
Catastrophic fire danger (FFDI 100)	130	40.2

Table 17 and Table 18 show summary results of the GFDI analysis. They reveal the significantly more severe fire weather conditions on days of elevated fire danger.

The applicable South Australian GFDI 110 threshold for building protection in AS 3959-2009, is likely to occur approximately every 18.7 years at Kimba. A day of Catastrophic fire danger is likely to occur every 40.2 years at Kimba.

2.4.2.3.2 Temperature, relative humidity and wind

At Kimba across the fire season the 3pm mean monthly temperatures at Kimba vary from around 24 to 30 °C mean relative humidity is generally between 30 and 35 % and wind speed varies from around 8 to 13 km/hr.

Table 19 Mean daily 3pm weather conditions during the fire season (Oct – April)

Attribute	Mean 3pm value during the fire season
	Kimba
Relative humidity (%)	32.3
Temperature (˚C)	27.2
Wind speed (km/h)	11.2

2.4.2.3.3 Wind speed and direction

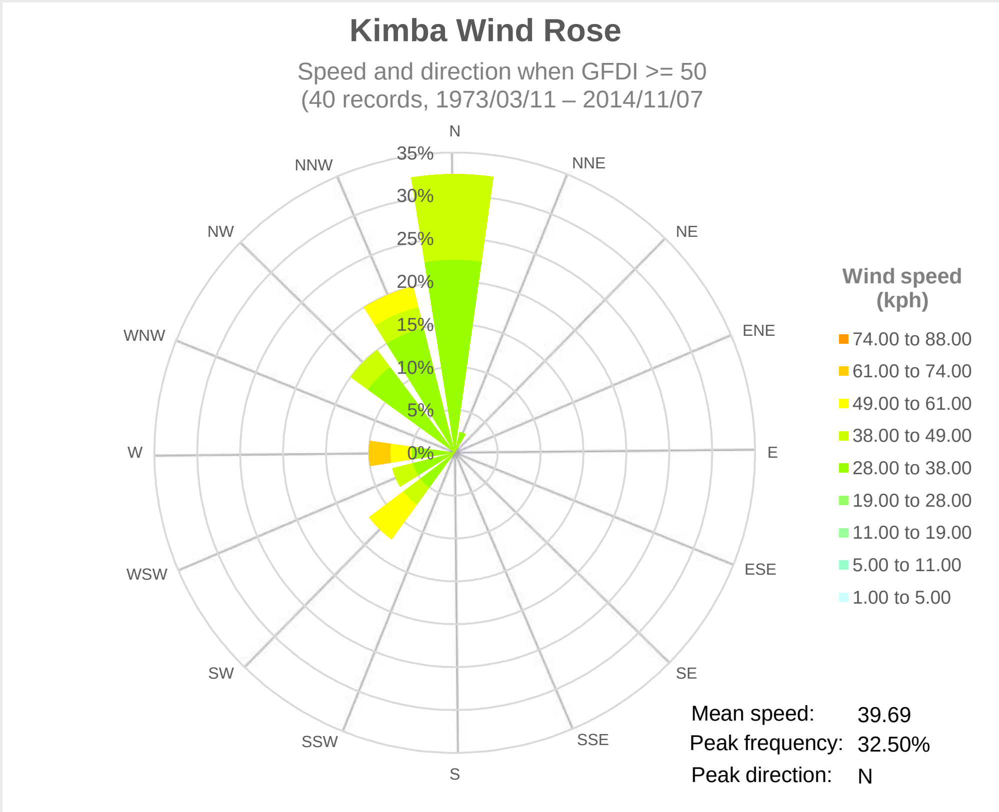
As wind speed and direction is a major influence on fire behaviour in grass and shrub and heath (Mallee-mulga) fuels, further analysis of wind data was undertaken to compare wind data for the two BOM sites.

[8] Deemed equivalent value by AS 3959-2009 (Standards Australia, 2011).
[9] An FFDI 80 (deemed equivalent to GFDI 110 by AS 3959-2009) applies throughout SA bushfire protection areas to determine vegetation setback distances from classified vegetation and associated building construction standards.

A wind rose for each weather station was generated to show the wind speeds and directions of wind, at 3pm on days of elevated fire danger (i.e. when calculated GFDI was >=50) during the fire danger period. The results are provided in Figure 11.

The Kimba data show the prevalence of northerly wind on days of elevated fire danger, although stronger winds may be experienced from the southwest and west.

Figure 11 Kimba wind rose for 3pm records during the fire season months when calculated GFDI >= 50.



2.4.2.3.4 Climate change

The weather analysis is based on historical data that may correlate poorly with future fire weather due to the impact of climate change, which is predicted to generate hotter and drier conditions across southeast Australia.

A 2007 study of bushfire weather across southeast Australia under various climate change scenarios concluded that by 2020 there could be up to a 4% increase in mean FFDI under low global warming scenarios, and up to 10% under high global warming scenarios. By 2050 the increased projected change in mean FFDI was 8% to 30% under the low and high scenarios respectively (Lucas *et al.*, 2007).

The same study identified the potential for a significantly increased number of elevated FDRs, as shown in Table 20.

Table 20 Percentage change in the number of days with very high and extreme fire weather – 2020 and 2050, relative to 1990 (Lucas *et al.*, 2007).

Fire Danger	2020		2050	
	Low global warming (0.4˚C)	High global warming (1˚C)	Low global warming (0.7˚C)	High global warming (2.9˚C)
Very High	+2-13%	+10-30%	+5-23%	+20-100%
Extreme	+5-25%	+15-65%	+10-50%	+100-300%

Climate analysis provided by AECOM identifies for Lyndhurst, that from 2030 to 2090:

- Mean maximum daily temperatures could increase by up to 1.2˚C to 4.1˚C;
- Mean 3pm relative humidity could decrease by up to 1.1% to 3.2%; and
- Mean 3pm wind speed could decrease by up to 4.4 km/h, or increase by up to 0.7km/h.

2.4.2.3.5 Summary of Assessment of Frequency and Severity of Bushfire Weather Conditions that will Influence Fire Behaviour

Analysis of historical BOM data from the Kimba weather station (located 15km southwest of Lyndhurst), identifies that a day of severe fire danger is likely to occur approximately once every 4 years, whilst a day of Catastrophic fire danger is likely to occur approximately every 40 years.

The applicable GFDI 110 fire weather threshold for building protection in AS 3959-2009, is likely to occur approximately every 19 years. During the fire season, the mean 3pm values for relative humidity, temperature and wind speed are 32.3%, 27.2˚C, and 11.2km/h respectively.

On days of elevated fire danger northerly winds are most likely to be experienced, however, strong winds from the northwest, west and southwest are also likely to occur, with the strongest winds most likely to be from the west.

Under Severe or higher fire weather conditions, strong (average 40km/h) northerly winds are most likely to be experienced. Less frequent, but more likely to be associated with higher wind speeds, are north-north-westerly, westerly or south-westerly winds.

It should be noted that the historical weather analysis may poorly correlate with future fire weather due to the impact of climate change, which is predicted to generate hotter and drier conditions across south-eastern Australia, including potential for significantly more frequent, and more severe, elevated fire danger days.

2.4.2.4 Bushfire scenarios

Based on the analysis of vegetation, topography and weather on days of elevated fire danger, credible bushfire scenarios are identified and their potential impacts analysed, including the potential for the ignition and development of a bushfire in the surrounding landscape.

2.4.2.4.1 Mallee-Woodland (Shrub and Heath) bushfire

This is the type of fire that could develop in the Lake Gilles Park to the east and northeast or occur in Mallee-Woodland vegetation on other land to the northwest and north.

The wind analysis for Kimba, shows a significant likelihood at Lyndhurst of winds from the north and north-northwest under elevated fire danger conditions. The landscape in these directions is dominated by Mallee-mulga vegetation extending for at least 4km to the northwest and beyond 10km to the north. The long fire runs possible and the likely low fuel moisture in the vegetation, means that a fire approaching from the northwest under strong winds, could be large, intense and fast moving.

As noted previously, the topography is benign and not conducive to extreme fire behaviour, however, the siting of a NRWMF at Lyndhurst should aim to maximise the setbacks from the northwest, or at least achieve the minimum 100m setback in AS 3959-2009 for vegetation to be deemed low threat. 100m setbacks from the two larger patches of Mallee-Woodland within the site are also desirable.

A fire from the north or in the Lakes Gilles Park to the northeast or east, would have to travel more than 1km through pasture before impacting the site as a grassfire.

2.4.2.4.2 Grassfire

The wind rose analysis shows strong winds from the west and southwest are likely to occur during the fire danger period. The landscape in these directions is however, pastoral, dominated by lesser hazard grass fuels that may be grazed and/or cropped in a relatively low fuel state for at least the latter half of the fire danger period. A fire approach from the southeast and south is less likely during the fire danger period and would also be through a pastoral landscape.

The rate and direction of fire spread on both the grassland and mallee-woodland vegetation would be determined by the wind speed and direction, with topography a negligible influence. Whilst these fires could be fast moving, they should not pose a significant or unacceptable risk to the site if appropriate low threat setbacks can be provided around assets commensurate with their vulnerability to bushfire attack.

2.4.2.4.3 Bushfire impacts

<u>Rate of spread, flame length and RHF</u>

The detailed Method 2 procedure of AS 3959-2009 was used to calculate potential rates of spread, flame lengths and RHF that may result from a large grassfire or shrub and heath (mallee-woodland) fire impacting the Lyndhurst site.

The AS 3959-2009 'default' inputs for weather, fuel and radiant heat impacts have been applied, based on both the FFDI 80 value (GFDI 110) that applies in SA for determining BAL construction standards and a higher, more precautionary, FFDI 100 (GFDI 130) input (i.e. Catastrophic FDR conditions, and which applies for determining BALs in Victorian non-alpine areas and some NSW regions). The inputs and results for a range of RHF safety thresholds for both a grassland fire scenario and a fire in Mallee-woodland, are summarised in Table 21.

Table 21 Summary of Method 2 calculations for a fire in Grassland and Mallee-Mulga

Attribute				
Input				
Vegetation	**Grassland**		**Mallee-Mulga**	
FFDI	80	100	80	100
Deemed equivalent GFDI	110	130	110	130
Flame temp (K)	1090			
Flame emissivity	0.95			
Flame width (m)	100			
Heat of combustion (kJ/kg)	18,600			
Average vegetation height (m)	n/a		3	
Wind speed (km/h)	45			
Overall fuel load (t/ha)	4.5		8	
Effective slope (°)	0			
Site slope (°)	0			
Output				
'Steady state' rate of spread (km/h)	14.3	16.9	4.2	4.2
Flame length (m)	6.9	7.5	6.9	6.9
Asset/Vegetation setbacks (m) for RHF threshold				
Distance to reach 40 kW/m^2	5.8	6.3	5.8	5.8
Distance to reach 29 kW/m^2	7.9	8.6	7.9	7.9
Distance to reach 19 kW/m^2	11.8	12.8	11.8	11.8
Distance to reach 12.5 kW/m^2	17.5	18.8	17.4	17.4
Distance to reach 10 kW/m^2	21.1	22.7	21.1	21.1
Distance to reach 2 kW/m^2	67.7	71.2	67.8	67.8

The results of the AS 3959-2009 Method 2 calculations show anticipated rates of spread of 14 – 17km/h and flame lengths of 7-8m for a grassfire under the two FFDI/GFDI scenarios. Whilst a grass fire forward rate of spread could be significantly faster than a fire in the Mallee-Woodland vegetation, the RHF setbacks are very similar.

Note that the rate of spread and flame length (and hence RHF setbacks) do not change for a Mallee-Woodland fire under the two GFDI/FFDI scenarios, as the shrub and heath equations used to model Mallee-Woodland do not include FFDI or GFDI as an input, but apply the wind speed, which in AS 3959-2009 is presumed to be 45km/h.

The appropriate setback to reduce RHF to reach an acceptable risk, depends on the vulnerability of future assets and infrastructure to RHF and the desired safety threshold. The RHF threshold range of 12.5 kW/m^2 to 40 kW/m^2 is commensurate with the range of BAL construction standards from BAL-12.5 to BAL-40 under AS 3959-2009 (see Table 24).

The RHF threshold of 10kW/m^2 is applied in some jurisdictions for 'vulnerable' developments such as schools, hospitals, aged care facilities, and similar development where large numbers of people may gather or be accommodated away from their usual place of residence. It is the upper RHF limit to which fire fighters in protective clothing can be exposed for short periods of time.

The RHF threshold of 2kW/m^2 is the upper limit for human exposure without protective clothing and is applied in Victoria for determining appropriate setbacks for sheltering in the open at a Neighbourhood Safer Place (NSP 'Place of Last Resort').

It is important to note that the Method 2 calculations are applied to determine setbacks for built assets based on RHF exposure levels. They may not appropriately represent actual anticipated fire behaviour. Advances have occurred in fire science and rate of spread modelling since the development of AS 3959-2009 and these models are likely to more accurately represent actual fire behaviour than those in AS 3959-2009.

For example, for grass and shrub and heath fuels, fuel moisture content as well as wind speed is an important determinant of fire behaviour that is not a direct input into the Method 2 calculation. *'Fire spread sustainability was primarily a function of litter fuel moisture content with wind speed having a secondary but still significant effect. The continuity of fine fuels close to ground level was also significant. Onset of active crowning was mostly determined by wind speed'* (Cruz *et al.*, 2013).

A West Australian study of fire ignitions also showed that fuel moisture content was a better predictor of fires than weather or fire danger variables that combine fuel availability and wind inputs. This is because the moisture content of surface litter is strongly linked to the sustainability of ignition and the availability of fuels to support combustion, whereas wind contributes more to fire spread (Plucinski, 2014).

Smoke, embers and wind

Other potential bushfire impacts that should be considered in the design of the facility include vulnerability to smoke, embers and wind, although these factors need not be considered for the site selection process as they will be similar at each site.

Embers are the most common cause of building loss from bushfire and can arrive well in advance of a discernible fire front and continue for a long time after a fire. Grassfires however, do not typically generate significant ember attack and all sites are considered to be equally exposed to a relatively low risk of embers, although the presence of small areas of trees or shrubs (potentially excludable under AS 3959-2009) may be a significant local source of embers.

Strong winds, which could be experienced at any of the sites during a bushfire, can increase the vulnerability of a building to ember attack by dislodging materials or opening gaps in the building fabric where embers could lodge. The impact of wind during a bushfire event is considered similar but not extreme at all sites and an appropriate design response can adequately mitigate the wind effects.

It is desirable that future buildings aim to facilitate wind flow over the building and maintenance (e.g. cleaning of gutters) and avoid complex roof lines with may allow build-up of debris (e.g. accumulation of leaves and bark) and trap embers. Walls and eaves should similarly avoid or minimise re-entrant corners and other features that may trap debris and embers.

2.4.2.4.4 Potential for ignition and fire development

Human-caused ignitions are the main source of wildfires in south-eastern Australia and population density has been found to be the most important variable related to the location of ignitions (Collins *et al.*, 2015). Human-caused fires are also more likely to occur on weekends and public holidays (Plucinski, 2014).

The population density in the landscape around all sites is low, 0.2 people per square km in the Kimba District Council area that Lyndhurst is part of (2006 data (Location SA Map Viewer, 2018)). As discussed and displayed in 2.6.1.3.4, the nearest dwellings is more than 1 km from the site, with surrounding human land use activities limited to broadacre cropping and grazing only.

2.4.2.4.5 Summary of Assessment of Likelihood and Nature of Bushfire Impact

The most hazardous bushfire threat is from a large, intense and fast moving fire in the Mallee-woodland to the northwest. It is also possible for a grassfire to approach under elevated fire weather conditions but it would be less intense than a fire in the Mallee-woodland. It is most likely for fire to impact the site from those directions typically associated with strong winds on days of elevated fire danger i.e. from the north, west or southwest). The rate and direction of fire approach and spread under both scenarios would be determined by the wind speed and direction, with topography a negligible influence.

Based on AS 3959-2009 presumptions about fire behaviour, anticipated rates of spread of 14 – 17km/h and flame lengths of 7-8m could result from a grassfire impacting under elevated fire danger conditions. Whilst the forward rate of spread of a grassfire could be significantly faster than a fire in the Mallee-Woodland vegetation, the Radiant Heat Flux (RHF) setback distances for assets from hazardous vegetation, are very similar. The appropriate setback to reduce RHF to reach an acceptable risk, depends on the vulnerability of future assets and infrastructure to RHF, the agreed design fire conditions (e.g. fire weather) and the desired safety threshold.

In addition to an appropriate BAL construction standard commensurate with the setback from vegetation, other potential bushfire impacts that should be considered in the design of the facility include vulnerability to smoke, embers and wind. Embers are the most common cause of building loss from bushfire and can arrive well in advance of a discernible fire front and continue for a long time after a fire. However, grassfires do not typically generate significant ember attack although if any areas of trees or shrubs in proximity to the facility were to ignite, they may be a significant local source of embers.

The most significant bushfire threat at Lyndhurst is a from fire in the Mallee-woodland to the northwest. However, it should not preclude the development occurring at the site, if sufficient setbacks from this vegetation and the other two large patches of Mallee-woodland within the site are achieved. A minimum setback of 100m is recommended.

A fire threatening a NRWMF at Lyndhurst could be fast moving, however, it would should not pose an unacceptable risk if appropriate low threat setbacks can be provided around assets commensurate with their vulnerability to bushfire attack, in addition to adequate provision of water for firefighting, access for emergency vehicles and personnel, and appropriate bushfire emergency management arrangements.

It is considered that the need for, and type of, bushfire protection measures is largely independent of the site selection process i.e. the same mitigation measures would be required, and should be able to be provided, at any of the sites under consideration. One possible exception may be the provision of an adequate water supply for fighting if water supply is a constraint at one or more of the sites.

CFS incident data for local brigades (within approximately 20-30km of the site ‘as the crow flies’) was examined for the occurrence of incidents in the landscape around the site that did, or could, generate a bushfire with the potential to threaten the site. Figure 9 and Table 22 show the three CFA brigades located around the Lyndhurst site.

Data were analysed for the period 1 May 2009 to 30 June 2015. The results are provided in Table 23. Note that other incident types not selected may also generate fires that could threaten the site e.g. building, vehicle or rubbish fires.

Table 22 CFS brigades closest to (within 20-30km of) Lyndhurst

Brigade	Distance and direction from site
Buckleboo	33km to northwest
Kimba	15km to southwest
Yalanda James	30km to southeast

Table 23 CFS incident data for brigades within 20-30km of the sites

Site	Lyndhurst
Incident/Brigade	**Kimba, Yalanda James and Buckleboo**
Grass or Stubble Fire	39
Scrub and Grass Fire	14
Tree Fire	1
Haystack	0
Grain / Crop Fire	3
Lightning (No Fire)	0
Forest Fire	0
Unauthorised Burning	0
Attempt to Burn	0
Total	**57**

Grass, grass stubble, scrub, grain and crop fires are the most common in the landscape surrounding the site, reflecting the generally pastoral landscape

The data are provided for comparison purposes only, as a guide to the possibility of ignitions and fire development and is not a measure of bushfire risk at any site. It indicates the fire suppression resourcing available around each site and the record of incidents and human activity that may result in bushfire ignition.

2.4.3 Design Issues and Mitigation Measures

The bushfire hazard is relatively low due to the lesser hazard nature of the vegetation on and around the site and the benign topography. The site is not in a SA Bushfire Protection Area that identifies the bushfire risk level and where specific planning and building controls apply (Location SA Map Viewer, 2018).

The Lyndhurst site, however, could be exposed to a large and intense and fast moving fire in the Mallee-woodland vegetation that abuts the 100ha site to the northwest. Consequently, siting of a NRWMF at this location should aim to maximise the setbacks from the northwest, or at least achieve the minimum 100m setback required under AS 3959-2009 for that vegetation to be deemed low threat. 100m setbacks from the two larger patches of Mallee-Woodland within the site are also desirable.

A summary discussion of each main protection and mitigation measure is provided below.

2.4.3.1 Buildings - BAL construction standards

If future buildings are constructed to an appropriate BAL construction standard, it is considered they will be adequately protected and will not require specific design features to protect against bushfire attack, unless the buildings need to protect assets with a particular vulnerability to smoke, wind, embers or radiant heat.

All BAL construction standards above BAL-Low are ‘deemed to satisfy’ the National Construction Code requirement that applicable buildings be designed and constructed to reduce the risk of ignition from a bushfire, appropriate to the:

(a) *'potential for ignition caused by burning embers, radiant heat or fame generated by a bushfire; and*
(b) *intensity of the bushfire attack on the building'* (ABCB, 2016).

An explanation of BAL options is provided in Table 24. A minimum BAL-12.5 construction standard for all future buildings is likely appropriate, if the buildings can achieve an appropriate setback from any hazardous vegetation (see for example the distances identified in Table 21 and discussed in Section 2.4.2.4.3).

Table 24 BAL construction standards (adapted from Standards Australia, 2011)

Bushfire Attack Level (BAL)	Risk Level	Construction elements are expected to be exposed to…	Comment
BAL-Low	VERY LOW: There is insufficient risk to warrant any specific construction requirements but there is still some risk.	No specification.	At 4kW/m^2 pain to humans after 10 to 20 seconds exposure. Critical conditions at 10kW/m^2 and pain to humans after 3 seconds. Considered to be life threatening within 1 minute exposure in protective equipment.
BAL-12.5	LOW: There is risk of ember attack.	A radiant heat flux not greater than 12.5 kW/m^2	At 12.5kW/m^2 standard float glass could fail and some timbers can ignite with prolonged exposure and piloted ignition.
BAL-19	MODERATE: There is a risk of ember attack and burning debris ignited by windborne embers and a likelihood of exposure to radiant heat.	A radiant heat flux not greater than 19 kW/m^2	At 19kW/m^2 screened float glass could fail.
BAL-29	HIGH: There is an increased risk of ember attack and burning debris ignited by windborne embers and a likelihood of exposure to an increased level of radiant heat.	A radiant heat flux not greater than 29 kW/m^2	At 29kW/m^2 ignition of most timbers without piloted ignition after 3 minutes exposure. Toughened glass could fail.
BAL-40	VERY HIGH: There is a much increased risk of ember attack and burning debris ignited by windborne embers, a likelihood of exposure to a high level of radiant heat and some likelihood of direct exposure to flames from the fire front.	A radiant heat flux not greater than 40 kW/m^2	At 42kW/m^2 ignition of cotton fabric after 5 seconds exposure (without piloted ignition).

Bushfire Attack Level (BAL)	Risk Level	Construction elements are expected to be exposed to…	Comment
BAL- FZ (Flame Zone)	EXTREME: There is an extremely high risk of ember attack and a likelihood of exposure to an extreme level of radiant heat and direct exposure to flames from the fire front.	A radiant heat flux greater than 40 kW/m^2	At $45kW/m^2$ ignition of timber in 20 seconds (without piloted ignition).

2.4.3.2 Other assets and infrastructure

The vulnerability of other assets and infrastructure to the mechanisms of bushfire attack (smoke, embers, wind, radiant heat and flame contact) will need to be determined and adequate setbacks provided, e.g. to protect essential services such as exposed telecommunication, power, sewerage, drainage, heating/cooling or water infrastructure. Additional design and construction features may be required if the assets have a particular vulnerability.

2.4.3.3 Asset Protection Zones (APZs) and vegetation management

APZs around buildings should be provided, for a distance commensurate with their construction standard and/or desired RHF safety threshold under agreed design fire conditions. All vegetation in the APZs should be managed in a low threat state, as non-hazardous vegetation, including grass no more than 100 mm high with few shrubs or trees. Future landscaping should not increase the hazard around the buildings/assets.

Other assets may also need to be provided with an appropriate APZ including access roads and essential infrastructure.

The creation and maintenance of appropriately sized and strategically located APZs, should be considered across the balance of the site and/or appropriate 'whole of site' vegetation management (e.g. grazing) implemented beyond the building setback areas. This should aim to ensure that any fire originating from an ignition on the site does not have significant potential to develop and threaten neighbouring properties. It would also serve to slow and help control or extinguish a fire burning onto the site and threatening assets and infrastructure.

2.4.3.4 Water and access

Provision of an adequate water supply will need to be provided for fire-fighting, to the satisfaction of the relevant fire authority (presumably the CFS). This should include consideration of an appropriate reticulated water system dedicated for firefighting with adequate pumps, hydrants and other outlets/hoses.

A sufficient capacity of static water, as an additional supply, should be provided in a non-combustible, above ground tank(s), with appropriate fittings and access for emergency services.

2.4.4 Data Gaps and Recommendations for Stage 2 Work Program

2.4.4.1 Data Gaps and Limitations

Key data gaps in the bushfire hazard assessment include:

- The configuration and layout of the development including type and location of buildings and other assets and infrastructure.
- Information on the vulnerability of future assets associated with the NRWMF including the number of people that will be present on the site at any time and the nature of their occupancy.
- Agreement about the appropriate design fire conditions for calculating APZs.

2.4.4.2 Recommendations for Stage 2 Work Program

A site visit by a specialist bushfire consultant and subsequent assessment to determine BALs and the extent of APZs should be undertaken once the concept design and asset layout plan is completed. Appropriate design fire inputs and RHF safety thresholds will need to be agreed.

2.5 Hydrology and Flood Risks

2.5.1 Methodology and Results

AECOM has prepared a detailed Desktop Assessment for the Lyndhurst site focused on surface water and flooding potential.

Assessment of the presence and seasonality of surface waters, including retention structures such as dams, has been addressed as part of a review of hydrological processes and flood risks at each site. The assessment is generally based on relevant existing publicly available data sources, with site based data utilised where available. The types of data include:

- Rainfall depth and intensity data
- River flow data
- Topographical data – e.g. watercourses
- Terrain elevation data – e.g. digital terrain models (LiDAR, SRTM)
- Satellite and aerial photography
- Soils information
- Anecdotal flood information

2.5.1.1 Site Characteristic Criteria

The key criteria used to assess the site for use as a NRWMF are informed by the International Atomic Energy Agency (IAEA) Specific Safety Guide SSG-18, Meteorological and Hydrological Hazards in Site Evaluation for Nuclear Installations (IAEA SSG-18, 2011). The guide lists a number of key criteria used to assess siting nuclear installations. The guide also addresses an extended range of nuclear installations, including spent fuel storage facilities. Given this, it has been used to inform the characterisation of the site.

AECOM has undertaken a preliminary assessment of surface water (hydrology) at the Lyndhurst site. The key criteria considered include the following:

- Free from localised flooding (water logging or extreme rainfall) – this may lead to disruption of site operations and potentially lead to the dispersion of radioactive material;
- Free from major flooding from a range of sources including from waterways, bodies of water or from sudden releases of water from natural or artificial storages– potentially leading to structural failures of the facility resulting in the potential dispersion of radioactive material;
- Have site access during flood events – ensuring staff and emergency services can access the site for both normal operational and emergency response activities; and
- Not be subject to flooding as a result of changes in rainfall and runoff from the catchment over time (climate induced change).

2.5.1.2 Desktop Methods and Results

AECOM reviewed water databases relevant to the Lyndhurst site. The following data and search results were accessed, and where data was available, were utilised to complete this assessment:

Publicly available mapping and report datasets accessed from on-line databases:

- Data SA South Australian Government Data Directory map viewers; specifically:
  - *Location SA Map Viewer* http://location.sa.gov.au/viewer/
    Location SA Map Viewer is a public-facing application to enable citizens to visualise much of the state government data in the Location SA repository. Where this data is available for download the user is provided with a link to data.sa.gov.au.
  - *WaterConnect* https://www.waterconnect.sa.gov.au/Pages/Home.aspx

WaterConnect has the latest information about South Australia's water resources and flood awareness, providing direct access to water-related publications and data. Available river flow data in the vicinity of the site was interrogated using the map function. Links to any relevant flood reports and visualisation of known flood extents was provided by the Flood Awareness Map portal.

- GIS watercourse data from Geosciences Australia
- Water information from the Australian Hydrological Geospatial Fabric (Geofabric) (http://www.bom.gov.au/water/geofabric/)

  The Geofabric is a specialised Geographic Information System (GIS). It registers the spatial relationships between important hydrological features such as rivers, water bodies, aquifers and monitoring points. For this study, it has been used to determine the presence of significant waterways, their alignments and catchment areas.

- Planning Scheme overlay data – e.g. Land Subject to Inundation Overlay (LSIO)

  Planning schemes often have overlays that delineate flood prone land as LSIO or floodway zones

- Aerial photography (from various open sources)

  Satellite and other aerial photography is available from a range of open sources (e.g. Google Earth and Google Map Satellite) and is used to visually identify key overland flow paths, waterways, dams and other infrastructure that may obstruct overland flows.

- Geoscience Australia National 1 arc second (~30m) SRTM Digital Elevation Model Version 1.0, Hydrologically Enforced (DEM-H): https://ecat.ga.gov.au/geonetwork/srv/eng/search#!aac46307-fce8-449d-e044-00144fdd4fa6

  The 1 second Shuttle Radar Topography Mission (SRTM) Digital Elevation Models Version 1.0 comprises three surface models: the Digital Elevation Model (DEM), the Smoothed Digital Elevation Model (DEM-S) and the Hydrologically Enforced Digital Elevation Model (DEM-H). The DEMs were derived from the SRTM data acquired by NASA in February 2000. The DEM-H captures flow paths based on SRTM elevations and mapped stream lines, and supports delineation of catchments and related hydrological attributes. The vertical accuracy of the data has been tested and shown to be in the order of +/- 7.6 m (95th percentile).

- Rainfall Intensity Frequency Duration (IFD) information from the Bureau of Meteorology http://www.bom.gov.au/water/designRainfalls/revised-ifd/?year=2016

  This is a standard industry tool to calculate rainfall intensities and total depths of rainfall for locations across Australia. The tool uses the procedures and data contained in the industry guideline called Australian Rainfall and Runoff (ARR, 2016).

- Existing flood studies and flood extent mapping from the Australian Flood Risk Information Portal (http://www.ga.gov.au/flood-study-web/#/search)

  This national web portal is similar to the SA WaterConnect Flood Awareness Map web portal described above. The portal was used to identify any existing flood studies, reports and GIS flood mapping available in the vicinity of the site.

Specific project datasets:

- Soils information

  The Desktop Assessment includes available soils information for the site. The soils information informs the hydrology, infiltrations losses and hence likely runoff and water logging.

- Climate and climate change information

The Desktop Assessment includes available climate and climate change information for the site. The climate and climate change information informs the rainfall intensities, evaporation losses and hence likely runoff and water logging.

2.5.1.3 Field Methods and Results

There were no field datasets collected for the hydrology and flood risk component of the assessment.

2.5.2 Assessment Against Criteria

2.5.2.1 Assessment Criteria 1 – Localised flooding (water logging or extreme rainfall)

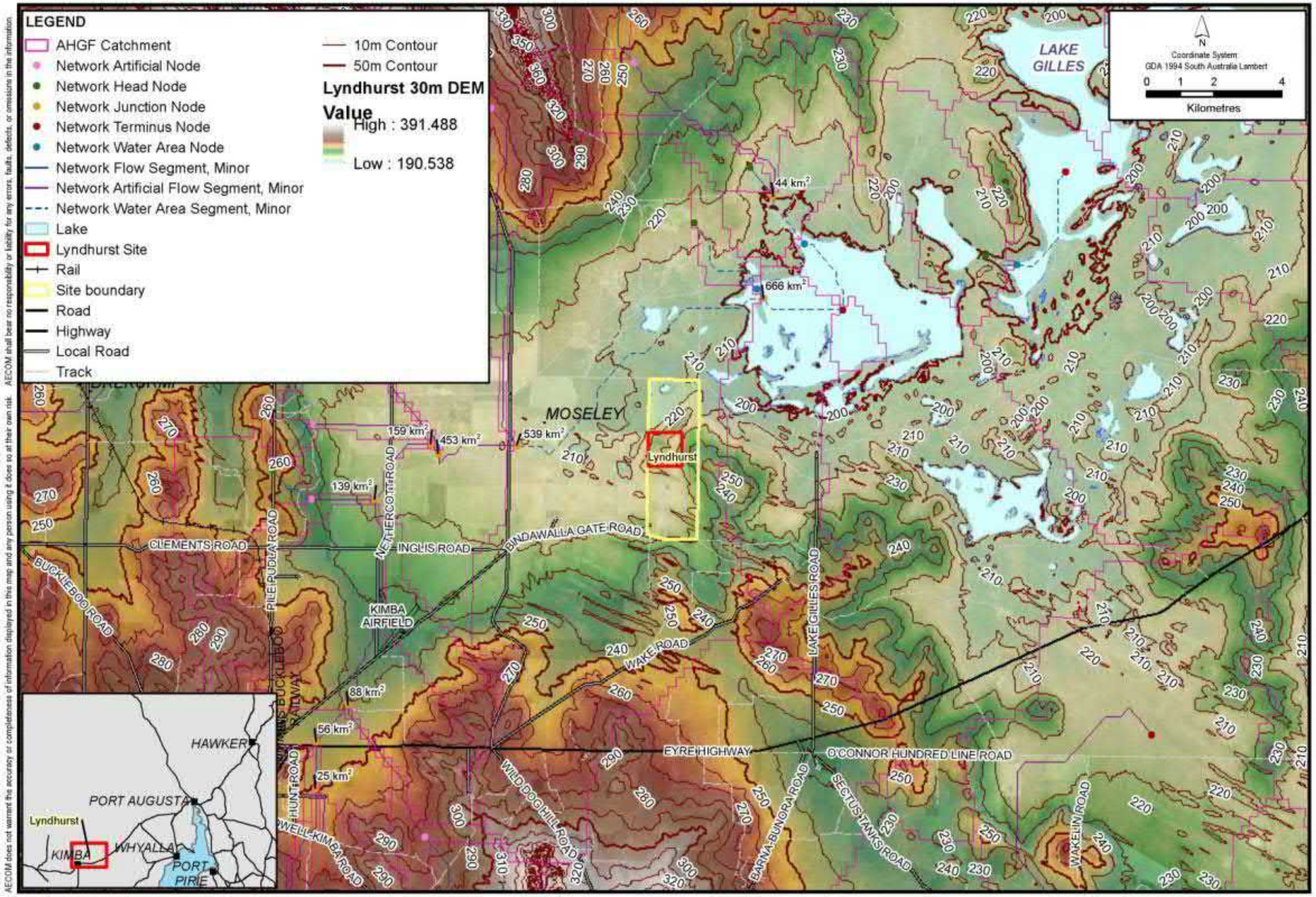
The available topographic and Geofabric information are illustrated in Figure 12 and Figure 13. From Figure 12 it can be seen that the Geofabric data indicates a non-perennial drainage depression located approximately 2 km north-west of the site boundary. The Geofabric data lists the upstream catchment for the watercourse in the order of 540 km^2. The catchment drains to Lake Gilles. Figure 13 illustrates the LiDAR elevation data and the associated drainage lines in the vicinity of the site. There are clearly local drainage paths through the site, running between vegetated sand ridges. These serve relatively small localised catchments and are therefore considered minor. The slopes are typically flat, consisting of localised depression storages along the eastern boundary of the site. The side slopes leading to the local depression storages are typically in the order of 4%. These slopes are relatively flat. It is expected that overland flows through the site from the local catchments would be relatively small and generally slow moving.

Based on a review of all of the available data sources, there is limited relevant flood information for the localised drainage lines. There are no known flood studies, flood extents or planning overlays covering these drainage lines (refer to Section 2.5.2.2 for a discussion on major flooding associated with the non-perennial depression). There is some relevant anecdotal information. The soils at the site are a sandy loam on a relatively impermeable calcrete/silcrete layer at a depth of approximately 0.3m, with some waterlogging (approximately every 5 years) and runoff (approximately every 10 years) (source: Brett Rayner, 22 Feb 2018). This is based on approximately 20 years of experience at the property. There is rainfall Intensity Frequency Duration (IFD) data from the BoM, as well as some more detailed soil profile information from the desktop assessment addressing Soils found elsewhere in this report.

The IFD data provides a range of ‘design’ rainfall intensities for a given storm frequency and duration. The data for frequent and rare events, both in terms of rainfall intensity (mm/hr) and total rainfall depth (mm for the given event) are presented in Table 25 through to Table 28. The IFD data can be compared to available soil profile data to determine whether it is likely that soil profiles in the vicinity of the site are likely to result in water logging or generate significant runoff.

If the soil is not ‘hydrophobic’ (repels water when it first wets) and the soil conductivity rates (the rate at which water can soak into the ground) exceeds the rate of rainfall, it is unlikely that significant runoff or waterlogging will occur. The section in this report addressing soils indicates that the soils within the vicinity of the site are predominantly loam over poorly structured red clay and siliceous sand, with some smaller areas of calcareous loam on clay. There are soil profiles in the Kimba region (EE051 and EE052) that indicate that the soil profiles are likely to be moderately well drained and that water may perch on top of the dispersive clayey subsoil for up to a week following heavy or prolonged rain. The profiles indicate that the hydraulic conductivity ranges from 40 to 60 mm/hr at the surface to 2 to 3 mm/hr at approximately 0.5 m depth (Refer to Soils Desktop Assessment). From Table 3, an infrequent (1% AEP) event with relatively intense rainfall burst of 1 hour has an intensity of 41.3 mm/hr. This is one of the events that would typically be used to design site drainage. The top layers in the soil’s profile have hydraulic conductivity similar to the design rainfall intensity; hence it is possible it would produce significant runoff. At deeper levels in the soil profile, impervious layers or layers with low hydraulic conductivity are likely to produce water logging if the longer duration storms (over days) fill the upper soil layers, and the intensity of the rainfall exceeds the ability of the soil to drain the water to ground water. The lower layers in the soil’s profile have a hydraulic conductivity less than the design rainfall intensity (e.g. 4.73 mm for the 1%AEP 24 hour storm), hence it is likely it would retain significant water and could cause water logging. These conclusions are supported by anecdotal information that the sites do periodically waterlog and generate runoff (source: Brett Rayner, 22 Feb 2018).

Figure 12 Topography and Geofabric



Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Map Document: (\\AUMEL1FP003.AU.AECOMNET.COM\Groups\WTR\SpatialSys\Projects\2018\NRWMF\4.99_GIS\02_Maps\Hydrology_20180313.mxd)

Figure 13 Drainage lines from LiDAR data

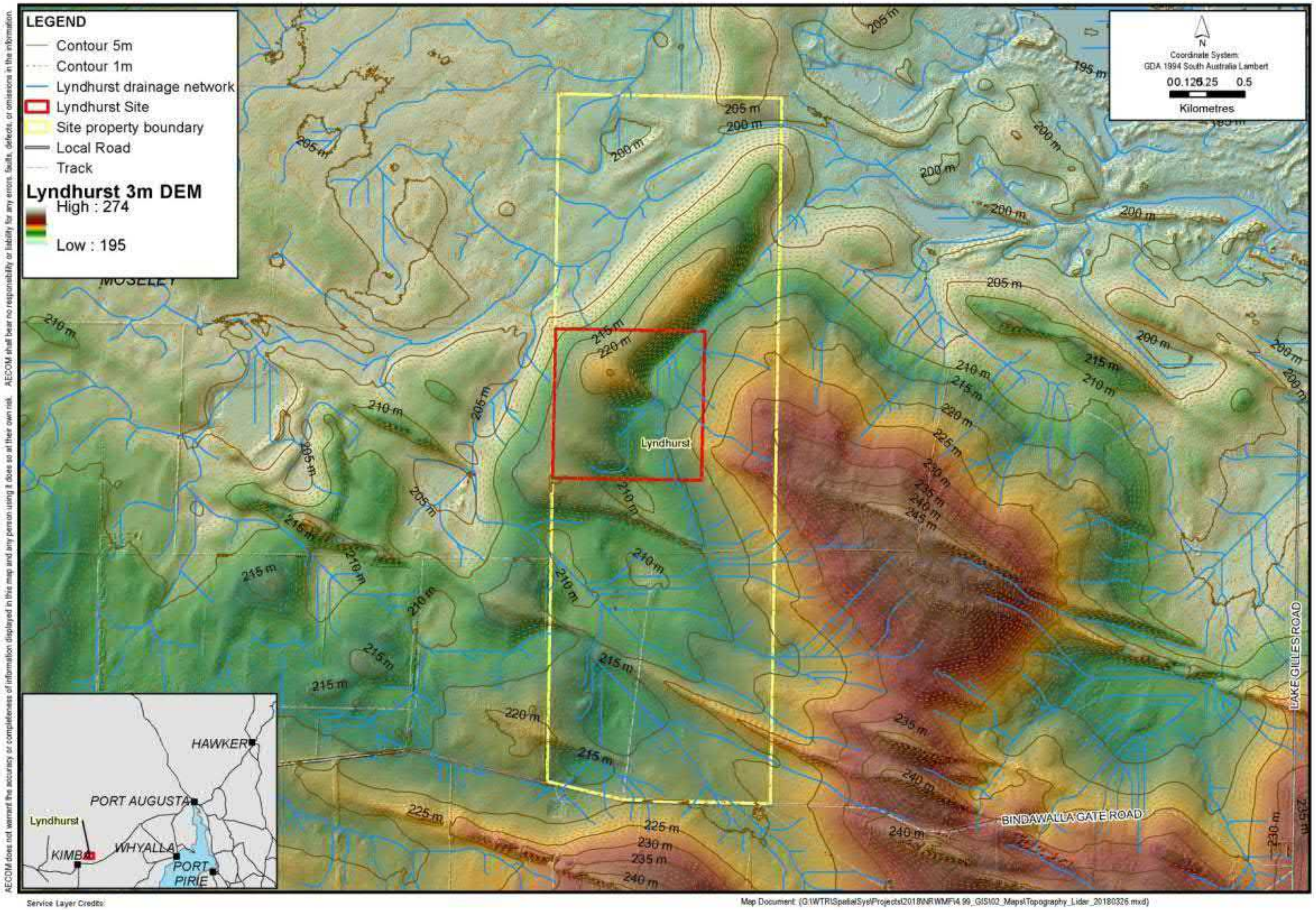


Table 25 Rainfall depths for frequent to infrequent events (mm)

Duration	Annual Exceedance Probability (AEP)						
	63.20%	50%	20%	10%	5%	2%	1%
1 min	1.1	1.28	1.9	2.37	2.87	3.6	4.22
2 min	1.94	2.25	3.32	4.15	5	6.2	7.21
3 min	2.6	3.02	4.46	5.57	6.72	8.35	9.73
4 min	3.15	3.66	5.41	6.75	8.15	10.2	11.9
5 min	3.62	4.2	6.22	7.75	9.38	11.7	13.7
10 min	5.28	6.14	9.1	11.3	13.7	17.3	20.3
15 min	6.38	7.42	11	13.7	16.6	21	24.6
30 min	8.48	9.85	14.6	18.2	22.1	27.7	32.6
1 hour	10.9	12.7	18.7	23.3	28.2	35.3	41.3
2 hour	13.8	16	23.5	29.3	35.3	44.1	51.5
3 hour	15.8	18.3	26.8	33.3	40.1	50.1	58.5
6 hour	19.6	22.7	33.2	41.2	49.8	62.5	73.2
12 hour	23.8	27.5	40.6	50.6	61.5	77.8	91.7
24 hour	27.9	32.3	48.1	60.7	74.7	95.5	114
48 hour	31.5	36.4	54.9	70.2	87.7	113	135
72 hour	33.3	38.5	58.1	74.8	93.9	121	146
96 hour	34.5	39.9	60.1	77.3	97.3	126	152
120 hour	35.6	41.1	61.5	78.7	99.1	128	154
144 hour	36.6	42.2	62.7	79.6	99.9	129	155
168 hour	37.6	43.3	63.7	80.1	100	130	156

Table 26 Rainfall depths for rare events (mm)

Duration	Annual Exceedance Probability (AEP)				
	1 in 100	1 in 200	1 in 500	1 in 1000	1 in 2000
24 hour	114	131	160	186	214
48 hour	135	166	210	249	296
72 hour	146	176	221	262	310
96 hour	152	179	224	265	311
120 hour	154	181	226	266	312
144 hour	155	183	228	268	314
168 hour	156	185	231	272	319

Table 27 Rainfall intensities for frequent to infrequent events (mm/hr)

Duration	Annual Exceedance Probability (AEP)						
	63.20%	50%	20%	10%	5%	2%	1%
1 min	66.2	76.9	114	142	172	216	253
2 min	58.1	67.4	99.6	124	150	186	216
3 min	52	60.4	89.2	111	134	167	195
4 min	47.3	54.9	81.2	101	122	152	178
5 min	43.4	50.5	74.7	93	113	141	164
10 min	31.7	36.8	54.6	68	82.5	104	122
15 min	25.5	29.7	44	54.9	66.6	83.8	98.5
30 min	17	19.7	29.2	36.4	44.1	55.5	65.1
1 hour	10.9	12.7	18.7	23.3	28.2	35.3	41.3
2 hour	6.92	8.01	11.8	14.6	17.7	22	25.7
3 hour	5.27	6.1	8.94	11.1	13.4	16.7	19.5
6 hour	3.27	3.78	5.54	6.87	8.31	10.4	12.2
12 hour	1.98	2.3	3.38	4.21	5.13	6.48	7.64
24 hour	1.16	1.35	2	2.53	3.11	3.98	4.73
48 hour	0.655	0.759	1.14	1.46	1.83	2.35	2.82
72 hour	0.462	0.534	0.807	1.04	1.3	1.69	2.03
96 hour	0.36	0.416	0.626	0.805	1.01	1.31	1.58
120 hour	0.297	0.342	0.513	0.656	0.825	1.07	1.29
144 hour	0.254	0.293	0.435	0.553	0.694	0.898	1.08
168 hour	0.224	0.258	0.379	0.477	0.596	0.772	0.926

Table 28 Rainfall intensities for rare events (mm/hr)

Duration	Annual Exceedance Probability (AEP)				
	1 in 100	1 in 200	1 in 500	1 in 1000	1 in 2000
24 hour	4.73	5.47	6.69	7.74	8.92
48 hour	2.82	3.46	4.37	5.2	6.16
72 hour	2.03	2.44	3.07	3.64	4.3
96 hour	1.58	1.87	2.34	2.76	3.24
120 hour	1.29	1.51	1.88	2.22	2.6
144 hour	1.08	1.27	1.58	1.86	2.18
168 hour	0.926	1.1	1.37	1.62	1.9

2.5.2.2 Assessment Criteria 2 – Major flooding from upstream catchments

As discussed in Section 2.5.2.1, the available topographic and Geofabric information are illustrated in Figure 12. From Figure 12 it can be seen that the Geofabric data indicates a non-perennial drainage depression located approximately 2 km north-west of the site boundary. The Geofabric data lists the upstream catchment for the watercourse in the order of 540 km^2. Figure 13 illustrates the LiDAR elevation data and the associated drainage lines in the vicinity of the site. There are clearly local drainage paths through the site. There are no significant dams or reservoirs in proximity to the site. The upstream extent of Lake Gilles is situated near the north-east corner of the Lyndhurst property boundary; however is approximately 1.5km north of the 100 hectare site boundary.

Based on a review of all of the available data sources, there is no flood information available for the non-perennial drainage depression or Lake Gilles. The catchment is large, and therefore likely to produce significant runoff during infrequent and rare flood events. Lake Gilles shoreline is some 1.5 km to the north of the 100 hectare site and, based on SRTM terrain data, is more than 10m lower than the lowest point within the 100 hectare site. To determine flood extents and Lake Gilles flood levels, hydrological and hydraulic modelling would be required as part of the Stage Two assessment should the Lyndhurst site be further considered for the NRWMF.

Information on significant permanent and temporary surface water obstructions was reviewed. The presence of significant permanent water bodies within the upstream catchment, such as lakes and large dams or storage reservoirs, were reviewed using topographic and aerial photographic data. The presence of temporary water holding structures, such as elevated road and rail embankments, were reviewed using the available topographic and digital elevation datasets, as well as from site inspections and local knowledge from members of the community.

The assessment determined that there are no significant permanent surface water obstructions or temporary surface water obstructions upstream of the site.

2.5.2.3 Assessment Criteria 3 – Site access during flood events

The site is accessed from Kimba via Bindawalla Road. There is no recorded or anecdotal flood information or other supporting data to determine the broader nature of access to the area.

2.5.2.4 Assessment Criteria 4 – Change in Risks of Flooding Due to Changes in Rainfall and Runoff with Time

SSG-18 highlights the need to assess changes in hazards with time. Climatic variability and climate change may affect the frequency and severity of floods. The Desktop Assessments in this report addressing Climate and Climate Change, identified trends in rainfall out to 2090. Based on the RCP 8.5 2090 Scenario, for Lyndhurst, the average annual rainfall depth of 348 mm is expected to reduce by 9% (estimated range is -37% to +6 % for the 10^{th} to 90^{th} percentile). While annual rainfall is expected to reduce, rainfall is expected to occur less frequently with greater intensity. The average annual temperatures are expected to increase by 3.3°C (+2.6°C to +4.1°C for the 10^{th} to 90^{th} percentile).

There is an industry ‘rule of thumb’ that for every one degree increase in average annual maximum temperature, rainfall intensity increases by 5%. Thus, for Lyndhurst, this equates to an approximate 15 to 20% increase in rainfall intensity. The impact of this will be an increase in the magnitude of floods experienced in the catchment and an increased frequency and severity of potential road closures. The impacts of these changes on the sites will require hydrological and hydraulic modelling as part of the Stage Two assessment should the site be further considered.

2.5.3 Design Issues and Mitigation Measures

Based on the desktop assessment, there are a number of design and mitigation measures that could be considered to manage the potential flooding hazards at the site. These are summarised in Table 29.

Table 29 Design Issues and Mitigation Measures

Design Issue	Potential Mitigation Measure
Local overland flows through site	Localised filling and regrading of the site. Potential diversion drains
Waterlogging	Surface and subsurface drainage design to control surface runoff and saturation of the soil profile
Large flood affecting site	Bund / Levee
Flood prone access	Upgrade local roads and drainage structures Provide an alternative access route

2.5.4 Data Gaps and Recommendations for Stage 2 Work Program

2.5.4.1 Data Gaps and Limitations

There is a general lack of available information on flooding in the area. There is no flood data for the non-perennial watercourse to the north-west of the site. There are no surveyed levels along the historic shoreline of Lake Gilles. Therefore, key gaps to enable the desktop assessment to be refined are:

- Flood studies to determine reliable flood extents corresponding to localised and catchment wide flood events for a range of AEP;
- Dimensions and levels of key structures that would need to be included in the flood model of the catchment (e.g. road culverts); and
- Information on suitable hydrological rainfall loss parameters for the catchment.

2.5.4.2 Recommendations for Stage 2 Work Program

To enable a more detailed assessment of the site, for the Stage 2 work program it is recommended that:

- Flood modelling is undertaken to quantify flood and geomorphological risks at the site and key access routes. This will include:
  - Obtaining information on existing relevant drainage infrastructure. Where there are gaps, obtaining the information through field survey;
  - A detailed hydrological study;
  - A detailed hydraulic modelling study; and
  - Potentially obtaining additional LiDAR data to cover flood prone areas identified through initial hydraulic modelling results.

It would also be desirable to obtain:

- Soil hydraulic conductivity tests at a number of sites through the catchment.

2.6 Impacts of Nearby Human Activities and Land Use Planning

2.6.1 Methodology and Results

A detailed desktop assessment for the Lyndhurst site was undertaken to investigate risks from the potential impacts of human activities.

The desktop assessment included a review of relevant publically accessible databases, planning documents and property information.

To determine the likely impact of human activities on a facility at the Lyndhurst site the following considerations inform our assessment:

- Identification of current land uses on the subject site and surrounding properties; including identifying separation distances from current sensitive land uses and recreational and tourist areas;
- Development Plan/Zoning review of the site and surrounding properties, to ascertain development potential and future land uses envisaged on the land and adjacent properties;
- Identification of any current and recently approved development applications on the site and within the locality;
- Population density assessment within the locality, including future trends;
- Identification of any mineral, petroleum, geothermal and gas leases and tenements (exploration & production) on the site and within the locality;
- Identification of any major chemical/ fertiliser or oil facilities, mines and mineral deposits, military facilities, intensive primary production and bulk handling facilities within the locality;
- Identification of transport infrastructure on the land and within the locality, including airfields, main roads, tourist routes and railway lines;
- Review of any flight path and crash data within the area (commercial, private and agricultural);
- Review of water extraction (e.g. from surface water, rainwater, groundwater) and nature of usage (potable, irrigation, stock watering, etc.) around the site and local area – information on this item was obtained during the hydrology and hydrogeology assessments; and
- Location and nature of water retention structures that could lead to flooding – information addressed under the hydrological/ flood risk assessment.

2.6.1.1 Site Characteristic Criteria

The following Site Characteristic Criteria have been determined to be relevant to the impacts of nearby human activities and land use planning:

Criteria A – Existing and potential future land uses that may adversely impact the site

Criteria B – Existing and potential future sensitive land uses on the site and in surrounding areas

The assessment criteria have been formed having regard to IAEA Specific Safety Guides SSG-35 *Site Survey and Site Selection for Nuclear Installations* and IAEA Safety Requirements NS-R-3 (Rev.1) *Site Evaluations for Nuclear Installations.*

2.6.1.1.1 Criteria A – Existing and potential future land uses that may adversely impact the site

The intent of Criteria A is to identify the presence of, and future potential for, development on the site and within the locality that may adversely impact use of the site for the NRWMF.

For the purpose of the assessment development that may adversely affect the facility has been considered to include:

- Major extractive industries
- Chemical and fertiliser storage facilities

- Airfields
- Major transport infrastructure
- Military facilities
- Broadcasting and communication networks

These uses have the potential to create hazardous human induced events which may affect the proposed facility.

In addition to the above listed development, intensive primary production development, including bulk handling/storage facilities and intensive animal keeping have also been considered. Given the rural characteristics of the area there is potential for these types of facilities and as such were added to the considerations.

Intensive primary production activities have also been considered as potential origins for human induced hazards associated with the risks relating to fires and high frequency of heavy vehicle transportation.

2.6.1.1.2 Criteria B – Existing and potential future sensitive land uses on the site and in surrounding areas

The intent of Criteria B is to identify the existence of sensitive land uses and potential for sensitive land use to be established on the site or within the locality. The encroachment of such sensitive land uses has the potential to impact and be impacted by the construction and operations of the proposed facility.

For the purposes of the assessment sensitive land uses considered under this Assessment Criteria include:

- Residential development (single dwellings & townships)
- Tourist development and areas (conservation and recreation areas)
- Commercial, Industrial and Employment developments
- Community facilities and areas

2.6.1.2 Desktop Methods and Results

2.6.1.2.1 Data Sources

The following key resources were accessed and utilised to complete this assessment:

- Department of Environment, Water and Nature Resources online mapping tool – NatureMaps;
- Government of South Australia online mapping tool - Location SA;
- Department of Planning, Transport and Infrastructure online mapping tool – Property Location Browser (PLB)
- Department of State Development South Australian Resources Information Geoserver mapping tool;
- Google Maps
- Kimba Council Development Plan; consolidated 25 October 2012
- Australian Bureau of Statistics - Population Data;
- Department of Planning, Transport and Infrastructure, SA Planning Portal – Public Register;
- Australian Transport Safety Bureau – civil aviation accident and incidents data; and
- Discussions with staff from District Council of Kimba

2.6.1.3 Review of Data

The following is a summary of the investigations undertaken as described in section 2.6.1.

The assessment focuses on land uses and development within an 8 kilometre buffer area around the sites. The 8 kilometre buffer has been established having regard to the screening value examples outlined in Table II-1 of Annex II in IAEA Specific Safety Guides SSG-35 *Site Survey and Site Selection for Nuclear Installations.*

Notwithstanding the above, where relevant any notable features outside of the buffer area have also been identified.

2.6.1.3.1 Existing Land Uses

As identified by a site visit and a review of aerial photography, the site consists of vacant land which has a longstanding historical use for agricultural, namely cropping and grazing.

Primary production is the predominant land use of the adjoining land and other properties throughout the wider locality, particularly to the south and west. Large areas of vegetation exist on the properties to the north, northwest and west of the site.

Based on a review of aerial photography sensitive land uses in the locality are principally limited to dwellings and farm buildings. The nearest sensitive land uses consist of:

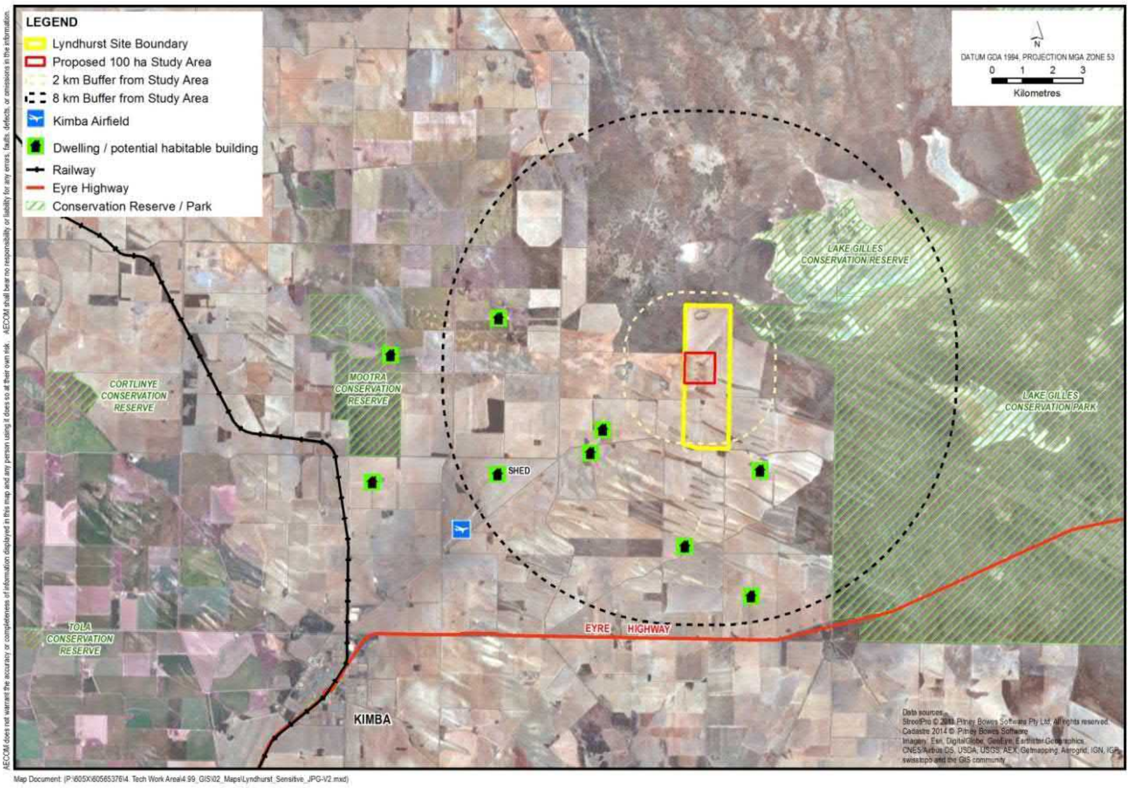
- The closest dwelling which is located approximately 2.6 kilometres to the southwest of the site. A further five dwellings are located within 8 kilometres of the site boundary. These dwellings are mainly to the south and west of the site.
- Kimba, the closest township to the site which is located approximately 14 kilometres southwest of the site.

Other sensitive land uses in the area include:

- The Lake Gilles Conservation Park which is located approximately 2 kilometres to the east of the site. Limited tourist facilities are provided within the park and self-sufficient bush camping is permitted throughout the park. A public observation area is located approximately 3 kilometres east of the site at the northern end of Lake Gilles Road.
- The Moonta Conservation Park is located approximately 10 kilometres to the west.

The key existing features within the locality are depicted in Figure 14 below. The uses identified in the figure have been confirmed by staff from the District Council of Kimba.

Figure 14 Key existing features within locality



2.6.1.3.2 Development Plan Review

The Development Act 1993 is South Australia's core legislation dealing with the planning and development system. The Development Act requires all areas of the state, including councils and areas not covered by a council area, to have a designated development plan.

A development plan is a statutory policy document, which guides the type of development that is envisaged to occur within a particular area and provides the basis against which development assessment decisions are made. The purpose of reviewing the development plan which is applicable to the site and surrounding properties is to identify the types of land uses and development that may be established on the surrounding properties in the future.

The relevant Development Plan for the site and surrounding areas is the Kimba Council Development Plan, consolidated 25 October 2012. The review of the Development Plan identified:

- The site is located within the Primary Production Zone as illustrated on Zone Map Kim/1 within Council's Development Plan. The Primary Production zoning applies to the surrounding properties and the majority of the land outside of the Kimba Township. The intent of the Primary Production Zone is to maintain and support Primary Production activities. Policy also seeks to protect the scenic qualities of rural landscape.
- Development envisaged in the zone principally consists of a range of primary production uses. Tourist accommodation and wind farms are also envisaged forms of development. Dwellings are contemplated in the zone where established in association with primary production and limited to one dwelling per allotment.

The boundaries of the District Council of Kimba are located approximately 1.5 kilometres and 4 kilometres to the north and east respectively of the site. The land outside of the Kimba Council is held within the Remote Areas Zone of the *Land not within a Council Area Eyre, Far North, Riverland and Whyalla Development Plan*. Policy within the Remote Areas Zone envisages a range of mining, agricultural, residential (remote settlements) and renewable energy (specifically wind farms) land uses.

Both development plans (Kimba and Land not within a Council Area) also contains council wide policy which guides development generally across the entire area affected by the development plan. Relevant council wide policy encourages non-rural development to be established within and adjacent existing townships or within other appropriate zones.

In summary, the primary intent of the development plan policies for the site and surrounding land is to maintain primary production activities. The development plan policy also promotes that urban and other forms of development be established within existing townships or appropriate zones.

Based on the current development plan policy the likelihood of any urban development adversely affecting the potential future use of the Lyndhurst site for a low level radioactive waste facility would be low.

2.6.1.3.3 Current and Recently approved Development Applications

The purpose of this review was to identify development that may be approved, but yet to be constructed.

Staffs from the District Council of Kimba have confirmed that no recent development applications have been lodged or approved within the site or on surrounding properties.

To assess the surrounding land outside the District Council of Kimba, a review of South Australian Government's planning portal was undertaken. No recent development applications or approvals were identified on land within 8 kilometres of the site.

2.6.1.3.4 Population Assessment

A review of Australian Bureau of Statistics (ABS) Census Data identified:

- The Lyndhurst site is located in the Local Government Area (LGA) of Kimba and with the suburb of Mosley.
- The Kimba LGA has experienced a slight decrease in population from 1,088 in 2011 to 1,067 in 2016.

- The suburb of Moseley recorded a population of 19 in 2016. ABS changed their data collecting boundaries in 2016 and therefore there was no population data recorded in the 2011 census for the suburb of Mosley.
- In 2011 the ABS released population projections for local government areas which forecast the population of the District Council of Kimba reducing to 921 by 2031.

The review of ABS data indicates an historical and projected decline in population within the region.

2.6.1.3.5 Mineral, Petroleum, Geothermal and Gas Leases and Tenements

A review of Department of State Development South Australian Resources Information Geoserver mapping tool (SARIG) was completed to identify any current Mineral, Petroleum, Geothermal and Gas Leases and Tenements over or within proximity of the site. The presence of any leases and tenements could indicate potential for mining and other extractive activities to occur in the future.

Based on the review, no exiting tenements exist over the site. However, three mineral licences/leases are located within 8 kilometres of the site and will require further assessment should the Lyndhurst site be selected as the preferred site.

The nearest active tenement is a small scale gypsum mineral lease which is located approximately 3.5 kilometres to the east of the site.

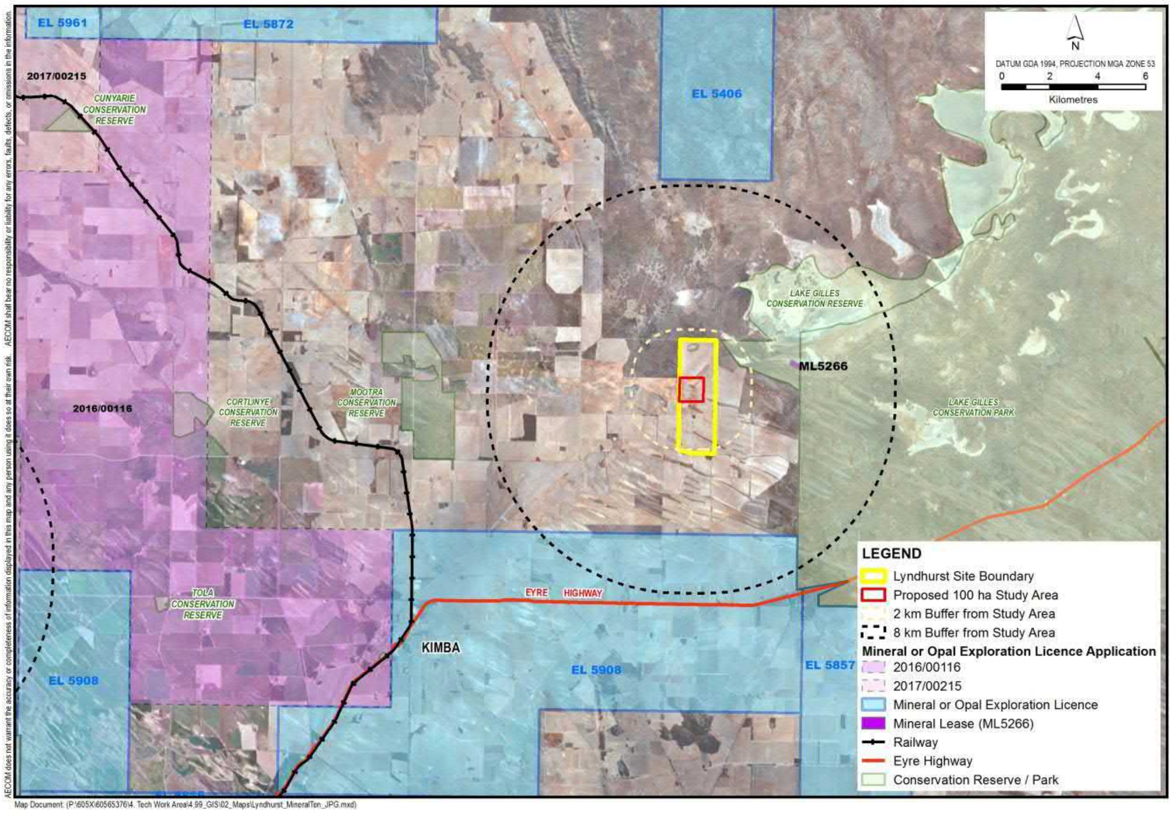
Table 30 provides detail of each lease and license identified and Figure 15 below illustrates the location of each tenement with respect to the site.

Table 30 Leases and Tenements

Lease/Tenement No.	Lease/Tenement Owner	Lease/Tenement Type	Distance from Site
5266	Kayser, Trina, Cummings, Nita, Rawson, Tanya Marie	Mineral Lease – Gypsum (strip mining) Expiry Date: 02/04/2020	3.5km to the east
5908	Investigator Resources Limited	Exploration Licence – Mineral (Silver, Graphite, Gold, Zinc, Copper & Lead) Expiry Date: 05/11/2018	5.5 km to the south
5857	Gawler Resources Pty Ltd	Exploration Licence – Mineral (Graphite) Expiry Date: 26/04/2018	9km to the south, south west
5406	Gawler Resources Pty Ltd	Exploration Licence – Mineral (Silver, Gold) Expiry Date: 19/04/2018	8km to the north

Unlike other development which is assessed pursuant to the Development Act 1993, in South Australia the Mining Act 1971 and the Petroleum and Geothermal Act 2000 are the core legislation relating to mining, petroleum, gas and geothermal activities.

Figure 15 Location of each tenement



2.6.1.3.6 Major chemical/ fertiliser or oil facilities, mines and mineral deposits, military facilities, intensive primary production and bulk handling facilities

Developments that may adversely affect use of the Lyndhurst site for the facility include:

- major chemical/ fertiliser or oil facilities,
- military facilities,
- broadcasting and communication networks
- intensive primary production and bulk handling facilities,

None of these land uses were identified within 8 kilometres of the sites.

Current and future potential for mines and mineral deposits is addressed in section 2.6.1.3.5.

It is noted that the nearest military facility is located at Cultana which is approximately 55 kilometres to the east of the site.

2.6.1.3.7 Major Transport Infrastructure

Transport infrastructure within the locality of the site consists of:

- Eyre Highway located approximately 9 kilometres to the south
- Kimba Aerodrome located approximately 8 kilometres to the south west

2.6.1.3.8 Flight Path and Crash Data

The Kimba Aerodrome is located approximately 8 kilometres to the south west of the site and is approximately10.5 kilometres from the site via the existing road network.

The aerodrome is a CASA registered aerodrome (registered 8/01/04) and is the main aerodrome in the region.

Staff from the District Council of Kimba advised that the airfield is a 24 hour facility and currently accommodates approximately 1 flight per week. The airfield is principally used for emergency services (Royal Flying Doctor), together with pilot training flights from Port Pire and Adelaide and private aircraft.

As outlined in the Kimba Aerodrome Master Plan 2016 prepared by the Council, and confirmed by Council staff, there are no current plans to expand the existing aerodrome.

No flight path data is available, however, the Kimba runway is orientated northeast-southwest, and as such, aircraft approach and take-off movements would likely be aligned towards the site which is located to the northeast of the aerodrome.

Considering the above, further assessment in relation to existing aircraft flight patterns in relation to the site may be required at the next stage of the assessment should the Lyndhurst site be further considered. However, given the scale and use of the aerodrome together with the separation distance from the site, it is not anticipated that the site would be located within a major flight path area and subject to a high level of risk from an aviation impact perspective.

A review of the Australian Transport Safety Bureau aviation safety database indicates that no aviation accidents or incidents have occurred on the site or within the wider locality since 1991.

2.6.1.4 Water extraction and Water Retention Structures

These issues have been investigated as part of Flora, Fauna and Conservation (insert reference), and Climatic Conditions (insert reference) – refer to relevant desktop assessment.

2.6.2 Assessment Against Criteria

The following provides a summary of the investigations which are relevant to Site Characteristic Criteria A & B.

2.6.2.1 Criteria A - Existing and potential future land uses that may adversely impact the site

Based on the data review, the findings for existing and potential land uses that may adversely impact the facility indicates that:

- No development that may adversely affect the facility was identified on the site or within 8 kilometres of the site. In addition, no recent development applications have been lodged or approved for such development within the site or on the land within 8 kilometres of the site.
- Based on the current development plan policy, the likelihood of adversely impacting development occurring in proximity of the site in the future would be low.
- The nearest transport infrastructure is the Kimba Aerodrome located approximately 8 kilometres to the south west. As a result of the orientation of the runway towards the site, further consideration of potential aviation impacts may be required at the next stage of the assessment.
- The site is well separated from other major transport infrastructure including main roads.
- A number of mineral tenements exist within close proximity of the site. The existence of these tenements results in the potential for extractive industry activities to occur in the future adjacent the proposed site.

2.6.2.2 Criteria B - Existing and potential future sensitive land uses on the site and in surrounding areas

Based on the data review, the findings of existing and potential sensitive land uses are:

- A number of sensitive land uses were identified within 8 kilometres of the site. These principally consist of dwellings, with the nearest dwelling located approximately 2.6 kilometres to the south west of the site. The dwellings exist at a very low density with 5 dwellings located within an 8 kilometres radius of the site.
- Based on the relevant zoning, dwellings and tourist accommodation in association with primary production activities are envisaged on land within and surrounding site. The potential for more intensive residential or urban development to be established within proximity of the site is low

based on the current development plan policy and considering the declining population trend within the region.

2.6.2.3 Assessment Summary

The site is well separated from adversely affecting development and sensitive land uses.

The land zoning, together with the physical characteristic of land within the locality and declining population trend, suggests that the likelihood of adversely affecting and sensitive development being developed in proximity of the site in the future would be unlikely.

A key consideration is the existence of a number of mineral tenements within close proximity to the Lyndhurst site. If these tenements proceed to major production, the associated activities may have the potential to impact the facility and will require further assessment. In addition, further consideration of potential aviation impacts associated with the nearby Kimba Aerodrome may be required at the next stage of the assessment.

2.6.3 Design Issues and Mitigation Measures

The design of the proposed NRWMF should consider setback distances from the project and property boundaries to maximum separation distances to other properties and uses (existing and future).

Further consideration should be given to the establishment of buffers around the site to restrict the encroachment of uses that have the potential to adversely impact the facility, in particular future mining activities. Such buffers could be formed by way of planning scheme amendments, land acquisition or legislation. This issue will be considered at the next stage of the assessment.

2.6.4 Data Gaps and Recommendations for Stage 2 Work Program

2.6.4.1 Data Gaps and Limitations

No significant data gaps were identified as part of the desktop study.

2.6.4.2 Recommendations for Stage 2 Work Program

It is recommended that further investigations be undertaken to identify whether there is any further information available on the mining tenements in the vicinity, and whether there is a likelihood that exploration activities could result in development of mining operations in the future. In addition, further assessment of potential aviation impacts associated with the nearby Kimba Aerodrome should be undertaken if Lyndhurst is considered further.

3.0

Subsurface Environment

3.0 Subsurface Environment

A desktop and field assessment of the subsurface environmental conditions within the site and surrounds is outlined below. The characteristics of the subsurface environment covered in this assessment include hazards associated with stability of the landscape and landforms, soils, geology and hydrogeology (including geotechnical stability and geochemistry), and seismicity.

Site characteristic assessment criteria that have the potential, either alone or in combination with other criteria, to impact on siting of the facility were developed. Desktop and anecdotal information relevant to the site and the local and regional area was reviewed. Aerial surveys of the bedrock (magnetics) and the terrain/ topography (using LiDAR) of the site and surrounds were undertaken. An on-ground seismic survey, a borehole drilling and test pitting program, geophysical and geotechnical field tests, and the analysis of soil and groundwater sample samples was also carried out. The desktop and field data of the surface environment interpreted for assessment against the site characteristic criteria.

Site characteristic values and hazards can often be mitigated by the facility design. Potential design issues and mitigation measures that could be employed to address them have been identified. The Site Characterisation and facility design are running in parallel and will inform the other as the site selection process progresses.

Assessment data gaps and recommendations for additional work scope items to fill such gaps in a more detailed second stage of the Site Characterisation studies are provided for each of subsurface environmental characteristics.

3.1 Geology, Hydrogeology, Geochemistry, Geotechnical and Soil

3.1.1 Methodology and Results

3.1.1.1 Site Characteristic Suitability Criteria

Subsurface characteristics favourable for meeting the three assessment objectives for this investigation are as follows:

Table 31 Geological, Hydrogeological, Geochemical, Soil and Geotechnical Site Characteristic Criteria

Assessment Objective	Site Characteristic Criteria	Preferred Characteristic
Infrastructure Foundation Stability	Presence of collapsing or expansive soils	Relatively flat topography Cohesive soil profile Watertable at depth (>10m)[10]
	Slope instability	
	Subsidence due to ground features	
	Long-term settlement	
	Scour and erosion processes	
	Potential of soil liquefaction	
Soil Quality	Detrimental soil quality properties that may lead to degradation and hydraulic properties that may increase the severity of flooding or erosion	Soils that are not saline, sodic, dispersive, do not have an aggressive pH, nor prone to waterlogging
In-situ Water Supply	Current of potential beneficial uses of groundwater	Presence of a pumpable groundwater supply aquifer (Yield min. 175 m^3/d or 2 L/s)
		Water Quality - Potable to brackish salinity groundwater[11]
Potential for Subsurface Solute Transport	Subsurface material with chemical attenuation properties	Subsurface with acid buffering capacity and surface sites for adsorption and ion exchange
	Depth to groundwater and vertical connectivity between groundwater horizons Potential for vertical migration of solutes through sediments or bedrock	Deep (>10m)[10] regional watertable & piezometric surfaces
		No perched watertable
		Few or widely (vertical) separated aquifers
		Thick, impermeable to low permeability aquitards
	Potential for horizontal migration of solutes through saturated sediments or bedrock	Low horizontal hydraulic gradient
		No, few or distant third-party groundwater users/receptors

[10] 10m depth to saturated subsurface conditions is considered sufficiently “deep” to avoid interactions with deep building or infrastructure foundations/footings or buried services (i.e. within 2m of ground surface), including an allowance for capillary rise in potential fine grained sediments within the vadose zone and the natural seasonal/diurnal variation in groundwater levels which cumulatively may vary cycle over a range of several meters

[11] For the purposes of this assessment potable (< 1,000 mg/L as Total dissolved salts: TDS) water quality is more favourable than brackish (< 5,000 mg/L as TDS) which is more favourable than saline (>10,000 mg/L as TDS).

3.1.1.2 Desktop Methods and Results

Natural Resource Management Setting

The Natural Resource Management Setting for the site provides the context for the density of information available for review.

The Natural Resources Management Act 2004 divides South Australia into eight regions. This is to ensure that the natural resources of each area are managed in an appropriate and sustainable way.

The WaterConnect database provides an overview of the Natural Resource Management (NRM) Regions and the management areas within those areas.

A summary of the relevant management areas in relation to the Lyndhurst site is provided in Table 32.

Table 32 Natural Resource Management zones for Lyndhurst

NRM Categories	Management Zone
NRM Region	Eyre Peninsula (EP)
Surface Water Basin	Gairdner
Groundwater	Eyre Peninsula Non Prescribed Groundwater Area Non Prescribed Groundwater Management Zone Low competition for resources with low consumptive use and use of the water resource is uncapped or has not been fully allocated.
Surface Water	Eyre Peninsula Non Prescribed Surface Water Area Non Prescribed Surface Water Management Zone Outside of Specified Areas Surface Water Management Zone

By virtue of the site being located in a non-prescribed area the water resources tend not to be utilised and available information is often sparse or of poor quality.

It is noted that the absence of information does not imply that a range of beneficial uses of the groundwater and surface water do not exist locally. For example, without documented evidence, the presence of groundwater dependent ecosystems or the potential for groundwater systems to support *stygofauna*[12] beneath the site or immediate surrounds cannot be discounted.

The desktop study reviewed publicly available reports and mapping datasets accessed from on-line databases which are listed in the references section of this report. The aim of the desktop study was to understand the hydrogeological setting of the site and surrounds with respect to the assessment criteria listed above and to inform a planned drilling program to gather specific sub-surface information within the nominated site.

Soil and Geotechnical Desktop Overview

AECOM reviewed publically accessible databases and literature relating to relevant soils and geotechnical conditions at the Lyndhurst site, as specified in the references section. There was no published site specific information on the soil or geochemical profile for neither the site nor the broader local area.

Information reviewed for the likely soil conditions underlying the site have been sourced from map coverages provided by the Location SA Map Viewer and ASRIS on-line data bases. Information provided for these coverages are compiled from individual land resource surveys completed over many years using various methods and cover the parts of Australia where 1:50,000 to 1:250,000 (approximately) land resource surveys have been undertaken.

[12] Stygofauna are any fauna that live in groundwater systems or aquifers, such as caves and fissures.

The South Australian spatial data from ASRIS is taken directly from Land and Soil Spatial Data for Southern South Australia - for GIS Applications (Soil and Land Program, 2005). This dataset is based on an interpretation of 1:40,000 stereo colour aerial photography and limited field inspection of landscapes and soils by soil scientists. Soil Landscape Map Unit boundaries were traced onto 1:50,000 and 1:100,000 base maps which were digitised or scanned into a GIS, where the spatial data were edited. Soil Landscape Map Unit boundaries were determined after an integration of field observations and recordings, laboratory analyses, stereoscopic examination of aerial photographs, understanding of regional landscape processes and stratigraphy, existing soil and geological mapping data, and an examination of land and soil attributes.

SA Base Mapping Scales: Eyre Peninsula may have been mapped at 1:100,000. Total compound registration error could be up to 300 metres at 1:100,000 scale or 150 metres at 1:50,000 scale. This scale of coverage is equivalent to the ASRIS 2004 Technical Specification Level 5. This has been created from the map viewer accessed on 5/03/18 and shows the soil subgroups within and surrounding the Lyndhurst site. Soil classes are based on those described in the reference publication The Soils of Southern South Australia (Hall *et al*. 2009).

Information reviewed for the likely soil conditions underlying the site have been sourced from map coverages provided by the Location SA Map Viewer and ASRIS on-line data bases. Information provided for these coverages are compiled from individual land resource surveys completed over many years using various methods and cover the parts of Australia where 1:50,000 to 1:250,000 (approximately) land resource surveys have been undertaken.

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SA Base Mapping Scales indicates that data coverages for the Eyre Peninsula may have been mapped at 1:100,000. Total compound registration error could be up to 300 metres at 1:100,000 scale or 150 metres at 1:50,000 scale. This scale of coverage is equivalent to the ASRIS 2004 Technical Specification Level 5.

Figure 16 has been created from the map viewer accessed on 5/03/18 and shows the soil subgroups within and surrounding the Lyndhurst site. Soil classes are based on those described in the reference publication The Soils of Southern South Australia (Hall *et al*. 2009).

ASRIS map view provides mapped extents based on area weighted averages for a given unit.

ASRIS Level 5 Feature ID:	Composition
PNK_HTB1 = D3	D3 34% Hillslope landform element, ref profile CM022 D2 26% Hillslope landform element, ref profile CM056 A5 25% Hillslope landform element, ref profile CM002 H2 8% Dune landform element, ref profile EF021 G1 7% Dune landform element, ref profile EE068
PNK_UkI1 = A5	A5 65% Swale landform element, ref profile CM002 H2 20% Dune landform element, ref profile EF012 G1 15% Dune landform element, ref profile EE068
PNK_U-C1 = H2	H2 55% Dune landform element, ref profile EF012 G1 45% Dune landform element, ref profile EE068
THU_ZI-1 = N2	N2 75% Swamp landform element, ref profile MM068 A8 25% Lunette landform element, ref profile MM155

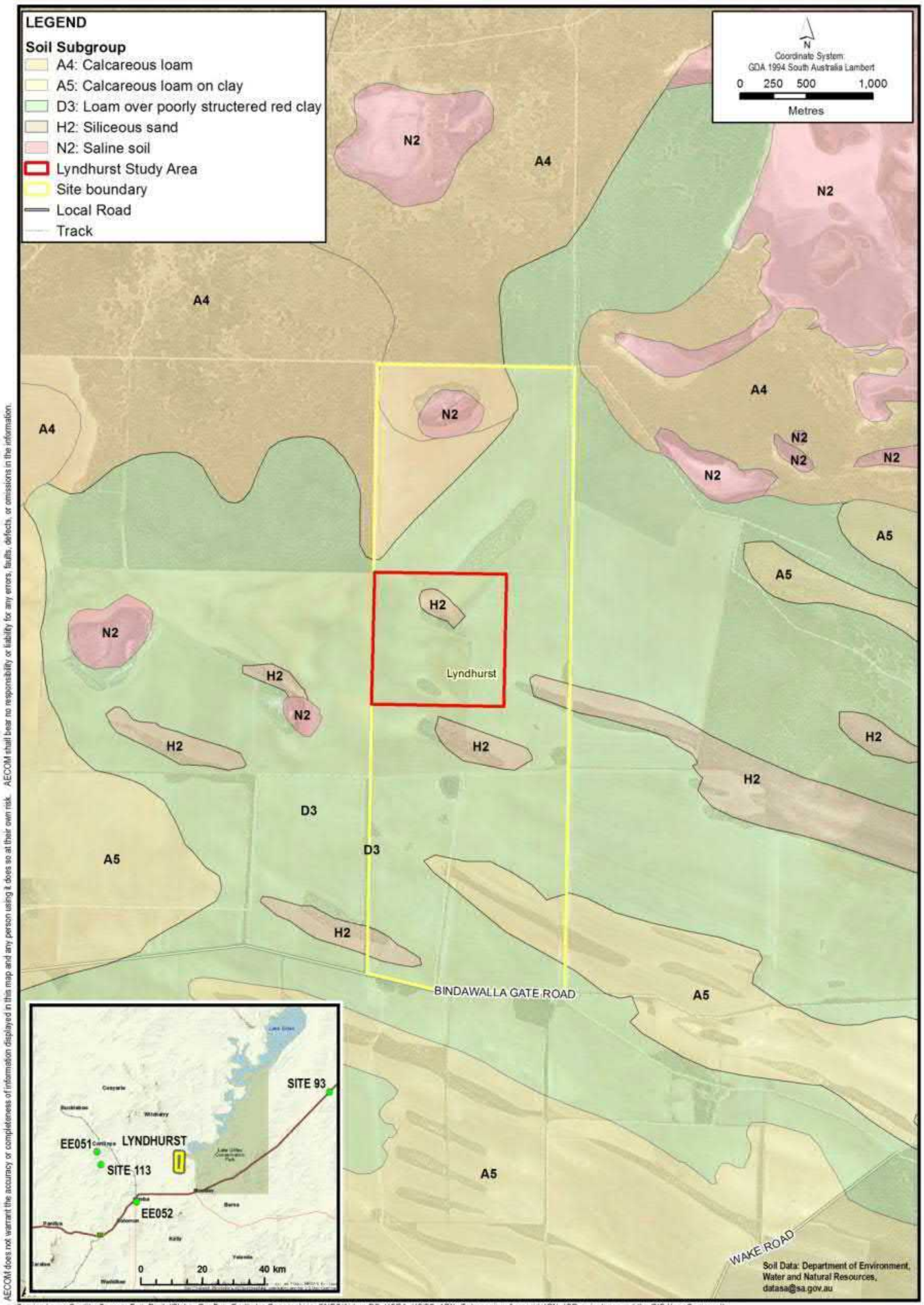
The landforms are described by ASRIS are low hills and ridges and plains with salt lakes and dunes. The generalised description is consistent with site inspection observations made by AECOM on the 22 February 2018 of the site and summarised below:

- The local landscape comprises a series of sand ridges (some parts still with Mallee eucalypt vegetation). The generally isolated sand ridges are aligned in a northwest-southeast orientation, causing localised surface water to runoff in a number of directions.
- Soil types (as indicated in the soils info update) within the site are inferred by the mapping to comprise a thin loam over calcareous clay (D3) with potential for some areas to comprise siliceous sands (H2, likely associated with sand ridges). In nearby areas the soil types may include calcareous loams and saline soils at locations in which salt lakes are present within the broader Lyndhurst site boundary.
- A low lying salt scald is inferred from the mapping to be located in the northern portion of the property outside the site (classified as soil subgroup N2 with a swamp landform element).
- Anecdotal information from the landholder of ponding in winter in localised areas, likely due to calcrete horizons near-surface or poor draining clays with the greatest extent of calcareous horizons reported to be located in the southern portion of the site.
- Site reconnaissance photographs that were taken by AECOM on 22 February 2018 show general landforms for the Lyndhurst site.

Low lying area to the south of the site (mapped as H2 soil subgroup) where ponded water has previously been observed.

Majority of site showing red-brown soils (D3 soil subgroup) with nodular calcrete. Vegetated dunes in the distance.

Figure 16 Soil distribution map for Lyndhurst, mapped at landscape scale (Soil & Land Program, 2005)



Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community
Map Document: (P:\605X\60565376\4. Tech Work Area\4.99_GIS\02_Maps\Lyndhurst_Soils_JPG.mxd)

ASRIS information for the surface and subsurface profile (to a depth of around 2 m) for the most spatially prevalent soil types in the site mapped at the landscape scale (without field surveys) include:

- D3, a surface loam over a poorly structured clay. is inferred by mapping to be the most prevalent soil type in the site and across the site, with the following properties[13] based on testing of the reference soil type:
  - of neutral to slightly alkaline pH across the profile
  - a well-draining loam with an underlying clay that is likely to have a saturated hydraulic conductivity of around an order of magnitude lower
  - a non-saline surface loam with underlying clay of moderate salinity
  - a non-sodic surface loam with underlying sodic clay becoming strongly sodic with depth
  - potentially highly dispersive clays at depth
- H2, a 'siliceous soil' comprising sand underlain at depth potentially by a thin clayey sand and sandy clayey loam, is inferred by mapping to potentially be present on a sand ridge in the site, with the following properties based on testing of the reference soil type:
  - very well drained sands with moderate drainage in underlying soils at depth
  - neutral pH soils
  - non-saline soils across the profile
  - non-sodic sands underlain by a sodic clayey sand then a strongly sodic sandy clayey loam
  - potentially highly dispersive clays at depth.

Outside the site soil types A5 (calcareous loam over clay) and N2 (saline soil, inferred by AECOM to be associated with a salt pan) have also be inferred mapped within the property boundary but outside the site. It is considered possible that soil type A5 could potentially be present within the site, in which the profile has similar properties to soil type D3.

The Atlas of Australian Acid Sulfate Soils was compiled by CSIRO to provide a consistent national coverage. Based on the ASRIS map interrogation function, all three soil subgroups at the Lyndhurst site are identified as Cp(p4), as having an extremely low probability of occurrence (mapped at a source map scale of 1:2M) under the Acid Sulfate Soil Classification risk assessment criteria. It is noted that confidence Level 4 is ascribed to this risk assessment as it is a provisional classification inferred from surrogate data with no on ground verification.

Table 33 summarises the assessment based on only of the likelihood of the presence of the geotechnical hazards at the site. It should be noted that these findings are based on the data available at this point in the assessment process and that further investigations will be required should Lyndhurst progress as a potential site.

[13] Hazelton, P. and Murphy, B. 2007. *Interpreting Soil Results: What do the Numbers Mean?,* CSIRO Publishing.

Table 33 Desktop Assessment of Potential Geohazards

Geohazard	Likelihood	Findings
Slope instability	Unlikely	Based on the ground elevation data from NatureMaps (Feb, 2018), the proposed site is located on a flat area with an elevation of approximately 220 mAHD.
Soil liquefaction	Unlikely	Generally, soils susceptible to liquefaction are non-cohesive soils such as sand and gravels occurring in loosely deposited conditions below the water table (IAEA Safety Guide No. NS-G-3.6). Based on the desktop data that while sands are present at the site, it is considered unlikely for the site soils to be subject to soil liquefaction due to deep groundwater (> 20 m bgs) present at the site as identified based on the review of registered well data from WaterConnect. It is noted that there is a potential for shallow perched groundwater (<3.66 m bgs) which was recorded in one well.
Presence of collapsing or expansive soil	Collapsing – Possible Expansive - unlikely	Based on the surface geology information indicating the presence of sands across the site, it is unlikely that expansive soils will be present. It is possible that collapsing soils are present in the region (Selby, 1979). South Australia has a large percentage of Australia's collapsing soils with these soils generally known as brown solonised/calcareous soils which contain calcium carbonate contents. These soils are generally aeolian or wind-blown deposits.
Subsidence due to underground features	Unlikely	With reference to 1:250,000 Whyalla Sheet SI5308 in the SA Geological Atlas Series, there are no natural features such as caverns and a review of topographic maps and SARIG database suggests it is unlikely that human-made features such as underground mines are present.
Long term settlement	Unlikely	Based on the surface geology information, it is unlikely for the site soils to present long term settlement issues.
Scour and erosion processes	Possible	The semi-arid environment and severe rainfall events provide the potential for flash flooding in drainage channels/ interdune swales and adjacent low lying areas, which may lead to water erosion. If dunes on-site or off-site are cleared of vegetation then the sandy material will be more susceptible to wind erosion with the potential to lead to the deposition of windblown material on the site.

Geology and Hydrogeology Assessment Overview

The desktop study did not identify any site-specific lithological or geochemical information on the geological subsurface profile underlying the site or the broader Lyndhurst site in general.

Assessment of the geological profile was primarily reliant on mapped surficial extents and on-line data base queries via the WaterConnect and South Australian Resources Information Gateway (SARIG) search engines. All registered bores within a 10 km radius of the site are shown on Figure 17 with collated relevant information provided in Appendix C. From that review it was inferred that the site was likely to be underlain by approximately 30 to 50 m of unconsolidated sediments overlying a schist inferred to represent the consolidated basement rock.

Figure 17 also shows the location of the bores installed within the site during drilling works conducted in May 2018 which are discussed in greater detail in Section 3.1.1.3.

In addition to review of the existing available information, non-intrusive surveys of the site were also undertaken at the desktop assessment stage.

A seismic survey of the site was undertaken by Velseis Pty Ltd (Velseis) on behalf of AECOM in February 2018 to inform the drilling program planned for the site. The aim of the seismic survey was to identify any potential sub-surface structural features and to assist estimating the depth to basement (indurated rock) at depths between the surface and approximately 200 m below ground surface. A preliminary assessment of the site specific data obtained and interpreted by Velseis is included herein as Appendix C.

In addition, Daishsat Pty Ltd (Daishsat), was commissioned by AECOM to undertake an airborne geophysical survey of magnetics and radiometrics for the Lyndhurst site. As part of the commissioned work, a staff geophysicist with over 40 years' experience undertook a preliminary desktop assessment of the available geophysical data sets to ascertain whether significant basement structures exist below or adjacent the site. This preliminary interpretation of sub-surface conditions was refined with the acquisition and processing of the site specific airborne survey undertaken over two consecutive days (5^{th} to 6^{th} of April 2018) included here as Appendix C. The aim of the airborne magnetic survey was to collect data within the site and immediate surrounds at a higher resolution than available with existing data sets in order to better understand the nature and approximate depth of magnetic basement structures. The complementary airborne radiometric survey aimed at mapping the extent of naturally occurring surficial radioactive materials; specifically as Thorium (Th), Potassium (K) and Uranium (Ur) to provide baseline data.

Inferred Geological and Hydrogeological Profile

Information on the surficial geological cover has been sourced from the Whyalla Sheet SI 53-8 Geological Map Series 1:250,000 scale. Figure 18 shows the location of the Lyndhurst site in relation to the mapped surficial coverage which is covered in undifferentiated Quaternary Holocene-aged sediments. The site is predominantly draped in a veneer of white, pale grey and orange sand forming dunes (Moornaba Sand) with undifferentiated Quaternary veneers of red/brown sands, silts and clays south of the site. Outcrops of inferred Early Proterozoic Hutchinson Group quartzite occur east of the site. Mafic intrusions and metamorphic rocks (Miltalie Gneiss) occur within 6 km, to the south east. Charleston Granite also outcrops about 10 km to the south east of the site.

Review of available geophysical datasets was undertaken by Daishsat to ascertain whether significant basement structures exist below or adjacent the site.

Figure 17 Lyndhurst –Bores within a 10 km radius (including newly installed bores)

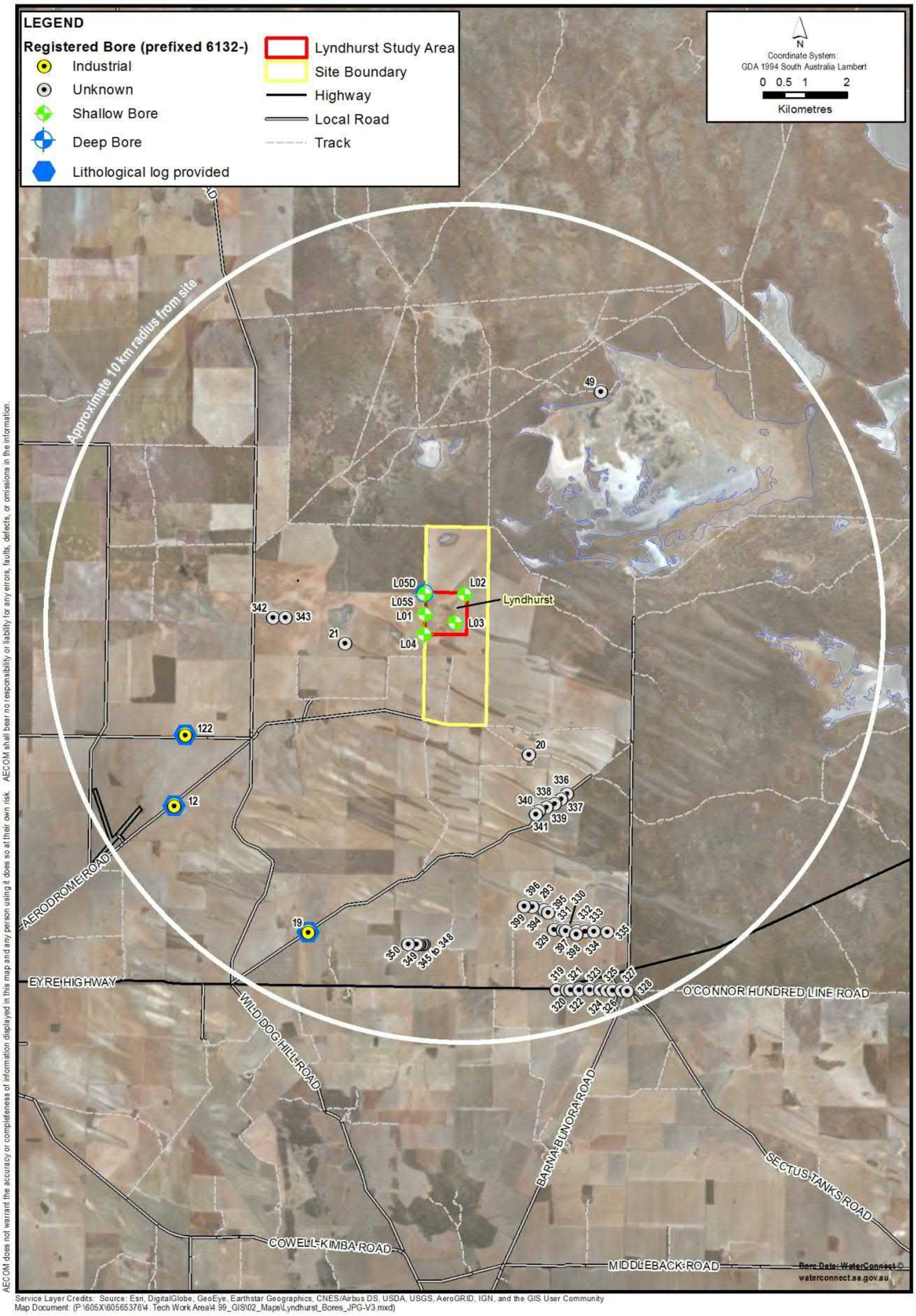
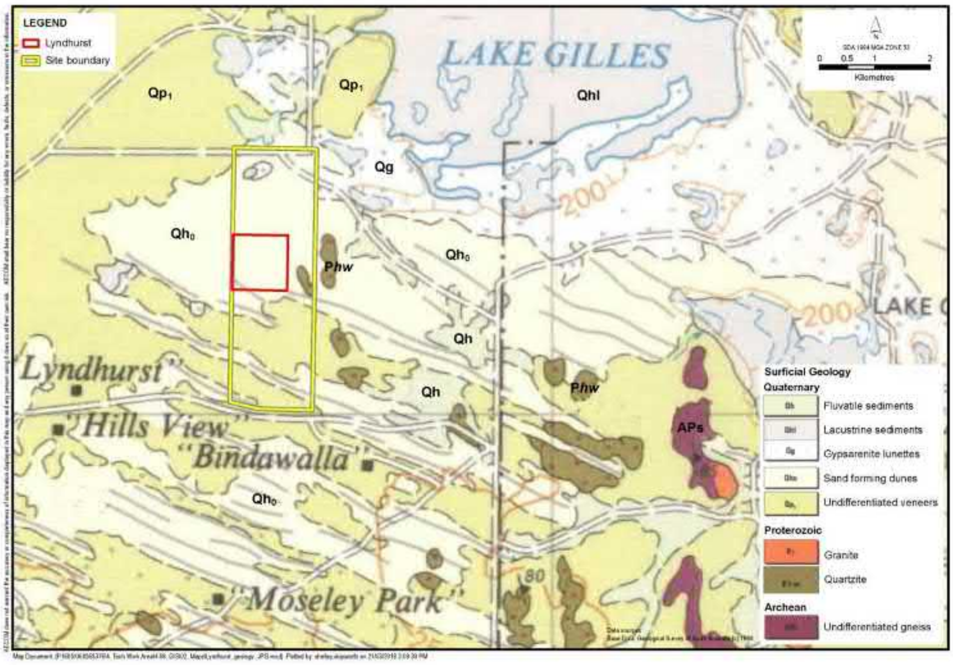


Figure 18 Lyndhurst Geology modified from Map 1:250,000 Whyalla Sheet SA 53-8



The findings of the Daishsat investigation indicate:

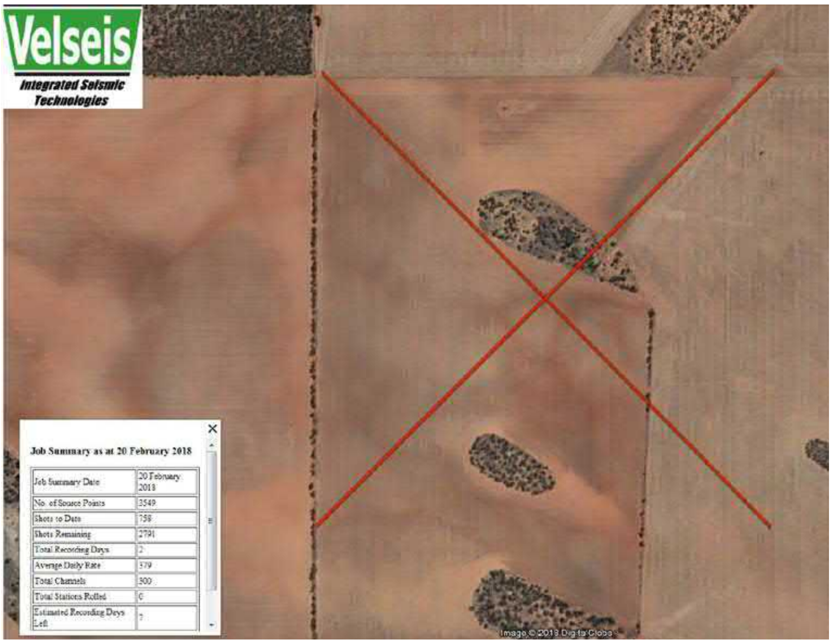
- The gravity response indicates that this site occurs over a relatively strong gravity gradient with an area of dense basement rocks to the west. The broad nature of the gravity response indicates that the dense basement is deep and would be unlikely to affect near surface sediments.
- Using company held magnetic data collected at a higher resolution an overlay of the Total Magnetic Intensity (TMI) image on the geology map, the geological units corresponding to a high magnetic response in close proximity to the investigation site are likely to be:
  - Miltalie Gneiss
  - Charleston Granite
  - Mafic Intrusions.

  The elongated north-westerly shape of the magnetic anomaly in the survey area is not typical of what is expected from a granite body, hence the basement rocks and source of the magnetic anomaly is most likely Miltalie Gneiss or a Mafic intrusion.
- From the detailed modelling of the magnetic data there is no evidence to suggest the presence of shallow basement or extensive faulting or structures at Lyndhurst. Magnetic models outlined in the interpretation report indicate that basement rocks are at least 500 m deep, and that shallower bodies overlying the basement are between 240 and 400 m deep.
- Airborne radiometric data, in particular the potassium and thorium response, has indicated a possible change in surface sediment composition to the south of the 1 km^2 target area. While this difference may be due to a change in the underlying rocks, this is unlikely to have any effect on the general geology of the target area.

A seismic survey was undertaken at the site with the objective to map any structure and if possible examine the potential for hydrological connectivity between the basement and shallow sediments. The scope of work undertaken by Velseis was tailored to maintain fold and horizon continuity, ranging from <40 to 200 m depth. Given the shallow depth and variable survey objectives, a 4 m geophone and shot interval was undertaken. The lighter energy source Mini-SOSIE technique was deployed which minimised vegetation disturbance and reduced the likelihood of contaminating primary reflected energy.

Two seismic lines orientated diagonally within the 1 km^2 Lyndhurst site were completed by Velseis on the 20th of February 2018 (see Figure 19 below).

Figure 19 Job completion summary for Lyndhurst seismic data acquisition



Once the data was acquired Velseis output a refraction solution to provide an indication of the depth to the weathered / un-weathered boundary. Velseis then provided a preliminary interpretation of the processed data which is attached as Appendix C**.** It is noted that given the lack of borehole control available at the time of the survey, only more prominent potential structures have been inferred and given the complexity of the data smaller scale structures are also likely to be present.

The preliminary interpretation of the Velseis acquired data indicates:

- Numerous potential structural features are present and extend from approximately 40 m bgs up to 220 m bgs
- Top of crystalline basement occurs at depths between approximately 20 and 35 m bgs with prominent near surface reflectors (possibly calcrete layers) at between approximately 10 and 15 m bgs where sediment thickness over basement is thickest
- Crystalline basement surface is inferred to have significant relief with top of basement occurring approximately 10 m deeper on the western portion of the site compared to the eastern portion.

The entire Velseis powerpoint presentation is appended for reference (Appendix C).

The available lithological information (Appendix C) generally supports the preliminary interpretations of the site specific seismic data.

It was anticipated that the unconsolidated sediments and weathered basement are likely to be dominated by low permeability fine grained clays and/or sandy clays.

On the balance, given the available information reviewed, the lithological profile beneath the site was inferred to comprise:

Key	Broad Lithological description	Depth from (m bgs)	Depth to (m bgs)
	Unconsolidated sediments	0	1
	Less permeable horizon (calcrete?)	1	3
	Unconsolidated sediments	3	10-15
	Weathered basement	10 - 15	20 – 35
	Crystalline basement	20 - 35	>35

Database bore summary information for bores within a 10 km radius of the Lyndhurst site is tabulated and presented in Appendix C. Little data is available for the identified registered bores.

Registered bore search information suggested groundwater at depths of between approximately 20 and 30 m bgs with relatively high salinities (>10,000 mg/L Total Dissolved Solids).

The purpose of bores drilled within the search area is rarely identified however a number of monitoring bores drilled in 1995 were not constructed as groundwater observation bores and immediately backfilled. Given the lack of identified groundwater use and the availability of reticulated water in the Kimba a reconnaissance survey of the existing bores in the vicinity of the site was not incorporated into the planned Stage 1 drilling program.

On the basis of the information gathered and reviewed as part of the desktop assessment, the drilling program for Lyndhurst included allowance for investigation boreholes of up to 50 m depth to intersect the watertable aquifer within inferred unconsolidated sediments and a deep borehole up to 60 m depth to intersect the underlying indurated basement rock.

Geophysical wireline logging was incorporated into the program to assist in identifying additional potential water bearing zones between the watertable aquifer and the basement rock.

3.1.1.3 Field Methods and Results

The location of each investigation bore and test pit within the Lyndhurst site is displayed within Figure 20 below.

Drilling, Sampling & Bore Construction Program

In order to provide sub-surface information specific to the site a drilling program was undertaken with the primary objectives of:

- Identify the depth, flow direction and water quality of the watertable aquifer within unconsolidated sediments
- Identify the depth to the consolidated bedrock and assess the water quality and likely interaction between the deeper and shallower water bearing zones
- Describe and geophysically log the lithological profile beneath the site in order to identify zones of permeable and less permeable sediments.
- Collect geotechnical information from the top 15 m of the profile

Borehole Drilling

Groundwater bores were installed by appropriately licenced drillers in accordance with the *Minimum Construction Requirements for Water Bores in Australia, Edition 3*[14].

The drilling program commenced on 4th May 2018 with completion of the last bore on the 16th May 2018.

Investigation borehole drilling was carried out by South West Drilling using a track mounted Sonic-Drill 450. Six holes were drilled and numbered L01 to L05. Two bores are installed at site L05; L05D (Deep) and L05S (Shallow). Investigation bore locations in relation to the existing bores are shown in Figure 17.

All bores were drilled using sonic coring and case methodology from surface. Sonic drilling uses high quality (fresh) [15] water as a drilling fluid in order to aid coring and hole flushing.

Drilling proceeded using a 168 mm diameter core barrel inside a 219 mm diameter temporary casing (which was withdrawn once drilling was completed. The drill and casing string progressed in 1.5 or 3.0 m lengths depending on the required drilling or sampling run.

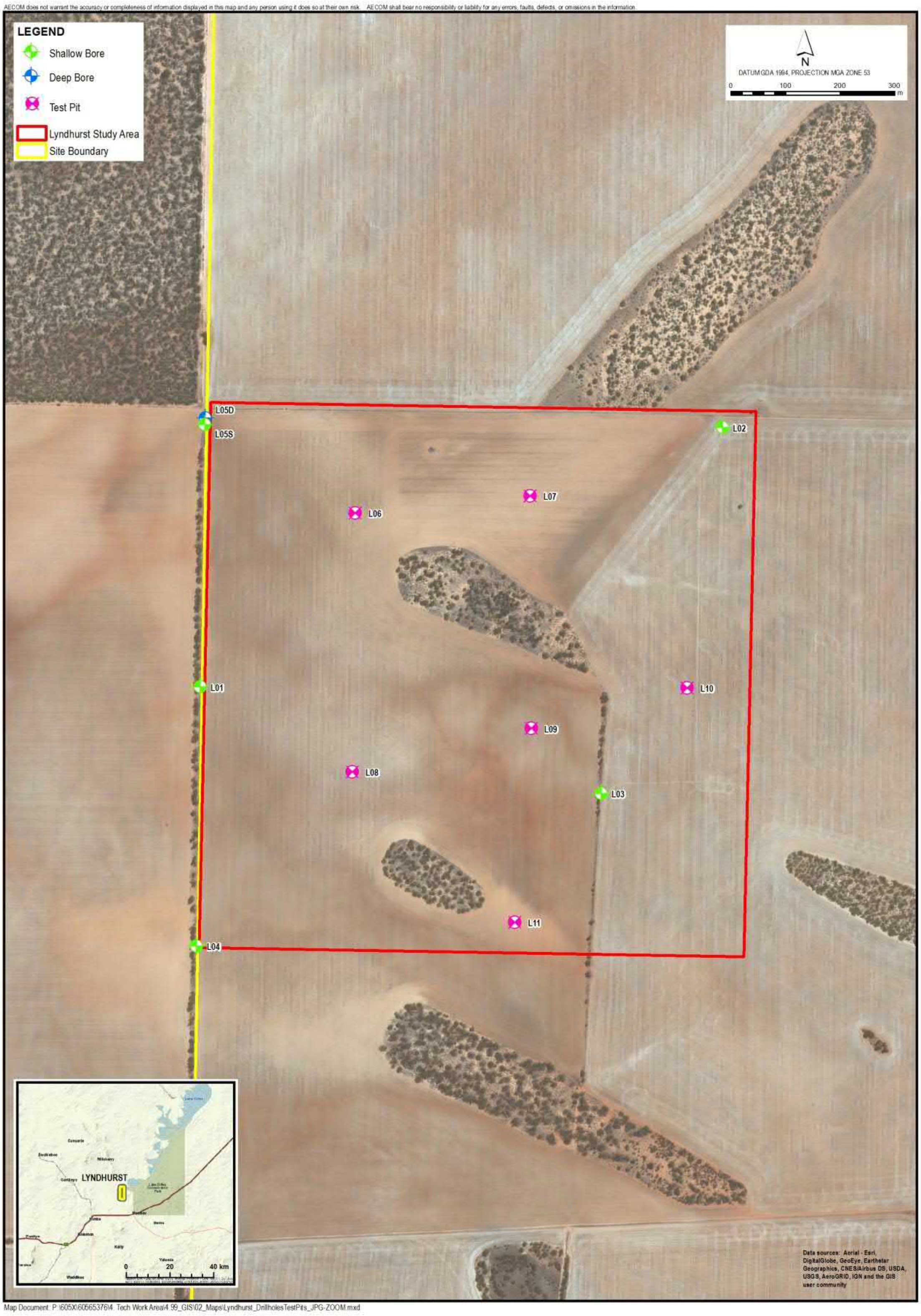
In general, bores typically used between 6 – 10 m^3 of water to achieve final depth, depending on the amount of circulation losses.

Cores of drilled sediments were continuously recovered as drilling proceeded and lithologies were recorded by on-site by an experienced and qualified AECOM geologist/hydrogeologist. Bore logs are provided in Appendix C.

[14] NUDLC, 2012 *Minimum Construction Requirements for Water Bores in Australia V3* developed by the National Uniform Drillers Licensing Committee, Third Edition, February 2012

[15] Drilling water was sourced from Kimba via the Murray - Kimba pipeline supply to the township and delivered to the site by tanker. The quality was therefore suitable for domestic household use.

Figure 20 Location of investigation bores and test pits within Lyndhurst site



Geotechnical Testing from Bores

Geotechnical information was collected throughout the borehole drilling, mainly focused on the ground profile for top 15 m depth. The geotechnical investigation methods included geotechnical logging of soils, in-situ testing and collection of samples for laboratory testing.

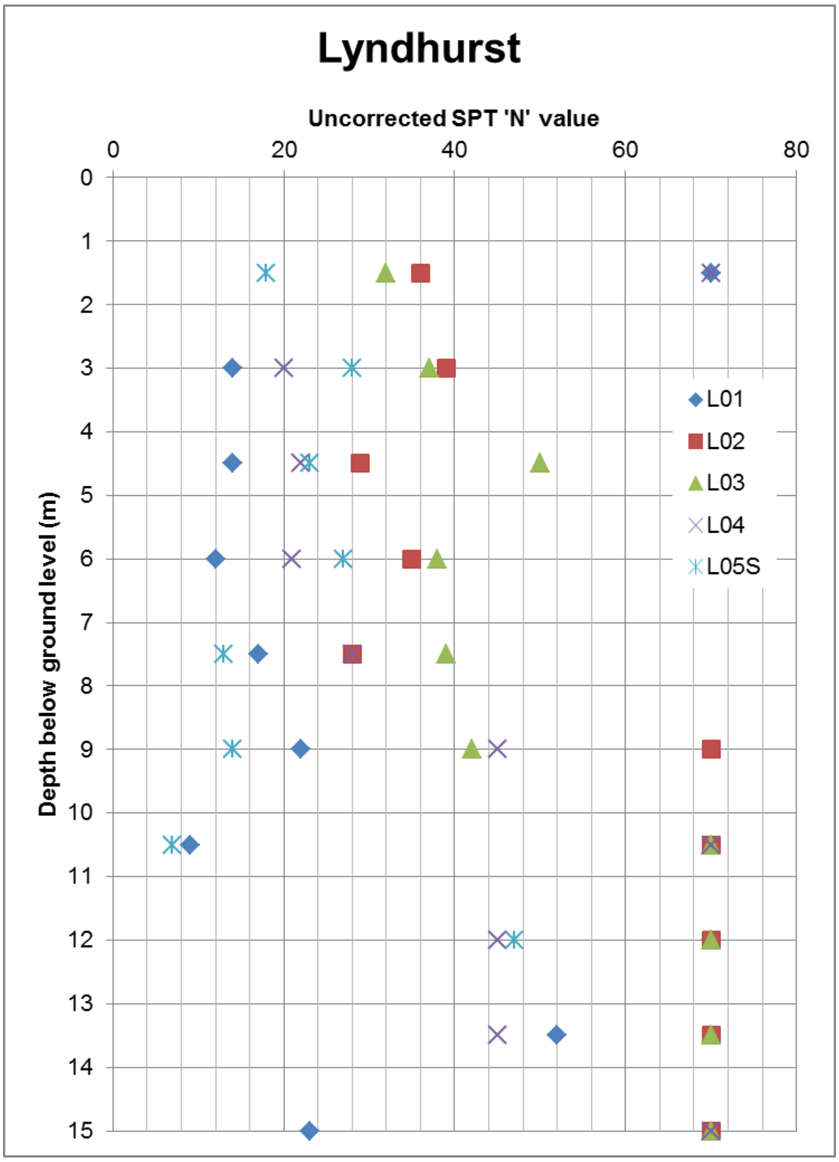
The geotechnical information collected included:

- Soil profile logging to 15 m depth;
- Insitu testing of Standard Penetration Testing (SPT) conducted at nominally 1.5 m interval in accordance with AS1289.6.3.2 to 15 m depth;
- Collecting of disturbed samples recovered from top 15 m depth; and

It is noted that laboratory results for U63 samples selected for permeability testing were not available at the time of reporting.

Figure 21 presents the summary of uncorrected SPT values recorded with depth (within top 15m depth). Where refusal was met during the SPT, this is shown with the uncorrected SPT value of 70 for graphical purposes.

Figure 21 Uncorrected SPT Values with Depth



Geophysical Logging

Downhole geophysics (wireline logging) was conducted in all holes to refine lithology and observations made during the drilling process.

The contractor engaged for this work was Borehole Wireline. Details of the types of logging undertaken are as follows:

- Deep Bore – L05D (Completed 7 May 2018). Upon reaching target depth, wireline logging was completed in the un-constructed bore through the temporary sonic casing and into the un-cased fresh bedrock at the base of the hole. The following tools were run to provide a geophysical profile over the full lithology sequence into bedrock:
  - Natural Gamma
  - Neutron Porosity
  - Compensated Density, Resolution Matched Density and Density Correction
  - Spontaneous Potential
  - Resistivity
  - Acoustic Scanner
- Shallow Bores (31 May 2018). Logging of shallow bores was completed after construction, within the PVC cased borehole. Due to the limited annulus diameter (50mm) of the constructed boreholes, the following tools were run:
  - Natural gamma
  - Dual induction.

Geophysical logs have been incorporated into the final lithological and construction logs for each borehole. The logs are provided in Appendix C.

Observation Bore Construction and Development

All investigation boreholes were converted to groundwater observation bores. Bore construction details are provided in Table 34.

Bore are constructed using 50 mm diameter class 18uPVC casing with 0.4 mm slotted over 6 m screen length.

A filter-pack consisting of 8/16" washed river sands was introduced to fill the external annulus of the bore between the casing and the natural lithology and gravity fed from surface to a depth of a 1 m above the top of screen.

A seal consisting of 3/8" bentonite pellets were gravity fed from surface until a thickness of 3 m above the top of the gravel-pack was obtained. Pellets were hydrated and allowed to cure for a minimum of one hour. The remaining annulus was then backfilled to surface with a cement grout with 5% bentonite. The grout was mixed at surface and tremie piped down the annulus in 200 L batches.

The surface completion of the bores consists of lockable, powder coated (yellow) steel monuments, seated 0.7 – 1.0 m above ground level.

In conformance with Section 12 of the *Minimum Construction Requirements for Water Bores in Australia, Edition 3,* bore development was undertaken to optimise bore performance by:

- Removing any drilling fluids (water or mud) introduced into the aquifer during drilling;
- Stabilising the gravel filter pack; and
- Ensuring groundwater obtained during sampling events is representative of groundwater from the aquifer.

Following construction all newly constructed bores were developed (pumped to remove residual drilling fluids and improve groundwater flow through screens). The quality of water being removed was monitored in the field using portable testing equipment supplied by a rental company with calibration certificates.

Field parameters monitored included Electrical Conductivity (EC in µS/cm), pH, Dissolved Oxygen (DO in mg/L), Redox Potential (in mV) and temperature (in ^{o}C). Field parameters and observations of groundwater turbidity and odour were collected periodically, dependent upon yield.

Bores were developed using a hired 400 cubic feet/minute (cfm) air compressor attached to a 1/5" tremie pipe. Air was then used to purge the bore of sediment and drilling fluids. Development was completed using a bailer (at all shallow bores) after the compressor had been moved to the next location.

Deep bore L05D was able to be air lifted continuously for one hour at a low yield averaging around 0.1 L/s.

Shallow bore L05S was able to be air lifted continuously for one hour at a very low yield averaging around 0.05 L/s. The remaining shallow bores were much lower yielding and generally ran dry after 10-20 min of purging. Shallow bores were continually developed over a number of days until salinity (as EC) was as close as possible to the deep bore salinity in the time available.

The development yields from the bores suggest the yield potential for both the water table and bedrock aquifers is low.

Bore development and sampling records are provided as Appendix C.

Table 34 Bore Construction Details – Lyndhurst

						metres below ground level			metres AHD		
Bore ID	**Install Date**	**Easting**	**Northing**	**Borehole diam (mm)**	**pvc casing diam (mm)**	**Original Bore Depth**	**Screen**	**Sand pack**	**Casing RL**	**Ground RL**	**Standpipe RL**
L01	9/05/2018	644261.35	6342736.86	169	50	21	15.0-21.0	14.0-21.4	216.54	215.91	216.61
L02	16/05/2018	645219.45	6343212.65	169	50	24	18.0-24.0	17.0-24.0	213.53	212.86	213.63
L03	15/05/2018	644997.06	6342541.43	169	50	24	18.0-24.0	17.0-24.0	215.43	214.88	215.47
L04	10/05/2018	644254.11	6342261.46	169	50	24	18.0-24.0	17.0-24.0	220.83	220.07	221.00
L05S	8/05/2018	644269.84	6343217.88	169	50	12	6.0-12.0	5.0-14.0	208.83	208.27	208.95
L05D	7/05/2018	644270.04	6343230.03	169	50	73	67.0-73.0	66.0-73.0	208.86	208.01	208.96

Notes:

Surveying by Veris conducted 29/05/18, data provided in Appendix C
Depths are in metres below pvc casing unless otherwise stated
AHD = Australian Height Datum
RL = Reduced Level to common datum being metres below AHD

Test Pit Excavation, DCP and Laboratory Testing

Six (6) test pits were excavated within the footprint of the 100 hectare site at Lyndhurst. The test pits were excavated using a 30 tonne excavator. All the test pits were excavated to a nominal depth of 3.0 m and generally one bulk sample was collected from each test pit for geotechnical laboratory testing. At the completion of the test pitting, the test pit was backfilled with spoil and compacted with the excavator by tracking.

The field investigation was performed under the direction of geotechnical engineer who was responsible for logging the recovered samples in general accordance with the visual-tactile methods outlined in AS 1726 “Geotechnical Site Investigations”, collecting disturbed samples of selected soils and photographing the test pit. Bulk soil samples were collected for geotechnical laboratory testing. Discrete soil samples were also collected and place into snaplock bags and laboratory supplied jars for environmental laboratory testing. Samples were submitted to the NATA accredited laboratories for testing under chain of custody procedures. A limited number of samples were collected for laboratory analysis with the aim of identifying any geotechnical hazards or detrimental soil quality properties within the soil types present.

The test pit locations carried out at each site and photograph of the test pit are presented in Figure 20 and respectively Appendix C.

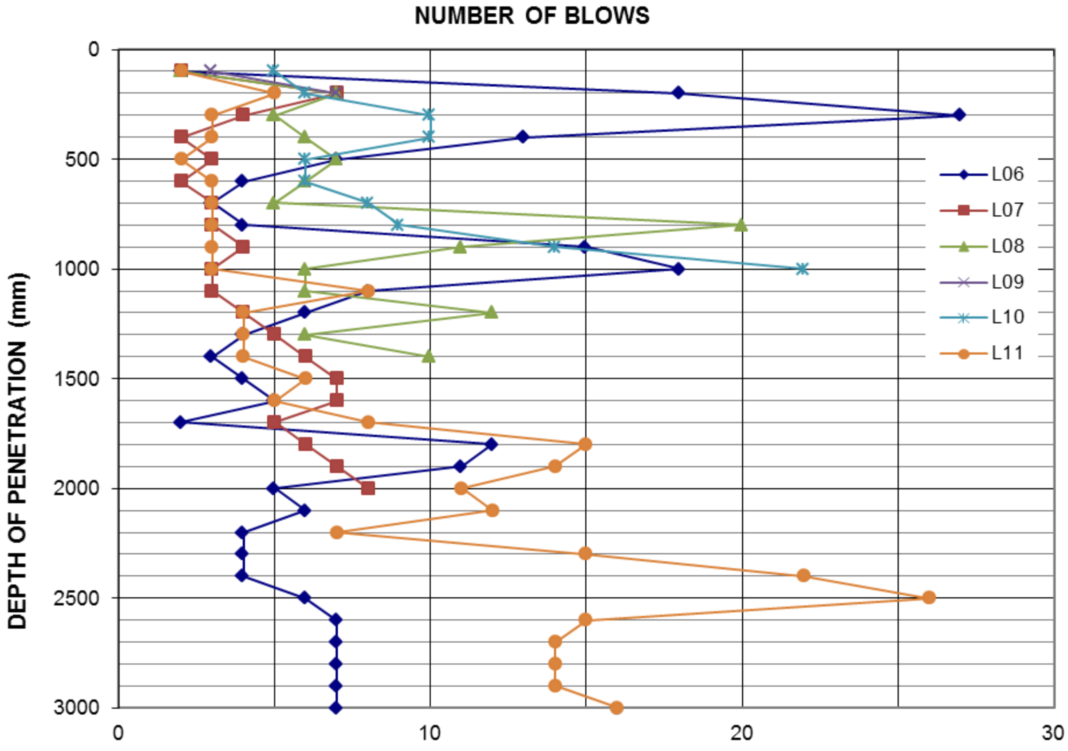
Dynamic cone penetration tests (DCP) were undertaken adjacent to test pits in general accordance with AS1289.6.3.2 to a target nominal depth of 3.0 mbgl. Blows were measured every 100 mm of penetration. At some DCPs locations, refusal was encountered which is summarised in Table 35.

Figure 22 presents a summary of DCP results recorded number of blows per 100 mm with depth.

Table 35 Summary of DCPs Termination Depth

DCP No.	Termination Depth (mbgl)
L06	3.0
L07	2.0
L08	1.4
L09	0.2
L10	1.0
L11	3.0

Figure 22 DCP Blows per 100 mm with depth



The objective of the environmental laboratory testing was to collect information from laboratory test results to identify the presence and nature of any detrimental soil quality properties. The soil samples were submitted to NATA accredited laboratory ALS Environmental for analysis of pH, electrical conductivity, and exchangeable cations (to calculate the cation exchange capacity and exchangeable sodium percentage).

The objective of the geotechnical laboratory testing was to collect further geotechnical information from laboratory test results to further inform the site characterisation and assessment against criteria (geohazards).

The nominated laboratory testing included the following:

- Moisture content;
- Particle size distribution;
- Atterberg limits;
- Standard compaction test;
- California Bearing Ratio (CBR) remoulded at 98% standard maximum dry density);
- Emerson Class
- Undisturbed permeability (selected samples from deep drilling program)

Laboratory analytical reports and tables are provided within Appendix C.

Observed Soil and Geological Profile

The geological profile for the site, as typified by the deep bore L05D is as follows:

Table 36 Representative Stratigraphy – Bore L05D

Depth From (m bgs)	Depth To (m bgs)	Strata	Relative Permeability (H/M/L)
0.0	1.0	Sand	H
1.0	7.7	Clayey Sand	M
7.7	10.5	Sandy Clay	L
10.5	12.0	Clayey Sand	M
12.0	23.3	Sandy Clay	L
23.3	24.1	Silty Sand	L/M
24.1	36.0	Clays (Marine)	L
36.0	66.5	Kaolin (clay) Weathered Bedrock	L
66.5	73.0	Mafic Bedrock (Weathered)	M

The relative subsurface strata permeability above is approximated from industry accepted ranges of saturated permeability and hydraulic conductivity (Table 2.2, Freeze and Cherry,1979) where strata range from near impermeable unfractured metamorphic and igneous rocks and shale to highly permeable gravel or karst limestone. Strata above the watertable (i.e. unsaturated or vadose zone) will have a lower permeability than the equivalent saturated permeability due to complex hydrostatic and pore pressure process that occur at an interstitial scale. The above approximations assume the applicable strata are saturated. For the purpose of this assessment, the relative permeabilities are based on the literature ranges shown in Table 37:

Table 37 Table of Relative Coefficients of Permeability

Relative Permeability	Range of Equivalent Strata	Permeability (k = darcy)	Hydraulic conductivity (K = cm/s)
Low (L)	Shale, unfractured rock to unweathered clay	1×10^{-8} to 1×10^{-4}	1×10^{-11} to 1×10^{-7}
Medium (M)	Weathered clay to fine sand	1×10^{-4} to 1×10^{1}	1×10^{-7} to 1×10^{-2}
High (H)	Fine sand to coarse gravel or karst limestone	1×10^{1} to 1×10^{5}	1×10^{-2} to 1×10^{2}

Undisturbed cored samples of aquitard material were collected during the investigation borehole drilling program and submitted for laboratory permeability testing. Two samples were collected and tested from the site.

Table 38 Laboratory Testing Results – Undisturbed Aquitard / Aquiclude Permeability

Borehole	Depth (m)	Strata	K (cm/sec)	K (m/d)	Testing Laboratory	Testing Standard
L05S	13.5 – 13.9	Clay	4×10^{-11}	3.5×10^{-8}	GHD	AS1289.6.7.3
L01	21.0 - 21.4	Sandy Clay	1×10^{-9}	8.6×10^{-7}	GHD	AS1289.6.7.3

The results for this site confirm the literature estimated relative permeabilities for the low permeability aquitard/aquiclude strata at the depths indicated and based on the representative stratigraphic sequence adopted from investigation borehole L05D.

Some silcrete and/or calcrete (around 0.5-1.0 m thickness) was encountered in the shallow soil profile (< 5 m) in several holes indicating in-situ partial cementation of near surface deposits had occurred at some time in the recent past (i.e. Quaternary Age) possibly due to impedance of seepage water at the interface between alluvial/fluvial sediments and the lower permeability weathered bedrock (clays) over timescale of 1,000’s to 10,000’s years. Calcrete and/or silcrete was identified at only approximately 1 m depth in a number of boreholes along the western boundary of the site (L05S/D, L01, L04) and in the south-east of the site (L03). There was no evidence of permanent water ponding (i.e. perched watertable) above the shallow cemented sediment bands in those bores in which the material was observed at the time of the field investigation. There may however, be occasional retardation of rainfall seepage water by the cemented layers following flooding events or extended high rainfall periods. It is likely that any ponding effects would be transitory as these units are not impervious to water nor do they appear to be form a consistent depth or thickness horizon across the site where water could not drain laterally from their surface.

The profile is consists of sedimentary (alluvial and marine deposits overlying an extremely weathered metormophised granite. The granite has been intruded at depth by mafic rocks and fresh competent bedrock was not encountered.

The borehole and test pit logs indicate that the site is dominated by sandy soils in the surface and subsurface (inferred likely to be soil type H2, a ‘siliceous soil’), due to the prevalence of sandy ridges across the landscape. A soil profile similar to soil type D3, ‘a surface loam over a poorly structured clay’, is likely present in between the sand ridges, as indicated in test pit L08 only.

The laboratory analytical results for soil samples from test pits L07 and L10, inferred likely to be soil type H2, has been interpreted[16] to provide the following information about soil chemical quality properties within the profile from surface to around 2 m depth:

- of neutral to moderately alkaline pH (becoming more alkaline with depth)
- is non-saline across the profile
- varies from a very low to low cation exchange capacity (increasing with depth)
- is non-sodic at surface with sodicity increasing with depth and becoming strongly sodic and dispersive by a depth of 2 m

The laboratory analytical results for soil samples from test pit L08, inferred likely to similar but not necessarily like in nature to soil type D3, has also been interpreted to provide the following information about soil chemical quality properties within the profile from surface to around 2 m depth:

- of slightly acidic to moderately alkaline pH (becoming more alkaline with depth)
- is non-saline across the profile
- comprises a very low to low cation exchange capacity (increasing with depth)
- is non-sodic at surface becoming strongly sodic and dispersive thereafter from a depth of 1 m

The water table is encountered largely within coarser layers of the alluvial sequence, with the finer grained layers reducing the bulk permeability of the sequence. Finer grained weathered rock tends to have low permeability due to the weathering of rock to clay minerals.

[16] Hazelton, P. and Murphy, B. 2007. *Interpreting Soil Results: What do the Numbers Mean?,* CSIRO Publishing.

From the data obtained the main water bearing / high permeability zones have been identified as:

- Water table 9-20.5 m depth (199 mAHD), found in interbedded sand /clay layers which persist from surface to 36 m depth (~172 mAHD)
- First confined aquifer in gabbro found from approximately 66 m depth (~142 mAHD).

Groundwater Sampling & Laboratory Analysis

Groundwater Gauging

Groundwater levels in all bores were gauged at the following times:

- At construction completion
- Throughout development to monitor water quality recovery. and
- Prior to collection of groundwater samples after sufficient recovery time.

Groundwater levels collected prior to sampling are considered stable and representative of the ambient groundwater condition. Groundwater levels were measured using an electronic water level dipper which was rinsed with potable water between measurements.

Standing groundwater levels recorded in the bores immediately prior to sampling are as follows:

Table 39 Gauging Data for Lyndhurst Investigation Bores

Bore No	Date	Reduced Level (Top of casing mAHD)	Groundwater Level (m below top of casing)	Reduced Groundwater Level (mAHD)
L01	22/5/18	216.54	17.20	199.34
L02	22/5/18	213.53	14.29	199.24
L03	22/5/18	215.43	15.75	199.67
L04	22/5/18	220.83	21.18	199.65
L05S	22/5/18	208.83	9.70	199.16*
L05D	22/5/18	208.86	11.84	203.08*

**salinity density corrected – to site a standard of 43,000 mg/L*

Based on the above data, the watertable is between 9.7 to 21 metres below ground surface. A 12 metre difference in standing water levels exits between bore sites L04 and L05 where topographic elevation declines from north to south by approximately the same amount. This conforms with the existence of the salt lake, Lake Giles to the north east of the site, where locally to the site, the ground elevation would be expected to mimic general topography and decline towards a regional topographic depression.

The reduced levels of groundwater in the shallow aquifer, based on water levels reported in 22 May 2018, range from 199.13 (199.16 density corrected) mAHD in Bore L05S on the north western portion of the site to 199.67 mAHD at Bore L03 in the south-eastern portion of the site. The inferred groundwater contour map across the site based on the above data is shown as Figure 23.

The hydraulic gradient, as defined by water level data from bores L01 to L04, is low, at around 0.0002. Based on these data, the groundwater contours for the watertable aquifer decline in elevation from south to north, inferring groundwater flow is to the north-north-west. Groundwater flow is largely dependent on both the pressure gradient (hydraulic gradient) and the conductive property (hydraulic conductivity) of the transiting material (usually and aquifer). The migration of water through an aquifer is dependent on the coefficient of permeability of an aquifer and a low hydraulic gradient within the aquifer or between aquifers. The rate of movement will therefore depend on the relative orders of magnitude of the above properties. In an aquifer of comparable hydraulic conductivity, an hydraulic gradient of 1.0, that is one meter drop in hydraulic head per meter horizontal (or vertical) distance is considered very high, and the relative migration of groundwater would be high, compared to an almost flat gradient of 0.0001 (i.e. a 1 meter loss in hydraulic head per 10,000 meters or 10 km length of travel) is considered very low and would represent a regional groundwater flow pattern. The inferred horizontal hydraulic gradient of the watertable at this site is calculated at 0.0002. In terms of assessing this site as having a low or very low hydraulic gradient, it can be considered that in relative terms from the perspective of groundwater migration, this hydraulic gradient is low and of a magnitude that is preferable compared to higher orders of magnitude.

Based on the density corrected standing water level in the deep bore L05D, a vertical upward hydraulic gradient of around 0.07 appears to exist between the deep and highly saline (168,000 mg/L total dissolved solids) bedrock aquifer and the overlying, less saline watertable aquifer (at around 43,000 mg/L as total dissolved solids) at site L05. An upward hydraulic gradient from deep to shallow aquifers would be expected in the vicinity of groundwater discharge zones and the proximity of the site to the nearby saline playa, Lake Gilles seems to support this conceptual model. The difference in water level between the shallow and deeper aquifer is measurable, suggesting that there is good hydraulic disconnect between the two systems, with upward flow is limited by low permeabilty kaolin clay (weathered bedrock) that lies above the bedrock.

Further, the salinity differential between the shallow and deeper aquifer are such that, in spite of the upward hydraulic gradient, mixing of the two waters would be difficult since lower density fluids will “float” on higher density fluids. In this case we have the shallower groundwater density of around 1.031 overlying groundwater at a density of around 1.131. The saline shallow groundwater will in effect “float” on the denser deeper groundwater and mixing of the two waters would be very slow, if at all.

This inferred direction of groundwater flow in the watertable aquifer conforms with expectation of groundwater moving northward and ultimately discharging below Lake Gilles, 4 kilometres to the north-east of the site. Lake Gilles is considered to represent a termination point for groundwater discharge in the vicinity of the site.

A review of nearby registered groundwater bores from the South Australian WaterConnect database shows a number of bores within a 10 km radius of the site. Data relating to these bores and an understanding of the broader hydrogeological setting is limited (see Appendix C).

As shown above, the preliminary inferred direction of groundwater flow from site derived groundwater level data suggests watertable groundwater flow is to the north (north-west). There are no reported, registered groundwater bores being used for consumptive purposes (i.e. potential groundwater receptors) within 10 km of the Lyndhurst site in the inferred direction of groundwater flow.

Figure 23 Interpreted Groundwater Contours and Inferred Flow Direction 22/05/18 – Watertable Aquifer Lyndhurst

Groundwater Sampling and Analysis

Groundwater sampling was undertaken by trained AECOM field staff in general accordance with AECOM standard procedures which have been developed with reference to the following guidance documents:

- AS NZS 5667.1 – 1998: Water Quality - Sampling – Guidance on the design of sampling programs, sampling techniques and the preservation and handling of samples; and
- AS NZS 5667.11 -1998: Water Quality - Sampling - Guidance on sampling of groundwaters.
- EPA Victoria, 2000, A Guide to the Sampling and Analysis of Waters, Wastewaters, Soils and Wastes, Publication 441, March 2000
- EPA Victoria, 2000, Groundwater Sampling Guidelines, Publication 669, April 2000.
- EPA Victoria, 2006, Hydrogeological Assessment (Groundwater Quality) Guidelines, Publication 668, September 2006
- EPA, South Australia, 2007, Regulatory monitoring and testing *Groundwater sampling*, June 2007
- NEPC, 2009. National Environmental Protection (Assessment of site contamination) Measure. Schedule B (2): Guideline on data collection, sample design and reporting. National Environment Protection Council, Canberra.

Given reporting dates and the extension of the drilling program past initial estimates, it was assessed that grab sampling of groundwater using a disposable bailer soon after development would provide indicative water chemistry information suitable for inclusion in this technical report.

Following development, groundwater bores were sampled using disposable bailers. The aim was to collect groundwater field chemistry data during the sampling round and compare it with development records to provide evidence of stabilised conditions indicative of native groundwater.

Field parameters (Dissolved Oxygen, Electrical Conductivity, pH, Redox Potential and Temperature) were recorded on-site at the time of groundwater sample collection.

Appendix C provides the sampling records and includes a table summarising the field chemistry parameters at each bore prior to collecting the sample. Bore development records are also included for comparison showing that grab sample field chemistry was comparable to that of the stabilised conditions observed at the end of the bore development phase.

Groundwater samples and Quality Assurance/Quality Control (QA/QC) samples (intra-lab blind field duplicates and equipment rinse blanks) were sent by courier, under Chain of Custody protocols (COC), to the primary laboratory (ALS Melbourne). An inter-lab field triplicate was collected to represent reporting precision for sampling conducted on the 23 May 2018 and was sent by courier to the secondary laboratory (MGT Eurofins). No trip blanks were collected as the analytical program did not extend to volatile organic compounds.

Quality assurance and control measures were incorporated into the groundwater sampling and analysis works to ensure that the specified data quality objectives could be achieved and to demonstrate accuracy, precision, comparability, representativeness and completeness with regard to the data generated. The data validation guidelines adopted by AECOM provide a consistent approach for the evaluation of analytical data. These guidelines are based upon data validation guidance documents published by the United States Environmental Protection Agency's contract Laboratory Program (US EPA 2017)[17] and the NEPM (National Environment Protection Council (NEPC, 1999))[18]. The process involves the checking of analytical procedure compliance and an assessment of the

[17] US EPA (2017) Superfund Contract Laboratory Program National Functional Guidelines for Data Review, https://www.epa.gov/clp/superfund-clp-national-functional-guidelines-data-review

[18] NEPC (1999) National Environment Protection (Assessment of Site Contamination) Measure 1999, National Environment Protection Council, amended 2013

accuracy and precision of analytical data form a range of QA/QC measures, generated from sampling and analytical programs.

Specific elements that have been checked and assessed for this project are:

- A comparison of field data to laboratory data;
- Preservation and storage of samples upon collection and during transport to the laboratory;
- Sample holding times;
- Use of appropriate analytical and field sampling procedures;
- Required Limits Of Reporting (LORs);
- Frequency of conducting quality control measurements;
- Rinsate blank results;
- Laboratory blank results;
- Field duplicate and triplicate results;
- Laboratory duplicate results;
- Matrix spike results;
- Surrogates spike results; and
- The occurrence of apparently unusual or anomalous results, e.g. laboratory results that appear to be inconsistent with field observations or measurements.

The data validation process identified no major quality assurance/quality control issues in the field or laboratory datasets that could have a material implication to decision-making on the project.

Available laboratory reports and a tabulated summary of groundwater chemistry including a QA/QC assessment is provided in Appendix C.

The relative potential for use of groundwater at the site (raw, untreated condition) is summarized below with several major chemical parameters compared against national quality guidelines (NHMRC 2011 Drinking Water Guidelines and ANZECC 2000 Fresh and Marine Water Quality Guidelines). The selection of parameters is not the full suite analysed however the relative suitability of the groundwater for the major potential beneficial uses can be established from the selected sub-set.

Table 40 Groundwater Quality vs National Guidelines for Beneficial Uses of Water – Selected Analytes: Lyndhurst

		National Quality Guideline					Laboratory Reported Groundwater Quality (by borehole)					
	Analyte	1	2	3	4	5	L01	L02	L03	L04	L05S	L05D
Major Parameters	TDS*	1,200	3,000 to 13,000	400 to 7,800	65 to 3,250	1,000	27,820	28,210	29,770	20,215	17,810	109,200
	pH	6.5 to 8.5	-	-	6.5 to 9.0	5.0 to 9.0	6.7	4.2	4.5	7.2	8.7	6.7
	SO_4	250	2,000	-	-	400	1,470	1,020	1,230	1,220	1,200	8,780
	Cl	5.0	-	40 to 700	-	400	16,100	16,400	16,300	11,800	10,400	78,800
Metals	Fe	0.3	-	0.2	-	0.3	10.6	5.1	2.9	41.7	32.7	9.1
	As	0.01	0.5 to 5.0	0.1	0.013 to 0.024	0.05	<0.002	0.002	<0.002	<0.001	0.002	<0.005
	Hg	0.001	0.002	0.002	0.0006	0.001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Nutrient	NO_3**	50	400	-	0.7	10	0.97	0.39	0.39	<0.04	0.26	<0.04

Number Codes to Beneficial Use Guidelines

1 – Drinking Water (Raw: Acceptable) : NHMRC (2011)

2 – Agriculture (Stock watering): ANZECC (2000)

3 – Agriculture (Irrigation) : ANZECC (2000)

4 – Maintenance of Freshwater Ecology: ANZECC (2000)

5 – Primary Contact Recreation: ANZECC (2000)

Notes –

All units expressed as mg/L

* - laboratory reported units as electrical conductivity (EC) converted to total dissolved solids (mg/L) = EC * 0.65

** - laboratory reported NO_3 as N concentrations are unit converted to NO_3 as NO_3 where 1 mg/l NO_3 as N = 4.43 mg/l NO_3 as NO_3

SO_4 – sulphate, Cl – chloride, Fe – iron, As – arsenic, Hg – mercury, NO_3 - nitrate

In summary and based on data collected in the field and supported by the analytical data, the groundwater in the watertable aquifer is dominantly saline and the salinity reported in most bores would preclude all consumptive and recreational beneficial uses. The pH varied across the site from slightly acidic (L02-L03) to slightly alkaline (L05S).

Groundwater within the deeper water bearing zone intersected by L05D is approximately four times more saline than the shallower aquifer.

Highly salinity of groundwater may be a result of the influence of the depositional and groundwater discharge environment associated with Lake Gilles.

Any anticipated use of groundwater from this site for most applications would require extensive pre-treatment.

3.1.2 Assessment Against Criteria

The assessment criteria for the geological, hydrogeological, geochemical, soil and geotechnical characteristics of the site are tabulated in Section 3.1.1.1. Data collected during the recent field investigations has allowed AECOM to assess suitability against the criteria/ preferred site characteristic.

Objective: Infrastructure Foundation Stability

Characteristic criteria: Liquefaction potential, collapsing or expansive soils, slope instability, subsidence due to ground features, long-term settlement

Preferred Characteristic: Relatively flat topography

The site at Lyndhurst is located in an area of a series of sand ridges (some parts still with Mallee eucalypt vegetation). It is located on a generally flat area with gently sloped ground surfaces observed across the site due to the low angle sand ridges and dune spreads. Generally, this was consistent with the findings of desktop assessment. Based on the site topography and site observations, the site is unlikely to be constrained by slope instability.

Preferred Characteristic: Watertable at depth (>10 m)

A water table of depths generally exceeding 10 m is present across the site and is considered generally favourable for the proposed facility.

Preferred Characteristic: Cohesive soil profile

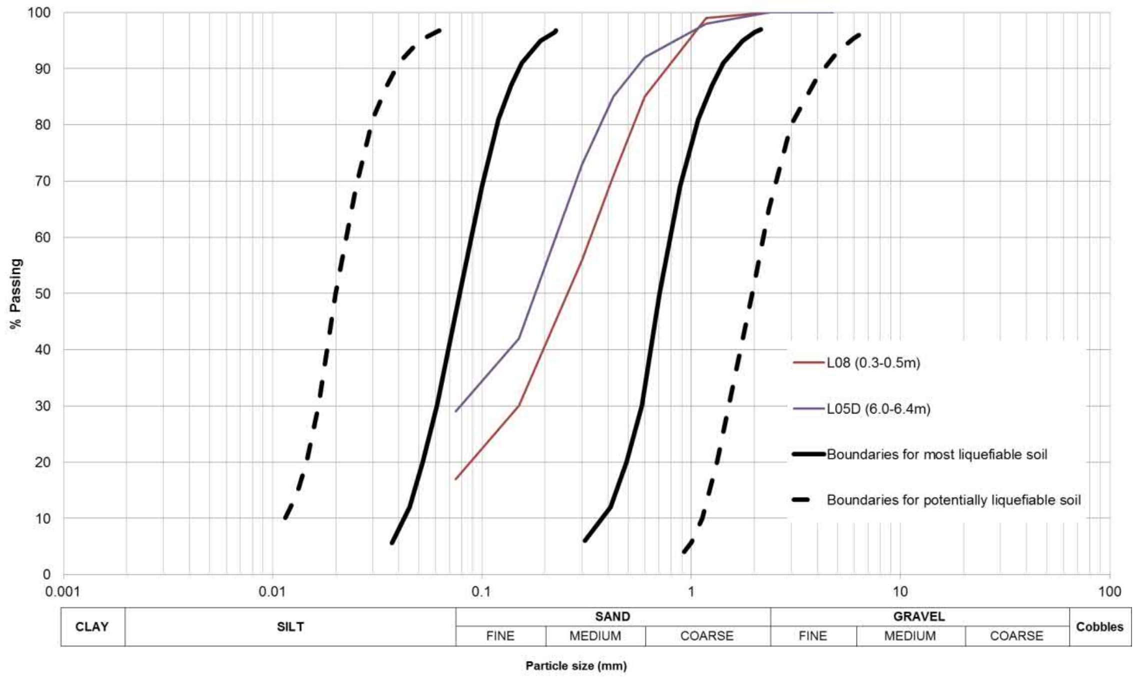
Liquefaction

Liquefiable soils create a significant hazard for infrastructure during the seismic events. Liquefaction refers to the significant loss of strength and stiffness resulting from the generation of excess pore water pressure in saturated, predominantly cohesionless soils such as sand and gravel. IAEA Safety Guide No. NS-G-3.6 provides a list of evaluation criteria to assess liquefaction potential. Some of the key conditions for liquefaction to occur include:

- The soil is saturated (i.e. below the water table);
- The soil is predominantly coarse grained;
- The soil is loose (relative density less than about 40 percent); and
- The ground motion is sufficiently strong.

One of the site characterisation measurements commonly used for evaluation of liquefaction potential includes characterisation of grain size distribution. It has been long recognised that saturated sands, silty sands and gravelly sands are susceptible to liquefaction (Fell, et al., 2005). Figure 24 shows the boundaries suggested in 1985 by USNRC with particle size distribution of tested materials.

Figure 24 Particle Size Distribution of Tested Materials



Based on the above figure, the tested site materials can be characterised as liquefiable soil based on particle size distribution.

The cohesionless soil materials encountered onsite were predominantly medium dense with localised loose layers encountered. The soils observed on site generally were interbedded layers of cohesive and cohesionless materials.

However, based on the site investigation observations, groundwater levels were observed at nominal 10 m depth.

Although some of the materials are classified as liquefiable soils due to their particle size, most of the key conditions for soil to liquefy are not presence, most notably being the presence of saturated soils. Therefore, it is unlikely that the soils encountered onsite would experience liquefaction during the earthquake event.

Collapsing or Expansive Soils

Collapsing soils are generally found in semi-arid regions. These soils are commonly associated with loess and other fine grained aeolian soils. Internal soil support, which is considered to provide temporary strength, is derived from a number of sources. Included are capillary tension, which provides temporary strength in partially saturated fine-grained cohesionless soils; cementing agents, which may include iron oxide, calcium carbonate, or clay in the clay welding, of grains; and other agents, which include silt bonds, clay bonds, and clay bridges (Hunt, 2005). These soils are liable to collapse upon wetting with resulting settlement.

Based on the soil profile encountered, generally the top 8 m of soils consisted of cohesionless material of aeolian origin, underlain by interbedded of cohesive and cohesionless materials. Most of the site was observed to be covered with sand ridges and dune spreads. There were no signs of crab holes or site features that indicate the presence of collapsible soils onsite. Various empirical methods can be used for the identification of collapsing soil.

Table 41Table 41 shows the criteria for identification of collapsible soils using physical properties developed by several authors.

Table 41 Criteria for Identification of Collapsible Soils

Author	Criteria	Conditions to Identify Collapse	Soil Conditions
Priklonskij (1952)	$Kd = \frac{LL - w_0}{LL - PL}$	Kd < 0	Highly collapsible
		1 > Kd > 0	Collapsible
		Kd > 1	Non-collapsible
Kassif & Henkin (1967)	$K = \gamma_d \times w_0$	K < 15	Collapsible

Notes: LL – Liquid Limit; W_0 – Moisture Content; PL – Plastic Limit; γ_d – dry density

Calculations and classification to determine the collapsible behaviour of the tested soils using indicated criteria in Table 41 are presented in Table 42. Based on empirical assessment, the materials found onsite were classified as non-collapsible soils.

Table 42 Results of Collapse Identification and Classification based on the Physical Parameters

Sample	Parameter		Classification	
	Kd	K	Kd	K
L08 (0.3-0.5m)	2.0	18.0*	Non-collapsible	Non-collapsible
L05D (6.0-6.4m)	1.2	-	Non-collapsible	-

Notes:

Kd – Priklonskij (1952); K – Kassif & Henkin (1967); * assumed the material compacted to 95% standard compaction & at optimum moisture content.

Expansive soils are also generally found in semi-arid region. The soils undergo volume changes upon wetting and drying, thereby causing ground heave and settlement problems.

Based on site investigation findings, cohesive materials were found (nominally beyond 8 m depth) throughout the borehole drilling. These materials found onsite were generally in dry conditions and groundwater levels were generally observed at 10 m depth. As a result, it is not expected that the cohesive materials will experience wetting and drying effects (shrinking or swelling), due to their depth, the groundwater depth and the arid low rainfall environment.

Many tests and empirical methods have been developed to assess shrink-swell potential of soils. Indirect methods involve the use of soil properties and classification schemes to estimate shrink-swell potential is commonly used in site characterisation stage. Table 43 shows the criteria for identification of expansive soils using physical properties developed by several authors.

Table 43 Criteria for Identification of Expansive Soils

Author	Criteria	Degree of Expansion
Daksanamurthy and Raman (1973) using liquid limit	LL > 70	Very high
	50 – 70	High
	35 – 50	Medium
	20 – 35	Low
Holtz and Gibbs (1956) using plasticity index	PI > 35	Very high
	25 – 35	High
	18 – 25	Medium
	PI < 18	Low
Public Works Department (1977); Mills et al. (1980); Hicks (2007) using linear shrinkage	LS >22	Very high
	17 – 22	High
	12 – 17	Medium
	LS < 12	Low

Notes: LL – Liquid Limit; PI – Plasticty Index; LS – Linear Shrinkage

Figure 25 presents the plasticity chart for the soils tested from site. Classification to determine the swell potential of the tested soils using indicated criteria in Table 43 are presented in Table 44. Based on empirical assessment, the shallow/near surface materials found onsite were classified as low swell potential and the deeper soil materials (6 m depth) were classified as medium swell potential.

Figure 25 Plasticity Chart for Tested Materials

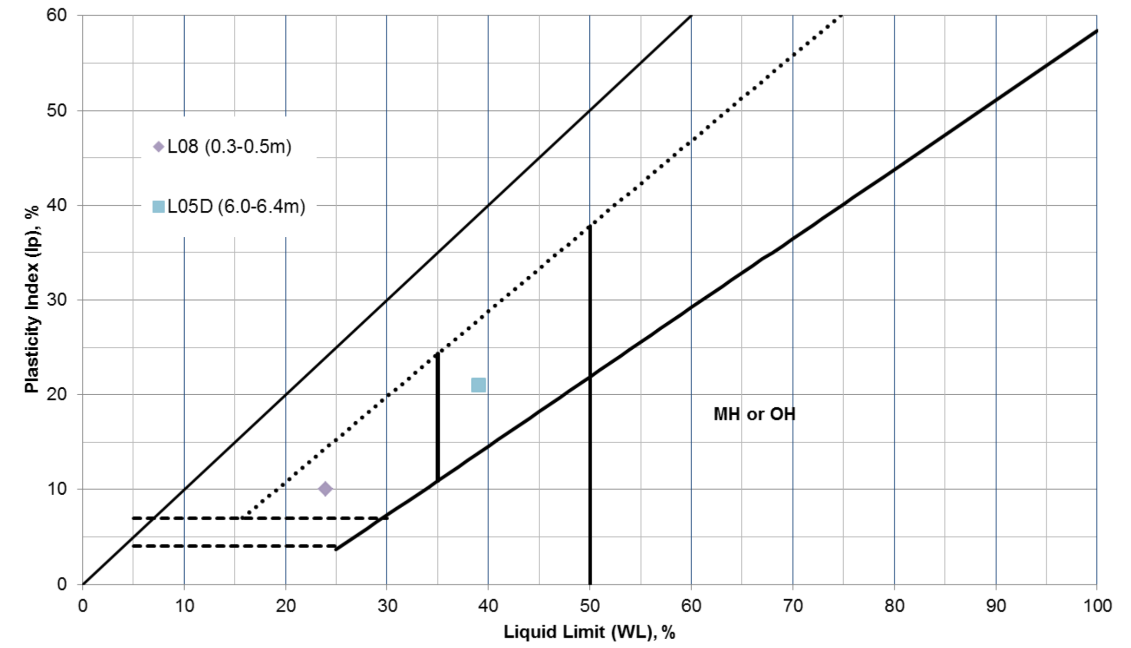


Table 44 Results of Swell Potential Classification based on the Physical Parameters

Sample	Swell Potential Classification		
	[1]	[2]	[3]
L08 (0.3-0.5m)	Low	Low	Low
L05D (6.0-6.4m)	Medium	Medium	Low

Notes: [1] Daksanamurthy and Raman (1973); [2] Holtz and Gibbs (1956); [3] Public Works Department (1977); Mills et al. (1980); Hicks (2007)

Scour and Erosion Processes

Tunnelling susceptibility refers to the likelihood of tunnels forming in a body of a soil as a consequence of water flow through the soil (Hazelton & Murphy, 2007). A soil that is easily detached and transported by water flow usually means that soil is highly dispersible material.

Localised scour and erosion was not observed across the Lyndhurst site. The gentle slope of the overall site and low rainfall means the site is unlikely to have scour and erosion processes.

The Emerson Crumb test identifies dispersive soil behaviour (AS 1289.3.8.1 “Determination of Emerson Class Number of a Soil”). Emerson Crumb test results for the site soils indicate the soils are class 4 which indicates a soil with non-dispersion with calcium carbonate (calcite) or calcium sulfate (gypsum) present within the soil.

Long-term Settlement and Subsidence

Ground subsidence generally arises from natural occurrences or as a result of human activities that change an environmental condition. The site is generally located in an area of agricultural land use. No signs of ground subsidence were observed.

No natural features such as caverns and human-made features such as underground mines that will contribute to the ground subsidence were identified or observed.

Based on the observations, the site is considered unlikely to be subject to ground subsidence due to underground features.

Settlement is one of the important factors associated with deformation of foundations supporting the buildings or infrastructure. Long term settlement is generally associated with soft clay deposits, compressible soils or deep fill.

Based on the site investigation, it is considered unlikely for long term settlement to occur as a result of the site soils as no fill was observed and the natural soils encountered were generally in medium dense conditions and dry. Short-term and elastic settlement are anticipated which can be mitigated through engineering design and construction techniques.

Objective: Soil Quality

Characteristic Criteria: Detrimental soil quality properties that may lead to degradation and hydraulic properties that may increase the severity of flooding or erosion

Preferred Characteristic: Soils that are not saline, sodic, dispersive, do not have an aggressive pH, or are not prone to waterlogging

Sandy soil profiles associated with sand ridges present across the site and landscape are inferred likely to be relatively free-draining and non-saline, neither aggressive in acidity or alkalinity, non-sodic at surface but strongly sodic and likely dispersive by around 2 m depth. A clayey sand profile, inferred potentially present between sand ridges across the site has the potential to be relatively free-draining and non-saline, neither aggressive in acidity or alkalinity, non-sodic at surface but strongly sodic and likely dispersive by around 1 m depth.

Calcrete and/or silcrete was identified at approximately 1 m depth in a number of borehole along the western boundary of the site (L05S/D, L01, L04) and in the south-east of the site (L03). Poorly cemented horizons identified at these investigations are not likely to be shallow enough to lead to ponding under wet winter conditions. The landholder anecdotally reported ponding in winter in localised areas, likely due to calcrete horizons near-surface or poor draining clays with the greatest extent of calcareous horizons reported to be located in the southern portion of the site. Due to the variable surface elevations within the site, further intrusive investigation would be required to assess the presence of any near-surface calcrete or silcrete horizons that may have the potential to lead to waterlogging.

Strongly sodic and/ or potentially moderate saline soils, if present in the subsurface and exposed or used as fill for construction are likely to lead to land degradation from one or more processes including surface crusting/ hardening, dispersion of clay fines, and restrictions on the healthy growth of plants. Strongly sodic soils, especially if clayey in nature, are also highly susceptible to severe gully erosion and being poorly drained have the potential to increase the ponding of surface water.

Objective: Groundwater Supply

Characteristic Criteria: Current and potential beneficial uses of groundwater

Preferred Characteristic: Presence of a pumpable groundwater supply aquifer

Yield potential of watertable aquifer (kaolin clay – weathered bedrock) and bedrock aquifer is inferred based on well development yield to be low much lower than the minimum requirement of 175 m^3/d.

Preferred Characteristic: Potable to brackish salinity groundwater

Groundwater quality in watertable and bedrock aquifers is saline.

Objective: Potential for Subsurface Solute Transport

Characteristic Criteria: Potential for vertical migration of solutes and vertical connectivity between groundwater horizons

Preferred Characteristic: Presence of thick, impermeable to low permeability aquitards

There is no clear aquifer/aquitard distinction, the watertable “aquifer” is a thick (6 - 45m depth) layer of weathered bedrock (kaolin clay) of low permeability.

Preferred Characteristic; Lack of perched watertable

There is no clearly defined perched system identified on the site, however the presence of shallow (< 5m depth) silcrete and/or calcrete layers provide potential for occasional and transient retardation of surface seepage following flooding or high intensity rainfall periods. Based on subsurface conditions identified in boreholes drilled at the site to date, there is no evidence of permanent shallow, perched watertable conditions.

Preferred Characteristic: Deep (>10m) regional watertable & piezometric surfaces

The watertable and deep aquifer piezometric surfaces are reported at depths that generally exceed 10 m across the site.

Preferred Characteristic: Few or widely (vertical) separated aquifers

There are two aquifers within top 60 m of ground surface – low permeable kaolin clay and bedrock aquifer and a moderate vertical depth separation (30 m).

Preferred Characteristic: Presence of subsurface material with chemical attenuation properties.

The upper sand layers within the soil profile are shown to have relatively low cation exchange capacities (CECs) which are generally unfavourable, however, this is potentially mitigated somewhat by the underlying sandy clay layers, and the thickness of kaolin which have relatively high CEC (more favourable).

The presence of clay, low salinity and neutral- to moderately-alkaline pH are favourable soil properties for attenuation. Increasing levels of exchangeable sodium with depth are, however, likely to lead to a detrimental impact on the capacity of the soil for attenuation. Attenuation studies, developing distribution coefficients and cation exchange/surface sorption models, will provide a greater level of detail.

Preferred Characteristic: Low horizontal hydraulic gradient

A low horizontal hydraulic gradient at around 0.0002 is present in the water table aquifer.

Preferred Characteristic: No, few or distant third-party groundwater receptors

There are no identified down-hydraulic gradient groundwater receptors within 10 km of site.

The above findings are summarised in the table below.

Table 45 Summary of Findings: Site Characteristic Criteria Assessment

Assessment Objective	Site Characteristic Criteria	Preferred Characteristic	Assessment Against Preferred Characteristic
Infrastructure Foundation Stability	Presence of collapsing or expansive soils	Relatively flat topography Cohesive soil profile Watertable at depth (>10m)	Present with exception of collapsing soils, low expansive soils at surface, medium at a depth of 6 m
	Slope instability		
	Subsidence due to ground features		
	Long-term settlement		
	Scour and erosion processes		
	Potential of soil liquefaction		
	Presence of collapsing or expansive soils		
Soil Quality	Detrimental soil quality properties that may lead to degradation and hydraulic properties that may increase the severity of flooding or erosion	Soils that are not saline, sodic, dispersive, do not have an aggressive pH, nor prone are waterlogging	The subsurface clayey soils, if exposed may restrict healthy plant growth, be prone to crusting, waterlogging, and dispersion of clay fines as they are moderately saline and strongly sodic
Ground Water Supply	Current of potential beneficial uses of groundwater	Presence of a pumpable groundwater supply aquifer (Yield min. 175 m^3/d or 2 L/s)	Absent
		Water Quality - Potable to brackish salinity groundwater*	Absent
Potential for Subsurface Solute Transport	Subsurface material with chemical attenuation properties	Subsurface with acid buffering capacity and surface sites for adsorption and ion exchange	Present (indicative)
	Depth to groundwater and vertical connectivity between groundwater horizons Potential for vertical migration of solutes through sediments or bedrock	Deep (>10m) regional watertable & piezometric surfaces	Present
		No perched watertable	Present
		Few or widely (vertical) separated aquifers	Present (moderate)
		Thick, impermeable to low permeability aquitards	Present
	Potential for horizontal migration of solutes through saturated sediments or bedrock	Low horizontal hydraulic gradient	Present
		No, few or distant third-party groundwater users/receptors	Present

3.1.3 Design Issues and Mitigation Measures

Geology and Hydrogeology

A groundwater monitoring borehole network, targeting all identified aquifers below the site at numerous locations both within and outside the waste storage facility boundary is required to establish baseline conditions prior to construction.

Soils and Geotechnical

Detrimental Soil Quality Properties

The layout of the facility, and the footings and civil design should have regard to the presence of surface and subsurface soils with detrimental chemical or hydraulic properties which if unmanaged could lead to environmental degradation or localised surface water ponding or flooding.

The clayey subsoils being poor draining, sodic and moderately saline in nature if excavated and used as general fill have the potential to be detrimental due to the potential high susceptibility to erosion, ponding of surface water due to a surface crust/ hardening, and the dispersion of clay fines within surface water.

If the depth of the overlying soils is reduced then the cemented subsurface layers, where present, could limit the drainage of surface water from the overlying surface soil, increase the risk of seasonal ponding of surface water, and limit the health growth of plants.

Foundations

Foundation design for the NRWMF infrastructure should include the potential for large bearing pressures, dynamic loading and often strict tolerance on both total and differential settlements.

The site is predominantly underlain by undifferentiated Quaternary Holocene-aged sediments. Generally, shallow foundations and deep foundations are the two common systems available to transfer the superstructure loads to the ground. Based on the findings of recent site investigation, shallow foundations appear to be the suitable for distribution of the loadings anticipated within the NRWMF facility based on our understanding of the site infrastructure.

Shallow foundation design should be carried out in accordance with AS 2870 and pile foundations designed in accordance with AS2159 considering available site geotechnical information. Unsuitable materials may be treated by excavation and replaced with engineered compacted fill. Ground improvements may be necessary for localised loose layer of cohesionless subsurface materials found that are not capable of carrying the infrastructure loadings. Presence of expansive soils can be mitigated through design system and construction techniques. Site preparation for the foundation should be carried out in accordance with AS3798. Subsurface wetting can significantly impact structures founded on shallow foundation. The foundation backfill or structural fill should be adequately compacted and have positive surface drainage to prevent water ponding.

It should be noted that the geotechnical investigations conducted as part of this study were to characterise the site and further, detailed investigations will be required for design of structures and foundations should the NRWMF be further considered at this site.

Earthworks/Construction Materials

Construction of the NRWMF will require several construction materials including:

- General and select fill for bulk and detailed earthworks;
- Sub-base course and base course pavement materials;
- General fill and structural fill for the foundation systems;
- Concrete aggregates and sands.

A borrow source assessment should be completed for the preferred site. Detailed investigation will be required during subsequent phases of the project to confirm the construction material availability. It appears that the insitu material at the site would only be suitable to be used as general bulk earthwork and most of the other construction materials (e.g. pavement and structural fill) would need to be imported from local quarry/borrow source. Re-use of site soils should consider the soil quality properties noted above.

General earthwork requirements are presented in the AS 3798-2007 “Guidelines on Earthworks for Commercial and Residential Development”. Topsoils or severely root-affected subsoil are unsuitable to support the proposed loadings or for incorporation in fill, and should be stripped off and removed to spoil. The base of any ground to be filled should be examined to ensure all deleterious and loose material is removed prior to placing and compacting engineered fill. General fill utilised on the site should comprise suitable materials free from organic soils, construction waste and other deleterious materials.

Excavatability

Based on the findings of the site investigation, it is anticipated that the soil within the proposed site should be excavatable with standard earthmoving equipment without significant issues. Hard digging conditions could be found in localised area due to the calcrete horizons near the ground surface.

3.1.4 Data Gaps and Recommendations for Stage 2 Work Program

Geology, Hydrogeology, Geochemistry

The aim of any Stage 2 Field Program will be to build a robust Conceptual Site Model (CSM) which describes the relationships between potential sources of impacts, receptors and exposure pathways between those sources and receptors.

As outlined in the National Environment Protection (Assessment of Site Contamination) Measure Schedule B2 Site Characterisation (NEPC, 1999) a CSM is an essential part of all site assessments. The preliminary CSM is developed based on information gained from the desktop review and the planned site specific intrusive works. The initial CSM will be developed as part of the technical reporting stage of the works and will identify key data gaps. The CSM will be continually refined as additional information is acquired.

At the site characterisation stage, prior to any development of the site, identifying the complete and potential exposure pathways and potential receptors are the key objectives of the CSM development.

Works to fill remaining data gaps will be aimed at building confidence in the preliminary Conceptual Site Model.

It is envisaged that the Stage 2 field work will target collection of hydraulic data for the aquifer(s) identified from Stage 1, with an expanded hydraulic and water quality investigation of any potential deeper aquifers and aquitards identified below the watertable aquifer within the unconsolidated sequence at the site.

Key elements of the Stage 2 program will be developed to:

- Reassess gauged groundwater level and groundwater analytical information to:
    - Confirm dataset resulting from this Stage 1 investigation, and
    - Provide a baseline for temporal water level and quality variation in the event an ongoing monitoring program is adopted for the site,
    - Applying the same analytical dataset as Stage 1 with inclusion of additional analyses (e.g. ammonia/ammonium).
- Collect aquifer parameter information by:
    - Designing a pump test trial
    - Undertaking pump testing to provide hydraulic conductivity, transmissivity and storativity/specific storage characteristics
- Better understand receptors by:

  - Undertaking a door knock of neighbouring properties to identify any unregistered groundwater use
  - Undertaking a bore reconnaissance survey of identified registered and unregistered bores including recording standing water level, depth and use, relative elevations and coordinates of the bore casings estimated from hand held GPS and checked against available topographic data
  - Expanded groundwater gauging event to include suitable bores (if any) outside the site to confirm regional groundwater flow direction in the watertable aquifer in addition to local flow direction indicated by the site monitoring network
  - Based on updated groundwater flow direction information, re-appraise the presence of down hydraulic gradient receptors (e.g. groundwater users and ecosystems)
  - Testing the watertable aquifer for the presence of stygofauna to confirm whether Groundwater Dependent Ecosystems exist beneath the site.
- Better understand exposure and migration pathways by:
  - Assessing whether potential pathways actually exist for example whether faults connect shallow and deeper water bearing zones by undertaking additional investigations such as'
    - 3D seismic across the entire site or extended seismic lines beyond the site
    - Where faults have been inferred from the enhanced magnetic images, more reliable results will be obtained by the inclusion of detailed gravity data over the survey area
    - Targeted drilling at faults and inferred intersecting fault planes if interconnection is considered likely given the balance of available site specific data.
  - Assessing the chemical attenuation potential of subsurface materials at the site by conducting specific studies involving a series of batch tests that could be used as inputs to model reactive transport and attenuation using industry-leading software such as PHREEQC[19]. The model would also provide an understanding of the potential movement of ions in groundwater, especially where low pH environments may lead to increased mobility.
  - Assessing migration and chemical fate and transport vertically through the vadose zone and laterally through the saturated zones using current versions of industry standard models e.g. MODFLOW[20] and MT3D to terminal discharge points.

Geotechnical

Additional detailed geotechnical site investigation is recommended for the selected site and should consider the proposed site layouts, structure loadings and coverage of the site.

Geotechnical insitu and laboratory testing should be conducted with samples obtained by borehole drilling and test pitting. The interpretation of the laboratory data with the field data will provide inputs for the parameters for use in the engineering design.

Detrimental Soil Quality Properties

The depth and extent of shallow localised cemented calcrete or silcrete layers across portions of the site requires further assessment. Such cemented layers limit the drainage of surface water from the overlying surface soil which may lead to seasonal ponding of surface water.

Additional targeted investigations and soil analytical testing shall be undertaken within the footprint of the preferred layout of the facility within the site (which will be influenced by a range of site characteristics including topography) to further inform the nature and presence of detrimental soil quality and hydraulic properties.

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[19] Parkhurst, D.L., and Appelo, C.A.J., 2013, Description of input and examples for PHREEQC version 3—A computer program for speciation, batch-reaction, one-dimensional transport, and inverse geochemical calculations: U.S. Geological Survey Techniques and Methods, book 6, chap. A43, 497 p

[20] MODFLOW is the U.S. Geological Survey's modular hydrologic model commonly used to simulate three-dimensional (3D) groundwater flow. The MT3D is a groundwater solute transport code also released by USGS which can accommodate flow terms calculated by MODFLOW packages.

3.2 Landform Stability

3.2.1 Methodology and Results

A desktop assessment of the geomorphology of the site within the short-listed Lyndhurst site has been undertaken by Brizga Environmental with the objective of identifying and assessing key threats to long term site stability. A site inspection was conducted by geomorphologist Dr Sandra Brizga on 20 July 2018 to ground-truth and confirm the desktop assessment.

3.2.1.1 Site Characteristic Criteria

The key geomorphological site suitability assessment criterion is to identify processes (including fluvial, aeolian, slope/ mass movement) with the potential to impact on long-term site stability.

Assessment against this criterion has been employed via consideration of the following aspects:

- Landforms
- Drivers of geomorphological processes
- Key geomorphological processes with potential to impact on long term site stability.

3.2.1.2 Desktop Methods and Results

The characterisation methodology and data sources utilised are outlined below for aspects relevant to the assessment criteria.

Landforms

The landforms at each site were characterised based on:

- Published 1:250,000 topographic maps – to establish the regional context;
- Digital elevation models of each site prepared by AECOM based on detailed LiDAR survey;
- Published geological mapping (1:250,000);
- Subsurface data from bores and test pits at the Lyndhurst site provided by AECOM;
- Relevant geomorphological literature as cited; and
- Assessments of other aspects of the subsurface environment undertaken by AECOM as part of the present study.

Underlying drivers of Geomorphological Processes

Underlying drivers of geomorphological processes include climate, tectonics and base level.

Rainfall interacts with site landforms to generate catchment runoff, streamflows and overbank flood flows as well as infiltration to soil water and groundwater, which in turn affect fluvial and slope processes. Rainsplash can also directly erode the ground surface. Wind is important for aeolian processes, including the formation and movement of dunes. Relevant climatic characteristics were identified based on literature as cited. Information on surface water flow through the landscape was obtained from the assessment of hydrology and flood risks undertaken by AECOM as part of the present study.

Tectonics and seismicity were assessed based on relevant geomorphological literature and online historical earthquake data (Location SA Map Viewer http://location.sa.gov.au/). Geomorphological implications of seismic activity include:

- The effects of earthquake vibrations on landform stability – e.g. mass movement and liquefaction;
- Direct alteration of landforms, including vertical displacement (e.g. uplift or subsidence) or horizontal displacement (e.g. offsetting or rifting) of the land surface;
- Altering the relationship of land surfaces to sea level, with implications for the influence of coastal processes and base level;
- Secondary responses such as the incision of uplifted alluvial fans or deposition in areas of subsidence (Quigley et al. 2010).

Sea level and other coastal drivers are not examined in this report because the nominated site is situated inland well above present sea levels.

Key Geomorphological Processes

Key geomorphological processes were identified based on:

- Inferences from landforms and geomorphological drivers; and
- Relevant geomorphological literature as cited.

3.2.2 Assessment Against Criteria

Geology and Landforms

Figure 13 shows the digital elevation model output from an acquired LiDAR (Light Detection And Ranging) airborne topographic survey for the Lyndhurst site and surrounds. Figure 18 shows the surficial geology in the vicinity of the site. These figures display the geology and landforms at the site.

The Lyndhurst site is situated on the Eyre Peninsula, which is underlain by the Gawler Craton. Geological mapping shows that the Lyndhurst site consists of parallel dunes formed of Quaternary age Moornaba sand. This formation consists of white, pale grey and orange sand forming dunes and spreads. The digital elevation model (DEM) shows two longitudinal dunes with a north-west to south east orientation that is consistent with the orientation of other longitudinal dunes in the local dunefield. The longitudinal dunes are superimposed on a larger ridge that runs perpendicular to the dunefield, with a general north-east to south-west orientation.

The site inspection by the geomorphologist confirmed the presence of ridges associated with sand dunes. Areas of native vegetation were observed present on unconsolidated sands. Large burrows assumed formed by wombats were observed on the parallel dune immediate south of the site.

The DEM indicates that the Lyndhurst site is situated immediately adjacent to a low-lying area associated with Lake Gilles, a salina (saline playa lake). Hydrological and hydraulic modelling is required to determine whether the low-lying areas of the site and surrounds may be subject to inundation during large infrequent flood events. The shoreline of Lakes Gilles (based on SRTM data) is about 15 m lower than the Lyndhurst site (100 ha study area), hence the potential for site to be exposed to lake-shore processes is unlikely. A topographical survey of Lakes Gilles is required confirm elevation differences between the lake and the site.

AECOM provided data on subsurface conditions from six boreholes and six shallow test pits (Refer Appendix. Bedrock (gneiss) was only encountered in the deepest borehole, L05D, at a depth of 45 m bgl. The other boreholes are all less than 25 m deep. The borelogs show layers of sand, clay and calcrete, consistent with multiple phases of dune deposition and migration. The test pits show a thin layer of topsoil over sand to the base on the pits, which is 3 to 3.5 m bgl (Table 1). Gravel was observed in pits L09 and L10, at the base of the topsoil (depths of 0.2 – 0.5 m), above the main sand layer.

Drivers of Geomorphological Processes

Climate

The climate in the north-eastern part of the Eyre Peninsula is semi-arid. Kimba has a mean annual rainfall of 346 mm/a (Berens et al. 2011) Surface water is scarce – with low rainfall, high evaporation and relatively flat topography, only small amounts of annual rainfall occur as runoff (Berens et al. 2011).

The area is subject to infrequent large, high intensity rainfall events. Intense rainfall events are associated with high levels of groundwater recharge, and a strong correlation between groundwater levels and rainfall has been noted (Berens et al. 2011).

Wind is also important from a geomorphological viewpoint, as it drives aeolian processes.

Tectonics and Seismicity

Geoscience Australia's National Earthquake Hazard Map of Australia (Burbidge et al 2012) and mapping of historical earthquakes and neotectonic features (Quigley et al. 2010) indicates seismic activity in the Eyre Peninsula. Quigley et al. (2010) included the eastern part of the Eyre Peninsula in the Flinders Seismic Zone, one of four zones of particularly high seismic activity in Australia.

Historical earthquakes in the northern part of the Eyre Peninsula from the Location SA Map Viewer (http://location.sa.gov.au/). Historically earthquakes have occurred on the Eyre Peninsula, although less than in the Flinders Ranges / Mt Lofty Ranges. The Kimba 24 April 1993 earthquake (magnitude 2.3) has an epicentre approximately 2 km from the Lyndhurst property boundary and approximately 3 km from the detailed study site.

This formation consists of cobbles, gravel, sand silt and clay; red-brown and often poorly sorted. It includes consolidated and dissected terrace and distal fan deposits that may have incipient soil horizons, gibber spreads and gypseous materials (Reid and Preiss 1999).

3.2.2.1 Drivers of Geomorphological Processes

Climate

The climate in the north-eastern part of the Eyre Peninsula is semi-arid. Kimba has a mean annual rainfall of 346 mm/a (Berens et al. 2011) Surface water is scarce – low rainfall, high evaporation & relatively flat topography, only small amounts of annual rainfall occur as runoff (Berens et al. 2011).

The area is subject to infrequent large, high intensity rainfall events. Intense rainfall events are associated with high levels of groundwater recharge, and a strong correlation between groundwater levels and rainfall has been noted (Berens et al. 2011).

Wind is also important from a geomorphological viewpoint, as it drives aeolian processes.

Tectonics and Seismicity

The Eyre Peninsula is an area of relatively high seismic activity. This is indicated by Geoscience Australia's National Earthquake Hazard Map of Australia (Burbidge et al 2012) and mapping of historical earthquakes and neotectonic features (Quigley et al. 2010). Quigley et al. (2010) included the eastern part of the Eyre Peninsula in the Flinders Seismic Zone, one of four zones of particularly high seismic activity in Australia.

Historical earthquakes in the northern part of the Eyre Peninsula can be viewed via Location SA Map Viewer (http://location.sa.gov.au/). Historically earthquakes have occurred on the Eyre Peninsula, although less than in the Flinders Ranges / Mt Lofty Ranges. The Kimba 24 April 1993 earthquake (magnitude 2.3) has an epicentre approximately 2 km from the Lyndhurst property boundary and approximately 3 km from the detailed study site.

3.2.2.2 Geomorphological Processes

Fluvial

There are no major rivers or streams at or in close proximity of the Lyndhurst site (Figure 13), although a watercourse with a catchment area of 540 km^2 occurs to the north-west of the site (see hydrology section). Hydrological and hydraulic modelling should be undertaken to determine local surface flow patterns and associate energy conditions, including the extent of flows through interdune swales. Anecdotal information indicates that waterlogging has been observed (approximately every 5 years) and runoff (approximately every 10 years), which has been attributed the presence of subsurface layers with low hydraulic conductivity including impervious calcrete (see hydrology section).

Lacustrine

The Lyndhurst site is situated immediately adjacent to low-lying land associated with Lake Gilles and a low-lying salt scald extends onto the northern section of the subject property (although not the specific study site).). No specific information was found regarding the hydrologic regime of Lake Gilles. Given the semiarid climatic setting and extensive evaporite deposits, it is likely that it is only filled during infrequent episodic flooding. For example, Lake Torrens has filled twice since European settlement, in 1989 and 1878 (Bye et al. 1989).

If Lake Gillies and the adjacent low-lying areas are flooded, the adjacent corner of the site would potentially be subject to lakeshore processes including shoreline erosion and accretion. Bourne and Twidale (2010) drew attention to the rapid shoreline change that can occur in playa lakes in times of flood.

The site inspection by the geomorphologist did not observe lake shoreline erosion at the edge of the site.

Slope/Mass Movement

The Lyndhurst site is characterised by approximately 15 m of local relief (Figure 18). Dune slopes, even if vegetated, are susceptible to erosion and mass movement, especially at times of high rainfall or flood. Processes include sapping, collapse, surface wash and gulling (Twidale 2008). These processes have the potential to impact on long term site stability, especially if the vegetation cover is not maintained or surface water runoff managed.

Sodic and likely dispersive clayey sand subsoils likely exist at the site by around 2 m depth. If sodic and dispersive or slaking clayey material is present and exposed, it would be at risk of rill, tunnel and gully erosion depending on how detrimental these properties are. Further targeted testing is required to characterise these detrimental soil properties.

Aeolian

The longitudinal dunes of the Eyre Peninsula are considered to be relict dunes as they are extensively vegetated with only local areas of mobile sand where the vegetation cover is disturbed (Twidale, 2008). The sandy surface is potentially at risk of wind erosion (deflation), dune reactivation or transgressive dune development if the vegetation cover or dune surface is disturbed. Such processes have the potential impact to impact on long term site stability.

The study site is also expected to receive wind-blown sediment from the bed of Lake Gilles.

3.2.2.3 Summary

The Lyndhurst study site is situated on Quaternary dunes, which appear to be relics from a period of greater aeolian activity but remain potentially susceptible to aeolian processes, particularly if the vegetation cover is disturbed.

Slope and mass movement processes need to be considered, particularly at times of high rainfall and in relation to seismic activity.

These processes have the potential to impact on long term site stability if the vegetation cover is not maintained or surface water runoff managed appropriately.

The north-western edge of the study site abuts a low-lying area that requires modelling to determine whether it may be inundated when Lake Gilles is also in flood, exposing the site to lake-shore processes.

3.2.3 Design Issues and Mitigation Measures

The potential for slope mass movement associated with the geology of the dunes and/or triggered by high rainfall events or seismic activity should be addressed in the context of the geotechnical properties of the soil within the civil design for the facility.

The potential for wind erosion should be addressed through vegetation management to retain surface cover across the site.

3.2.4 Data Gaps and Recommendations for Stage 2 Work Program

Further assessment of the geomorphology of this site would require ground-truthing of the desktop assessment by a geomorphologist.

As limited testing of site soils has occurred to determine the presence and severity of sodic and dispersive clayey material at depth, further targeted testing should be undertaken for sodicity, slaking and dispersiveness.

Hydrological and hydraulic modelling should be undertaken to determine local surface flow patterns and associated energy conditions, including the extent of flows through interdune swales.

Further assessment of the flooding regime of Lake Gilles is required to assess the potential implications of lake-shore processes for the site. The likely extent of flooding associated with Lake Gilles would also be established by hydrologic and hydraulic modelling. The shoreline of Lakes Gilles (based on SRTM data) is about 15 m lower than the Lyndhurst site (100 ha study area), hence the potential for site to be exposed to lake-shore processes is unlikely. A topographical survey of Lakes Gilles is required confirm elevation differences between the lake and the site.

The site inspection by the geomorphologist did not observe lake shoreline erosion at the edge of the site. The maximum extent of flooding of Lake Gilles should be considered as part of the hydrological and hydraulic modelling.

3.3 Seismic Risks

A detailed review of a draft of this section was provided by Clark (2018c), containing interpretations of data and suggestions for further analysis of that data and for further data collection.

3.3.1 Methodology and Results

The objective of this study is to evaluate information that has an influence on the seismic hazards at the potential NRWMF site at Lyndhurst. This information is being used to screen sites for suitability, and will also form input into seismic hazard analyses, the methodology for which is described in Somerville and Moriwaki (2002), that would be performed in the design phase. Seismic ground motion hazard analysis requires the use of earthquake source models including both fault sources and distributed earthquake sources (e.g. Hall et al., 2007), and ground motion prediction models (e.g. Somerville et al., 2009). Seismic fault displacement and ground deformation hazard analysis requires the use of fault models (e.g. Thio and Somerville, 2016).

The four criteria listed in section 3.3.1.1 below describe two different categories of earthquake hazard. The first two criteria describe several types of ground deformation that could potentially disrupt the site, including surface fault displacement, folding, and other forms of ground deformation due to earthquake faulting. The third and fourth criteria describe ground shaking hazard.

A neotectonic feature is defined as one that has hosted measurable displacement in the current crustal stress regime (Machete, 2000; Clark et al., 2011), i.e. within the last 5-10 Ma in Australia (Sandiford et al. 2004) but is not necessarily an active fault. Verifying these features as active faults (or not) is an ongoing process. In Australia, the rate of earthquake activity on most active faults and neotectonic features is estimated from the amount of vertical displacement of landscape features they are inferred to have caused due to dip-slip (reverse) faulting. The inferred displacements are typically in the range of several tens of metres to several hundred metres, and the ages over which they are assumed to have occurred are typically 5 to 10 million years, yielding fault slip rates in the approximate range of 0.01 to 0.1 mm/yr, and recurrence intervals in the tens of thousands to hundreds of thousands of years or more. Consequently, the slip rates are typically averaged over a much longer time interval than the 100,000 year interval which might be considered to be an appropriate upper limit of engineering significance. Hence, as pointed out by Clark (2009), it is unclear whether long term slip rates (and the recurrence estimates based upon them) are appropriate for probabilistic seismic hazard assessment.

Further, there is evidence for pronounced episodic surface rupture behaviour on many Australian faults (e.g. Crone et al. 1997; Clark et al. 2011; 2012). Typically, clusters of several surface faulting events occur with intervals between events of several tens of thousands of years, separated by intervals of hundreds of thousands or millions of years without surface faulting. Conventional seismic hazard analysis assumes that earthquakes on faults occur randomly in time, at an average rate that is controlled by the long term average slip rate of the fault. However, it is unclear whether long term slip rates (and the recurrence estimates based upon them) are appropriate representations of the temporal and spatial clustering of surface faulting earthquakes for probabilistic seismic hazard assessment.

Two primary data sets were used in this study: the earthquake catalogue and the neotectonic feature database described above and illustrated in Figure 26 through Figure 30. Each of these data sets provides information about both of the earthquake hazards addressed above: ground deformation and ground shaking. The neotectonic feature database contains geological structures that could potentially be active faults. The earthquake catalogue contains earthquakes, which always occur on active faults, but unless their magnitudes are quite large, their fault dimensions are quite small and so they may not break the ground surface and appear as surface faults, especially in non-cratonic regions of Australia including the Northern Flinders Ranges. Consequently, it is usually not possible to associate small earthquakes with individual mapped faults in Australia, and this is found to be the case in the Flinders Ranges (Love et al., 2006).

Conversely, there are typically numerous mapped faults close to or in the region surrounding any site in Australia, but most or all of these faults are “bedrock faults” (ones that do not displace geologically recent materials such as alluvium). These faults were once active but are not known to be currently active, although they potentially could be reactivated under the current stress regime if they are favourably oriented. This is a further reason why the correlation between small historical earthquakes and individual mapped faults in Australia is generally not very strong.

In the past century, about ten Australian earthquakes have broken the ground surface (Clark et al., 2011; 2012) and thus can be associated with identified faults. All of these earthquakes occurred in cratonic regions, including the Gawler Craton, of the western part of Australia, where hypocentres tend to be very shallow because the shallow crust is very strong. This feature of Cratonic earthquakes makes it likely that they will cause surface faulting and thus potentially be detected. For example, the Mw 6.0 Petermann Ranges earthquake produced 20 km of surface fault rupture (Clark, 2016; Gold et al., 2017). However, none of these earthquakes occurred on a fault that had already been identified as a potentially active fault. As described by Clark et al (2012) and Clark (2016), earthquakes occurring in some Cratonic domains appear to be one-off events. This implies that we may not necessarily expect Cratonic earthquakes to recur at the locations of past earthquakes, and that the locations of future Cratonic earthquakes may be difficult to predict.

At most sites that are distant (several tens of km) from faults in Australia, the probabilistic ground shaking hazard is dominated by randomly occurring earthquakes that are modelled by distributed earthquake sources. At near fault sites (within a few tens of km of active faults), identified faults also make a significant contribution to the ground shaking hazard at a site in Australia. Also, these nearby faults could potentially cause ground deformation at the site.

Clark et al (2011, 2012) made an Australia-wide assessment of active faulting based on neotectonic features. They analysed a catalogue of 333 neotectonic features, 47 of which are associated with named fault scarps. The data were derived from analysis of Digital Elevation Models (DEMs), aerial photos, satellite imagery, geological maps and consultation with state survey geologists and a range of other earth scientists. The catalogue varies in completeness because sampling is biased by the available databases, the extent of unconsolidated sedimentary cover, and the relative rates of landscape and tectonic processes. Clark et al. (2011, 2012) assessed their confidence that each feature in their data base is a neotectonic feature (active in the past 5 to 10 million years), using the rankings of A: Definite; B: Probable and C: Possible. The distribution of numbers of features in each category is A: 17%, B: 32% and C: 51%.

The earliest records of earthquakes in Australia go back only about 180 years, and instrumental recordings of earthquakes have only been made for the past century. Geoscience Australia (2018) assessed the completeness of detection of earthquakes in their revised earthquake catalogue. The Lyndhurst site is located in the Gawler Craton neotectonic domain. In both this domain and the adjacent Northern Flinders Ranges neotectonic domain, the detection and location of earthquakes became complete in 1900 for earthquake magnitudes Mw of 6 and larger, and it was not until 1966 that the detection and location of earthquakes of magnitude Mw 3.0 or larger became complete.

The recurrence intervals of surface faulting earthquakes in Australia are thought to typically lie in the range of 10,000 to 100,000 years during seismically active periods (Clark et al., 2011, 2012), so the historical earthquake catalogue provides a very limited picture of earthquake potential in Australia. It would be preferable to have an earthquake catalogue that is complete for a much longer period of time in order to have a better understanding of the earthquake potential of Australia. Conversely, the current assessment of neotectonic features is based on activity within the past 5-10 Ma. It would be preferable to be able to identify potentially active faults in geologically recent materials such as alluvium in more recent geological time in order to be more confident that they are currently active.

These limitations notwithstanding, the locations of historical earthquake epicentres have a strong spatial association with the locations of neotectonic features in the study region, as shown in Figure 30. This is true for the Flinders Ranges and their southward continuation in the Mount Lofty Ranges on the east side of Spencer Gulf, and for the faults on the eastern margin of the Eyre Peninsula on the west side of Spencer Gulf. There is a clear association of faults and historical earthquakes, shown in Figure 30, with the topography of the Flinders and Mount Lofty Ranges shown in Figure 31, indicating that large earthquakes occurring on these faults are building the ranges (Braun et al., 2009; Clark, 2010; Sandiford et al., 2013; Clark et al. (2014).

3.3.1.1 Site Characteristic Criteria

ARPANSA (2016) states that: “In accordance with Government policy, ARPANSA has adopted the ‘trusted international standard’ (TIS) principle http://www.arpansa.gov.au/Regulation/ibp/index.cfm, under which additional requirements should not be imposed beyond international best practice, unless it can be demonstrated that there is a good reason to do so. This regulatory guide is based on the accepted standards published by the International Atomic Energy Agency (IAEA) The relevant IAEA Guidelines for seismic hazard evaluation are excerpted from IAEA Seismic Safety Guide SSG-9 (2000) in Appendix A of this report.

This report addresses the following four key criteria:

Absence of potentially active faults that could cause surface faulting through the facility

Hazards due to surface fault displacement are sensitive to the precise locations of faults, and can potentially be avoided if the precise locations of faults are know with certainty and if the occurrence of faulting at other locations can be ruled out with high confidence. However, it is well know that distributed faulting can occur off the main fault strand, and in particular, for the reverse and thrust faults that constitute most of the faults in South Australia, it could be expected that there is potential for significant faulting and deformation on the hanging wall of these faults.

IAEA (2000) Chapter 8. Potential for Fault Displacement at the Site, states on page 31, under the heading “Capable Fault Issues for New Sites:”

> *“8.8. Where reliable evidence shows that there may be a capable fault with the potential to affect the safety of a plant at a site, the feasibility of design, construction and safe operation of a plant at this site should be re-evaluated and, if necessary, an alternative site should be considered.”*

Absence of near-surface faults that could cause folding or other deformation within the facility

Hazards due to near-surface faults that can cause ground deformation can potentially be avoided if the precise locations of the faults are know with certainty and if the occurrence of faulting at other locations can be ruled out with high confidence. However, it is well know that ground deformation can occur off the main fault strand, and in particular, for the reverse and thrust faults that constitute most of the faults in South Australia, it could be expected that there is potential for significant folding and deformation on the hanging wall of these faults.

IAEA (2000) Chapter 8. Potential for Fault Displacement at the Site, states on page 31, under the heading “Capable Fault Issues for New Sites:”

> *“8.8. Where reliable evidence shows that there may be a capable fault with the potential to affect the safety of a plant at a site, the feasibility of design, construction and safe operation of a plant at this site should be re-evaluated and, if necessary, an alternative site should be considered.”*

Absence of nearby faults that could cause hanging wall or rupture directivity effects, which amplify ground motions

IAEA (2000) Chapter 5: Evaluation of the Ground Motion Hazard, does not identify any specific conditions that should be avoided if possible. However, there are several readily identifiable conditions that can cause large ground motion levels at sites located near faults. These include two near-fault effects that are prominent within about 20 km of an active fault: rupture directivity effects and hanging wall effects.

In the rupture directivity effect (Somerville et al., 1997), the propagation of fault rupture at a speed that is almost as large as the speed of shear waves in rock causes most of the wave energy from the fault to arrive in a single large pulse of ground motion.

The hanging wall is the ground that lies above a dipping fault. In the hanging wall effect (Abrahamson and Somerville, 1996), the ground motion on hanging wall sites is amplified by the proximity of the site to a large part of the underlying fault plane.

Absence of ridge crests which amplify ground motions

IAEA (2000) Chapter 5: Evaluation of the Ground Motion Hazard does not identify any specific conditions that should be avoided if possible. However, there are several readily identifiable conditions that can cause very large ground motion levels. These include topographic amplification effects (EC8, 2003).

It is well know that earthquake ground motion can be significantly amplified at sites on or near the crests of steep topographic slopes. Incorporation of topographic amplification effects in design ground motions has been codified in Eurocode 8 (EC8, 2003), which models topographic amplification as a function of the ratio H/L, where H is the height of the slope and L is its horizontal length. EC8 incorporates surface topography via the soil ground motion amplification parameter ST, which varies between 1.2 and 1.4 depending on the slope angle and the topographic feature. Typically, for mean slope angles < 15 degrees (H/L < 0.27), topographic effects can be neglected. For isolated cliffs and slopes near the top edge, ST ≥ 1.2 is recommended. For ridges with crest width significantly less than the base and slope height H > 30 m, the recommended values are ST ≥ 1.2 and ST ≥ 1.4 for mean slope angle exceeding 15 degrees and 30 degrees respectively. The highest values apply near the top of the slopes while the amplification factor can be assumed to linearly decrease towards the base, where it becomes unity. The suggested amplification factors are increased by at least 20% in the case of soil layer more than 5 m thick.

3.3.1.2 Desktop Data Collection

Clark, D. (2018a) performed a desktop study of crustal architecture in the region under consideration, documenting the presence of geologically recent fault displacements in the region. Clark (2018b) performed a desktop study of the neotectonic setting of the sites, addressing neotectonic features (Figure 26) that are potentially active faults. This study made use of an updated version of the neotectonic feature database for Australia compiled by Clark et al. (2011).

Geoscience Australia (2018, unpublished) provided a revised Australian earthquake catalogue for use in this study. In a probabilistic seismic ground motion hazard analysis for a site, it is necessary to consider potential earthquake sources within approximately 300km of the site. Figure 27 shows a map of historical earthquake epicentres in the study region that extends that distance from the sites, using the Geoscience Australia (2018) earthquake catalogue. Figure 28 shows identified neotectonic features (potential active faults) in the same region from Clark et al. (2011), and Figure 30 shows the superposition of these features on the earthquake epicentre map. There is a clear association of faults and historical earthquakes, shown in Figure 30, with the topography of the Flinders and Mount Lofty Ranges shown in Figure 31.

Use was made of topographic maps to assess the potential for topographic amplification of ground motions at the site.

Figure 26 Map of neotectonic features and site locations. Source: Clark, 2018b

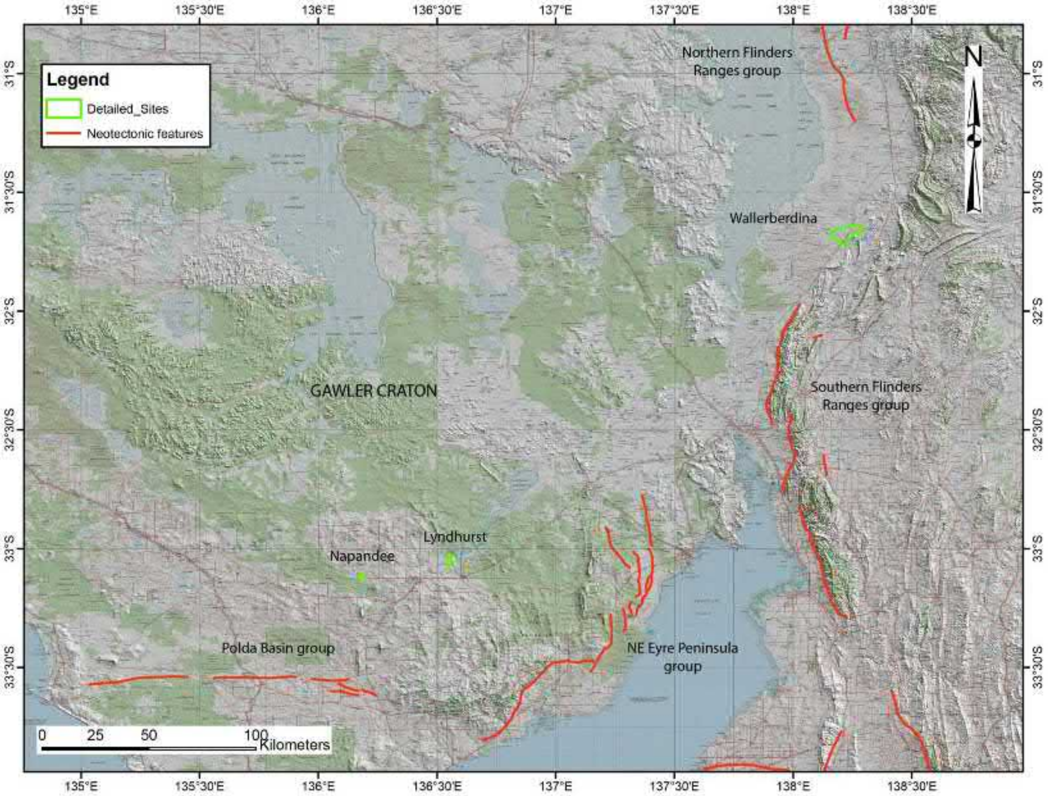


Figure 27 Historical seismicity within about 300 km of the site locations, shown by the yellow stars, based on the Geoscience Australia (2018) revised earthquake catalogue.

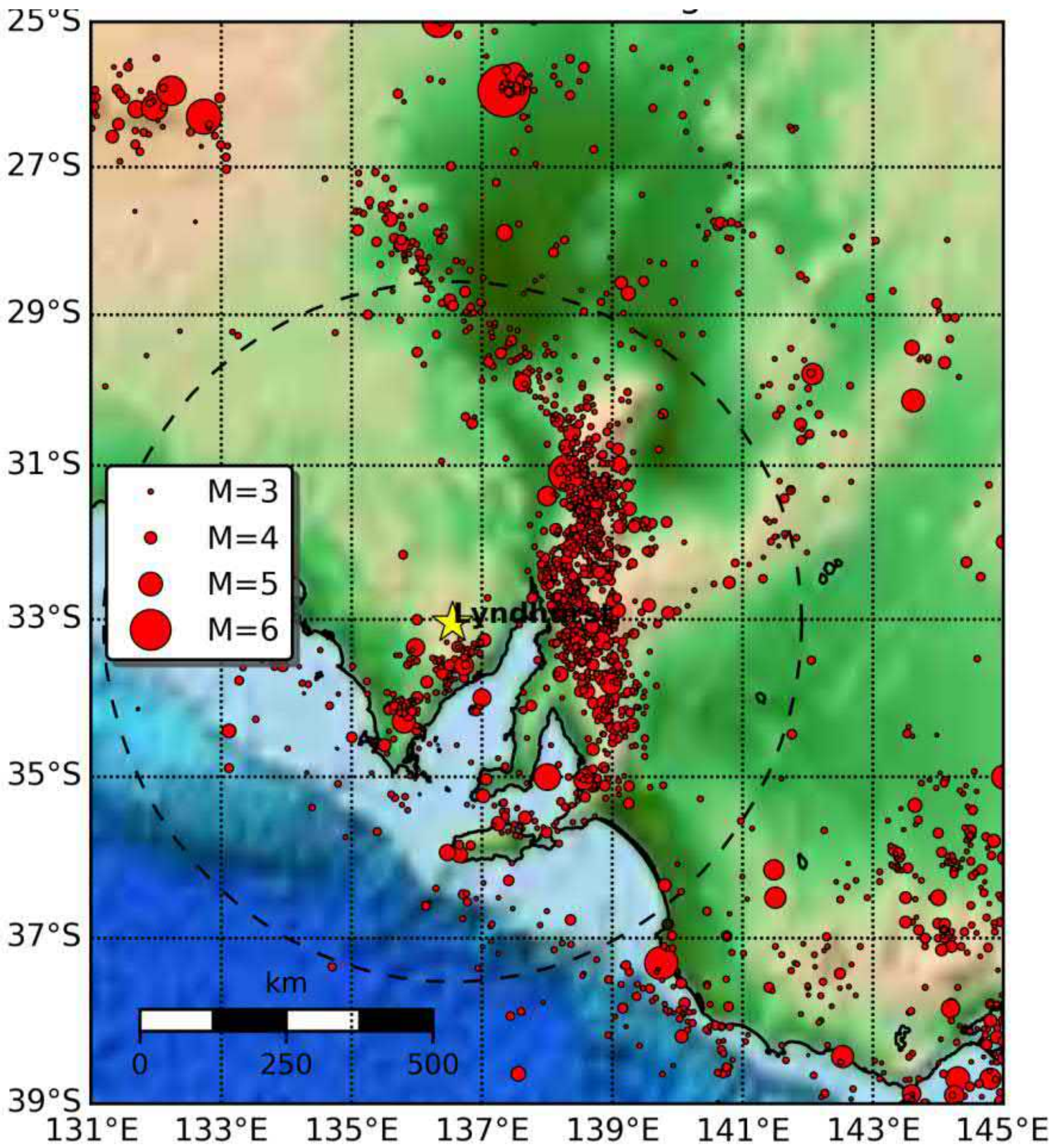


Figure 28 Neotectonic features in the study region based on Clark et al. (2011).

The top edges of the faults are shown by dark lines and their surface projections are shown by the coloured bands.

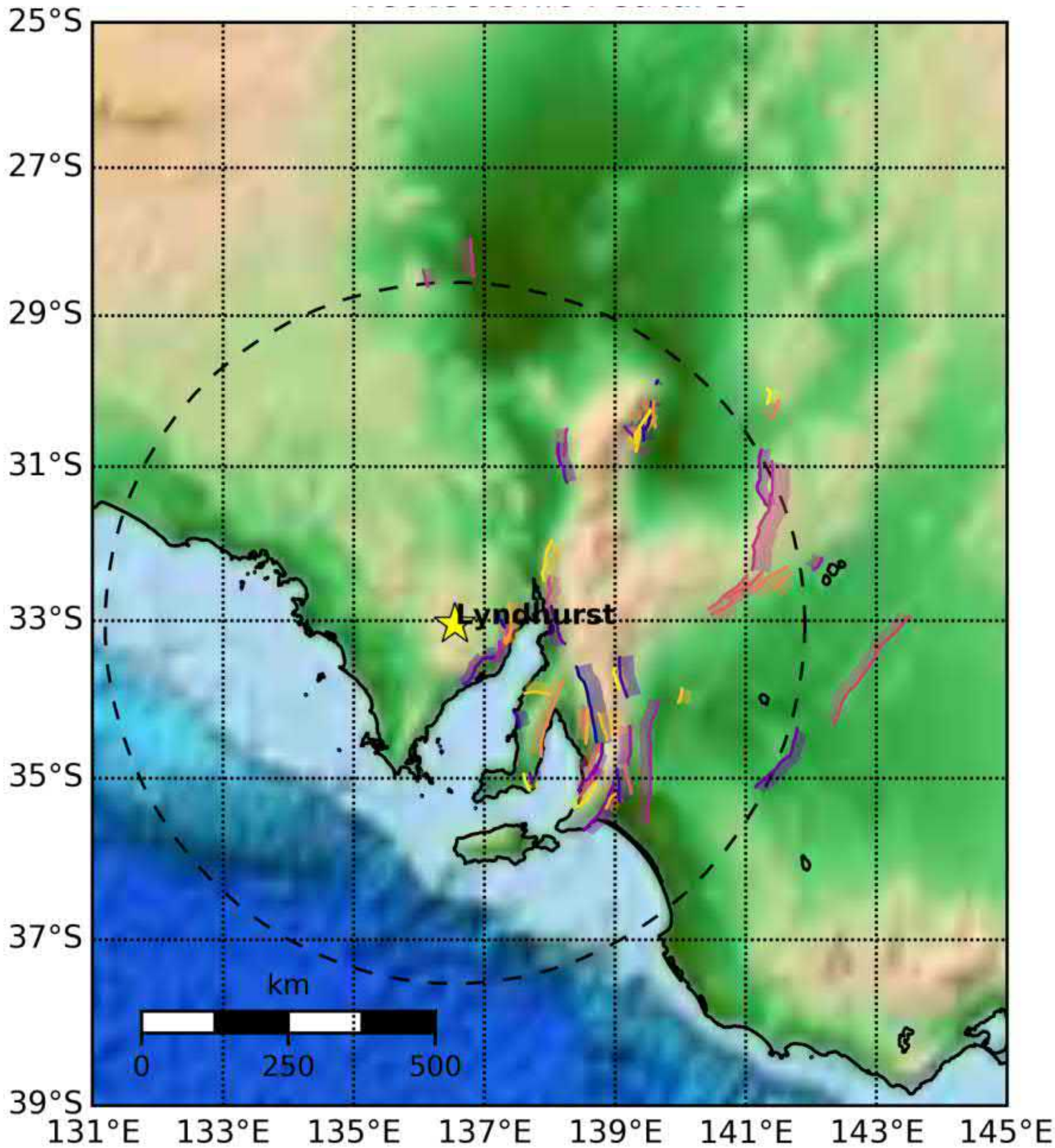


Figure 29 Legend for neotectonic features in the study region based on Clark et al. (2011).

Figure 30 Neotectonic features and historical earthquakes for the study region based on Clark et al. (2011) and Geoscience Australia (2018) respectively.

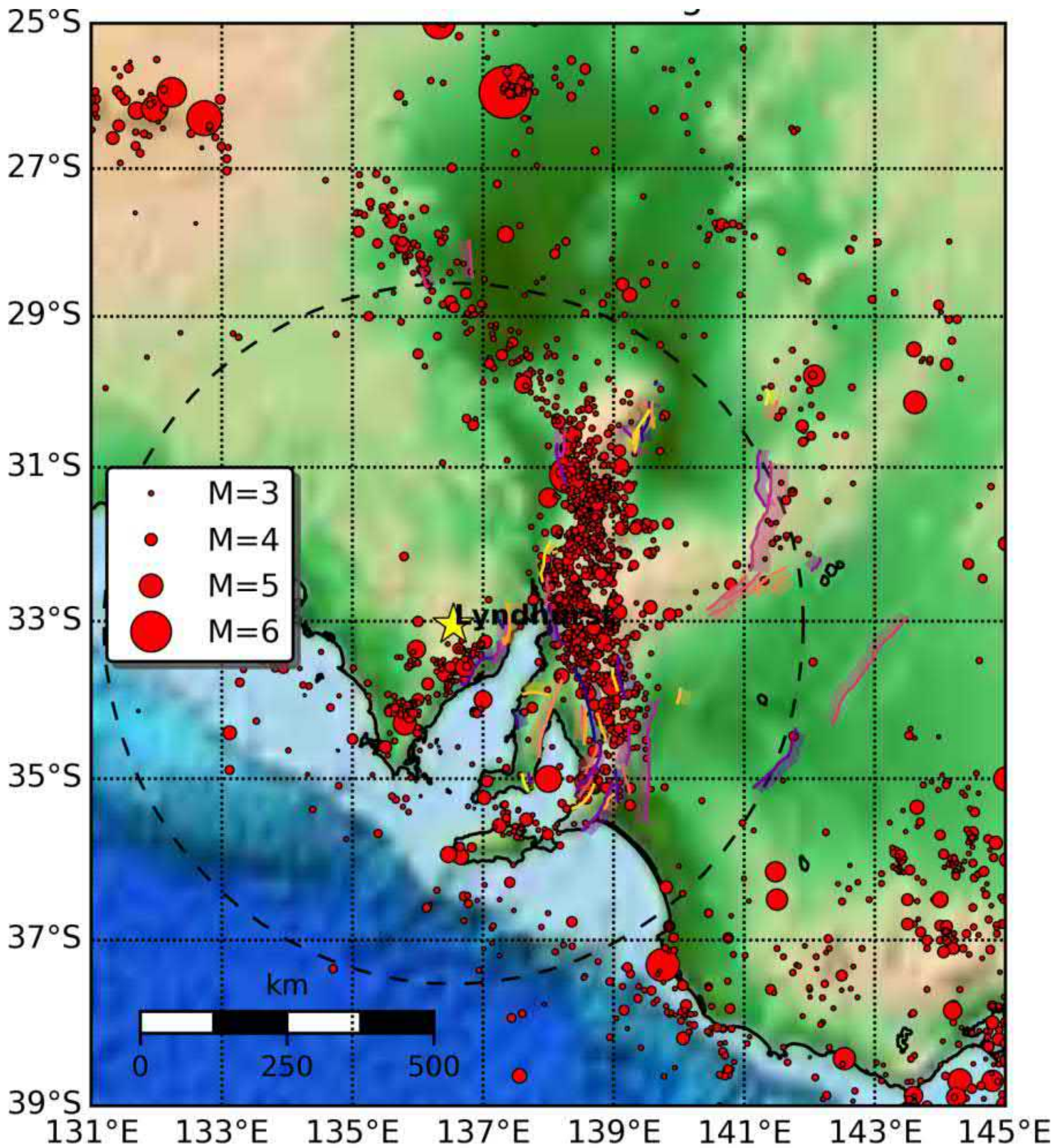
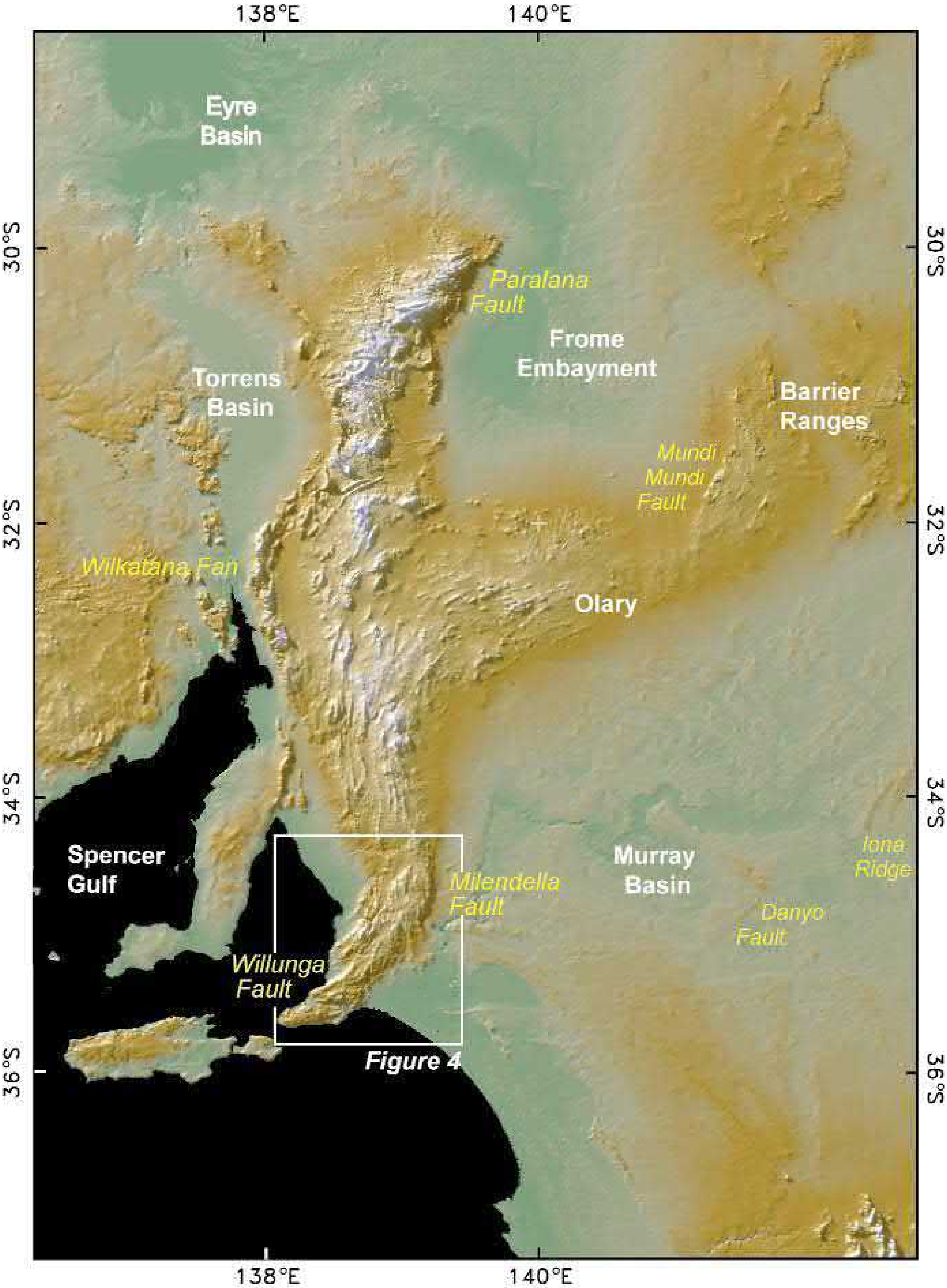


Figure 31 Topography of the Flinders and Mount Lofty Ranges. Source: Sandiford et al., 2013.



3.3.1.3 Field Data

Two shallow seismic reflection profiles together with a preliminary interpretation, described below, were obtained at Lyndhurst by Velseis Pty Ltd (Velseis).

Daishsat Pty Ltd (Daishsat), undertook an airborne survey of magnetics and radiometrics for the Lyndhurst site, and a preliminary desktop assessment of the available geophysical data sets at the site.

3.3.2 Review Against Criteria

Clark (2018a) states:

> *"The Kimba sites (which include Lyndhurst) occur within the Archaean to Paleoproterozoic core of the Gawler Craton. The Gawler Craton is a stable crystalline basement province that has not been significantly deformed or remobilised since about 1450 Ma (Drexel et al., 1993). The SARIG mapserver indicates the existence of Archaean to Early Mesoproterozoic faults within 2 km of the rror site, and 9 km of the Lyndhurst site. However, there is no evidence, at the resolution of the SRTM DEM data … to suggest reactivation of any faults within 50 km of either site during the last several hundred thousand years. Both sites were not affected by Pliocene marine transgression, and so the landscape record may be much longer than late Pleistocene."*

Mapped fault scarps and historical seismicity in the vicinity of the Lyndhurst site are shown in Figure 32, from Clark (2017). The closest fault scarps are located about 50 km to the south of the site, and additional fault scarps lie to the east of the site. Figure 33 shows neotectonic features from Clark et al. (2011) and historical seismicity from the 2018 Geoscience Australia earthquake catalogue. This map does not show the scarps to the south of the sites that appear in the more recent database used by Clark (2017) in Figure 32.

Figure 32 Geological setting, mapped scarps and historical seismicity. The Lyndhurst site is the green rectangle in the right centre of the map. Source: Clark (2018b).

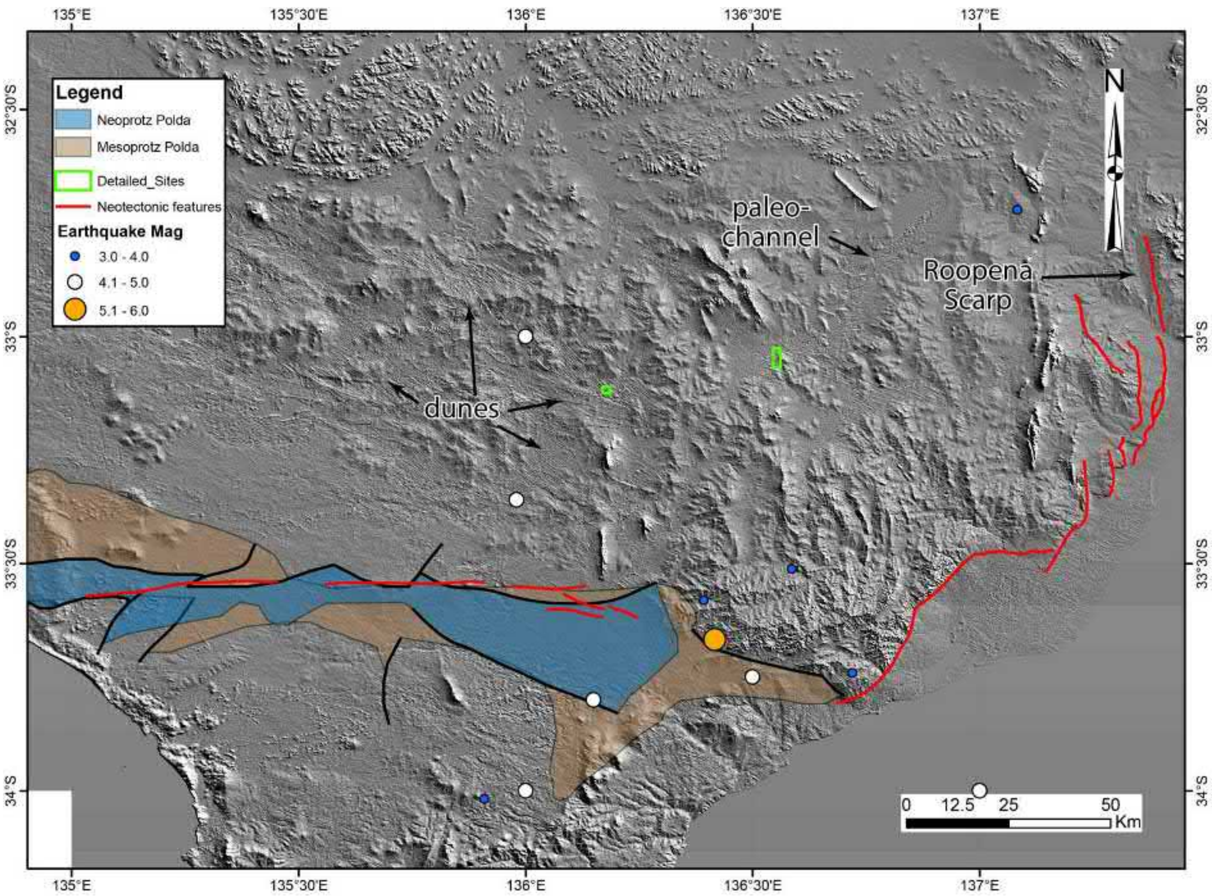
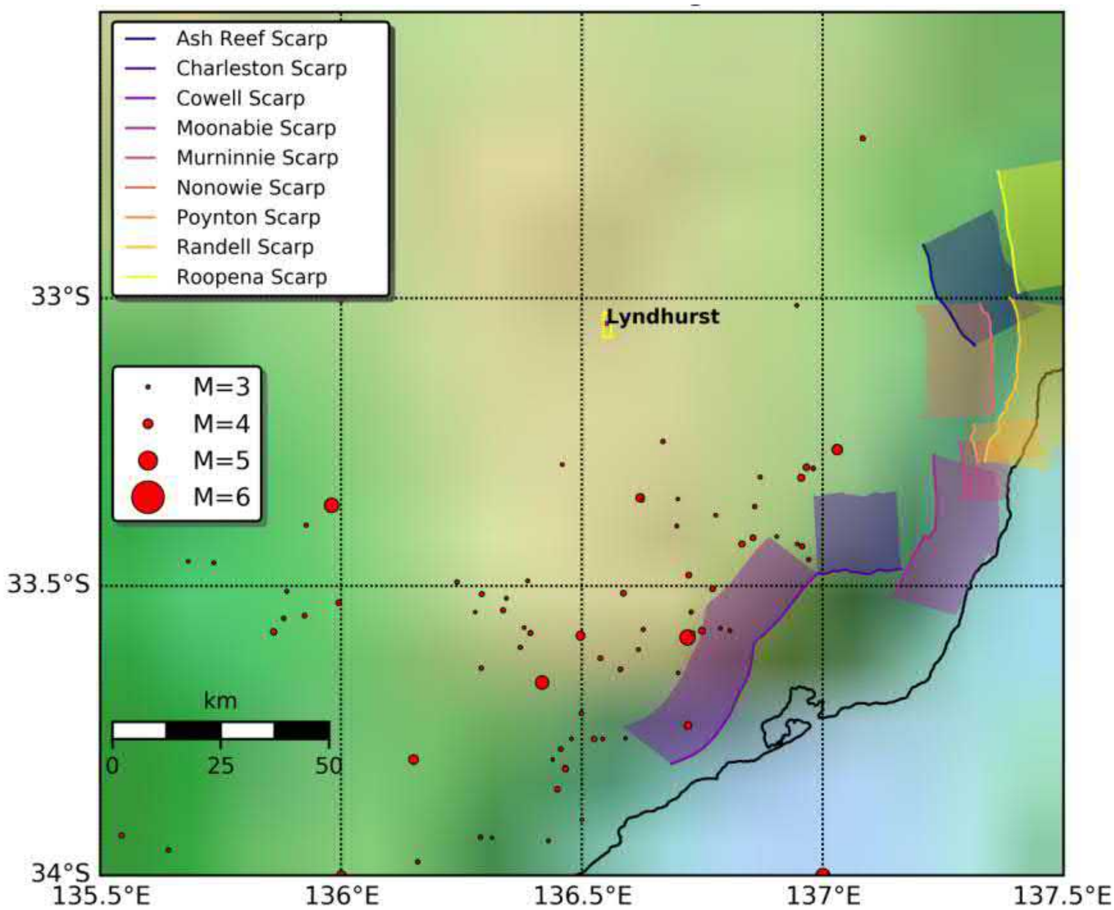


Figure 33 Neotectonic features and historical seismicity near the Lyndhurst site based on Clark et al. (2011) and Geoscience Australia (2018).

The top edges of the faults are shown by dark lines and their surface projections are shown by the coloured bands.



A deep crustal seismic reflection profile to the north of the Kimba sites is shown in Figure 34. These sites lie within the Archaean to Paleoproterozoic core of the Gawler Craton. The sites are project onto seismic profile 08GA-G1 at approximately CDP 7100 and CDP 9000 (red arrows in Figure 34). A series of near-surface, east-dipping faults are imaged between CDPs 7000 and 9500, which appear to sole onto a sub-horizontal detachment surface at the top of the reflective middle crust at about ~7.5-9 km depth. Clark (2018c) concluded that there was no evidence found to suggest reactivation of any of these faults within recent geological time, at the vertical resolution of the Shuttle Radar Topography Mission digital elevation models; this resolution is of multiple event scarps more than 2-3m high.

Daishsat (2018) concluded that although only regional data have been examined from the existing 1:250 000 geology map, drill-holes, gravity and magnetic data, there is no evidence to suggest the presence of shallow basement or structures at Lyndhurst.

Two shallow seismic reflection profiles were obtained at Lyndhurst by Velseis Pty Ltd (Velseis), included as Appendix C. In Profile 1, shown in Figure 35, interpreted faults are shown by blue lines that extend down to depths of 250 m, and where possible, interpreted slip direction is indicated. The interpreted fault at the western end of the section intersects the surface of the basement rocks, but these interpreted faults all lie below the base of weathering of basement rocks, indicating the absence of faulting in recent geological time (Cenozoic; 66Ma). One interpretation is that there is a step in the base of the weathering profile, of approximately 10 m, associated with a basement fault mapped in the Velseis seismic line (Lyndhurst 01), and a disturbance of reflections extending to the surface that may relate to this step and fault. The significance and origin of the step has multiple possible interpretations, including being related to faulting, to differential weathering across an inactive fault, or to poor velocity control during seismic processing in the sandy (low velocity) dune sediments overlying the site to variable depth. If the feature is related to a geologically recent fault displacement, a lack of surface expression in the LiDAR data suggests that a large earthquake has not occurred on the fault in the last several tens of thousands of years at least. The significance and interpretation of this feature will be addressed in the Stage 2 study if the site progresses. In summary, at the resolution available in these profiles, there is no conclusive evidence for geologically recent surface faulting at the site.

Daishsat (2018) concluded that although only regional data have been examined from the existing 1:250 000 geology map, drill-holes, gravity and magnetic data, there is no evidence to suggest the presence of shallow basement or structures at Lyndhurst.

Figure 34 Top: Location and Bottom: Interpretation of deep crustal seismic line 08GA-G1 (from Fraser et al. 2010). Source: Clark (2018a).

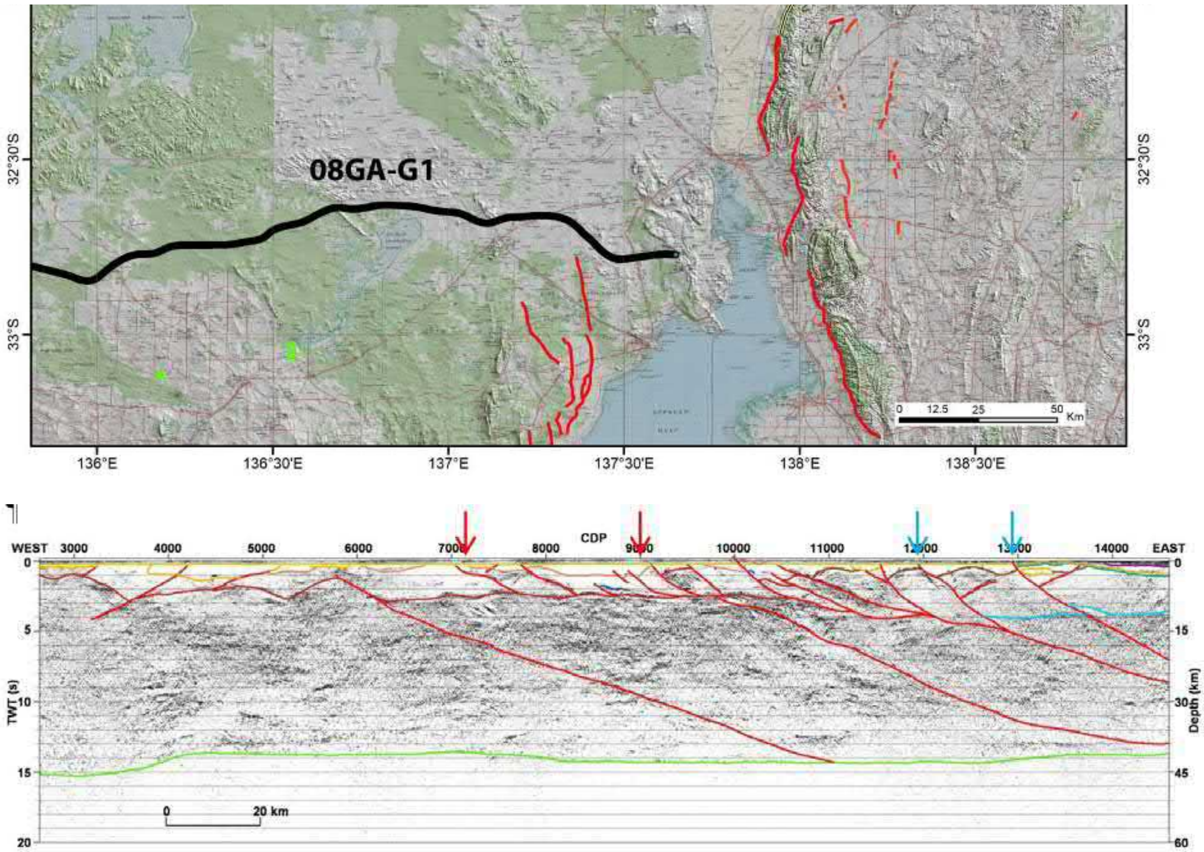
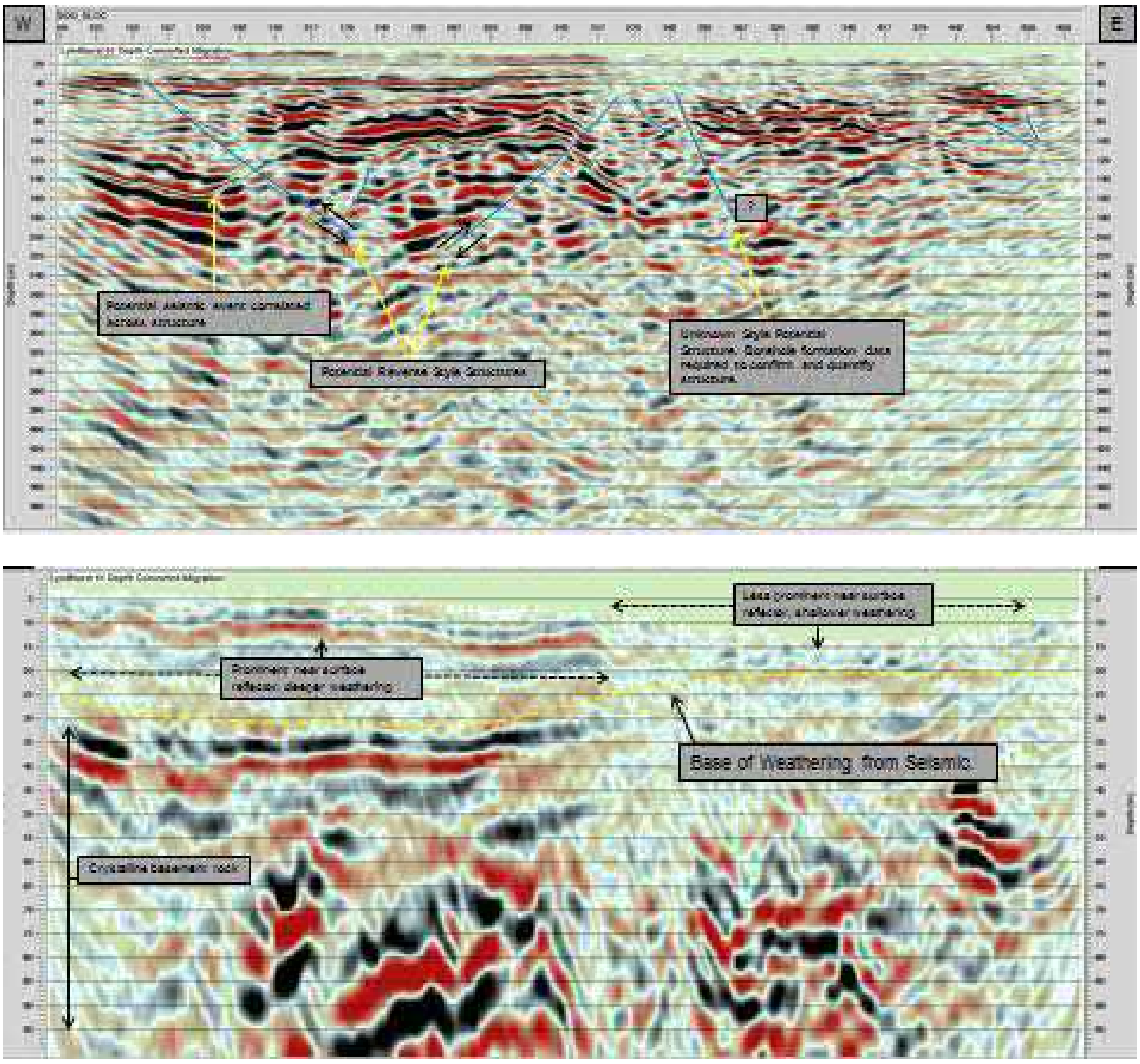


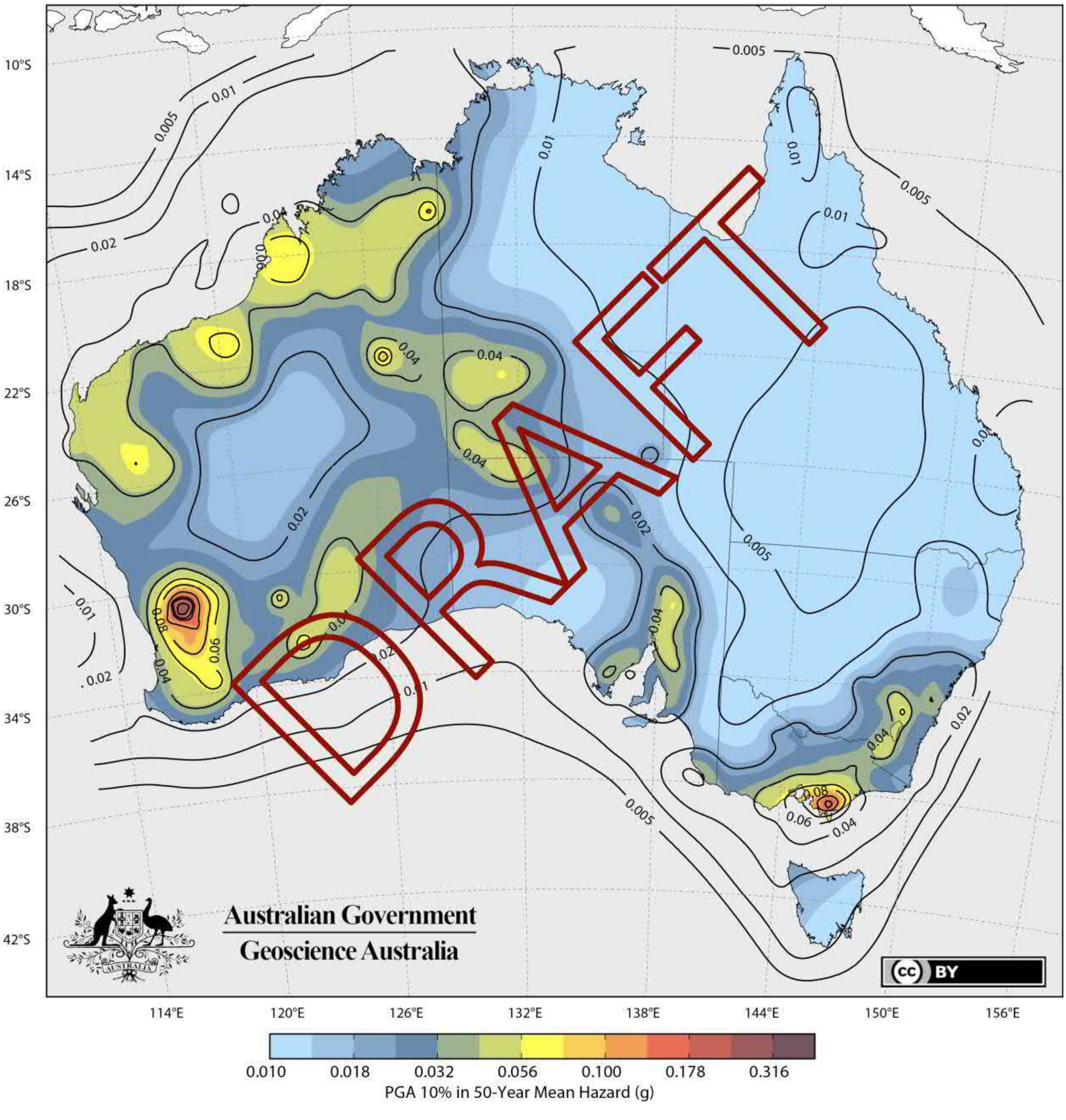
Figure 35 Lyndhurst 01 Depth Converted Migrated Stack Interpreted Structure (top) and Interpreted Section at Near Surface (bottom). Source: Velseis.



A provisional seismic hazard map of Australia is shown in Figure 36. The map shows peak acceleration having a 10% probability of exceedance in 50 years for site class B_e. The hazard value at the Lyndhurst site is approximately 2.5%g, which is well below the damage threshold for ordinary structures.

Figure 36 Provisional peak ground acceleration (PGA) as proposed for the AS1170.4–2018 as of May 2017.

Note: values from the NSHA18 within this map are in draft form only and the hazard contours are likely to change prior to the completion of the final model by June 2018. Source: Allen et al. (2017).



3.3.2.1 Assessment Criterion 1 - Absence of potentially active faults in the foundation

There is no evidence, at the resolution of the SRTM DEM, LiDAR topographical and the on-ground seismic survey data, to suggest reactivation of any faults in the foundation of the Lyndhurst site during the last several hundred thousand years. However, the step in the base of the weathering profile, of approximately 10 m, associated with a basement fault mapped in the Velseis seismic line (Lyndhurst 01) needs further assessment, As noted above, Cratonic earthquakes tend to occur at shallow depths and rupture the surface, even those with moderate magnitudes (Mw 6 or less), enhancing the possibility that they will be identified in neotectonic studies. However, earthquakes occurring in some Cratonic domains appear to be one-off events. This implies that earthquakes may not necessarily be expected to recur at the locations of past Cratonic earthquakes, and that the locations of future cratonic earthquakes may be difficult to predict. Subject to this uncertainty, the site displays absence of this hazard.

3.3.2.2 Assessment Criterion 2 - Absence of near-surface faults beneath or near the foundation

As noted above, there is evidence for the absence of recent shallow faulting in the foundations of the site from the Velseis profiles at the site. However, the step in the base of the weathering profile, of approximately 10 m, associated with a basement fault mapped in the Velseis seismic line (Lyndhurst 01) needs further assessment. There is no evidence, at the resolution of the SRTM DEM, LiDAR topographical and the on-ground seismic survey, to suggest recurrent reactivation of any near-surface faults beneath or near the foundation of the Lyndhurst site during the last several hundred thousand years. Subject to the possible occurrence of one-off earthquakes, the site displays absence of this hazard.

3.3.2.3 Assessment Criterion 3 - Absence of nearby faults

There is no evidence, at the low resolution of the SRTM DEMand other publically available DTM data sets, to suggest recurrent reactivation of any faults within 20 km of the Lyndhurst site during the last several hundred thousand years. However, these datasets are of insufficient resolution to detect single surface rupture events. As noted above, Cratonic earthquakes tend to occur at shallow depths and rupture the surface, even those with moderate magnitudes (Mw 6 or less), enhancing the possibility that they will be identified in neotectonic studies. However, earthquakes occurring in some Cratonic domains appear to be one-off events. This implies that earthquakes may not necessarily be expected to recur at the locations of past Cratonic earthquakes, and that the locations of future cratonic earthquakes may be difficult to predict. Subject to this uncertainty, the site displays absence of this hazard.

A provisional seismic hazard map of Australia (Figure 36, Allen et al., 2017) shows that the peak acceleration having a 10% probability of exceedance in 50 years for site class B_e at the Lyndhurst site is approximately 2.5%g. AECOM expects that seismic design of the facility would be based on a higher ground motion level having a lower probability of exceedance. A preliminary estimate of the peak accelerations having a 2% to 1% probability of exceedance in 50 years for site class B_e (annual exceedance probabilities of 1/2,500 to 1/5,000) is 7.5%g to 10%g. IAEA (2000) does not indicate any ground motion conditions that should be avoided, and seismic design for these levels is expected to be straightforward.

3.3.2.4 Assessment Criterion 4 - Absence of ridgecrests at the site

Ridge crests can amplify earthquake ground motions. The sites do not have slopes large enough to generate topographic amplification based on Eurocode 8 criteria. The site therefore satisfies this criterion.

3.3.2.5 Summary Assessment

The table below provides a summary of the qualitative desktop assessment of site suitability against the seismic criteria.

Table 46 Desktop Assessment Summary of Site Conditions against Seismic Criteria

Assessment Criterion	Site Condition	Confidence
Absence of potentially active faults in the foundation	Absent based on neotectonic and deep seismic data and shallow seismic data	High, subject to the possibility of one-off faulting
Absence of near-surface faults beneath or near the foundation	Absent based on neotectonic and deep seismic data	High, subject to the possibility of one-off faulting
Absence of nearby faults	Absent based on neotectonic and deep seismic data	High, subject to the possibility of one-off faulting
Absence of ridgecrests	Absent based on topographic maps	Very High

3.3.3 Design Issues and Mitigation Measures

This section addresses two categories of seismic hazard: ground deformation and ground shaking.

3.3.3.1 Ground Deformation Hazard

For sites being evaluated for new nuclear installations, IAEA (2006) recommends that:

> *“Where reliable evidence shows that there may be a capable fault with the potential to affect the safety of a plant at a site, the feasibility of design, construction and safe operation of a plant at this site should be re-evaluated and, if necessary, an alternative site should be considered.”*

No evidence for potential surface faulting at the site has been identified at Lyndhurst. If it were to be identified in further field investigations, it would be necessary to develop design procedures to withstand ground deformation hazards. At present, there are no codified procedures for such design, but in recent years a considerable body of knowledge has been developed that could be used in developing design for ground deformation hazard (Bray, 2001; Kerr et al., 2003; Oettle et al., 2013; 2015; Van Dissen et al. (2006). The following summary of available approaches is taken from Oettle et al. (2013)

Fault-induced angular distortion and lateral ground strain can cause beams to yield and eventually lead to structural collapse. When avoidance is not possible, geotechnical mitigation strategies can be employed. These strategies include spreading fault displacement over a large area, causing the structure to respond with rigid-body movement, and diverting the fault rupture around the structure. The effectiveness of these strategies can vary from protecting life safety to preventing significant damage and can be effective for a range of fault displacements. Earth fills should be sufficiently thick and ductile to prevent the underlying fault dislocation from developing at the ground surface. Thick reinforced-concrete mat foundations can be especially effective in shielding the superstructure from the damaging effects of the underlying ground movements. Although more challenging to implement, because they require excellent fault characterization, several fault diversion strategies also prove effective at protecting structures from fault movement.

3.3.3.2 Ground Shaking Hazard

The Lyndhurst site is not expected to be subject to near-fault ground motions, so no special design issues or mitigation measures are expected to be necessary. Australian Standard AS1170.4 specifies design procedures that are appropriate for this site.

3.3.4 Data Gaps and Recommendations for Stage 2 Work

No evidence for potential surface faulting at the site has been identified. If it were to be identified in further field investigations, the IAEA (2000) and McConnell et al (1993) guidelines could be used to develop an approach to the identification and investigation of fault displacement hazards. For example, McConnell et al. (1993) suggest an approach that leads to the identification of three types of faults: Type III faults - need not be investigated in detail; Type II faults - candidates for detailed investigation; Type I faults - should be investigated in detail because they are subject to displacement and are of sufficient length and located such that they may affect repository design and/or performance or could provide significant input into models used to assess repository performance.

4.0

Enabling Infrastructure Considerations

4.0 Enabling Infrastructure Considerations

A desktop and limited field assessment was undertaken to consider the nature and significance of any constraints of existing enabling infrastructure required to construct and operate the facility including power (renewable and non-renewable options), transport, utilities (including communications, water) and non-radioactive waste infrastructure.

Site characteristic assessment criteria that have the potential, either alone or in combination with other criteria, to impact on siting of the facility were developed. Published and anecdotal information relevant to the site, local and regional area was reviewed and vehicular inspections of road infrastructure was undertaken to inform assessment against the site characteristic criteria.

Options for the provision of the enabling infrastructure have been outlined along with potential design issues and mitigation measures.

Data gaps and uncertainties in our understanding of the proximity, capacity and constraints of enabling infrastructure for connection and provision to the site with reference to the site characteristic criteria have been outlined below along with recommendations for further data to be collected. It is noted that AECOM has also been commissioned to further the assessment of options and to prepare a concept design for the preferred option for each enabling infrastructure element. This work will be informed by detail on the facility requirements and the provision of information by existing enabling infrastructure asset owners.

4.1 Transport

4.1.1 Methodology and Results

A desktop study of the Lyndhurst site was undertaken to investigate site access, possible transport routes to the proposed site and any key constraints arising from the existing site conditions. The assessment also considered multi-modal transport options such as sea, rail and road access. It should be noted that high level decisions regarding transportation modes such as sea and rail as alternatives to road transport have not been made and would require consideration by the Commonwealth and relevant state agencies. Accordingly, this desktop review only documents sea and rail transport as options based on existing infrastructure with further decision making and detailed assessment required should these modes be given serious consideration. The construction and operational requirements of the site are also considered at a high level noting that the facility design and operational aspects are still in progress.

This study included a review of aerial imagery, state road authority classifications / restrictions and operational information provided by Australian Nuclear Science and Technology Organisation (ANSTO). Additional data requirements / gaps have been highlighted. This assessment considered the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) code for the Safe Transport of Radioactive Materials as well Australian and local road design guidelines. International safety standards for radioactive materials were also considered.

4.1.1.1 Site Characteristic Criteria

The criteria used to evaluate the site are the capacity of the overall and local road network to carry the required loads and the overall complexity of transport logistics. As such, the following criteria were used to assess the characteristics of the site:

- Proximity to waste source locations and implications for transport routes and modes.
- Capacity of overall access routes (including potential for multi modal transport) for transport of wastes in conformance with ARPANSA guidelines.
- Capacity of localised network (reliability and proximity) for supply, staff and emergency access.
- Road and infrastructure upgrade requirements.

4.1.1.2 Methods and Results

The following data was used in this desktop assessment:

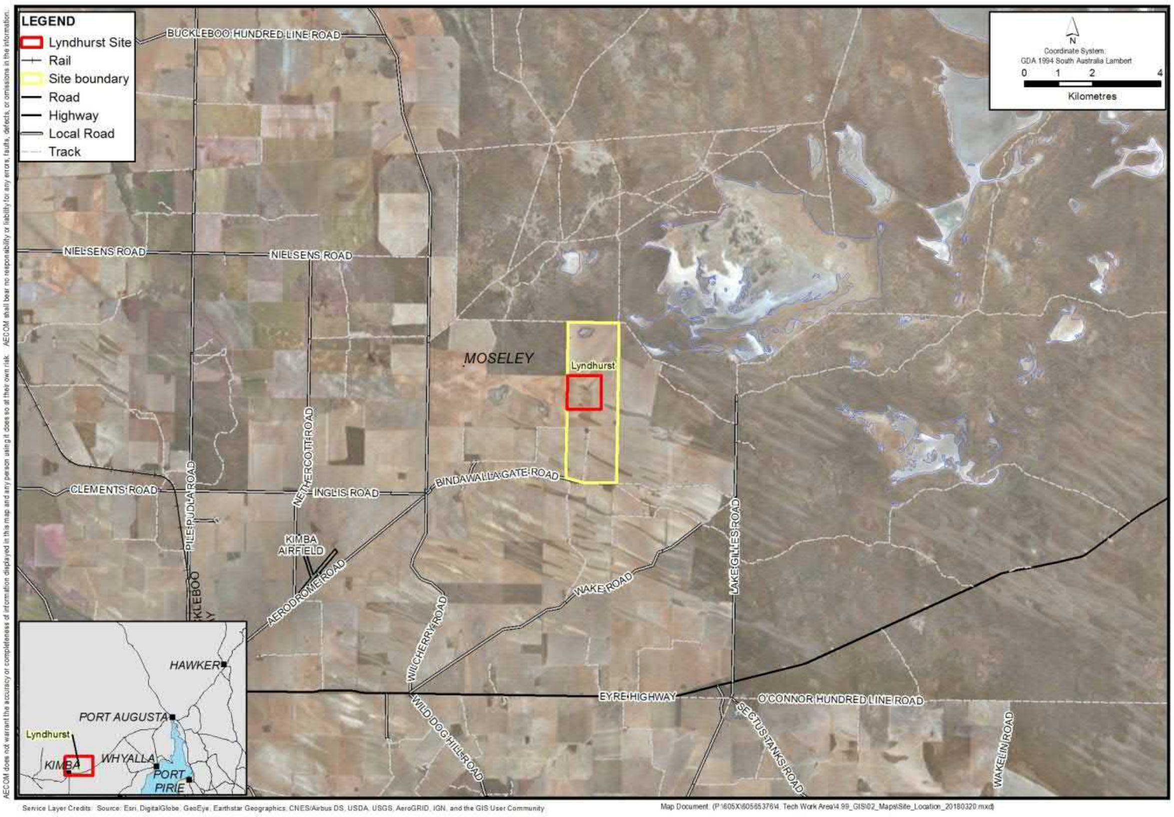
- Aerial imagery
- Road and rail GIS datasets (sourced 05/03/2018)
- State road authority traffic volumes and heavy vehicle restrictions (sourced 05/03/2018)
- Operational information provided by ANSTO (provided 28/02/2018)
- Images taken from site visits (obtained 04/27/2018)

4.1.2 Assessment Against Criteria

The proposed waste facility potentially located on the Eyre Peninsula 16 km north east of Kimba, SA (see Figure 37) will generate additional traffic during both the construction and operational phases. The operational phase will involve the movement of facility staff and the transport of waste to the site. Radioactive waste is currently stored at various facilities around Australia, such as Woomera, SA, Lucas Heights, NSW, and various hospitals / laboratories.

Multi-modal methods of waste transport (road, rail and sea) are considered as part of this assessment and will involve the movement of B-doubles, semi-trailers and very infrequent movements of large TN81 containers (four over the operational life of the facility) containing medium level waste for interim storage. The capacity of the site to accommodate the required heavy vehicle and over-dimensional and / or over-mass movements during the construction and operation phases will be considered. Refer to Figure 37 for the location of the Lyndhurst site.

Figure 37 Lyndhurst site



4.1.2.1 Existing conditions

The Lyndhurst site is located approximately 9 km north of the Eyre Highway (part of the National Land Transport Network) on private land and is serviced by unsealed local roads.

4.1.2.1.1 Arterial road network

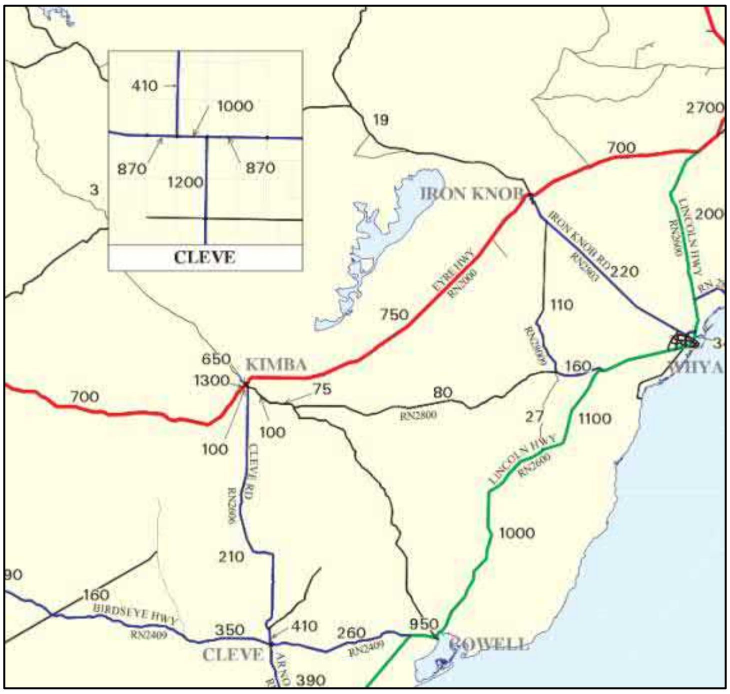
The Eyre Highway is the arterial road that will provide primary access to the local road network (subsequently the site) and is shown in Table 47.

Table 47 Arterial roads surround the facility site

Arterial Road	Road Management Authority	Road Category	AADT
Eyre Highway	DPTI	Arterial	750

The Eyre Highway is a two-way, sealed and marked road with a designated speed limit of 110 km/h. Annual Average Daily Traffic (AADT) estimates are provided for the state-managed arterial roads in the vicinity of the site, as shown in Figure 38. The Eyre Highway has a low estimated AADT, with traffic flows of 750 vehicles /day along the section between Iron Knob and Kimba.

Figure 38 Annual Average Daily Traffic Estimate 24 hour two way flows (Department of Planning, Transport and Infrastructure, 2015)



4.1.2.1.2 Approved Heavy Vehicle Routes

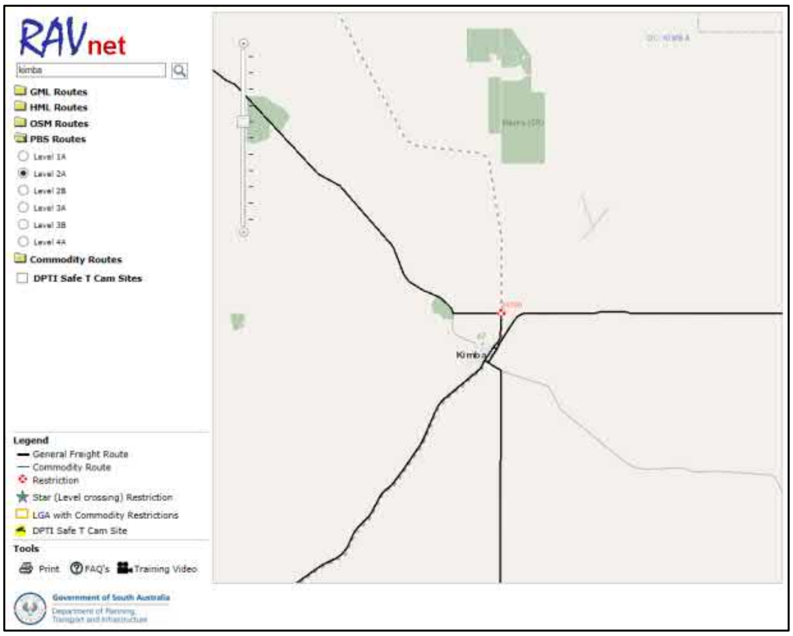
The Performance Based Standards (PBS) scheme provides the operating environment for the vehicles that fit within the specified PBS categories. In turn they provide limits and restrictions for the categories of vehicles on the road network as a way of maintaining safety, vehicle productivity and infrastructure quality standards. The performance levels are classified according the vehicle length as shown in Table 48 and RAVnet, accessed via the DPTI website (2016a), identifies the approved routes for each class.

Figure 39 indicates the access routes for the PBS category of level 2B vehicles, such as 26m B-double configurations which would be the largest type of vehicles used for most of the construction and operational activities (with the exception of the over-weight loads transporting the TN81 Containers which occurs very infrequently). Eyre Highway is the only road in the vicinity of the site that is classified as a PBS approved route.

Table 48 PBS route network classification (National Transport Commision, 2008)

	Network Access by Vehicle Length (m)	
Vehicle Performance Level	**Access Class A**	**Access Class B**
Level 1	L ≤ 20	
Level 2	L ≤ 26	26 < L ≤ 36.5
Level 3	L ≤ 36.5	36.5 < L ≤ 42
Level 4	L ≤ 53.5	53.5 < L ≤ 60

Figure 39 Approved restricted access vehicle routes approved under PBS Level 2A – 26m B-double (Department of Planning, Transport and Infrastructure, 2018)



4.1.2.1.3 Local Roads

The area surrounding the potential site has a local road network mostly consisting of unsealed, low trafficked roads. Some are all-weather roads however may be less appropriate for carrying heavy loads during the winter months as a result of rainfall. The Lyndhurst site is bounded to the south by Bindawalla Gate Road and to the east / west by unnamed vehicle tracks (see Figure 40 below).

Figure 40 Bindawalla Gate Road

4.1.2.1.4 Townships

Kimba

Kimba is located 16 km southwest of the site with a population of approximately 636. The Eyre Highway runs through the middle of the town meaning potential transportation impacts (social, economic etc.) on the community and sensitive users must be considered. Potential sensitive users include (but are not limited to):

- Kimba Area School
- Kimba District Hospital

4.1.2.1.5 Rail

The Cumming-Buckleboo Railway forms part of the Eyre Peninsula Railway (operated by Genesee & Wyoming Australia) and runs south from Buckleboo, through Kimba to Cummins. The Eyre Peninsula Railway is isolated from the rest of the Australian rail network and is primarily used for seasonal grain transport to Port Lincoln. For waste to be transported to Kimba via rail, it would first need to be shipped to Port Lincoln. Due to the railway being privately operated, any transport of waste would be subject to third party restrictions. It should also be noted that the use of rail to transport waste will require transfer from one mode of transport to another. This process would be subject to relevant approvals.

4.1.2.1.6 Proximity to Ports

There is potential to have waste shipped from Port Kembla, NSW to key port locations such as Whyalla, Port Pirie and Port Lincoln. From here, waste would either be shipped via road or rail to the waste facility location. This may be necessary for the infrequent transportation of TN81 containers which also require the use of over-dimensional vehicles for transport via road.

The ports of Port Pirie and Port Lincoln are operated by Flinders Ports and the port of Whyalla is operated by OneSteel. The capacity of the Whyalla port will be influenced by third party access arrangements (AECOM Australia Pty Ltd., 2018).

The previous South Australian Government had pledged a $2 billion infrastructure package which would involve the development of a new commodities port in the Upper Spencer Gulf region (ABC News, 2018). There may be potential in the future for this port to be utilised in the transport of waste to the facility.

4.1.2.2 Waste Source Locations

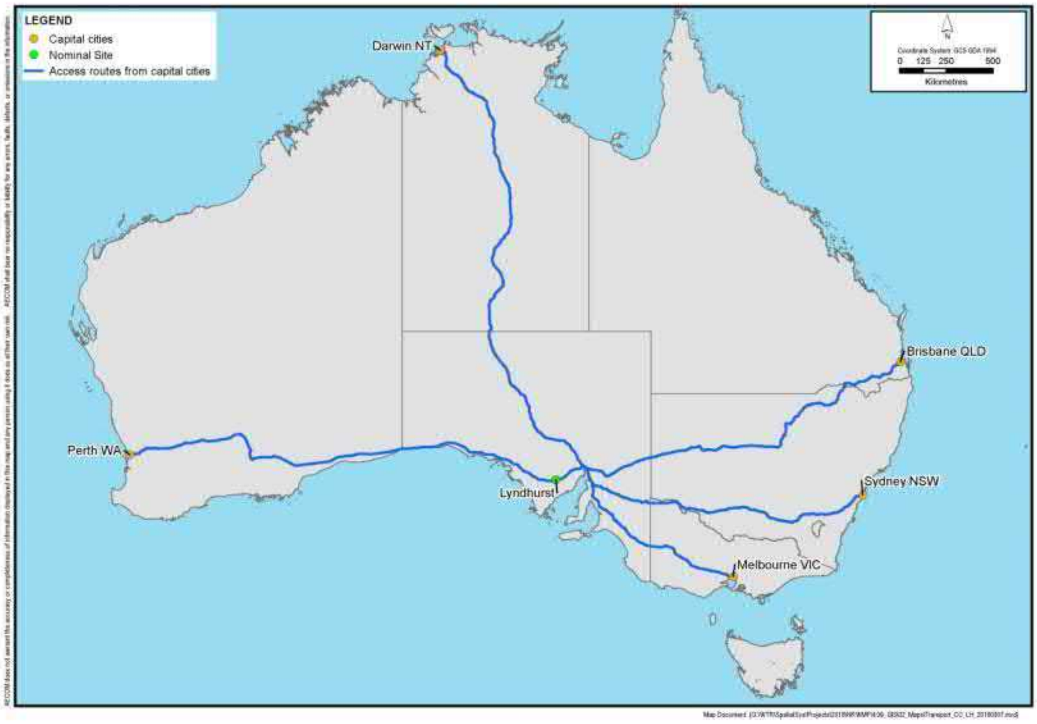
The waste to be stored at the national Radioactive Waste Management Facility (NRWMF) is expected to originate from:

Woomera, SA
A CSIRO research facility is located at Woomera and has been identified as a key source of low-level waste (Department of Industry, Innovation and Science, 2018). The Lyndhurst site is located approximately 350 km away from Woomera on the National Highway Network (via Port Augusta). There is not expected to be any significant constraints on the movement of low level waste via this section of the National Highway Network.

Lucas Heights, NSW
The ANSTO facility is located at Lucas Heights and stores large portions of Australia’s low level and intermediate level waste (Department of Industry, Innovation and Science, 2018). The Lyndhurst site is located approximately 1700 km away from Lucas Heights on the National Highway network.

Hospitals and Laboratories
Nuclear medicine and radiology are a key source of radioactive waste. For the purposes of this assessment, transport routes from hospitals located in state capital cities have been assessed. The site’s location in relation to state capital cities is shown in Figure 41.

Figure 41 Access routes from capital cities



4.1.2.3 Construction Phase

Vehicles used to transport materials and components to the proposed site during construction are expected to originate from the following locations:

Table 49 Origin on construction materials and components

Material / Component	Descriptions	Likely origin on associated transport to site
Locally manufactured or sources components	Various	Greater Metropolitan Adelaide and Eyre Peninsula
Construction materials	Steel reinforcing, concrete, quarry material etc.	Greater Metropolitan Adelaide and Eyre Peninsula
Labour	Staff and contractors	Greater Metropolitan Adelaide and Local Region

Based on the provided reference design of the waste facility, no construction components are expected to fall into the over-dimensional and / or over-mass category for access on the road network. Due to the amount of concrete required to construct this facility and the lack of a local concrete batching plant, it is likely that temporary batching plant be built on-site. This would reduce the total number of vehicle movements during the construction and operational phases of the project.

Locally manufactured and sources components are likely to be transported to the site in general access vehicles and can therefore use most of the surrounding road network for access. However, this is dependent on a number of the existing unsealed roads and intersection surrounding the site being upgraded to appropriate standards. This will likely both involve widening and sealing existing roads and intersections as well as potentially constructing entirely new roads. In later sections, different access routes through the local road network are discussed.

Table 50 Maximum limits for general access (National Heavy Vehicle Regulator, 2016)

Dimension	Maximum Limit	Units
Gross Mass	42.5	Tonne
Width	2.5	Metre
Height	4.3	Metre
Length*	19.0	metre

*Refers to an articulated vehicle

Labour associated with the construction of the proposed waste management facility will likely arrive on site via passenger vehicles or 4WD vehicles from towns surrounding the site. There is also potential for accommodation on-site or within Kimba for construction and operation personnel.

When determining potential access routes for both construction and operation vehicles, the following factors were considered:

- Capacity of the routes for all weather access and the structural capacity of the road infrastructure (pavement and bridges / culverts)
- Limitations of the existing road network (vertical and horizontal geometry)
- The general impact on road users and surrounding communities

The total number of vehicles required for construction is not currently known. A detailed assessment of the impact construction activities will have on the wider network will need to be undertaken as part of future works.

4.1.2.4 Operational Phase

As per information provided by the Australian Nuclear Science and Technology Organisation (ANSTO), the following assumptions were made regarding the size of vehicles and frequency of trips made when transporting waste to the facility:

Table 51 Operational vehicle size and movement frequency

Item	Size & Weight of Load	Peak Frequency
TN81 Container (or similar)	130 tonnes – over-dimensional and over-mass	1 p/a for the first 2 years 1 in 2035 1 in 2055
Intermediate Level Waste (shielded containers)	B-Double – estimated max weight of 50 tonnes	1 movement/bi-weekly for 4 years
Low Level Waste	Semi-trailer – max payload weight capacity of 35 tonnes Exceptional packages may increase to 70 tonnes	1 movement/bi-weekly for 4 years

As shown in Table 51, the largest vehicle that will typically need to access the site will be the B-doubles used to transport intermediate level waste. However, when TN81 containers need to be transported to the site it will be necessary to do so via over-dimensional and / or over-mass vehicles.

ANSTO has also advised that there will be approximately 20 personnel on site during typical operations which represents up to 40 vehicle movements per day as staff move to and from the site. Due to the overall low traffic volumes experienced in this region, this is expected to have minimal impact on the wider road network.

4.1.2.4.1 Over-dimensional and Over-mass Requirements for Operations

An aspect of the operation phase for the facility is the movement of TN81 Containers used to transport intermediate level waste. The TN81 Containers are 6.5 metres long, 3 metres in diameter and weigh approximately 100 tonnes when empty (Australia Nuclear Science and Technology Organisation, 2011). Therefore, the use of an over-dimensional / mass vehicle is required.

Figure 42 TN81 Container being transported (Department of Industry, Innovation and Science, 2016)

Further investigations into the type of vehicle required and appropriate transport routes will be performed as part of the Stage 2 works. As shown in Figure 42, it is likely that a prime mover and low loader combination will be necessary to transport the container over the road network.

4.1.2.5 Proposed Access Routes

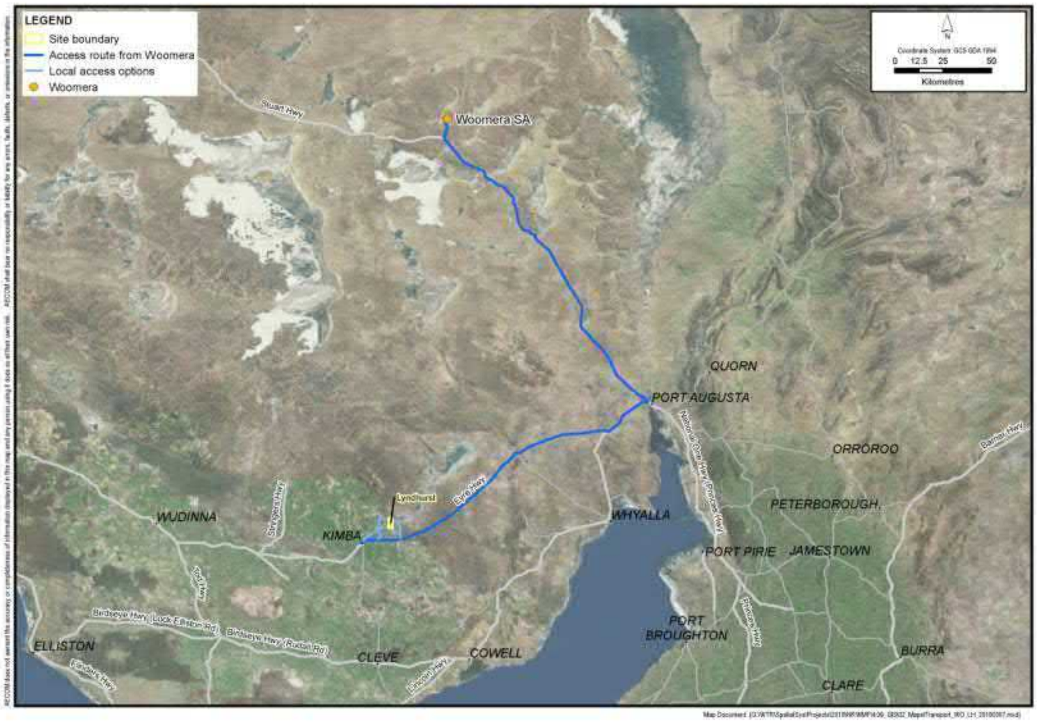
4.1.2.5.1 Woomera

Access to the site from Woomera will be via the National Highway Network as described below:

1. Olympic Dam Highway (B97)
2. Stuart Highway (A87)
3. Eyre Highway (A1)

There is no feasible alternate route along the National Highway Network to travel between Woomera and Lyndhurst. This is mainly due to there being no approved B-double routes that do not run through Port Augusta between Woomera and Lyndhurst, and Olympic Dam Highway terminating north of Woomera at Olympic Dam.

Figure 43 Access route from Woomera



As part of the Upper Spencer Gulf Regional Infrastructure Plan developed by AECOM, a number of proposed major projects were identified which would improve the road infrastructure in an around Port Augusta. These projects are as follows (AECOM Australia Pty Ltd., 2018):

- Duplication of the Port Augusta Bridge to avoid occurrences of complete shutdown. This would improve the efficiency of freight movements and user safety.
- Upgrading the Yorkeys Crossing heavy-vehicle bypass route with all-weather treatment. This crossing is used by over-dimensional vehicles to bypass the Port Augusta Bridge. This bridge has restrictions in place for over-dimensional vehicles greater than 4.0 m wide and 5.8 m high (Department of Planning, Transport and Infrastructure, 2012).

These projects will improve heavy vehicle access through Port Augusta if implemented.

4.1.2.5.2 Lucas Heights

Access to the site from Lucas Heights will likely be via the National Highway network as described below:

1. Hume Highway (M31)
2. Sturt Highway (A20)
3. Goyder Highway (B64)
4. Clare Highway (B64)
5. Princes Highway (A1)
6. Eyre Highway (A1)

Figure 44 Access routes from Lucas Heights

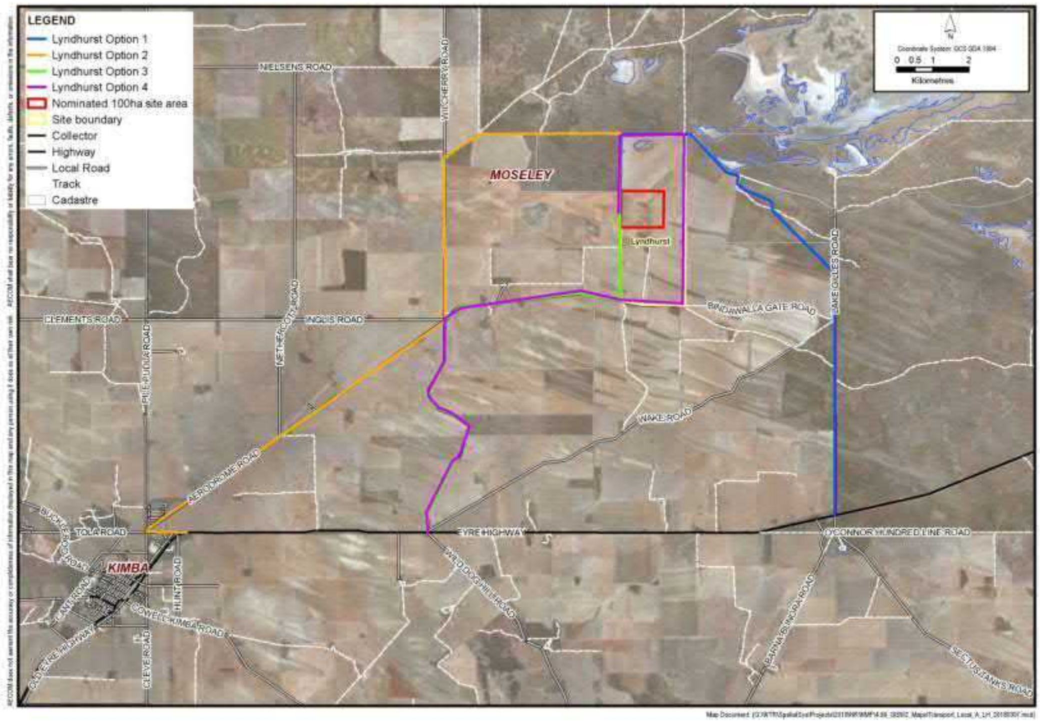
Further investigations will need to consider the local road network through key towns and cities along the proposed route to determine if there are approved heavy vehicle routes that will allow shipments to bypass these towns. Future investigations will further narrow down this route to minimise the number of towns / cities that are travelled through.

4.1.2.5.3 Local Road Access to the Site

Access to the site from the National Highway Network is discussed in previous sections. Three options have been highlighted which utilise local roads to access the site. These options are described below and are shown in Figure 45. It should be noted that this not an exhaustive list and additional options may be considered in future investigations.

- Option 1: Lake Gilles Road
- Option 2: Aerodrome Road
- Option 3: Wilcherry Road (including constructing a new length of road along the fence line to the south of the site)
- Option 4: Wilcherry Road

Figure 45 Local access routes



As can be seen in Figure 45, there is not a substantial difference in length for each of the potential local access routes. Key differentiating factors are likely to be the proximity to the township of Kimba and the upgrade requirements for each route. Required upgrades for the chosen access route will be determined during later design stages. Access routes may also be adjusted to minimise potential disruption to the local community. It should also be noted that if a road is upgraded to a higher standard (i.e. sealed), locals may use this road in preference to the surrounding unsealed roads. This would benefit the local community by improving local transport infrastructure and reducing the maintenance requirements compared to the existing roads.

Due to the large number of vehicles required to access the site during construction and operation, it is recommended that all access routes be both widened and sealed to accommodate the projected heavy vehicle requirements.

A qualitative assessment of the advantages and disadvantages of local road options is summarised in Table 52 below:

Table 52 Option comparison

Option	Description	Advantages	Disadvantages
Option 1	Lake Gilles Road	• Waste movements do not need to pass through Kimba	• Vehicles will need to travel in close proximity to Lake Gilles Conservation Park
Option 2	Aerodrome Road	• Aerodrome Road appears to be of better quality than other surrounding local roads	• The longest of the access options (21 km) • Vehicles will need to make a sharp turn
Option 3	Wilcherry Road (including construction of new road along fence line south of the site)	• Waste movements do not need to pass through Kimba • The shortest route of the proposed options (13.3 km)	• Requires construction of a new road south of the site
Option 4	Wilcherry Road	• Waste movements do not need to pass though Kimba • Does not require construction of new road compared to Option 3	• Route appears 'inefficient' due to there being no road to directly access the site from the south

Additional commentary on the site's performance against the key assessment criteria is included in following sections.

4.1.2.6 Assessment Criteria 1 – Proximity to Waste Source Locations

Given the Lyndhurst site's location in central South Australia, it is in a good location to receive waste from hospitals and laboratories from around Australia despite the significant distances to some of the waste sources. The site is approximately 1700 km from Lucas Heights and 350 km from Woomera via the National Highway Network. There is also potential for waste to be shipped to Whyalla, Port Pirie or Port Lincoln and then transported via road or rail (only from Port Lincoln) to the site.

4.1.2.7 Assessment Criteria 2 – Capacity of Overall Access Routes

Access to the site would primarily be via the national highway network which is typically approved as a B-double route. This will be appropriate for all movements of waste to the facility excluding the very infrequent shipments of the TN81 Containers. These over-dimensional and over-mass loads will require permits to be approved by relevant state road authorities prior to their transport. As mentioned previously, it may be possible to have these containers shipped from Port Kembla to ports such as Whyalla, Port Pirie and Port Lincoln which would substantially reduce their impact on the wider road network if this transport option was selected. Transport of waste to Port Augusta via rail would also reduce the impact on the road network. The variety and quality of overall transport options means the Lyndhurst site satisfies this criterion.

4.1.2.8 Assessment Criteria 3 – Capacity of Local Road Network

The local roads that surround the site are typically unsealed, low trafficked roads. Some of these are all-weather roads but are likely to be less appropriate for carrying heavy loads during the winter months. Roads surrounding the site are unlikely to be wide enough to accommodate the heavy vehicle movements based on aerial imagery. The road geometry would need to be assessed as part of later design stages. Based on the current status of local roads, the Lyndhurst site satisfies this criterion subject to road upgrades being undertaken for any preferred route. The multiple access route options provides resiliency in the cases of emergency access / egress and large rainfall events.

Agriculture is a major part of Kimba's local economy. As a result, vehicle movements through the local road network may need to be scheduled so as either not to conflict with Kimba's harvest season or to minimise the impact on local road users through improved communications and notifications. This is applicable to both construction and operation phases.

4.1.2.9 Assessment Criteria 4 – Upgrade Requirements

Due to the frequent use of the local road network by B-double vehicles during both the construction and operational phases, it is recommended that any access routes be both sealed and widened to suit these vehicle movements. This may also be necessary to accommodate the very infrequent over-dimensional and over-mass (ODOM) vehicles necessary to transport the TN81 Containers. This would result in up to 21 km of sealed roads needing to be constructed. The sealing of these roads is also recommended as it would mitigate any damage that significant rainfall events may cause to an unsealed road network.

While the Eyre Peninsula rail network is isolated from the rest of Australia's railway network, if the option of using this railway to transport waste into Kimba from Port Lincoln were to be pursued, an additional spur may need to be constructed. This could be used to transport waste from Kimba to the Lyndhurst site. Due to this rail being primarily used for seasonal grain transport, it is likely that significant upgrades would be required to ensure it is appropriate for the movement of B-Doubles and the ODOM movements of the TN-81 containers. Upgrades to the local road network to facilitate these movements will be considered as part of the enabling works.

4.1.2.10 Summary

An assessment of the site has been undertaken against the above criteria and is summarised in Table 53. This is intended to provide a high level overview of the site's performance based on existing conditions and highlight any key criteria which may limit its selection.

Table 53 Site performance against assessment criteria

Assessment Criteria	Criteria Satisfied	Comments
Proximity of Waste Source Locations	✓	Site's location within central South Australia is an ideal location to receive waste from around the country.
Capacity of Overall Access Routes	✓	The site is within close proximity to the national highway network and shipping ports (Whyalla and Port Pirie).
Capacity of Local Road Network	✓	There are multiple access route options to allow for site access. Vehicle movements may need to be scheduled to not conflict with Kimba's harvest season.
Upgrade Requirements	✓	Roads will need to be upgraded to accommodate frequent B-Double movements and infrequent ODOM vehicles. There does not appear to be the need to acquire land to accommodate new road reserves.

The infrastructure costs to facilitate the construction and operation of the facility will be considered as part of the enabling works.

4.1.3 Design Issues and Mitigation Measures

4.1.3.1 Road Upgrades

The local roads leading to and surrounding the site are primarily unsealed, low trafficked roads which may not be appropriate for frequent B-double movements and infrequent over-dimensional and over-mass vehicle movements. It is recommended that access routes along existing roads are sealed or have the existing unsealed surface improved (subject to appropriate maintenance requirements) and widened to accommodate these vehicle movements. Note that these required upgrades will be further considered as part of the enabling works.

4.1.3.2 Rail Upgrades

As mentioned previously, a section of the Eyre Peninsula Railway runs between Kimba and Cummins. This railway is used for seasonal grain transport throughout the Eyre Peninsula. If the option of transporting waste via rail to the sure is pursued, an additional spur connecting the site to the rail line may be required. The existing condition of the railway is currently unknown. Should the option of rail transport be pursued, inspections of the railway should be performed to determine its condition. It is possible that major upgrades to the rail network are required to ensure it is appropriate to transport radioactive waste.

4.1.4 Data Gaps and Recommendations for Stage 2 Work Program

The following sections detail the relevant data gaps and recommendations for work to be undertaken as part of the Stage 2 Work Program once a preferred site is nominated. It should be noted that high level designs of the enabling infrastructure (roads and utilities etc.) will be completed as part of the enabling works. These will be used to inform relevant stakeholders when nominating a preferred site.

4.1.4.1 Data Gaps and Limitations

Key gaps in the available data include:

- Detailed survey of local road network to determine its condition, width, formation and traffic volumes;
- Operational procedures for waste management facility (shift hours, number of staff etc.);
- Frequency and volumes of waste to be delivered during operations requires clarification.

4.1.4.2 Recommendations for Stage 2 Work Program

Further works to be undertaken as part of the Stage 2 data collection include:

- Additional site investigations to determine the geometry and quality of the road network;
- Capacity of rail to transport TN81 containers as well as large shipments on intermediate and low level waste to be determined; and
- Refining of access routes through the National Highway Network and local road network.

4.2 Waste

As part of the site characterisation desktop assessment, AECOM investigated considerations that are likely to pose constraints for future use of the potential site at Lyndhurst for the NRWMF. Following the desktop study, AECOM contacted a number of the identified waste management facilities to obtain further information on the types of waste accepted and capacity of the sites to accept waste generated from the Project during construction and operation. This report outlines the approach taken and results obtained from these additional investigations.

4.2.1 Methodology and Results

4.2.1.1 Site Characteristic Criteria

The following site characteristic criteria were used in this study:

1. Availability and proximity of facilities to treat, recycle or dispose of all generated waste streams.

During the desktop analysis, AECOM identified a number of licenced waste facilities around the proposed Lyndhurst site location. The types of waste facilities relevant to this assessment are as follows:

- **Landfill/Refuse Depot** - a waste disposal site used for the controlled deposit of solid waste onto land
- **Material Recovery Facility (MRF)** - a depot for the treatment of waste for resource recovery, other than a composting depot.
- **Transfer Station** - a depot for the reception and aggregation of waste streams prior to their transport to another depot or location for further sorting, resource recovery or disposal.
- **Container Deposit Legislation (CDL) depot** - a depot for the reception of certain beverage types covered by the CDL.

Identifying the different types of waste infrastructure in the local region will enable assessment of key logistical issues and associated costs related to the collection, transport, treatment and disposal of each waste stream generated from the Project. For example, potential cost implications due to unavailability of facilities to handle particular waste stream(s), or significant transport distances could support the case for constructing an onsite waste management facility.

2. Potential for on-site treatment, recycling and disposal.

In order to assess potential collection, treatment, recycling and disposal options, it is important to first understand the characteristics and types of waste likely to be generated from the Project. A preliminary assessment of the potential waste generated during construction and operation of the site was conducted.

4.2.1.2 Desktop Methods and Results

4.2.1.2.1 Methodology

The desktop assessment involved research and reviewing available information in regards to waste management and the NRWMF. This included reviewing background information, reference design documents[21] and South Australia's waste management legislation[22]. Furthermore, the use of aerial photography, Google maps and South Australia's council maps[23] enabled AECOM to locate the proposed Lyndhurst site in relation to potential waste infrastructure locations.

The built facility general arrangement obtained from the reference design enabled the identification of typical waste streams anticipated at the NRWMF. This information was critical in assessing any

[21] WSP (2016). Reference Design Modules for Site Characterisation
[22] EPA Environmental Info. Waste Management. Available at: http://www.epa.sa.gov.au/environmental_info/waste_management [Accessed 7-14 March 2018].
[23] Local Government Association of South Australia. Council Map. Available at: https://www.lga.sa.gov.au/councilmaps [Accessed 9-14 March 2018].

potential on- site and off- site waste management/disposal options. Approximate distances to offsite waste treatment, recovery and disposal infrastructure were estimated using Google mapping tools.

It is important to note that only licensed waste infrastructure were evaluated using licensing information obtained from the South Australia Environment Protection Authority (EPA)[24]. As part of the Stage 2 works, targeted investigations would be undertaken to confirm the availability and capacities of the identified off site facilities.

Referenced data used in the desktop assessment is listed below:

- EPA (2009). Waste Guidelines. Waste Definitions. (EPA 842/09).
- EPA (Version 22.2.2018). South Australia Environment Protection 1993
- EPA (Version 24.11.2011). South Australia Environment Protection (Waste to Resources) Policy 2010.
- EPA (2009). Waste Guidelines (EPA 842/09)
- Office of Green Industries SA (2015). South Australia's Waste Strategy 2015-2020.
- WSP (2016). Reference Design Modules for Site Characterisation.
- Zero Waste SA (2018). South Australia's Waste and Resource Recovery Infrastructure Plan.
- EPA Environmental Info (Waste Management). Available at: http://www.epa.sa.gov.au/environmental_info/waste_management [Accessed 7-14 March 2018].
- EPA Environmental Authorisations (Licenses). Available at: http://www.epa.sa.gov.au/data_and_publications/environmental_authorisations_licences [Accessed 7 - 14 March 2018].

Local Government Association of South Australia (Council Map). Available at: https://www.lga.sa.gov.au/councilmaps [Accessed 9 - 14 March 2018].

[24] EPA Data & Publications. Environmental Authorisations. Available at: http://www.epa.sa.gov.au/data_and_publications/environmental_authorisations_licences [Accessed 7-14 March 2018]

4.2.1.2.1 Results

The following section summarises the anticipated waste generated during the construction and operation stages of the Project based on the desktop review. *This table would need to be reviewed and updated with waste generation rates, as the design of the facility progresses.*

Construction Works Waste Types

Construction activities are anticipated to generate the following waste streams (Table 54)

Table 54 Construction Waste Generation

Waste Type
Main Construction Works
Construction and Demolition (C&D) Waste (Mixed)
Construction and Demolition (C&D) Waste (Inert)
Ferrous and non-ferrous metals (sheet metals, steel, etc.)
Paper and cardboard
Dry recyclable general waste
Putrescible waste (e.g. food waste)
Packaging materials, including wood, plastic, cardboard and metals
Hazardous and/or Listed waste (e.g. asbestos)
Wastewater; pump out septage (sewage)
Plant Maintenance during construction
Empty oil (and other) drums/tins (e.g. fuel, chemicals, paints, spill clean ups)
Air filters and rags
Waste Oil
Wastewater (from pump maintenance activities)
Oil filters
Batteries

Operation Waste Types

Radioactive wastes to be managed at the NRWMF have not been described or considered in this assessment as they are not a waste stream to be taken off-site. Since there was no available data on Equivalent Full Time Employees (EFTEs), area schedules and/or floor plans for the proposed NRWMF at the time of writing this report, the anticipated waste generation rates (quantities) were not estimated. *As noted earlier, this table would be updated with waste generation rates, as the design and operation plans for the facility progress to the next stage of development.*

However; AECOM has identified the potential waste generation areas based on the Reference Design Modules for Site Characterisation. Table 55 shows the types of infrastructure and associated types of waste to be generated.

Table 55 Potential Waste Generating Areas - NRWMF

Type of Infrastructure/Activity	Typical Waste Generated	Estimated Waste Quantities
Guard house	Commercial and Industrial (C&I) Waste (General)*	Minor
Helipad	N/A	N/A
Visitor carpark	N/A	N/A
Security Building	Commercial and Industrial (C&I) Waste (General)	Minor
Administration Area	Commercial and Industrial (C&I) Waste (General)	Minor
Information Station	N/A	N/A
Water and non-radioactive area	N/A	N/A
Power and Communication area	N/A	N/A
Construction and Maintenance	Commercial and Industrial (C&I) Waste (General), Construction and Demolition (C&D) Waste (Mixed), Waste Oil, Batteries, Scrap Metal, Used Tyres, E-Waste, Waste Fill, Whole Used Tyres, Waste Fuel, Hazardous/Listed Waste (e.g. asbestos)	Minor
v	N/A	N/A
Radioactive Waste Storage Facilities	N/A	N/A

Assessment criterion 1: Availability and proximity of facilities to treat recycle or dispose of all generated waste streams

Figure 46 shows the different waste and recycling facilities that would potentially accept waste from the Lyndhurst site and Table 56 shows further details of waste types, license details and approximate distances of facilities within 200 km from the potential site

Figure 46 Identified waste, effluent and resource recovery facilities that could potentially accept waste from the proposed Lyndhurst site

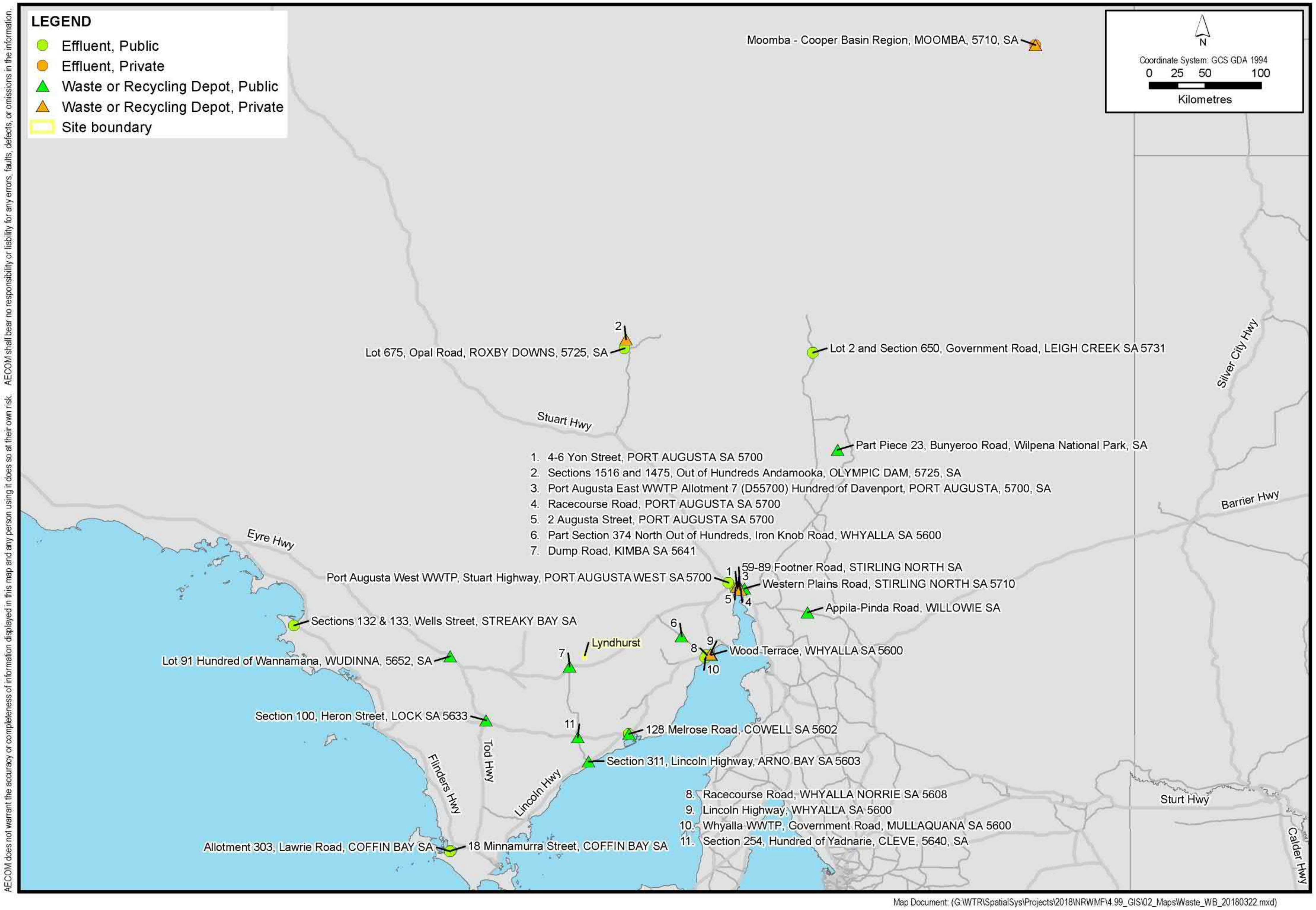


Table 56 Licensed waste infrastructure within 200km of the proposed Lyndhurst site and types of waste accepted

License Holder	District Council of Kimba	District Council of Cleve (Cleve)	District Council of Franklin Harbour (Cowell)	District Council of Wudinna (Wannamana)	District Council of Cleve (Arno Bay)	City of Whyalla	District Council of Elliston (Lock)
Licensed Activities	Waste recycling depot (waste for resource recovery) Waste or recycling depots (solid waste for on-site disposal)	Waste recycling depot (Waste for resource recovery or transfer)	Sewage treatment works or septic tank effluent disposal schemes (discharge other than to marine waters or a Water Protection Area) Waste recycling depots (Waste for resource recovery or transfer) Waste or recycling depots (solid waste for on-site disposal)	Waste or recycling depots (Solid waste for on-site disposal)	Waste or recycling depots (Solid waste for on-site disposal)	Waste or recycling depots (Solid waste for on-site disposal)	Waste recycling depots (Waste for resource recovery or transfer) Waste or recycling depots (solid waste for on-site disposal)
Site Address	Dump Road, KIMBA SA 5641	Section 254, Hundred of Yadnarie, CLEVE, 5640, SA	128 Melrose Road, Cowell SA 5602	Lot 91 Hundred of Wannamana, WUDINNA, 5652, SA	Section 311, Lincoln Highway, ARNO BAY SA 5603	Part Section 374 North Out of Hundreds, Iron Knob Road, WHYALLA SA 5600	Section 100, Heron Street, LOCK SA 5633
Waste Type	**Permitted to Receive (Yes/No)**						
Friable asbestos	No	No	No	No	No	Yes	No
Non-friable asbestos	No	No	No	No	No	Yes	No
CDL - Containers	No	No	No	No	No	No	Yes
Construction and Demolition (C&D) Waste (Inert)	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Construction and Demolition (C&D) Waste (Mixed)	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Commercial and Industrial (C&I) Waste (General)	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Compostable Organic Waste	No	No	No	No	No	Yes	No
E-waste	No	No	Yes	Yes	Yes	Yes	Yes
Ferrous and non-ferrous metals	No	Yes	No	No	No	Yes	No
Green Waste	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Hazardous Waste	No	No	No	No	No	No	No
Lead Acid Batteries	Yes	Yes	Yes	Yes	Yes	Yes	No
Listed Waste	No	No	No	No	No	No	No
Shredded Tyres	Yes	No	No	No	No	No	No
Scrap Metal	Yes	No	Yes	Yes	Yes	No	No
Used Tyres	Yes	Yes	Yes	No	Yes	Yes	Yes
Waste Fuel	Yes	No	Yes	No	No	No	No
Waste Fill	Yes	No	Yes	Yes	Yes	Yes	No
Waste Oil	Yes	Yes	Yes	Yes	No	Yes	Yes
Other Parameters							
License Expiry Date	31 July 2022	30 September 2020	31 July 2022	31 July 2021	31 July 2021	30 April 2021	31 July 2022
Approximate distance to proposed site	17 km	88 km	104 km	115 km	115 km	145 km	150 km

Assessment criterion 2: Potential for onsite treatment, recycling and disposal

Waste management requirements/disposal options

Waste arising from the construction phase would need to be transported to licensed off-site facilities for material reuse/recovery purposes before final disposal. Potential destinations include waste transfer stations, material recovery facilities (MRFs) and landfills (classified as waste and/or recycling depots).

According to the information provided in Table 56 there are waste streams which would potentially be generated at the Lyndhurst site, however not accepted at some of the nearby waste and/or recycling depots. These waste streams may need to be managed on-site.

Table 57 shows a summary of potential waste management options for waste generated at the Lyndhurst site.

Table 57 Details of Waste Management at the proposed Lyndhurst site

Waste Type	Potential for on-site management	Nearest off-site facility accepting waste type
Commercial and Industrial Waste (C&I) (General)	• Source-separate organics (for on-site composting/worm farms) • Recycling and residual waste to off-site facilities	District Council of Kimba (Approx. 17km)
Construction and Demolition Waste (C&D) (Inert)	To off-site facilities	District Council of Kimba (Approx. 17km)
Construction and Demolition Waste (C&D) (Mixed)	To off-site facilities	District Council of Kimba (Approx. 17km)
E-waste	To off-site facilities	District Council of Wudinna (Wannamana) (Approx. 115km)
Friable and non-friable asbestos	To off-site facilities	City of Whyalla (Approx. 145km)
Ferrous and Non-ferrous metal	To off-site facilities	District Council of Cleve (Cleve) (Approx. 88km)
Green Waste	On-site processing (composting/worm farms)	District Council of Kimba (Approx. 17km)
Hazardous Waste	Pre-treatment prior to off-site disposal	No site within (at least) 150km
Listed Waste	Pre-treatment prior to off-site disposal	No site within (at least) 150km
Scrap metal	To off-site facilities	District Council of Kimba (Approx. 17km)
Whole Used Tyres	To off-site facilities	District Council of Kimba (Approx. 17km)
Waste Fuel	To off-site facilities	District Council of Kimba (Approx. 17km)
Waste Fill	If suitable, use on site as fill material or sent to an off-site facility	District Council of Kimba (Approx. 17km)
Waste Oil	To off-site facilities	District Council of Kimba (Approx. 17km)

Potential on-site waste treatment options at the NRWMF will depend on the waste streams generated and the distance and capacity of the off-site disposal or resource recovery facilities. Potential on-site treatment options could include on-site organics processing and on-site hazardous waste or listed waste treatment. Implementation of source-separation of organic waste from the general waste stream would result in a cleaner organics stream suitable for on-site composting or worm farms, thereby reducing the amount of residual waste requiring disposal at on off-site landfill. An on-site small scale incineration facility could be a potential option for hazardous waste treatment, however this would need to be further assessed in the context of the relevant regulatory setting.

4.2.1.3 Field Methods and Results

AECOM contacted (via telephone and email) the existing licensed waste facilities within 200km of the Lyndhurst site (as identified during the desktop study) to confirm if these facilities were still active, the waste types accepted, and capacity/estimated remaining life. Stakeholders contacted included local councils and private waste contractors operating the facilities.

Additional information obtained during this phase of the assessment is presented in Table 58.

Table 58 Waste Management Facilities within 200km of the Lyndhurst site – Additional Information from councils

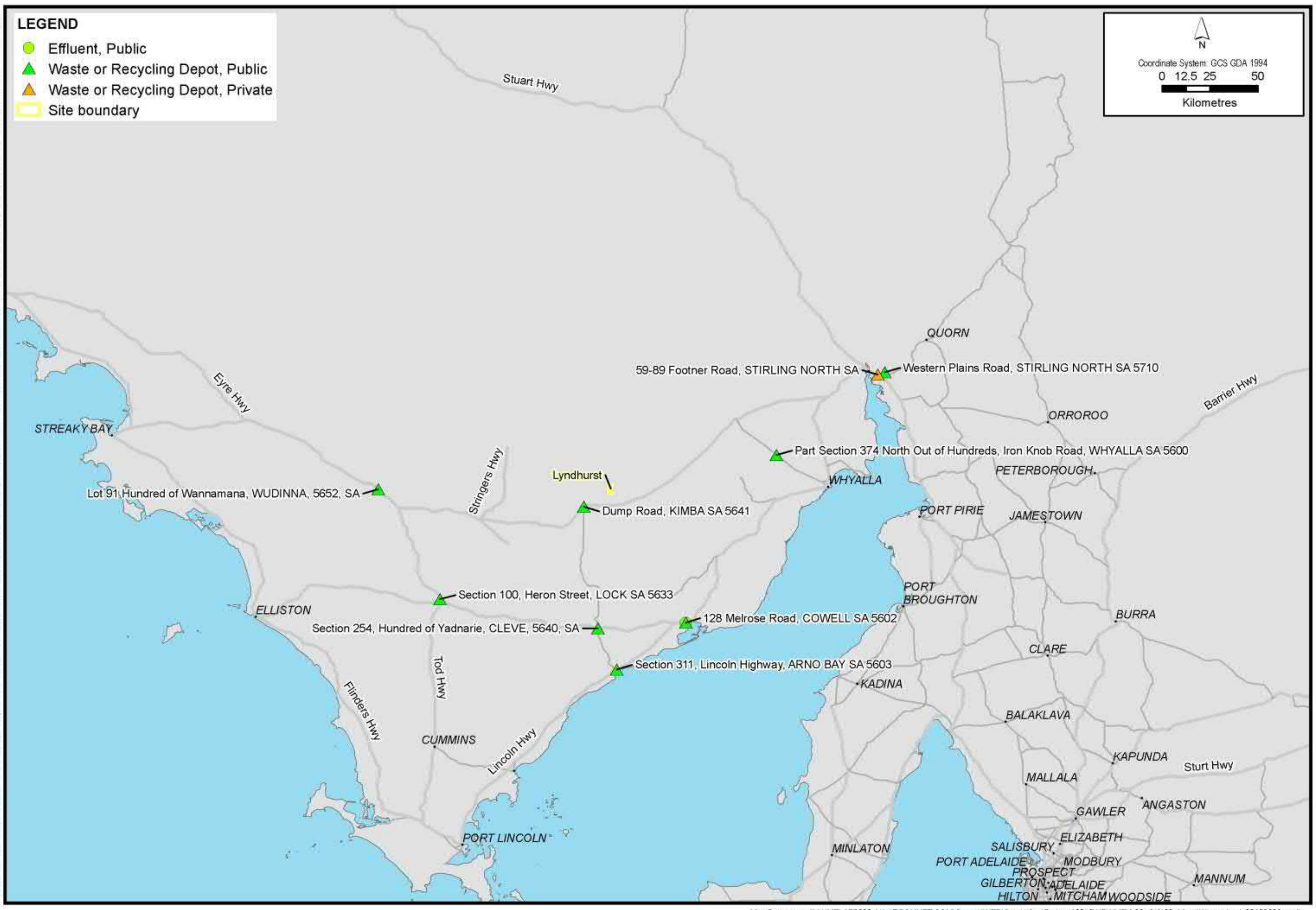
Operator/Licence Holder	Waste Management Facility	Approximate Distance from potential site	Types of waste accepted/not accepted	Estimated remaining life/Capacity/Notes
District Council of Kimba	Landfill and waste recycling centre	17 km	As per licence • Accepted – C&I waste, C&D waste, MSW • Not accepted – Listed waste, Hazardous waste, Radioactive waste, tyres	50 years (Expected)
District Council of Cleve	Transfer Station (Cleve)	88 km	• All rubbish • No asbestos	TBC
	Landfill (Arno Bay)	115 km		Closing at the end of June 2018. This will be operated as a waste transfer station
District Council of Franklin Harbour	Landfill	104km	As per license (Listed in Table 56) Asbestos waste and liquid waste not accepted.	20 years
	Waste Transfer Station			
District Council of Elliston	Awaiting information from the District Council of Elliston	150 km	TBC	TBC
City of Whyalla	Landfill	145km	Hard waste, kerbside waste, E-waste, concrete, green waste, tree stumps, steel, rough fill, clean fill (soil), engine oil, batteries, non-friable asbestos, quarantine waste, residential hazardous waste	3 years. New site proposed (exact location TBC)

4.2.2 Assessment Against Criteria

Assessment criteria 1: Availability and proximity of facilities to treat, recycle or dispose of all generated waste streams.

Figure 47 shows the location of the waste management facilities within 200 km of the potential Lyndhurst site.

Figure 47 Identified waste and resource recovery facilities within 200km of the Lyndhurst site



The potential waste management facilities to receive waste generated from the Project have been presented in Table 58.

. Among these, no facility has been identified as being suitable to receive hazardous or listed waste that could potentially be generated from the Project.

The waste facility located closest to the site is a landfill and recycling centre located approximately 17 km from the proposed Lyndhurst site. This facility is expected to be operational for the next 50 years and could potentially accept waste generated from the Project.

The District Council of Cleve operates a transfer station and a landfill. These facilities could potentially be used for disposal of waste generated by the Project, however; the landfill site located at Section 311, Lincoln Highway, ARNO BAY SA 5603, (approximately 115 km from the proposed site) will potentially be closed by the end of June 2018. It is planned to be operated as a waste transfer station (details to be confirmed).

District Council of Franklin Harbour also operates a transfer station and a landfill, both located at the same site; 128 Melrose Road, Cowell SA 5602 (approx. 104 km from the proposed site). These facilities are expected to be operational for the next 20 years and could potentially be used to dispose waste generated from the Project.

The City of Whyalla landfill is located approximately 145 km from the proposed Lyndhurst site however; this facility is anticipated to cease operations in the next 3 years. A new site has been proposed (details to be confirmed).

Summary

- Two landfills and two transfer stations have been identified within 150km from the proposed site, which will remain operational for the next 20 years.
- It should be noted that further discussions and arrangements with Councils could be warranted to confirm acceptance of waste generated from the Project at the potential facilities**.**
- No waste facilities within 200km of the Lyndhurst site were identified that accept hazardous and listed waste.

Assessment criteria 2: Potential for on-site treatment, recycling and disposal

Onsite treatment of waste generated from the Project would be applicable to organic waste and hazardous and listed waste.

Organic waste – implementation of source separation of organic waste from the general waste stream would result in a cleaner organics stream suitable for on-site composting or worm farms, thereby reducing the amount of residual waste requiring disposal at off-site disposal facilities. This would require establishment of an on-site organics processing facility.

Hazardous and/or Listed waste – hazardous and/or listed waste could require pre-treatment on-site prior to off-site disposal. At the time of writing this report (during the technical assessment stage), there were no facilities identified within 200 km of the proposed Lyndhurst site that could accept hazardous or listed waste. This would potentially require on-site processing (e.g. an on-site incinerator, depending on the nature of the hazardous or listed waste generated) unless alternative arrangements are made.

Summary

- On-site treatment of waste at the proposed Lyndhurst site would still require off-site waste recycling and disposal facilities to dispose of other waste types that would be generated by the Project, for example residual solid waste, packaging waste, etc.
- Other arrangements need to be made for disposal of hazardous and listed waste that could potentially be generated from the Project.

4.2.3 Design Issues and Mitigation Measures

Potential waste management options that could be employed at the Lyndhurst site are based on the site characteristic criteria discussed in Section 4.2.2, and may include:

- constructing a waste management facility at the Lyndhurst site (e.g. waste storage room, composting facility)
- treating hazardous /listed waste
- transporting waste to off-site disposal and/or recycling depots

4.2.3.1.1 Design Issues

Design issues related to the above options include, but are not limited to:

- Materials of construction
- Buffer distances (sensitive receptors will be identified depending on the option considered)
- Air emissions from potential on-site waste management infrastructure/activities e.g. waste incinerator
- Supporting infrastructure (e.g. safe road access and routes for the anticipated waste collection vehicles to waste facilities)

It is worth noting that other design considerations are linked to site specific issues identified in other assessments of other site characteristics or enabling infrastructure elements. As a result, reference would be made to design and mitigation measures identified in these report sections.

Table 59 Possible impacts to waste infrastructure design of site characteristics and enabling infrastructure

Site Characteristic/ Enabling Infrastructure	Possible design impact(s)
Conservation and special use area	• Buffer distances (proximity to sensitive receptors)
Risks from the surrounding environments (e.g. bushfires)	• Safety considerations (e.g. storage requirements for flammable waste material) • Materials of construction
Climatic conditions	• Safety considerations • Materials of construction
Climate change and long term environmental scenarios	
Site characteristics which have the potential to impact on site safety	• Safety considerations
Risks from the potential impacts of human activities on site-suitability	• Planning/zoning, and regulatory issues
Transport considerations	• Distances to waste and recycling facilities • Safe access /routes for waste collection vehicles • Potential road upgrades
Utilities, energy and infrastructure	• Wastewater treatment systems, power requirements etc.

4.2.3.1.2 Mitigation Measures

Wastes (mixed solid wastes) generated by the facility are assumed to be transported to off-site waste transfer stations or disposal facilities. Certain waste types (e.g. hazardous and/or Listed Waste) may need to be treated and disposed on-site or pre-treated and then sent off-site for management.

As a result, potential waste containment, treatment and storage facilities would be designed for satisfactory performance to minimise the impacts of waste. Some of the mitigation measures include:

- Waste and environmental management plans (etc.)
- Design of waste storage facilities according to the Building Code of Australia (BCA) and other relevant Australian Standards
- Spill kits and implementation of appropriate chemical storage requirements
- Conformance to air quality and monitoring regulations
- Emergency procedures

4.2.4 Data Gaps and Recommendations for Stage 2 Work Program

4.2.4.1 Data Gaps and Limitations

During the technical assessment stage of the Project, AECOM has identified some data gaps requiring further action as listed below:

- Quantities of waste generated during the construction and operation phases based on the proposed design of the facility.

Details on new or proposed waste facilities in the region as presented in Table 58.

- .
- Confirmation of availability and suitability of the potential waste management infrastructure identified in the region to accept waste generated by the Project. This will include discussions with local councils and private waste contractors.

4.2.4.2 Recommendations for Stage 2 Work Program

A Stage 2 work plan would be prepared with the objective of preparing concept design and capital cost estimates for new on-site waste management infrastructure and in further quantifying waste streams, end of-life of waste facilities and management and waste reduction options for each waste stream based on a summary of applicable regulations and guidelines.

The following scope of work has been proposed for Stage 2 works:

1. Waste Characterisation

Review of updated facility design and operation plans / reports provided by the NRWMF Design team to enable identification of waste types and quantities to be generated from the proposed development during the construction and operation phases.

2. Identification of waste management options

This part of the study will involve the identification of potential solutions for management of each type of waste generated, including considerations from collection, transport, processing and disposal.

3. Existing Facilities Assessment

Investigations on capacity and suitability of the existing resource recovery and disposal sites to accept waste generated from the Project, consisting primarily of targeted site inspections of existing waste facilities located in the local region around the site and additional discussions with local waste contractors and Councils.

4. Waste management options analysis

Based on the information collected, a high level options analysis will be undertaken for both the construction and operation phases of the Project. This analysis will include a high level cost-benefit analysis as well as a non-financial analysis taking into account environmental, social, regulatory and technical issues for each option. The outcome of the options analysis will be a recommendation on how each waste stream should be managed taking into consideration both off-site and on-site options.

4.3 Utilities

4.3.1 Methodology and Results

The general methodology used for the development of desktop assessment of the enabling Utilities, Energy and Infrastructure was to review the available service and utility data to assess the site in regards to available service/utility connections. This included the following tasks:

1. Access the publicly available databases and review the available information for the following utilities and services:
    - Power
    - Water supply main
    - Gas (reticulated network)
    - Telecommunications
    - Wastewater (reticulated network)
    - Stormwater
2. Review of the aerial photography databases and websites – this source was utilised to identify the site location, extents and any above ground infrastructure.
3. Review of site visit photographs and notes to enable confirmation of utility infrastructure.

The list of databases and information sources utilised is as below:

- Verification of above and below ground utilities using aerial photography sources, site visits and photographs.
- Reference to the Dial Before You Dig (DBYD) system to obtain local utility/service maps from the specified providers.
- Reference to the National Map website to obtain utility data, ground levels, distances, etc.
- Reference to utility and service provider website for further information on specific sites and data.
- Reference to infrastructure provider websites for further information on specific plant and systems.
- Australian Energy Market Operator (AEMO).
- Australian Renewable Energy Mapping Infrastructure (AREMI).
- SA Power Networks Distribution Annual Planning Report 2017/18 to 2021/22.
- Government of South Australia, Location SA Map Viewer.
- Essential Services Commission of South Australia (ESCOSA).
- Input of load requirements from memo.

4.3.1.1 Site Characteristic Criteria

Assessment criteria developed to address the availability and vulnerability of site services are detailed in the table below.

Table 60 Utilities Assessment Criteria

	Power	Water Supply Main	Wastewater (Reticulation)	Telecommunications	Gas (Reticulation)	Stormwater
1. Proximity to Site	X	X	X	X	X	X
2. Nature of Service/Utility and capacity/ constraints	X	X	X	X	X	X

The assessment of each of the utilities/services was undertaken to gain an understanding of the existing infrastructure on or near to site and the scale of the requirements to extend the infrastructure to the Lyndhurst site.

4.3.1.2 Desktop Methods and Results

The data sources accessed are listed below, the dates of access have also been provided as data within these sources is subject to change:

- Dial Before You Dig (DBYD) utility service plans database data obtained in March 2018.
- Aerial Photography – Google Maps accessed between 7th and 14th March 2018
- Location SA – Website utilised to provide additional SA Water and SAPN data, accessed between 7th March 2018 and 14th March 2018.
- National Broadband Network (NBN) Rollout Map – accessed 7th to 13th March 2018
- National Map – Website for map-based access to spatial data from Australian Government agencies. – accessed 7th to 13th March 2018
- SA Water website – data on Kimba water supply – accessed 9th March 2018.

4.3.2 Assessment Against Criteria

4.3.2.1 Utility/Service Assessment

An assessment was undertaken for each of the utilities/services listed below by reviewing the data sources listed in Section 4.3.1.2. The following describes the infrastructure which is assessed to be available within a distance to the site that is deemed feasible for connection.

4.3.2.1.1 Power

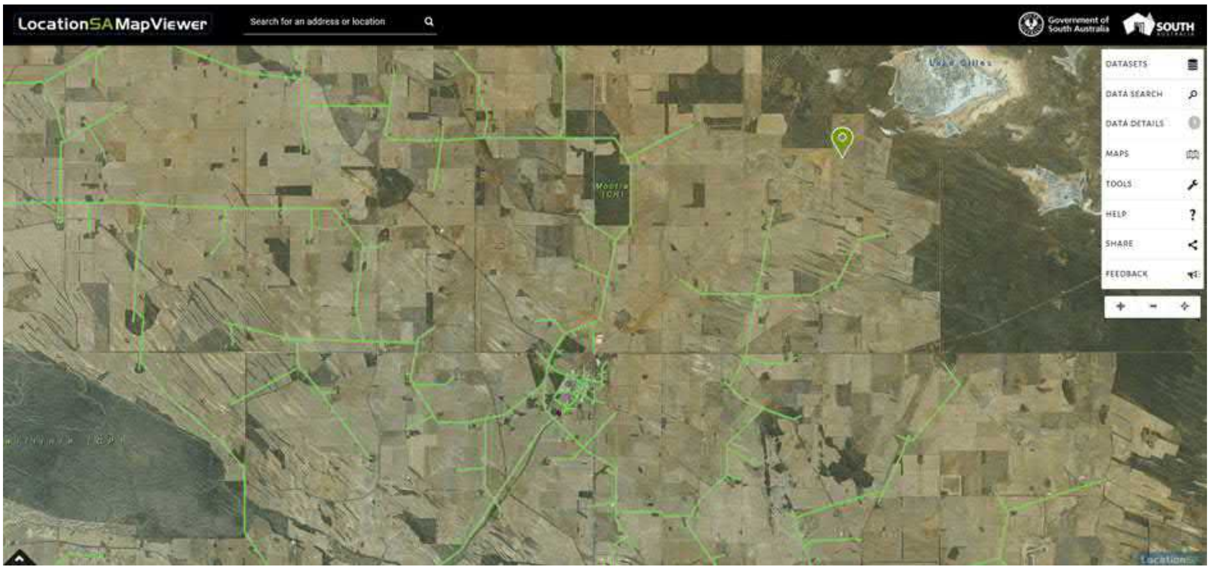
<u>Assessment Criterion 1 Proximity to site</u>

The Lyndhurst site is approximately 55km from the closest transmission substation (Middleback Tee) and approximately 45km from any transmission line (132kV Cultana to Yadnarie). This can be seen in the image below from AREMI showing in green both the distances from the 132kV transmission line and the transmission substation.

Figure 48 AREMI – Site Map

Most of the region surrounding the Lyndhurst site is serviced via a single phase network, shown in green below. A single phase network is not suitable for connection of the NRWMF.

Figure 49 Location SA MapViewer screenshot showing local power network



The closest substation to the Lyndhurst site is the Kimba Regulator Station, which is approximately 18km from the proposed site. The Kimba Regulator Station operates at 11kV.

Figure 50 Location SA MapViewer screenshot showing distance to closest power station

Assessment Criterion 2 Nature of service, capacity and constraints

In the Distribution Annual Planning Report from SA Power Networks, it is stated that there are “No current limitations on primary distribution feeders under normal conditions in the Eyre Peninsula region in the next two years.”

The Caralue 66/11kV transformer (Kimba feeder connects to 11kV side) has a nameplate rating of 2.5 MVA, with load expected to be around 2.3MVA under current conditions over the next ~5 years. This limits the options available for connection to the network if full load was required from the grid without supporting the augmentation of the network in the area.

According to the Essential Services Commission of South Australia (ESCOSA), “Over the 10 years to 2015-16, regions on the Eyre Peninsula supplied by long, radial distribution feeders (remote from the transmission network) had the greatest total minutes off supply.” . This means that as well as the constraints on the network for power rating, the long length of distribution feeders into the Kimba area have low comparative (to other regions in Australia) network reliability. In October 2017, the Final Report for the enquiry into the reliability and quality of electricity supply on the Eyre Peninsula was released and proposes a focus on increasing localised supply of power, network hardening (e.g. re-insulating feeders), and understanding the projects being developed in the area (mines, renewable energy).

4.3.2.1.2 Water Supply Main

Assessment Criterion 1 – Proximity of water supply infrastructure to site

A 375mm diameter potable water main is located to the South of the site which is approximately 6.3km from the site property boundary. A local supply 90mm diameter potable water main is located on the Southern boundary of the site. Figure 51 below shows the location of the site in relation to the water supply network in the area.

Figure 51 Location SA MapViewer screenshot showing the site location in relation to the nearest water main

<u>Assessment criterion 2 - Nature of service, capacity and constraints</u>

Future construction and operational water supply needs are yet to be defined through the facility design process. This will establish the minimum size of a local supply potable waterman needed for the site.

As noted in the design issues section the proposal for the water supply of the site would be to connect to the existing 90mm diameter water main for construction purposes while a permanent connection is made to the 375mm diameter main to the South. This would enable construction works to continue on site while the main supply for the operation phase of the project is established.

As also noted in the design issues section, the size of water main would be established during the concept design phase and agreed with SA Water, the requirement for any additional pumping mains would also discussed at this time.

The SA Water potable water supply line is likely to have sufficient capacity to supply any potential needs to the NRWMF during construction and operation, nor is it expected that the supply will be constrained.

Groundwater could be utilised as an alternate supply of water (in non-potable form). There are a number of existing groundwater wells drilled within a 10km radius of the site. The purpose of the wells drilled is rarely identified; however of the wells with data available it seems they were drilled for industrial purposes. A number of the wells have been abandoned due to a low yield or high salinity of the water extracted, and as such it is expected that the groundwater is unlikely to present a suitable water supply option.

As noted in the design issues section, the NRWMF design could allow for the capture and storage of stormwater to supply non-potable water to the site.

4.3.2.1.3 Wastewater

<u>Assessment Criterion 1 – Proximity of wastewater infrastructure to site</u>

There is no wastewater infrastructure within 15km of the site location. The nearest facilities would be in the town of Kimba which is located 15km directly west of the site. However, it is noted that stormwater will most likely be dealt with on-site via a combination of diversion of clean stormwater around the site and collection and potential treatment and/or reuse of stormwater falling on the site.

<u>Assessment Criterion 2 - Nature of service, capacity and constraints</u>

Future construction and operational estimates of wastewater volumes and the preferred option for management of wastewater is yet to be determined by the NRWMF designer. Design issues and options for wastewater, grey water and trade waste are outlined below. No discussion of capacity or constraints is therefore provided.

4.3.2.1.4 Telecommunications

The preliminary information provided to AECOM regarding the minimum telecommunication requirements for the site are as stated below:

- Mobile and landline coverage – 100% availability
- Minimum of 10 phones available within the NRWMF (VoIP)
- Mobile coverage across entire 100 Ha site
- Data connection of minimum 25Mbps

Utilising the data available on the National Map website the following points were identified with regard to the existing communications networks:

- The broadband coverage in the project area is rated as the lowest availability (E).
- NBN's fixed wireless service is not available in this area.
- 3G mobile coverage is available, where mobile broadband services are available; they will typically offer speeds of between 1-20 Mbps downstream and up to 3 Mbps upstream.
- ADSL median speed is 6.31 Mbps

Assessment Criterion 1 – Proximity of communications infrastructure to site

The existing telecommunications network in the region of the project site is limited to a copper wire connection to a residential property approximately 2.5km from the site. This connection would be inadequate for the requirements of the proposed NRWMF.

Assessment Criterion 2 - Nature of service, capacity and constraints

As noted in the design issues section below which discusses capacity and constraints, to provide a suitable telecommunication link to the Lyndhurst site installation of additional equipment will be required, for which there are two potentially suitable options including connection to the Sky Muster satellite or installation of fibre optic cable from the pending NBN station in Kimba to the project site and therefore provide data connection to the site. Mobile coverage could be achieved using one of the providers by the installation of mobile repeater station installation within the site and possible also on the route from Kimba to the site.

4.3.2.1.5 Gas

There is no reticulated gas infrastructure located within the region. The nearest town of Kimba 16km to the West does not have a reticulated gas supply. The onsite requirements for gas (if any) would be required to be considered in the NRWMF design.

4.3.2.1.6 Stormwater

Assessment Criterion 1 – Proximity of stormwater infrastructure to site

There is no reticulated stormwater infrastructure located with the project boundary or within the surrounding area. The existing topography of the site would allow any sheet flow to flow across the surface from west to east and drain via drainage ditches and the like.

Assessment Criteria 2 - Nature of service, capacity and constraints

The stormwater network required would need to be designed to specifically deal with the capacity and address constraints for all flow within the site. Any overland flow would be diverted around the site boundaries.

Reference should be made to the flood risk assessment for the site when undertaking this design element.

4.3.2.2 Utility/Service Assessment Summary before implementation of design mitigations

Table 61 below indicates whether the site satisfies the assessment criteria in relation to the proximity to, capacity and constraints of the existing utilities and services. Where no utility is present in the vicinity of the site it will not satisfy the proximity criteria (and the capacity criteria). Where there is infrastructure in the vicinity of the site but it does not have sufficient capacity to facilitate the construction / operation of the site it will not satisfy the capacity criteria.

Table 61 Existing Site Utility Assessment (prior to implementing any mitigation measures)

Service / Utility	Criteria 1 - Proximity	Criteria 2 – Capacity	Comments
Power	×	×	The Lyndhurst site is approximately 55km from the closest transmission substation and approximately 45km from any transmission line.
Water Supply Main	✓	✓	A 375mm diameter potable water main is located to the South of the site which is approximately 6.3km
Wastewater	×	×	There is no wastewater infrastructure within 15 km of the site.
Telecommunications	×	×	Existing network in the region of the site is inadequate for the proposed NRWMF.
Gas	×	×	There is no reticulated gas infrastructure located within the region.
Stormwater	×	×	There is no reticulated stormwater infrastructure in the area surrounding the site.

Section 4.3.3 discusses the utility/service issues within the site and the infrastructure required to be constructed to meet the specifications required on site.

4.3.3 Design Issues and Mitigation Measures

The following sub sections list the potential design issues with the various services/utilities and potential mitigation measures which could be deployed to overcome the various issues.

4.3.3.1 Power

The Lyndhurst site is not located within a reasonable connection distance to the transmission network. The closest MV substation is limited and already operating at around 90% capacity of a 2.5MVA transformer. Network augmentation to increase the capacity of the supplying network should be considered. Supplementing the load with generation on site (e.g. renewables) should be considered. The region is known for low reliability of supply and criticality of supply for the NRWMF should be considered.

4.3.3.2 Water Supply Main

The proposal for the water supply of the site would be to connect to the existing 90mm diameter water main for construction purposes while a permanent connection is made to the 375mm diameter main to the South. This would construction works to continue on site while the main supply for the operation phase of the project is established.

The size of water main would be established during the concept design phase of the concept and agreed with SA Water and the requirement for any additional pumping mains also discussed at this time.

The water main would require booster pumping stations along the route due to the distance of the connection. Prior to entering the site, the water main would require to be connected to a backflow prevention system. The internal network should consider stormwater and rainwater collection reuse.

The provision of a water supply bore for this site has been reviewed. It is understood the nearby town of Kimba groundwater supply was under threat due to reduced rainfall and as a result the issue of groundwater extraction licenses has been reduced to protect the supply. Kimba is now supplied by the aforementioned 375mm diameter water main which runs from Iron Knob and was installed in 2006.

While the potential for water supply from groundwater exists, available information suggests this is unlikely to supply the yield and quality required, especially if concrete batching is to be considered on site.

4.3.3.3 Wastewater

The existing site has no wastewater connections within a suitable distance to allow a connection therefore the potential options relate to treatment of the wastewater on site. Therefore the wastewater must be or treated on site or stored and removed from site.

There are various options with respect to the handling and treatment of the various discharges across the proposed site. The separation of the discharges from the various sources could be separated into wastewater, grey water and trade waste flows. The following describes potential sources from each:

- Wastewater – Discharge generated from sources that have faecal contamination.
- Grey water – Discharge generated from sources such as sinks, showers, kitchens without faecal contamination.
- Trade waste –Discharge generated from industrial activities, this may be of a high volume and/or contaminated.

Options to manage the wastewater will be addressed in the NRWMF design but could include:

Wastewater Option 1 – Subsurface Effluent Disposal System and Trade Waste Evaporation Pond
A subsurface effluent disposal system would require the design of a reticulated network, septic tank and an irrigation field. When designing this system reference should be made to the location of the irrigation field in relation to any groundwater bores used on or off site and the potential for contamination. The existing geological conditions on site would require assessment as to whether the treated effluent would infiltrate through the specific geological conditions on site.

Wastewater Option 2 – Holding Tanks and Evaporation Pond
Holding tanks could be suitable to store wastewater discharge in large tanks (sized to accommodate the maximum discharge). The holding tanks would be emptied by tankers on a regular basis therefore negating the need for a treatment system on site. The costs for the septic tank maintenance would be ongoing and would be a consideration.

Wastewater Option 3 – On-site Treatment Plant and Evaporation Pond
The installation of a packaged treatment plant to treat the wastewater discharge could be considered. A packaged treatment plant such as an Aerobic Wastewater Treatment System which uses accelerated natural biological processes could be used to treat the wastewater. This system would then be combined with an irrigation network to dispose of the treated water. A typical system would require minimal maintenance, and this could be undertaken by the supplier at a minimal cost.

Trade Waste Option

A Trade Waste evaporation pond would be require to have an impermeable liner which is sized to consider the site meteorological conditions and with the require freeboard. The settled solids material would either require off-site disposal or potentially be retained in a storage facility on site (dependent of the level of contamination). Alternatively a Trade Waste collection tank would be required.

4.3.3.4 Telecommunications

To provide a suitable telecommunication link to the Lyndhurst site installation of additional equipment will be required. Through investigation of Government websites and data there are two suitable options for providing the communications requirements which are set out in 4.3.2.1.4. The options are described below:

- Connection to the Sky Muster satellite via the installation of a satellite communications tower. This would provide a private connection to the communications network and therefore a greater surety of connection speed. An individual connection to the Sky Muster satellite can provide a maximum speed of 75Mbps therefore several connections may be required to provide the required minimum data connection speed of 25Mbps. To provide the required mobile coverage across the 100Ha site a mobile repeater tower would require to be constructed on site. An installation of this type could be used to allow connection to a mobile network or data connection for adjacent landowners.
- Reviewing the NBN website states that the town of Kimba (16km to the West of the site) is planned to have availability of NBN Fixed Wireless service from July 2018 to September 2018. An installation of fibre optic cable from the NBN station in Kimba to the project site could be achieved and therefore provide data connection direct to the site. Mobile coverage could be achieved by the installation of mobile repeater station installation within the site and on the route from Kimba to the site.

4.3.3.5 Gas

The onsite requirements for gas would be required to be considered in the NRWMF design. It is envisaged that gas would be trucked to site and on-site gas storage tanks would be filled on a regular basis.

The factors to discuss during further stages of the design would be:

- Gas requirements – heating, kitchen areas, power generation, etc.
- Location and size of gas storage tanks – small gas cylinders for kitchen, heating use or large "bullet" tanks for greater onsite capacity.
- Safety requirements around gas storage delivery and tanks onsite.

4.3.3.6 Stormwater

Stormwater requirements will be required to be considered in the NRWMF design. This would include consideration of diversion of stormwater generated in upstream catchments around the site and also management of stormwater generated on-site, including detention and treatment. Stormwater re-use may be considered in the NRWMF design.

The recommended stormwater design philosophy would be to collect and treat all stormwater generated on site due to the lack of any infrastructure to connect in the surrounding area. Due to the type of facility, it would be prudent to minimise any perceived negativity around the potential for stormwater runoff entering nearby watercourses.

4.3.3.7 Utility/Service Assessment Summary after implementation of design mitigations

Table 62 below provides an assessment against the criteria upon implementation of design solutions/ mitigation measures. Where no utility is present in the vicinity of the site it will not satisfy the proximity criteria (and the capacity criteria). Where there is infrastructure in the vicinity of the site but it does not have sufficient capacity to facilitate the construction / operation of the site it will not satisfy the capacity criteria.

Table 62 Proposed Site Utility Assessment upon implementation of design solutions / mitigation measures

Service / Utility	Criteria 1 - Proximity	Criteria 2 - Capacity	Comments
Power	✓	✓	The site is not located within a reasonable distance to the transmission network. Connecting to existing transmission lines is expected to be costly. Supplementing the load with generation on site should be considered.
Water Supply Main	✓	✓	Site would be connected to the existing 90 mm main for construction while a permanent connection is made to the existing 375 mm diameter main to the south.
Wastewater	✓	✓	The existing site has no wastewater connections within a suitable distance. Therefore wastewater must be treated on site or stored and removed from site.
Telecommunications	✓	✓	Connection to the Sky Muster satellite or NBN will be required.
Gas	✓	✓	It is expected that gas will be transported to site and on-site gas storage tanks would be filled on a regular basis.
Stormwater	✓	✓	It is recommended that stormwater would be collected and treated on site.

The relative cost to undertake the required engineering upgrades to facilitate the construction / operations of the NRWMF will be further detailed as part of the enabling works.

4.3.4 Data Gaps and Recommendations for Stage 2 Work Program

The following sections detail the relevant data gaps and recommendations for work to be undertaken as part of the Stage 2 Work Program once a preferred site is nominated. It should be noted that high level designs of the enabling infrastructure (roads and utilities etc.) will be completed as part of the enabling works. These will be used to inform relevant stakeholders when nominating a preferred site.

4.3.4.1 Data Gaps and Limitations

4.3.4.1.1 Power

The information required to allow progression of the power supply assessment is as listed below:

- Detailed load profiles.

- Details of criticality of supply for NRWMF.
- Incorporating potential for generation as well as load.

4.3.4.1.2 Water Supply Main

The following information is required to progress the water supply assessment:

- Water supply pressures.
- Water consumption rates to be confirmed.
- Confirmation of Fire Fighting Water requirements.
- Confirmation of ground water supply issues.

4.3.4.1.3 Telecommunications

The following information required to allow progression of the telecommunications assessment is as listed below:

- Specific telecommunication requirements for the site.
- The specific requirements for the Sky Muster satellite system and the required infrastructure and the number of connections required.
- The number of and location of mobile repeater stations.
- Confirmation of reliability of the satellite system.

4.3.4.2 Recommendations for Stage 2 Work Program

The following is a list of recommendations for the additional data collection which is required for a more detailed assessment of the site characteristic criteria to be undertaken. It should be noted that the design of enabling infrastructure will be considered as part of the enabling works. The following items will be considered as part of the enabling works.

4.3.4.2.1 Power

- Discussions with ElectraNet and SA Power Networks.
- Feasibility modelling of connection of load/generation to network.
- Verification of power supply requirements.

4.3.4.2.2 Water Supply Main

- Discussions with SA Water with regard to water pressure, security of supply and connection to existing main potential.
- Confirmation of potential groundwater extraction constraints and quality issues.

4.3.4.2.3 Telecommunications

- Discussions with NBN regarding the Sky Muster satellite option.
- Discussions with NBN regarding the fixed wireless network to be installed in Kimba and the requirements to connect into this network.
- Verification of telecommunication requirements.

4.4 Renewable Energy

4.4.1 Methodology and Results

This desktop study has assessed the different renewable energy technologies that could be used at Lyndhurst. The technologies were assessed as a means of potentially offsetting the energy load requirements of the facility.

AECOM has conducted a literature review of publicly available information on different renewable energy generation technologies that are available in the Australian market. The generation technologies assessed are:

- Solar Photovoltaic (PV);
- Solar Thermal;
- Wind;
- Geothermal;
- Hydro; and
- Tidal / wave.

Information was gathered on the following topics for each generation type:

- Availability of resource in vicinity of site;
- Strategic costings (indicative Levelised Cost of Energy (LCOE), Capital Expenditure (Capex and Operating Expenditure (Opex);
- Risks;
- Technical characteristics;
- Pathways to construction; and
- Estimates of time to market.

4.4.1.1 Site Characteristic Criteria

The key criterion is the appropriateness of renewable energy resource options to provide renewable power sources to the site (and the local site setting to generate renewable energy).

Considerations relevant to the criteria are outlined below.

4.4.1.1.1 Resource availability

For each technology investigated, the availability of the resource in proximity to the site was assessed.

4.4.1.1.2 Technology Risk

The maturity of the technology and the process used was assessed in relation to activities in the vicinity of a NRWMF.

4.4.1.1.3 Cost

The commercial implication of each technology was assessed.

4.4.1.1.4 Scalability

Scalability and modularity of the technologies were assessed.

4.4.1.2 Desktop Methods and Results

4.4.1.2.1 Solar PV

Australia has the highest solar radiation per square metre of any continent [3] globally. Installations of solar PV technology have increased significantly over the past few years internationally and in

Australia. Globally there is over 300 GW of solar PV plants installed with improvements being implemented as confidence in the technology continues to increase.

One of the main factors for this increased uptake is the significant reduction in costs, with The Climate Council Australia noting that “Solar costs have dropped 58% in five years and are expected to continue to fall by a further 40-70% by 2040” [2]. Compared to electricity prices for new coal power stations at A$160/MWh, solar PV is expected to continue to drop below A$110/MWh as more systems are installed [2].

The key drivers of declining costs and improved economic viability of large scale solar PV include:

- Declining technology costs (mass production and increased competition)
- Increased scale of deployment in Australia
- High Large Scale Generation Certificate and electricity prices
- Availability of federal grant funding and access to financing

Project site and technology selection has a major influence on the capex, opex and Levelised Cost of Energy.

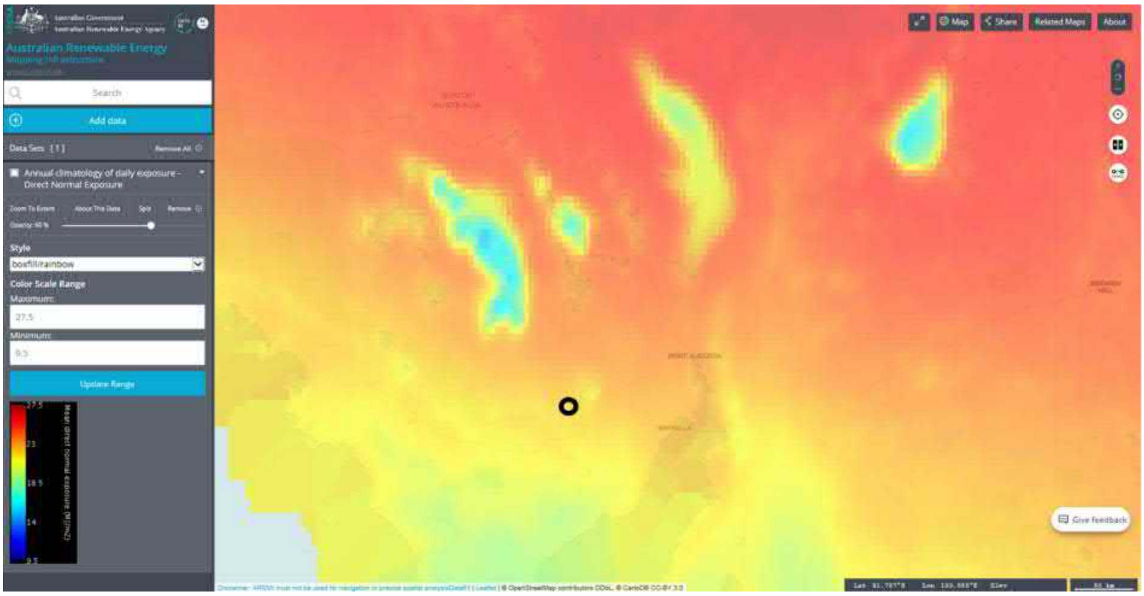
Solar PV technology has the added benefit of modularisation. Different sized solar farms can be designed and built to suit available land area. The modularity of the system also reduces down-time of the system, as some components can be repaired or replaced without affecting the other parts of the system (e.g. panel replacement). The asset life of a solar farm is around 25-30 years.

Solar PV panels can be installed as either a fixed structure that has the panels locked in place with no moving parts, or mounted on tracking devices that change the orientation of the panel to maximise exposure to sunlight. These can either be single-axis tracking (SAT) devices, which change the orientation along one axis, or dual-axis tracking (DAT), which can change orientation along two axes. Fixed tilt systems are the simplest for installation and operation. While SAT systems increase performance (typically by 15-20% depending on the location), they require more land for the same total capacity and have a higher capex and opex. However, in the last couple of years the cost of SAT systems in Australia has fallen more rapidly than for fixed tilt solar and is now often preferred for new projects where available space and topography allow.

Lyndhurst resource

South Australia is known for having a high solar resource. In Figure 52 below, it can be seen that South Australia has some of the highest mean direct normal exposure of solar in Australia (>23 MJ/m^2/year). While the Lyndhurst site (shown circled in black) is not in an area with the highest exposure (~21 MJ/m2/year), it still has typically more exposure than most of the state of Victoria.

Figure 52 Solar Resource in Lyndhurst Region [1]



The area of moderate/high exposure makes it worthwhile to consider the site as offering potential for installing solar as a generation source. However, considerations for solar PV also need to include temperature and soiling of the panels.

Solar PV panels derate in high temperatures. According to the Bureau of Meteorology [4], high ambient temperatures in the Kimba region (weather station in proximity to the Lyndhurst Site) average over 30°C from November to March and could cause the power output of the panels to derate by about 2% from the specified rating [5].

In areas with little rainfall, additional manual cleaning of panels would be required to ensure the performance of the panels is not significantly reduced from soiling. Soiling can cause around 0.2% losses per day when there is no rain or cleaning. The average annual soiling losses could range from 1% to 4% depending on the site and cleaning regime.

These factors need to be considered in detailed design and commercial considerations for solar PV technologies.

Solar PV metrics for utility scale projects

Table 63 Strategic costs and other key metrics for Solar PV [6,7,8,9,10,11,12,13,14,15,16] [25]

Metric	Lower limit	Typical	Upper limit
Levelised Cost of Energy	$58/MWh	$98/MWh	$171/MWh
Capex	$1.1M/MW	$2.1M/MW	$2.6M/MW
Opex - Variable	$0/MWh	$0/MWh	$0/MWh
Opex – Fixed	$11,000/MW/year	$28,000/MW/year	$57,000/MW/year
Time to Market[26]	1 year	1.5 years	3 years
Land required	0.5 ha/MW_{dc} (5.5m^2/kW_{dc}) (roof mount fixed)	1.8 ha /MW_{dc} (ground mount)	2ha / MW_{dc} (ground mount tracking)

Assessment of Solar PV for Lyndhurst

Solar PV technology is relatively low cost compared to other forms of renewable generation and has the benefit of scalability. The Lyndhurst area has moderate/high irradiance; derating for temperature and soiling would need to be considered in detailed design. Solar PV technology is well known, with numerous qualified and certified designers and installers, and poses a low safety risk for operation.

4.4.1.2.2 Solar Thermal

This section focuses on solar thermal technology for electricity generation. Solar thermal technology can also be used for heating purposes as another means to offset energy use by using technology such as solar hot water. These heating systems are very typical and commonly used throughout Australia. In further detailed design, solar thermal heating systems could be investigated by the NRWMF designers for overall site efficiencies.

Solar thermal (electricity generation) technology is based on harnessing the sun's heat energy by concentrating sunlight reflected from mirrored surfaces to a receiver. The high temperature is then harnessed by passing a fluid (such as water, molten salt or synthetic oil) through a focal point (or tubes, depending on the design). Finally, steam turbines use the steam to generate electricity [6].

Some solar thermal systems can also store the heat energy before it is used to produce steam. This facilitates the plant to continue producing electricity even when sunlight is unavailable or below ideal radiation levels [6]. These systems are also called Concentrated Solar Power (CSP) systems. There

[25] Prices based on states with large numbers of utility solar farm installations
[26] Time to market includes development and design, approval, construction, commissioning

are multiple types of CSP technologies and the figures provided in our analysis are based on one type, called 'Central Receiver'.

Commercial capacity of Concentrated Solar Power (CSP) systems have been concentrated in a few countries around the world, mostly Spain and the United States, but numerous projects are being developed in the Middle East, North Africa, as well as in Australia, India, China and South Africa [18]. CSP systems have not had the same accelerated growth as seen with solar PV. Competition from lower-cost solar PV is challenging deployment, as evidenced by some projects in the United States having converted from CSP to solar PV. However its market penetration may increase by virtue of its suitability for integration with a fossil fuel plant and storage, which can enhance its value through dispatchability [18].

Currently, the installed costs of CSP systems are high compared to wind and solar PV; current installed costs per MW are as high as twice the cost of other renewable systems [18].

Solar thermal technologies are not typically scalable and tend to be installed for generation more than 50MW due to the cost effectiveness of larger thermal masses. The life of the asset is similar to typical thermal generation plants, in excess of 40 years. [19].

Technical risks of thermal solar developments include molten salt leaks, safety risks, including instances of fires and explosions at facilities, and the risk of inadequate solar radiation.

Lyndhurst resource

South Australia is known for having a high solar resource. Solar thermal technology requires direct sunlight (solar PV can still produce energy in diffuse light situations). South Australia has some of the best resource in the world for direct exposure. In Figure 52, above, it can be seen that South Australia has some of the highest mean direct normal exposure of solar in Australia (>23 MJ/m^2/year). The Lyndhurst site (shown circled in black), is in an area of moderate/high solar exposure as shown in Figure 52, above.

Solar thermal metrics for utility scale projects

Table 64 Strategic costs and other key metrics for Solar thermal [18, 6, 9, 20, 21] [27]

Metric	Lower limit	Typical	Upper limit
Levelised Cost of Energy	$119/MWh	$185/MWh	$300/MWh
Capex	$5M/MW	$7M/MW	$9M/MW
Opex - Variable	$4/MWh	$7/MWh	$13/MWh
Opex – Fixed	$65,000/MW/year	$70,000/MW/year	$76,000/MW/year
Time to Market [28]	5 years	6 years	10 years

Assessment of Solar thermal for Lyndhurst

Solar thermal technology has not been well developed in Australia and remains at costs double that of other renewable technologies. At the nearby region of Whyalla, a new solar thermal plant is being built to prove the suitability of this technology in the region. Local Australian contractors are inexperienced with design, development and construction of solar thermal facilities and international involvement would likely be required.

4.4.1.2.3 Wind

Wind generation technology is one of the most mature renewable energy technologies available, and remains the lowest cost renewable generation type. Wind farms are heavily dependent on location; an area with suitable open land as well as consistency in wind speed at the correct height and availability of wind is required to efficiently operate. These topology factors heavily influence the turbine selection and layout.

[27] Based on adjusted global and local figures.
[28] Time to market includes development and design, approval, construction, commissioning

Wind generation is considered to be the fastest growing renewable energy technology in Australia with a current share of 4.9% of Australia's primary energy consumption [22].

The five key components that impact the Levelised Cost of Energy are up-front capital costs (Capex), ongoing operating costs (Opex), cost of financing, performance (capacity factor) and project design life.

All five of these cost drivers are continually seeing improvements with large scale wind energy development. The most significant improvements have recently come from capacity factor increases and reduction in capital expenditure. Capacity factor is increasing for wind turbines due to the increasing hub height and capacity of the turbines and the larger rotor diameters being installed. As the industry continues to mature, financing costs and project contingencies continue to be reduced.

Additionally, turbine component durability and reliability continues to improve.

It is expected that there would be a period of very limited to nil reduction in costs from 2021-2024. Most grade one wind farm sites (with high wind resource and favourable planning conditions) will have been used up by project developers by the early 2020's and sites with lower wind resource in more challenging geographies would be available for construction [18].

Being a mature technology, wind energy is well understood by the industry and is considered a low risk technology. The main challenge for the implementation of wind energy generation in Australia is the changing requirements of the management of quality and stability of the transmission system due to relatively sudden changes in electrical output sent into the system. Wind energy has an increasing level of penetration into the electricity network (along with solar PV) which is inherently variable in output due to the variability of meteorological conditions.

The typical asset life of Wind farms is 20-25 years [23] for utility scale farms. Small scale wind turbines are not common in Australia.

Lyndhurst resource

The area for Lyndhurst shows a moderate wind resource area as outlined in Figure 53 below (Lyndhurst is the black circle). Lyndhurst is in a region of yellow colour (moderate). This resource is typical in the region surrounding Lyndhurst. Similarly to solar PV, some turbines derate at high temperatures and some stop operating at temperatures between 40^{o}C and 45^{o}C. This region reaches these temperatures and must be considered for the annual output.

Figure 53 Wind resource at Lyndhurst sites [1]

Wind metrics

Table 65 Strategic costs and other key metrics for wind [6, 7, 8, 9, 11, 12, 13, 14, 15, 16, 21]

Metric	Lower limit	Typical	Upper limit
Levelised Cost of Energy	$60/MWh	$92/MWh	$120/MWh
Capex	$2.2M/MW	$2.5M/MW	$2.8M/MW
Opex - Variable	$0/MWh	$8/MWh	$16/MWh
Opex – Fixed	$19,000/MW/year	$35,000/MW/year	$55,000/MW/year
Time to Market[29]	4.5 year	6 years	9 years
Land required (Permanent Direct Impact Area land use)	<0.1 ha /MW	0.2 ha /MW	>1.5 ha /MW
Land required (Total wind farm area)	<10 ha /MW	25 ha /MW	>70 ha /MW

Assessment of Wind for Lyndhurst

Wind turbines are a well-established technology and comparatively low cost for renewable technologies. The resource in the direct vicinity of the Lyndhurst site is suitable for further analysis; however, additional land would need to be sourced to provide the power at a viable scale. Community support is critical for the NRWMF and additional visual impacts from wind turbines, construction works and additional land use would need to be considered. Conversely, community support for renewable energy and generation support into the grid may be welcomed by the community, landowners and stakeholders.

4.4.1.2.4 Geothermal

Geothermal power production is based on using the heat of the earth as an energy source. Geothermal energy can be drawn from the hot water circulating among rocks below the earth's surface, or by pumping cold water into the hot rocks and returning the heated water to the surface. This can drive steam turbines to produce electricity [24]. Temperatures as low as 30^{o}C can be used for direct use applications and temperatures in excess of 100^{o}C can be used for generating electricity. Currently drilling technology limits economic development of geothermal resources to a maximum depth of about five kilometres. Thus, companies are exploring for regions of elevated temperatures at five kilometres deep or less [25]. Geothermal energy has the potential to provide constant and baseload power due to the stable resource.

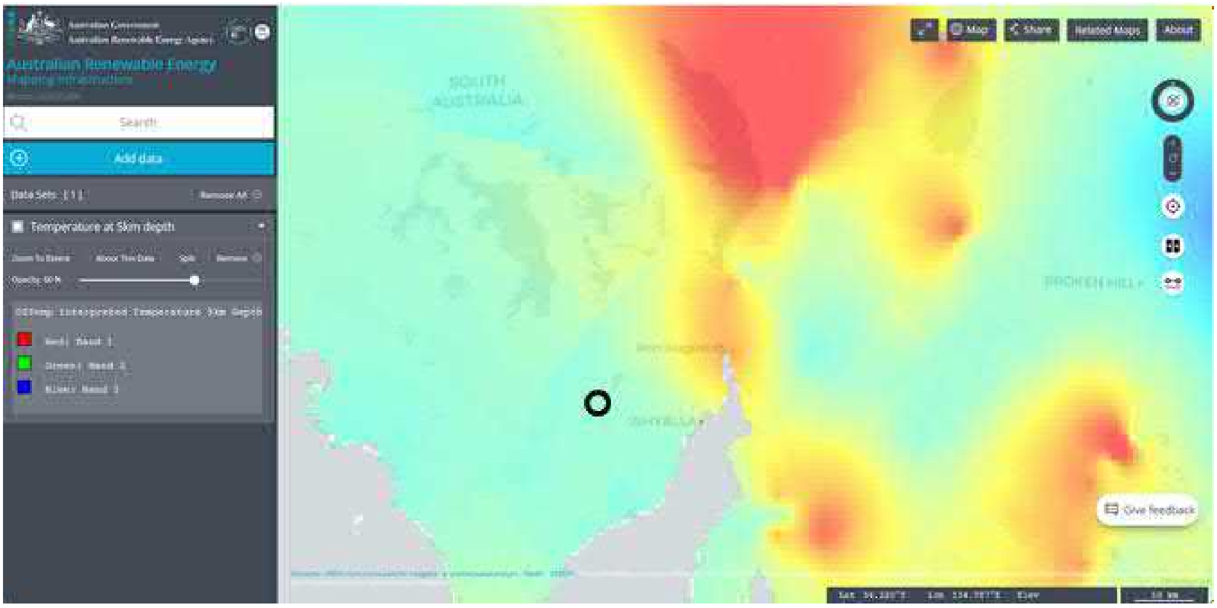
Geothermal technologies are not well developed in Australia. While studies have been conducted into potential locations, most current projects in Australia are still at proof-of-concept or early demonstration stage [24]. Capital costs are high due to the significant infrastructure requirements and novelty of the technology in Australia. As geothermal power production in Australia requires drilling into the surface (elsewhere in the world the heat is more accessible through natural phenomenon such as geysers), there is the potential for drilling to cause instability in the region surrounding the source. There is also the potential for releasing gases from the earth's surface [26].

Lyndhurst Resource

The area for Lyndhurst shows a low/medium geothermal resource area as outlined in Figure 54 below (the black circle shows the Lyndhurst site). The Lyndhurst site is in a region of green/blue, representing moderate temperatures (Red is high, dark blue is low). The band colours are based on interpreted temperatures at 5 km depth from the OZTemp data set [27]

[29] Time to market includes development and design, approval, construction, commissioning

Figure 54 Geothermal resource at Lyndhurst sites [1]



Geothermal Metrics

Metrics have not been assessed for the geothermal assessment due to limited history of projects in Australia.

Assessment of Geothermal for Lyndhurst

The risks associated with causing unstable land, potential release of gases and high capital costs make geothermal technology a high risk technology for use as a power source for the NRWMF.

4.4.1.2.5 Hydro

Hydro generation or hydropower generates electricity by capturing, storing and diverting water through hydro turbines and associated generation equipment. This involves the construction of a dam to restrict the flow of water, only allowing water to flow when electricity is to be generated. It is a mature dispatchable generation technology.

Hydropower systems range from less than 1MW to well over 1,000 MW, although in Australia most of our hydro generation capacity comes from a small number of large hydropower plants, the largest of which are associated with the Snowy Hydro scheme in NSW and Victoria. Hydropower is the largest source of renewable energy generation in Australia. In relation to the total electricity generated, both renewable and non-renewable, hydropower plants generated a total of 5.9% [6].

Hydropower schemes are broadly classified by the three main types:

- Run-of-river scheme - which usually has a small weir to divert flow rather than a large dam and no appreciable storage. As such, run-of-river schemes can only generate electricity when there is sufficient river flow. Consequently, it has no energy storage and although generation can be varied within the constraints of the available flow, it is not a form of reliable dispatchable generation.
- Reservoir storage scheme – where the water is stored in a reservoir that is restrained by a dam constructed upstream of the powerhouse. Stored water provides energy storage making reservoir storage schemes a form of fully dispatchable generation.
- Pumped storage scheme – where it works on the same idea of using flowing water from a high point to a low point to drive a turbine. Electricity demand peaks are met by releasing the stored water from the upper pond and running the turbine. The upper pond is replenished by the electric pumps during periods of low demand, making this an energy storage scheme.

Due to the large scale of typical hydropower projects, a considerable amount of project funding and capital investment is necessary. Development of new large scale-hydropower projects in Australia also poses significant environmental impacts, particularly via the construction of associated dams and reservoirs. Furthermore, concerns regarding climate change and reliability of future water sources (i.e. droughts) present significant risk for future developments.

Lyndhurst Resource

The area for Lyndhurst is a dry landscape with limited natural water sources in the vicinity. While pumped hydro is a form of storage, rather than generation, it has also been noted for completeness of the assessment. Studies recently conducted by the Australian National University identify potential sites across Australia [29]. There are no potential sites in the region near the Lyndhurst site.

Hydro (pumped hydro – storage) Metrics

Table 66 Strategic costs and other key metrics for hydro (pumped hydro – storage) [18, 6, 21, 20, 30, 31, 32]

Metric	Lower limit	Typical	Upper limit
Levelised Cost of Energy	$57/MWh ($161/MWh pumped)	$138/MWh ($190/MWh pumped)	$337/MWh ($220/MWh pumped)
Capex	$3M/MW	$5M/MW	$8M/MW
Opex - Variable	$5/MWh	$6/MWh	$7/MWh
Opex – Fixed	$3,000/MW/year	$19,000/MW/year	$35,000/MW/year
Time to Market[30]	3 years	**7 years**	20 years
Land required	Varies greatly	Varies greatly	Varies greatly

Assessment of Hydro for Lyndhurst

No sites have been identified in the surrounding are for pumped hydro. Run-of-river or reservoir schemes are not possible due to the limited water supply in the region.

4.4.1.2.6 Tidal / Wave

Tidal and wave power has not been considered due to the distance from the site to the sea (~100km).

4.4.1.3 Field Methods and Results

No field studies have been conducted for assessment of the renewable energy resource on site.

4.4.2 Assessment Against Criteria

The key assessment criteria applicable to considerations of renewable energy for the NRWMF include the appropriateness of renewable energy resource options to provide renewable power sources to the site including the potential for the local site setting to generate renewable energy.

A summary of the key renewable energy technologies assessed is provided below.

- **Utility-scale solar PV**: Australia is a key area for developments of utility scale solar PV because it has good solar resource. Utility-scale solar PV costs have reduced significantly in Australia in recent years, which has resulted in improved economic viability. The technology is NEG (National Energy Guarantee) compliant for emissions, but not with reliability as it is not dispatchable at all times. It also cannot provide ancillary services without energy storage included.
- **Solar thermal**: Solar thermal generation for electricity generation is currently expensive compared to other renewables, but there is high potential for cost reduction. Australia's experience to date with solar thermal is one of limited success but with strong learnings and continued interest. It is consistent with the NEG requirements for emissions and reliability and can provide ancillary services, but it is currently expensive compared to wind energy and solar PV, which has challenged its deployment. However, the potential for cost reduction going forward is very high, and is currently supported through ARENA funded research and development initiatives. Solar thermal technologies can also be used in the form of solar thermal heaters to offset heating loads (such as hot water); a well understood and implemented technology.

[30] Time to market includes development and design, approval, construction, commissioning

- **Wind**: Wind farms have increasingly sophisticated adaptive capability, as recent technology advances have seen fewer turbines needed to produce the same amount energy. Cost reductions enjoyed over the last few years, however, are expected to stall from 2021-2024, as the availability of most grade one wind farms diminishes. While wind generation is consistent with the NEG for emissions, it is inconsistent from a reliability perspective as it is not dispatchable, except in the case of storage being added. Accordingly, the main challenge for the implementation of wind energy generation across Australia is the changing requirements for the management of transmission stability and quality, as the penetration of variable renewable energy generation, increases in the NEM wide energy mix.
- **Geothermal**: Geothermal technology is relatively novel in Australia. Most projects are in the proof of concept stage or early demonstration. Costs vary dramatically depending on the resource availability and infrastructure required. The technology also poses potential risks for land stability and release of gases.
- **Hydro/ (pumped hydro – storage)**: Hydro generation has high development costs and potential environmental impacts, but it is renewable and dispatchable. Pumped hydro storage offers storage at a large scale, which can add flexibility to the power grid. Development may be impacted by high capital costs, long development timeframes, and potential environmental impacts. It is compliant with the NEG requirements around emissions and reliability, and is capable of offering ancillary services.
- **Tidal/ Wave**: Tidal and wave generation technology is not common in Australia. Studies are currently being undertaken to assess the viability of sites in Australia but most projects are still in early assessment phase. The site is located a large distance away from the ocean.

The appropriateness of the technologies assessed above are summarised in Table 67.

Table 67. Renewable technologies for Lyndhurst

Column heading	Utility-scale solar PV	Solar thermal	Wind	Geothermal	Hydro	Tidal/ Wave
Abundance of resource	Moderate	Moderate	Moderate	Low	Low	Low
Risk	Low	High	Moderate	High	High	High
Cost	Low	Moderate	Low	High	Moderate	-
Scalability	High	Moderate	Moderate	Moderate	High	-

4.4.3 Design Issues and Mitigation Measures

South Australia has some challenging network reliability conditions and potential instability. “Regions supplied by long, radial distribution feeders (remote from the transmission network) typically receive the greatest total minutes off supply” [33]. Based on the study conducted on the grid condition options for the Lyndhurst sites (Utilities and Energy considerations), the site location requires extensive distribution lines to be constructed, connected on a radial feeders multiple nodes away from the transmission network.

The inclusion of renewable energy for generation on site, as well as supporting energy storage technologies such as batteries (short term) and diesel (long term), is expected to provide both commercial and power reliability benefits to the project.

Consideration of the grid constraints, reliability, and potential connection points are key considerations for determining the amount of solar PV (the most suitable technology for the site) and storage required.

The critical loads would need to be considered, as well as the required redundancy for the site.

Further analysis into the potential of a fully islanded (microgrid) system may:

- increase site reliability (if able to switch between island and grid mode), or
- avoid grid network connection costs (if installed as a permanent islanded microgrid)

Care should be taken with storage of energy at a NRWMF, as fuel or some types of batteries are a high energy source and can be an explosive or fire risk.

These options will be considered as part of a more detailed renewable energy options assessment prior to the preparation of a concept design for the preferred option.

4.4.4 Data Gaps and Recommendations for Stage 2 Work Program

4.4.4.1 Data Gaps and Limitations

The information provided in Renewable Energy considerations is a preliminary assessment with more information required to continue the assessment of the energy load and power requirements.

Additional information requested as part of the Enabling Works includes:

- Load profiles (daily profiles including seasonal variation);
- Critical loads;
- NRWMF power equipment (e.g. switchrooms);
- Site security requirements (e.g. how the buffer zone can be used);
- Community perspective and development requirements for area surrounding the 100 ha designated site;
- Minimum load requirements;
- Maximum load requirements (construction and operation);
- Understanding the risk associated with radioactive material near electrical equipment (e.g. for installation on roofs and vault mounted technologies); and
- Site SLD.

4.4.4.2 Recommendations for Stage 2 Work Program

A more detailed renewable energy options assessment is being carried out prior to the preparation of a concept design for the preferred option.

5.0

Summary of Technical Assessment

5.0 Summary of Technical Assessment

The table below provides a summary of the Site Characterisation studies conducted by AECOM. The studies were undertaken to enable an assessment against site characteristic criteria developed with reference to ARPANSA guidelines and IAEA standards relating to the selection and evaluation of sites being considered for the siting of radioactive waste facilities.

It should also be noted that the assessments contained in the below table make no allowance for design solutions or operational management measures which could be implemented to mitigate or offset existing hazards or constraints.

There are a number of potential environmental constraints identified at Lyndhurst that would likely require mitigation or management should the proposed NRWMF be further considered at the site. These include bushfire within in the landscape, localised or catchment flooding, and wind erosion or mass movement of sands from dunes/ sand ridges.

Groundwater in the water table aquifer is present at depths generally exceeding 10 m below ground surface across the site which would provide good separation between the base of any proposed NRWMF and groundwater. Water quality in the water table and bedrock aquifers is highly saline (similar to that of seawater) and is not considered suitable for any realistic beneficial use.

The seismic hazard level of the Lyndhurst site is low based on review and interpretation of seismic data indicating with a high-level confidence that potentially active faults in the foundation, near-surface faults beneath or near the foundation, and faults in the nearby area are not present (excluding the possibility of one-off faulting). The site is not expected to be subject to near-fault ground motions, so no special design issues or mitigation measures are expected to be necessary. Australian Standard AS1170.4 specifies design procedures that are appropriate for this site.

There are no threatened ecological communities within the Lyndhurst site and surrounds. Linear corridors of vegetation in good condition present along roadways, with only degraded vegetation present elsewhere within the site. If vegetation clearance is required for development of the NRWMF, then it will be important to conduct further targeted field surveys to determine likelihood and significance of any impacts on individual Commonwealth and State listed flora and fauna species that have the potential for occurrence in the local area.

The site is well served by major road networks with several local unsealed road access options. There is an absence of utilities, including potable water, power and communications, of appropriate capacity in the near vicinity of the site. Potable water and power will require pipelines and distribution lines, respectively, to be installed over large distances to connect with existing networks. Communications towers and possibly an in-ground fibre optic NBN cable from Kimba (once rolled out) would need to be constructed to connect to mobile phone and data communications. The inclusion of renewable energy for generation on site, as well as supporting energy storage technologies such as batteries (short term) and diesel (long term), would provide both commercial and power reliability benefits to the project.

IAEA (2015) provides a range of safety related criteria to be considered in the siting process including extreme meteorological events (e.g. high winds, bushfire, flooding, dust storms), geotechnical hazards (e.g. slope stability), seismic hazards which could result in in ground displacement (from surface faulting, subsidence or ground collapse), bushfire, transport considerations (access/ egress routes and access to emergency facilities) and risks from potential impacts of human activities (e.g. air traffic, mining or quarrying, surface transportation, other hazardous facilities). There are no site characteristics which have been identified with the potential to materially impact on the safety of site personnel and safe operation of the NRWMF. A hospital is located within Kimba, approximately 15 km drive south-west from the site. An aerodrome operated by the District Council of Kimba is located approximately 10 km south-west of the site, from which an air ambulance (Royal Flying Doctor Service) can provide medical evacuation to a major hospital in Adelaide.

The site is well separated from adversely affecting development and sensitive land uses. There are a number of mineral tenements in the local area with the closest being around 4 km away from the site, which if they proceed to development for extraction could have an impact on the NRWMF and its enabling infrastructure and would require further assessment.

In summary, there are no significant constraints identified to date which would preclude siting of the NRWMF at the Lyndhurst site, particularly if design and operational mitigations are implemented.

The site characteristic hazards and constraints of enabling infrastructure can often be mitigated by the NRWMF and enabling infrastructure design processes (e.g. establishment of asset protection zone for bushfire risk and fire-fighting infrastructure, primary and alternative access/ egress routes). Potential design issues and mitigation measures that could be employed have been identified to address enabling infrastructure constraints and environmental hazards, or to protect environmental values. The Site Characterisation and NRWMF design works are running in parallel and will inform the other as the site selection process progresses. A detailed options assessment and concept design for the enabling infrastructure has also commenced.

A separate safety case document must be prepared as part of the license application to the regulator ARPANSA, prior to any approval for construction and operation of the NRWMF on the preferred site. The safety case will consider not only site characteristics with potential safety impacts, but also the NRWMF design and operational activity measures and mitigations employed to appropriately mitigate site characteristic hazards, and the transport, storage and disposal of radioactive wastes. A safety in design process will also need to be followed by the designer to address design requirements for safety of the site personnel.

A second stage of more detailed Site Characterisation studies will be conducted once a preferred site is selected by the responsible Minister. Assessment data gaps and recommendations for additional work scope items to fill such gaps have been provided for this second stage. The development of a robust conceptual site model and environmental dataset will support the development of a safety case for the NRWMF and applications for licensing and environmental approvals. Baseline conditions must also be established to enable future surveillance and monitoring during construction and operation of the NRWMF.

Table 68 Site Assessment Summary for Lyndhurst

Site Characteristic	Objective of Assessment	Key Legislation, Standards and Guidelines	Preferred Site Characteristics	Assessment Findings
Flora & Fauna	To characterise the flora and fauna present on and adjacent to the site and identify any significant or threatened species and supporting habitats which could preclude use of the site for the proposed NRWMF.	*Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). *Native Vegetation Act 1991* (SA) *National Parks and Wildlife Act 1972* (SA)	Absence of Commonwealth or State threatened species and supporting habitat, minimal requirement for vegetation clearance.	The Lyndhurst site has no threatened ecological communities and only around 5% of the area is vegetated comprising low quality habitat. There is high quality habitat within vegetated areas nearby to the site. There are Commonwealth and State listed flora and fauna species with potential of occurrence, for which some have been recorded within 10 km of the site. Further field surveys will be required to determine the likelihood of occurrence and significance of any potential impacts on the listed species.
Conservation and special use areas	To identify any Conservation or Recreational Parks in close proximity to the site and Aboriginal heritage or State and Local listed heritage sites which could preclude use of the site for the proposed NRWMF.	*National Parks and Wildlife Act 1972* (SA) *Heritage Places Act 1993* (SA)	Absence of Parks (National Parks, Conservation Parks, Conservation Reserves, Recreational Parks, Wilderness Protected Areas and native vegetation Heritage Agreements) and Aboriginal or State and Local heritage sites on or adjacent to the site	The Lyndhurst site has no Aboriginal heritage sites or State or Local heritage sites within the site and its surrounds. Five areas of native vegetation conserved under heritage agreements are present either directly or the local vicinity of the site and Lake Gilles Conservation Park is 2 km from the site.

Site Characteristic	Objective of Assessment	Key Legislation, Standards and Guidelines	Preferred Site Characteristics	Assessment Findings
Radiation, background and risks	Establish a baseline for future environmental monitoring and identify potential elevated background conditions that could affect safety of personnel	IAEA-TECDOC-1363 Guidelines for radioelement mapping using gamma ray spectrometry data. IAEA NS-R-3 (Rev.1) Site Evaluations for Nuclear Installations.	Background radiation levels within the ARPANSA Action Levels for workplaces and not sufficiently elevated to impact on environmental monitoring	Results from published historical data and a subsequent targeted intensive aerial radiometric survey do not indicate the presence of elevated background radiation conditions that could affect safety of personnel or impact future environmental monitoring.
Climate change and long term environmental scenarios	Establish existing climatic conditions for the site based on historic average and identify likely changes to climate based on projections and identify resultant key hazards that could impact on the future NRWMF and workers	AS5534-2013 Climate change adaptation for settlement and infrastructure – A risk based approach. IAEA SSG-18 Specific Safety Guide Meteorological and Hydrological Hazards in Site Evaluation for Nuclear Installations.	Future climate change conditions where the frequency and intensity of climatic events have minimal impacts or where design measures can mitigate risks	Potential climate change impacts include higher intensity rainfall events, extreme heat and fire weather. These events have the potential to impact on variables including worker safety, infrastructure damage, waste transport, flooding, power supply and maintenance costs amongst others. Potential climate change impacts should be used to inform design and operation of the NRWMF.
Bushfire Risks	Characterise bushfire threat from factors including vegetation/ fuel hazard at local and landscape level, site slopes, bushfire weather frequency/ severity and assess the likelihood and nature of bushfire impact based on potential for ignition, development and approach in the landscape.	AS 3959-2009 Construction of Buildings in Bushfire Prone Areas. Department of Environment, Water and Natural Resources, 2012. Overall Fuel Hazard Guide for South Australia	Combination of climatic conditions, fuel loadings, topography and ability to create buffers which minimises the risk and potential severity of bushfires	The site is not unduly impacted by bushfire hazards (fuel load from vegetation including Mallee woodland directly to the northwest), site slopes, bushfire weather conditions, potential for ignition and fire development in local area) if appropriate low threat setbacks (i.e. areas of cleared vegetation) are established around assets commensurate with their vulnerability to bushfire attack and provision of firefighting infrastructure.

Site Characteristic	Objective of Assessment	Key Legislation, Standards and Guidelines	Preferred Site Characteristics	Assessment Findings
Hydrology and Flood Risks	Assess potential localised flooding (water logging or extreme rainfall) or episodic major flooding or avulsion potential from upstream catchments now, and as a result of climate change, that could impact operations and site access without mitigation	IAEA SSG-18 Meteorological and Hydrological Hazards in Site Evaluation for Nuclear Installations. Ball J, et al.2016, Australian Rainfall and Runoff (ARR): A Guide to Flood Estimation	Minimal catchment areas and watercourses draining into the site, an absence of 'hydrophobic' soils, high soil conductivity rates and lower intensity rainfall events	There are no creek lines in the local area. Drainage lines exist through the site and there is anecdotal evidence of periodic waterlogging. Hydrological and hydraulic modelling to quantify the potential for and if relevant risks of flooding from Lake Gilles and a nearby non-perennial drainage depression with approx. 540 km^2 catchment will require assessment. Climate change predictions for the area suggest a future increase in rainfall intensity resulting in a potential increase in the magnitude of floods and infrastructure impacts such as road closures.
Impacts of Nearby Human Activities and Land Use Planning	Identify existing and potential future land uses on, or in proximity to the site, (sensitive land uses, extractive or hazardous activities) that may adversely impact on the site or be impacted by the NRWMF	IAEA Safety Requirements NS-R-3 (Rev.1) Site Evaluations for Nuclear Installations. Kimba Council Development Plan; consolidated 25 October 2012	Minimal sensitive land uses (e.g. residences, community facilities) on or proximal to the site, suitable buffer distances from nearest sensitive land uses. Minimal land uses (e.g. mining tenements, hazardous facilities, airfields) on or close to the site which could adversely impact on the NRWMF	The site is well separated from adversely affecting development and sensitive land uses. The land zoning, together with the physical characteristic of land within the locality and declining population trend, suggests that the likelihood of adversely affecting and intensive residential or urban development being developed in proximity of the site in the future would be low. A key consideration is the existence of a number of mineral tenements over and within close proximity to the site. If these tenements proceed to production, the associated activities may have the potential to impact the NRWF or its enabling infrastructure and will require further assessment if Lyndhurst is given further consideration.

Site Characteristic	Objective of Assessment	Key Legislation, Standards and Guidelines	Preferred Site Characteristics	Assessment Findings
Geology, hydrogeology, geochemistry, geotechnical and soils	Characterise the site sub-surface environment to determine geological, hydrogeological and geochemical characteristics	AS1726 – 2017 Australian Standard Geotechnical Site Investigations. AS1289 series Australian Standard Method of testing soils for engineering purposes. AS/NZS 5667.1 Water quality – Sampling Guidance on the design of sampling programs, sampling techniques and preservation and handling of samples NUDLC, 2012 *Minimum Construction Requirements for Water Bores in Australia V3* developed by the National Uniform Drillers Licensing Committee, Third Edition, February 2012	Deep watertable, low potential for vertical or horizontal migration of water through underlying soil, poor quality groundwater, presence of subsurface material with chemical attenuation properties, limited or no groundwater users, absence of geotechnical hazards (potential for slope instability, soil liquefaction, collapsing or expansive soils, subsidence due to ground features, long-term settlement, soil scour and erodibility).	The geological, hydrogeological, soil and geotechnical conditions at the site do not present hazards or constraints that would not be manageable through appropriate design and operational protocols. Groundwater in the watertable aquifer was found to be present at depths generally >10 m below ground surface, be of very limited beneficial use due to its high salinity and low yield observed during bore development and sampling. The relative high vertical difference over a short distance suggests there is poor hydraulic connection between the watertable and deeper aquifers (also saline), which is consistent with the assumed relative low permeability of the kaolin (clay) weathered bedrock profile. The subsurface clays and kaolin exhibit chemical attenuation properties. These subsurface clays however if exposed or used as fill may have due to their sodicity and potential for dispersion lead to surface hardening/ crusting and waterlogging, and be limiting to plant growth. Geohazards are unlikely to be present at the site, with the exception of soils of low expansive potential at surface increasing to medium at 6 m depth, which can be mitigated via design standards (AS2870). This assessment is based on current data but further investigations would be required for site specific aspects such as design of footings and

Site Characteristic	Objective of Assessment	Key Legislation, Standards and Guidelines	Preferred Site Characteristics	Assessment Findings
				structures.
Landform stability	Identify geomorphological processes (including fluvial, aeolian, slope/ mass movement) with potential to impact on long term site stability	No recognised applicable standards or guidelines	Stable landform, minimal potential for slope or mass movement processes	The Lyndhurst study site is situated on Quaternary dunes, which appear to be relics from a period of greater aeolian activity but remain potentially susceptible to aeolian processes, particularly if the vegetation cover is disturbed. The potential for slope and mass movement processes need to be considered, particularly at times of high rainfall and in relation to seismic activity. The north-western edge of the study site abuts a low-lying area that requires modelling to determine whether it may be inundated when Lake Gilles is also in flood, exposing the site to lake-shore processes.
Seismic activity	Characterise potential seismic hazards with emphasis on active faults beneath or near the site, near surface faults and the presence of ridge crests in the site vicinity	IAEA SSG-9 Seismic Hazards in Site Evaluation for Nuclear Installations, relevant peer-reviewed technical information listed in our methodology and scope and other referenced IAEA documents	Absence of potentially active faults that could cause surface faulting through the NRWMF, near-surface faults that could cause folding or other deformation within the NRWMF, nearby faults that could cause hanging wall or rupture directivity effects which amplify ground motions and ridge crests which amplify ground motions	The seismic hazard level of the Lyndhurst site is assessed with a high level of confidence to be low based on the review and interpretation of seismic data indicating the absence of potentially active faults in the foundation, near-surface faults beneath or near the foundation, and faults in the nearby area (excluding the possibility of one-off faulting).

Site Characteristic	Objective of Assessment	Key Legislation, Standards and Guidelines	Preferred Site Characteristics	Assessment Findings
Transport considerations	Assess proximity of the site to waste sources and characterise the national, regional and local transport networks (including multi-modal) to enable safe site access and egress	ARPANSA, 2014. The Code for the Safe Transport of Radioactive Material ARPANSA (2008) Code of Practice for the Safe Transport of Radioactive Materials Austroads Guide to Road Design National Heavy Vehicle Regulator, 2017. Performance-Based Standards Scheme – Network Classification Guidelines National Heavy Vehicle Regulator, 2017. Performance-Based Standards Scheme – Vehicle Certification Rules	Major highway access from waste sources around Australia, good local access road network with minimal upgrade requirements and potential for multi-modal transport options	The Lyndhurst site is well served by major road networks with several local site access options which would require both road upgrades and sealing (up to 21 kilometres) to accommodate frequent B-double movements and infrequency ODOM movements. A detailed survey of local road network to determine its condition, width, formation, traffic volumes, presence and significance of roadside vegetation habitat is required for the preferred option(s). .
Capacity to deal with NRWMF wastes and emissions	Assess availability and proximity of facilities to treat, recycle or dispose of all generated waste streams and consider the potential for on-site treatment, recycling and disposal	Applicable waste classification, treatment and disposal criteria and guidelines	Proximity to suitable waste management facilities and site attributes that can accommodate potential onsite waste management options	Given the site's location (15 km from Kimba), there are a number of waste and recycling depots capable of receiving and/or accepting waste generated from the Project. However, certain waste types (e.g. hazardous and/or Listed Waste) may need to be managed on-site then sent off-site further afield outside the region. Further definition of waste streams and volumes as the facility design progresses is required to refine the assessment.

Site Characteristic	Objective of Assessment	Key Legislation, Standards and Guidelines	Preferred Site Characteristics	Assessment Findings
Utilities, energy and infrastructure	Assess the proximity to, and capacity of, key services and utilities at and near the site (power, water, wastewater, gas telecommunications, storm water)	Relevant Australian Standards to apply at detailed design phase	Close proximity to all required services and utilities with minimal upgrade and connection requirements	There is an absence of services and utilities in the vicinity of the site (power, water, wastewater, gas, telecommunications and stormwater). The site is 55km from the closest transmission substation and 45km from any transmission line. Connection can be made to a local 90mm diameter potable water at the edge of the site initially during construction, whilst permanent connection is made to the existing 375 mm diameter main 6.3 km to the south (along with establishment of booster pumping stations along the route). The existing communications network in the region is inadequate. Mobile coverage and data may be provided via a tower to connect to the Sky Muster satellite, or a tower for mobile coverage plus fixed fibre optic cable from Kimba once the NBN is available in town.

Site Characteristic	Objective of Assessment	Key Legislation, Standards and Guidelines	Preferred Site Characteristics	Assessment Findings
Renewable or non-renewable natural resources and the site potential to use renewable resources	Assess availability of renewable resources in the site area to provide power to the site and offset grid supplied energy.	Relevant Australian Standards to apply at detailed design phase	Location which has high potential to generate renewable energy, particularly solar and wind resources, which can be harnessed by technology in a manner which will increase the (network) reliability of power supply to the site.	The Lyndhurst site is located in an area of moderate / high solar exposure and is a moderate wind resource area. The site requires extensive distribution lines to be constructed for connection to the power transmission network. The inclusion of renewable energy for generation on site, as well as supporting energy storage technologies such as batteries (short term) and diesel (long term) should be further considered and could provide both commercial and power reliability benefits to the project. Consideration of the grid constraints, reliability, and potential connection points are key considerations for determining the amount of solar PV (the most suitable technology for the site) and storage required

There are a number of potential environmental constraints identified at Lyndhurst that would likely require mitigation or management should the proposed NRWMF be further considered at the site. These include bushfire within in the landscape, localised or catchment flooding, slope erosion, and wind erosion or mass movement of sands from dunes/ sand ridges.

Groundwater in the water table aquifer is present at depths generally exceeding 10 m below ground surface across the site which would provide good separation between the base of any proposed NRWMF and groundwater. Water quality in the water table and bedrock aquifers is highly saline (similar to that of seawater) and is not considered suitable for any realistic beneficial use.

The seismic hazard level of the Lyndhurst site is low based on review and interpretation of seismic data indicating with a high-level confidence that potentially active faults in the foundation, near-surface faults beneath or near the foundation, and faults in the nearby area are not present (excluding the possibility of one-off faulting). The site is not expected to be subject to near-fault ground motions, so no special design issues or mitigation measures are expected to be necessary. Australian Standard AS1170.4 specifies design procedures that are appropriate for this site.

There are no threatened ecological communities within the Lyndhurst site and surrounds. Linear corridors of vegetation in good condition present along roadways, with only degraded vegetation present elsewhere within the site. If vegetation clearance is required for development of the NRWMF, then it will be important to conduct further targeted field surveys to determine likelihood and significance of any impacts on individual Commonwealth and State listed flora and fauna species that have the potential for occurrence in the local area.

The site is well served by major road networks with several local unsealed road access options. There is an absence of utilities, including potable water, power and communications, of appropriate capacity in the near vicinity of the site. Potable water and power will require pipelines and distribution lines, respectively, to be installed over large distances to connect with existing networks. Communications towers and possibly an in-ground fibre optic NBN cable from Kimba (once rolled out) would need to be constructed to connect to mobile phone and data communications. The inclusion of renewable energy for generation on site, as well as supporting energy storage technologies such as batteries (short term) and diesel (long term), would provide both commercial and power reliability benefits to the project.

IAEA (2015) provides a range of safety related criteria to be considered in the siting process including extreme meteorological events (e.g. high winds, bushfire, flooding, dust storms), geotechnical hazards (e.g. slope stability), seismic hazards which could result in in ground displacement (from surface faulting, subsidence or ground collapse), bushfire, transport considerations (access/ egress routes and access to emergency facilities) and risks from potential impacts of human activities (e.g. air traffic, mining or quarrying, surface transportation, other hazardous facilities). There are no site characteristics which have been identified with the potential to materially impact on the safety of site personnel and safe operation of the NRWMF. A hospital is located within Kimba, approximately 15 km drive south-west from the site. An aerodrome operated by the District Council of Kimba is located approximately 10 km south-west of the site, from which an air ambulance (Royal Flying Doctor Service) can provide medical evacuation to a major hospital in Adelaide.

The site is well separated from adversely affecting development and sensitive land uses. There are a number of mineral tenements in the local area with the closest being around 4 km away from the site, which if they proceed to development for extraction could have direct or indirect impact on the NRWMF and its enabling infrastructure.

In summary, there are no significant hazards of the site characteristics nor enabling infrastructure constraints identified to date which would preclude siting of the NRWMF at the Lyndhurst site.

The site characteristic and enabling infrastructure constraints can often be mitigated by the NRWMF and enabling infrastructure design processes (e.g. establishment of asset protection zone for bushfire risk and fire-fighting infrastructure, primary and alternative access/ egress routes). Potential design issues and mitigation measures that could be employed have been identified to address enabling infrastructure constraints and environmental hazards, or to protect environmental values. The Site Characterisation and NRWMF design works are running in parallel and will inform the other as the site selection process progresses. A detailed options assessment and concept design for the enabling infrastructure has also commenced.

A separate safety case document must be prepared as part of the license application to the regulator ARPANSA, prior to any approval for construction and operation of the NRWMF on the preferred site. The safety case will consider not only site characteristics with potential safety impacts, but also the NRWMF design and operational activity measures and mitigations employed to appropriately mitigate site characteristic hazards, and the transport, storage and disposal of radioactive wastes. A safety in design process will also need to be followed by the designer to address design requirements for safety of the site personnel.

A second stage of more detailed Site Characterisation studies will be conducted once a preferred site is selected by the responsible Minister. Assessment data gaps and recommendations for additional work scope items to fill such gaps have been provided for this second stage. The development of a robust conceptual site model and environmental dataset will support the development of a safety case for the NRWMF and applications for licensing and environmental approvals. Baseline conditions must also be established to enable future surveillance and monitoring during construction and operation of the NRWMF.

6.0

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6.2 Subsurface Environment

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- WaterConnect https://www.waterconnect.sa.gov.au/Pages/Home.aspx

  WaterConnect has the latest information about South Australia's water resources, providing direct access to water-related publications and data. Available lithological, depth to groundwater and hydrogeochemistry information in the vicinity of the site was interrogated using the map function. The site also provides links to technical reports for the groundwater management areas and these reports were reviewed to provide broader geological and hydrogeological context.

- South Australian Resources Information Geoserver (SARIG) https://map.sarig.sa.gov.au/

  SARIG is a secure online map based web application that delivers state wide geological and geospatial data. Available exploration drill hole data and historical mining tenements were identified using the map function. The site provides links to mining reports that contain further data that may provide context for sub-surface mineralogy and lithology in the vicinity of the subject site.

- Australian Soil Research Information System (ASRIS) http://www.asris.csiro.au/

  ASRIS provides online access to the best publicly available information on soil and land resources in a consistent format across Australia. Available soil data in the vicinity of the site was interrogated using the map function. Specific reference soil profiles and soil characterisation site information accessed from ASRIS is provided via links below.

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Appendix A

Flora, Fauna and Conservation

Australian Government
Department of the Environment and Energy

EPBC Act Protected Matters Report

This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected.

Information on the coverage of this report and qualifications on data supporting this report are contained in the caveat at the end of the report.

Information is available about Environment Assessments and the EPBC Act including significance guidelines, forms and application process details.

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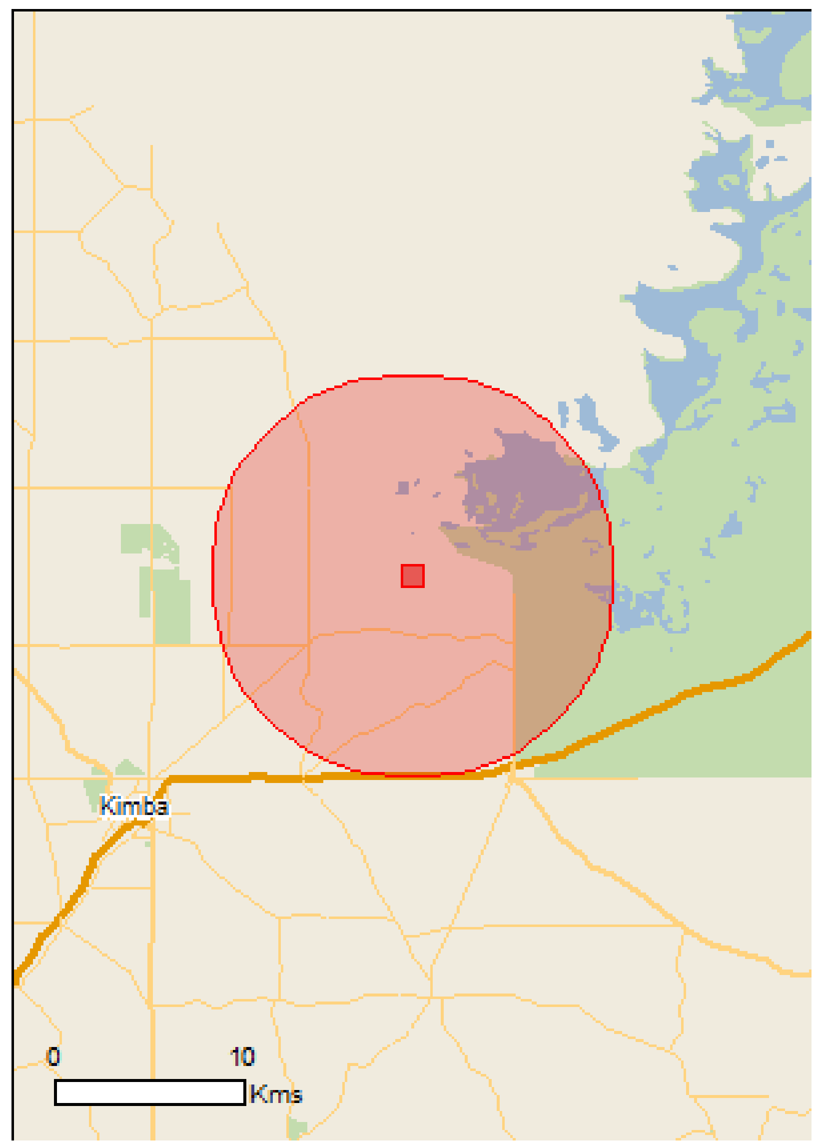

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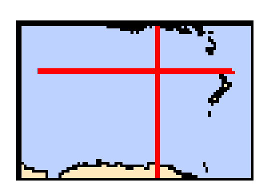

Summary

Matters of National Environmental Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the Administrative Guidelines on Significance.

World Heritage Properties:	None
National Heritage Places:	None
Wetlands of International Importance:	None
Great Barrier Reef Marine Park:	None
Commonwealth Marine Area:	None
Listed Threatened Ecological Communities:	None
Listed Threatened Species:	11
Listed Migratory Species:	10

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place. Information on the new heritage laws can be found at http://www.environment.gov.au/heritage

A permit may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species.

Commonwealth Land:	None
Commonwealth Heritage Places:	None
Listed Marine Species:	14
Whales and Other Cetaceans:	None
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Commonwealth Reserves Marine:	None

Extra Information

This part of the report provides information that may also be relevant to the area you have nominated.

State and Territory Reserves:	5
Regional Forest Agreements:	None
Invasive Species:	17
Nationally Important Wetlands:	None
Key Ecological Features (Marine)	None

Details

Matters of National Environmental Significance

Listed Threatened Species		[Resource Information]
Name	Status	Type of Presence
Birds		
Amytornis textilis myall Western Grasswren (Gawler Ranges) [64454]	Vulnerable	Species or species habitat known to occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
Leipoa ocellata Malleefowl [934]	Vulnerable	Species or species habitat known to occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area
Pedionomus torquatus Plains-wanderer [906]	Critically Endangered	Species or species habitat may occur within area
Pezoporus occidentalis Night Parrot [59350]	Endangered	Extinct within area
Mammals		
Sminthopsis psammophila Sandhill Dunnart [291]	Endangered	Species or species habitat likely to occur within area
Plants		
Acacia rhetinocarpa Neat Wattle, Resin Wattle (SA) [11282]	Vulnerable	Species or species habitat may occur within area
Caladenia tensa Greencomb Spider-orchid, Rigid Spider-orchid [24390]	Endangered	Species or species habitat likely to occur within area
Pterostylis mirabilis Nodding Rufoushood [86228]	Vulnerable	Species or species habitat known to occur within area
Swainsona pyrophila Yellow Swainson-pea [56344]	Vulnerable	Species or species habitat likely to occur within area

Listed Migratory Species		[Resource Information]
* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.		
Name	Threatened	Type of Presence
Migratory Marine Birds		

Name	Threatened	Type of Presence
Apus pacificus		
Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Migratory Terrestrial Species		
Motacilla cinerea		
Grey Wagtail [642]		Species or species habitat may occur within area
Motacilla flava		
Yellow Wagtail [644]		Species or species habitat may occur within area
Migratory Wetlands Species		
Actitis hypoleucos		
Common Sandpiper [59309]		Species or species habitat may occur within area
Calidris acuminata		
Sharp-tailed Sandpiper [874]		Species or species habitat may occur within area
Calidris ferruginea		
Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
Calidris melanotos		
Pectoral Sandpiper [858]		Species or species habitat may occur within area
Charadrius veredus		
Oriental Plover, Oriental Dotterel [882]		Species or species habitat may occur within area
Gallinago hardwickii		
Latham's Snipe, Japanese Snipe [863]		Species or species habitat may occur within area
Numenius madagascariensis		
Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area

Other Matters Protected by the EPBC Act

Listed Marine Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Birds		
Actitis hypoleucos		
Common Sandpiper [59309]		Species or species habitat may occur within area
Apus pacificus		
Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Ardea alba		
Great Egret, White Egret [59541]		Species or species habitat likely to occur within area
Ardea ibis		
Cattle Egret [59542]		Species or species habitat may occur within area
Calidris acuminata		
Sharp-tailed Sandpiper [874]		Species or species habitat may occur within

Name	Threatened	Type of Presence
		area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat may occur within area
Charadrius veredus Oriental Plover, Oriental Dotterel [882]		Species or species habitat may occur within area
Gallinago hardwickii Latham's Snipe, Japanese Snipe [863]		Species or species habitat may occur within area
Haliaeetus leucogaster White-bellied Sea-Eagle [943]		Species or species habitat may occur within area
Merops ornatus Rainbow Bee-eater [670]		Species or species habitat may occur within area
Motacilla cinerea Grey Wagtail [642]		Species or species habitat may occur within area
Motacilla flava Yellow Wagtail [644]		Species or species habitat may occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area

Extra Information

State and Territory Reserves [Resource Information]

Name	State
Lake Gilles	SA
Unnamed (No.HA1385)	SA
Unnamed (No.HA1501)	SA
Unnamed (No.HA472)	SA
Unnamed (No.HA610)	SA

Invasive Species [Resource Information]

Weeds reported here are the 20 species of national significance (WoNS), along with other introduced plants that are considered by the States and Territories to pose a particularly significant threat to biodiversity. The following feral animals are reported: Goat, Red Fox, Cat, Rabbit, Pig, Water Buffalo and Cane Toad. Maps from Landscape Health Project, National Land and Water Resouces Audit, 2001.

Name	Status	Type of Presence
Birds		
Columba livia Rock Pigeon, Rock Dove, Domestic Pigeon [803]		Species or species habitat likely to occur within area

Name	Status	Type of Presence
Passer domesticus House Sparrow [405]		Species or species habitat likely to occur within area
Streptopelia chinensis Spotted Turtle-Dove [780]		Species or species habitat likely to occur within area
Sturnus vulgaris Common Starling [389]		Species or species habitat likely to occur within area
Turdus merula Common Blackbird, Eurasian Blackbird [596]		Species or species habitat likely to occur within area
Mammals		
Bos taurus Domestic Cattle [16]		Species or species habitat likely to occur within area
Capra hircus Goat [2]		Species or species habitat likely to occur within area
Felis catus Cat, House Cat, Domestic Cat [19]		Species or species habitat likely to occur within area
Mus musculus House Mouse [120]		Species or species habitat likely to occur within area
Oryctolagus cuniculus Rabbit, European Rabbit [128]		Species or species habitat likely to occur within area
Vulpes vulpes Red Fox, Fox [18]		Species or species habitat likely to occur within area
Plants		
Asparagus asparagoides Bridal Creeper, Bridal Veil Creeper, Smilax, Florist's Smilax, Smilax Asparagus [22473]		Species or species habitat likely to occur within area
Carrichtera annua Ward's Weed [9511]		Species or species habitat likely to occur within area
Chrysanthemoides monilifera Bitou Bush, Boneseed [18983]		Species or species habitat may occur within area
Chrysanthemoides monilifera subsp. monilifera Boneseed [16905]		Species or species habitat likely to occur within area
Olea europaea Olive, Common Olive [9160]		Species or species habitat may occur within area
Rubus fruticosus aggregate Blackberry, European Blackberry [68406]		Species or species habitat likely to occur within area

Caveat
The information presented in this report has been provided by a range of data sources as acknowledged at the end of the report.

This report is designed to assist in identifying the locations of places which may be relevant in determining obligations under the Environment Protection and Biodiversity Conservation Act 1999. It holds mapped locations of World and National Heritage properties, Wetlands of International and National Importance, Commonwealth and State/Territory reserves, listed threatened, migratory and marine species and listed threatened ecological communities. Mapping of Commonwealth land is not complete at this stage. Maps have been collated from a range of sources at various resolutions.

Not all species listed under the EPBC Act have been mapped (see below) and therefore a report is a general guide only. Where available data supports mapping, the type of presence that can be determined from the data is indicated in general terms. People using this information in making a referral may need to consider the qualifications below and may need to seek and consider other information sources.

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Threatened, migratory and marine species distributions have been derived through a variety of methods. Where distributions are well known and if time permits, maps are derived using either thematic spatial data (i.e. vegetation, soils, geology, elevation, aspect, terrain, etc) together with point locations and described habitat; or environmental modelling (MAXENT or BIOCLIM habitat modelling) using point locations and environmental data layers.

Where very little information is available for species or large number of maps are required in a short time-frame, maps are derived either from 0.04 or 0.02 decimal degree cells; by an automated process using polygon capture techniques (static two kilometre grid cells, alpha-hull and convex hull); or captured manually or by using topographic features (national park boundaries, islands, etc). In the early stages of the distribution mapping process (1999-early 2000s) distributions were defined by degree blocks, 100K or 250K map sheets to rapidly create distribution maps. More reliable distribution mapping methods are used to update these distributions as time permits.

Only selected species covered by the following provisions of the EPBC Act have been mapped:

- migratory and
- marine

The following species and ecological communities have not been mapped and do not appear in reports produced from this database:

- threatened species listed as extinct or considered as vagrants
- some species and ecological communities that have only recently been listed
- some terrestrial species that overfly the Commonwealth marine area
- migratory species that are very widespread, vagrant, or only occur in small numbers

The following groups have been mapped, but may not cover the complete distribution of the species:

- non-threatened seabirds which have only been mapped for recorded breeding sites
- seals which have only been mapped for breeding sites near the Australian continent

Such breeding sites may be important for the protection of the Commonwealth Marine environment.

Coordinates

-33.039767 136.544839,-33.039839 136.544925,-33.039839 136.544925,-33.039695 136.555482,-33.048688 136.555396,-33.04876 136.545096,-33.039767 136.544839

Acknowledgements

This database has been compiled from a range of data sources. The department acknowledges the following custodians who have contributed valuable data and advice:

- -Office of Environment and Heritage, New South Wales
- -Department of Environment and Primary Industries, Victoria
- -Department of Primary Industries, Parks, Water and Environment, Tasmania
- -Department of Environment, Water and Natural Resources, South Australia
- -Department of Land and Resource Management, Northern Territory
- -Department of Environmental and Heritage Protection, Queensland
- -Department of Parks and Wildlife, Western Australia
- -Environment and Planning Directorate, ACT
- -Birdlife Australia
- -Australian Bird and Bat Banding Scheme
- -Australian National Wildlife Collection
- -Natural history museums of Australia
- -Museum Victoria
- -Australian Museum
- -South Australian Museum
- -Queensland Museum
- -Online Zoological Collections of Australian Museums
- -Queensland Herbarium
- -National Herbarium of NSW
- -Royal Botanic Gardens and National Herbarium of Victoria
- -Tasmanian Herbarium
- -State Herbarium of South Australia
- -Northern Territory Herbarium
- -Western Australian Herbarium
- -Australian National Herbarium, Canberra
- -University of New England
- -Ocean Biogeographic Information System
- -Australian Government, Department of Defence
- Forestry Corporation, NSW
- -Geoscience Australia
- -CSIRO
- -Australian Tropical Herbarium, Cairns
- -eBird Australia
- -Australian Government – Australian Antarctic Data Centre
- -Museum and Art Gallery of the Northern Territory
- -Australian Government National Environmental Science Program
- -Australian Institute of Marine Science
- -Reef Life Survey Australia
- -American Museum of Natural History
- -Queen Victoria Museum and Art Gallery, Inveresk, Tasmania
- -Tasmanian Museum and Art Gallery, Hobart, Tasmania
- -Other groups and individuals

The Department is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

Please feel free to provide feedback via the Contact Us page.

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Lyndhurst Flora Records

Native Plant Life form	
All strata of vegetation heavily impacted and native vegetation represented by only scattered plants	
All strata of vegetation impacted with limited structural diversity, largely uniform age classes and reduced vegetation cover	
At least one strata of vegetation has been impacted, with reduced structural diversity, elements may be missing (such as plant species that provide specific structural features e.g. sedges or mid layer shrubs) and reduce vegetation cover	X
Limited impacts on native vegetation, with a diversity of structural features and a varied age class, with only a minor loss in structurally diversity, vegetation cover or structural elements	
All strata of vegetation present, litlte or no sign of distrubance. A varity of life forms and assocaited age classes present. Vegetation cover near complete	

Regeneration	
No regeneration present	
Very low regeneration, conisting of highly scattered juvinille plants but a limited number of species	X
Regeneration present, consisting of multiple individual juvinelle plants but a limited number of species	
Multiple species regenerating, but low numbers of juvenile plants	
Multiple species regenerating with multiple individual juviniles present with varying age classes	

"Treeless in its natural state (refer to manual)? Y/N	N

Fallen Timber/debris (log size = that of canopy species (+ emergent species if present)				4.5
Log diameter	None	Limited and sparse	Numerous	Score
Trunk Size	0	2	3	0
Branch size	0	0.5	1	0.5
Litter	Little or none	Sparse and/or patchy littler layer	Dense and more or less continuous litter layer	Score
Litter	0	0.5	1	0.5

Native: Exotic Understorey Biomass	3
Included dead material if attached & recognisable as native	
% native	
76%+	3
40-75%	2
May-40	1
<5	0

Hollow-bearing Trees (sm hollows = <5cm, large hollows =>5cm)	1
None	0
Sm hollows only	1
Large +/- sm hollows in very small proportion of	2
Large +/- sm hollows scattered but not common	3
Large +/- sm hollows common in trees	4
Large +/- sm hollows in a large majority of trees	5

Tree Health (excl. long-dead trees)	5
<10% dieback	5
10-25% dieback, few braches dead	4
26-50% dieback,many braches dead	3
51-75% dieback, most branches dead +/- epicormic growth	2
76-99% dieback, most epicormic growth dead	1
100% dieback	0

Bare Ground	2
excludes soil crust, litter, exposed rock	
>51% of site bare ground	0
31-50% bare ground	1
21-30% bare ground	2
11-20% bare ground	3
5-10% bare ground	4
<5% bare ground	5

Bushland assessment for small sites (<0.5 ha) or narrow linear sites (<5m wide)

Weed Scores		Cover Rating	
Does the site contain plant species declared under the NRM Act 2004	0	Not many, cover <1%	1
		Plentiful, cover <1%	1a
Cover rating for all delcared weeds	0	Covering 1 - 5%	2
Does the site contain environmental weeds (introduced plants with the capacity to invade and exclude native species from bushland. This typically includes species with a BCM weed threat rating of 3, 4 or 5).	0	Covering 6 - 25%	3
		Covering 26 - 50%	4
		Covering 51 - 75%	5
Cover rating for all environmental weeds	0	Covering >75%	6

Vegetation Association Description:

Recorder/s: Floora de Wit

Native Plant Life form	
All strata of vegetation heavily impacted and native vegetation represented by only scattered plants	
All strata of vegetation impacted with limited structural diversity, largely uniform age classes and reduced vegetation cover	
At least one strata of vegetation has been impacted, with reduced structural diversity, elements may be missing (such as plant species that provide specific structural features e.g. sedges or mid layer shrubs) and reduce vegetation cover	X
Limited impacts on native vegetation, with a diversity of structural features and a varied age class, with only a minor loss in structurally diversity, vegetation cover or structural elements	
All strata of vegetation present, litlte or no sign of distrubance. A varity of life forms and assocaited age classes present. Vegetation cover near complete	

Regeneration	
No regeneration present	
Very low regeneration, conisting of highly scattered juvinille plants but a limited number of species	X
Regeneration present, consisting of multiple individual juvinelle plants but a limited number of species	
Multiple species regenerating, but low numbers of juvenile plants	
Multiple species regenerating with multiple individual juviniles present with varying age classes	

Bushland assessment for small sites (<0.5 ha) or narrow linear sites (<5m wide)

"Treeless in its natural state (refer to manual)? Y/N				N
Fallen Timber/debris (log size = that of canopy species (+ emergent species if present)				3.5
Log diameter	None	Limited and sparse	Numerous	Score
Trunk Size	0	2	3	2
Branch size	0	0.5	1	1
Litter	Little or none	Sparse and/or patchy littler layer	Dense and more or less continuous litter layer	Score
Litter	0	0.5	1	0.5

Native: Exotic Understorey Biomass	3
Included dead material if attached & recognisable as native	
% native	
76%+	3
40-75%	2
May-40	1
<5	0

Hollow-bearing Trees (sm hollows = <5cm, large hollows =>5cm)	0
None	0
Sm hollows only	1
Large +/- sm hollows in very small proportion of	2
Large +/- sm hollows scattered but not common	3
Large +/- sm hollows common in trees	4
Large +/- sm hollows in a large majority of trees	5

Tree Health (excl. long-dead trees)	5
<10% dieback	5
10-25% dieback, few braches dead	4
26-50% dieback,many braches dead	3
51-75% dieback, most branches dead +/- epicormic growth	2
76-99% dieback, most epicormic growth dead	1
100% dieback	0

Bare Ground	2
excludes soil crust, litter, exposed rock	
>51% of site bare ground	0
31-50% bare ground	1
21-30% bare ground	2
11-20% bare ground	3
5-10% bare ground	4
<5% bare ground	5

Weed Scores	
Does the site contain plant species declared under the NRM Act 2004	0
Cover rating for all delcared weeds	0
Does the site contain environmental weeds (introduced plants with the capacity to invade and exclude native species from bushland. This typically includes species with a BCM weed threat rating of 3, 4 or 5).	0
Cover rating for all environmental weeds	0

Cover Rating	
Not many, cover <1%	1
Plentiful, cover <1%	1a
Covering 1 - 5%	2
Covering 6 - 25%	3
Covering 26 - 50%	4
Covering 51 - 75%	5
Covering >75%	6

Vegetation Association Description:

Recorder/s: Floora de Wit

Bushland Assessment	Site	Lyn 2		Date:	17-Apr-18	Zone	
	Datum	GDA	E:	645087	N: 6343351	Ph dir'n:	

d=dominant, v=voucher, p=planted, R=regen (perennials).

Native spp.	Ht (cm)	Cover (%)				Weed spp.	Ht (cm)	Cover (%)
Acacia nyssophylla	200	0.5						
Acacia acanthoclada ssp. acanthoclada	50	0.1						
Acacia rigens	200	0.1						
Acacia hakeoides	300	4						
Callitris gracilis	300	1						
Dianella revoluta	30	0.1						
Enchylaena tomentosa var. tomentosa	50	0.2						
Enneapogon avenaceus	20	1						
Eucalyptus incrassata	600	8						
Eucalyptus socialis subsp. viridans	400	15						
Bertya tasmanica subsp. vestita	200	0.2						
Lomandra leucocephala subsp. robusta	30	1						
Amphipogon caricinus var. caricinus	30	5						
Scaevola spinescens	30	0.1						
Senna artemisioides subsp. zygophylla	20	0.1						
Solanum coactiliferum	20	0.1						
Eremophila crassifolia	20	0.1						
Westringia rigida	30	0.2						
Triodia ?irritans	50	15						

Native Plant Life form	
All strata of vegetation heavily impacted and native vegetation represented by only scattered plants	
All strata of vegetation impacted with limited structural diversity, largely uniform age classes and reduced vegetation cover	
At least one strata of vegetation has been impacted, with reduced structural diversity, elements may be missing (such as plant species that provide specific structural features e.g. sedges or mid layer shrubs) and reduce vegetation cover	X
Limited impacts on native vegetation, with a diversity of structural features and a varied age class, with only a minor loss in structurally diversity, vegetation cover or structural elements	
All strata of vegetation present, litlte or no sign of distrubance. A varity of life forms and assocaited age classes present. Vegetation cover near complete	

Regeneration	
No regeneration present	X
Very low regeneration, conisting of highly scattered juvinille plants but a limited number of species	
Regeneration present, consisting of multiple individual juvinelle plants but a limited number of species	
Multiple species regenerating, but low numbers of juvenile plants	
Multiple species regenerating with multiple individual juviniles present with varying age classes	

"Treeless in its natural state (refer to manual)? Y/N				N
Fallen Timber/debris (log size = that of canopy species (+ emergent species if present)				1
Log diameter	None	Limited and sparse	Numerous	Score
Trunk Size	0	2	3	0
Branch size	0	0.5	1	0.5
Litter	Little or none	Sparse and/or patchy littler layer	Dense and more or less continuous litter layer	Score
Litter	0	0.5	1	0.5

Native: Exotic Understorey Biomass	3
Included dead material if attached & recognisable as native	
% native	
76%+	3
40-75%	2
May-40	1
<5	0

Hollow-bearing Trees (sm hollows = <5cm, large hollows =>5cm)	0
None	0
Sm hollows only	1
Large +/- sm hollows in very small proportion of	2
Large +/- sm hollows scattered but not common	3
Large +/- sm hollows common in trees	4
Large +/- sm hollows in a large majority of trees	5

Tree Health (excl. long-dead trees)	5
<10% dieback	5
10-25% dieback, few braches dead	4
26-50% dieback,many braches dead	3
51-75% dieback, most branches dead +/- epicormic growth	2
76-99% dieback, most epicormic growth dead	1
100% dieback	0

Bare Ground	2
excludes soil crust, litter, exposed rock	
>51% of site bare ground	0
31-50% bare ground	1
21-30% bare ground	2
11-20% bare ground	3
5-10% bare ground	4
<5% bare ground	5

Bushland assessment for small sites (<0.5 ha) or narrow linear sites (<5m wide)

Weed Scores	
Does the site contain plant species declared under the NRM Act 2004	0
Cover rating for all delcared weeds	0
Does the site contain environmental weeds (introduced plants with the capacity to invade and exclude native species from bushland. This typically includes species with a BCM weed threat rating of 3, 4 or 5).	0
Cover rating for all environmental weeds	0

Cover Rating	
Not many, cover <1%	1
Plentiful, cover <1%	1a
Covering 1 - 5%	2
Covering 6 - 25%	3
Covering 26 - 50%	4
Covering 51 - 75%	5
Covering >75%	6

Vegetation Association Description:

Recorder/s: Floora de Wit

Bushland Assessment	Site	Lyn 3		Date:		17-Apr-18	Zone	
	Datum	GDA	E:	644733	N:	6342366	Ph dir'n:	

d=dominant, v=voucher, p=planted, R=regen (perennials).

Native spp.	Ht (cm)	Cover (%)				Weed spp.	Ht (cm)	Cover (%)
Acacia nyssophylla	50	0.1				Asphodelus fistulosus	30	0.1
Eucalyptus socialis subsp. viridans	600	15						
Eucalyptus gracilis	400	2						
Eucalyptus gracilis	500	2						
Lomandra leucocephala subsp. robusta	30	5						
Melaleuca acuminata subsp. acuminata	250	1						
Melaleuca lanceolata	250	2						
Gramineae sp.	40	1						
Asphodelus fistulosus	30	0.1						
Triodia ?irritans	50	1						

Native Plant Life form	
All strata of vegetation heavily impacted and native vegetation represented by only scattered plants	
All strata of vegetation impacted with limited structural diversity, largely uniform age classes and reduced vegetation cover	
At least one strata of vegetation has been impacted, with reduced structural diversity, elements may be missing (such as plant species that provide specific structural features e.g. sedges or mid layer shrubs) and reduce vegetation cover	
Limited impacts on native vegetation, with a diversity of structural features and a varied age class, with only a minor loss in structurally diversity, vegetation cover or structural elements	
All strata of vegetation present, litlte or no sign of distrubance. A varity of life forms and assocaited age classes present. Vegetation cover near complete	X

Regeneration	
No regeneration present	
Very low regeneration, conisting of highly scattered juvinille plants but a limited number of species	
Regeneration present, consisting of multiple individual juvinelle plants but a limited number of species	X
Multiple species regenerating, but low numbers of juvenile plants	
Multiple species regenerating with multiple individual juviniles present with varying age classes	

Bushland assessment for small sites (<0.5 ha) or narrow linear sites (<5m wide)

"Treeless in its natural state (refer to manual)? Y/N	N

Fallen Timber/debris (log size = that of canopy species (+ emergent species if present)				4.5
Log diameter	None	Limited and sparse	Numerous	Score
Trunk Size	0	2	3	3
Branch size	0	0.5	1	1
Litter	Little or none	Sparse and/or patchy littler layer	Dense and more or less continuous litter layer	Score
Litter	0	0.5	1	0.5

Native: Exotic Understorey Biomass	3
Included dead material if attached & recognisable as native	
% native	
76%+	3
40-75%	2
May-40	1
<5	0

Hollow-bearing Trees (sm hollows = <5cm, large hollows =>5cm)	1
None	0
Sm hollows only	1
Large +/- sm hollows in very small proportion of	2
Large +/- sm hollows scattered but not common	3
Large +/- sm hollows common in trees	4
Large +/- sm hollows in a large majority of trees	5

Tree Health (excl. long-dead trees)	5
<10% dieback	5
10-25% dieback, few braches dead	4
26-50% dieback,many braches dead	3
51-75% dieback, most branches dead +/- epicormic growth	2
76-99% dieback, most epicormic growth dead	1
100% dieback	0

Bare Ground	4
excludes soil crust, litter, exposed rock	
>51% of site bare ground	0
31-50% bare ground	1
21-30% bare ground	2
11-20% bare ground	3
5-10% bare ground	4
<5% bare ground	5

Weed Scores	
Does the site contain plant species declared under the NRM Act 2004	0
Cover rating for all delcared weeds	0
Does the site contain environmental weeds (introduced plants with the capacity to invade and exclude native species from bushland. This typically includes species with a BCM weed threat rating of 3, 4 or 5).	0
Cover rating for all environmental weeds	0

Cover Rating	
Not many, cover <1%	1
Plentiful, cover <1%	1a
Covering 1 - 5%	2
Covering 6 - 25%	3
Covering 26 - 50%	4
Covering 51 - 75%	5
Covering >75%	6

Vegetation Association Description:

Recorder/s: Floora de Wit

Bushland Assessment	Site	Lyn 4		Date:		18-Apr-18	Zone	
	Datum	GDA	E:	644229	N:	6343282	Ph dir'n:	

d=dominant, v=voucher, p=planted, R=regen (perennials).

Native spp.						**Weed spp.**		
	Ht (cm)	Cover (%)					Ht (cm)	Cover (%)
Acacia merrallii	40	1						
Cratystylis conocephala	40	0.2						
Dianella revoluta	30	0.1						
Eremophila deserti	50	1						
Eremophila scoparia	60	5						
Eucalyptus brachycalyx	600	1						
Eucalyptus socialis	500	20						
Eucalyptus gracilis	600	5						
Eucalyptus porosa	700	2						
Beyeria opaca	30	0.1						
Microcybe multiflora subsp. multiflora	50	1						
Lomandra leucocephala subsp. robusta	20	0.1						
Maireana erioclada	20	0.1						
Maireana sp.	10	0.01						
Maireana georgei	10	0.1						
Maireana radiata								
Olearia muelleri	40	4						
Halgania andromedifolia	40	0.5						
Gramineae sp.	10	0.1						
Sclerolaena brevifolia	10	0.1						
Triodia ?irritans	30	0.1						
Westringia rigida	30	4						

Native Plant Life form	
All strata of vegetation heavily impacted and native vegetation represented by only scattered plants	
All strata of vegetation impacted with limited structural diversity, largely uniform age classes and reduced vegetation cover	
At least one strata of vegetation has been impacted, with reduced structural diversity, elements may be missing (such as plant species that provide specific structural features e.g. sedges or mid layer shrubs) and reduce vegetation cover	X
Limited impacts on native vegetation, with a diversity of structural features and a varied age class, with only a minor loss in structurally diversity, vegetation cover or structural elements	
All strata of vegetation present, litlte or no sign of distrubance. A varity of life forms and assocaited age classes present. Vegetation cover near complete	

Regeneration	
No regeneration present	
Very low regeneration, conisting of highly scattered juvinille plants but a limited number of species	X
Regeneration present, consisting of multiple individual juvinelle plants but a limited number of species	
Multiple species regenerating, but low numbers of juvenile plants	
Multiple species regenerating with multiple individual juviniles present with varying age classes	

"Treeless in its natural state (refer to manual)? Y/N	N

Fallen Timber/debris (log size = that of canopy species (+ emergent species if present)				3.5
Log diameter	None	Limited and sparse	Numerous	Score
Trunk Size	0	2	3	2
Branch size	0	0.5	1	1
Litter	Little or none	Sparse and/or patchy littler layer	Dense and more or less continuous litter layer	Score
Litter	0	0.5	1	0.5

Native: Exotic Understorey Biomass	3
Included dead material if attached & recognisable as native	
% native	
76%+	3
40-75%	2
May-40	1
<5	0

Hollow-bearing Trees (sm hollows = <5cm, large hollows =>5cm)	1
None	0
Sm hollows only	1
Large +/- sm hollows in very small proportion of	2
Large +/- sm hollows scattered but not common	3
Large +/- sm hollows common in trees	4
Large +/- sm hollows in a large majority of trees	5

Tree Health (excl. long-dead trees)	3
<10% dieback	5
10-25% dieback, few braches dead	4
26-50% dieback,many braches dead	3
51-75% dieback, most branches dead +/- epicormic growth	2
76-99% dieback, most epicormic growth dead	1
100% dieback	0

Bare Ground	2
excludes soil crust, litter, exposed rock	
>51% of site bare ground	0
31-50% bare ground	1
21-30% bare ground	2
11-20% bare ground	3
5-10% bare ground	4
<5% bare ground	5

Bushland assessment for small sites (<0.5 ha) or narrow linear sites (<5m wide)

Weed Scores	
Does the site contain plant species declared under the NRM Act 2004	0
Cover rating for all delcared weeds	0
Does the site contain environmental weeds (introduced plants with the capacity to invade and exclude native species from bushland. This typically includes species with a BCM weed threat rating of 3, 4 or 5).	0
Cover rating for all environmental weeds	0

Cover Rating	
Not many, cover <1%	1
Plentiful, cover <1%	1a
Covering 1 - 5%	2
Covering 6 - 25%	3
Covering 26 - 50%	4
Covering 51 - 75%	5
Covering >75%	6

Vegetation Association Description:

Recorder/s: Floora de Wit

Bushland Assessment	Site	Lyn 5		Date:		18-Apr-18	Zone	
	Datum	GDA	E:	644608	N:	6344466	Ph dir'n:	

d=dominant, v=voucher, p=planted, R=regen (perennials).

Native spp.	Ht (cm)	Cover (%)				Weed spp.	Ht (cm)	Cover (%)
Atriplex stipitata	50	8						
Cratystylis conocephala	50	0.1						
Enchylaena tomentosa var. tomentosa	20	4						
Enneapogon avenaceus	15	0.1						
Eremophila deserti	150	0.2						
Eucalyptus gracilis	500	4						
Eucalyptus leptophylla	500	15						
Lomandra leucocephala subsp. robusta	20	0.1						
Maireana georgei	20	0.1						
Melaleuca acuminata subsp. acuminata	300	2						
Rhagodia crassifolia	40	0.1						
Rhagodia preissii subsp. preissii	60	0.2						
Gramineae sp.	2	0.1						
Sclerolaena brevifolia	10	0.5						
Solanum coactiliferum	20	0.1						
Triodia ?irritans	40	2						

Native Plant Life form	
All strata of vegetation heavily impacted and native vegetation represented by only scattered plants	
All strata of vegetation impacted with limited structural diversity, largely uniform age classes and reduced vegetation cover	
At least one strata of vegetation has been impacted, with reduced structural diversity, elements may be missing (such as plant species that provide specific structural features e.g. sedges or mid layer shrubs) and reduce vegetation cover	X
Limited impacts on native vegetation, with a diversity of structural features and a varied age class, with only a minor loss in structurally diversity, vegetation cover or structural elements	
All strata of vegetation present, litlte or no sign of distrubance. A varity of life forms and assocaited age classes present. Vegetation cover near complete	

Regeneration	
No regeneration present	X
Very low regeneration, conisting of highly scattered juvinille plants but a limited number of species	
Regeneration present, consisting of multiple individual juvinelle plants but a limited number of species	
Multiple species regenerating, but low numbers of juvenile plants	
Multiple species regenerating with multiple individual juviniles present with varying age classes	

"Treeless in its natural state (refer to manual)? Y/N				N
Fallen Timber/debris (log size = that of canopy species (+ emergent species if present)				4
Log diameter	None	Limited and sparse	Numerous	Score
Trunk Size	0	2	3	2
Branch size	0	0.5	1	1
Litter	Little or none	Sparse and/or patchy littler layer	Dense and more or less continuous litter layer	Score
Litter	0	0.5	1	1

Native: Exotic Understorey Biomass	2
Included dead material if attached & recognisable as native	
% native	
76%+	3
40-75%	2
May-40	1
<5	0

Hollow-bearing Trees (sm hollows = <5cm, large hollows =>5cm)	0
None	0
Sm hollows only	1
Large +/- sm hollows in very small proportion of	2
Large +/- sm hollows scattered but not common	3
Large +/- sm hollows common in trees	4
Large +/- sm hollows in a large majority of trees	5

Tree Health (excl. long-dead trees)	3
<10% dieback	5
10-25% dieback, few braches dead	4
26-50% dieback,many braches dead	3
51-75% dieback, most branches dead +/- epicormic growth	2
76-99% dieback, most epicormic growth dead	1
100% dieback	0

Bare Ground	2
excludes soil crust, litter, exposed rock	
>51% of site bare ground	0
31-50% bare ground	1
21-30% bare ground	2
11-20% bare ground	3
5-10% bare ground	4
<5% bare ground	5

Bushland assessment for small sites (<0.5 ha) or narrow linear sites (<5m wide)

Weed Scores	
Does the site contain plant species declared under the NRM Act 2004	0
Cover rating for all delcared weeds	0
Does the site contain environmental weeds (introduced plants with the capacity to invade and exclude native species from bushland. This typically includes species with a BCM weed threat rating of 3, 4 or 5).	0
Cover rating for all environmental weeds	0

Cover Rating	
Not many, cover <1%	1
Plentiful, cover <1%	1a
Covering 1 - 5%	2
Covering 6 - 25%	3
Covering 26 - 50%	4
Covering 51 - 75%	5
Covering >75%	6

Vegetation Association Description:

Recorder/s: Floora de Wit

Bushland Assessment	Site	Lyn 6		Date:	18-Apr-18		Zone	
	Datum	GDA	E:	644811	N:	6342874	Ph dir'n:	

d=dominant, v=voucher, p=planted, R=regen (perennials).

Native spp.	Ht (cm)	Cover (%)				Weed spp.	Ht (cm)	Cover (%)
Callitris gracilis	300	15						
Dianella revoluta	40	0.1						
Enchylaena tomentosa var. tomentosa	20	1.5						
Eucalyptus incrassata	600	0.2						
Rhagodia spinescens	30	0.5						
Triodia sp.	40	0.5						
Gramineae sp.	50	0.5						

Native Plant Life form	
All strata of vegetation heavily impacted and native vegetation represented by only scattered plants	
All strata of vegetation impacted with limited structural diversity, largely uniform age classes and reduced vegetation cover	
At least one strata of vegetation has been impacted, with reduced structural diversity, elements may be missing (such as plant species that provide specific structural features e.g. sedges or mid layer shrubs) and reduce vegetation cover	X
Limited impacts on native vegetation, with a diversity of structural features and a varied age class, with only a minor loss in structurally diversity, vegetation cover or structural elements	
All strata of vegetation present, litlte or no sign of distrubance. A varity of life forms and assocaited age classes present. Vegetation cover near complete	

"Treeless in its natural state (refer to manual)? Y/N				N
Fallen Timber/debris (log size = that of canopy species (+ emergent species if present)				2.5
Log diameter	None	Limited and sparse	Numerous	Score
Trunk Size	0	2	3	2
Branch size	0	0.5	1	0.5
Litter	Little or none	Sparse and/or patchy littler layer	Dense and more or less continuous litter layer	Score
Litter	0	0.5	1	0

Native: Exotic Understorey Biomass	3
Included dead material if attached & recognisable as native	
% native	
76%+	3
40-75%	2
May-40	1
<5	0

Regeneration	
No regeneration present	
Very low regeneration, conisting of highly scattered juvinille plants but a limited number of species	X
Regeneration present, consisting of multiple individual juvinelle plants but a limited number of species	
Multiple species regenerating, but low numbers of juvenile plants	
Multiple species regenerating with multiple individual juviniles present with varying age classes	

Hollow-bearing Trees (sm hollows = <5cm, large hollows =>5cm)	0
None	0
Sm hollows only	1
Large +/- sm hollows in very small proportion of trees	2
Large +/- sm hollows scattered but not common	3
Large +/- sm hollows common in trees	4
Large +/- sm hollows in a large majority of trees	5

Tree Health (excl. long-dead trees)	3
<10% dieback	5
10-25% dieback, few braches dead	4
26-50% dieback,many braches dead	3
51-75% dieback, most branches dead +/- epicormic growth	2
76-99% dieback, most epicormic growth dead	1
100% dieback	0

Bare Ground	0
excludes soil crust, litter, exposed rock	
>51% of site bare ground	0
31-50% bare ground	1
21-30% bare ground	2
11-20% bare ground	3
5-10% bare ground	4
<5% bare ground	5

Bushland assessment for small sites (<0.5 ha) or narrow linear sites (<5m wide)

Weed Scores		Cover Rating	
Does the site contain plant species declared under the NRM Act 2004	0	Not many, cover <1%	1
		Plentiful, cover <1%	1a
Cover rating for all delcared weeds	0	Covering 1 - 5%	2
Does the site contain environmental weeds (introduced plants with the capacity to invade and exclude native species from bushland. This typically includes species with a BCM weed threat rating of 3, 4 or 5).	0	Covering 6 - 25%	3
		Covering 26 - 50%	4
		Covering 51 - 75%	5
Cover rating for all environmental weeds	0	Covering >75%	6

Vegetation Association Description:

Recorder/s: Floora de Wit

Bushland Assessment	Site	Lyn 7		Date:	18-Apr-18		Zone	
	Datum	GDA	E:	644736	N:	6344527	Ph dir'n:	

d=dominant, v=voucher, p=planted, R=regen (perennials).

Native spp.	Ht (cm)	Cover (%)				Weed spp.	Ht (cm)	Cover (%)
Compositae sp. (dead)	30	0.01						
Atriplex vesicaria	30	1						
Eucalyptus sp.	500	0.1						
Maireana astrotricha	10	1						
Gramineae sp.	1	0.1						
Tecticornia halocnemoides	40	6						
Tecticornia indica	40	8						
Tecticornia pergranulata								

Appendix B

Climatic Conditions and Climate Change

Appendix B Climatic Conditions and Climate Change

Climate Data: Kimba Weather Station and SSW Flatlands NRM

Variable	Annual historic trend	Climate change projections	RCP 8.5 2030 scenario		RCP 4.5 2090 Scenario		RCP 8.5 2090 scenario	
Weather station: Kimba			Most likely – 50th percentile (10th- 90th percentile)	Degree of confidence	Most likely – 50th percentile (10th- 90th percentile)	Degree of confidence	Most likely – 50th percentile (10th- 90th percentile)	Degree of confidence
Mean maximum daily temperature (°C) [1]	23.6	Absolute change	+0.8 (+0.6 to +1.2)	Very high model agreement on substantial increase	+1.6 (+1.1 to +2.2)	Very high model agreement on substantial increase	+3.3 (+2.6 to +4.1)	Very high model agreement on substantial increase
Mean minimum daily temperature (°C) [1]	10.3	Absolute change	+0.7 (+0.5 to +1.1)	Very high model agreement on substantial increase	+1.4 (+1 to +1.9)	Very high model agreement on substantial increase	+2.9 (+2.3 to +3.7)	Very high model agreement on substantial increase
Days above 35 °C (Adelaide)[2]	20 (1995 baseline)	Absolute change	26 (24 to 29 (RCP 4.5)	Very high confidence that projected warming will result in more frequent, and hotter, hot days	32 (29 to 38)	Very high confidence that projected warming will result in more frequent, and hotter, hot days	47 (38 to 57)	Very high confidence that projected warming will result in more frequent, and hotter, hot days

Variable	Annual historic trend	Climate change projections	RCP 8.5 2030 scenario		RCP 4.5 2090 Scenario		RCP 8.5 2090 scenario	
Weather station: Kimba			Most likely – 50th percentile (10th- 90th percentile)	Degree of confidence	Most likely – 50th percentile (10th- 90th percentile)	Degree of confidence	Most likely – 50th percentile (10th- 90th percentile)	Degree of confidence
Highest recorded temperature (°C) [3]	46 (Jan 2013)	N/A	Heat related extremes are projected to increase at a similar rate as projected mean temperature with a substantial increase in the number of warm spell days					
Frost (days with min. temp. <2 °C) (Adelaide / Alice Springs)[4]	1.1 / 3.3 (1981-2010 baseline)	Absolute change	0.5 (0.8 to 0.4) / 24 (28 to 19) (RCP 4.5)	High confidence in a substantial decrease	0.2 (0.4 to 0.1) / 13 (20 to 8.4)	High confidence in a substantial decrease	0.0 (0.0 to 0.0) / 2.1 (6.0 to 0.8)	High confidence in a substantial decrease
Severe fire danger days per year (FFDI > 50) (Ceduna)[5]	11.1 (1995 baseline)	Absolute change	11.4 to 13	High confidence that climate change will result in harsher fire weather; low confidence in magnitude of change	12.4 to 13.1	High confidence that climate change will result in harsher fire weather; low confidence in magnitude of change	12.1 to 15.6	High confidence that climate change will result in harsher fire weather; low confidence in magnitude of change
Rainfall (mm) [1]	348.3	Percentage change	-2 (-13 to +5)	Medium model agreement on little change	-7 (-18 to +3)	High model agreement on substantial decrease	-9 (-37 to +6)	Medium model agreement on substantial decrease
Rainfall intensity [6]	N/A	N/A	There is a high confidence that intensity of heavy rainfall events will increase in the SSW Flatlands cluster, but there is low confidence in the magnitude of change					
Evapotranspiration (%) [1]	N/A	Percentage change	+3 (+2.1 to +4.5)	Very high model agreement on substantial increase	+5.1 (+3.4 to +7.3)	Very high model agreement on substantial increase	+10.2 (+7.4 to +15.7)	Very high model agreement on substantial increase

Variable	Annual historic trend	Climate change projections	RCP 8.5 2030 scenario		RCP 4.5 2090 Scenario		RCP 8.5 2090 scenario	
Weather station: Kimba			Most likely – 50th percentile (10th- 90th percentile)	Degree of confidence	Most likely – 50th percentile (10th- 90th percentile)	Degree of confidence	Most likely – 50th percentile (10th- 90th percentile)	Degree of confidence
Mean 9 am relative humidity (%) [1]	55	Percentage change	-0.5 (-1.1 to 0.3)	High model agreement on little change	-0.8 (-2 to -0.1)	Medium model agreement on little change	-1.6 (-3.2 to -0.3)	High model agreement on substantial decrease
Mean 3 pm relative humidity (%) [1]	30	Percentage change						
Mean 9 am wind speed (km/h) [1]	20.3	Percentage change	-0.5 (-3.1 to +0.7)	High model agreement on little change	-1.4 (-3.8 to +0.1)	Medium model agreement on substantial decrease	-1.8 (-4.4 to 0)	Medium model agreement on substantial decrease
Mean 3 pm wind speed (km/h) [1]	12.8	Percentage change						
Solar radiation (%) [1]	N/A	Percentage change	+0.5 (-0.5 to +1.4)	Medium model agreement on little change	+1.1 (+0.1 to +2.3)	Medium model agreement on substantial increase	+1.5 (-0.1 to +3.6)	Medium model agreement on substantial increase
Soil moisture (%) [1]	N/A	Percentage change	-1.3 (-4.7 to +0)	Medium model agreement on substantial decrease	-1.8 (-5.6 to +1)	Medium model agreement on substantial decrease	-4.4 (-8.7 to -0.9)	High model agreement on substantial decrease

[1] Projection data obtained from Climate Change in Southern and South Western Flatlands, Hope, P. et al. 2015 Figures obtained from Appendix, Table 1 Eastern Sub Cluster.

[2] Projection data obtained from Climate Change in Australia Technical Report, Table 7.1.2 (projection for Adelaide), CSIRO & BOM 2015. Confidence statement sourced from p95.

[3.] Qualitative projection analysis obtained from Climate Change in Australia Southern and South Western Flatlands, Chapter 4, Section 4.2.1 Extremes (p22), Hope, P. et al. 2015.

[4] Projection data obtained from Climate Change in Australia Technical Report, Table 7.1.3 (projections for Adelaide and Alice Springs), CSIRO & BOM 2015.

[5] Baseline and projection data obtained from Climate Change in Australia Southern and South Western Flatlands Cluster Report, Hope, P. et al. 2015. Figures obtained from Appendix Table 2. Fire weather is estimated using the McArthur Forest Fire Danger Index (FFDI); where FFDI exceeds 50, fire weather is deemed ‘severe’.

[6] Qualitative projection analysis obtained from Climate Change in Australia Southern and South Western Flatlands, Chapter 4, Section 4.4.1 Heavy Rainfall Events, Hope, P. et al. 2015.

Climate Data: Nonning Weather Station and Rangelands NRM

Variable	Annual historic trend	Climate change projections	RCP 8.5 2030 scenario		RCP 4.5 2090 Scenario		RCP 8.5 2090 scenario	
Weather station: Nonning			Most likely – 50th percentile (10th- 90th percentile)	Degree of confidence	Most likely – 50th percentile (10th- 90th percentile)	Degree of confidence	Most likely – 50th percentile (10th- 90th percentile)	Degree of confidence
Mean maximum daily temperature (°C) [1]	24.9	Absolute change	+1.1 (+0.7 to +1.4)	Very high model agreement on substantial increase	+2.2 (+1.2 to +2.8)	Very high model agreement on substantial increase	+4.3 (+2.8 to +5.2)	Very high model agreement on substantial increase
Mean minimum daily temperature (°C) [1]	10.2	Absolute change	+1 (+0.6 to +1.3)	Very high model agreement on substantial increase	+1.8 (+1.2 to +2.4)	Very high model agreement on substantial increase	+3.8 (+3 to +4.6)	Very high model agreement on substantial increase
Days above 35 °C (Adelaide)[2]	20 (1995 baseline)	Absolute change	26 (24 to 29 (RCP 4.5)	Very high confidence that projected warming will result in more frequent, and hotter, hot days	32 (29 to 38)	Very high confidence that projected warming will result in more frequent, and hotter, hot days	47 (38 to 57)	Very high confidence that projected warming will result in more frequent, and hotter, hot days
Highest recorded temperature (°C) [3]	Not known	N/A	Heat related extremes are projected to increase at a similar rate as projected mean temperature with a substantial increase in the number of warm spell days					

Variable	Annual historic trend	Climate change projections	RCP 8.5 2030 scenario		RCP 4.5 2090 Scenario		RCP 8.5 2090 scenario	
Weather station: Nonning			Most likely – 50th percentile (10th- 90th percentile)	Degree of confidence	Most likely – 50th percentile (10th- 90th percentile)	Degree of confidence	Most likely – 50th percentile (10th- 90th percentile)	Degree of confidence
Frost (days with min. temp. <2 °C) (Adelaide / Alice Springs)[4]	1.1 / 3.3 (1981-2010 baseline)	Absolute change	0.5 (0.8 to 0.4) / 24 (28 to 19) (RCP 4.5)	High confidence in a substantial decrease	0.2 (0.4 to 0.1) / 13 (20 to 8.4)	High confidence in a substantial decrease	0.0 (0.0 to 0.0) / 2.1 (6.0 to 0.8)	High confidence in a substantial decrease
Severe fire danger days per year (FFDI > 50) (Woomera) [5]	17.7 (1995 baseline)	Absolute change	19.1 to 25.2	Low confidence in the projections of future fire weather for the Rangelands, however if and when bushfire does occur in future climates it can be expected to exhibit more extreme behaviour.	21.0 to 25.2	Low confidence in the projections of future fire weather for the Rangelands, however if and when bushfire does occur in future climates it can be expected to exhibit more extreme behaviour.	21.1 to 37.9	Low confidence in the projections of future fire weather for the Rangelands, however if and when bushfire does occur in future climates it can be expected to exhibit more extreme behaviour.

Variable	Annual historic trend	Climate change projections	RCP 8.5 2030 scenario		RCP 4.5 2090 Scenario		RCP 8.5 2090 scenario	
Weather station: Nonning			Most likely – 50th percentile (10th- 90th percentile)	Degree of confidence	Most likely – 50th percentile (10th- 90th percentile)	Degree of confidence	Most likely – 50th percentile (10th- 90th percentile)	Degree of confidence
Rainfall (mm) [1]	248	Percentage change	-2 (-10 to +8)	High model agreement on little change	- 5 (-19 to +7)	Medium model agreement on little change	-4 (-29 to +13)	Medium agreement on decrease
Rainfall intensity [6]	N/A	N/A	There is high confidence that the intensity of heavy rainfall extremes will increase in the cluster, but there is low confidence in the magnitude of this change.					
Evapotranspiration (%) [1]	N/A	Percentage change	+2.7 (+1.1 to +4.8)	Very high model agreement on substantial increase	+4.7 (+2.6 to +7.1)	Very high model agreement on substantial increase	+10.5 (+6.4 to +14.5)	Very high model agreement on substantial increase
Mean 9 am relative humidity (%) [1]	64	Percentage change	-0.8 (-1.8 to +0.8)	Medium model agreement on little change	-1.6 (-3.7 to +0.3)	Medium model agreement on substantial decrease	-2.6 (-5.1 to +0.4)	High model agreement on substantial decrease
Mean 3 pm relative humidity (%) [1]	35	Percentage change						
Mean 9 am wind speed (km/h) [1]	8.8	Percentage change	-0.1 (-1.2 to +1)	Medium model agreement on little change	-0.4 (-2 to +0.8)	High model agreement on little change	+0.7 (-2.4 to +2)	Medium model agreement on increase
Mean 3 pm wind speed (km/h) [1]	11	Percentage change						

Variable	Annual historic trend	Climate change projections	RCP 8.5 2030 scenario		RCP 4.5 2090 Scenario		RCP 8.5 2090 scenario	
Weather station: Nonning			Most likely – 50th percentile (10th- 90th percentile)	Degree of confidence	Most likely – 50th percentile (10th- 90th percentile)	Degree of confidence	Most likely – 50th percentile (10th- 90th percentile)	Degree of confidence
Solar radiation (%) [1]	N/A	Percentage change	0 (-1.2 to 1.1)	High model agreement on little change	-0.4 (-0.8 to 1.5	Medium model agreement on little change	-0.3 (-1.8 to +1.4)	Medium model agreement on little change
Soil moisture (%) [1]	N/A	Percentage change	-0.7 (-3.4 to +0.2)	Medium model agreement on little change	-1.5 (-3.5 to +0.5)	Medium model agreement on substantial decrease	-1.7 (-5.9 to -0.5)	Medium model agreement on substantial decrease

[1] Projection data obtained from Climate Change in Rangelands, CSIRO & BOM 2015. Figures obtained from Appendix, Table 1 Southern Sub Cluster.

[2] Projection data obtained from Climate Change in Australia Technical Report, Table 7.1.2 (projection for Adelaide), CSIRO & BOM 2015.

[3] Qualitative projection analysis obtained from Climate Change in Australia Rangelands, Chapter 4, Section 4.2.1 Extremes (p20), CSIRO & BOM 2015

[4] Projection data obtained from Climate Change in Australia Technical Report, Table 7.1.3 (projections for Adelaide and Alice Springs), CSIRO & BOM 2015.

[5] Baseline and projection data obtained from Climate Change in Australia Rangelands Cluster Report, CSIRO & BOM 2015. Figures obtained from Appendix Table 2. Fire weather is estimated using the McArthur Forest Fire Danger Index (FFDI); where FFDI exceeds 50, fire weather is deemed 'severe'.

[6] Qualitative projection analysis obtained from Climate Change in Australia Rangelands, Chapter 4, Section 4.4.1 Heavy Rainfall Events (p26), CSIRO & BOM 2015.

Appendix C

Geology, Hydrogeology and Geochemistry, Geotechnical and Soil

Appendix C Geology, Hydrogeology and Geochemistry, Geotechnical and Soil

Inferred Hydrogeological Setting – Desktop Study

A WaterConnect registered well search for a 10 km radius from the centre of the site provides only a single lithological profile available. The WaterConnect search was undertaken on 6 March 2018.

Figure 55 (main text) identifies the registered wells within a 10 km radius of the site including Unit No. 6131-105 located approximately 5 km south.

Well detail summary information from the bore search is attached as a table with the figure below showing available well depth and salinity information for wells in the general vicinity of the site.

Figure 55 Registered Groundwater Bores & Summary Data – 10 km Radius of Site (source WaterConnect)

Downloaded lithological data for selected wells within the search area (6131-12, 6131-122 and 6231-19) information is provided in below. All three wells are situated to the south west of the property, approximately 4 km distant.

Lithological Log for Bore 6131-12 downloaded from WaterConnect 06/03/18

Lithology Depth from	Lithology Depth to	Major lithology code	Minor lithology code	Description	AECOM inferred profile
0	0.61	SOIL		Red brown sandy soil	
0.61	13.72	CLYU		Light brown gritty clay	
13.72	20.73	SAND	CLYU	Pink clayey fine-coarse sand with pockets of white gritty clay and subangular grit	
20.73	23.16	SAND	GRIT	Buff clayey fine-coarse sand with abundant subangular grit	
23.16	29.26	SAND	GRIT	Light brown clayey fine-coarse sand and grit	
29.26	30.78	SAND		Brown and grey medium-coarse grained clayey sand	
30.78	32	CLYU		Grey sandy clay with mica	
32	38.1	SAND		Buff clayey fine sand with mica	
38.1	40.84	SAND	SILT	Light grey fine sand and silt with abundant mica	
40.84	42.06	SAND	GRIT	White clayey fine sand with abundant subangular quartz grit, gravel and green clay	
42.06	44.5	CLYU	GRIT	Green clay with abundant subangular grit and mica	
44.5	45.11	SAND	GRIT	Yellow fine sand with abundant subangular grit	
45.11	51.21	SAND	GRIT	Buff fine-coarse sand, grit and gravel with subangular quartzite boulders	
51.21	53.04	SAND	GRIT	Cream medium grained sand and grit with coarse angular quartzite gravel	

Note:

AECOM inferred changes in broad rock type key:

Unconsolidated sediments

Weathered basement

Basement

Lithological Log for Bore 6131-122 downloaded from WaterConnect 06/03/18

Lithology Depth from	Lithology Depth to	Major lithology code	Minor lithology code	Description	AECOM inferred profile
0	0.3	SAND		Light brown clayey fine sand	
0.3	20.42	CLYU		Brown sandy and gritty clay	
20.42	24.69	CLYU	GRIT	Light brown sandy clay with abundant subangular quartz grit	
24.69	31.39	SAND	GRIT	Brown slightly clayey fine-coarse sand and grit	
31.39	34.14	CLYU		Grey and yellow brown sandy and gritty clay	
34.14	36.27	SAND		Light brown clayey fine-coarse sand	
36.27	44.81	SAND	GRIT	Cream fine-coarse sand and subangular grit	
44.81	46.02	CLYU		Light brown sandy clay	
46.02	46.94	CLYU		Light brown-white gritty clay	
46.94	57.91	CLYU		White sandy clay with mica	

Note:

AECOM inferred changes in broad rock type key:

Unconsolidated sediments

Weathered basement

Basement

Lithological Log for Bore 6231-19 downloaded from WaterConnect 06/03/18

Lithology Depth from	Lithology Depth to	Major lithology code	Minor lithology code	Description	AECOM inferred profile
0	0.3	SAND		Light brown clayey fine sand	
0	0.15	SOIL		Light brown sandy soil	
0.15	0.61	CLYU		Red brown sandy clay	
0.61	2.13	CLYU		Light brown gritty clay	
2.13	10.67	SAND	GRIT	Light brown clayey fine-coarse sand and grit	
10.67	11.28	CLYU		Pink and white gritty clay	
11.28	30.78	SAND	GRIT	Cream clayey fine-coarse sand and grit and gravel	
30.78	35.97	CLYU		Cream and white gritty clay	
35.97	37.19	SCHT		Light grey decomposed quartz feldspar schist	
37.19	38.4	CLYU		Cream gritty and micaceous clay	
38.4	40.84	CLYU	GRIT	White clay with abundant sub-ungular quartzitic grit, gravel and boulders	
40.84	41.45	GRIT		Light grey clayey quartz grit	
41.45	51.82	CLYU		Cream micaceous and gritty clay	
51.82	53.34	SCHT		Light grey mud schist with abundant quartz	

Note:

AECOM inferred changes in broad rock type key:

Unconsolidated sediments

Weathered basement

Basement

The lithological descriptions for the wells presented suggest that appreciable thicknesses of unconsolidated sediments (>50 m) occur in the vicinity of the site. It is noted however that interpretation of the site specific seismic data and review of the available geophysical data sets suggest that the basement is shallow beneath the site.

Stratigraphic information downloaded from the search and presented in Appendix C indicates that basement rock (inferred to be consistent with descriptions of Warrow Quartzite, Hutchinson Group, Hiltaba Suite, Miltalie Gneiss and Gairdner Dolerite) may also occur as shallow <5 m bgs within a 10 km radius of the site. It is noted that basement rock may be present as a weathered horizon and may not represent a competent rock.

In the review undertaken by Daishsat (refer to Appendix C), a series of shallow drill holes to the south east (Maximum depth 37 m bgs) were completed by Pasminco Australia evaluating the Galah exploration prospect. Typically, these shallow holes are aimed at collecting geochemical samples from calcrete horizons.

The available lithological information generally supports the preliminary interpretations of the site specific seismic data.

It is anticipated that the unconsolidated sediments and weathered basement are likely to be dominated by low permeability fine grained clays and/or sandy clays.

The thickness of the inferred unconsolidated sediments, which includes both undifferentiated Quaternary sediments and weathered basement, remains unclear with estimates ranging from less than 5 m to greater than 50 m based on lithological descriptions and between 15 and 35 m based on preliminary seismic interpretation which includes shallower reflectors.

On the balance, given the available information reviewed, the potential lithological profile beneath the site may be:

Key	Broad Lithological description	Depth from (m bgs)	Depth to (m bgs)
	Unconsolidated sediments	0	1
	Less permeable horizon (calcrete?)	1	3
	Unconsolidated sediments	3	10-15
	Weathered basement	10 - 15	20 – 35
	Crystalline basement	20 - 35	>35

Natural Resource Management Setting

The Natural Resources Management Act 2004 divides South Australia into eight regions. This is to ensure that the natural resources of each area are managed in an appropriate and sustainable way.

The WaterConnect database provides an overview of the Natural Resource Management (NRM) Regions and the management areas within those areas. A summary of the relevant management areas in relation to the Lyndhurst site is provided below.

Natural Resource Management zones for Lyndhurst

NRM Categories	Management Zone
NRM Region	Eyre Peninsula (EP)
Surface Water Basin	Gairdner
Groundwater	Eyre Peninsula Non Prescribed Groundwater Area Non-Prescribed Groundwater Management Zone Low competition for resources with low consumptive use and use of the water resource is uncapped or has not been fully allocated.
Surface Water	Eyre Peninsula Non Prescribed Surface Water Area Non Prescribed Surface Water Management Zone Outside of Specified Areas Surface Water Management Zone

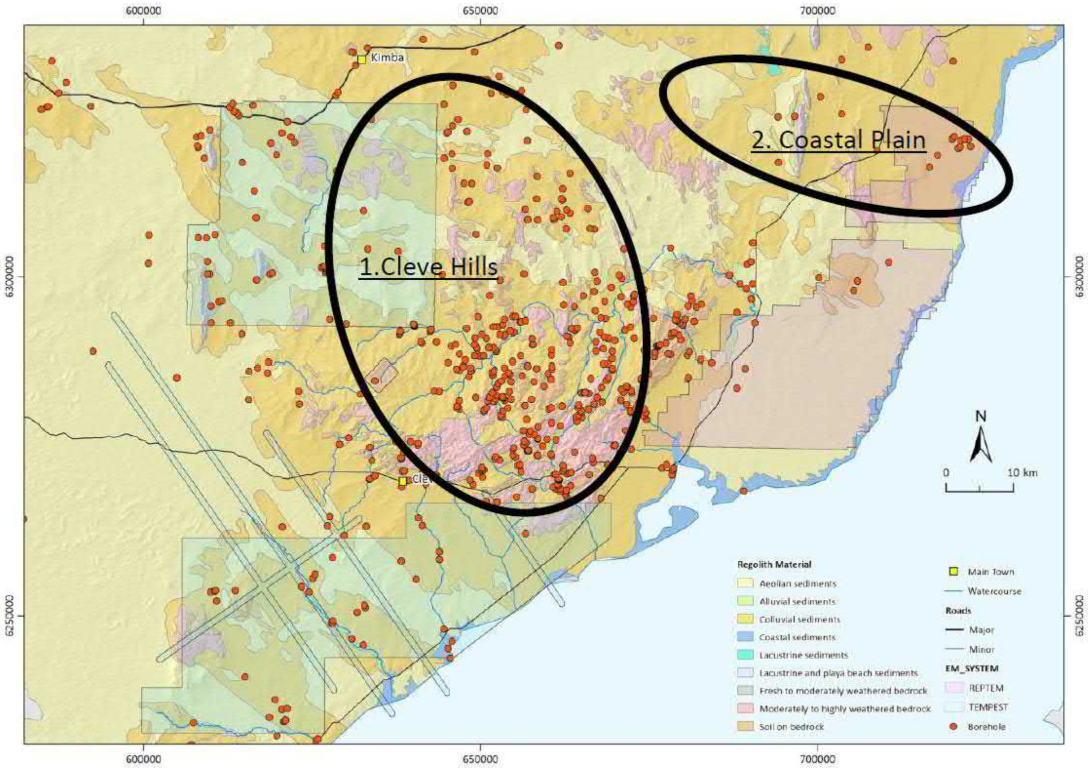
The Lyndhurst location is situated within the Eyre Peninsula NRM (EPNRM) Region. DEWNR Tech Report 2011/16 (Berens *et al*, 2011) indicates the following:

- Regional groundwater monitoring networks within the non-prescribed regions of the EPNRM Region are mainly used to monitor water level fluctuations with some limited salinity monitoring. There are no current or historical regional observation bores within 30 km of the site. The closest DEWNR monitoring network is west of Darke Peake, monitoring dryland salinity, >30 km south-east of the Lyndhurst site.
- Regionally, most groundwater occurs in saline or brackish aquifers with generally low yields. Groundwater occurs within Quaternary, Tertiary and Jurassic sediments and within weathered and fractured Pre-Cambrian basement rocks. Limited hydrogeological information is available and since the mid-1970's, only a small number of water wells have been drilled and few groundwater investigations conducted (SKM 2008).
- The SA Water reticulation network is well distributed across the area covered by the Kimba 1:100,000 map sheet and due to relatively low reliance on groundwater, salinity data is sparse.

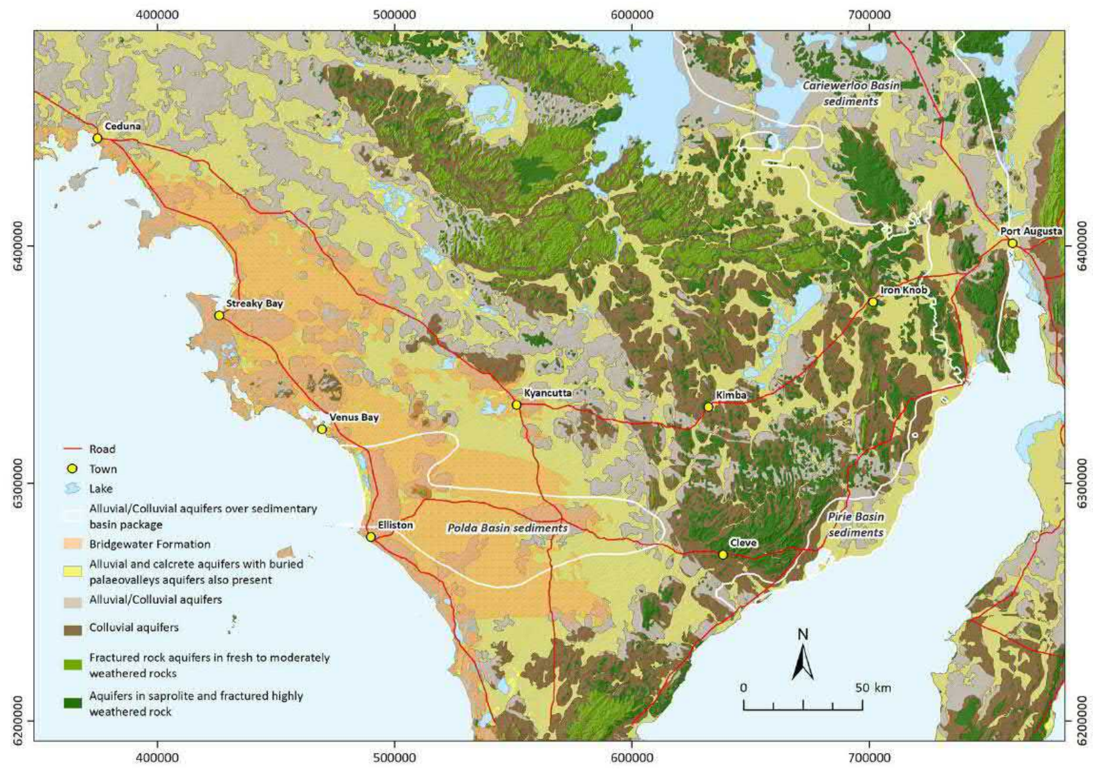
Understanding of the hydrogeological framework in northern Eyre Peninsula has been improved by completion of Goyder Institute for Water Research funded project *Facilitating Long-term Outback Water Solutions* (referred to as G-FLOWS Stage-2). The research used a combination of regional geophysical data (magnetics), local airborne geophysical surveys (industry supplied Airborne Electromagnetic (AEM) data sets), terrain indices derived from surface topography and existing South Australian regolith and geological data and hydrogeological data .

The hydrogeological framework supplements existing knowledge of the aquifer systems and their spatial variability in the northern Eyre Peninsula based on case study areas in the Cleve Hills and Coastal Plain areas presents the refined hydrogeological framework.

G-Flows Stage 2 case study areas (from Gilfedder et al, 2015)



Refined hydrogeological framework developed for the northern Eyre Peninsula by G-Flows Stage 2 (from Gilfedder *et al*, 2015)



Key findings from the case study area south of Kimba in the Cleve Hills which may be relevant to understanding the hydrogeological environment in the vicinity of the Lyndhurst site are presented below:

- The aquifer extent is limited by bedrock topography, and no regional scale systems are identifiable. Unlike many other parts of South Australia, no large scale sedimentary aquifer systems exist. Lenses of groundwater commonly exist as smaller scale (<10 km) bodies with flow direction driven by variations in the water table. Surficial sedimentation over geologically very old bedrock is quite variable, with varying weathering depths of sub-surface rocks across the region of about 50 +/– 100 metres. This presents itself as a defining factor in the characterisation of much of the vertical hydrogeology, as confining units appear to be discontinuous.
- Substantial variability and undulation in hydrochemistry suggests that local groundwater flow systems dominate over any regional groundwater flow-paths. There are also likely to be many discharge and recharge points in the landscape, which further complicates the interpretation of flow systems in this region.
- Results from hydrological modelling in the Cleve Hills setting (Taylor *et al*, 2015) are in agreement with the presence of multiple local systems, with no identified flow-paths spanning the entire transect length. The main conclusion from the modelling here suggests that at reasonable depths to an impermeable base of the order of 100 m, the subsurface water flow cannot proceed along the entire transect.

Registered Well Search Results

Database well summary information for wells within a 10 km radius of the Lyndhurst site is tabulated and presented in the attached table. Little data is available for the identified registered wells.

Of note:

- The purpose of wells drilled within the search area is rarely identified however a number of monitoring wells drilled in 1995 were never constructed and immediately backfilled.
- Two water wells south-west of the site were drilled for industrial purposes in 1961-62 (6131-12 and 6131-122) to depths of approximately 53 and approximately 62 m bgs respectively. Additional information for 6131-12 collected in 1961 indicates a standing water level of 22.86 m bgs, a salinity of approximately 18,070 mg/L Total Dissolved Solids (TDS) and a yield of 2.53 L/s. Although no water level information was available for 6131-122 it also records the same salinity and a yield of 1.39 L/s.
- A third industrial well (6231-19) was also drilled to approximately 53 m bgs with a standing water level of 33.53 m bgs (1962) with the same TDS but is recorded as being abandoned potentially due to the reported low yield (0.13 L/s).
- Well 6231-21 was drilled to 3.66 m bgs with a salinity of approximately 18,790 mg/L TDS however no standing water level information or drill date information was provided and its status and purpose is unknown.

Assessment of Groundwater Beneficial Use

An assessment of the current and potential beneficial use of the groundwater within the regional water table aquifer in the vicinity of the site has been made with reference to Section 3.4 of the SA EPA Guidance Document:

- SA EPA, 2009 – Site contamination: Guidelines for the assessment and remediation of groundwater contamination, February 2009.

The beneficial use assessment examines the suitability of current and future uses based on a number of criteria including:

- Aquifer characteristics that make it suitable for abstraction (e.g. hydraulic conductivity, saturated aquifer thickness, storativity, specific yield)
- Hydraulic connectivity and the potential for impacts to migrate between water bearing zones and affect beneficial use of other aquifers

- Existing nature and type of groundwater users in the area
- Realistic limitations on the basis of groundwater salinity.

Given the existing paucity of data for the site, the beneficial use assessment presents probable realistic uses mainly based on limited salinity data.

In addition, an assessment of the likely environmental values ascribed to the unconfined groundwater in the vicinity of the site has been undertaken with reference to the SA EPP Policy:

- SA EPP (Water Quality), 2015 -South Australian Environment Protection (Water Quality) Policy 2015 under the Environment Protection Act 1993. Government of South Australia.

Applicable Environmental Value (EPP 2015) and Beneficial Use Assessment

Environmental Value	Probable Applicable Environmental Value (EPP 2015)	Probable Realistic Beneficial Use	Justification
Potable use	No as TDS >1,200 mg/L	No	Given the elevated salinity, availability of mains water and sparseness of wells within the area any significant use of the aquifer for drinking water purposes is considered to be highly unlikely.
Aquatic ecosystems (fresh and marine waters)	No	No	No fresh or marine water receptors are present within a 5 km radius of site.
Recreation and Aesthetics	Potential	Potential	Although recreational use is considered to be unlikely with no registered domestic wells located within 10 km radius of the site, potential for use of groundwater for domestic purposes such as use of shallow groundwater for filling swimming pools cannot be excluded if sufficient yields are available.
Industrial use	NA	Yes	Potential for commercial/industrial use of groundwater possible as limited well data suggests industrial use in the vicinity of the site. Available data on aquifer yield suggests that it is variable (approximately0.013 to 2.53 L/s).
Agriculture (irrigation)	No as TDS >3,000 mg/L	No	Potential for use of groundwater for irrigation is limited based on the available salinity information. The Lyndhurst area is a pastoral farming district with no evidence of irrigated horticulture within a 10 km radius of the site.
Agriculture (stock watering)	No as TDS >13,000 mg/L	No	The available salinity information suggests that stock watering as a beneficial use is precluded.
Aquaculture	No as TDS >13,000 mg/L	Yes	Aquaculture is not considered a likely beneficial use of groundwater, however current or future use of groundwater for such purposes cannot be definitively excluded.

Lyndhurst Well Search - 06/03/18
Stratigraphic Download

Unit Number	Stratigraphy depth from	Stratigraphy depth to	Stratigraphic name
6231-19	0	11.28	Unnamed GIS Unit - see description
6231-19	11.28	53	Unnamed GIS Unit - see description
6231-20	0	68	Unnamed GIS Unit - see description
6231-319	0	18	Unnamed GIS Unit - see description
6231-319	18	20	Warrow Quartzite
6231-320	0	16	Unnamed GIS Unit - see description
6231-320	16	32	Warrow Quartzite
6231-320	32	37	Warrow Quartzite
6231-321	0	12	Unnamed GIS Unit - see description
6231-321	12	24	Hutchison Group
6231-321	24	29	Hutchison Group
6231-322	0	14	Unnamed GIS Unit - see description
6231-322	14	54	Hutchison Group
6231-322	54	56	Hutchison Group
6231-323	0	22	Unnamed GIS Unit - see description
6231-323	22	32	Hutchison Group
6231-324	0	10	Unnamed GIS Unit - see description
6231-324	10	20	Hutchison Group
6231-324	20	32	Hutchison Group
6231-325	0	10	Unnamed GIS Unit - see description
6231-325	10	36	Hutchison Group
6231-325	36	44	Miltalie Gneiss
6231-325	44	48	Hutchison Group
6231-326	0	22	Unnamed GIS Unit - see description
6231-326	22	40	Warrow Quartzite
6231-326	40	48	Warrow Quartzite
6231-327	0	16	Unnamed GIS Unit - see description
6231-327	16	32	Hutchison Group
6231-327	32	34	Hutchison Group
6231-328	0	12	Unnamed GIS Unit - see description
6231-328	12	18	Warrow Quartzite
6231-328	18	38	Warrow Quartzite
6231-329	0	2	Unnamed GIS Unit - see description
6231-329	2	10	Unnamed GIS Unit - see description
6231-329	10	19	Warrow Quartzite
6231-330	0	4	Unnamed GIS Unit - see description
6231-330	4	14	Unnamed GIS Unit - see description
6231-330	14	30	Warrow Quartzite
6231-331	0	2	Unnamed GIS Unit - see description
6231-331	2	8	Unnamed GIS Unit - see description
6231-331	8	50	Warrow Quartzite
6231-332	0	2	Unnamed GIS Unit - see description
6231-332	2	6	Unnamed GIS Unit - see description
6231-332	6	32	Warrow Quartzite
6231-333	0	2	Unnamed GIS Unit - see description
6231-333	2	6	Unnamed GIS Unit - see description
6231-333	6	28	Warrow Quartzite
6231-334	0	2	Unnamed GIS Unit - see description
6231-334	2	4	Unnamed GIS Unit - see description
6231-334	4	29	Warrow Quartzite
6231-335	0	4	Unnamed GIS Unit - see description
6231-335	4	13	Warrow Quartzite
6231-336	0	6	Unnamed GIS Unit - see description
6231-336	6	20	Unnamed GIS Unit - see description
6231-336	20	35	Warrow Quartzite

Unit Number	Stratigraphy depth from	Stratigraphy depth to	Stratigraphic name
6231-337	0	4	Unnamed GIS Unit - see description
6231-337	4	24	Unnamed GIS Unit - see description
6231-337	24	30	Warrow Quartzite
6231-337	30	33	Warrow Quartzite
6231-338	0	6	Unnamed GIS Unit - see description
6231-338	6	18	Unnamed GIS Unit - see description
6231-338	18	37	Warrow Quartzite
6231-339	0	6	Unnamed GIS Unit - see description
6231-339	6	24	Warrow Quartzite
6231-340	0	8	Warrow Quartzite
6231-341	0	4	Unnamed GIS Unit - see description
6231-341	4	22	Warrow Quartzite
6231-342	0	24	Unnamed GIS Unit - see description
6231-343	0	33	Unnamed GIS Unit - see description
6231-345	0	2	Unnamed GIS Unit - see description
6231-345	2	6	Unnamed GIS Unit - see description
6231-345	6	36	Hutchison Group
6231-346	0	2	Unnamed GIS Unit - see description
6231-346	2	8	Unnamed GIS Unit - see description
6231-346	8	36	Hutchison Group
6231-347	0	2	Unnamed GIS Unit - see description
6231-347	2	51	Hutchison Group
6231-348	0	2	Unnamed GIS Unit - see description
6231-348	2	7	Hiltaba Suite
6231-349	0	2	Unnamed GIS Unit - see description
6231-349	2	3	Sleaford Complex
6231-350	0	1	Unnamed GIS Unit - see description
6231-350	1	6	Hutchison Group
6231-350	6	17	Hiltaba Suite
6231-393	0	10	Unnamed GIS Unit - see description
6231-393	10	52	Warrow Quartzite
6231-393	52	53	Gairdner Dolerite
6231-394	0	8	Unnamed GIS Unit - see description
6231-394	8	36	Warrow Quartzite
6231-394	36	50	Warrow Quartzite
6231-394	50	53	Hiltaba Suite
6231-395	0	10	Unnamed GIS Unit - see description
6231-395	10	50	Warrow Quartzite
6231-395	50	54	Warrow Quartzite
6231-395	54	60	Hiltaba Suite
6231-396	0	12	Unnamed GIS Unit - see description
6231-396	12	41	Warrow Quartzite
6231-397	0	10	Unnamed GIS Unit - see description
6231-397	10	34	Hiltaba Suite
6231-397	34	46	Hiltaba Suite
6231-397	46	50	Warrow Quartzite
6231-398	0	14	Unnamed GIS Unit - see description
6231-398	14	20	Hiltaba Suite
6231-398	20	32	Hiltaba Suite
6231-399	0	2	Unnamed GIS Unit - see description
6231-399	2	96	Unnamed GIS Unit - see description
6232-49	0	6	Unnamed GIS Unit - see description

Lyndhurst 10 km radius registered well search results - WaterConnect query 06/03/18

Drill Hole No.	Unit No	Obs Well No.	drillhole class	Aquifer	Orig drilled depth	Orig drilled date	cased_to	case min diam	purpose	latest status	latest status date	standing water level (m)	reduced swl (m AHD)	water level date	Total Dissolved Solids (mg/L)	Electrical Conductivity (uS/cm)	salinity date	pH	pH date	yield (L/s)	yield date	MGA easting	MGA northing	Decimal Long	Neg Decimal Lat	water info	salinity	water chemistry	geophys_ log	drill log	lith log
15842	6131-12		WW		53.04	16/12/1961	53.04	127	IND	OPR	26/06/1962	22.86		16/12/1961	18070	29569	15/12/1961			2.53	16/12/1961	638251	6338151	136.481	-33.0865	Y	Y	N	N	N	Y
15952	6131-122		WW		61.87	2/02/1962	48.46	152	IND	NIU	30/01/2013				18070	29569	1/02/1962			1.39	2/02/1962	638523	6339850	136.484	-33.0711	N	Y	N	N	N	Y
17771	6231-19		WW		53.34	1/03/1962			IND	ABD	1/03/1962	33.53		1/03/1962	18070	29569	27/02/1962			0.13	1/03/1962	641459	6335128	136.516	-33.1133	Y	Y	N	N	N	Y
17772	6231-20		WW							BKF	31/08/1978											646743	6339391	136.572	-33.0742	N	N	N	N	N	Y
17773	6231-21		WW							UKN		3.66			18789	30642						642343	6342045	136.525	-33.0508	Y	Y	N	N	N	N
134881	6232-49		MW		6	28/05/1985				UKN	28/05/1985											648469	6348071	136.589	-32.9957	N	N	N	N	N	N
165183	6231-319		MW		20	1/01/1995				UKN	1/01/1995											647399	6333751	136.58	-33.1249	N	N	N	N	N	N
165184	6231-320		MW		37	1/01/1995				UKN	1/01/1995											647649	6333761	136.583	-33.1248	N	N	N	N	N	N
165185	6231-321		MW		29	1/01/1995				UKN	1/01/1995											647739	6333751	136.584	-33.1249	N	N	N	N	N	N
165186	6231-322		MW		56	1/01/1995				UKN	1/01/1995											647939	6333751	136.586	-33.1249	N	N	N	N	N	N
165187	6231-323		MW		32	1/01/1995				UKN	1/01/1995											648199	6333751	136.589	-33.1248	N	N	N	N	N	N
165188	6231-324		MW		32	1/01/1995				UKN	1/01/1995											648449	6333751	136.591	-33.1248	N	N	N	N	N	N
165189	6231-325		MW		48	1/01/1995				UKN	1/01/1995											648599	6333741	136.593	-33.1249	N	N	N	N	N	N
165190	6231-326		MW		48	1/01/1995				UKN	1/01/1995											648749	6333741	136.594	-33.1248	N	N	N	N	N	N
165191	6231-327		MW		34	1/01/1995				UKN	1/01/1995											648949	6333741	136.597	-33.1248	N	N	N	N	N	N
165192	6231-328		MW		38	1/01/1995				UKN	1/01/1995											649099	6333731	136.598	-33.1249	N	N	N	N	N	N
165193	6231-329		MW		19	1/01/1995				UKN	1/01/1995											647339	6335191	136.579	-33.112	N	N	N	N	N	N
165194	6231-330		MW		30	1/01/1995				UKN	1/01/1995											647549	6335181	136.581	-33.112	N	N	N	N	N	N
165195	6231-331		MW		50	1/01/1995				UKN	1/01/1995											647689	6335181	136.583	-33.112	N	N	N	N	N	N
165196	6231-332		MW		32	1/01/1995				UKN	1/01/1995											647889	6335171	136.585	-33.1121	N	N	N	N	N	N
165197	6231-333		MW		28	1/01/1995				UKN	1/01/1995											648079	6335161	136.587	-33.1121	N	N	N	N	N	N
165198	6231-334		MW		29	1/01/1995				UKN	1/01/1995											648299	6335151	136.589	-33.1122	N	N	N	N	N	N
165199	6231-335		MW		13	1/01/1995				UKN	1/01/1995											648619	6335141	136.593	-33.1122	N	N	N	N	N	N
165200	6231-336		MW		35	1/01/1995				UKN	1/01/1995											647659	6338441	136.582	-33.0826	N	N	N	N	N	N
165201	6231-337		MW		33	1/01/1995				UKN	1/01/1995											647509	6338321	136.58	-33.0837	N	N	N	N	N	N
165202	6231-338		MW		37	1/01/1995				UKN	1/01/1995											647359	6338201	136.579	-33.0848	N	N	N	N	N	N
165203	6231-339		MW		24	1/01/1995				UKN	1/01/1995											647169	6338121	136.577	-33.0856	N	N	N	N	N	N
165204	6231-340		MW		8	1/01/1995				UKN	1/01/1995											646979	6338041	136.575	-33.0863	N	N	N	N	N	N
165205	6231-341		MW		22	1/01/1995				UKN	1/01/1995											646909	6337961	136.574	-33.087	N	N	N	N	N	N
165206	6231-342		MW		24	1/01/1995				UKN	1/01/1995											640619	6342671	136.506	-33.0454	N	N	N	N	N	N
165207	6231-343		MW		33	1/01/1995				UKN	1/01/1995											640919	6342671	136.509	-33.0454	N	N	N	N	N	N
165233	6231-345		MW		36	30/06/1994				UKN	30/06/1994											644219	6334851	136.546	-33.1154	N	N	N	N	N	N
165234	6231-346		MW		36	30/06/1994				UKN	30/06/1994											644179	6334851	136.545	-33.1155	N	N	N	N	N	N
165235	6231-347		MW		51	30/06/1994				UKN	30/06/1994											644129	6334851	136.545	-33.1155	N	N	N	N	N	N
165236	6231-348		MW		7	30/06/1994				UKN	30/06/1994											644099	6334851	136.544	-33.1155	N	N	N	N	N	N
165237	6231-349		MW		3	30/06/1994				UKN	30/06/1994											644059	6334851	136.544	-33.1155	N	N	N	N	N	N
165238	6231-350		MW		17	30/06/1994				UKN	30/06/1994											643859	6334851	136.542	-33.1155	N	N	N	N	N	N
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165353	6231-398		MW		32	30/06/1993				UKN	30/06/1993											647879	6335081	136.585	-33.1129	N	N	N	N	N	N
165354	6231-399		MW		96	30/06/1993				UKN	30/06/1993											646629	6335751	136.571	-33.107	N	N	N	N	N	N

DAISHSAT
GEODETIC SURVEYORS

Lyndhurst

Geophysical Data Interpretation NRWMF Site Characterisation Project

Geophysical Data Interpretation
NRWMF Site Characterisation Project

DAISHSAT
Australia's Leading Provider of GPS Positioned Gravity Surveys

Author: Bernie Stockill **Date:** 25/04/2018

Contents

Geophysical Data Interpretation
NRWMF Site Characterisation Project

DAISHSAT
Australia's Leading Provider of GPS Positioned Gravity Surveys

Author: Bernie Stockill **Date:** 25/04/2018

1.0 Introduction

Daishsat is an Australian owned and operated geophysical surveying company which has been proudly based in Murray Bridge South Australia for over 23 years.

The company completes high quality ground gravity and geodetic surveys for clients in the government and private sectors throughout Australia and around the globe. In addition to gravity surveys, Daishsat undertakes detailed airborne magnetic and radiometric surveys using both helicopter and fixed wing platforms.

Bernie Stockill is a Daishsat geophysicist with over 40 years' experience in collecting, reviewing and interrogating geophysical data sets. Bernie has previously undertaken a review of internally held and publicly available on-line database information in the vicinity of the NRWMF Site Characterisation Project short listed sites that included Lyndhurst.

Dr James Hanneson is a highly regarded South Australian consulting geophysicist with vast experience in interpretation and modelling of airborne magnetic data. James is considered a specialist in the South Australian Gawler Craton domain, and has undertaken sophisticated modelling and interpretation of geophysical data for many of the major exploration companies working in the region.

Following the preliminary investigation, Daishsat completed an airborne magnetic and radiometric survey over the proposed Lyndhurst site in the Kimba area of South Australia This survey was flown over two days in April, 2018 and consisted of a total of 385 line kilometres of airborne surveying at 50 metre line spacing.

This report provides an interpretation of the geophysical data collected over the Lyndhurst area and includes Dr Hanneson's in-depth modelling and interpretation report. The study area of 1km^2 has been defined and an extended survey area of 16km^2 surrounding the proposed site was covered for logistical reasons of airborne data collection, and also to provide sufficient contrasting background data to give meaningful results.

All geophysical images produced as a result of the airborne survey are included with this report. Selected images are also displayed within the report.

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2.0 Geology

2.1 Overview

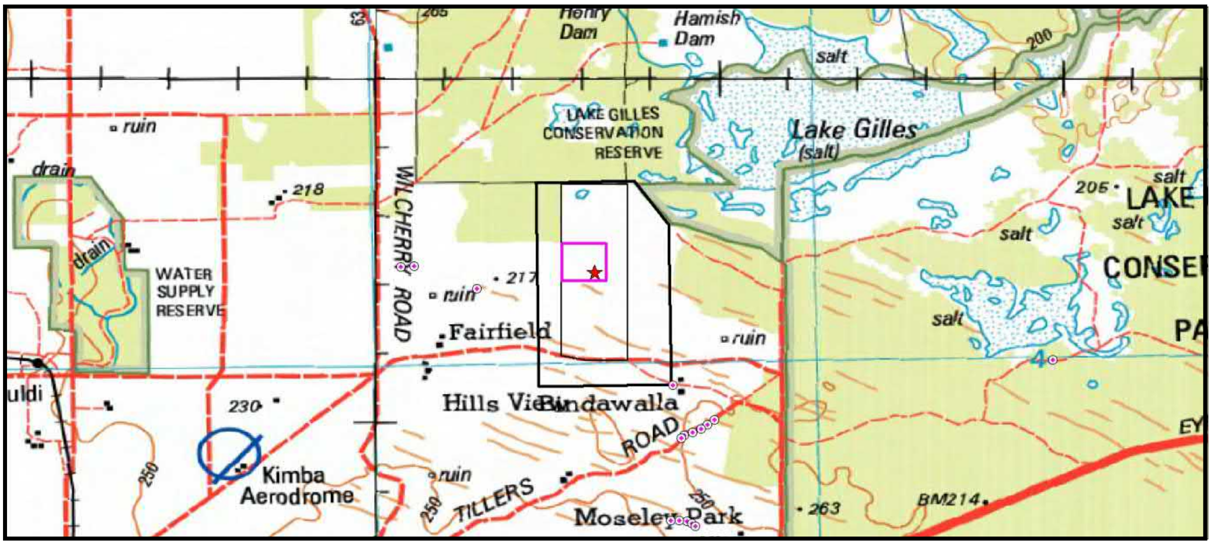

Image 1 Lyndhurst Survey Site outline on topographic background

The area under consideration at Lyndhurst is shown above. The main target area is approximately $1km^2$ (magenta square) and is located on recent surface sediments south west of Lake Gilles, about 15 kilometres north east of Kimba. The area covered by the airborne geophysical survey is shown in black. Geological background information for the Whyalla 1:250 000 Sheet SI53-08 was downloaded from the SARIG website and provided with the preliminary report.

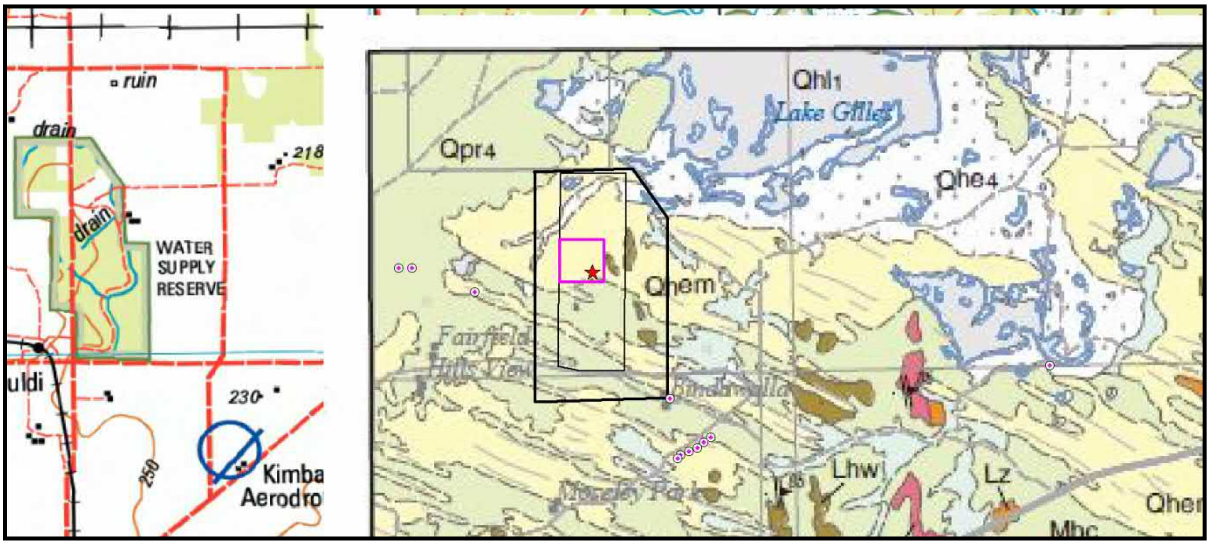

Image 2 Lyndhurst Survey Site on the 1:250 000 geology map

2.2 Geology of the Lyndhurst area

Surface cover is shown as Qhem, Moornaba Sand and consists of aeolian quartz sands with carbonates. The outcropping rocks within the study area are quartzite (Warrow Quartzite). Mafic intrusions and metamorphic rocks (Miltalie Gneiss) occur within 6 kilometres to the south east. Charleston Granite also outcrops about 10km to the south east of the study area.

There is nothing obvious from the surface geology to indicate rock type or structures in the geological basement rocks. The north-east corner of the survey area lies adjacent to the Lake Gilles salt lake that forms part of a Conservation area.

3.0 Gravity

3.1 Overview

Gravity data over the Lyndhurst area is restricted to a 1 kilometre station interval grid of publically available regional stations collected in 2008. This data consists of accurate GPS controlled stations and provides a good regional perspective of gravity response over the area.

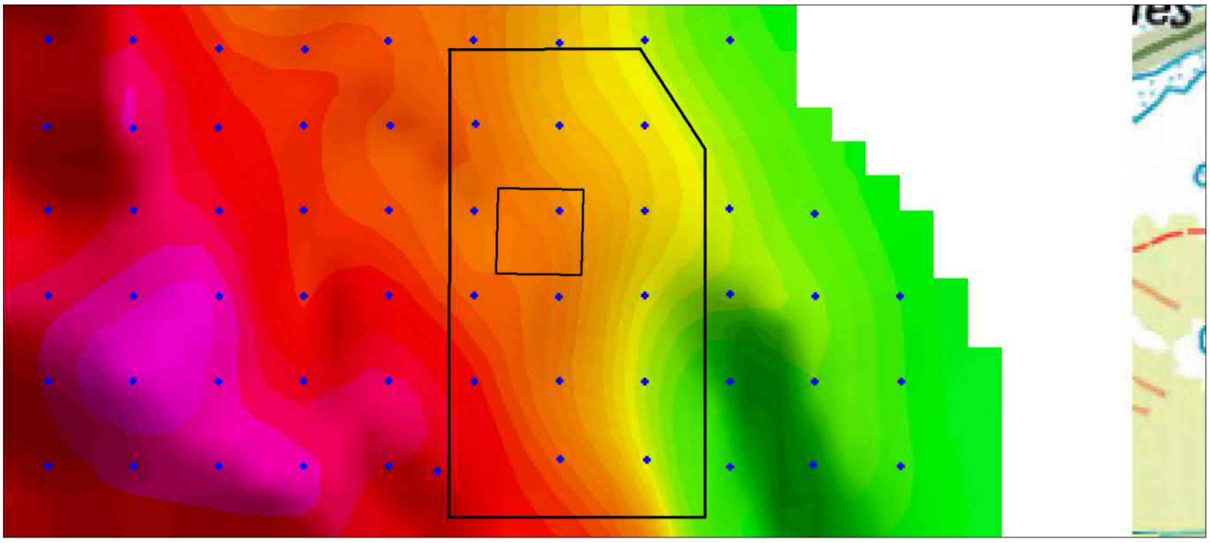

Image 3. Lyndhurst regional gravity image with station plot.

3.2 Regional Gravity in the Lyndhurst area

The 1 kilometre station interval does not provide detail on short wavelength anomalous responses and at best, would respond to deep sources of little significance to this investigation. There is however, sufficient variation in the gravity response shown to expect significant detail to be obtained from a close spaced (200 metre) survey over the investigation area. This additional gravity data would provide an input to the magnetic modelling that would improve reliability and reduce ambiguity in modelled outcomes.

4.0 Radiometrics

4.1 Overview

Airborne radiometrics measures the naturally occurring radiation emitted from the Earth's surface sediments or rocks and is expressed in terms of percent potassium and parts-per-million thorium and uranium.

Surface water masks the radiation emitted and will show on a ternary image as very dark or black. Rocks or surface sediments high in potassium, thorium or uranium will show as increasing "hot" colours such as red on the individual element images.

Correspondingly, rocks or surface sediments containing low concentrations of these elements will display “cool” colours, such as blue and green.

A composite image of all three elements is termed a Ternary image and may range from black (low) to white (high). In the ternary display the ternary ratio provides the relative proportion of potassium, thorium and uranium by assigning the colours red, green and blue to each channel (element).

The relative proportion is useful in mapping the variations in the surface materials and shows a strong correlation to geology and soils.

While the radiometric data is often directly related to the sub-surface geology (in the case of in-situ weathering for example), where the surface consists of transported sediments, such as sand dunes, little or no evidence of sub-surface geology is provided. The potassium channel usually provides the dominant response and this is largely due to the breakdown of feldspar (K-Feldspar) into one of the most common weathering products, namely clays.

4.2 Interpretation

Published geology maps show only quartzite rocks outcropping at the Lyndhurst site. Relevant images have been reproduced here (Images 4 to 8) and detailed images accompany this report. The predominance of dunes in the Lyndhurst investigation area indicates that for the most part, radiometric images are influenced by transported sediments and dominant trends shown on the images are not necessarily indicative of the underlying geology. The composition of the dunes is predominantly quartz sand that typically has a low radiometric response and this overall pattern seen in the radiometric images is dominated by the north-west dune response.

The overall radiometric response increases to the south of the 1km^2 Lyndhurst target area with respect to potassium and thorium (see Images 6 and 7) however this is not reflected in any change in the published surface geology map. This increased response would represent a change in surface sediments that is possibly related to subtle changes in the subsurface geology. Any apparent change in this area would have little impact on the Lyndhurst target area.

There is no dominant pattern showing on the uranium image (Image 8) and the only conclusion that can be made is that no anomalous areas are defined and the image presents as expected for normal random background.

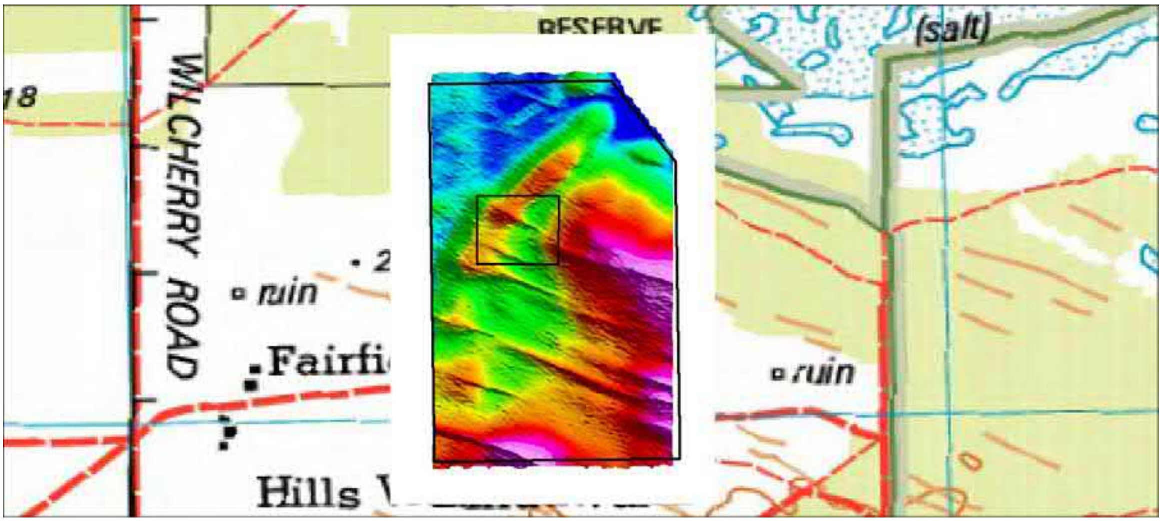

Image 4. Lyndhurst surface elevation image.

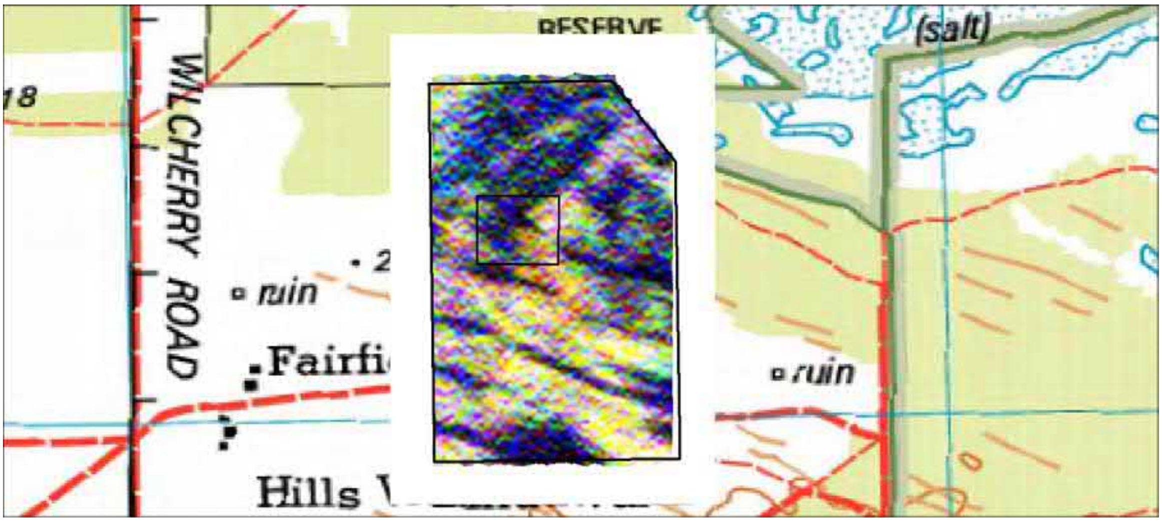

Image 5. Lyndhurst Ternary radiometric image.

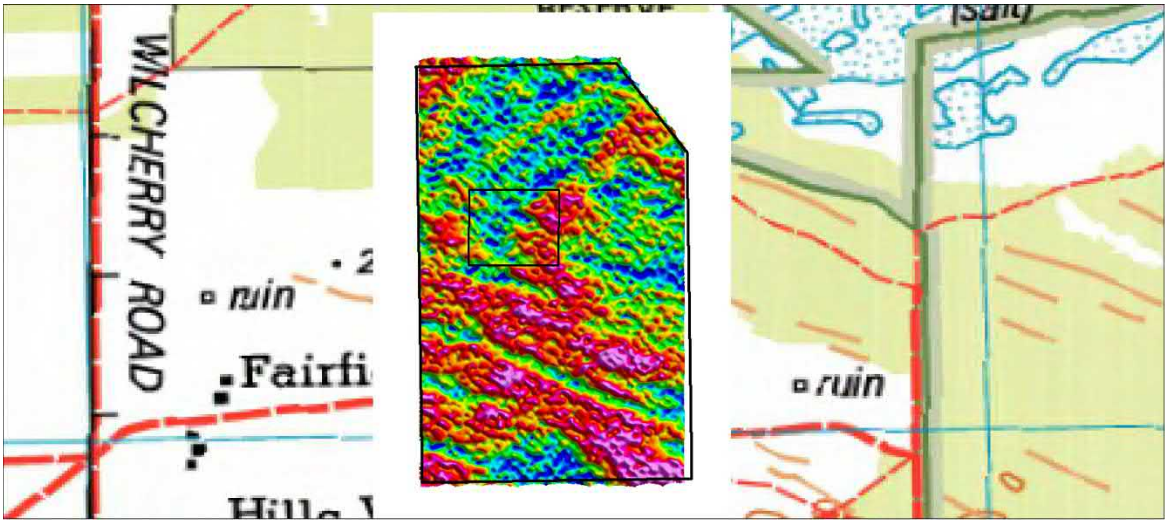

Image 6. Lyndhurst Potassium radiometric image.

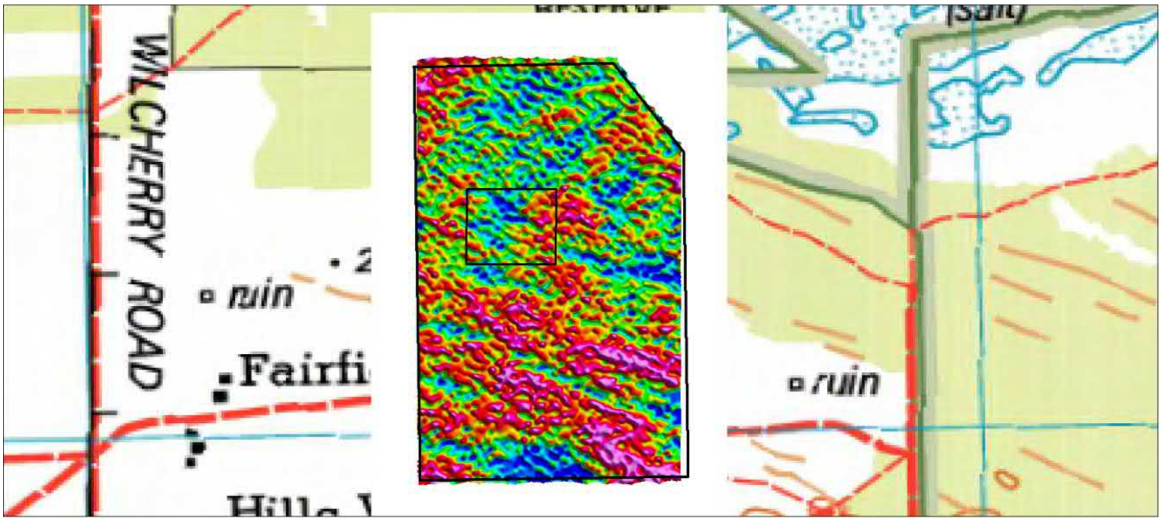

Image 7. Lyndhurst Thorium radiometric image.

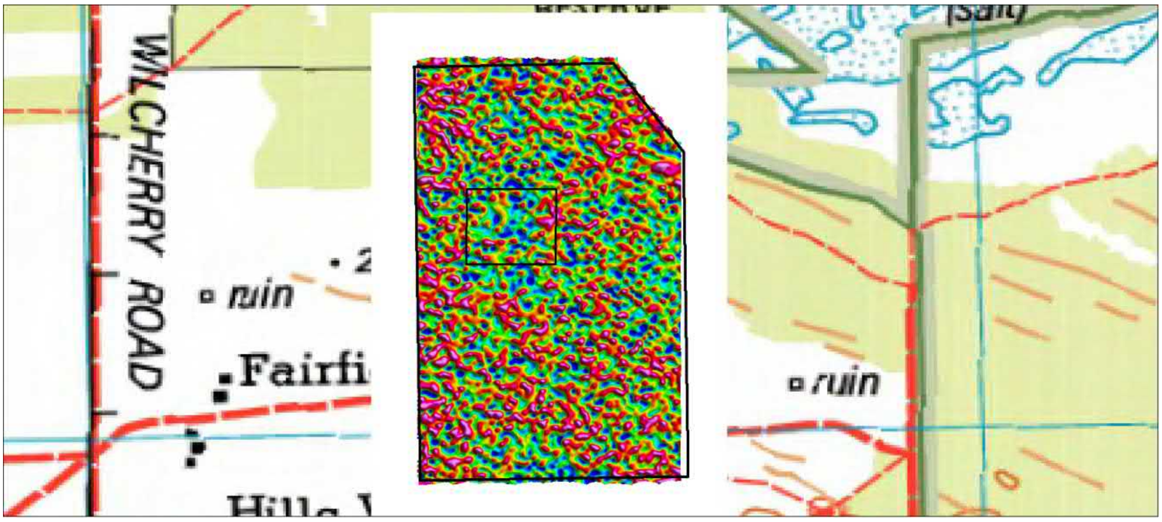

Image 8. Lyndhurst Uranium radiometric image.

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Author: Bernie Stockill **Date:** 25/04/2018

5.0 Magnetics

5.1 Overview

Daishsat completed an airborne magnetic and radiometric survey over the proposed site at Lyndhurst in the Kimba area of South Australia. This survey was flown over two days from 4th to 5th April, 2018 and consisted of a total of 385 line kilometres of airborne surveying.

Data was collected along north-south flight lines 50 metres apart at a nominal flying height of 50 metres. Location data were recorded in GDA94 datum.

Data was processed by Baigent Geosciences to provide diurnally corrected, levelled and tied line data. Data were gridded and imaged using Oasis Montaj Geophysical software with a cell size of 10 metres.

Magnetic data were reformatted and models constructed along east-west profiles over the entire airborne survey area. Cross-sections were produced to show the relative position and depth of models. Models were constructed in such a way that the profile generated from the model matched the field data profiles.

5.2 Magnetic response in the Lyndhurst area

A complete magnetic susceptibility model and interpretation report completed by James Hanneson accompanies this report and only a brief summary is provided here. The interpretation report includes a series of modelled sections and the location of these sections (T4, T5 and T6), relevant to the Lyndhurst 1km^2 target area is shown below.

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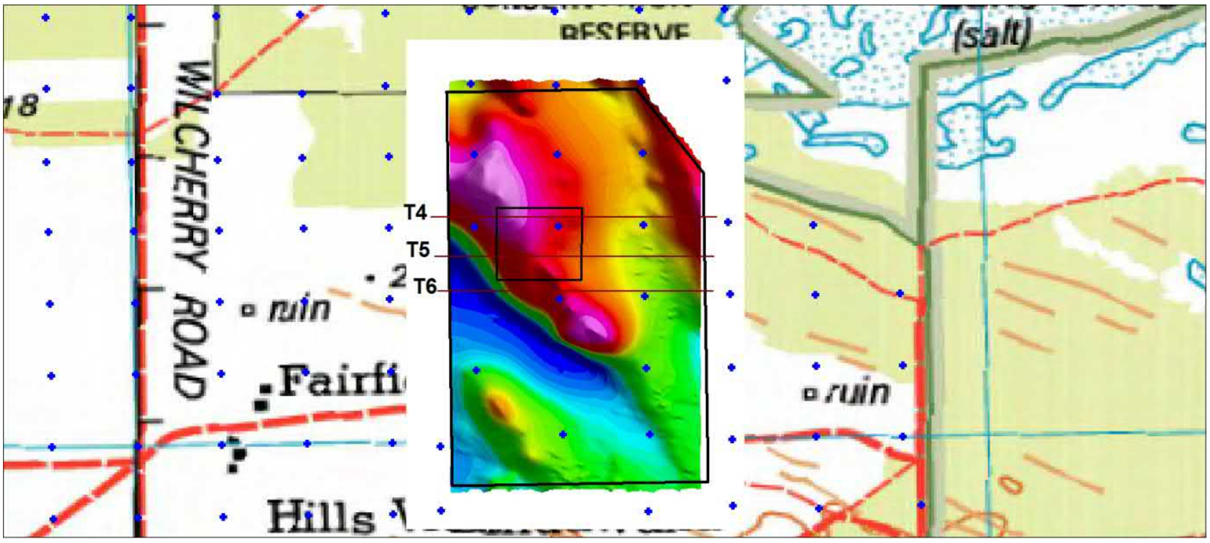

Image 9. Lyndhurst TMI image showing the location of modelled sections.

Models have been presented as polygons to represent the magnetic source rocks. Full details of the model bodies and modelling parameters are provided in Table 1 of the Interpretation Report.

Depth to the top of the modelled bodies is between 240 and 400 metres over these traverses. A considerable basement block is also required (depth to top of approx. 500 metres) to match the observed magnetic profile.

There is nothing to indicate shallow magnetic source rocks within the target area. Truncation and terminations of anomalous magnetic response have indicated possible faults within the target area (Image 10). At least two of these traverses cross the target area. However as they are interpreted from the enhanced magnetics and there is minimal contribution to the magnetics from shallow sedimentary sources, these possible faults may not extend into the surface sediments and may have no surface expression.

Ground gravity as proposed may be used to adequately define these faults and any other structures that display a minimal magnetic response.

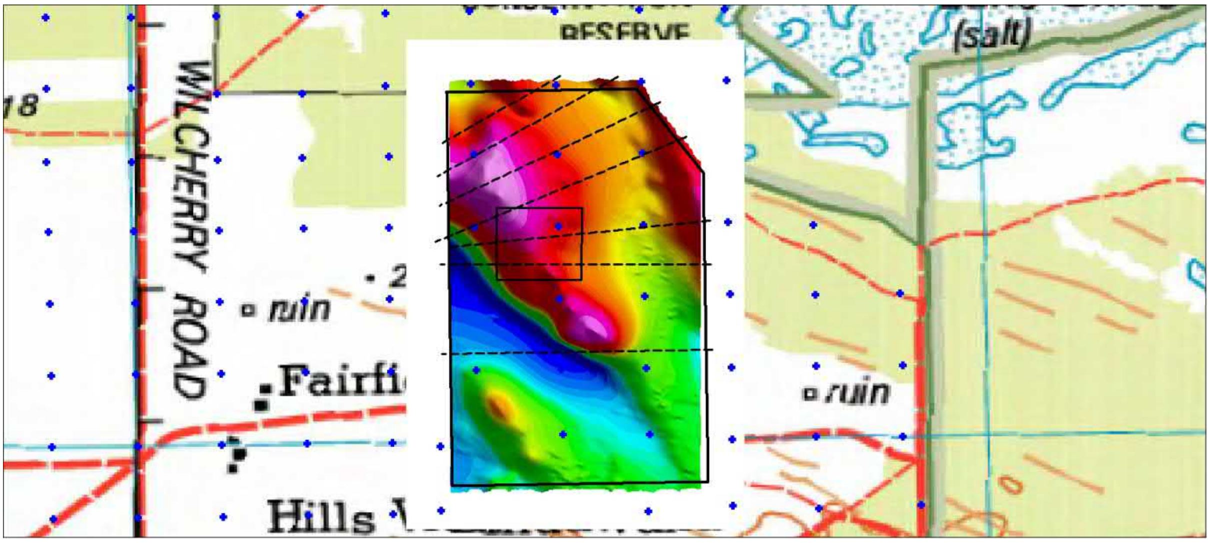

Image 10. TMI magnetic image with possible interpreted faults.

6.0 Conclusion

From the detailed modelling of the magnetic data there is no evidence to suggest the presence of shallow basement or extensive faulting or structures at Lyndhurst. Magnetic models outlined in the interpretation report indicate that basement rocks are at least 500 metres deep, and that shallower bodies overlying the basement are between 240 and 400 metres deep.

Where faults have been inferred from the enhanced magnetic images, more reliable results will be obtained by the inclusion of detailed gravity data over the survey area.

Airborne radiometric data, in particular the potassium and thorium response, has indicated a possible change in surface sediment composition to the south of the 1km^2 target area. While this difference may be due to a change in the underlying rocks, this is unlikely to have any effect on the general geology of the target area.

7.0 Referenced Data

The attached interpretation report by James Hanneson provides the detailed modelling and interpretation of the magnetic data from Lyndhurst. Original full sized elevation, magnetic and radiometric images included in the text are attached.

Data Item	Media	Source	Size	Date Completed	Date Accessed
SA State Gravity Image - SA_GRAV	Geotiff Image	SARIG Digital Download	528.437Mb	2015	Jan-18
SA State Magnetic Image - SA_TMI_RTP	Geotiff Image	SARIG Digital Download	528.437Mb	2015	Jan-18
SH53_08 Whyalla 1:250 000 Geology Map	PDF	SARIG Digital Download	7.82Mb		Jan-18
SH53_08 DHGeochem	CSV: XL Spreadsheets	SARIG Digital Download	8.734Mb/29.950Mb		Feb-18
SH53_08 drillholeDetail	CSV: XL Spreadsheets	SARIG Digital Download	2.043Mb/0.832Mb		Feb-18
SH53_08 rockSamples	CSV: XL Spreadsheets	SARIG Digital Download	5.922Mb (combined)		Feb-18
ENV10493 Aquila Resources Reports	PDF	SARIG Historical Mineral Reports	259.357Mb	2004-2011	Feb-18
SARIG On-line Gravity database	Digital, CSV or ASCII	SARIG		Download 2017	Jan-18
Geoscience Australia GADDS on-line gravity database	Digital, CSV or ASCII	Geoscience Australia		Download 2017	Jan-18
Daishsat data	CSV	Daishsat	22.991Mb	Aug-17	Jan-18
Daishsat Open File SA Company Gravity database V3	CSV	Daishsat	22.089Mb	Sep-17	Jan-18
19911SA12_Lake Gilles GDA94 Airborne Magnetic survey erMapper grids and line data	ER Mapper Grids, ASCII Line data	SARIG Digital Download	353Mb	Jun-05	Feb-18
Ancilliary Reports:ENV05074; ENV10431; ENV11080; ENV11497; ENV11811; ENV12512; ENV12809; ENV12961	PDF	SARIG Historical Mineral Reports			Feb-18
Kimba airborne Magnetic and Radiometric data	ASCII Data, er Mapper grids, PDF, tiff images	Daishsat	140Mb	Apr-18	Apr-18
Lyndhurst magnetic and radiometric High Resolution images	tiff images	Daishsat	78.3Mb	Apr-18	Apr-18
Lyndhurst Model	PDF	Daishsat/Hanneson	2.8Mb	Apr-18	Apr-18

AMG
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ABN 77 085 429 698 tel: (08) 8370-7493 fax: (08) 8370-7364 email: jim.hanneson@bigpond.com

MEMORANDUM

To:	Bernard Stockill Business Development Manager Daishsat Geodetic Surveyors *via* email: bernie.stockill@daishsat.com	**Affiliation:**	Daishsat Ltd Murray Bridge South Australia
From:	J.E. Hanneson	**Costing:**	
Date:	18 April, 2018	**Reference:**	AMG18/10
Subject:	**A Magnetic Susceptibility Model for the Lyndhurst Area, Daishsat Geodetic Surveyors Ltd, South Australia**		

1. INTRODUCTION AND SUMMARY

This report presents a magnetic susceptibility model for the Lyndhurst Area near Kimba, South Australia, using magnetic data collected recently by Daishsat Geodetic Surveyors. The objective of this work is to estimate the depth and properties of any magnetic units and to seek evidence of faulting in order to appraise the structural stability of the area. I understand that the thickness of the cover rocks is unknown and that there is essentially no gravity data available.

In summary, the magnetic bodies used to simulate the data range in depth from 120m to 600m with few deeper bodies that simulate regional trends. Magnetic trends are NNW, and most magnetic bodies are thought to comprise 2 to 3 percent magnetite; however, but nothing is known about their densities as could be estimated if gravity data were available. By enhancing anomalies in the data that have short spatial wavelengths, several linear magnetic features with similar trends can be perceived in the images that otherwise appear bland. Base on truncations and discontinuities in both strong and very weak linear highs, seven faults are hypothesised to cross-cut the magnetic features with orientations ranging from NE to east-west.

2. DATA

Figure 1 shows the topography as derived from GPS and sensor height measurements during the aeromagnetic survey, and surface variations are seen to be bland with WNW trending features that appear to be dunes.

The magnetic data, shown in Figure 2.1, reveals two dominant magnetic highs on a NNW trend in the north-western part of the area, and seems to show no sharp features that would arise from shallow magnetic sources. However, when this image is lightly smoothed (Figure 2.2) and when the smoothed image is subtracted from the original image, a residual magnetic image is obtained, which is shown with and without contours in Figures 2.3a and 2.3b, respectively. Numerous short wavelength features become apparent that suggest near surface sources.

Residual images enhance shorter wavelength features.

These sharper features, not apparent in the original image, can be amplified (in this case multiplied by ten) and added back to the original image to provide an impression of many sharper features while retaining some of the broader features of the initial map. Figure 2.4 can be used for qualitative interpretation but must not be use for quantitative modelling.

3. MODEL

A magnetic susceptibility model was developed using the methods of Talwani (1960, 1961) and the writer (Hanneson, 2003), whose calculated magnetic response, shown in Figure 3.1 is a fair simulation of the data in Figure 2.1. Likewise a residual of the magnetic model response (Figure 3.2) is a reasonable simulation of the residual image (Figures 2.3b) derived from the data.

The model body tops shown in plan as black polygons in Figures 3.1 and 3.2 are shown alone in Figure 4, where the colours depend on the physical properties of the bodies which accord with the background colours in the inset phase/scatter diagram (Hanneson, 2003). Thus, weakly magnetic bodies are yellow-green in colour, becoming bluer for higher susceptibilities. Model body numbers are posted at the centroid of each body with depth to the top of each body.

Straight east-west lines in Figure 4 labelled P1 to P11 give the locations of cross-sections through the model that are shown in Figures 5.1 to 5.11, along with profiles of the calculated magnetic model response (dotted) and the magnetic data (solid).

Figure 6 shows where each model body plots on the combined phase/scatter diagram, from which can be read the density and magnetic susceptibility as well as the inferred concentrations of magnetite. In this model (because there is no gravity data), gravity responses have not been calculated, and all bodies have been given the weak density expected for felsic rock with minor magnetite.

Table 1 following the diagrams gives additional details of the model, including depth to top, depth extent, magnetic susceptibility and estimated magnetite concentrations among other things.

4. DISCUSSION

In the model, the depths of the magnetic rocks are inferred from the shape of the profiles of magnetic amplitude. The parameters of model bodies are adjusted until the calculated model response matches the data. This means only that the model is *permitted* by the data. Because many models can have the same calculated response, selecting and presenting one model that simulates the data as an explanation for the observed data, rather than another model that may simulate the data equally well, is an act of interpretation. Any model used for further work should therefore be subjected to geological assessment and rejected if not deemed credible.

In the Gawler Craton, it is often assumed that the inferred depth of magnetic features is an indication of depth to basement. While the cover rocks are in general more oxidised than the basement (and therefore more likely to have iron in the form of hematite than magnetite), this is often true; however, I understand that mafic units like the Gairdner dikes can intrude the cover as high as the top of the Pandurra.

Faults, which may be taken as evidence for unstable geology, need some physical property which contrasts with the country rock in order to be directly detectable geophysically. For example, faults often permit deep access for meteoric waters that may oxidise the country rock in the vicinity of the fault. This may lead to deep erosion, for which the residual or infill material can be less dense than the country rock and thus generate a local gravity low. Deep erosion may also be magnetite destructive which may yield a magnetic low along the line of the fault.

Alternatively, connate waters or hydrothermal fluids may percolate through the porous rocks of a fault zone altering the rocks, possibly with the addition of magnetite, so that a fault is manifest as a linear magnetic high.

Magnetite destructive processes can provide evidence for faulting, but only if the country rocks contain enough magnetite that destroying it yields a significantly lower magnetic susceptibility within the fault zone. Even if the country rock is non-magnetic, faults may still be evident if other magnetic features (dike, sills, magnetic stratigraphy etc.) exist, and if they are seen to terminate or are discontinuous at different points along strike. If several truncations or discontinuities are seen to line up, this may be seen as evidence for faulting.

With the exception of two pink areas in Figure 2.1, the magnetic map of the Lyndhurst Area is somewhat bland. However, the residual magnetic image in Figure 2.3, and the high-frequency enhanced image in Figure 2.4 give a different impression.

While the susceptibility model (Figures 4 and 5.1 to 5.11, and Table 1) gives information on size, depth, orientation, susceptibility, and so on for the rocks that the model bodies represent, the final image of the residual magnetics may in fact be more important for assessing the long term geological stability of the area. Figure 2.3b shows seven dotted lines with directions ranging from east-west to northeast-southwest along which the dominantly NNE trending magnetic stratigraphy is seen to be truncated and/or discontinuous.

The best evidence that faults occur in the area is a very weak east-west trending magnetic low centred near (646000E, 6342500N) with weak parallel high a hundred metres or so to the south. It suggests that the country rock is not entirely devoid of magnetite and the negative susceptibility contrast of -0.01 SI for Body 83 (see Table 1) that simulates this weak low suggests that the fault zone contains perhaps 0.4 percent less magnetite than the mean value for country rock.

To infer a minimum age for the faults posited on the basis of discontinuities and truncations therefore requires knowledge of the ages of the truncated units. At Lyndhurst the shallowest magnetic model bodies are at 120m, suggesting that the faults may be relatively young, but further understanding requires a geological assessment.

The study area is considerably larger than the immediate area of interest; however, restricting attention only to the smaller area would probably not have yielded the interpreted faults. There may also be other linear features that are less conspicuous.

If detailed gravity data was collected, the inferred faults might be confirmed as low gravity values over less dense, deeply weathered rocks. Also gravity highs coinciding with some of the more magnetic features might suggest that they were emplaced during a mafic intrusive event.

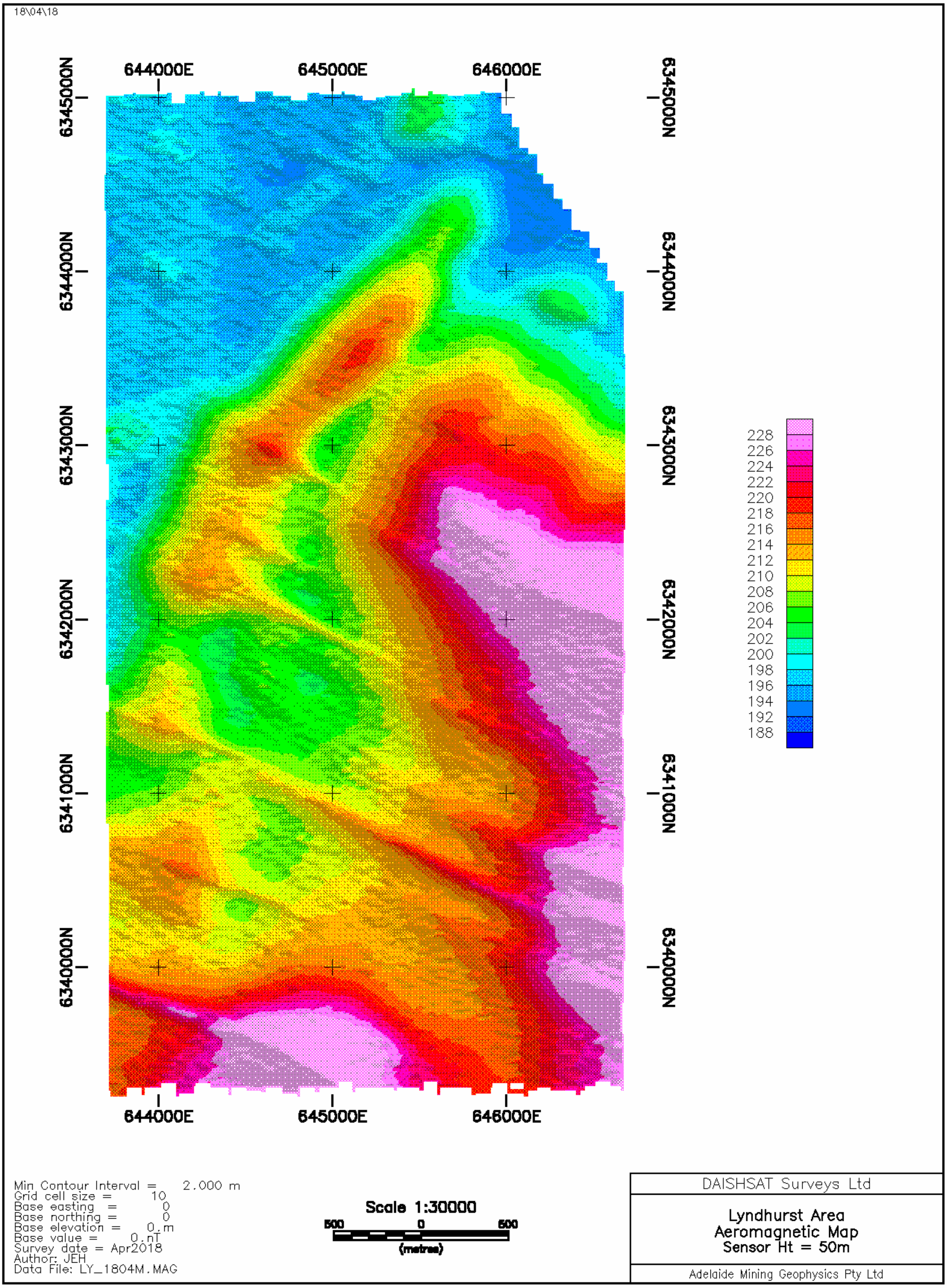
No magnetic remanence is evident in the observed responses, and the dominant magnetic features exhibit lows to the south (and west) as expected for a local Earth's field having inclination -65 and declination 7 degrees, respectively.

5. REFERENCES

Hanneson, J.E., 2003; On the use of magnetics and gravity to discriminate between gabbro and iron-rich ore-forming systems, Exploration Geophysics, V34, No 1&2, pp110-113.

Talwani, M., 1961, Computation with the help of a digital computer of the magnetic anomalies caused by bodies of arbitrary shape, Geophysics, V26, p203.

Talwani, M., 1960, Rapid computation of gravitational attraction of three-dimensional bodies of arbitrary shape, Geophysics, V25, p203.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Survey date = Apr2018
Author: JEH
Data File: LY_1804M.MAG
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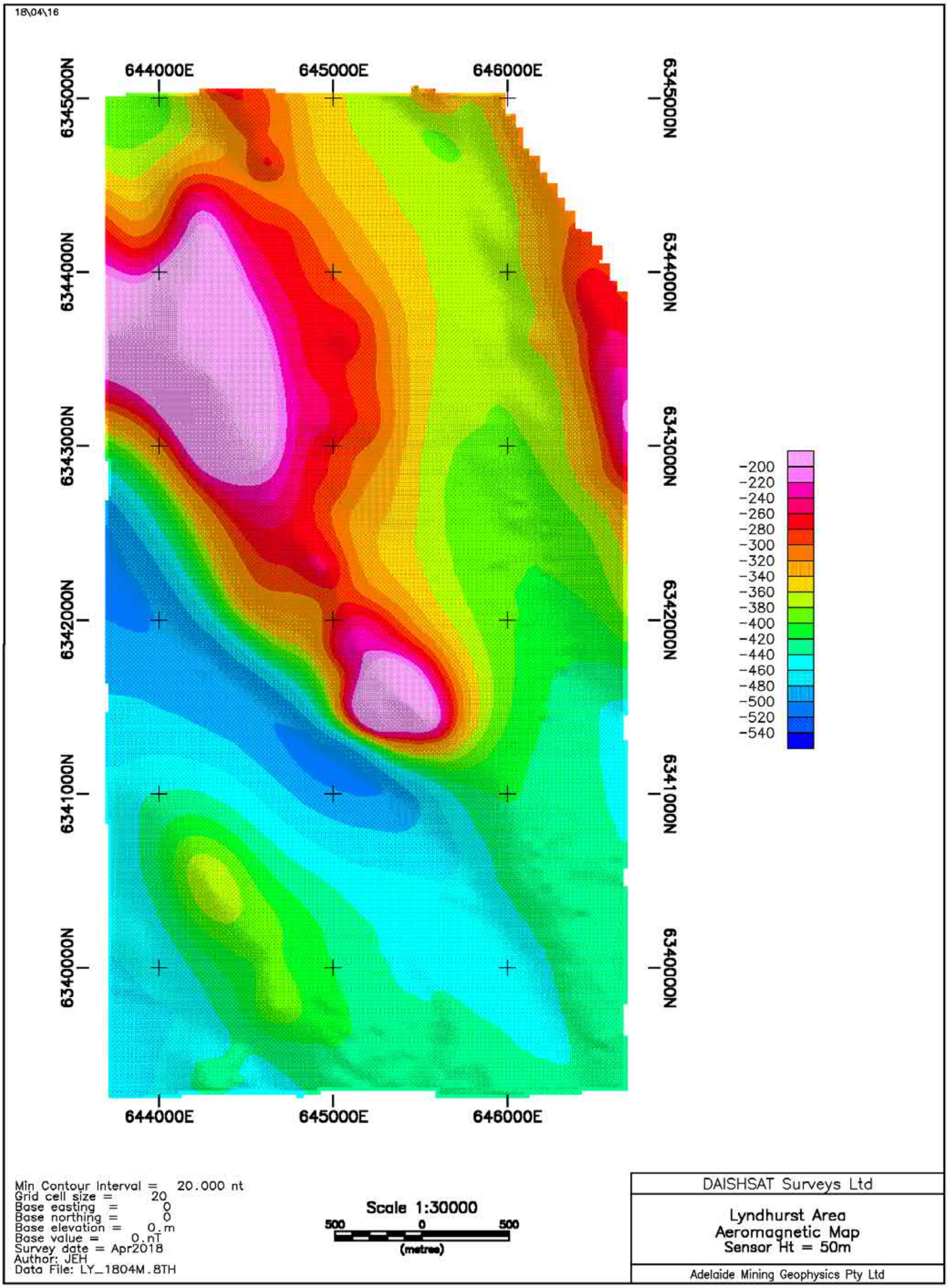
(metres)
DAISHSAT Surveys Ltd
Lyndhurst Area
Aeromagnetic Map
Sensor Ht = 50m
Adelaide Mining Geophysics Pty Ltd

Figure 1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DAISHSAT Surveys Ltd
Lyndhurst Area
Aeromagnetic Map
Sensor Ht = 50m
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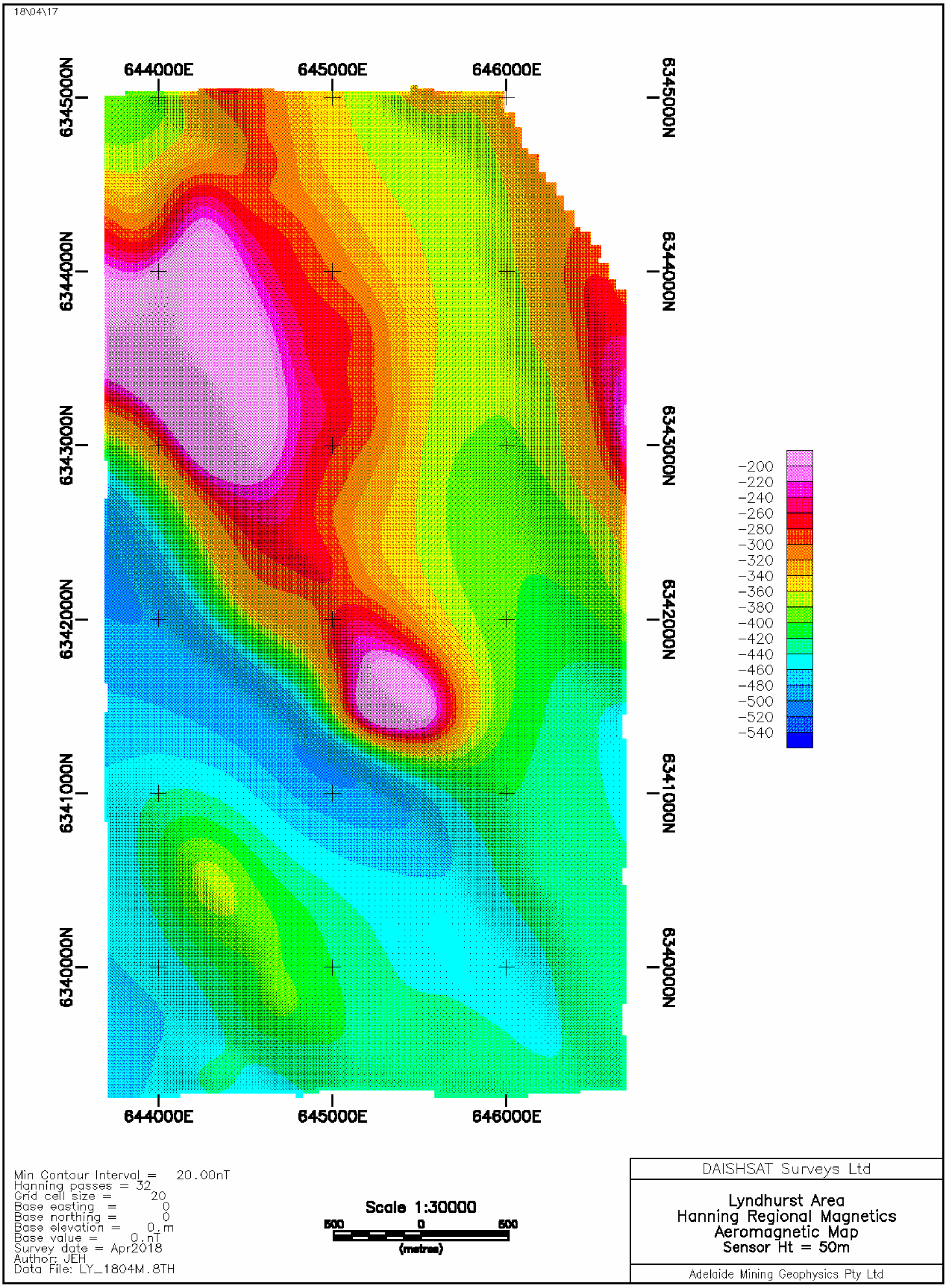
Figure 2.1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Author: JEH
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(metres)
DAISHSAT Surveys Ltd
Lyndhurst Area
Hanning Regional Magnetics
Aeromagnetic Map
Sensor Ht = 50m
Adelaide Mining Geophysics Pty Ltd

Figure 2.2

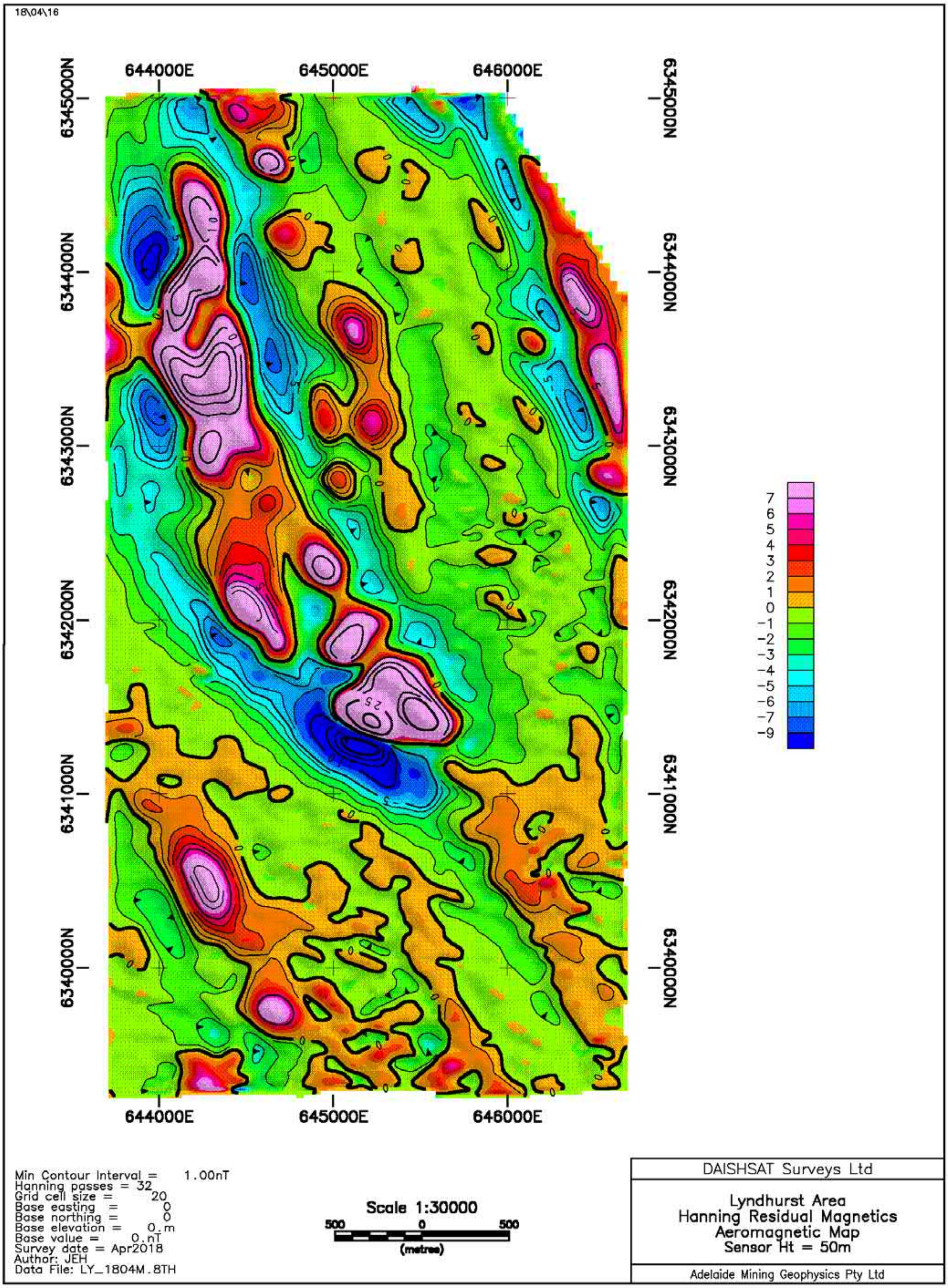

18\04\16
644000E
645000E
646000E
6345000N
6344000N
6343000N
6342000N
6341000N
6340000N
7
6
5
4
3
2
1
0
-1
-2
-3
-4
-5
-6
-7
-9
Min Contour Interval = 1.00nT
Hanning passes = 32
Grid cell size = 20
Base easting = 0
Base northing = 0
Base elevation = 0.m
Base value = 0.nT
Survey date = Apr2018
Author: JEH
Data File: LY_1804M.8TH
Scale 1:30000
500
0
500
(metres)
DAISHSAT Surveys Ltd
Lyndhurst Area
Hanning Residual Magnetics
Aeromagnetic Map
Sensor Ht = 50m
Adelaide Mining Geophysics Pty Ltd

Figure 2.3a

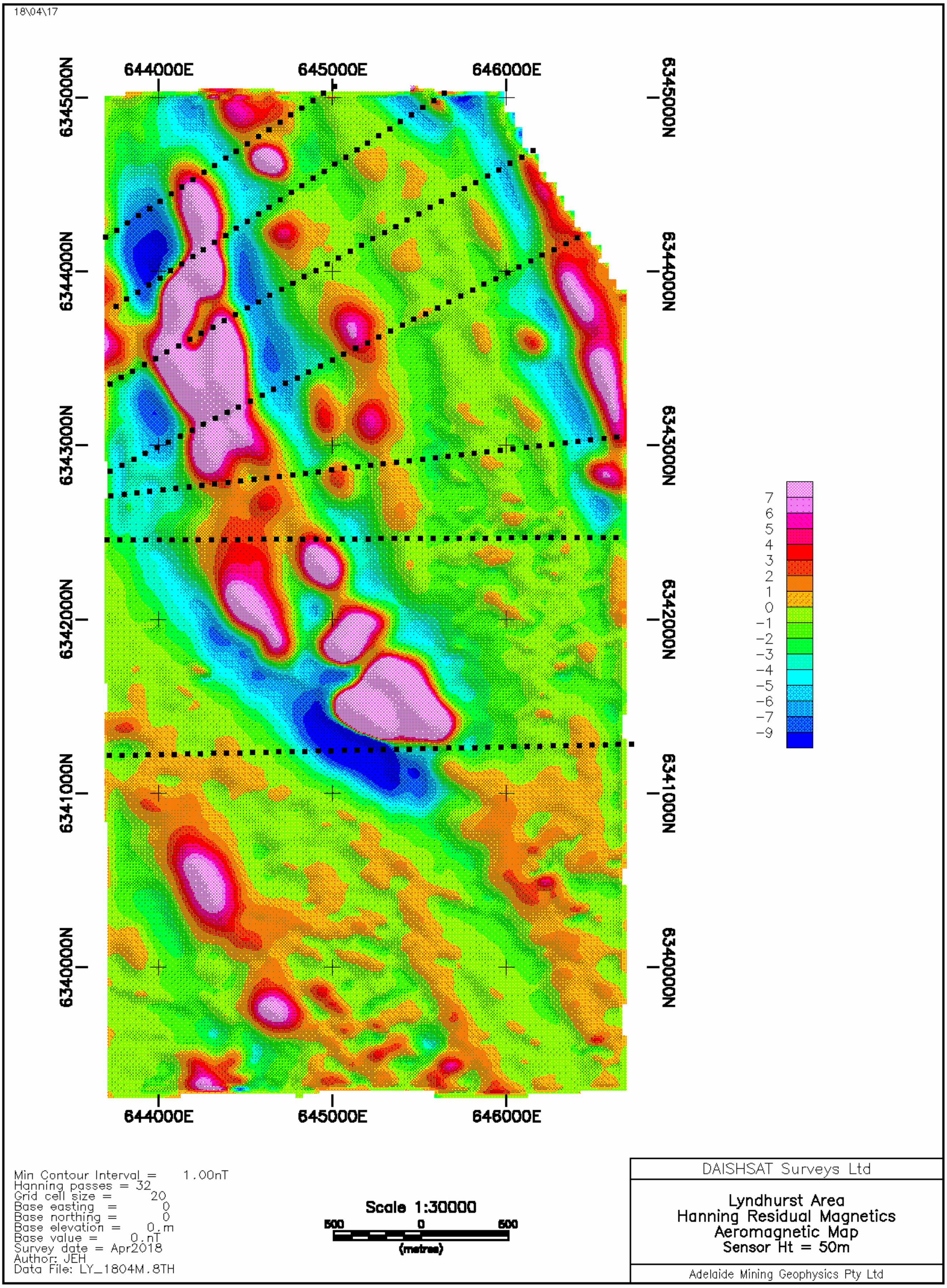


Figure 2.3b Dotted lines suggest possible faults based on truncations and discontinuities.

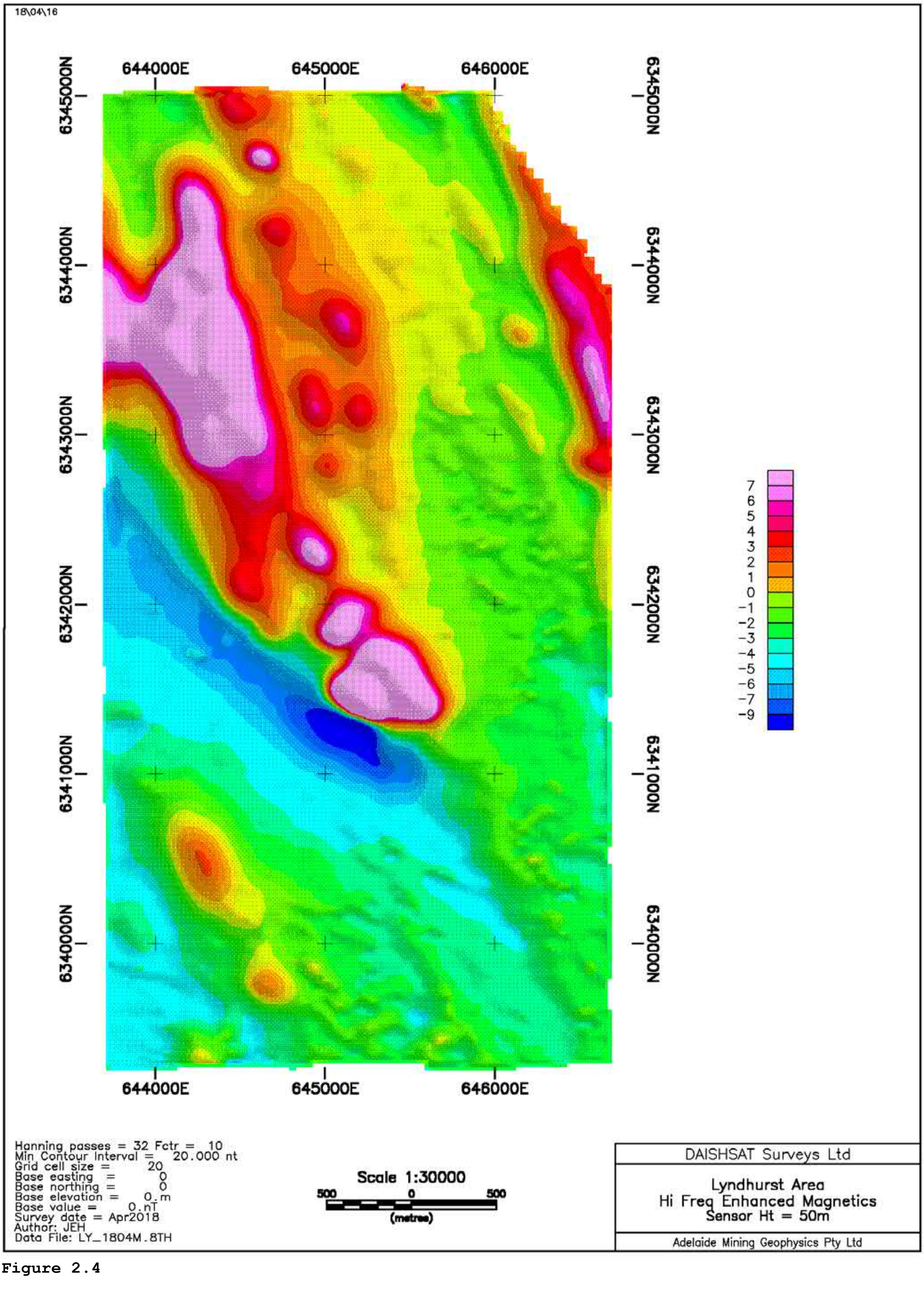

18\04\16
644000E
645000E
646000E
6345000N
6344000N
6343000N
6342000N
6341000N
6340000N
7
6
5
4
3
2
1
0
-1
-2
-3
-4
-5
-6
-7
-9
Hanning passes = 32 Fctr = 10
Min Contour Interval = 20.000 nt
Grid cell size = 20
Base easting = 0
Base northing = 0
Base elevation = 0.m
Base value = 0.nT
Survey date = Apr2018
Author: JEH
Data File: LY_1804M.8TH
Scale 1:30000
500 0 500
(metres)
DAISHSAT Surveys Ltd
Lyndhurst Area
Hi Freq Enhanced Magnetics
Sensor Ht = 50m
Adelaide Mining Geophysics Pty Ltd

Figure 2.4

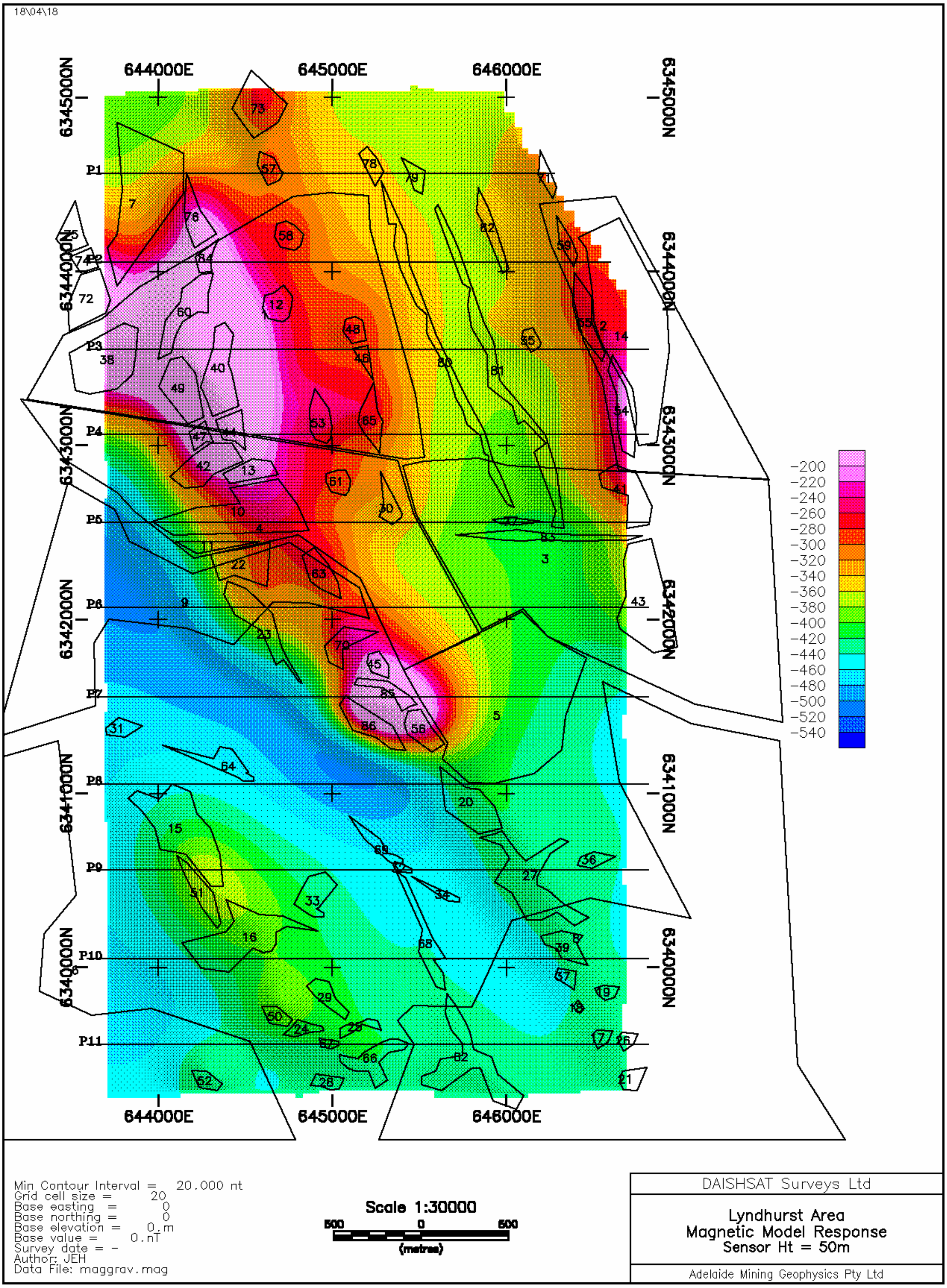
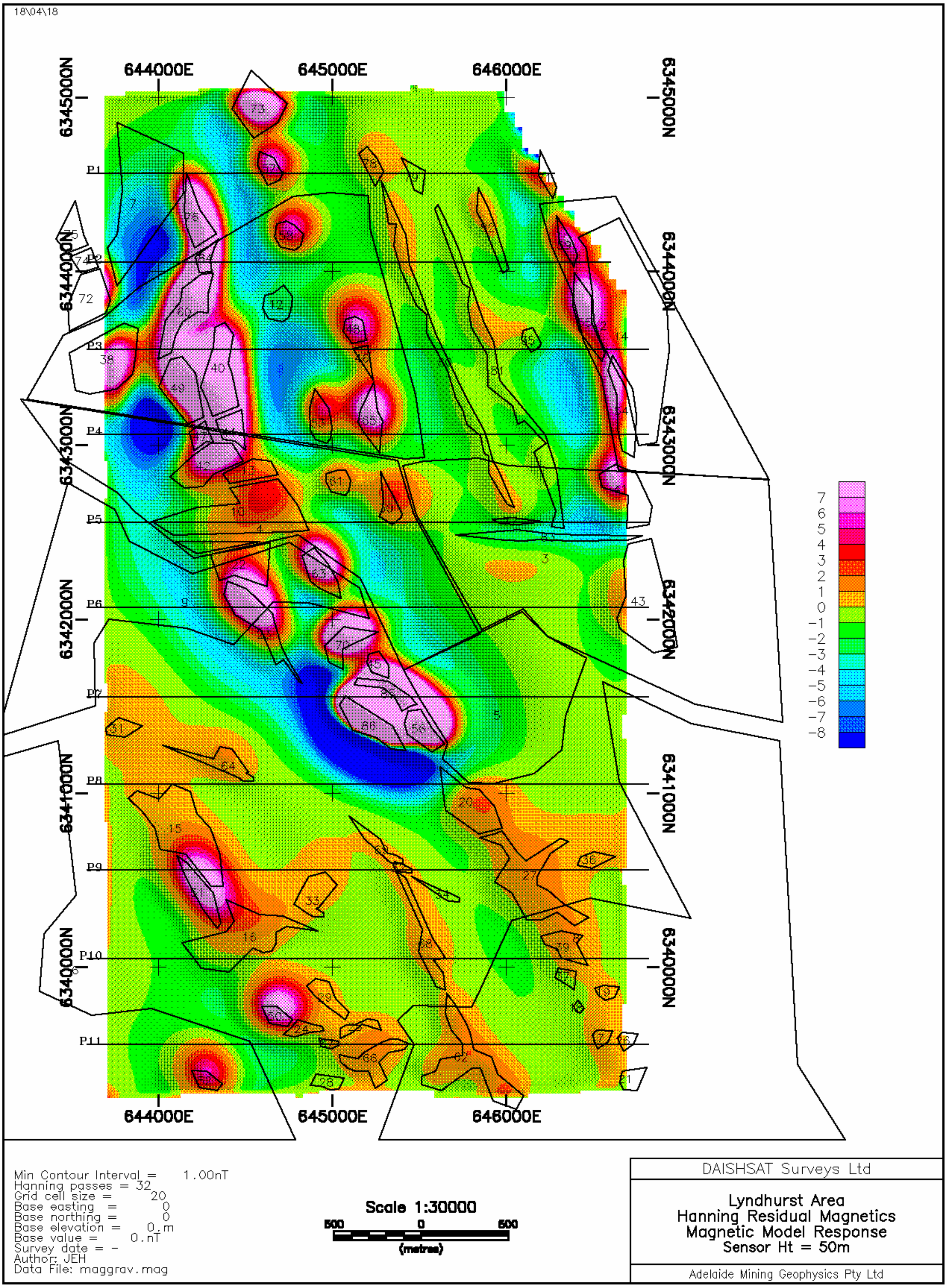

18\04\18
644000E
645000E
646000E
6345000N
6344000N
6343000N
6342000N
6341000N
6340000N
P1
P2
P3
P4
P5
P6
P7
P8
P9
P10
P11
-200
-220
-240
-260
-280
-300
-320
-340
-360
-380
-400
-420
-440
-460
-480
-500
-520
-540
Min Contour Interval = 20.000 nt
Grid cell size = 20
Base easting = 0
Base northing = 0
Base elevation = 0.m
Base value = 0.nT
Survey date = -
Author: JEH
Data File: maggrav.mag
Scale 1:30000
500 0 500
(metres)
DAISHSAT Surveys Ltd
Lyndhurst Area
Magnetic Model Response
Sensor Ht = 50m
Adelaide Mining Geophysics Pty Ltd

Figure 3.1



18\04\18
644000E
645000E
646000E
6345000N
6344000N
6343000N
6342000N
6341000N
6340000N
P1
P2
P3
P4
P5
P6
P7
P8
P9
P10
P11
7
6
5
4
3
2
1
0
-1
-2
-3
-4
-5
-6
-7
-8
Min Contour Interval = 1.00nT
Hanning passes = 32
Grid cell size = 20
Base easting = 0
Base northing = 0
Base elevation = 0.m
Base value = 0.nT
Survey date = -
Author: JEH
Data File: maggrav.mag
Scale 1:30000
500
0
500
(metres)
DAISHSAT Surveys Ltd
Lyndhurst Area
Hanning Residual Magnetics
Magnetic Model Response
Sensor Ht = 50m
Adelaide Mining Geophysics Pty Ltd

Figure 3.2

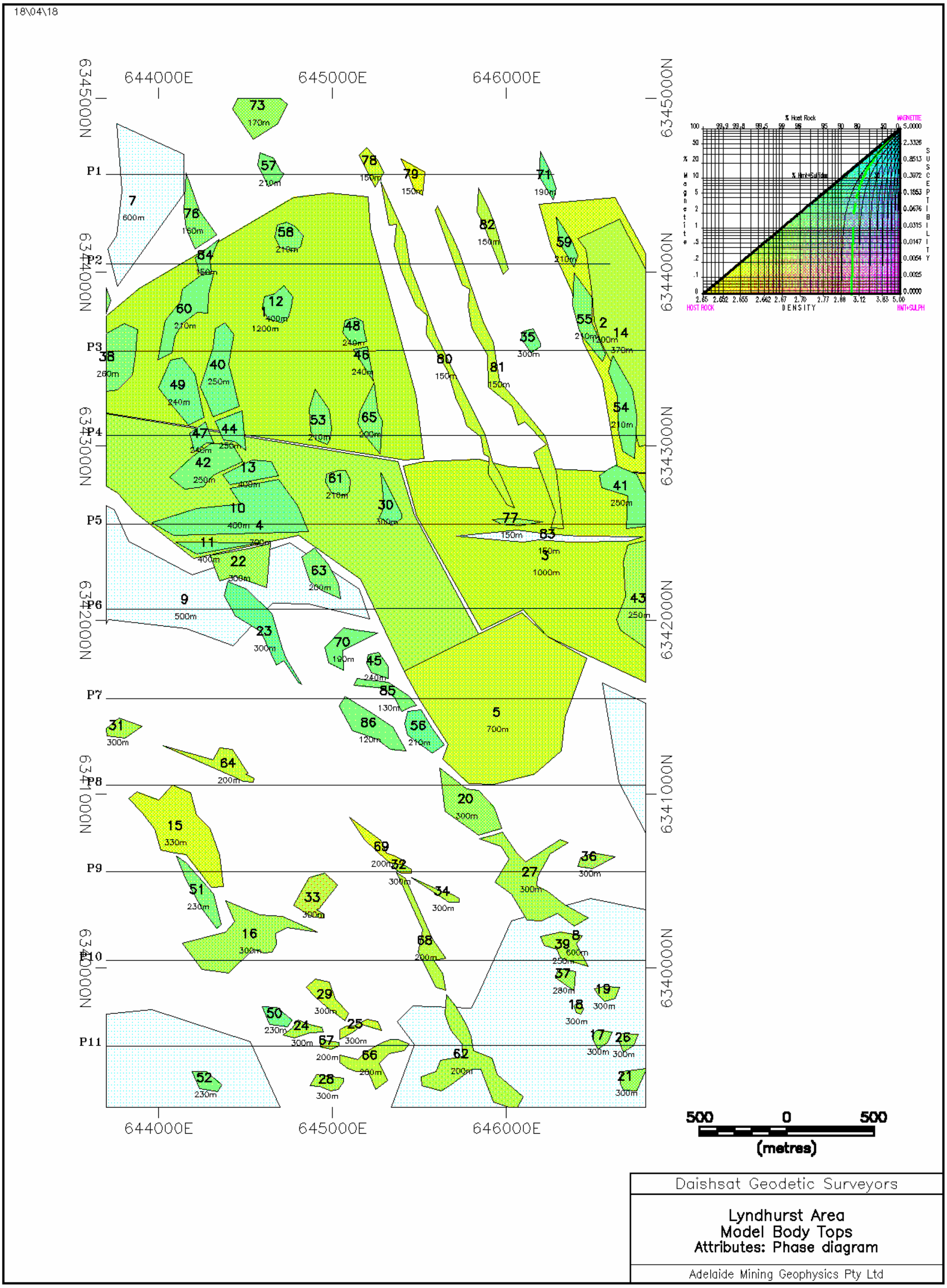

18\04\18
Daishsat Geodetic Surveyors
Lyndhurst Area
Model Body Tops
Attributes: Phase diagram
Adelaide Mining Geophysics Pty Ltd
500 0 500
(metres)

Figure 4.

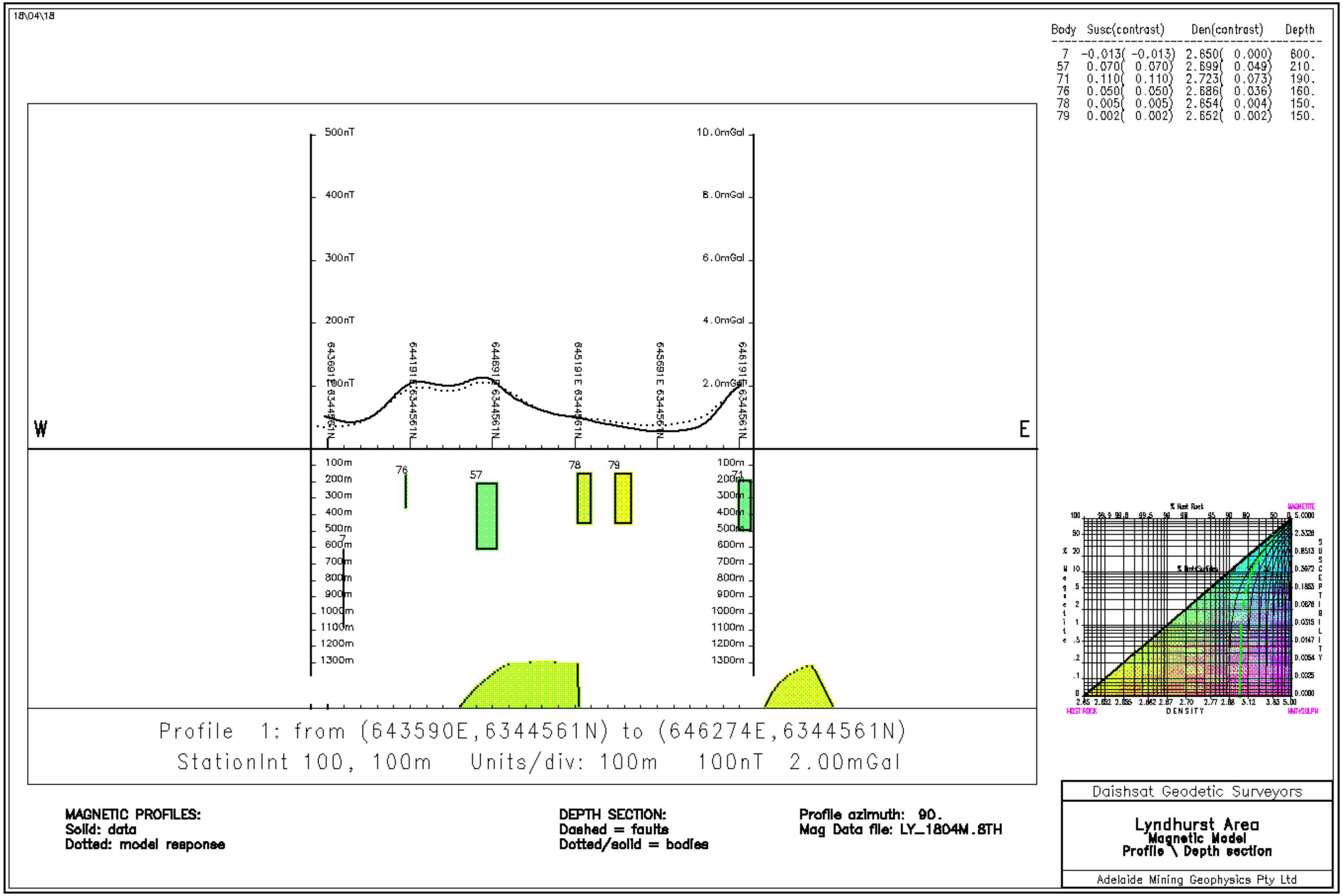
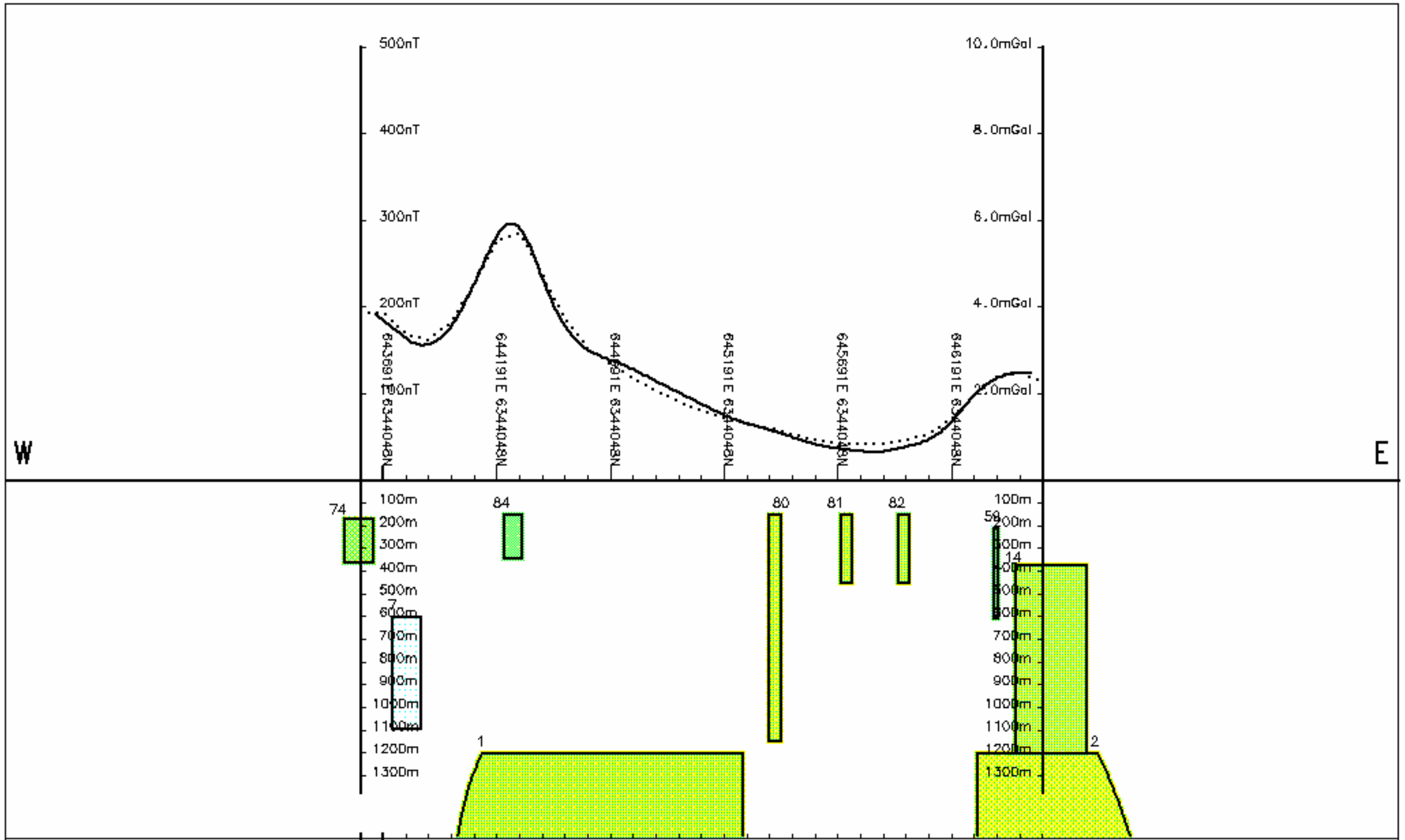

18\04\18
Body Susc(contrast) Den(contrast) Depth
7 -0.013(-0.013) 2.650(0.000) 600.
57 0.070(0.070) 2.699(0.049) 210.
71 0.110(0.110) 2.723(0.073) 190.
76 0.050(0.050) 2.686(0.036) 160.
78 0.005(0.005) 2.654(0.004) 150.
79 0.002(0.002) 2.652(0.002) 150.
W
E
500nT
400nT
300nT
200nT
100nT
10.0mGal
8.0mGal
6.0mGal
4.0mGal
2.0mGal
643691E 6344561N
644191E 6344561N
644691E 6344561N
645191E 6344561N
645691E 6344561N
646191E 6344561N
100m
200m
300m
400m
500m
600m
700m
800m
900m
1000m
1100m
1200m
1300m
76
57
78
79
71
7
Profile 1: from (643590E,6344561N) to (646274E,6344561N)
StationInt 100, 100m Units/div: 100m 100nT 2.00mGal
MAGNETIC PROFILES:
Solid: data
Dotted: model response
DEPTH SECTION:
Dashed = faults
Dotted/solid = bodies
Profile azimuth: 90.
Mag Data file: LY_1804M.STH
% Host Rock
MAGNETITE
DENSITY
HOST ROCK
HMT+SULPH
Daishsat Geodetic Surveyors
Lyndhurst Area
Magnetic Model
Profile \ Depth section
Adelaide Mining Geophysics Pty Ltd

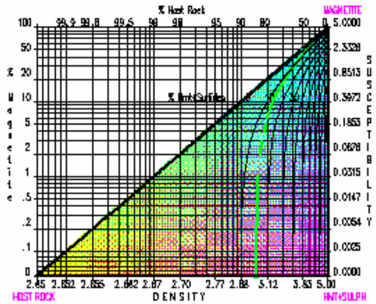
Figure 5.1

18\04\18

Body	Susc(contrast)	Den(contrast)	Depth
1	0.009(0.009)	2.654(0.004)	1200.
2	0.004(0.004)	2.654(0.004)	1200.
7	-0.013(-0.013)	2.650(0.000)	600.
14	0.011(0.011)	2.659(0.009)	370.
59	0.080(0.080)	2.705(0.055)	210.
74	0.030(0.030)	2.672(0.022)	170.
80	0.006(0.006)	2.655(0.005)	150.
81	0.006(0.006)	2.655(0.005)	150.
82	0.010(0.010)	2.658(0.008)	150.
84	0.070(0.070)	2.699(0.049)	150.



Profile 2: from (643590E,6344048N) to (646594E,6344048N)
StationInt 100, 100m Units/div: 100m 100nT 2.00mGal



MAGNETIC PROFILES:
Solid: data
Dotted: model response

DEPTH SECTION:
Dashed = faults
Dotted/solid = bodies

Profile azimuth: 90.
Mag Data file: LY_1804M.STH

Daishsat Geodetic Surveyors

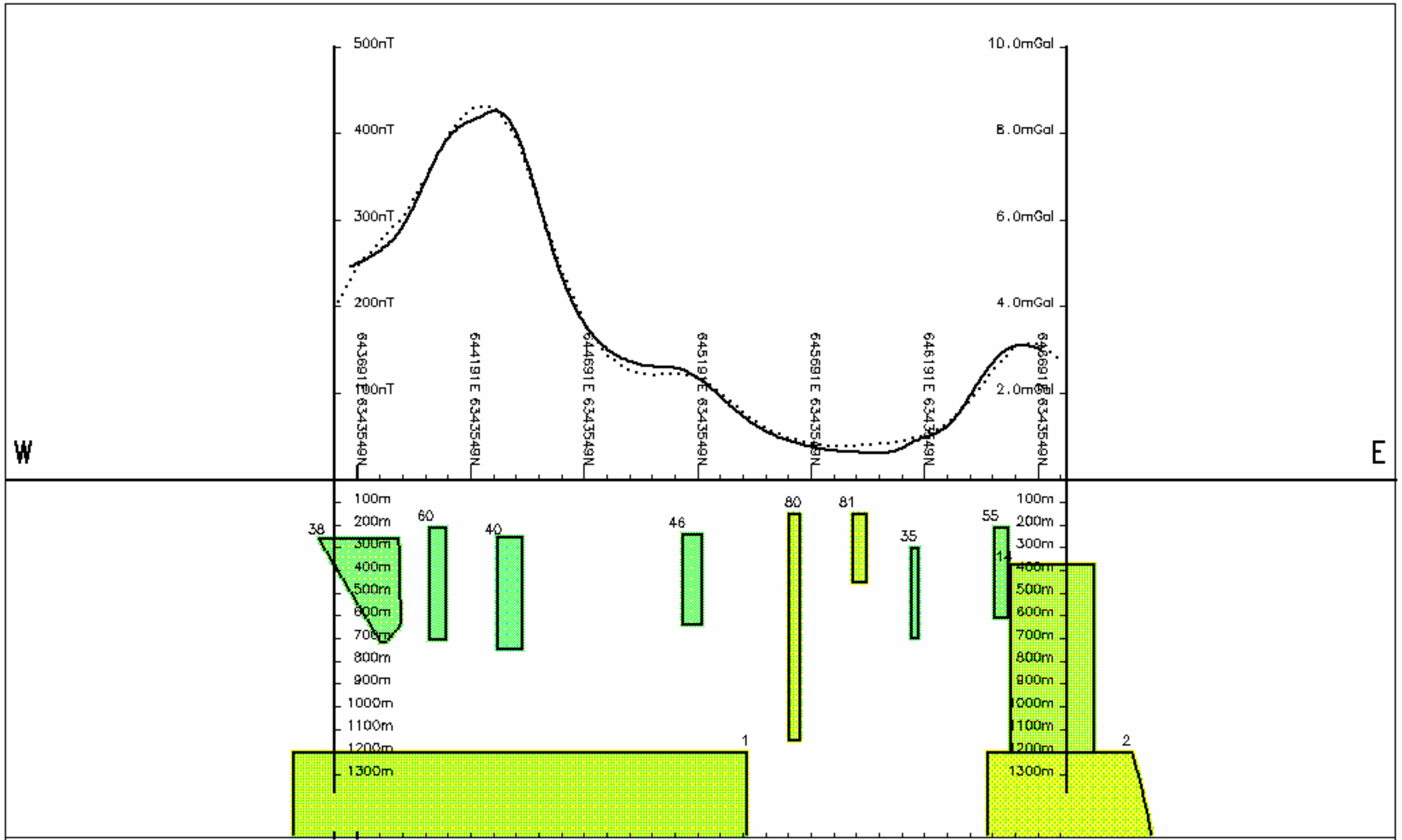
Lyndhurst Area
Magnetic Model
Profile \ Depth section

Adelaide Mining Geophysics Pty Ltd

Figure 5.2

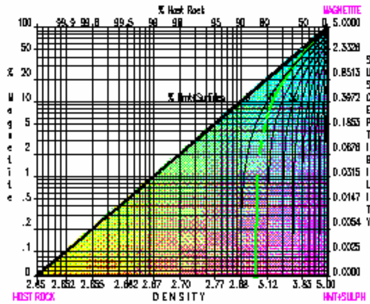
18\04\18

Body	Susc(contrast)	Den(contrast)	Depth
1	0.009(0.009)	2.654(0.004)	1200.
2	0.004(0.004)	2.654(0.004)	1200.
14	0.011(0.011)	2.659(0.009)	370.
35	0.100(0.100)	2.717(0.067)	300.
38	0.060(0.060)	2.692(0.042)	260.
40	0.100(0.100)	2.717(0.067)	250.
46	0.070(0.070)	2.699(0.049)	240.
55	0.050(0.050)	2.686(0.036)	210.
60	0.085(0.085)	2.708(0.058)	210.
80	0.006(0.006)	2.655(0.005)	150.
81	0.006(0.006)	2.655(0.005)	150.



Profile 3: from (643590E,6343549N) to (646814E,6343549N)

StationInt 100, 100m Units/div: 100m 100nT 2.00mGal



MAGNETIC PROFILES:
Solid: data
Dotted: model response

DEPTH SECTION:
Dashed = faults
Dotted/solid = bodies

Profile azimuth: 90.
Mag Data file: LY_1804M.8TH

Daishsat Geodetic Surveyors

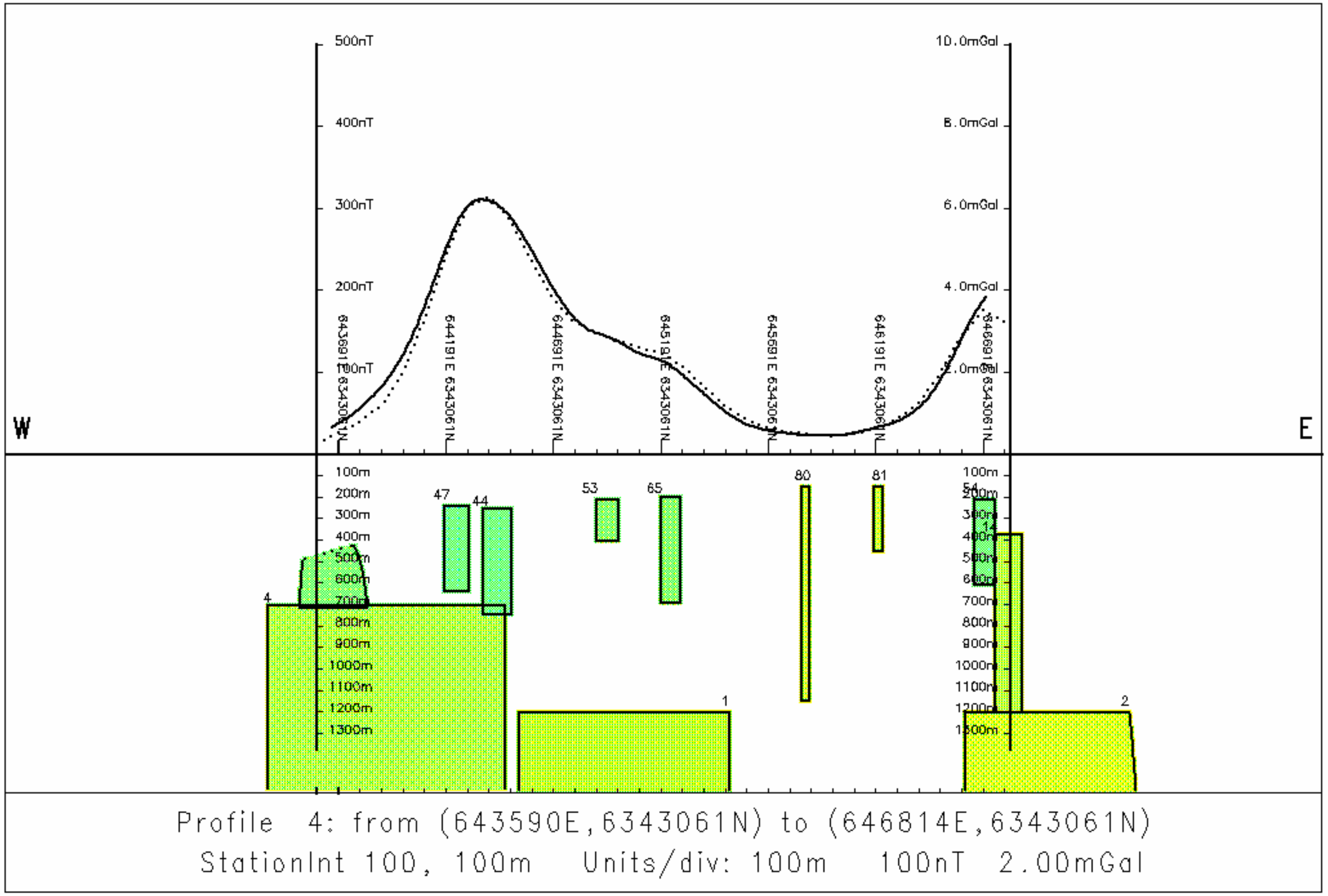
Lyndhurst Area
Magnetic Model
Profile \ Depth section

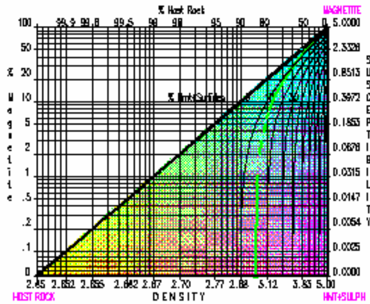
Adelaide Mining Geophysics Pty Ltd

Figure 5.3

18\04\18

Body	Susc(contrast)	Den(contrast)	Depth
1	0.009(0.009)	2.654(0.004)	1200.
2	0.004(0.004)	2.654(0.004)	1200.
4	0.013(0.013)	2.661(0.010)	700.
14	0.011(0.011)	2.659(0.009)	370.
44	0.100(0.100)	2.717(0.067)	250.
47	0.100(0.100)	2.717(0.067)	240.
53	0.050(0.050)	2.686(0.036)	210.
54	0.080(0.080)	2.705(0.055)	210.
65	0.050(0.050)	2.686(0.036)	200.
80	0.006(0.006)	2.655(0.005)	150.
81	0.006(0.006)	2.655(0.005)	150.





MAGNETIC PROFILES:
Solid: data
Dotted: model response

DEPTH SECTION:
Dashed = faults
Dotted/solid = bodies

Profile azimuth: 90.
Mag Data file: LY_1804M.8TH

Daishsat Geodetic Surveyors

Lyndhurst Area
Magnetic Model
Profile \ Depth section

Adelaide Mining Geophysics Pty Ltd

Figure 5.4

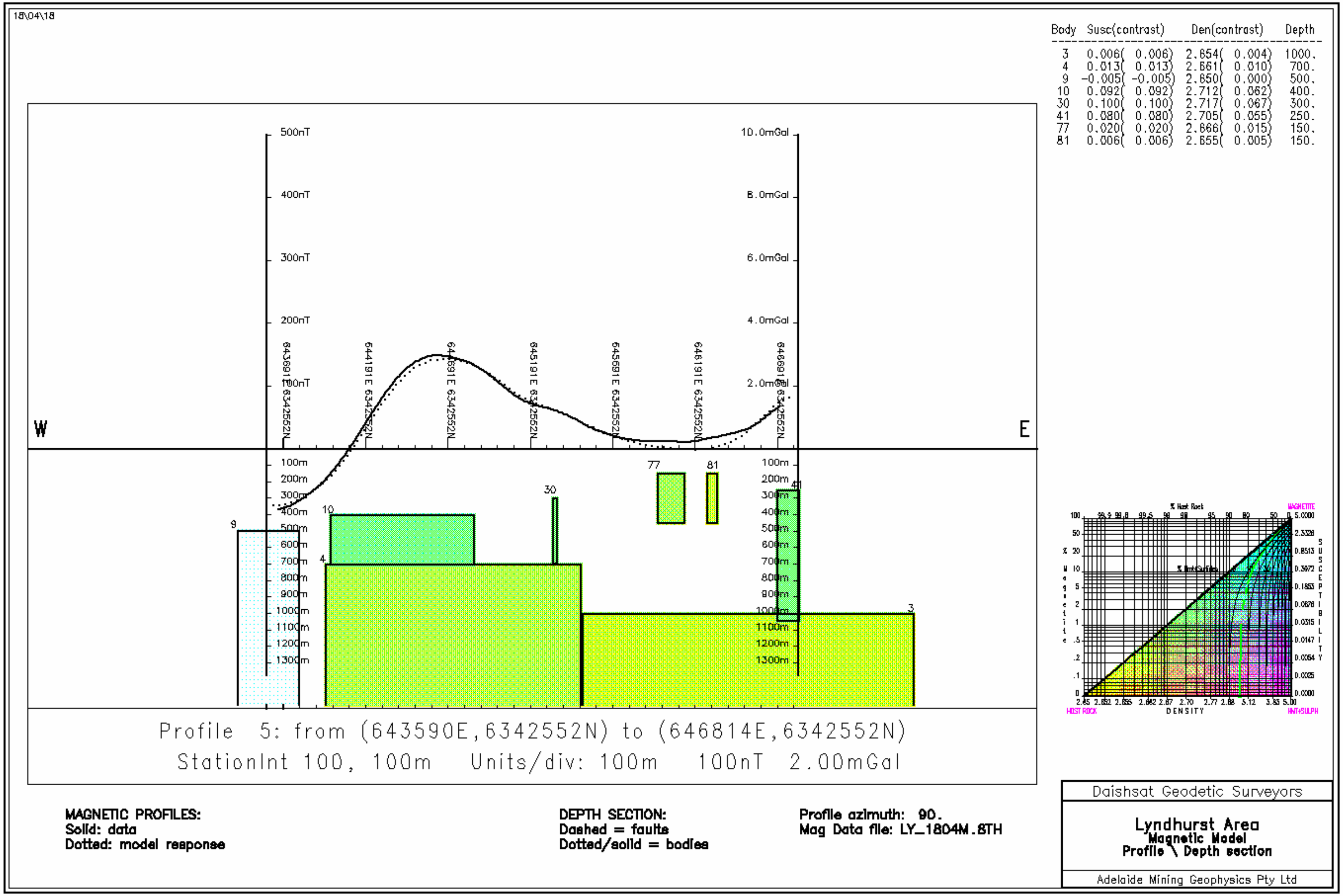

18\04\18
Body Susc(contrast) Den(contrast) Depth
3 0.006(0.006) 2.654(0.004) 1000.
4 0.013(0.013) 2.661(0.010) 700.
9 -0.005(-0.005) 2.650(0.000) 500.
10 0.092(0.092) 2.712(0.062) 400.
30 0.100(0.100) 2.717(0.067) 300.
41 0.080(0.080) 2.705(0.055) 250.
77 0.020(0.020) 2.666(0.015) 150.
81 0.006(0.006) 2.655(0.005) 150.
500nT
400nT
300nT
200nT
100nT
10.0mGal
8.0mGal
6.0mGal
4.0mGal
2.0mGal
W
E
643691E 6342552N
644191E 6342552N
644691E 6342552N
645191E 6342552N
645691E 6342552N
646191E 6342552N
646691E 6342552N
100m
200m
300m
400m
500m
600m
700m
800m
900m
1000m
1100m
1200m
1300m
9
10
4
30
77
81
41
3
Profile 5: from (643590E,6342552N) to (646814E,6342552N)
StationInt 100, 100m Units/div: 100m 100nT 2.00mGal
HOST ROCK
DENSITY
HNT+SULPH
MAGNETITE
MAGNETIC PROFILES:
Solid: data
Dotted: model response
DEPTH SECTION:
Dashed = faults
Dotted/solid = bodies
Profile azimuth: 90.
Mag Data file: LY_1804M.8TH
Daishsat Geodetic Surveyors
Lyndhurst Area
Magnetic Model
Profile \ Depth section
Adelaide Mining Geophysics Pty Ltd

Figure 5.5

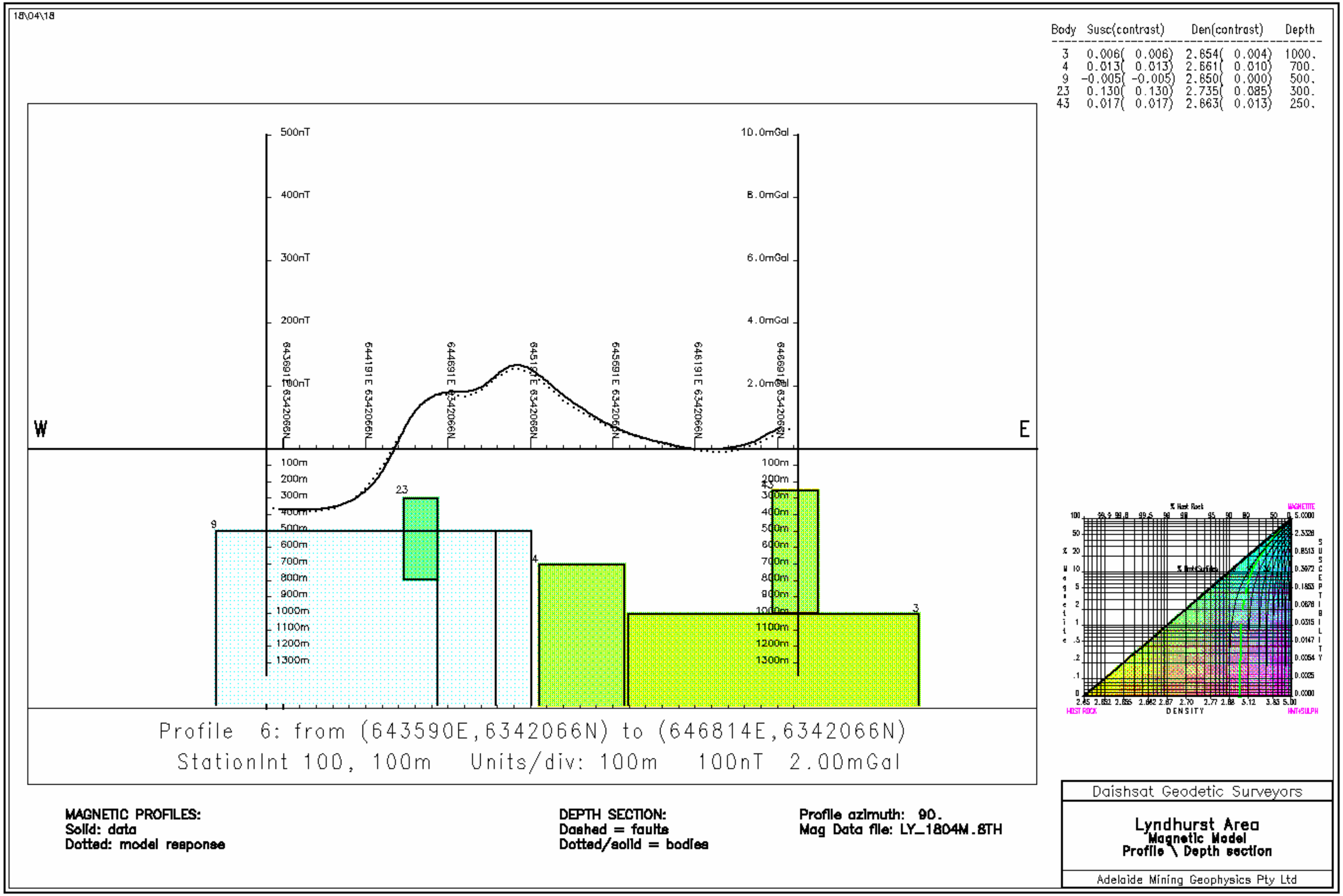

18\04\18
Body Susc(contrast) Den(contrast) Depth
3 0.006(0.006) 2.654(0.004) 1000.
4 0.013(0.013) 2.661(0.010) 700.
9 -0.005(-0.005) 2.650(0.000) 500.
23 0.130(0.130) 2.735(0.085) 300.
43 0.017(0.017) 2.663(0.013) 250.
500nT
400nT
300nT
200nT
100nT
10.0mGal
8.0mGal
6.0mGal
4.0mGal
2.0mGal
W
E
643691E 6342066N
644191E 6342066N
644691E 6342066N
645191E 6342066N
645691E 6342066N
646191E 6342066N
646691E 6342066N
100m
200m
300m
400m
500m
600m
700m
800m
900m
1000m
1100m
1200m
1300m
9
23
4
43
3
Profile 6: from (643590E,6342066N) to (646814E,6342066N)
StationInt 100, 100m Units/div: 100m 100nT 2.00mGal
DENSITY
HOST ROCK
MAGNETITE
% Host Rock
Daishsat Geodetic Surveyors
Lyndhurst Area
Magnetic Model
Profile \ Depth section
Adelaide Mining Geophysics Pty Ltd
MAGNETIC PROFILES:
Solid: data
Dotted: model response
DEPTH SECTION:
Dashed = faults
Dotted/solid = bodies
Profile azimuth: 90.
Mag Data file: LY_1804M.8TH

Figure 5.6

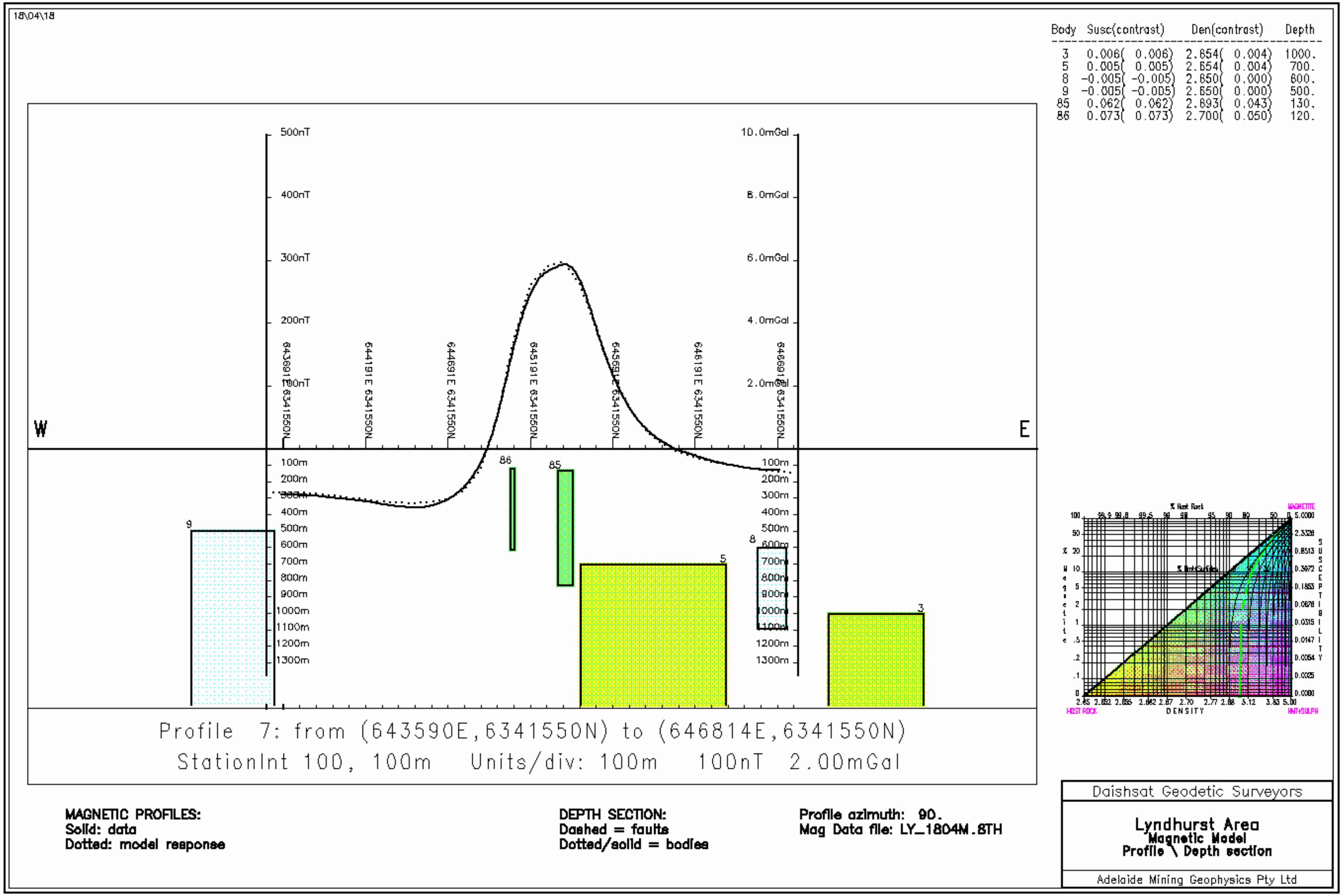

18\04\18
Body Susc(contrast) Den(contrast) Depth
3 0.006(0.006) 2.654(0.004) 1000.
5 0.005(0.005) 2.654(0.004) 700.
8 -0.005(-0.005) 2.650(0.000) 600.
9 -0.005(-0.005) 2.650(0.000) 500.
85 0.062(0.062) 2.693(0.043) 130.
86 0.073(0.073) 2.700(0.050) 120.
W
E
Profile 7: from (643590E,6341550N) to (646814E,6341550N)
StationInt 100, 100m Units/div: 100m 100nT 2.00mGal
MAGNETIC PROFILES:
Solid: data
Dotted: model response
DEPTH SECTION:
Dashed = faults
Dotted/solid = bodies
Profile azimuth: 90.
Mag Data file: LY_1804M.STH
Daishsat Geodetic Surveyors
Lyndhurst Area
Magnetic Model
Profile \ Depth section
Adelaide Mining Geophysics Pty Ltd

Figure 5.7

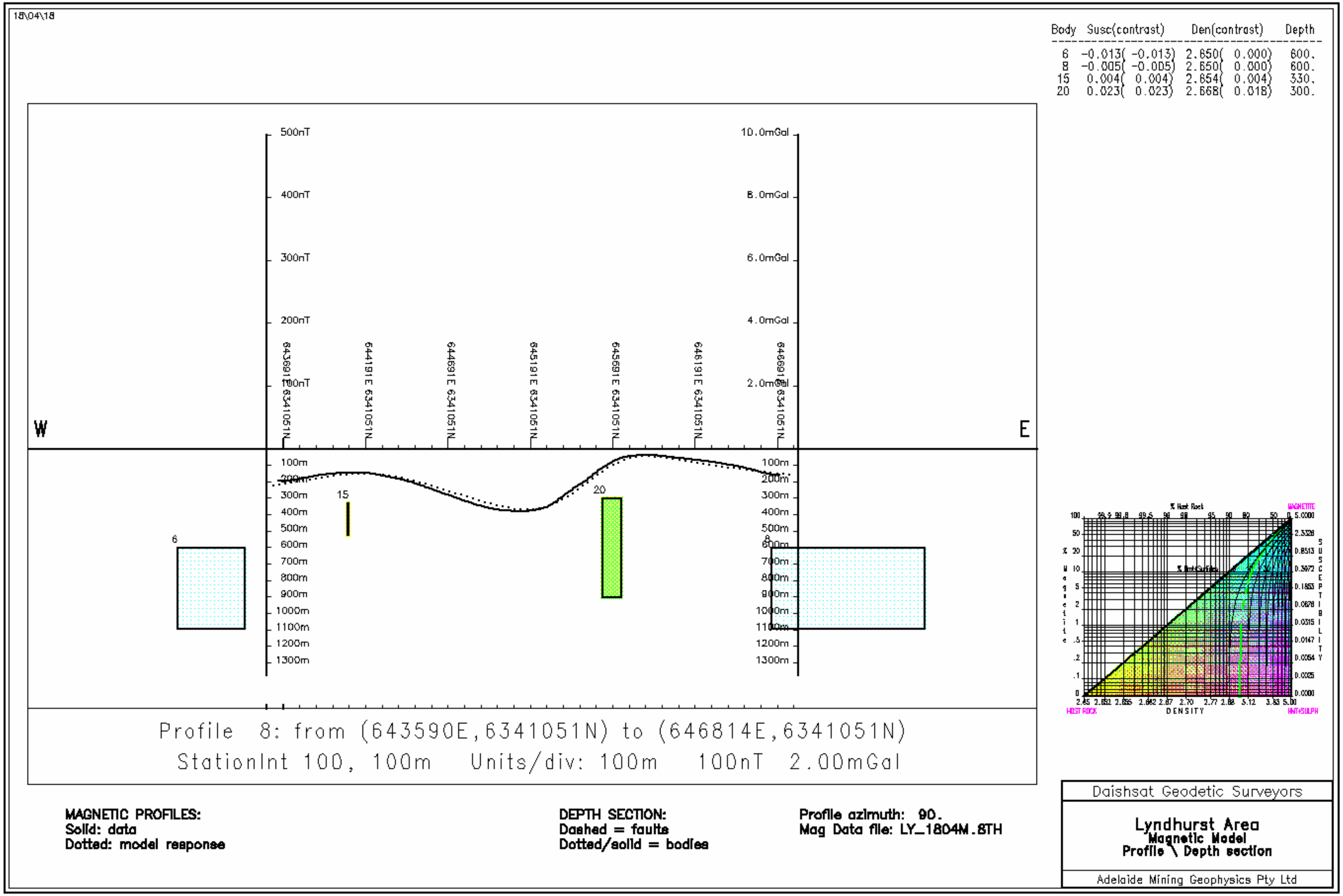
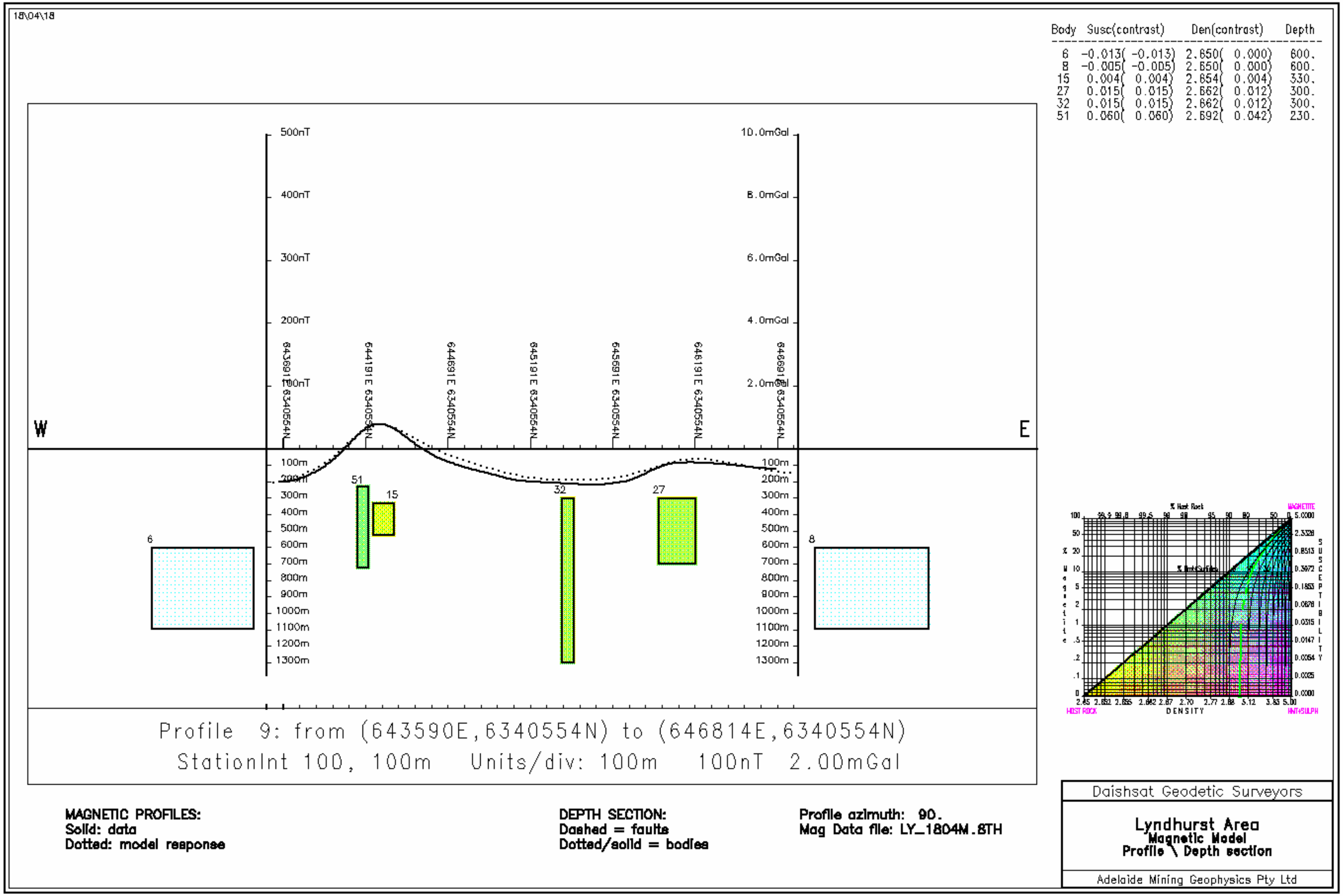

18\04\18
Body Susc(contrast) Den(contrast) Depth
6 -0.013(-0.013) 2.650(0.000) 600.
8 -0.005(-0.005) 2.650(0.000) 600.
15 0.004(0.004) 2.654(0.004) 330.
20 0.023(0.023) 2.668(0.018) 300.
500nT
400nT
300nT
200nT
100nT
10.0mGal
8.0mGal
6.0mGal
4.0mGal
2.0mGal
W
E
643691E 6341051N
644191E 6341051N
644691E 6341051N
645191E 6341051N
645691E 6341051N
646191E 6341051N
646691E 6341051N
100m
200m
300m
400m
500m
600m
700m
800m
900m
1000m
1100m
1200m
1300m
6
8
15
20
Profile 8: from (643590E,6341051N) to (646814E,6341051N)
StationInt 100, 100m Units/div: 100m 100nT 2.00mGal
MAGNETIC PROFILES:
Solid: data
Dotted: model response
DEPTH SECTION:
Dashed = faults
Dotted/solid = bodies
Profile azimuth: 90.
Mag Data file: LY_1804M.8TH
DENSITY
Daishsat Geodetic Surveyors
Lyndhurst Area
Magnetic Model
Profile \ Depth section
Adelaide Mining Geophysics Pty Ltd

Figure 5.8



18\04\18
Body Susc(contrast) Den(contrast) Depth
6 -0.013(-0.013) 2.650(0.000) 600.
8 -0.005(-0.005) 2.650(0.000) 600.
15 0.004(0.004) 2.654(0.004) 330.
27 0.015(0.015) 2.662(0.012) 300.
32 0.015(0.015) 2.662(0.012) 300.
51 0.060(0.060) 2.692(0.042) 230.
W
E
Profile 9: from (643590E,6340554N) to (646814E,6340554N)
StationInt 100, 100m Units/div: 100m 100nT 2.00mGal
MAGNETIC PROFILES:
Solid: data
Dotted: model response
DEPTH SECTION:
Dashed = faults
Dotted/solid = bodies
Profile azimuth: 90.
Mag Data file: LY_1804M.STH
Daishsat Geodetic Surveyors
Lyndhurst Area
Magnetic Model
Profile \ Depth section
Adelaide Mining Geophysics Pty Ltd

Figure 5.9

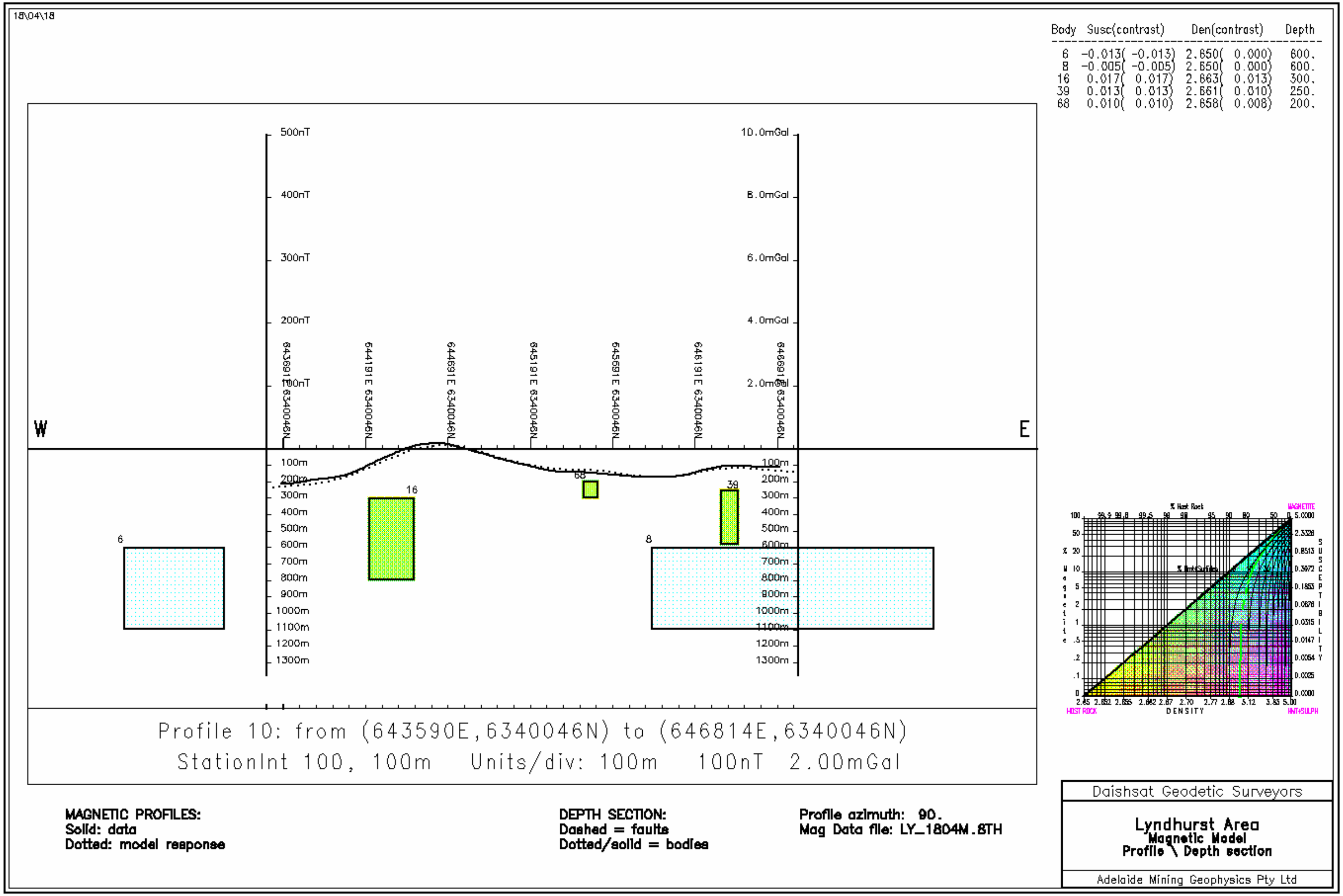

18\04\18
Body Susc(contrast) Den(contrast) Depth
6 -0.013(-0.013) 2.650(0.000) 600.
8 -0.005(-0.005) 2.650(0.000) 600.
16 0.017(0.017) 2.663(0.013) 300.
39 0.013(0.013) 2.661(0.010) 250.
68 0.010(0.010) 2.658(0.008) 200.
W
E
Profile 10: from (643590E,6340046N) to (646814E,6340046N)
StationInt 100, 100m Units/div: 100m 100nT 2.00mGal
MAGNETIC PROFILES:
Solid: data
Dotted: model response
DEPTH SECTION:
Dashed = faults
Dotted/solid = bodies
Profile azimuth: 90.
Mag Data file: LY_1804M.8TH
Daishsat Geodetic Surveyors
Lyndhurst Area
Magnetic Model
Profile \ Depth section
Adelaide Mining Geophysics Pty Ltd

Figure 5.10

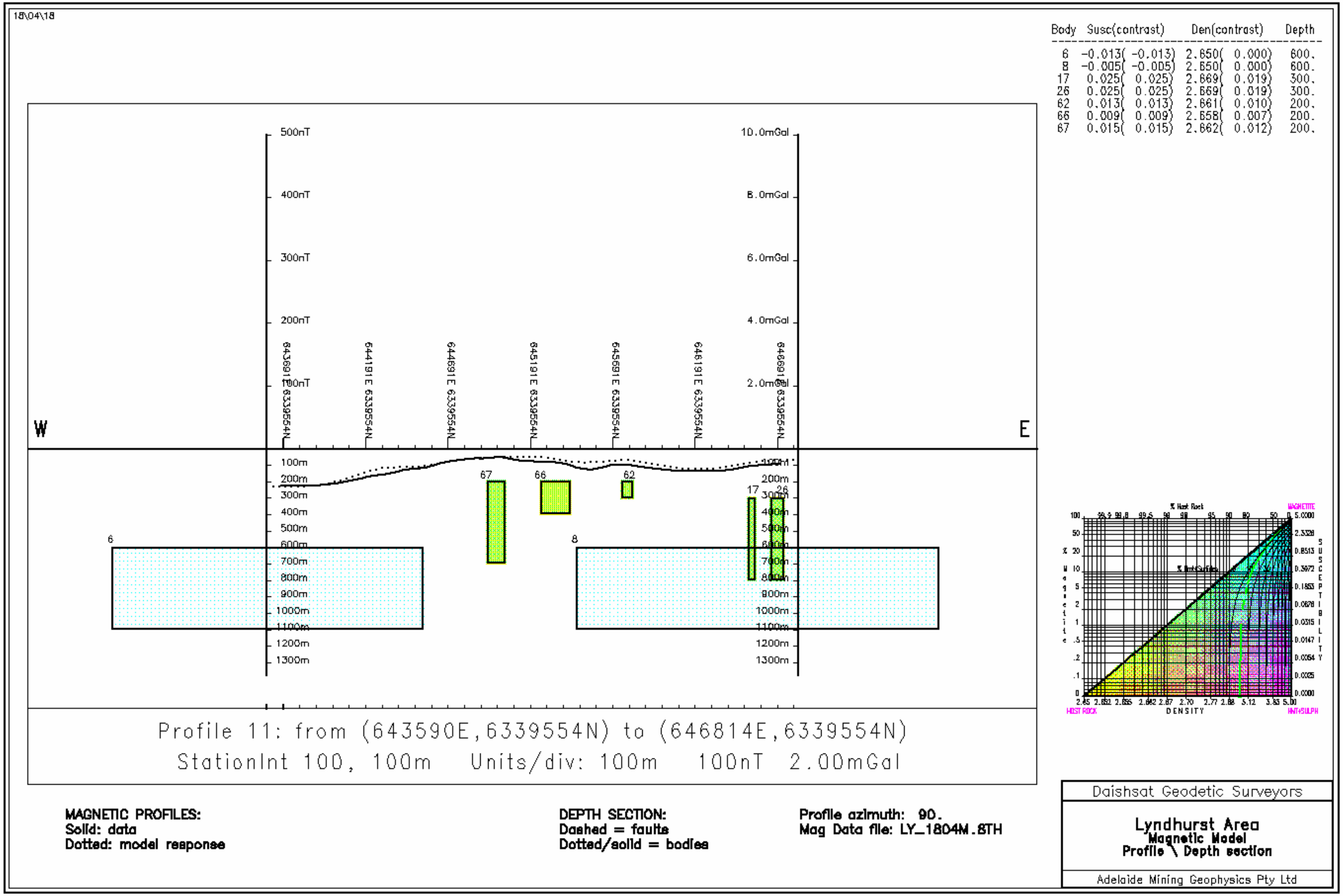

18\04\18
Body Susc(contrast) Den(contrast) Depth
6 -0.013(-0.013) 2.650(0.000) 600.
8 -0.005(-0.005) 2.650(0.000) 600.
17 0.025(0.025) 2.669(0.019) 300.
26 0.025(0.025) 2.669(0.019) 300.
62 0.013(0.013) 2.661(0.010) 200.
66 0.009(0.009) 2.658(0.007) 200.
67 0.015(0.015) 2.662(0.012) 200.
500nT
400nT
300nT
200nT
100nT
10.0mGal
8.0mGal
6.0mGal
4.0mGal
2.0mGal
W
E
643691E 6339554N
644191E 6339554N
644691E 6339554N
645191E 6339554N
645691E 6339554N
646191E 6339554N
646691E 6339554N
100m
200m
300m
400m
500m
600m
700m
800m
900m
1000m
1100m
1200m
1300m
6
8
17
26
62
66
67
Profile 11: from (643590E,6339554N) to (646814E,6339554N)
StationInt 100, 100m Units/div: 100m 100nT 2.00mGal
MAGNETIC PROFILES:
Solid: data
Dotted: model response
DEPTH SECTION:
Dashed = faults
Dotted/solid = bodies
Profile azimuth: 90.
Mag Data file: LY_1804M.STH
DENSITY
HOST ROCK
MAGNETITE
Daishsat Geodetic Surveyors
Lyndhurst Area
Magnetic Model
Profile \ Depth section
Adelaide Mining Geophysics Pty Ltd

Figure 5.11

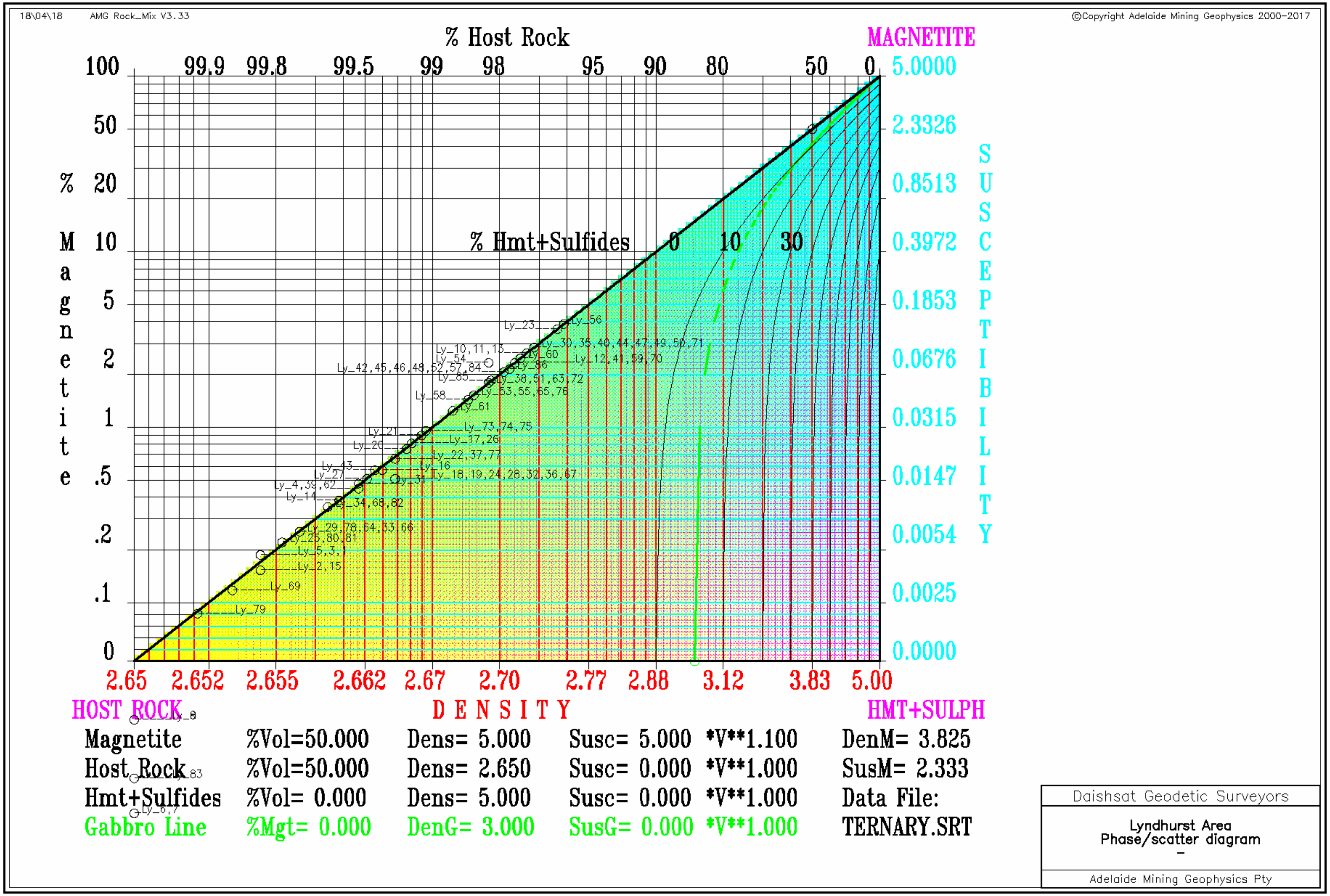

18\04\18
AMG Rock_Mix V3.33
©Copyright Adelaide Mining Geophysics 2000-2017
% Host Rock
MAGNETITE
100 99.9 99.8 99.5 99 98 95 90 80 50 0
5.0000
2.3326
0.8513
0.3972
0.1853
0.0676
0.0315
0.0147
0.0054
0.0025
0.0000
SUSCEPTIBILITY
% Magnetite
100 50 20 10 5 2 1 .5 .2 .1 0
% Hmt+Sulfides 0 10 30
2.65 2.652 2.655 2.662 2.67 2.70 2.77 2.88 3.12 3.83 5.00
HOST ROCK
DENSITY
HMT+SULPH
Magnetite %Vol=50.000 Dens= 5.000 Susc= 5.000 *V**1.100 DenM= 3.825
Host Rock %Vol=50.000 Dens= 2.650 Susc= 0.000 *V**1.000 SusM= 2.333
Hmt+Sulfides %Vol= 0.000 Dens= 5.000 Susc= 0.000 *V**1.000 Data File:
Gabbro Line %Mgt= 0.000 DenG= 3.000 SusG= 0.000 *V**1.000 TERNARY.SRT
Daishsat Geodetic Surveyors
Lyndhurst Area
Phase/scatter diagram
Adelaide Mining Geophysics Pty

Figure 6.

Table 1. Magnetic/Gravity Model specification report for use with Plan Map of Body Tops

Title: Lyndhurst Area
Client: Daishsat Geodetic Surveyors
User: Adelaide Mining Geophysics Pty Ltd

Magnetic data file name: LY_1804M.8TH

Intensity = 58290. Declination = 7.
Inclination = -65. Magnetometer height: 50.0m

Hmt+sulf Density = 5.00 Magnetite Density = 5.00
Magnetite MagSus = 5.00 Power Law Exponent = 1.10
CountryRock Dens = 2.65 Mafic Rock Density = 3.00
CountryRock Susc = 0.00

Number of Bodies = 86 Number of Faults = 0
Number of Profiles = 11 Gauss quad order = 10
Station Interval =100 Scale = 100nT/div

Body	No of Verts	Depth	Dip Extnt	Plng Azmth	Plng	Susc (SI)	Rem Dec	Rem Inc	K-Ratio	Density t/m**3	App%Mgt	App%Hmt (Felsic)	Volume m**3	ExcessMass tonnes	Total Mass tonnes	Centroid E	Centroid N
1	11	1200.	1500.	0.	90.	0.0090	0.	90.	0.00	0.004	0.32	-0.13	0.434E+10	0.191E+08	0.115E+11	644625	6343749
	(Except: Az= 0., Plg= 40. at 644775.4E, 6344431.0N)																
	(Except: Az= 0., Plg= 40. at 644989.1E, 6344454.5N)																
	(Except: Az= 0., Plg= 40. at 645207.7E, 6344433.5N)																
2	8	1200.	1500.	0.	90.	0.0040	0.	90.	0.00	0.004	0.15	0.00	0.237E+10	0.853E+07	0.629E+10	646573	6343687
	(Except: Az= 0., Plg= 40. at 646625.1E, 6344429.5N)																
3	11	1000.	1600.	0.	90.	0.0060	0.	90.	0.00	0.004	0.22	-0.07	0.349E+10	0.126E+08	0.926E+10	646240	6342348
4	11	700.	1600.	0.	90.	0.0130	0.	90.	0.00	0.010	0.45	0.00	0.236E+10	0.248E+08	0.628E+10	644598	6342522
5	12	700.	1600.	0.	90.	0.0050	0.	90.	0.00	0.004	0.19	0.00	0.104E+10	0.458E+07	0.276E+10	645960	6341448
6	11	600.	500.	0.	90.	-0.0130	0.	90.	0.00	0.000	-	-	0.113E+10	0.000E+00	0.299E+10	643540	6339985
7	7	600.	500.	0.	90.	-0.0130	0.	90.	0.00	0.000	-	-	0.111E+09	0.000E+00	0.295E+09	643869	6344387
8	15	600.	500.	0.	90.	-0.0050	0.	90.	0.00	0.000	-	-	0.184E+10	0.000E+00	0.488E+10	646416	6340166
9	15	500.	1600.	0.	90.	-0.0050	0.	90.	0.00	0.000	-	-	0.169E+10	0.000E+00	0.447E+10	644169	6342096
10	9	400.	300.	0.	90.	0.0920	0.	90.	0.00	0.062	2.65	0.00	0.485E+08	0.301E+07	0.131E+09	644472	6342621
11	3	400.	300.	0.	90.	0.0920	0.	90.	0.00	0.062	2.65	0.00	0.492E+07	0.306E+06	0.133E+08	644301	6342423
12	9	400.	500.	0.	90.	0.0800	0.	90.	0.00	0.055	2.33	0.00	0.123E+08	0.675E+06	0.333E+08	644692	6343809
13	5	400.	300.	0.	90.	0.0920	0.	90.	0.00	0.062	2.65	0.00	0.804E+07	0.500E+06	0.218E+08	644532	6342855
14	12	370.	830.	0.	90.	0.0110	0.	90.	0.00	0.009	0.38	0.00	0.306E+09	0.276E+07	0.814E+09	646673	6343627
15	15	330.	200.	0.	90.	0.0040	0.	90.	0.00	0.004	0.15	0.00	0.278E+08	0.100E+06	0.739E+08	644112	6340797
16	15	300.	500.	0.	90.	0.0170	0.	90.	0.00	0.013	0.57	0.00	0.603E+08	0.808E+06	0.161E+09	644540	6340175
17	6	300.	500.	0.	90.	0.0250	0.	90.	0.00	0.019	0.81	0.00	0.381E+07	0.724E+05	0.102E+08	646538	6339595
18	5	300.	1000.	0.	90.	0.0150	0.	90.	0.00	0.012	0.51	0.00	0.241E+07	0.290E+05	0.642E+07	646414	6339768
19	6	300.	1000.	0.	90.	0.0150	0.	90.	0.00	0.012	0.51	0.00	0.816E+07	0.979E+05	0.217E+08	646572	6339857
20	8	300.	600.	0.	90.	0.0230	0.	90.	0.00	0.018	0.75	0.00	0.405E+08	0.712E+06	0.108E+09	645782	6340951
21	6	300.	500.	0.	90.	0.0280	0.	90.	0.00	0.021	0.90	0.00	0.683E+07	0.144E+06	0.183E+08	646700	6339357
22	6	300.	700.	0.	90.	0.0200	0.	90.	0.00	0.015	0.66	0.00	0.392E+08	0.608E+06	0.105E+09	644477	6342315
23	13	300.	500.	0.	90.	0.1300	0.	90.	0.00	0.085	3.62	0.00	0.305E+08	0.259E+07	0.833E+08	644624	6341914

Body	No of Verts	Depth	Dip Extnt	Plng Azmth	Plng	Susc (SI)	Rem Dec	Rem Inc	K-Ratio	Density t/m**3	App%Mgt	App%Hmt (Felsic)	Volume m**3	ExcessMass tonnes	Total Mass tonnes	Centroid E	Centroid N
24	8	300.	500.	0.	90.	0.0150	0.	90.	0.00	0.012	0.51	0.00	0.577E+07	0.693E+05	0.154E+08	644839	6339646
25	9	300.	500.	0.	90.	0.0060	0.	90.	0.00	0.005	0.22	0.00	0.452E+07	0.235E+05	0.120E+08	645147	6339658
26	6	300.	500.	0.	90.	0.0250	0.	90.	0.00	0.019	0.81	0.00	0.381E+07	0.724E+05	0.102E+08	646685	6339579
27	21	300.	400.	0.	90.	0.0150	0.	90.	0.00	0.012	0.51	0.00	0.431E+08	0.518E+06	0.115E+09	646151	6340530
28	8	300.	500.	0.	90.	0.0150	0.	90.	0.00	0.012	0.51	0.00	0.586E+07	0.703E+05	0.156E+08	644982	6339340
29	8	300.	500.	0.	90.	0.0070	0.	90.	0.00	0.006	0.25	0.00	0.109E+08	0.655E+05	0.290E+08	644973	6339828
30	7	300.	400.	0.	90.	0.1000	0.	90.	0.00	0.067	2.85	0.00	0.707E+07	0.475E+06	0.192E+08	645324	6342640
31	5	300.	300.	0.	90.	0.0140	0.	90.	0.00	0.011	0.48	0.00	0.426E+07	0.477E+05	0.113E+08	643779	6341372
32	7	300.	1000.	0.	90.	0.0150	0.	90.	0.00	0.012	0.51	0.00	0.397E+07	0.476E+05	0.106E+08	645398	6340572
33	11	300.	300.	0.	90.	0.0070	0.	90.	0.00	0.008	0.25	0.10	0.107E+08	0.890E+05	0.285E+08	644902	6340383
34	7	300.	1000.	0.	90.	0.0100	0.	90.	0.00	0.008	0.35	0.00	0.726E+07	0.603E+05	0.193E+08	645648	6340420
35	7	300.	400.	0.	90.	0.1000	0.	90.	0.00	0.067	2.85	0.00	0.381E+07	0.256E+06	0.104E+08	646138	6343604
36	5	300.	1000.	0.	90.	0.0150	0.	90.	0.00	0.015	0.51	0.15	0.114E+08	0.176E+06	0.303E+08	646490	6340618
37	4	280.	320.	0.	90.	0.0200	0.	90.	0.00	0.015	0.66	0.00	0.287E+07	0.445E+05	0.765E+07	646341	6339947
38	9	260.	460.	0.	108.	0.0600	0.	90.	0.00	0.042	1.79	0.00	0.825E+08	0.348E+07	0.222E+09	643721	6343491
	(Except: Az= 0., Plg= 138. at 643606.4E, 6343296.5N)																
	(Except: Az= 0., Plg= 138. at 643524.1E, 6343316.0N)																
	(Except: Az= 0., Plg= 148. at 643763.6E, 6343324.5N)																
39	9	250.	330.	0.	90.	0.0130	0.	90.	0.00	0.010	0.45	0.00	0.907E+07	0.953E+05	0.241E+08	646339	6340116
40	10	250.	500.	0.	90.	0.1000	0.	90.	0.00	0.067	2.85	0.00	0.348E+08	0.233E+07	0.945E+08	644358	6343445
41	10	250.	800.	0.	90.	0.0800	0.	90.	0.00	0.055	2.33	0.00	0.436E+08	0.239E+07	0.118E+09	646673	6342749
42	8	250.	470.	0.	90.	0.0700	0.	90.	0.00	0.049	2.06	0.00	0.273E+08	0.132E+07	0.737E+08	644275	6342881
43	9	250.	750.	0.	90.	0.0170	0.	90.	0.00	0.013	0.57	0.00	0.107E+09	0.144E+07	0.286E+09	646773	6342104
44	5	250.	500.	0.	90.	0.1000	0.	90.	0.00	0.067	2.85	0.00	0.112E+08	0.752E+06	0.304E+08	644424	6343077
45	6	240.	700.	0.	90.	0.0700	0.	90.	0.00	0.049	2.06	0.00	0.880E+07	0.427E+06	0.238E+08	645256	6341743
46	3	240.	400.	0.	90.	0.0700	0.	90.	0.00	0.049	2.06	0.00	0.338E+07	0.164E+06	0.912E+07	645185	6343501
47	6	240.	400.	0.	90.	0.1000	0.	90.	0.00	0.067	2.85	0.00	0.489E+07	0.328E+06	0.133E+08	644256	6343051
48	7	240.	400.	0.	90.	0.0700	0.	90.	0.00	0.049	2.06	0.00	0.595E+07	0.289E+06	0.161E+08	645133	6343668
49	7	240.	400.	0.	90.	0.1000	0.	90.	0.00	0.067	2.85	0.00	0.237E+08	0.159E+07	0.645E+08	644129	6343329
50	5	230.	900.	0.	90.	0.1000	0.	90.	0.00	0.067	2.85	0.00	0.110E+08	0.739E+06	0.299E+08	644685	6339718
51	7	230.	500.	0.	90.	0.0600	0.	90.	0.00	0.042	1.79	0.00	0.148E+08	0.624E+06	0.398E+08	644241	6340429
52	5	230.	400.	0.	90.	0.0700	0.	90.	0.00	0.049	2.06	0.00	0.491E+07	0.238E+06	0.133E+08	644282	6339348
53	8	210.	200.	0.	90.	0.0500	0.	90.	0.00	0.036	1.52	0.00	0.547E+07	0.195E+06	0.147E+08	644935	6343127
54	9	210.	400.	0.	90.	0.0800	0.	90.	0.00	0.055	2.33	0.00	0.196E+08	0.108E+07	0.531E+08	646676	6343198
55	8	210.	400.	0.	90.	0.0500	0.	90.	0.00	0.036	1.52	0.00	0.150E+08	0.534E+06	0.402E+08	646466	6343707
56	7	210.	800.	0.	90.	0.1400	0.	90.	0.00	0.091	3.88	0.00	0.237E+08	0.216E+07	0.649E+08	645511	6341371
57	7	210.	400.	0.	90.	0.0700	0.	90.	0.00	0.049	2.06	0.00	0.670E+07	0.325E+06	0.181E+08	644652	6344589
58	8	210.	400.	0.	90.	0.0470	0.	90.	0.00	0.034	1.44	0.00	0.779E+07	0.263E+06	0.209E+08	644750	6344206
59	6	210.	400.	0.	90.	0.0800	0.	90.	0.00	0.055	2.33	0.00	0.505E+07	0.277E+06	0.137E+08	646349	6344149
60	12	210.	500.	0.	90.	0.0850	0.	90.	0.00	0.058	2.46	0.00	0.275E+08	0.159E+07	0.746E+08	644165	6343766
61	8	210.	400.	0.	90.	0.0400	0.	90.	0.00	0.029	1.24	0.00	0.633E+07	0.185E+06	0.170E+08	645038	6342792
62	23	200.	100.	0.	90.	0.0130	0.	90.	0.00	0.010	0.45	0.00	0.977E+07	0.103E+06	0.260E+08	645755	6339484
63	7	200.	480.	0.	90.	0.0600	0.	90.	0.00	0.042	1.79	0.00	0.153E+08	0.644E+06	0.411E+08	644939	6342261
64	10	200.	300.	0.	90.	0.0060	0.	90.	0.00	0.005	0.22	0.00	0.920E+07	0.479E+05	0.244E+08	644417	6341156
65	8	200.	500.	0.	90.	0.0500	0.	90.	0.00	0.036	1.52	0.00	0.148E+08	0.529E+06	0.398E+08	645228	6343142
66	17	200.	200.	0.	90.	0.0090	0.	90.	0.00	0.007	0.32	0.00	0.796E+07	0.597E+05	0.212E+08	645231	6339478
67	6	200.	500.	0.	90.	0.0150	0.	90.	0.00	0.012	0.51	0.00	0.218E+07	0.262E+05	0.581E+07	644983	6339563
68	10	200.	100.	0.	90.	0.0100	0.	90.	0.00	0.008	0.35	0.00	0.383E+07	0.318E+05	0.102E+08	645549	6340137
69	9	200.	400.	0.	90.	0.0030	0.	90.	0.00	0.003	0.12	0.00	0.617E+07	0.173E+05	0.164E+08	645299	6340676
70	7	190.	500.	0.	90.	0.0800	0.	90.	0.00	0.055	2.33	0.00	0.143E+08	0.783E+06	0.386E+08	645074	6341852

Body	No of Verts	Depth	Dip Extnt	Plng Azmth	Plng	Susc (SI)	Rem Dec	Rem Inc	K-Ratio	Density t/m**3	App%Mgt	App%Hmt (Felsic)	Volume m**3	ExcessMass tonnes	Total Mass tonnes	Centroid E	Centroid N
71	6	190.	300.	0.	90.	0.1100	0.	90.	0.00	0.073	3.11	0.00	0.359E+07	0.263E+06	0.979E+07	646234	6344536
72	6	170.	200.	0.	90.	0.0600	0.	90.	0.00	0.042	1.79	0.00	0.113E+08	0.476E+06	0.304E+08	643602	6343843
73	5	170.	200.	0.	90.	0.0300	0.	90.	0.00	0.022	0.96	0.00	0.135E+08	0.302E+06	0.360E+08	644586	6344935
74	4	170.	200.	0.	90.	0.0300	0.	90.	0.00	0.022	0.96	0.00	0.267E+07	0.598E+05	0.714E+07	643579	6344059
75	5	170.	200.	0.	90.	0.0300	0.	90.	0.00	0.022	0.96	0.00	0.548E+07	0.123E+06	0.147E+08	643516	6344213
76	6	160.	200.	0.	90.	0.0500	0.	90.	0.00	0.036	1.52	0.00	0.680E+07	0.243E+06	0.182E+08	644209	6344313
77	5	150.	300.	0.	90.	0.0200	0.	90.	0.00	0.015	0.66	0.00	0.208E+07	0.323E+05	0.556E+07	646040	6342564
78	5	150.	300.	0.	90.	0.0050	0.	90.	0.00	0.004	0.19	0.00	0.444E+07	0.196E+05	0.118E+08	645230	6344619
79	5	150.	300.	0.	90.	0.0020	0.	90.	0.00	0.002	0.08	0.00	0.377E+07	0.717E+04	0.100E+08	645470	6344541
80	27	150.	1000.	0.	90.	0.0060	0.	90.	0.00	0.005	0.22	0.00	0.885E+08	0.460E+06	0.235E+09	645663	6343478
81	25	150.	300.	0.	90.	0.0060	0.	90.	0.00	0.005	0.22	0.00	0.320E+08	0.166E+06	0.849E+08	645967	6343430
82	7	150.	300.	0.	90.	0.0100	0.	90.	0.00	0.008	0.35	0.00	0.725E+07	0.602E+05	0.193E+08	645908	6344250
83	10	150.	300.	0.	90.	-0.0100	0.	90.	0.00	0.000	-	-	0.110E+08	0.000E+00	0.292E+08	646253	6342473
84	6	150.	200.	0.	90.	0.0700	0.	90.	0.00	0.049	2.06	0.00	0.229E+07	0.111E+06	0.617E+07	644287	6344076
85	9	130.	700.	0.	90.	0.0620	0.	90.	0.00	0.043	1.85	0.00	0.133E+08	0.577E+06	0.358E+08	645335	6341571
86	8	120.	500.	0.	90.	0.0730	0.	90.	0.00	0.050	2.14	0.00	0.230E+08	0.116E+07	0.621E+08	645225	6341389

AECOM

Lyndhurst Area
Seismic Interpretation

The following slides present the un-interpreted and interpreted depth converted stacks, in colour contour format. Red events are troughs, black events are peaks.

A base map illustrating the positions of each seismic line is included in slide 3.

The two seismic lines have been depth converted so the vertical axis reads in metres. The depth indicated on section will contain some error, given the lack of velocity control, but provide a good approximation for evaluating the seismic sections and depth of weathering profiles.

An un-interpreted depth section is included for each seismic line, as flicking between this and the interpreted section illustrates the zone of reduced amplitude often observed where fault planes are seismically imaged. Flicking between these two slides can help the user understand why structures are interpreted as presented.

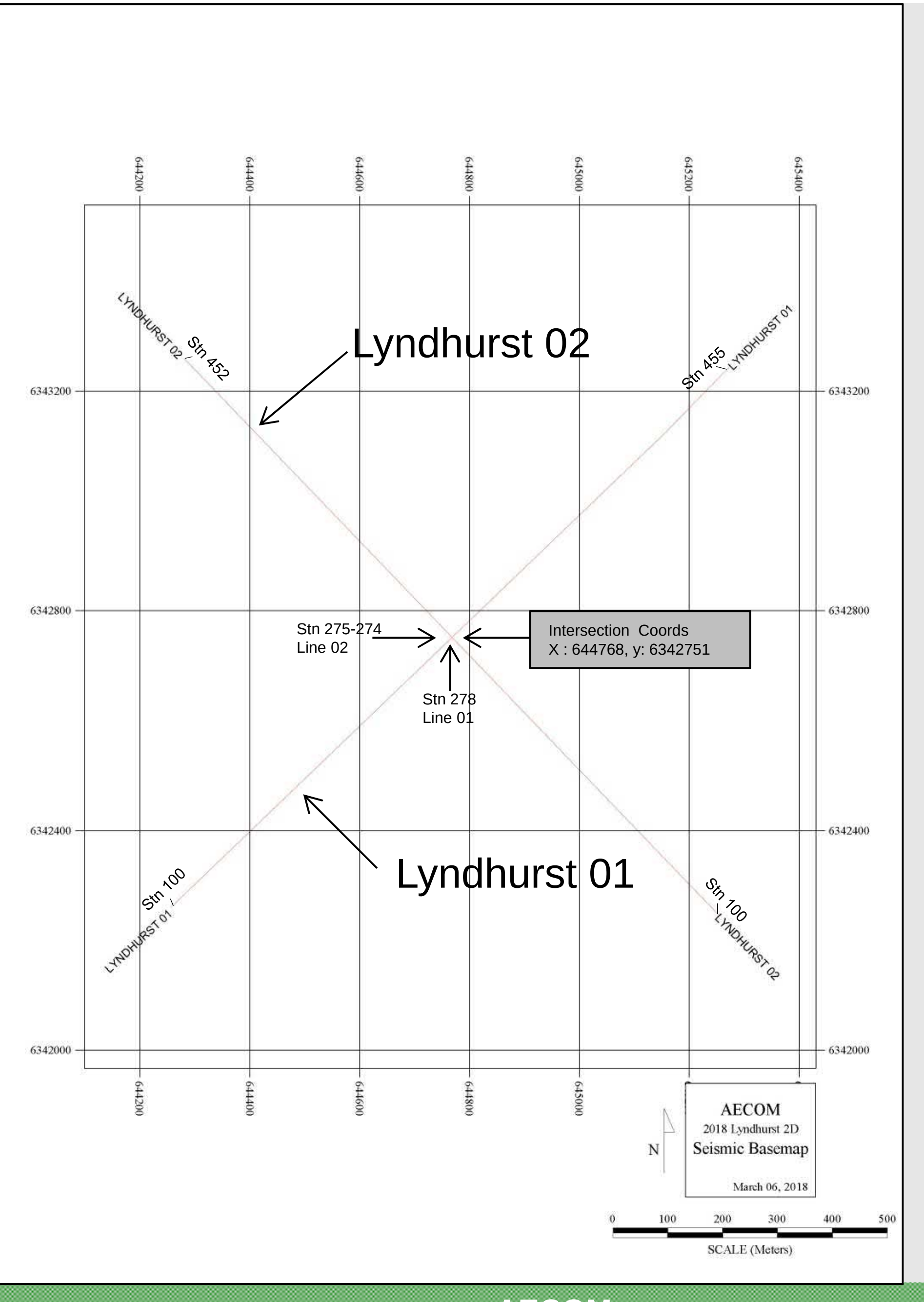
Given the lack of borehole control, only more prominent potential structures have been identified. Given the complexity of the data, it should be noted that smaller scale structures are also likely to be present.

Depth of Weathering profiles, derived from refraction statics, have been annotated across the top of each interpreted section. Slides 6 & 9 zoom in on the shallow areas of each line and provide more detail on depth of weathering along each section, including the approximate position of the top of the non weathered crystalline rocks.

There is some discrepancy between the two depth of weathering solutions, which is due to limited Vo control in the static solution and minor velocity variability in stacking velocities. However, both solutions provide the best guide available to determine weathering profile trends across each section. The depth of weathering provided by the statics solution should be the preferred solution.

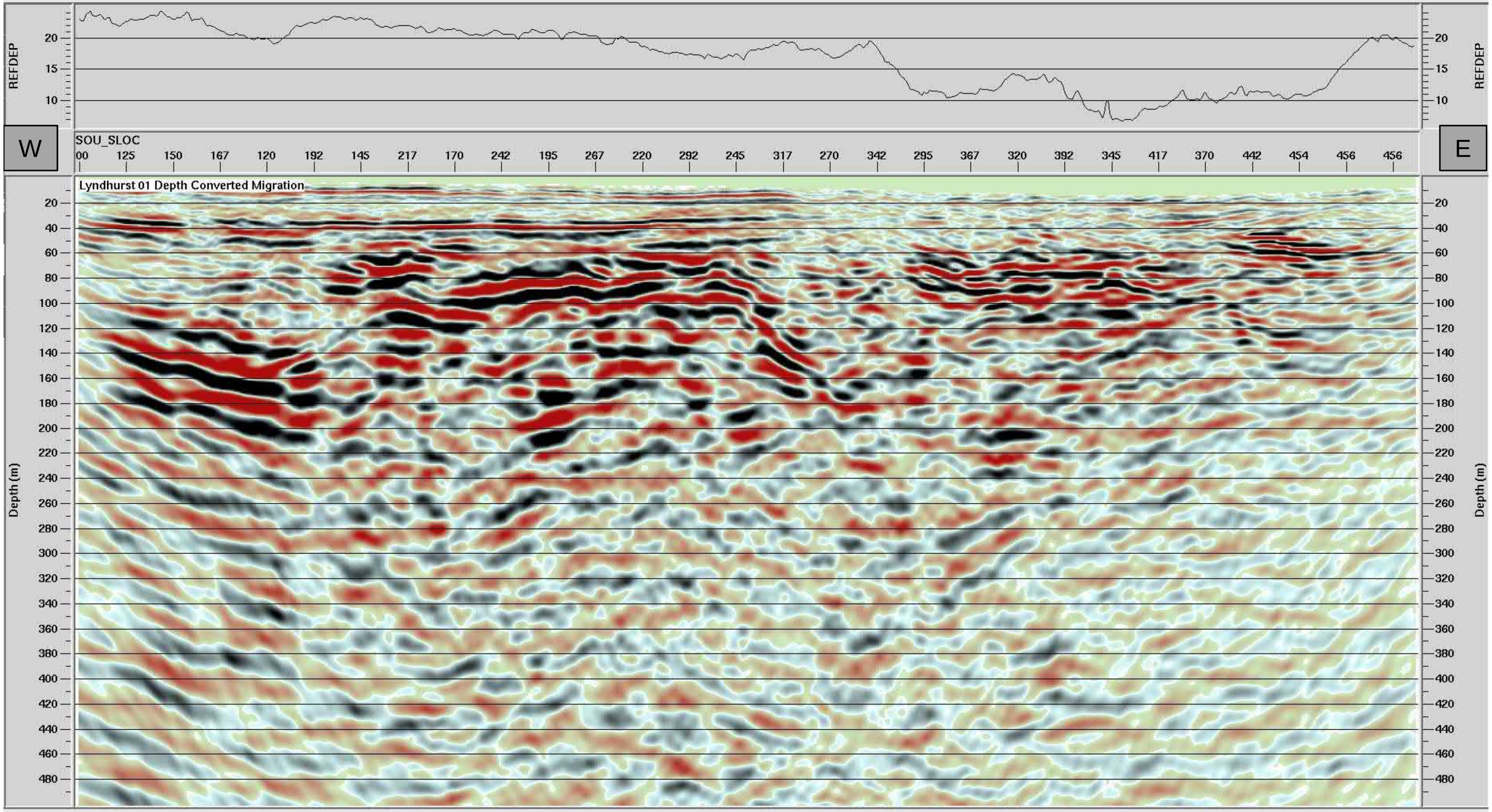
Potential Faulting is annotated by blue planes. Where possible, potential slip direction is indicated at the fault plane.

Where possible, stratigraphic horizons have been interpreted across some interpreted structures and are indicated by the aqua horizons.



Lyndhurst 02
Lyndhurst 01
LYNDHURST 02
Stn 452
Stn 455
LYNDHURST 01
Stn 275-274
Line 02
Intersection Coords
X : 644768, y: 6342751
Stn 278
Line 01
Stn 100
LYNDHURST 01
Stn 100
LYNDHURST 02
644200
644400
644600
644800
645000
645200
645400
6343200
6342800
6342400
6342000
AECOM
2018 Lyndhurst 2D
Seismic Basemap
March 06, 2018
N
0
100
200
300
400
500
SCALE (Meters)

Lyndhurst 01 Depth Converted Migrated Stack
No Interpretation



14 March, 2018
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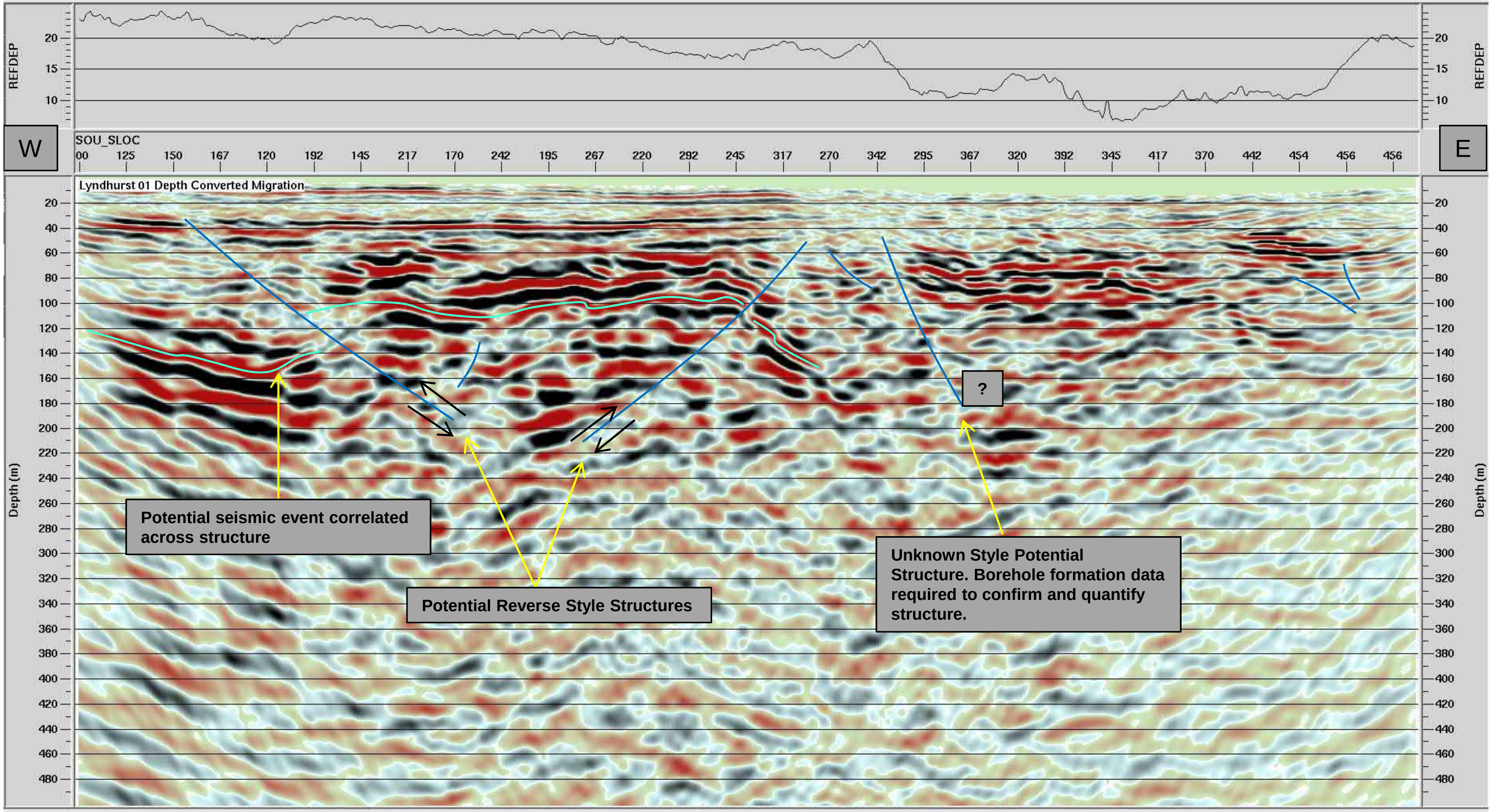
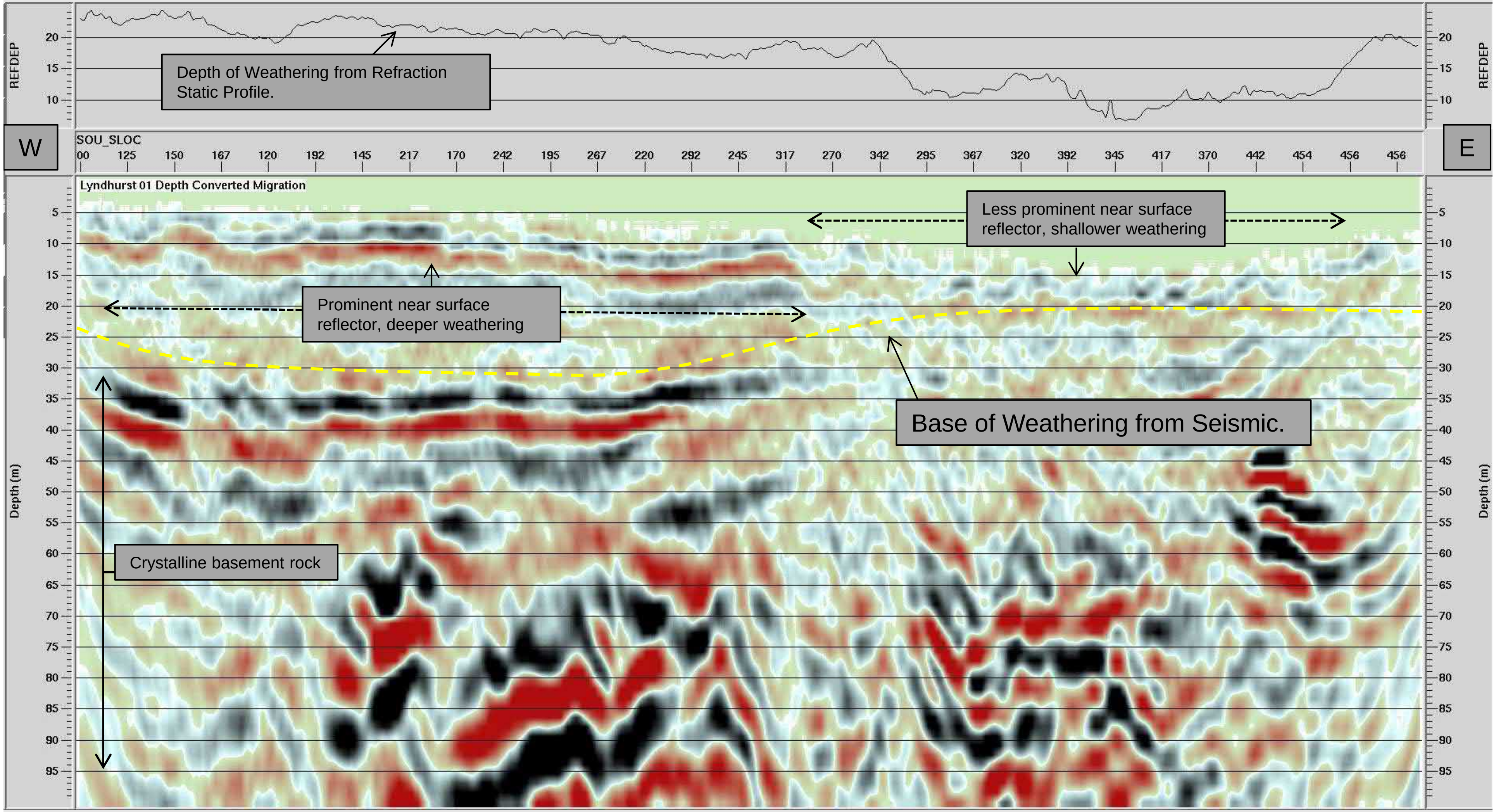
2018 2D Seismic Program

Lyndhurst 01 Depth Converted Migrated Stack
Interpreted Structure



Lyndhurst 01 Depth Converted Migrated Stack
Interpreted Section at near surface



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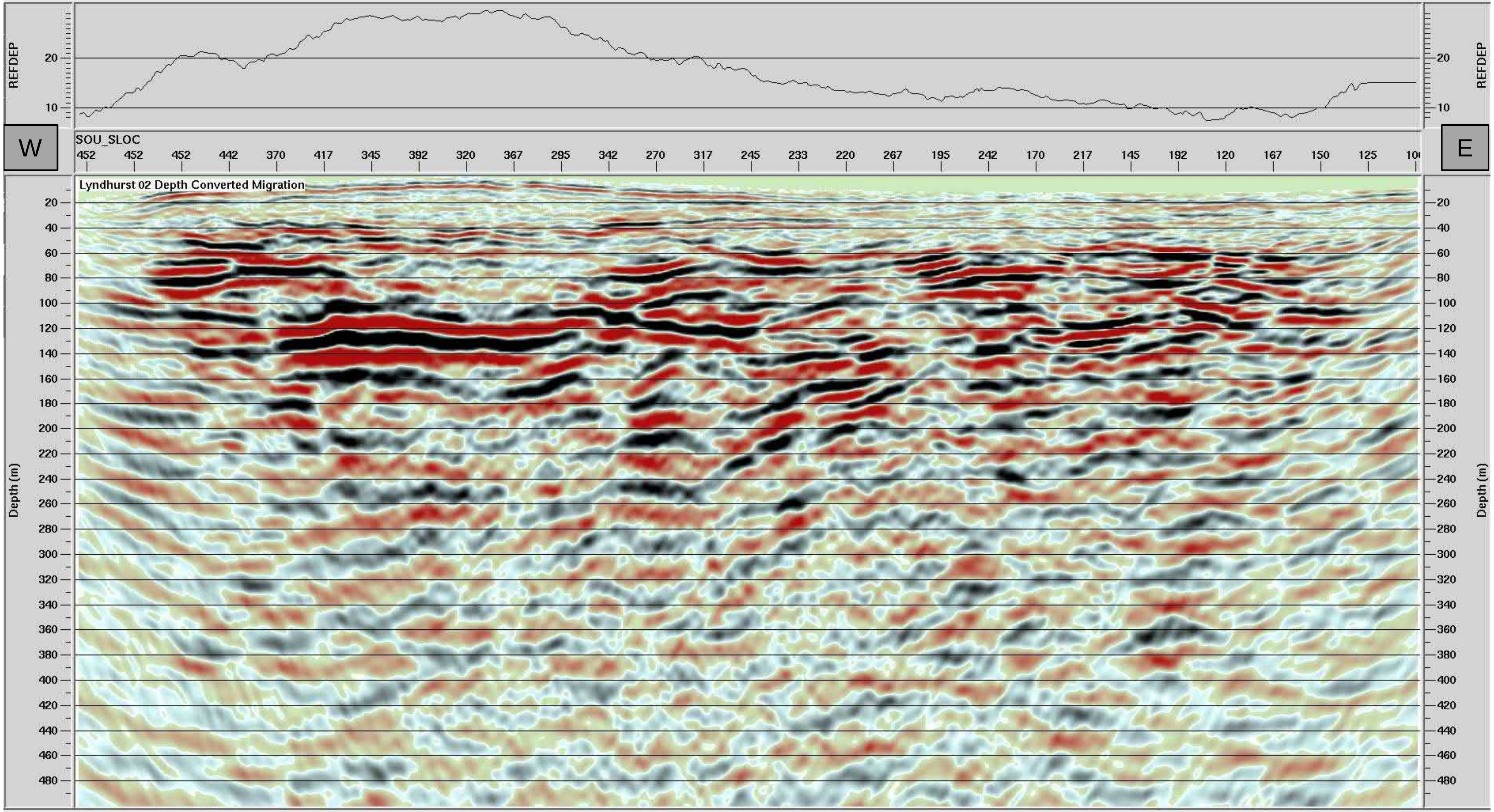
Lyndhurst 02 Depth Converted Migrated Stack



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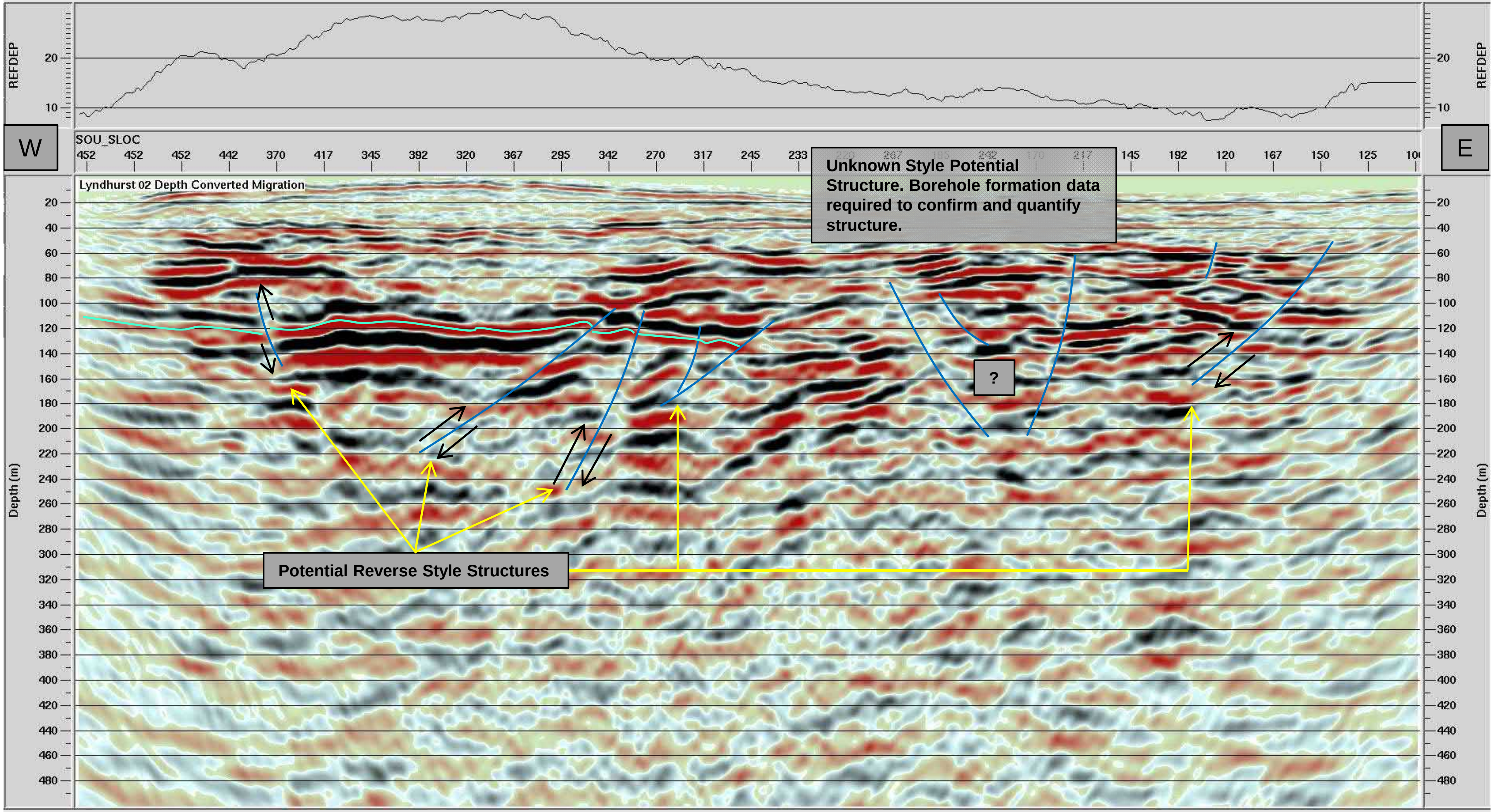
AECOM
2018 2D Seismic Program

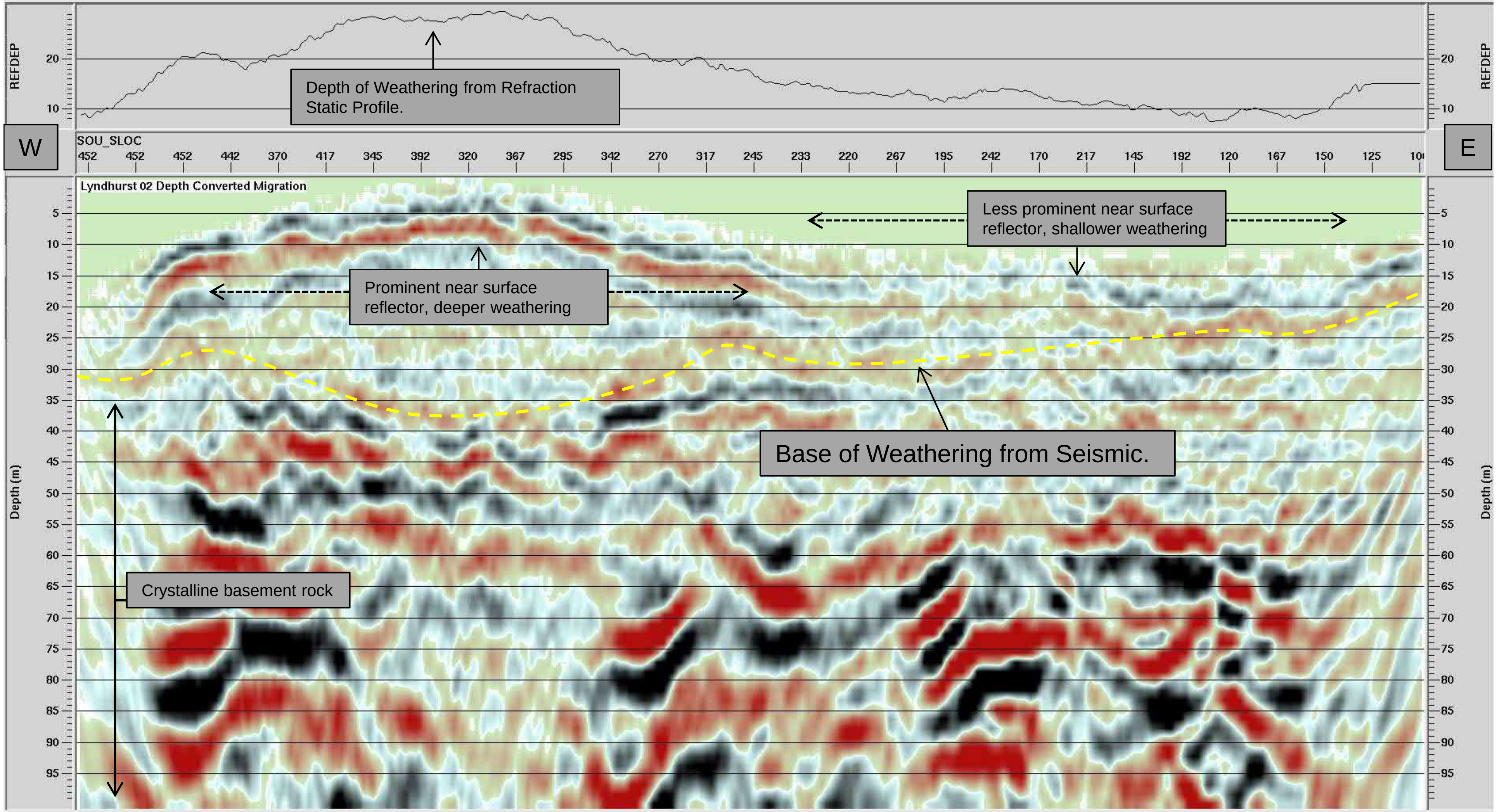
Lyndhurst 02 Depth Converted Migrated Stack
Interpreted Structure



14 March, 2018
Velseis Processing

AECOM
2018 2D Seismic Program

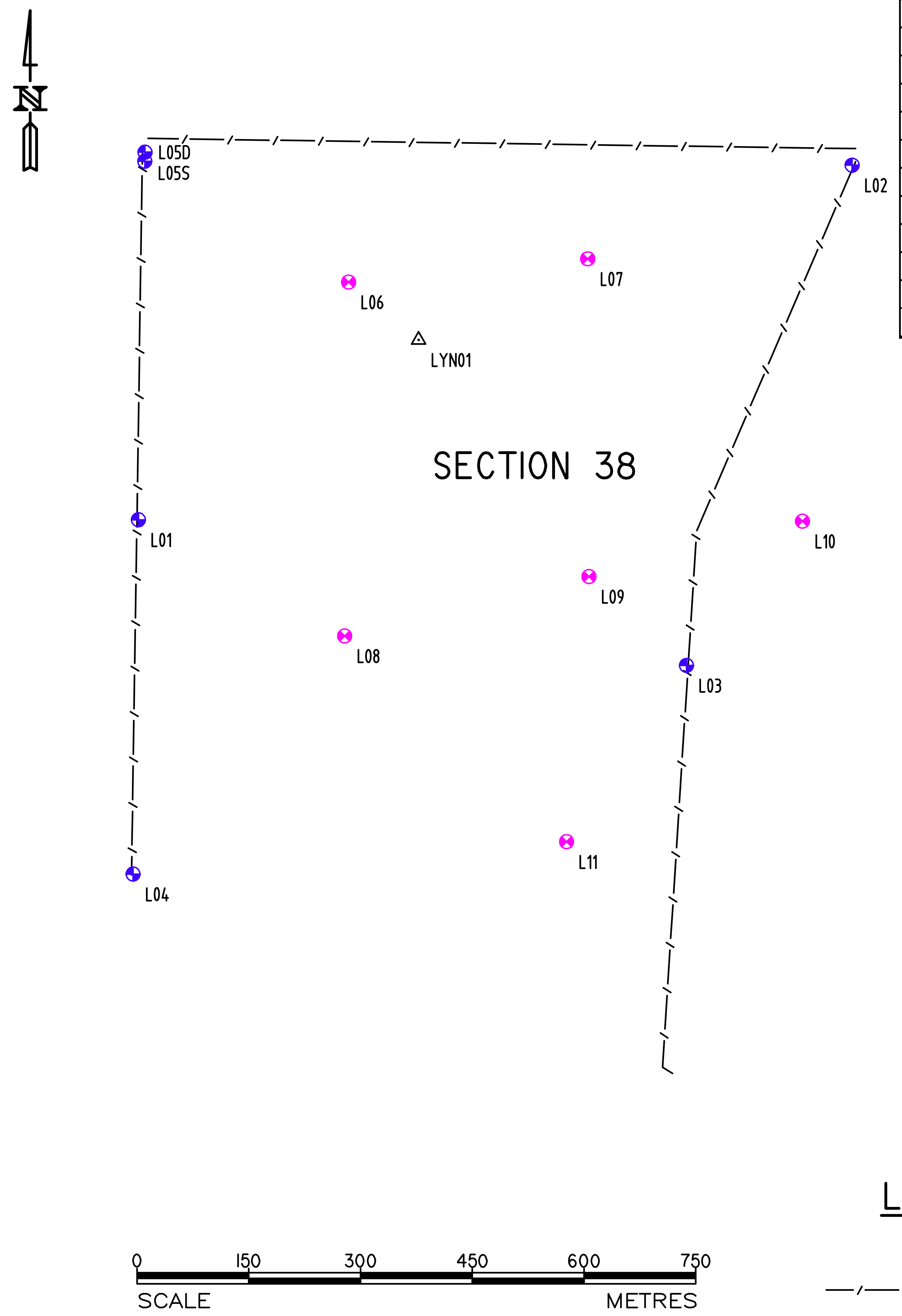
Lyndhurst 02 Depth Converted Migrated Stack
Interpreted Section at near surface



14 March, 2018
Velseis Processing

AECOM
2018 2D Seismic Program

Point ID	East	North	PVC Pipe RL	Lid RL	Ground RL	RL	Description
L01	644261.35	6342736.86	216.539	216.614	215.906		50 mm PVC BORE TOP
L02	645219.45	6343212.65	213.533	213.626	212.865		50 mm PVC BORE TOP
L03	644997.06	6342541.43	215.426	215.468	214.882		50 mm PVC BORE TOP
L04	644254.11	6342261.46	220.830	221.001	220.086		50 mm PVC BORE TOP
L05D (deep)	644270.04	6343230.03	208.864	208.964	208.011		50 mm PVC BORE TOP
L05S (shallow)	644269.84	6343217.88	208.834	208.954	208.269		50 mm PVC BORE TOP
L06	644543.41	6343055.77			222.136		Testhole Surface RL
L07	644864.41	6343086.98			217.432		Testhole Surface RL
L08	644538.20	6342580.99			218.010		Testhole Surface RL
L09	644866.17	6342660.69			213.041		Testhole Surface RL
L10	645152.77	6342734.98			216.430		Testhole Surface RL
L11	644836.06	6342304.95			213.078		Testhole Surface RL
LYN01	644637.45	6342978.21				225.336	DROPPER-SURVEY BASE



LEGEND

TEST HOLE
BORE HOLE
FENCE

EXAMPLE BORE

DEVELOP
WITH
CONFIDENCE ™

veris

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Adelaide SA 5000
08 8100 5700
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veris.com.au
ABN 25 098 991 210

NO	DATE	DRN	CHKD	DESCRIPTION
0	4/6/18	KS	RHH	FIRST ISSUE

This plan is not intended for attachment to sale contract documents

OUR REF: 300256_D2_rev0.DWG
CONTOUR INTERVAL: -
DATUM: MGA94 Zone53, AHD
SCALE: 1:7500 ORIGINAL SHEET SIZE: A3
DATE OF SURVEY: 29/5/2018 RHH
DRAWING No: 300256_D2 REV 0 SHEET No: 1 OF 1

AECOM AUSTRALIA PTY LTD
BORE HOLE LOCATIONS
LYNDHURST
16km NORTH-EAST OF KIMBA

AECOM

Engineering Summary Log

BOREHOLE No. L01

Client: Department of Industry, Innovation and Science	**Project No:** 60565376	**Start Date:** 08/05/2018	**Driller:** SWD	**Hole Diameter:** 169 mm	**Easting:** 644261.4 m
Project: NRWMF - Site Characterisation	**Logged by:** TS	**End Date:** 09/05/2018	**Drill Rig:** Sonic Geoprobe	**Inclination:** -90°	**Northing:** 6342736.9 m
Location: Lyndhurst (Kimba)	**Checked by:** HS	**Location Meth.:** dGPS0.1		**Bearing:** N/A	**Hor. Proj/Dat:** MGA94/GDA94-54H

RL: 215.9 m **Ver. Datum:** AHD **Surface:** Sand

Drilling Water: Potable water sourced from Kimba (measured EC <1000 µS/cm)

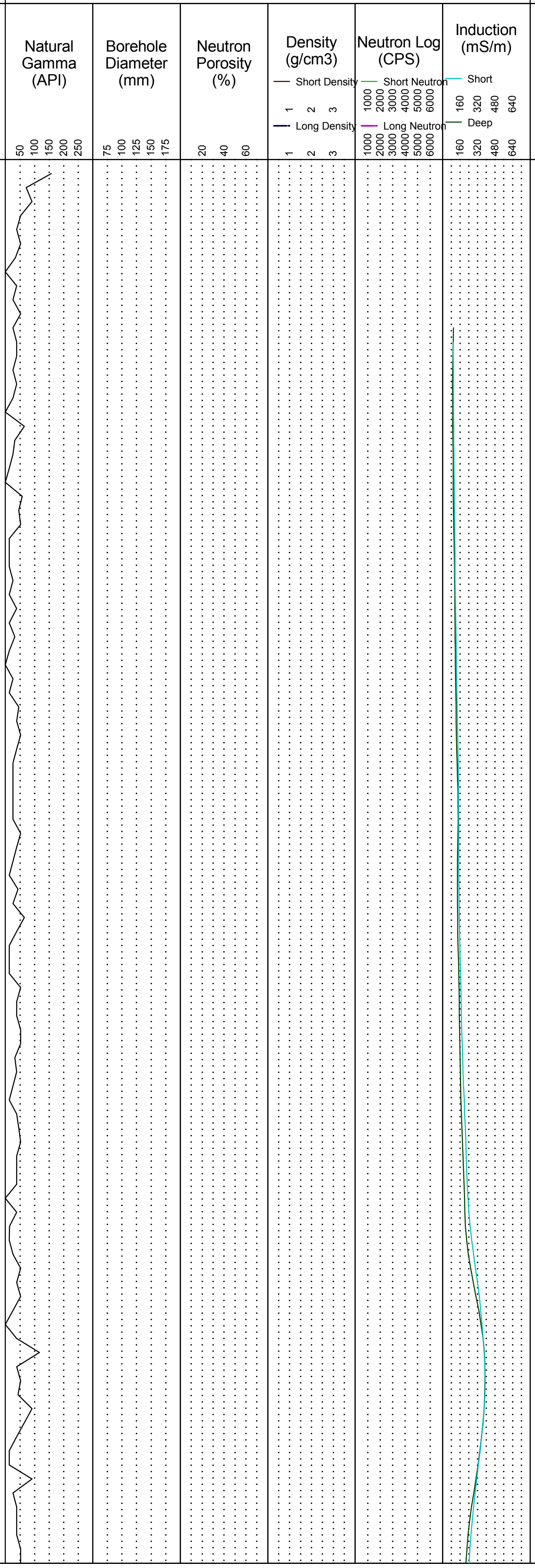
Piezometer Details

Casing Top RL: 216.54 m AHD
Response Zone Top RL: -
Response Zone Base RL: -
Length of Response Zone: 6.00 m
Development Date: 10/05/2018

0.6 above ground to 0.0 m: Steel Monument
0.0 to 11.0 m: CEMENT/ BENTONITE GROUT
0.0 to 15.0 m: 50 mm PVC

Reduced Level (m)	Depth (m)	Water	Field Tests	Samples	Classification Symbol	Description	Weathering/ Consistency	TCR (SCR) [RQD] (%)	Core Photo	Optical and Accoustic Televiewer
	0.0				SP	SAND: fine to medium grained; orange-brown; sub-rounded to sub-angular quartz, trace calcareous clay				
	0.5									
215	1.0					CALCRETE: fine grained; red-brown; with fine to medium grained sand, poorly cemented, very low strength				
	1.5		SPT:25/100mm N=R		SW	SAND: fine to coarse grained; angular to sub-angular; red-brown; siliceous, trace clay				
214	2.0									
	2.5				CL	sandy CLAY: low plasticity; orange-brown; sand is angular, fine grained, calcareous				
						CALCRETE: fine grained; orange-brown; clay matrix, with fine grained, angular sand, poorly cemented, very low strength				
213	3.0		SPT:9,7,7 N=14		SP	SAND: fine to medium grained; angular to sub-angular; red; siliceous, trace clay				
	3.5									
212	4.0									
	4.5		SPT:6,7,7 N=14			sandy CLAY: non-plastic; orange-brown; with fine to medium grained, angular to sub-angular sand, siliceous				
211	5.0					SILCRETE: fine grained; red-brown and cream; clay matrix, with fine to coarse grained, angular to rounded sand, poorly cemented, very low strength				
	5.5									
210	6.0		SPT:7,5,7 N=12		SW	SAND: fine to coarse grained; angular to sub-angular; red-brown; trace clay				
	6.5					at 6.50 m: increase in clay content				
209	7.0				CH	CLAY: high plasticity; red; with fine, angular sand				
	7.5		SPT:4,8,9 N=17							
208	8.0									
	8.5									
207	9.0		SPT:6,11,11 N=22		SC	clayey SAND: fine to medium grained; angular to sub-angular; red-brown; with clays, siliceous				
	9.5									
206	10.0									

Downhole Wireline



Laboratory Testing		Geology
Misc Laboratory Testing	Geochemical Testing	Geological Unit *(Geotech. Unit)*

AECOM

Engineering Summary Log

BOREHOLE No. L01

Client: Department of Industry, Innovation and Science	**Project No:** 60565376	**Start Date:** 08/05/2018	**Driller:** SWD	**Hole Diameter:** 169 mm	**Easting:** 644261.4 m
Project: NRWMF - Site Characterisation	**Logged by:** TS	**End Date:** 09/05/2018	**Drill Rig:** Sonic Geoprobe	**Inclination:** -90°	**Northing:** 6342736.9 m
Location: Lyndhurst (Kimba)	**Checked by:** HS	**Location Meth.:** dGPS0.1		**Bearing:** N/A	**Hor. Proj/Dat:** MGA94/GDA94-54H
RL: 215.9 m	**Ver. Datum:** AHD	**Surface:** Sand			

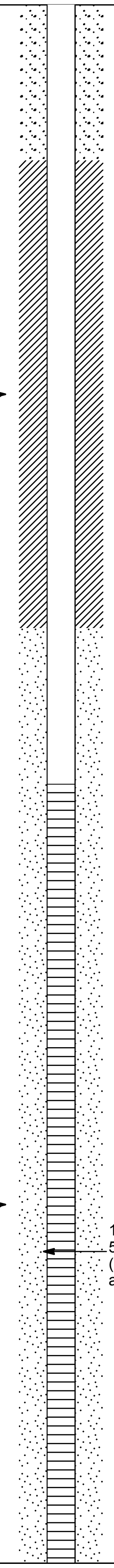
Drilling Water: Potable water sourced from Kimba (measured EC <1000 µS/cm)

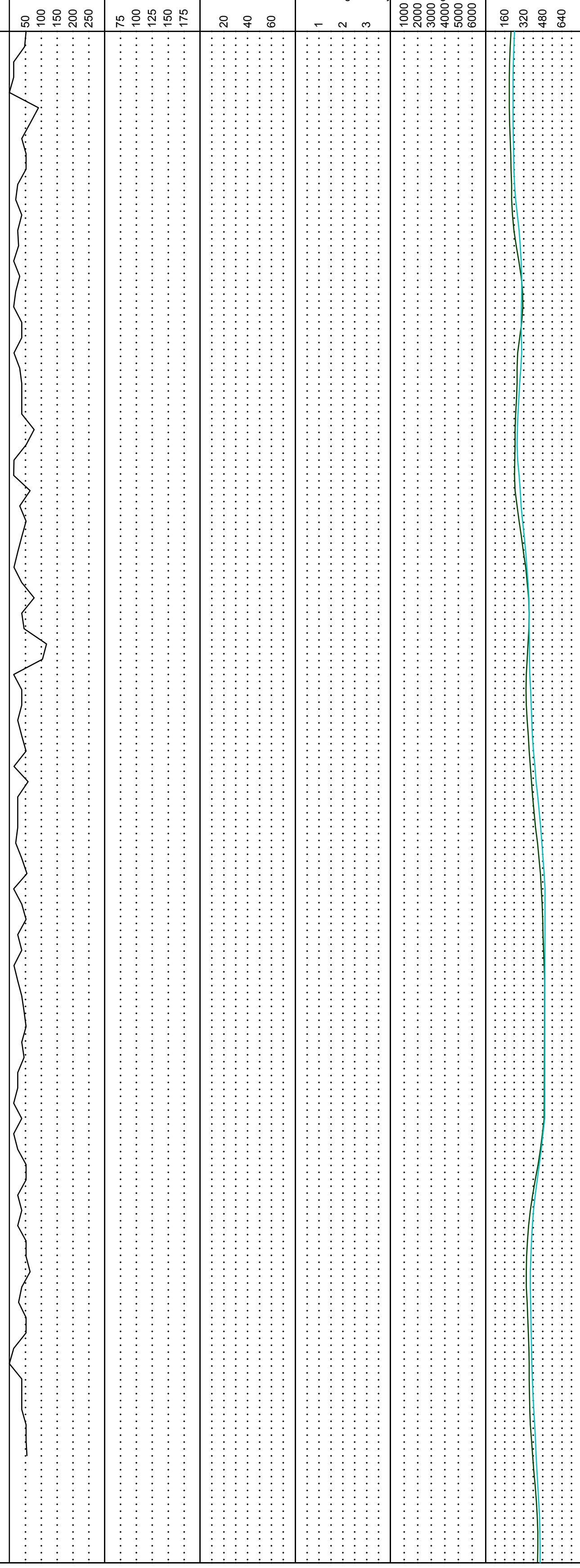
Piezometer Details

Casing Top RL: 216.54 m AHD
Response Zone Top RL: -
Response Zone Base RL: -
Length of Response Zone: 6.00 m
Development Date: 10/05/2018

Column headings: Field Data (Reduced Level (m) / Depth (m), Water, Field Tests, Samples); Material Description (Graphic Log, Classification Symbol, Description); Rock Condition (Weathering/Consistency, TCR (SCR) [RQD] (%), Core Photo, Optical and Accoustic Televiewer N E S W); Piezometer Details; Downhole Wireline (Natural Gamma (API), Borehole Diameter (mm), Neutron Porosity (%), Density (g/cm3) Short Density / Long Density, Neutron Log (CPS) Short Neutron / Long Neutron, Induction (mS/m) Short / Deep); Laboratory Testing (Misc Laboratory Testing, Geochemical Testing); Geology (Geological Unit *(Geotech. Unit)*)

Reduced Level (m)	Depth (m)	Water	Field Tests	Classification Symbol	Description
	10.5		SPT:5,5,4 N=9	SP	SAND: fine to medium grained; angular to sub-angular; red-brown; with clays, siliceous
205	11.0				from 11.20 m: coarse angular sane, trace well sorted gravel
	11.5			CL	sandy CLAY: low plasticity; grey mottled red; with fine to coarse grained, angular sand, moderately graded
204	12.0		SPT:23,30/100mm N=R		
	12.5			SP	SAND: fine grained; sub-rounded to sub-angular; grey; with silt and trace clays, partially cemented/indurated
203	13.0				
	13.5		SPT:20,24,28 N=52		from 13.50 m: becoming sand, with silt and trace clayey zones
202	14.0				
	14.5				
201	15.0		SPT:6,11,12 N=23	CI-CL	sandy CLAY: low to medium plasticity; red mottled grey; sand is fine to coarse grained
	15.5				at 15.60 m: becoming medium to high plasticity
200	16.0				
	16.5				
199	17.0				
	17.5			CL	gravelly CLAY: low plasticity; grey and red; with fine to coarse grained sand and fine to coarse grained angular gravel, moderately cemented
198	18.0			SW	SAND: fine to coarse grained; angular; dark red; ferruginous,some clay, trace fine grained, rounded gravel
	18.5			CL	sandy CLAY: low plasticity; light brown and grey mottled red; with fine to coarse grained sand and trace fine gravel, iron oxide cemented zones, water strike at 19.0 mbgs.
197	19.0	▽			
	19.5				
196	20.0				





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Engineering Summary Log

BOREHOLE No. L01
Sheet: 3 of 3

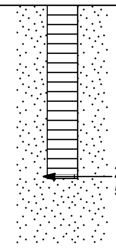
Client: Department of Industry, Innovation and Science	**Project No:** 60565376	**Start Date:** 08/05/2018	**Driller:** SWD	**Hole Diameter:** 169 mm	**Easting:** 644261.4 m	**RL:** 215.9 m
Project: NRWMF - Site Characterisation	**Logged by:** TS	**End Date:** 09/05/2018	**Drill Rig:** Sonic Geoprobe	**Inclination:** -90°	**Northing:** 6342736.9 m	**Ver. Datum:** AHD
Location: Lyndhurst (Kimba)	**Checked by:** HS	**Location Meth.:** dGPS0.1		**Bearing:** N/A	**Hor. Proj/Dat:** MGA94/GDA94-54H	**Surface:** Sand

Drilling Water: Potable water sourced from Kimba (measured EC <1000 µS/cm)

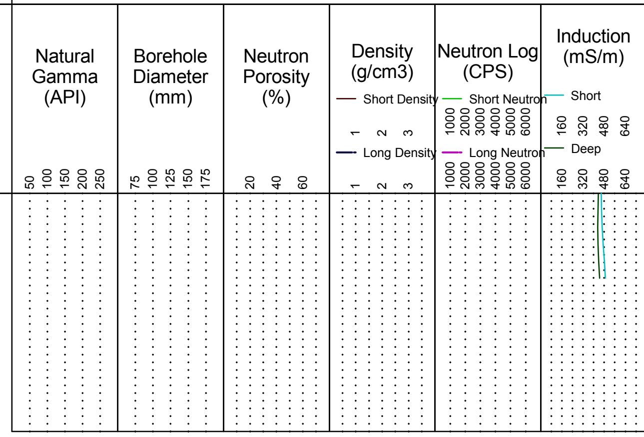
Piezometer Details

Casing Top RL: 216.54 m AHD
Response Zone Top RL: -
Response Zone Base RL: -
Length of Response Zone: 6.00 m
Development Date: 10/05/2018

Reduced Level (m)	Depth (m)	Water	Field Tests	Samples	Graphic Log	Classification Symbol	Description	Weathering/ Consistency	TCR (SCR) [RQD] (%)	Core Photo	Optical and Accoustic Televiewer	Piezometer Details	Misc Laboratory Testing	Geochemical Testing	Geological Unit (Geotech. Unit)
						CL									
	20.5					CH-CI	CLAY: medium to high plasticity; some fine to medium grained, sub-rounded sand						L01_21.0-21.4m: Permeability (U63): 1.0 x10^{-9} m/sec		
195	21.0			U63: L01_21.0-21.4m								21.0 to 21.0 m: 50 mm PVC	XRD: Kaolinite 9%; Muscovite - illite 1%; Albite 1%; Microcline/ rutile 1%; Quartz 86%; Anatase 1%; Ilmenite/ magnesite <1%		
	21.5						*Borehole L01 log continued as cored log from m.*								
194	22.0														
	22.5														
193	23.0														
	23.5														
192	24.0														
	24.5														
191	25.0														
	25.5														
190	26.0														
	26.5														
189	27.0														
	27.5														
188	28.0														
	28.5														
187	29.0														
	29.5														
186	30.0														



Downhole Wireline



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Engineering Summary Log

BOREHOLE No. L02
Sheet: 1 of 3

Client: Department of Industry, Innovation and Science	**Project No:** 60565376	**Start Date:** 16/05/2018	**Driller:** SWD	**Hole Diameter:** 169 mm	**Easting:** 645219.5 m
Project: NRWMF - Site Characterisation	**Logged by:** JT	**End Date:** 16/05/2018	**Drill Rig:** Sonic Geoprobe	**Inclination:** -90°	**Northing:** 6343212.7 m
Location: Lyndhurst (Kimba)	**Checked by:** HS	**Location Meth.:** dGPS0.1		**Bearing:** N/A	**Hor. Proj/Dat:** MGA94/GDA94-54J
Drilling Water: Potable water sourced from Kimba (measured EC <1000 µS/cm)				**RL:** 212.9 m	**Ver. Datum:** AHD
					Surface:

Field Data / Material Description

Reduced Level (m)	Depth (m)	Water	Field Tests	Samples	Classification Symbol	Description
					SM	silty SAND: fine to medium grained; dark brown; trace of roots and calcrete, medium to coarse, gravel sized, angular to sub-angular
	0.5				SP	SAND: fine to medium grained; light yellow-brown; with Calcrete, medium to coarse gravel sized fragments, angular to sub-angular
212	1.0					
	1.5		SPT:11,17,19 N=36		SC	clayey SAND: fine to medium grained; orange-brown; poorly graded, clay is low to medium plasticity
211	2.0					
	2.5				CI-CL	sandy CLAY: low to medium plasticity; orange-brown; sand is fine grained, poorly graded
210	3.0		SPT:13,16,23 N=39			
	3.5					
209	4.0					
	4.5		SPT:13,13,16 N=29			at 4.40 m: inclusion of fine to medium grained sand, orange-brown, poorly graded
208	5.0					at 5.00 m: inclusion of fine to medium grained sand, orange-brown, poorly sorted, colour becoming orange-brown mottled light grey
	5.5				SC	clayey gravelly SAND: medium to coarse grained; orange-brown; gravel are fine and poorly graded, sub-rounded to sub-angular, light yellow-brown
					CH-CI	sandy CLAY: medium to high plasticity; orange-brown mottled light grey; sand is fine grained, poorly sorted
207	6.0		SPT:9,14,21 N=35			
	6.5					
206	7.0					
	7.5		SPT:7,11,17 N=28			
205	8.0					at 8.00 m: trace fine gravel, angular to sub-angular, light yellow-brown
	8.5				SC	clayey SAND: fine to coarse grained; light grey mottled orange-brown; poorly graded, clay is medium to high plasticity
204	9.0		SPT:16,36,15/20mm N=R		SP	clayey gravelly SAND: medium to coarse grained; orange-brown mottled light grey; poorly graded, gravel is fine, sub-rounded to sub-angular
	9.5				GC	clayey sandy GRAVEL: fine grained; sub-rounded to sub-angular; red-brown and light grey; sand is fine to medium grained, yellow-brown
203	10.0			DS		from 9.80 m to 10.00 m: trace of gravel to cobble

Rock Condition

Weathering/ Consistency | TCR (SCR) [RQD] (%) | Core Photo | Optical and Accoustic Televiewer (N E S W)

Piezometer Details

Casing Top RL: 213.53 m AHD
Response Zone Top RL: -
Response Zone Base RL: -
Length of Response Zone: 6.00 m
Development Date: 17/05/2018

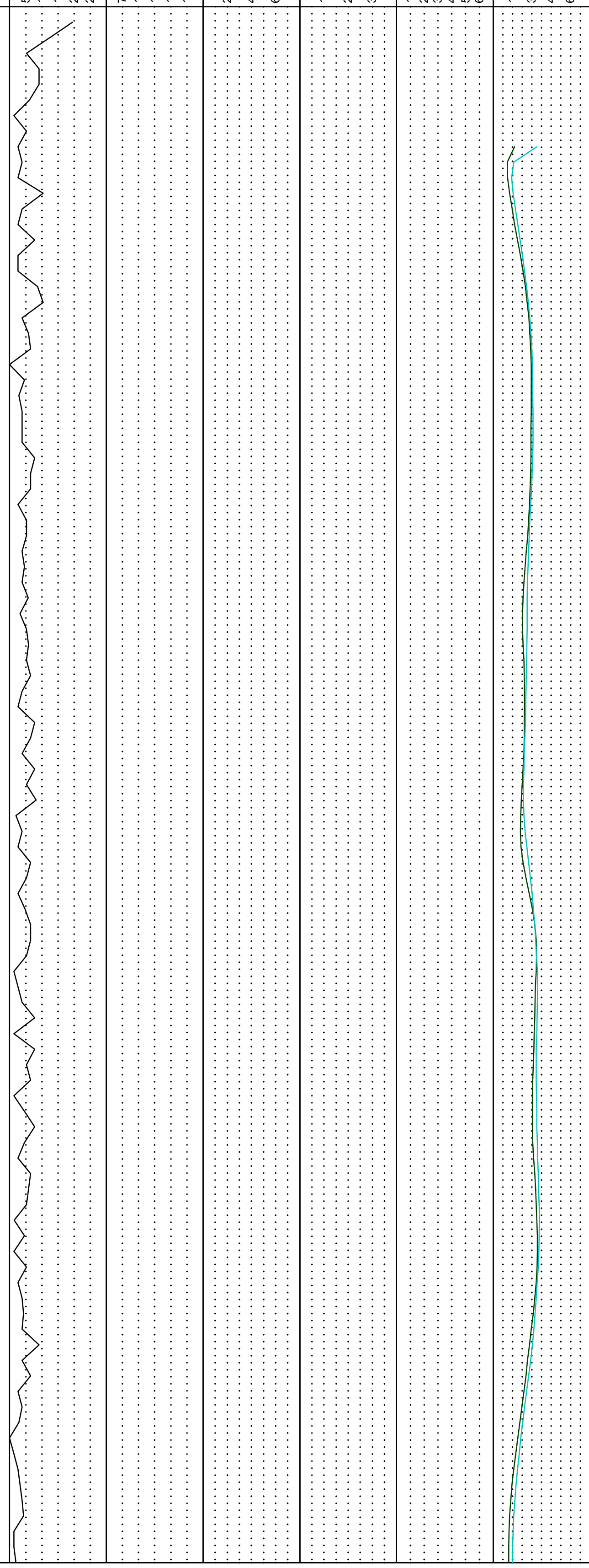
0.6 above ground to 0.0 m: Steel Monument

0.0 to 14.0 m: CEMENT/ BENTONITE GROUT

0.0 to 18.0 m: 50 mm PVC

Downhole Wireline

Natural Gamma (API): 50 100 150 200 250
Borehole Diameter (mm): 75 100 125 150 175
Neutron Porosity (%): 20 40 60
Density (g/cm3): Short Density 1 2 3; Long Density 1 2 3
Neutron Log (CPS): Short Neutron 1000 2000 3000 4000 5000 6000; Long Neutron 1000 2000 3000 4000 5000 6000
Induction (mS/m): Short 160 320 480 640; Deep 160 320 480 640



Laboratory Testing

Misc Laboratory Testing | Geochemical Testing

Geology

Geological Unit *(Geotech. Unit)*

AECOM

Engineering Summary Log

BOREHOLE No. L02

Client: Department of Industry, Innovation and Science	**Project No:** 60565376	**Start Date:** 16/05/2018	**Driller:** SWD	**Hole Diameter:** 169 mm	**Easting:** 645219.5 m
Project: NRWMF - Site Characterisation	**Logged by:** JT	**End Date:** 16/05/2018	**Drill Rig:** Sonic Geoprobe	**Inclination:** -90°	**Northing:** 6343212.7 m
Location: Lyndhurst (Kimba)	**Checked by:** HS	**Location Meth.:** dGPS0.1		**Bearing:** N/A	**Hor. Proj/Dat:** MGA94/GDA94-54J

RL: 212.9 m **Ver. Datum:** AHD **Surface:**

Drilling Water: Potable water sourced from Kimba (measured EC <1000 µS/cm)

Field Data | **Material Description** | **Rock Condition** | **Piezometer Details** | **Downhole Wireline** | **Laboratory Testing** | **Geology**

Column headings: Reduced Level (m) / Depth (m); Water; Field Tests; Samples; Graphic Log; Classification Symbol; Description; Weathering/Consistency; TCR (SCR) [RQD] (%); Core Photo; Optical and Accoustic Televiewer (N E S W); Natural Gamma (API) (50 100 150 200 250); Borehole Diameter (mm) (75 100 125 150 175); Neutron Porosity (%) (20 40 60); Density (g/cm3) (1 2 3) — Short Density, — Long Density; Neutron Log (CPS) (1000 2000 3000 4000 5000 6000) — Short Neutron, — Long Neutron; Induction (mS/m) (160 320 480 640) — Short, — Deep; Misc Laboratory Testing; Geochemical Testing; Geological Unit *(Geotech. Unit)*

Casing Top RL: 213.53 m AHD
Response Zone Top RL: -
Response Zone Base RL: -
Length of Response Zone: 6.00 m
Development Date: 17/05/2018

RL (m)	Depth (m)	Water	Field Tests	Samples	Classification Symbol	Description
				DS	GW	sized gravel, sub-angular
	10.5		SPT:30/75mm N=R			sandy GRAVEL: fine to coarse grained; angular to sub-angular; grey to light grey; sand is fine to coarse grained
202	11.0			DS		
	11.5					at 11.60 m: inclusion of clayey SAND, brown, fine to medium grained, poorly graded, clay is low plasticity with coarse grained gravel, angular to sub-angular
201	12.0		SPT:30/75mm N=R	DS	GW	clayey sandy GRAVEL: fine to coarse grained; angular to sub-angular; grey to light grey; clay is low to medium plasticity, light grey mottled yellow-brown, sand is fine to medium grained, poorly graded
	12.5				CI	sandy CLAY: medium plasticity; orange-brown mottled light grey; sand is fine grained, poorly graded
200	13.0					
	13.5		SPT:18,15/30mm N=R			
199	14.0			DS	GP	sandy GRAVEL: fine grained; sub-rounded to sub-angular; light grey; trace low to medium plasticity clay
	14.5	∇				
198	15.0		SPT:32,40/100mm N=R			
	15.5				SC	clayey SAND: fine and coarse grained; orange-brown mottled light grey; poorly graded
197	16.0				CH-CI	sandy CLAY: medium to high plasticity; white/light grey mottled orange-brown/yellow-brown; sand is fine to medium grained, orange-brown, poorly graded
	16.5					
196	17.0					
	17.5				GW	sandy GRAVEL: fine to coarse grained; angular to sub-angular; grey/light grey; sand is fine to medium grained
195	18.0			DS	SC	from 17.90 m to 18.00 m: inclusion of sandy CLAY: medium to high plasticity, orange-brown mottled light grey, sand is fine to medium grained, poorly graded
	18.5					clayey gravelly SAND: medium to coarse grained; orange-brown mottled light grey; gravel is fine, sub-rounded to sub-angular
194	19.0				CH-CI	sandy CLAY: medium to high plasticity; orange-brown mottled light grey; sand is fine to medium grained, poorly graded
	19.5					
193	20.0				GP	sandy GRAVEL: fine grained; sub-rounded to

Piezometer: 14.0 to 17.0 m: BENTONITE SEAL (PELLETS)

AECOM

Engineering Summary Log

BOREHOLE No. L02

Client: Department of Industry, Innovation and Science	**Project No:** 60565376	**Start Date:** 16/05/2018	**Driller:** SWD	**Hole Diameter:** 169 mm	**Easting:** 645219.5 m	**RL:** 212.9 m
Project: NRWMF - Site Characterisation	**Logged by:** JT	**End Date:** 16/05/2018	**Drill Rig:** Sonic Geoprobe	**Inclination:** -90°	**Northing:** 6343212.7 m	**Ver. Datum:** AHD
Location: Lyndhurst (Kimba)	**Checked by:** HS	**Location Meth.:** dGPS0.1		**Bearing:** N/A	**Hor. Proj/Dat:** MGA94/GDA94-54J	**Surface:**

Drilling Water: Potable water sourced from Kimba (measured EC <1000 µS/cm)

Piezometer Details

- **Casing Top RL:** 213.53 m AHD
- **Response Zone Top RL:** -
- **Response Zone Base RL:** -
- **Length of Response Zone:** 6.00 m
- **Development Date:** 17/05/2018

Column headings: Field Data (Reduced Level (m) / Depth (m); Water; Field Tests; Samples) | Material Description (Graphic Log; Classification Symbol; Description) | Rock Condition (Weathering/Consistency; TCR (SCR) [RQD] (%); Core Photo; Optical and Accoustic Televiewer N E S W) | Piezometer Details | Downhole Wireline (Natural Gamma (API) 50 100 150 200 250; Borehole Diameter (mm) 75 100 125 150 175; Neutron Porosity (%) 20 40 60; Density (g/cm3) 1 2 3 — Short Density, Long Density; Neutron Log (CPS) 1000 2000 3000 4000 5000 6000 — Short Neutron, Long Neutron; Induction (mS/m) 160 320 480 640 — Short, Deep) | Laboratory Testing (Misc Laboratory Testing; Geochemical Testing) | Geology (Geological Unit *(Geotech. Unit)*)

RL (m)	Depth (m)	Classification Symbol	Description
		SP	sub-angular; light grey; trace clay, low to medium plasticity
	20.5		gravelly SAND: medium to coarse grained; light grey mottled purple; gravel is fine, sub-rounded to sub-angular, trace clay
192	21.0	CH-CI	sandy CLAY: medium to high plasticity; white/light grey; sand is fine grained, poorly graded
	21.5	SP	gravelly SAND: coarse grained; light grey mottled purple; gravel is fine, sub-rounded to sub-angular, trace clay
191	22.0	CH-CI	sandy CLAY: medium to high plasticity; light grey mottled brown; sand is fine to medium grained, poorly graded
	22.5	SP	gravelly SAND: coarse grained; brown mottled light grey; gravel is fine to medium sized, sub-rounded to sub-angular, trace clay
190	23.0		from 22.80 m, becoming light grey mottled red-brown/purple
	23.5		
189	24.0		*Borehole L02 log continued as cored log from m.*
	24.5		
188	25.0		
	25.5		
187	26.0		
	26.5		
186	27.0		
	27.5		
185	28.0		
	28.5		
184	29.0		
	29.5		
183	30.0		

Piezometer construction:

- 17.0 to 24.0 m: 2 mm FILTER SAND
- 18.0 to 24.0 m: 50 mm PVC (0.04 mm apperture)
- 24.0 to 24.0 m: 50 mm PVC

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Engineering Summary Log

BOREHOLE No. L03
Sheet: 1 of 3

Client: Department of Industry, Innovation and Science
Project: NRWMF - Site Characterisation
Location: Lyndhurst (Kimba)
Drilling Water: Potable water sourced from Kimba (measured EC <1000 μS/cm)

Project No: 60565376
Logged by: JT
Checked by: HS

Start Date: 10/05/2018
End Date: 15/05/2018
Location Meth.: dGPS0.1

Driller: SWD
Drill Rig: Sonic Geoprobe

Hole Diameter: 169 mm
Inclination: -90°
Bearing: N/A

Easting: 644997.1 m
Northing: 6342541.4 m
Hor. Proj/Dat: MGA94/GDA94-54J

RL: 214.9 m
Ver. Datum: AHD
Surface:

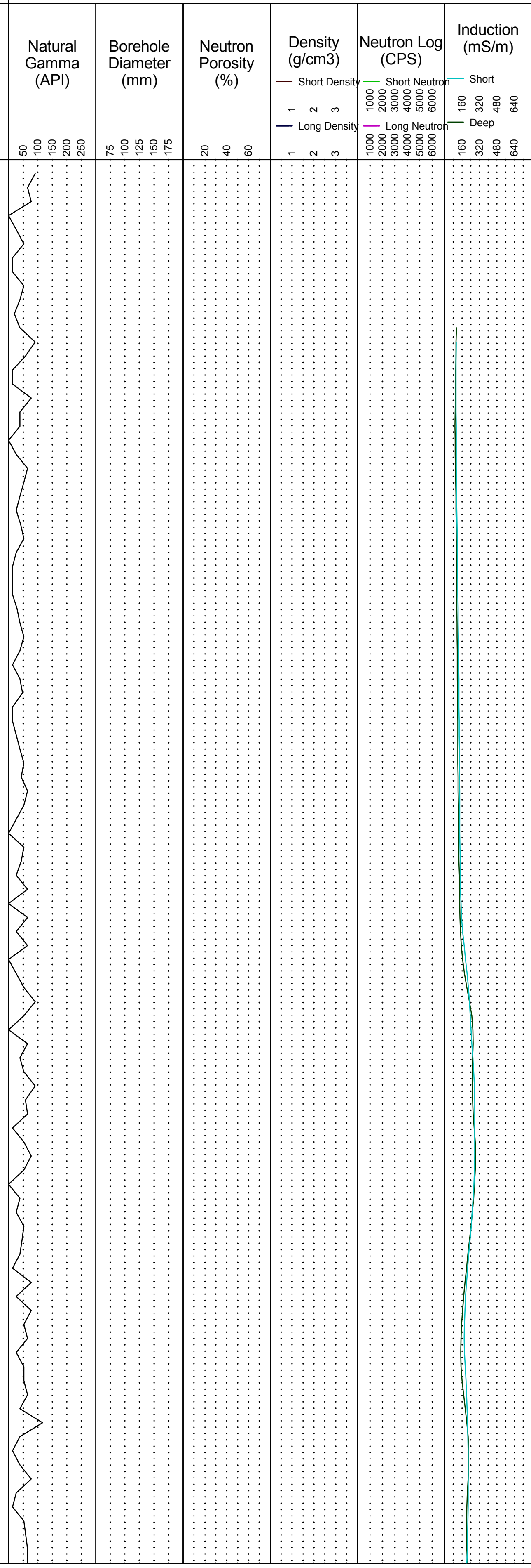
Piezometer Details

Casing Top RL: 215.43 m AHD
Response Zone Top RL: -
Response Zone Base RL: -
Length of Response Zone: 6.00 m
Development Date: 16/05/2018

Reduced Level (m)	Depth (m)	Field Tests	Samples	Classification Symbol	Description	Piezometer Details
	0.0 –				NO CORE	0.6 above ground to 0.0 m: Steel Monument
214	1.0				CALCRETE: light yellow-brown; moderately weathered, low to medium strength, poorly developed, with fine to medium grained sand, yellow-brown	
		SPT:17,11,21 N=32		CI-CL	sandy CLAY: low to medium plasticity; orange-brown and yellow-brown; sand is fine to medium grained	
213	2.0			SP	SAND: fine to medium grained; orange-brown; poorly graded, cemented, trace clay	
	2.5				from 2.50 m to 3.00 m: with Calcrete fragments, medium to coarse gravel, angular to sub-angular, light yellow-brown	
212	3.0	SPT:15,18,19 N=37				
211	4.0					
	4.5	SPT:15,27,28 N=55				
210	5.0			CI-CL	sandy CLAY: low to medium plasticity; orange-brown mottled light yellow-brown; sand is fine to medium grained	
209	6.0	SPT:12,16,22 N=38				
208	7.0		DS			0.0 to 14.0 m: CEMENT/ BENTONITE GROUT
	7.5	SPT:10,18,21 N=39				
207	8.0			SP	SAND: fine to medium grained; orange-brown and yellow-brown; trace clay	
206	9.0	SPT:12,19,23 N=42		CH-CI	sandy CLAY: medium to high plasticity; red-brown mottled light grey	0.0 to 18.0 m: Solid Pipe
205	10.0					

Column headings also printed: Water; Graphic Log; Weathering/ Consistency; TCR (SCR) [RQD] (%); Core Photo; Optical and Accoustic Televiewer (N E S W); Misc Laboratory Testing; Geochemical Testing; Geological Unit *(Geotech. Unit)*.

Downhole Wireline



Laboratory Testing

Geology

AECOM

Engineering Summary Log

BOREHOLE No. L03

Client: Department of Industry, Innovation and Science	**Project No:** 60565376	**Start Date:** 10/05/2018	**Driller:** SWD	**Hole Diameter:** 169 mm	**Easting:** 644997.1 m	**RL:** 214.9 m
Project: NRWMF - Site Characterisation	**Logged by:** JT	**End Date:** 15/05/2018	**Drill Rig:** Sonic Geoprobe	**Inclination:** -90°	**Northing:** 6342541.4 m	**Ver. Datum:** AHD
Location: Lyndhurst (Kimba)	**Checked by:** HS	**Location Meth.:** dGPS0.1		**Bearing:** N/A	**Hor. Proj/Dat:** MGA94/GDA94-54J	**Surface:**

Drilling Water: Potable water sourced from Kimba (measured EC <1000 µS/cm)

Piezometer Details

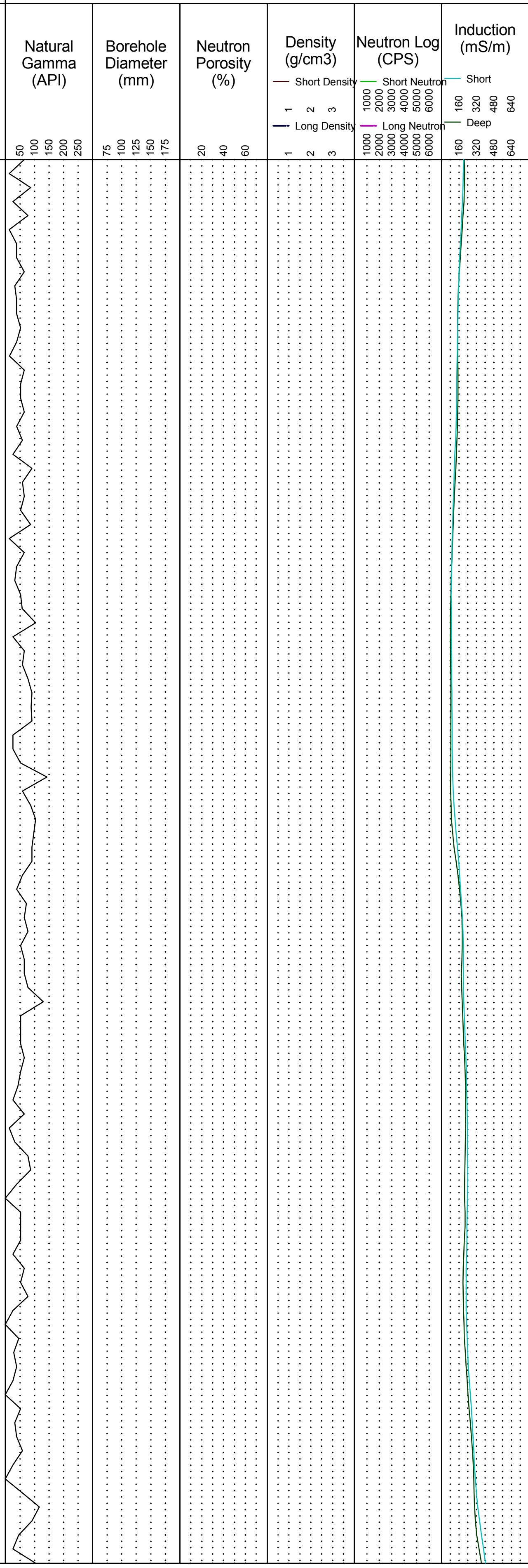
Casing Top RL: 215.43 m AHD
Response Zone Top RL: -
Response Zone Base RL: -
Length of Response Zone: 6.00 m
Development Date: 16/05/2018

Reduced Level (m)	Depth (m)	Water	Field Tests	Samples	Classification Symbol	Description
					CH-CI	sandy CLAY: medium to high plasticity; red-brown mottled light grey *(continued)*
	10.5		SPT:19,22,30/105mm N=R			
204	11.0					
	11.5				CH-CI	gravelly sandy CLAY: medium to high plasticity; red-brown mottled light grey; with ironstone nodules, black/dark grey, angular to sub-angular
203	12.0		SPT:25,27,30/100mm N=R	DS	CH-CI	sandy CLAY: medium to high plasticity; red-brown mottled light grey
	12.5					
202	13.0				CI-CL	gravelly sandy CLAY: low to medium plasticity; orange-brown mottled light grey; sand is fine to medium grained, gravel is fine to coarse sized, angular to sub-angular dark grey mottled yellow-brown (calcrete)
	13.5		SPT:33/110mm N=R			
201	14.0					
	14.5				CH-CI	sandy CLAY: medium to high plasticity; red-brown mottled light grey; sand is fine grained, poorly graded
200	15.0		SPT:23,30,R N=R	DS		
	15.5	∇			GC	clayey sandy GRAVEL: fine grained; sub-rounded to sub-angular; red-brown mottled light grey; sand is fine grained, poorly graded
199	16.0					
	16.5					
198	17.0					
	17.5					becoming sandy CLAY
197	18.0			DS	GP	clayey sandy GRAVEL: fine grained; sub-rounded to sub-angular; red-brown mottled yellow; clay is medium to high plasticity, sand is medium to coarse grained
	18.5					
196	19.0					
	19.5					
195	20.0					

Piezometer: 14.0 to 17.0 m: BENTONITE SEAL (PELLETS)

Rock Condition: Weathering/Consistency | TCR (SCR) [RQD] (%) | Core Photo | Optical and Accoustic Televiewer (N E S W)

Downhole Wireline



Laboratory Testing: Misc Laboratory Testing | Geochemical Testing

Geology: Geological Unit *(Geotech. Unit)*

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Engineering Summary Log

BOREHOLE No. L03

Sheet: 3 of 3

Client: Department of Industry, Innovation and Science	**Project No:** 60565376	**Start Date:** 10/05/2018	**Driller:** SWD	**Hole Diameter:** 169 mm	**Easting:** 644997.1 m	**RL:** 214.9 m
Project: NRWMF - Site Characterisation	**Logged by:** JT	**End Date:** 15/05/2018	**Drill Rig:** Sonic Geoprobe	**Inclination:** -90°	**Northing:** 6342541.4 m	**Ver. Datum:** AHD
Location: Lyndhurst (Kimba)	**Checked by:** HS	**Location Meth.:** dGPS0.1		**Bearing:** N/A	**Hor. Proj/Dat:** MGA94/GDA94-54J	**Surface:**

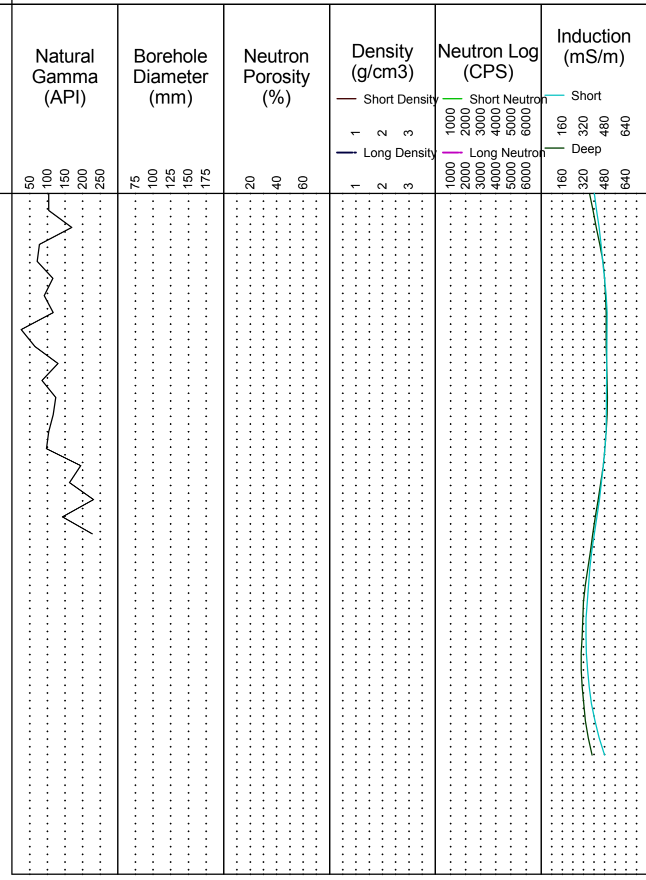
Drilling Water: Potable water sourced from Kimba (measured EC <1000 µS/cm)

Field Data | **Material Description** | **Rock Condition** | **Piezometer Details** | **Downhole Wireline** | **Laboratory Testing** | **Geology**

Piezometer Details
- **Casing Top RL:** 215.43 m AHD
- **Response Zone Top RL:** -
- **Response Zone Base RL:** -
- **Length of Response Zone:** 6.00 m
- **Development Date:** 16/05/2018

Reduced Level (m)	Depth (m)	Graphic Log	Classification Symbol	Description	Piezometer
			GP		
	20.5		CH-CI	sandy CLAY: medium to high plasticity; brown mottled red-brown/light grey; sand is fine to medium grained becoming light grey/ white	17.0 to 24.0 m: 2 mm FILTER SAND
194	21.0		CH-CI	CLAY: medium to high plasticity; brown mottled light grey; trace medium to coarse gravel, angular to sub-angular	18.0 to 24.0 m: Slotted Pipe
	21.5				
193	22.0				
	22.5				
192	23.0			from 22.80 m to 22.90 m: sandy GRAVEL: fine to coarse sized, angular to sub-angular, sand is fine to medium grained	
			CH-CI	CLAY: medium to high plasticity; light grey/white	
	23.5				
191	24.0			from 23.70 m to 23.80 m: light grey/white mottled red-brown	
				Borehole L03 log continued as cored log from m.	
	24.5				
190	25.0				
	25.5				
189	26.0				
	26.5				
188	27.0				
	27.5				
187	28.0				
	28.5				
186	29.0				
	29.5				
185	30.0				

Columns: Water | Field Tests | Samples | Weathering/ Consistency | TCR (SCR) [RQD] (%) | Core Photo | Optical and Accoustic Televiewer (N E S W) | Misc Laboratory Testing | Geochemical Testing | Geological Unit *(Geotech. Unit)*



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Engineering Summary Log

BOREHOLE No. L04
Sheet: 1 of 3

Client:	Department of Industry, Innovation and Science	**Project No:** 60565376	**Start Date:** 09/05/2018	**Driller:** SWD	**Hole Diameter:** 169 mm	**Easting:** 644254.1 m	**RL:** 220.1 m
Project:	NRWMF - Site Characterisation	**Logged by:** TS	**End Date:** 10/05/2018	**Drill Rig:** Sonic Geoprobe	**Inclination:** -90°	**Northing:** 6342261.5 m	**Ver. Datum:** AHD
Location:	Lyndhurst (Kimba)	**Checked by:** HS	**Location Meth.:** dGPS0.1		**Bearing:** N/A	**Hor. Proj/Dat:** MGA94/GDA94-54H	**Surface:** Sand

Drilling Water: Potable water sourced from Kimba (measured EC <1000 µS/cm)

Field Data: Reduced Level (m) / Depth (m) | Water | Field Tests | Samples

Material Description: Graphic Log | Classification Symbol | Description

Rock Condition: Weathering/Consistency | TCR (SCR) [RQD] (%) | Core Photo | Optical and Accoustic Televiewer (N E S W)

Piezometer Details:

Casing Top RL: 220.83 m AHD
Response Zone Top RL: -
Response Zone Base RL: -
Length of Response Zone: 6.00 m
Development Date: 16/05/2018

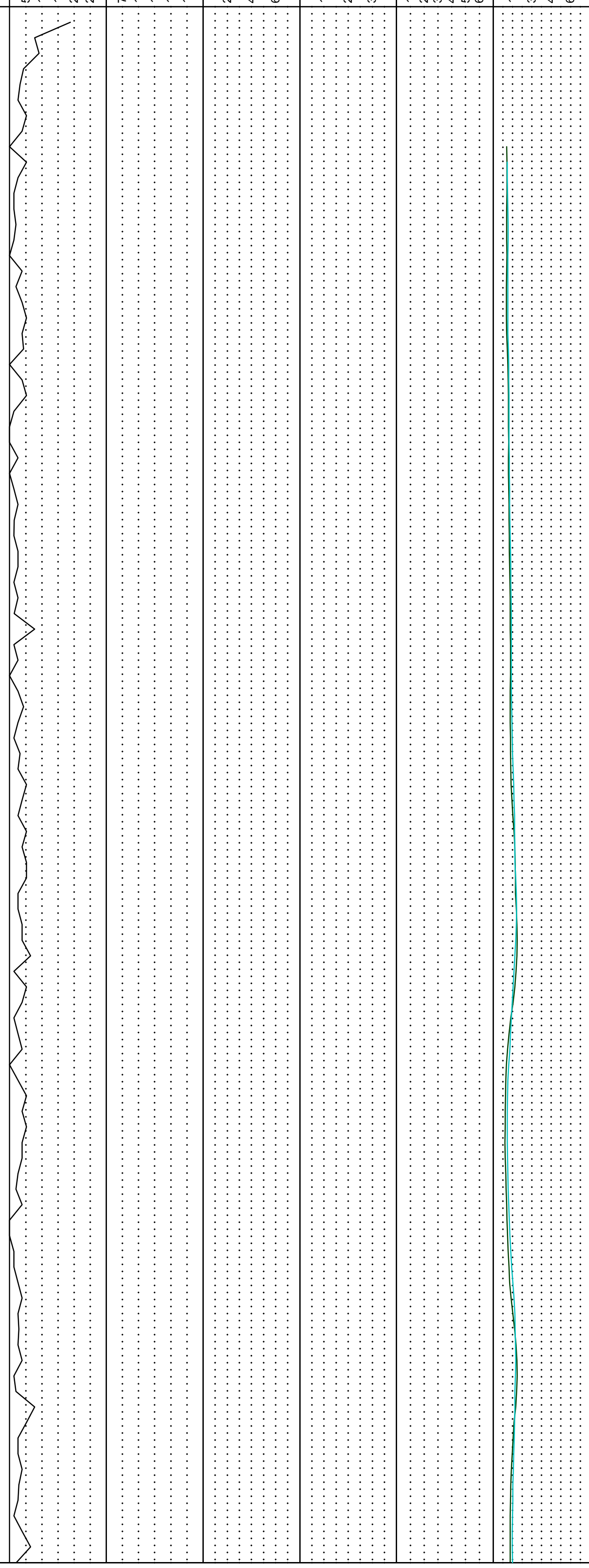
Downhole Wireline: Natural Gamma (API) | Borehole Diameter (mm) | Neutron Porosity (%) | Density (g/cm3) | Neutron Log (CPS) | Induction (mS/m)

Laboratory Testing: Misc Laboratory Testing | Geochemical Testing

Geology: Geological Unit *(Geotech. Unit)*

Field Tests	Classification Symbol	Description
	SP	SAND: fine to medium grained; orange-brown; siliceous, trace clay from 0.50 m: trace block organics, increase in clay content
		SILCRETE: fine grained; orange-brown; very low strength, poorly cemented, in a clay matrix
		CALCRETE: fine grained; cream; very low strength, poorly cemented, calcareous clay, with fine to coarse grained sand
SPT:30/50mm N=R	SP	SAND: fine grained; angular; red-brown; trace clay
		CALCRETE: fine grained; cream; calcareous clays, very low strength, poorly cemented, with fine to coarse grained, angular sand
SPT:9,11,9 N=20	SC	clayey SAND: fine to medium grained; red-brown; angular to sub-rounded, siliceous, with clay at 3.50 m: red at 4.20 m: bright red, increase in clay content
SPT:10,11,11 N=22	CI-CL	sandy CLAY: low to medium plasticity; brown; with fine to coarse grained sand and black organics
SPT:12,10,11 N=21 SPT:9,13,15 N=28	SC	clayey SAND: fine to coarse grained; angular to sub-rounded, with clay, light brown, poorly sorted from 7.00 m, becoming red-brown from 7.30 m to 7.40 m: Silcrete band, cream, very poorly cemented at 7.50 m: red
	CH	sandy CLAY: high plasticity; dark red; sand is fine to coarse grained, angular to sub-angular
SPT:18,22,23 N=45	SC	clayey SAND: fine to coarse grained; red-brown; angular to rounded, with clay, poorly sorted

Piezometer:
0.6 above ground to 0.0 m: Steel Monument
0.0 to 14.0 m: CEMENT/ BENTONITE GROUT
0.0 to 18.0 m: Solid Pipe



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Engineering Summary Log

Client: Department of Industry, Innovation and Science | **Project No:** 60565376 | **Start Date:** 09/05/2018 | **Driller:** SWD | **Hole Diameter:** 169 mm | **Easting:** 644254.1 m | **RL:** 220.1 m

Project: NRWMF - Site Characterisation | **Logged by:** TS | **End Date:** 10/05/2018 | **Drill Rig:** Sonic Geoprobe | **Inclination:** -90° | **Northing:** 6342261.5 m | **Ver. Datum:** AHD

Location: Lyndhurst (Kimba) | **Checked by:** HS | **Location Meth.:** dGPS0.1 | **Bearing:** N/A | **Hor. Proj/Dat:** MGA94/GDA94-54H | **Surface:** Sand

Drilling Water: Potable water sourced from Kimba (measured EC <1000 µS/cm)

Piezometer Details: Casing Top RL: 220.83 m AHD; Response Zone Top RL: -; Response Zone Base RL: -; Length of Response Zone: 6.00 m; Development Date: 16/05/2018

Reduced Level (m) / Depth (m)	Water	Field Tests	Classification Symbol	Description	Piezometer Details
210 / 10.0–12.0		SPT:18/30mm N=R (10.5)	SC	clayey SAND: fine to coarse grained; red-brown; angular to rounded, with clay, poorly sorted *(continued)* at 10.60 m: predominantly fine to medium grained, increasing clay content	
208 / 12.0–15.5		SPT:13,20,25 N=45 (12.0) SPT:10,15,30 N=45 (13.5) SPT:12,13,25/50mm N=R (15.0)	CH-CI	CLAY: medium to high plasticity; grey mottled red; with fine to coarse grained, angular to sub-angular sand from 12.10 m, becoming trace sand at 13.50 m: sandy CLAY	
15.5–18.0			SP	SAND: fine to medium grained; sub-angular; grey mottled red; with silt/clay zones of partial induration, moderately sorted at 16.50 m: light brown-grey, well cemented, trace gravel at 17.00 m: grey, poorly cemented	14.0 to 17.0 m: BENTONITE SEAL (PELLETS)
18.0–19.0	▽ (18.0)		SW	SAND: fine to coarse grained; angular; red-brown and grey; some clay, indurated, water strike at 18-18.5 mbgs from 18.50 m: grey mottled red-brown; not cemented, increasing clay content	
201 / 19.0–20.0			CL	sandy CLAY: low plasticity; dark red and grey; sand is fine to coarse grained, angular to sub-angular, siliceous at 19.80 m: weakly indurated	

Column headings also present: Samples; Graphic Log; Weathering/Consistency; TCR (SCR) [RQD] (%); Core Photo; Optical and Accoustic Televiewer (N E S W); Downhole Wireline: Natural Gamma (API) (50 100 150 200 250); Borehole Diameter (mm) (75 100 125 150 175); Neutron Porosity (%) (20 40 60); Density (g/cm3) (Short Density, Long Density; 1 2 3); Neutron Log (CPS) (Short Neutron, Long Neutron; 1000–6000); Induction (mS/m) (Short, Deep; 160 320 480 640); Laboratory Testing: Misc Laboratory Testing, Geochemical Testing; Geology: Geological Unit *(Geotech. Unit)*

AECOM

Engineering Summary Log

Client: Department of Industry, Innovation and Science
Project: NRWMF - Site Characterisation
Location: Lyndhurst (Kimba)
Drilling Water: Potable water sourced from Kimba (measured EC <1000 µS/cm)

Project No: 60565376
Logged by: TS
Checked by: HS

Start Date: 09/05/2018
End Date: 10/05/2018
Location Meth.: dGPS0.1

Driller: SWD
Drill Rig: Sonic Geoprobe

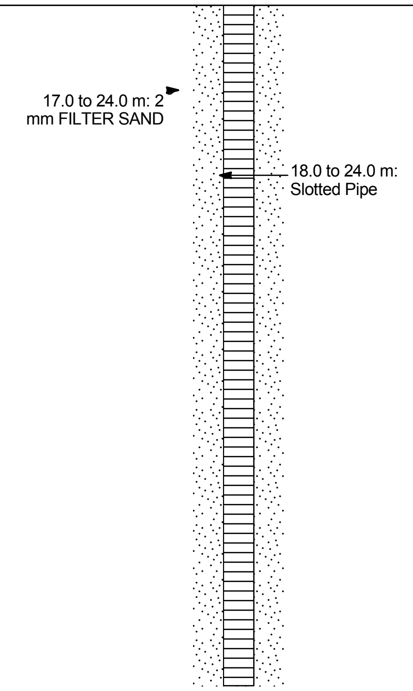
Hole Diameter: 169 mm
Inclination: -90°
Bearing: N/A

Easting: 644254.1 m
Northing: 6342261.5 m
Hor. Proj/Dat: MGA94/GDA94-54H

RL: 220.1 m
Ver. Datum: AHD
Surface: Sand

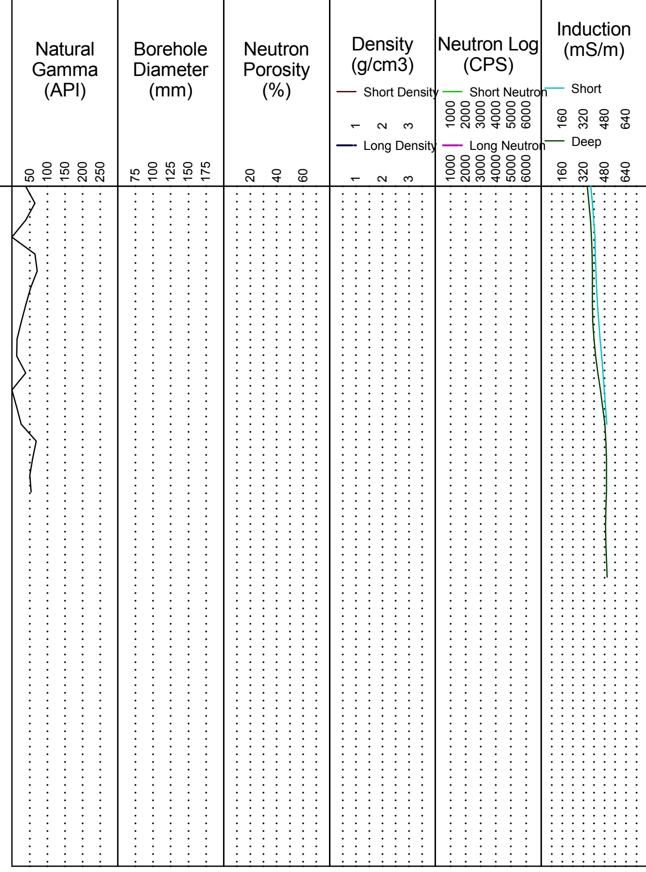
Piezometer Details

Casing Top RL: 220.83 m AHD
Response Zone Top RL: -
Response Zone Base RL: -
Length of Response Zone: 6.00 m
Development Date: 16/05/2018



Downhole Wireline

Natural Gamma (API); Borehole Diameter (mm); Neutron Porosity (%); Density (g/cm3) — Short Density, Long Density; Neutron Log (CPS) — Short Neutron, Long Neutron; Induction (mS/m) — Short, Deep



Material Description

Reduced Level (m)	Depth (m)	Water	Field Tests	Samples	Graphic Log	Classification Symbol	Description	Weathering/ Consistency	TCR (SCR) [RQD] (%)	Core Photo	Optical and Accoustic Televiewer	Misc Laboratory Testing	Geochemical Testing	Geological Unit (Geotech. Unit)
200	20.0–21.2					CL	sandy CLAY: low plasticity; dark red and grey; sand is fine to coarse grained, angular to sub-angular, siliceous *(continued)*							
199	21.2–24.0					CH-CI	CLAY: medium to high plasticity; grey mottled red-brown; some fine to coarse grained, angular sand							
197	23.50						from 23.50 m: increasing sand content							
196	24.0						*Borehole L04 log continued as cored log from m.*							

Depth scale: 20.5, 21.0, 21.5, 22.0, 22.5, 23.0, 23.5, 24.0, 24.5, 25.0, 25.5, 26.0, 26.5, 27.0, 27.5, 28.0, 28.5, 29.0, 29.5, 30.0
Reduced level scale: 200, 199, 198, 197, 196, 195, 194, 193, 192, 191

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Engineering Summary Log

BOREHOLE No. L05S

Client: Department of Industry, Innovation and Science	**Project No:** 60565376	**Start Date:** 08/05/2018	**Driller:** SWD	**Hole Diameter:** 169 mm	**Easting:** 644269.8 m
Project: NRWMF - Site Characterisation	**Logged by:** TS	**End Date:** 08/05/2018	**Drill Rig:** Sonic Geoprobe	**Inclination:** -90°	**Northing:** 6343217.9 m
Location: Lyndhurst (Kimba)	**Checked by:** HS	**Location Meth.:** dGPS0.1		**Bearing:** N/A	**Hor. Proj/Dat:** MGA94/GDA94-54H

RL: 208.3 m **Ver. Datum:** AHD **Surface:** Sand

Drilling Water: Potable water sourced from Kimba (measured EC <1000 µS/cm)

Field Data — Reduced Level (m) / Depth (m); Water; Field Tests; Samples
Material Description — Graphic Log; Classification Symbol; Description
Rock Condition — Weathering/Consistency; TCR (SCR) [RQD] (%); Core Photo; Optical and Accoustic Televiewer (N E S W)
Piezometer Details — Casing Top RL: 208.83 m AHD; Response Zone Top RL: -; Response Zone Base RL: -; Length of Response Zone: 6.00 m; Development Date: 17/05/2018
Downhole Wireline — Natural Gamma (API) (50 100 150 200 250); Borehole Diameter (mm) (75 100 125 150 175); Neutron Porosity (%) (20 40 60); Density (g/cm3) (1 2 3) — Short Density, Long Density; Neutron Log (CPS) (1000 2000 3000 4000 5000 6000) — Short Neutron, Long Neutron; Induction (mS/m) (160 320 480 640) — Short, Deep
Laboratory Testing — Misc Laboratory Testing; Geochemical Testing
Geology — Geological Unit *(Geotech. Unit)*

Reduced Level (m): 208, 207, 206, 205, 204, 203, 202, 201, 200, 199
Depth (m): 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5, 5.0, 5.5, 6.0, 6.5, 7.0, 7.5, 8.0, 8.5, 9.0, 9.5, 10.0

Classification Symbol	Description
SM	silty SAND: fine to coarse grained; red-brown; sub-angular to rounded, siliceous, with silt, poorly to moderately sorted from 1.00 m: becoming calcareous
	CALCRETE: red/cream; extremely weathered, very low strength, very poorly cemented, fine to coarse sand in cemented clayey matrix
	SILCRETE: red/cream; extremely weathered, very low strength, very poorly cemented
SP	SAND: fine to medium grained; orange-brown; sub-angular to rounded, siliceous, trace silt becoming red-brown, fine to coarse grained, angular to sub-rounded, some clay, moderately sorted, predominantly fine grained sand
SW	SAND: fine to coarse grained; red-brown mottled grey; sub-angular to rounded, siliceous, with clay, poorly sorted, well graded
SM	silty SAND: fine to medium grained; grey; angular to sub-rounded, with silt
SP	SAND: fine grained; red mottled grey; angular to sub-angular, with clays, ferruginous
CI-CL	sandy CLAY: low to medium plasticity; grey; with fine to medium grained sand, water strike at ~10.0 mbgs

Field Tests:
- SPT:10,9,9 N=18
- SPT:14,14,14 N=28
- SPT:14,14,9 N=23
- SPT:10,14,13 N=27
- SPT:11,8,5 N=13
- SPT:4,6,8 N=14

Piezometer Details:
- 0.6 above ground to 0.0 m: Steel Monument
- 0.0 to 2.0 m: CEMENT/ BENTONITE GROUT
- 0.0 to 6.0 m: Solid Pipe
- 2.0 to 5.0 m: BENTONITE SEAL (PELLETS)
- 6.0 to 12.0 m: Slotted Pipe
- 5.0 to 14.0 m: 2 mm FILTER SAND

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Engineering Summary Log

BOREHOLE No. L05S

Sheet: 2 of 2

Client:	Department of Industry, Innovation and Science	**Project No:**	60565376	**Start Date:**	08/05/2018	**Driller:**	SWD	**Hole Diameter:**	169 mm	**Easting:**	644269.8 m
Project:	NRWMF - Site Characterisation	**Logged by:**	TS	**End Date:**	08/05/2018	**Drill Rig:**	Sonic Geoprobe	**Inclination:**	-90°	**Northing:**	6343217.9 m
Location:	Lyndhurst (Kimba)	**Checked by:**	HS	**Location Meth.:**	dGPS0.1			**Bearing:**	N/A	**Hor. Proj/Dat:**	MGA94/GDA94-54H

RL: 208.3 m | **Ver. Datum:** AHD | **Surface:** Sand

Drilling Water: Potable water sourced from Kimba (measured EC <1000 µS/cm)

Piezometer Details

Casing Top RL: 208.83 m AHD
Response Zone Top RL: -
Response Zone Base RL: -
Length of Response Zone: 6.00 m
Development Date: 17/05/2018

Depth (m)	Field Tests	Samples	Classification Symbol	Description	Misc Laboratory Testing
10.2–12.0	SPT:3,2,5 N=7 (10.5–11.0)		SW	SAND: fine to coarse grained; red mottled grey; angular to sub-rounded, with clay from 10.50 m: clay content increases, non-plastic to low plasticity	
12.0–12.2			SP	SAND: fine grained; red-brown mottled grey; trace clay	
12.2–14.0	SPT:11,27,20 N=47 (12.05–12.5)	U_{63} (13.6–14.0)	CI	sandy CLAY: medium plasticity; grey; with fine to medium grained sand, indurated	L05D_13.5-13.9m: Permeability (U63): 4.0 x10^{-11} m/sec
14.0				*Borehole L05S log continued as cored log from m.*	

Column headings: Reduced Level (m) / Depth (m); Water; Field Tests; Samples; Graphic Log; Classification Symbol; Description; Weathering/Consistency; TCR (SCR) [RQD] (%); Core Photo; Optical and Accoustic Televiewer (N E S W); Natural Gamma (API) 50 100 150 200 250; Borehole Diameter (mm) 75 100 125 150 175; Neutron Porosity (%) 20 40 60; Density (g/cm3) 1 2 3 — Short Density — Long Density; Neutron Log (CPS) 1000 2000 3000 4000 5000 6000 — Short Neutron — Long Neutron; Induction (mS/m) 160 320 480 640 — Short — Deep; Misc Laboratory Testing; Geochemical Testing; Geological Unit *(Geotech. Unit)*

Depth scale: 10.5, 11.0, 11.5, 12.0, 12.5, 13.0, 13.5, 14.0, 14.5, 15.0, 15.5, 16.0, 16.5, 17.0, 17.5, 18.0, 18.5, 19.0, 19.5, 20.0
RL scale: 198, 197, 196, 195, 194, 193, 192, 191, 190, 189

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Engineering Summary Log

BOREHOLE No. **L05D**

Client: Department of Industry, Innovation and Science	**Project No:** 60565376	**Start Date:** 04/05/2018	**Driller:** SWD	**Hole Diameter:** 169 mm	**Easting:** 644270.0 m	**RL:** 208.0 m
Project: NRWMF - Site Characterisation	**Logged by:** TS	**End Date:** 07/05/2018	**Drill Rig:** Sonic Geoprobe	**Inclination:** -90°	**Northing:** 6343230.0 m	**Ver. Datum:** AHD
Location: Lyndhurst (Kimba)	**Checked by:** HS	**Location Meth.:** dGPS0.1		**Bearing:** N/A	**Hor. Proj/Dat:** MGA94/GDA94-54H	**Surface:** Sand

Drilling Water: Potable water sourced from Kimba (measured EC <1000 µS/cm)

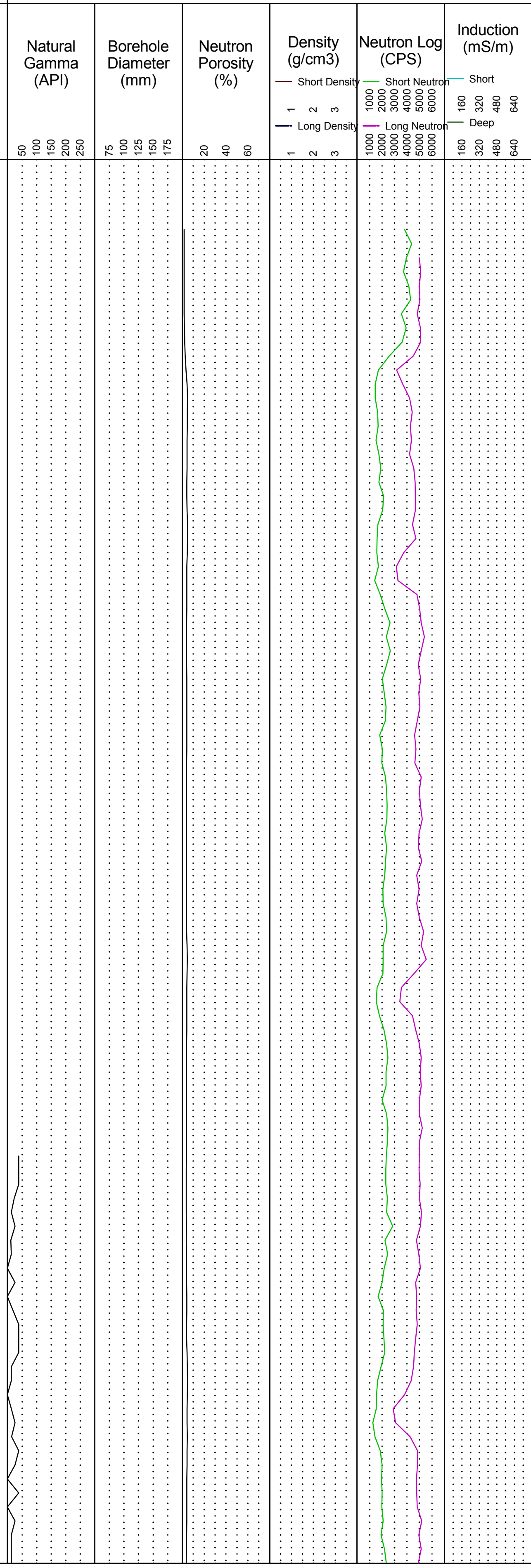
Piezometer Details

Casing Top RL: 208.86 m AHD
Response Zone Top RL: -
Response Zone Base RL: -
Length of Response Zone: 6.00 m
Development Date: 15/05/2018

0.6 above ground to 0.0 m: Steel Monument

Depth (m)	Samples	Classification Symbol	Description
0.0	BAG JAR	SP	SAND: fine grained; angular to sub-angular; light brown; siliceous, moderately sorted
1.0			CALCRETE: light brown; extremely low strength, very poorly cemented sandy clays
1.5			NO CORE: from 1.50 to 2.60m
2.6		SP	SAND: fine to medium grained; angular to sub-angular; red-brown; siliceous, with clay becoming angular
4.0	BAG JAR	SP	SAND: fine to medium grained; sub-angular; red; some clay, ferruginous at 4.60 m: red-brown, trace clay
6.0	U_{63}	SW	SAND: fine to coarse grained; angular to sub-angular; grey mottled red; some silt, moderately sorted
7.7			sandy CLAY: non-plastic; grey mottled red; ferruginous clay with fine to coarse siliceous sand becoming low to medium plasticity, grey mottled-purple

Downhole Wireline: Natural Gamma (API); Borehole Diameter (mm); Neutron Porosity (%); Density (g/cm3) — Short Density, Long Density; Neutron Log (CPS) — Short Neutron, Long Neutron; Induction (mS/m) — Short, Deep



Laboratory Testing: Misc Laboratory Testing | Geochemical Testing

Geology: Geological Unit *(Geotech. Unit)*

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Engineering Summary Log

BOREHOLE No. L05D

Client: Department of Industry, Innovation and Science	**Project No:** 60565376	**Start Date:** 04/05/2018	**Driller:** SWD	**Hole Diameter:** 169 mm	**Easting:** 644270.0 m
Project: NRWMF - Site Characterisation	**Logged by:** TS	**End Date:** 07/05/2018	**Drill Rig:** Sonic Geoprobe	**Inclination:** -90°	**Northing:** 6343230.0 m
Location: Lyndhurst (Kimba)	**Checked by:** HS	**Location Meth.:** dGPS0.1		**Bearing:** N/A	**Hor. Proj/Dat:** MGA94/GDA94-54H

RL: 208.0 m **Ver. Datum:** AHD **Surface:** Sand

Drilling Water: Potable water sourced from Kimba (measured EC <1000 µS/cm)

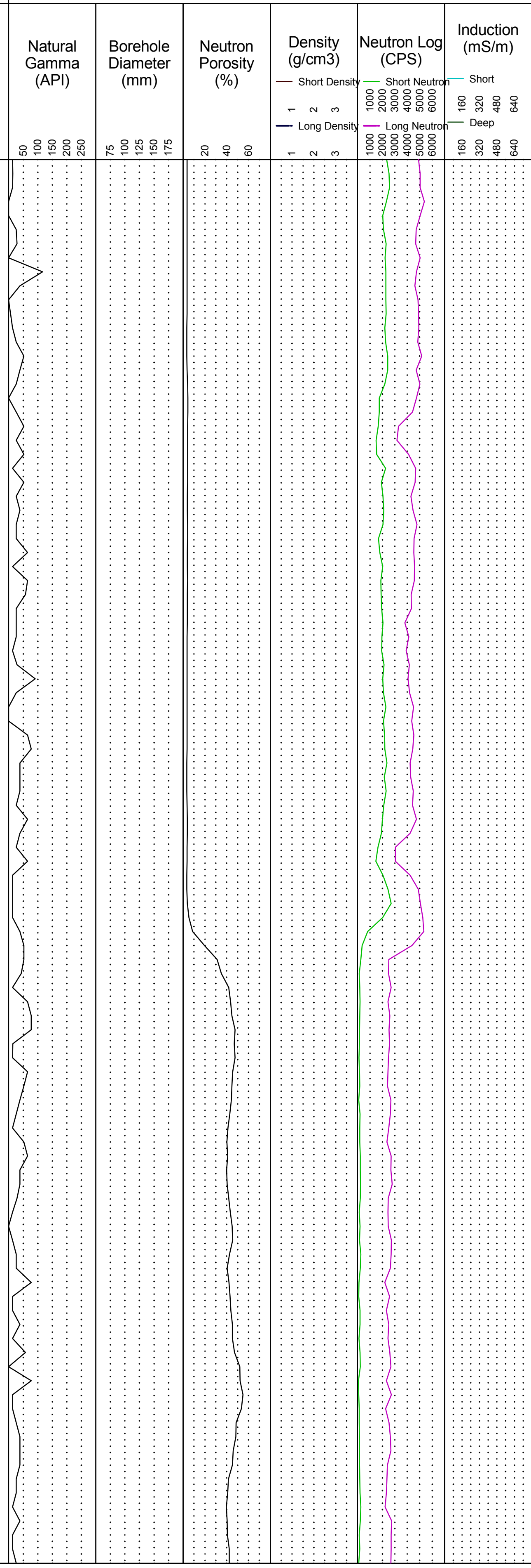
Piezometer Details: Casing Top RL: 208.86 m AHD; Response Zone Top RL: -; Response Zone Base RL: -; Length of Response Zone: 6.00 m; Development Date: 15/05/2018

Depth (m)	Samples	Classification Symbol	Description
to ~10.5		CI-CL	sandy CLAY: low to medium plasticity; fine to medium grained; grey mottled red; with fine to medium grained, sub-angular siliceous sand, water strike at ~10.0 mbgs
~10.5 – ~11.9		SC	clayey SAND: fine and coarse grained; angular to sub-angular; red; with clay
~11.9 – ~12.1	BAG JAR	SP	SAND: fine to medium grained; angular to sub-angular; red; with clay (ferruginous)
~12.1 – ~13.3		CH	CLAY: high plasticity; grey; angular quartz sand, indurated
~13.3 – ~15.8		CI-CL	sandy CLAY: low to medium plasticity; grey mottled red-brown; with fine to medium grained, angular to sub-angular sand, partially indurated at 15.00 m: sand becomes fine to coarse grained
~15.8 – ~16.9		CH	CLAY: high plasticity; grey mottled red; some fine to medium grained sand, angular to sub-angular, siliceous
~16.9 – 20.0		CI-CL	sandy CLAY: low to medium plasticity; grey/red; with bands of ferruginous sand, fine to coarse grained, angular becoming grey; sand is fine to medium grained, angular to sub-angular

Depth scale: 10.5, 11.0, 11.5, 12.0, 12.5, 13.0, 13.5, 14.0, 14.5, 15.0, 15.5, 16.0, 16.5, 17.0, 17.5, 18.0, 18.5, 19.0, 19.5, 20.0

Reduced Level (m): 198, 197, 196, 195, 194, 193, 192, 191, 190, 189

Downhole Wireline



Laboratory Testing: Misc Laboratory Testing | Geochemical Testing

Geology: Geological Unit *(Geotech. Unit)*

Client: Department of Industry, Innovation and Science
Project: NRWMF - Site Characterisation
Location: Lyndhurst (Kimba)
Drilling Water: Potable water sourced from Kimba (measured EC <1000 µS/cm)

Project No: 60565376
Logged by: TS
Checked by: HS

Start Date: 04/05/2018
End Date: 07/05/2018
Location Meth.: dGPS0.1

Driller: SWD
Drill Rig: Sonic Geoprobe

Hole Diameter: 169 mm
Inclination: -90°
Bearing: N/A

Easting: 644270.0 m
Northing: 6343230.0 m
Hor. Proj/Dat: MGA94/GDA94-54H

RL: 208.0 m
Ver. Datum: AHD
Surface: Sand

Piezometer Details
Casing Top RL: 208.86 m AHD
Response Zone Top RL: -
Response Zone Base RL: -
Length of Response Zone: 6.00 m
Development Date: 15/05/2018

Reduced Level (m) / Depth (m)	Samples	Classification Symbol	Description
188 / 20.0–23.6		CI-CL	sandy CLAY: low to medium plasticity; grey/red; with bands of ferruginous sand, fine to coarse grained, angular *(continued)* from 20.00 m: trace iron oxide cementation, up to 20mm in thickness from 21.30 m: sand is fine to coarse grained, increased oxidation, with clays
23.6–24.1	BAG JAR	SM	silty SAND: fine to coarse grained; angular; grey; poorly graded, predominantly fine grained, iron oxide bands and minor cementation, with silt
24.1–30.0		CH	CLAY: high plasticity; grey-green; some fine to coarse grained, angular quartz sands at 26.20 m: brown-grey; increased sand content, iron oxide discolouration at 28.00 m: orange-brown; oxidised clay, with sand at 29.10 m: grey; trace sands

Depth scale (m): 20.5, 21.0, 21.5, 22.0, 22.5, 23.0, 23.5, 24.0, 24.5, 25.0, 25.5, 26.0, 26.5, 27.0, 27.5, 28.0, 28.5, 29.0, 29.5, 30.0
Reduced Level (m): 188, 187, 186, 185, 184, 183, 182, 181, 180, 179

Column headings: Field Data (Water, Field Tests, Samples); Material Description (Graphic Log, Classification Symbol, Description); Rock Condition (Weathering/Consistency, TCR (SCR) [RQD] (%), Core Photo, Optical and Accoustic Televiewer); Piezometer Details; Downhole Wireline; Laboratory Testing (Misc Laboratory Testing, Geochemical Testing); Geology (Geological Unit *(Geotech. Unit)*)

Downhole Wireline

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Engineering Summary Log

BOREHOLE No. L05D
Sheet: 4 of 8

Client: Department of Industry, Innovation and Science	**Project No:** 60565376	**Start Date:** 04/05/2018	**Driller:** SWD	**Hole Diameter:** 169 mm	**Easting:** 644270.0 m	**RL:** 208.0 m
Project: NRWMF - Site Characterisation	**Logged by:** TS	**End Date:** 07/05/2018	**Drill Rig:** Sonic Geoprobe	**Inclination:** -90°	**Northing:** 6343230.0 m	**Ver. Datum:** AHD
Location: Lyndhurst (Kimba)	**Checked by:** HS	**Location Meth.:** dGPS0.1		**Bearing:** N/A	**Hor. Proj/Dat:** MGA94/GDA94-54H	**Surface:** Sand

Drilling Water: Potable water sourced from Kimba (measured EC <1000 µS/cm)

Piezometer Details: Casing Top RL: 208.86 m AHD; Response Zone Top RL: -; Response Zone Base RL: -; Length of Response Zone: 6.00 m; Development Date: 15/05/2018

Reduced Level (m)	Depth (m)	Samples	Classification Symbol	Description	Piezometer Details
178	30.0		CH	CLAY: high plasticity; grey-green; some fine to coarse grained, angular quartz sands *(continued)*	0.0 to 63.0 m: CEMENT/ BENTONITE GROUT
176	32.0		CH	CLAY: high plasticity; grey-green; with fine grained, siliceous sand, iron oxidation around sand, quartz crystals	0.0 to 67.0 m: Solid Pipe
174	34.0	BAG JAR (35.0)	CH	CLAY: high plasticity; grey-green; trace white, elongated, opaque crystals in matrix	
172	36.0			KAOLIN: fine grained; white/cream; extremely weathered, very low strength, remnant laminations visible, micaceous, trace quartz crystals throughout	
170	38.0			at 38.00 m: becoming fine to medium grained, with trace extremely weathered minerals (chlorite)	
169	39.0			from 39.00 m: increasing quartz content, very soapy texture	

Depth scale: 30.5, 31.0, 31.5, 32.0, 32.5, 33.0, 33.5, 34.0, 34.5, 35.0, 35.5, 36.0, 36.5, 37.0, 37.5, 38.0, 38.5, 39.0, 39.5, 40.0

Column headings: Field Data (Reduced Level (m) / Depth (m), Water, Field Tests, Samples); Material Description (Graphic Log, Classification Symbol, Description); Rock Condition (Weathering/ Consistency, TCR (SCR) [RQD] (%), Core Photo, Optical and Accoustic Televiewer N E S W); Piezometer Details; Downhole Wireline; Laboratory Testing (Misc Laboratory Testing, Geochemical Testing); Geology (Geological Unit *(Geotech. Unit)*)

Client:	Department of Industry, Innovation and Science	**Project No:**	60565376	**Start Date:**	04/05/2018	**Driller:**	SWD	**Hole Diameter:**	169 mm
Project:	NRWMF - Site Characterisation	**Logged by:**	TS	**End Date:**	07/05/2018	**Drill Rig:**	Sonic Geoprobe	**Inclination:**	-90°
Location:	Lyndhurst (Kimba)	**Checked by:**	HS	**Location Meth.:**	dGPS0.1			**Bearing:**	N/A

Easting:	644270.0 m	**RL:**	208.0 m
Northing:	6343230.0 m	**Ver. Datum:**	AHD
Hor. Proj/Dat:	MGA94/GDA94-54H	**Surface:**	Sand

Drilling Water: Potable water sourced from Kimba (measured EC <1000 µS/cm)

Piezometer Details

Casing Top RL: 208.86 m AHD
Response Zone Top RL: -
Response Zone Base RL: -
Length of Response Zone: 6.00 m
Development Date: 15/05/2018

Reduced Level (m)	Depth (m)	Description
168	40.0–44.6	KAOLIN: fine grained; white/cream; extremely weathered, very low strength, remnant laminations visible, micaceous, trace quartz crystals throughout *(continued)*
166	42.4	becoming pale grey, residual to extremely weathered
163	44.6–48.0	GNEISS: fine to medium grained; pale grey; extremely weathered, very low strength, laminated-banded, micaceous, abundant quartz crystals up to 2mm
160	48.0–50.0	KAOLIN: fine grained; white; residual to extremely weathered, very low strength, micaceous, trace biotite

Column headings: Field Data (Reduced Level (m) / Depth (m), Water, Field Tests, Samples); Material Description (Graphic Log, Classification Symbol, Description); Rock Condition (Weathering/Consistency, TCR (SCR) [RQD] (%), Core Photo, Optical and Accoustic Televiewer N E S W); Piezometer Details; Downhole Wireline; Laboratory Testing (Misc Laboratory Testing, Geochemical Testing); Geology (Geological Unit *(Geotech. Unit)*)

Reduced levels: 168, 167, 166, 165, 164, 163, 162, 161, 160, 159
Depths: 40.5, 41.0, 41.5, 42.0, 42.5, 43.0, 43.5, 44.0, 44.5, 45.0, 45.5, 46.0, 46.5, 47.0, 47.5, 48.0, 48.5, 49.0, 49.5, 50.0

Downhole Wireline

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Engineering Summary Log

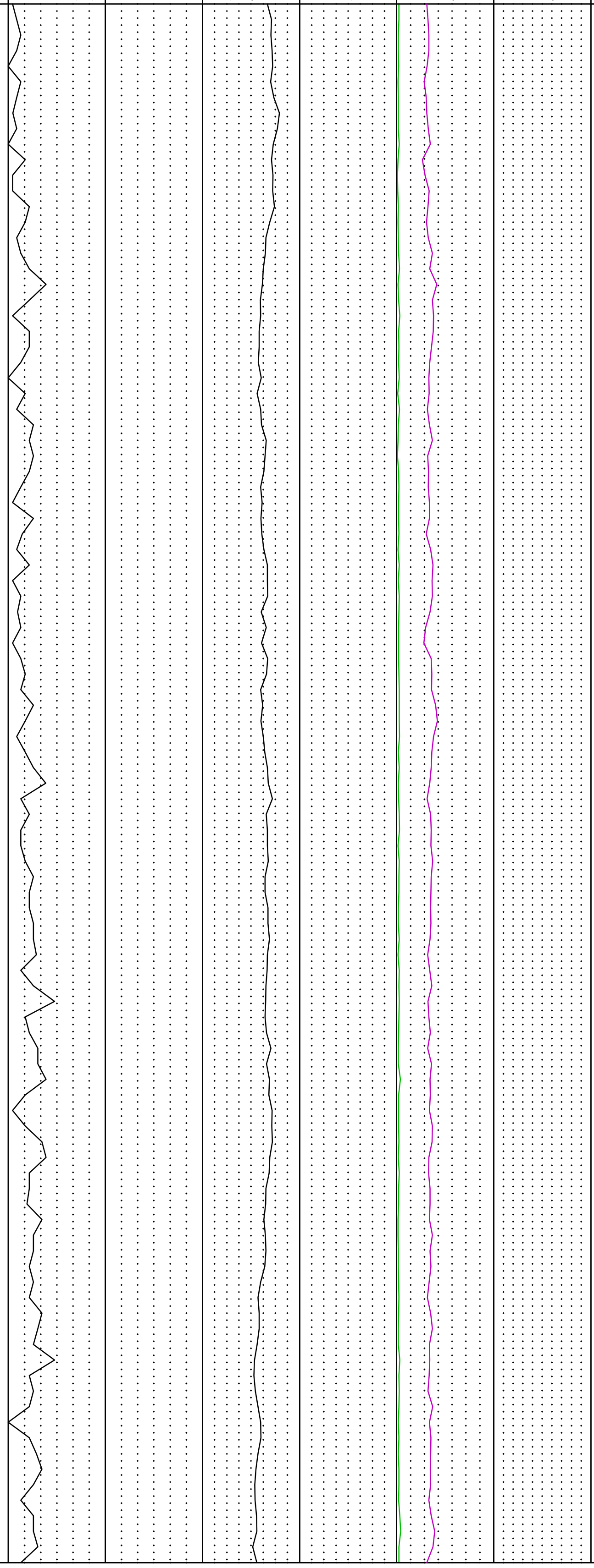
BOREHOLE No. L05D

Client: Department of Industry, Innovation and Science	**Project No:** 60565376	**Start Date:** 04/05/2018	**Driller:** SWD	**Hole Diameter:** 169 mm	**Easting:** 644270.0 m	**RL:** 208.0 m
Project: NRWMF - Site Characterisation	**Logged by:** TS	**End Date:** 07/05/2018	**Drill Rig:** Sonic Geoprobe	**Inclination:** -90°	**Northing:** 6343230.0 m	**Ver. Datum:** AHD
Location: Lyndhurst (Kimba)	**Checked by:** HS	**Location Meth.:** dGPS0.1		**Bearing:** N/A	**Hor. Proj/Dat:** MGA94/GDA94-54H	**Surface:** Sand

Drilling Water: Potable water sourced from Kimba (measured EC <1000 µS/cm)

Piezometer Details: Casing Top RL: 208.86 m AHD; Response Zone Top RL: -; Response Zone Base RL: -; Length of Response Zone: 6.00 m; Development Date: 15/05/2018

Reduced Level (m) / Depth (m)	Samples	Description
158 – 50.5	BAG JAR	KAOLIN: fine grained; white; residual to extremely weathered, very low strength, micaceous, trace biotite *(continued)* from 50.00 m: quartz crystals throughout
51.0 – 157		from 51.10 m: pale grey, faint laminae from 51.30 m to 51.40 m: quartz rich seam
52.5		from 52.50 m: white; trace quartz crystals, laminated with intense folding of laminae apparent
57.0 – 151		from 57.00 m: increase in content of quartz crystals (30-50%), no apparent structure (residual)
59.0 – 149		GNEISS: fine to coarse grained; grey, white and dark grey; extremely to highly weathered, very low strength, banded, predominantly felsic, iron oxide through quartz bands, biotite



Depth scale: 50.5, 51.0, 51.5, 52.0, 52.5, 53.0, 53.5, 54.0, 54.5, 55.0, 55.5, 56.0, 56.5, 57.0, 57.5, 58.0, 58.5, 59.0, 59.5, 60.0

Reduced level scale: 158, 157, 156, 155, 154, 153, 152, 151, 150, 149

Column headings: Field Data (Water, Field Tests, Samples); Material Description (Graphic Log, Classification Symbol, Description); Rock Condition (Weathering/Consistency, TCR (SCR) [RQD] (%), Core Photo, Optical and Accoustic Televiewer N E S W); Piezometer Details; Downhole Wireline (Natural Gamma (API) 50 100 150 200 250; Borehole Diameter (mm) 75 100 125 150 175; Neutron Porosity (%) 20 40 60; Density (g/cm3) Short Density, Long Density 1 2 3; Neutron Log (CPS) Short Neutron, Long Neutron 1000–6000; Induction (mS/m) Short, Deep 160 320 480 640); Laboratory Testing (Misc Laboratory Testing, Geochemical Testing); Geology (Geological Unit *(Geotech. Unit)*)

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Engineering Summary Log

BOREHOLE No. L05D
Sheet: 7 of 8

Client: Department of Industry, Innovation and Science	**Project No:** 60565376	**Start Date:** 04/05/2018	**Driller:** SWD	**Hole Diameter:** 169 mm	**Easting:** 644270.0 m	**RL:** 208.0 m
Project: NRWMF - Site Characterisation	**Logged by:** TS	**End Date:** 07/05/2018	**Drill Rig:** Sonic Geoprobe	**Inclination:** -90°	**Northing:** 6343230.0 m	**Ver. Datum:** AHD
Location: Lyndhurst (Kimba)	**Checked by:** HS	**Location Meth.:** dGPS0.1		**Bearing:** N/A	**Hor. Proj/Dat:** MGA94/GDA94-54H	**Surface:** Sand

Drilling Water: Potable water sourced from Kimba (measured EC <1000 µS/cm)

Field Data | **Material Description** | **Rock Condition** | **Piezometer Details** | **Downhole Wireline** | **Laboratory Testing** | **Geology**

Columns: Reduced Level (m) / Depth (m) | Water | Field Tests | Samples | Graphic Log | Classification Symbol | Description | Weathering/ Consistency | TCR (SCR) [RQD] (%) | Core Photo | Optical and Accoustic Televiewer (N E S W) | Piezometer Details | Natural Gamma (API) | Borehole Diameter (mm) | Neutron Porosity (%) | Density (g/cm3) | Neutron Log (CPS) | Induction (mS/m) | Misc Laboratory Testing | Geochemical Testing | Geological Unit *(Geotech. Unit)*

Casing Top RL: 208.86 m AHD
Response Zone Top RL: -
Response Zone Base RL: -
Length of Response Zone: 6.00 m
Development Date: 15/05/2018

Depth (m)	Description
60.0 – 66.6	GNEISS: fine to coarse grained; grey, white and dark grey; extremely to highly weathered, very low strength, banded, predominantly felsic, iron oxide through quartz bands, biotite *(continued)* from 60.00 m: fine grained dark bands, medium to coarse felsic bands becoming white; residual to extremely weathered, laminated becoming dark grey; extremely to highly weathered, very low strength, showing schistosity
66.6 – 70.0	GABBRO: fine to medium grained; grey to black; banded, extremely to highly weathered, very low strength, friable, some bands completely weathered to clay

Piezometer:
63.0 to 66.0 m: BENTONITE SEAL (PELLETS)
66.0 to 73.0 m: 2 mm FILTER SAND

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Engineering Summary Log

BOREHOLE No. L05D

Client:	Department of Industry, Innovation and Science	**Project No:**	60565376	**Start Date:**	04/05/2018	**Driller:**	SWD	**Hole Diameter:**	169 mm	**Easting:**	644270.0 m
Project:	NRWMF - Site Characterisation	**Logged by:**	TS	**End Date:**	07/05/2018	**Drill Rig:**	Sonic Geoprobe	**Inclination:**	-90°	**Northing:**	6343230.0 m
Location:	Lyndhurst (Kimba)	**Checked by:**	HS	**Location Meth.:**	dGPS0.1			**Bearing:**	N/A	**Hor. Proj/Dat:**	MGA94/GDA94-54H

RL: 208.0 m **Ver. Datum:** AHD **Surface:** Sand

Drilling Water: Potable water sourced from Kimba (measured EC <1000 µS/cm)

Field Data — Reduced Level (m) / Depth (m); Water; Field Tests; Samples

Material Description — Graphic Log; Classification Symbol; Description

Rock Condition — Weathering/Consistency; TCR (SCR) [RQD] (%); Core Photo; Optical and Accoustic Televiewer (N E S W)

Piezometer Details

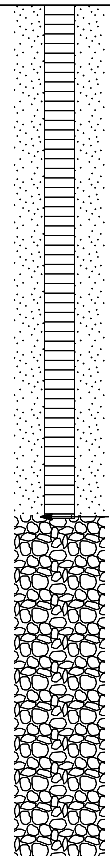
Casing Top RL: 208.86 m AHD
Response Zone Top RL: -
Response Zone Base RL: -
Length of Response Zone: 6.00 m
Development Date: 15/05/2018

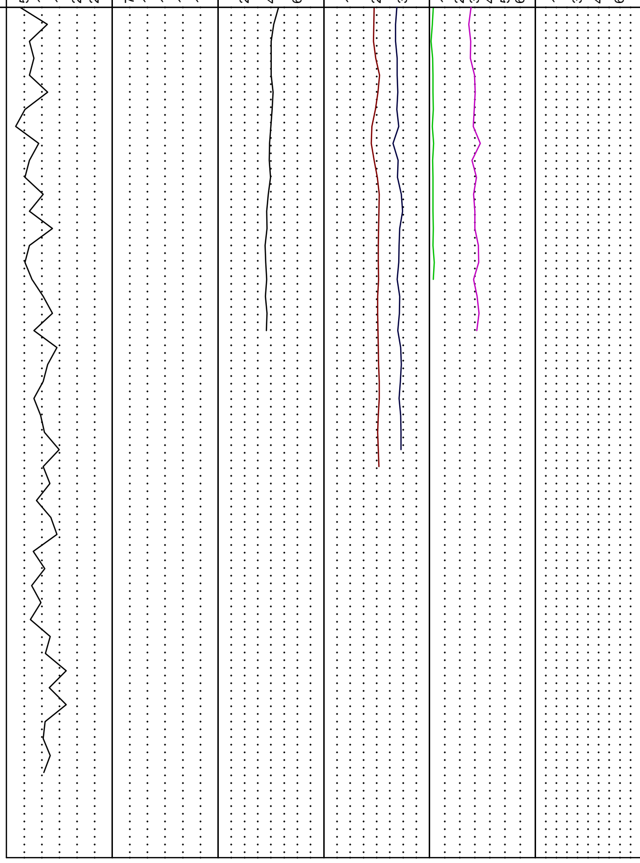
Downhole Wireline — Natural Gamma (API); Borehole Diameter (mm); Neutron Porosity (%); Density (g/cm3) (Short Density, Long Density); Neutron Log (CPS) (Short Neutron, Long Neutron); Induction (mS/m) (Short, Deep)

Laboratory Testing — Misc Laboratory Testing; Geochemical Testing

Geology — Geological Unit *(Geotech. Unit)*

Reduced Level (m)	Depth (m)	Samples	Description
138			GABBRO: fine to medium grained; grey to black; banded, extremely to highly weathered, very low strength, friable, some bands completely weathered to clay *(continued)*
	70.5		from 70.00 m: micaceous (both biotite and muscovite)
137	71.0		from 71.00 m: zones of laminations
	71.5		
136	72.0	BAG JAR	
	72.5		
135	73.0		
	73.5		
134	74.0		
	74.5		
133	75.0		*Borehole L05D log continued as cored log from m.*
	75.5		
132	76.0		
	76.5		
131	77.0		
	77.5		
130	78.0		
	78.5		
129	79.0		
	79.5		
	80.0		





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TEST PIT L06

Client:	Department of Industry, Innovation and Science			**Project No:**	60565376	**Start Date:**	26/04/2018
Project:	NRWMF - Site Characterisation			**Logged by:**	JT	**End Date:**	26/04/2018
Location:	Lyndhurst (Kimba)			**Checked by:**	KS	**Location Meth.:**	dGPS0.1
Contractor:	JMAC Hire	**Pit Length**	4	**Easting:**	644543.4 m	**Surface level:**	222.1 mRL
		Pit Width:	1.2	**Northing:**	6343055.8 m	**Ver. Datum:**	AHD
Equipment:	JCB JS290LC (30 tonne)	**Orientation:**		**Hor. Proj/Dat:**	MGA94/GDA94-54J	**Surface:**	Topsoil
		Pit Depth:	3.2				

Groundwater Data and Comments	Depth (m)	Graphic Log	Classification	LITHOLOGICAL DESCRIPTION	Moisture	Consistency/ Relative Density	Sample Interval	PID (ppm)	Sample ID
	0		SM	Topsoil: Silty SAND: fine to medium grained, orange-brown/brown, with roots	D				JAR
			SP	SAND: fine to coarse grained, orange-brown, trace of clay					
							B		BAG
				at 0.80 m: colour becoming light brown					
	1								JAR
	2								JAR
	3								
				L06 terminated at 3.20 m. *Target depth*					
	4								
	5								
	6								
	7								
	8								
	9								

Remarks:
0.00 m: ES & QC: Environmental sample & quality control sample
1.00 m: BS: Bulk sample for geotechnical analysis

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TEST PIT L07

Sheet: 1 of 1

Client:	Department of Industry, Innovation and Science	**Project No:**	60565376	**Start Date:**	26/04/2018
Project:	NRWMF - Site Characterisation	**Logged by:**	JT	**End Date:**	26/04/2018
Location:	Lyndhurst (Kimba)	**Checked by:**	KS	**Location Meth.:**	dGPS0.1
Contractor:	JMAC Hire; **Pit Length** 4	**Easting:**	644864.4 m	**Surface level:**	217.4 mRL
	Pit Width: 1.2	**Northing:**	6343087.0 m	**Ver. Datum:**	AHD
Equipment:	JCB JS290LC (30 tonne); **Orientation:**	**Hor. Proj/Dat:**	MGA94/GDA94-54J	**Surface:**	Topsoil
	Pit Depth: 3				

Groundwater Data and Comments	Depth (m)	Graphic Log	Classification	LITHOLOGICAL DESCRIPTION	Moisture	Consistency/ Relative Density	Sample Interval	PID (ppm)	Sample ID
	0		SM	Topsoil: Silty SAND: fine to medium grained, orange-brown/brown, with roots	D				JAR
			SP	SAND: fine to coarse grained, orange-brown, trace of clay					
									JAR
	1						B		BAG
				from 1.30 m: trace of cemented sand fragments, cobbles sized					
									JAR
	2								JAR
	3			*L07 terminated at 3.00 m. Target depth*					
	4								
	5								
	6								
	7								
	8								
	9								

Remarks: 0.00 m: ES & QC: Environmental sample & quality control sample
1.00 m: BS: Bulk sample for geotechnical analysis

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TEST PIT L08

Client:	Department of Industry, Innovation and Science			**Project No:**	60565376	**Start Date:**	26/04/2018
Project:	NRWMF - Site Characterisation			**Logged by:**	JT	**End Date:**	26/04/2018
Location:	Lyndhurst (Kimba)			**Checked by:**	KS	**Location Meth.:**	dGPS0.1
Contractor:	JMAC Hire	**Pit Length**	4	**Easting:**	644538.2 m	**Surface level:**	218.0 mRL
		Pit Width:	1.2	**Northing:**	6342581.0 m	**Ver. Datum:**	AHD
Equipment:	JCB JS290LC (30 tonne)	**Orientation:**		**Hor. Proj/Dat:**	MGA94/GDA94-54J	**Surface:**	Topsoil
		Pit Depth:	3.2				

Groundwater Data and Comments	Depth (m)	Graphic Log	Classification	LITHOLOGICAL DESCRIPTION	Moisture	Consistency/ Relative Density	Sample Interval	PID (ppm)	Sample ID
	0		SM	Topsoil: Silty SAND: fine to medium grained, orange-brown/brown, with roots	D				JAR
			SC	Clayey SAND: fine to medium grained, orange-brown, with cemented sand fragments, coarse gravels to cobbles sized			B		BAG
	1								JAR
	2								JAR
	3								
				L08 terminated at 3.20 m. *Target depth*					
	4								
	5								
	6								
	7								
	8								
	9								

Remarks: 0.00 m: ES & QC: Environmental sample & quality control sample
1.00 m: BS: Bulk sample for geotechnical analysis

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TEST PIT L09

Sheet: 1 of 1

Client:	Department of Industry, Innovation and Science	**Project No:**	60565376	**Start Date:**	26/04/2018
Project:	NRWMF - Site Characterisation	**Logged by:**	JT	**End Date:**	26/04/2018
Location:	Lyndhurst (Kimba)	**Checked by:**	KS	**Location Meth.:**	dGPS0.1
Contractor:	JMAC Hire	**Easting:**	644866.2 m	**Surface level:**	213.0 mRL
Equipment:	JCB JS290LC (30 tonne)	**Northing:**	6342660.7 m	**Ver. Datum:**	AHD
		Hor. Proj/Dat:	MGA94/GDA94-54J	**Surface:**	Topsoil

Pit Length 4 · **Pit Width:** 1.2 · **Orientation:** · **Pit Depth:** 3.5

Groundwater Data and Comments	Depth (m)	Graphic Log	Classification	LITHOLOGICAL DESCRIPTION	Moisture	Consistency/ Relative Density	Sample Interval	PID (ppm)	Sample ID
	0		SM	Topsoil: Silty SAND: fine to medium grained, orange-brown/brown, with roots	D				JAR
			GP	Sandy GRAVEL: fine to coarse sized, angular to subangular, with cobbles					
			SP	SAND: fine to coarse grained, orange-brown, dry, trace of clay					
	1								JAR
	2								BAG JAR
	3								
				L09 terminated at 3.50 m. *Target depth*					
	4								
	5								
	6								
	7								
	8								
	9								

Remarks: 0.00 m: ES & QC: Environmental sample & quality control sample
1.00 m: BS: Bulk sample for geotechnical analysis

AECOM

TEST PIT L10

Client: Department of Industry, Innovation and Science		**Project No:** 60565376		**Start Date:** 26/04/2018	
Project: NRWMF - Site Characterisation		**Logged by:** JT		**End Date:** 26/04/2018	
Location: Lyndhurst (Kimba)		**Checked by:** KS		**Location Meth.:** dGPS0.1	
Contractor: JMAC Hire	**Pit Length** 4	**Easting:** 645152.8 m		**Surface level:** 216.4 mRL	
	Pit Width: 1.2	**Northing:** 6342735.0 m		**Ver. Datum:** AHD	
Equipment: JCB JS290LC (30 tonne)	**Orientation:**	**Hor. Proj/Dat:** MGA94/GDA94-54J		**Surface:** Topsoil	
	Pit Depth: 3.1				

Groundwater Data and Comments	Depth (m)	Graphic Log	Classification	LITHOLOGICAL DESCRIPTION	Moisture	Consistency/ Relative Density	Sample Interval	PID (ppm)	Sample ID
	0		SM	Topsoil: Silty SAND: fine to medium grained, orange-brown/brown, with roots	D				JAR
			GP	Gravelly SAND: fine to coarse grained, brown/light-brown, gravel fine to coarse sized, angular to subangular, trace of clay			B		BAG
	1		SP	SAND: fine to coarse grained, orange-brown, dry, trace of clay					JAR
	2								JAR
				at 2.80 m: trace of cemented sand fragments, cobbles sized					
	3			*L10 terminated at 3.10 m.* *Target depth*					
	4								
	5								
	6								
	7								
	8								
	9								

Remarks: 0.00 m: ES & QC: Environmental sample & quality control sample
1.00 m: BS: Bulk sample for geotechnical analysis

AECOM

TEST PIT L11

Sheet: 1 of 1

Client:	Department of Industry, Innovation and Science	**Project No:**	60565376	**Start Date:**	26/04/2018
Project:	NRWMF - Site Characterisation	**Logged by:**	JT	**End Date:**	26/04/2018
Location:	Lyndhurst (Kimba)	**Checked by:**	KS	**Location Meth.:**	dGPS0.1
Contractor:	JMAC Hire	**Easting:**	644836.1 m	**Surface level:**	213.1 mRL
		Northing:	6342305.0 m	**Ver. Datum:**	AHD
Equipment:	JCB JS290LC (30 tonne)	**Hor. Proj/Dat:**	MGA94/GDA94-54J	**Surface:**	Topsoil

Pit Length 4
Pit Width: 1.2
Orientation:
Pit Depth: 3.2

Groundwater Data and Comments	Depth (m)	Graphic Log	Classification	LITHOLOGICAL DESCRIPTION	Moisture	Consistency/ Relative Density	Sample Interval	PID (ppm)	Sample ID
	0		SM	Topsoil: Silty SAND: fine to medium grained, orange-brown/brown, with roots	D				JAR
			SP	SAND: fine to coarse grained, orange-brown, dry, trace of cemented sand fragments, cobbles sized					
	1								JAR
	2								JAR
	3						B		BAG
				L11 terminated at 3.20 m. *Target depth*					
	4								
	5								
	6								
	7								
	8								
	9								

Remarks: 0.00 m: ES & QC: Environmental sample & quality control sample
1.00 m: BS: Bulk sample for geotechnical analysis

Test Pits Photographs - Lyndhurst

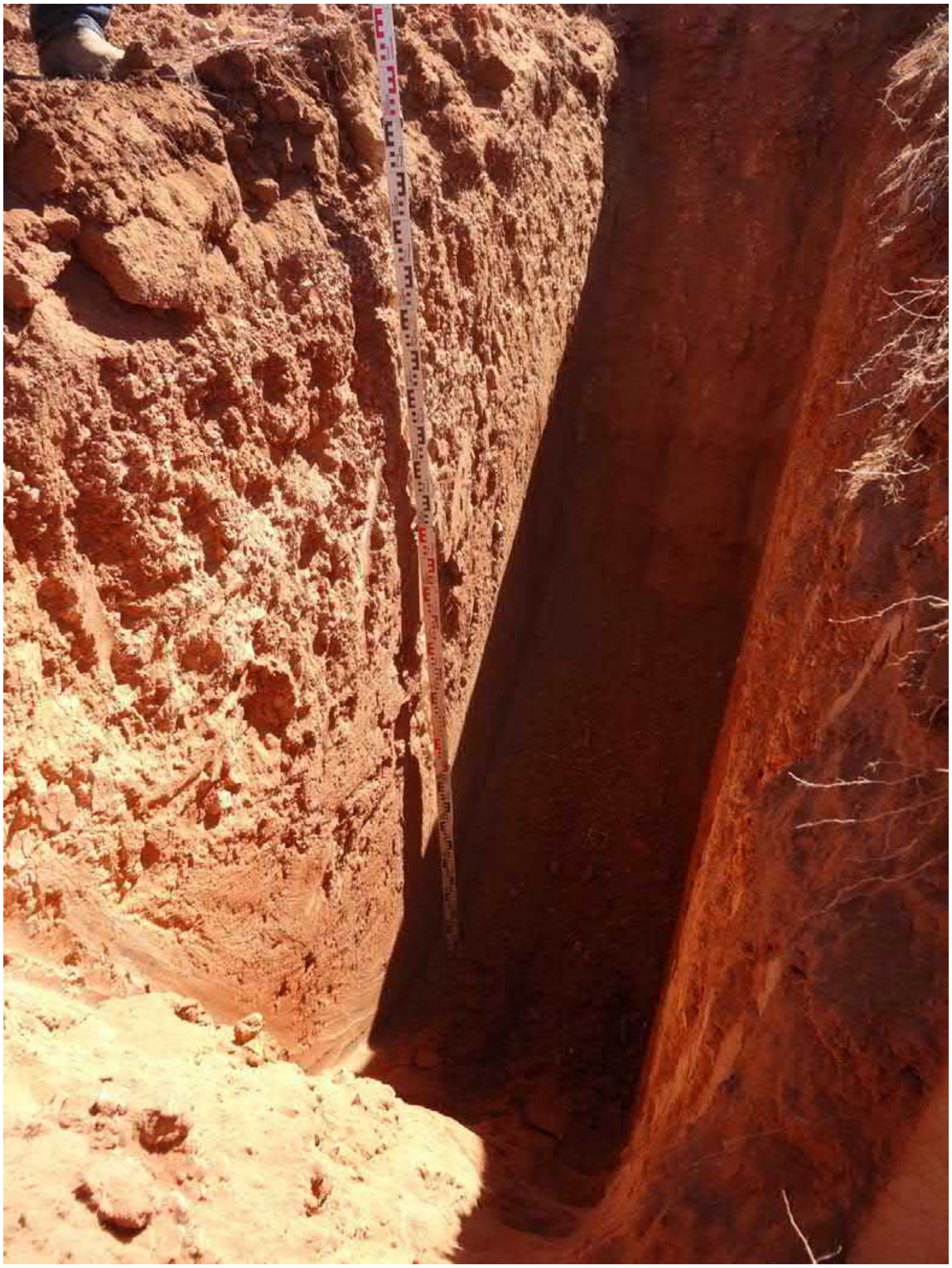
L06

L07

L08

L09

L10



L11

Field Chemistry Parameters - Lyndhurst

Field Chemistry Parameters - Lyndhurst

Sample ID	Development Period	Sample Date	pH	Lab pH	Lab EC (uS/cm)	EC (uS/cm)	Estimated TDS (mg/L)	DO (mg/L)	Redox (mV)	Temp (^oC)	Field Observations
L01	09/05/18-18/05/18	22/05/2018	6.15	6.74	42800	63777	41455	4.4	105.0	19.67	Grab sample obtained with dedicated disposable bailer, intially low turbidity, colourless, light brown, becoming moderately turbid during sample collection with bailer (5L removed).
L02	07/05/18-18/058/18	23/05/2018	7.2	4.19	43400	54619	35502	7.7	247.3	18.11	Grab sample obtained with dedicated disposable bailer, clear, colourless, very low turbidity during sample collection with bailer (5L removed).
L03	17/05/18-18/05/18	23/05/2018	4.24	4.63	45800	43760	28444	6.95	219.9	18.11	Grab sample obtained with dedicated disposable bailer, clear, colourless/white, low turbidity to start with becoming more turbid (red/pink/brown) during sample collection with bailer (5L removed).
L04	17/05/18-18/05/19	22/05/2018	7.98	7.22	31100	30541	19852	7.07	7.0	20.88	Grab sample obtained with dedicated disposable bailer, slgihtly brown, very low turbidity maintained during sample collection (5L removed).
L05S	08/05/18-18/05/18	23/05/2018	8.64	8.72	27400	32233	20951	0.9	-234.7	18.16	Grab sample obtained with dedicated disposable bailer, brown, moderate turbidity, becoming reddish brown and more turbid during sample collection (5L) removed. Note that development period indicated oxidising groundwater conditions however sampling parameters indicative of reducing (low oxygen) groundwater environment.
L05D	08/05/18-18/05/18	23/05/2018	8.07	6.68	168000	190309	123701	2.2	-130.6	17.13	Grab sample obtained with dedicated disposable bailer, clear, colourless, vey low turbidity during sample collection with bailer (5L removed). Salinity contrast with paired shallower well L05S indicates salinity density correction needs to be applied to calculate vertical hydraulic gradient.

Total Dissolved Solids (TDS) estimated from EC (uS/cm) x 0.65
SWL = Standing Water Level
EC = Electrical Conductivity
DO = Dissolved Oxygen
Redox = Redox potential (uncorrected field measurement)
NA = Not Applicable
Laboratory reported pH and EC (batch EM1808546)
Field measured pH may be unreliable due to faulty connection on meter

AECOM

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FQM - Groundwater Sampling and Purging Record

WELL DEVELOPMENT AND SAMPLING RECORD

Q4AN(EV)-405-FM1

						Bore ID:	101
Project Name:	NEWMF	Project Number:	60565376	PM Name:	James Rusk	Sample Date:	22/5/18
Client:	Oils	Project Location:	LYNDHURST	Fieldwork Staff:	Tim Smith / Joe Tan	Well Development or Well Sampling Event? (circle	

General Bore Information		Parameter Info.	Decontamination	Sampling Method	Hydrasleeve info.	
Date of GW Level: See below	Bore Radius (mm): 0.0845	Chem Kit Serial No.: SMART8	Decontaminated	Low Flow Pump rate:	Hydrasleeve Size:	Monitoring sequence followed (number in order):
Depth to GW (m-pvc): 17.018	Screen Interval (m): 15-21	Chem Kit Model: SMARTROLL	Dedicated	Intake depth: 21 m	Hydrasleeve Type:	
Bore Depth (m-pvc): 22 (silty)	Casing Radius (mm): 0.025	Corrected Redox: Y / N	Disposable	Bailer / Hydrasleeve	Sampling Depth (m-pvc):	Gauging
Depth to Product (m-pvc): –	Cover Type (gatic/stick up):	(The correction to apply is probe dependent)	Other (specify)	Peristaltic Pump / Waterra	Hydrasleeve install time:	Hydrasleeve in
Product Thickness (m): –	Bore Locked (YES/NO):	Parameter method: Downhole		Other (specify)	Sampling Start Time:	Hydrasleeve out
	Key Type (if applicable):	Retrieved				Parameters
Calculated bore volume (L): 30L	Includes/ excludes bore annulus (circle)	# purge volumes removed: –		Total purged volume (L): –		

Water Quality Parameters

Date	Time	Cumulative Vol. Removed (L)	SWL (m-pvc)	Pump Rate	DO (ppm or mg/L)	E.C. (mS/cm or µS/cm)	pH	Redox (mV)	Temp °C	Odour, Colour, Turbidity
9/5/18	pm	40	–	–	–	–	–	–	–	excess water removed with bailer
10/5/18	1200pm	70	–	–	8.37	14635	7.78	89.4	15.22	air lifted, dry after 30L, red turbid
17& 18/5/18	8:15am	–	17.20		4.97	59981.2	6.26*	159.8	18.61	quick recharge, clear (bailer)
22/5/18	4:00pm	5	–	–	4.40	63777	6.15	105.0	19.67	initially low turbidity, colourless/light br becoming moderately turbid reddish-br (bailer)
			SAMPLED							
	Acceptable Parameter Range:				± 10%	± 3%	± 0.05	± 10 mV	± 0.2 °C	± 10% turbidity (if using a turbidity meter)

Analytes Sampled for:		Bottles Collected						QA/QC Information
Field Filtered: DOC	Unfiltered:		x 40 mL Vial (HCl)		x 60 mL Ferrous	2	x 60 mL metals (HNO_3)	–
diss metals	See COC	3	x 40 mL Vial (H_2SO_4)	1	x 100 mL Amber	1	x 60 mL Plastic	
diss nitrate		1	1L p	1	125ml p	1	500ml p	
diss sulfide								

Field Comments

Bore volume calculation, bore condition, fate of tubing, redox correction etc.

BV (22 - 17.018) x 6 ≈ 30L

r = 0.025 m

R = 0.0845 m

h = 1 m

BV = 0.014 ((0.022 - 0.0196) x 0.2) ≈ 6L/m

H = 4.982 m

filterpack porosity of 20%

*potentially unreliable pH reading during development (JT).

Approval and Distribution

Fieldwork Staff Signature	22/5/18 Date	M. Morris Checker Name and Signature	30/5/18 Date
Project Manager Signature	30/5/18 Date	Distribution: Project Central File	

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FQM - Groundwater Sampling and Purging Record

WELL DEVELOPMENT AND SAMPLING RECORD

Q4AN(EV)-405-FM1

Project Name:	NEWMF	Project Number:	60565376	PM Name:	James Rusk	Bore ID:	L02
Client:	Dils	Project Location:	LYNDHURST	Fieldwork Staff:	Tim Smith / Joe Tan	Sample Date:	23/5/18
						Well Development or Well Sampling Event? (circle)	

General Bore Information		Parameter Info.	Decontamination	Sampling Method	Hydrasleeve info.	
Date of GW Level: See below	Bore Radius (mm): 0.0845	Chem Kit Serial No.: SMART8	☑ Decontaminated	☐ Low Flow Pump rate:	Hydrasleeve Size:	Monitoring sequence followed (number in order):
Depth to GW (m-pvc): 14.289	Screen Interval (m): 18-24	Chem Kit Model: SMARTROLL	☑ Dedicated	Intake depth:	Hydrasleeve Type:	
Bore Depth (m-pvc): 24.90	Casing Radius (mm): 0.025	Corrected Redox: Y / N	☑ Disposable	☑ Bailer ☐ Hydrasleeve	Sampling Depth (m-pvc):	Gauging
Depth to Product (m-pvc): –	Cover Type (gatic/stick up):	(The correction to apply is probe dependent)	☐ Other (specify)	☐ Peristaltic Pump ☐ Waterra	Hydrasleeve install time:	Hydrasleeve in
Product Thickness (m): –	Bore Locked (YES/NO):	Parameter method: ☐ Downhole		☐ Other (specify)	Sampling Start Time:	Hydrasleeve out
	Key Type (if applicable):	☑ Retrieved				Parameters
Calculated bore volume (L): 60L	Includes/ excludes bore annulus (circle)	# purge volumes removed: –		Total purged volume (L): –		

Water Quality Parameters

Date	Time	Cumulative Vol. Removed (L)	SWL (m-pvc)	Pump Rate	DO (ppm or mg/L)	E.C. (mS/cm or µS/cm)	pH	Redox (mV)	Temp °C	Odour, Colour, Turbidity
7/5/18	11:00am		15.10	–	5.80	48847	3.93*	266.1	18.79	muddy (air development)
18/5/18	7:25am		14.34	–	6.55	48947	4.07*	218.2	18.61	clear, recharged quickly (bailer)
										(bailer)
23/5/18	9:20am	5	14.289	–	7.07	54619	7.20	247.3	18.11	clear, colourless, very low turbidity
						SAMPLED				
Acceptable Parameter Range:					± 10%	± 3%	± 0.05	± 10 mV	± 0.2 °C	± 10% turbidity (if using a turbidity meter)

Analytes Sampled for:		Bottles Collected			QA/QC Information	Field Comments
Field Filtered: DOC metals (dissolved)	Unfiltered: see COC	9 x 40 mL Vial (HCl)	x 60 mL Ferrous	6 x 60 mL metals (HNO_3)	QC03 (dup)	Bore volume calculation, bore condition, fate of tubing, redox correction etc
		2 x 40 mL Vial (H_2SO_4)	2 x 100 mL Amber	3 x 60 mL Plastic	QC04 (triplicate)	BV = (24.90 - 14.289) x 6 ≈ 60L ✓
		3 1Lp	3 125mLp	3 500mLp		* Development pH potentially inaccurate. JT comment.

Approval and Distribution

[signature]	23/5/18	M. Mom [signature]	30/5/18
Fieldwork Staff Signature	Date	Checker Name and Signature	Date
for JR [signature]	30/5/18		
Project Manager Signature	Date	Distribution: Project Central File	

ANZ

FQM - Groundwater Sampling and Purging Record

AECOM

WELL DEVELOPMENT AND SAMPLING RECORD

Q4AN(EV)-405-FM1

Bore ID:	L03
Sample Date:	23/5/18
Well Development or Well Sampling Event? (circle)	

Project Name:	NEWMF	Project Number:	60565376	PM Name:	James Rusk
Client:	0115	Project Location:	LYNDHURST	Fieldwork Staff:	Tim Smith / Joe Tan

General Bore Information

Date of GW Level:	See below
Depth to GW (m-pvc):	15.754
Bore Depth (m-pvc):	24.90
Depth to Product (m-pvc):	-
Product Thickness (m):	-
Bore Radius (mm):	0.0845
Screen Interval (m):	18-24
Casing Radius (mm):	0.025
Cover Type (gatic/stick up):	
Bore Locked (YES/NO):	
Key Type (if applicable):	
Calculated bore volume (L):	55L
Includes/excludes bore annulus (circle)	
# purge volumes removed:	—
Total purged volume (L):	—

Parameter Info.

Chem Kit Serial No.:	SMART8
Chem Kit Model:	SMARTROLL
Corrected Redox:	Y / N
(The correction to apply is probe dependent)	
Parameter method:	☐ Downhole ☑ Retrieved

Decontamination

- ☑ Decontaminated
- ☑ Dedicated
- ☑ Disposable
- ☐ Other (specify)

Sampling Method

- ☐ Low Flow Pump rate:
- Intake depth:
- ☑ Bailer ☐ Hydrasleeve
- ☐ Peristaltic Pump ☐ Waterra
- ☐ Other (specify)

Hydrasleeve info.

Hydrasleeve Size:		Monitoring sequence followed (number in order):
Hydrasleeve Type:		
Sampling Depth (m-pvc):		Gauging
Hydrasleeve install time:		Hydrasleeve in
Sampling Start Time:		Hydrasleeve out
		Parameters

Water Quality Parameters

Date	Time	Cumulative Vol. Removed (L)	SWL (m-pvc)	Pump Rate	DO (ppm or mg/L)	E.C. (mS/cm or µS/cm)	pH	Redox (mV)	Temp °C	Odour, Colour, Turbidity
17/5/18	11:41am	-	19.10	-	6.74	47572	4.32*	221.2	20.65	muddy (air development)
18/5/18	7:02am	-	15.77	-	7.20	45858	4.71*	198.3	18.16	clear, recharged quickly (bailer)
23/5/18	10:00am	5	15.754	-	6.95	43760	4.24	219.9	18.11	clear, colourless/white, low turbidity becoming reddish/pinkish brown with high turbidity
				SAMPLED						
Acceptable Parameter Range:					± 10%	± 3%	± 0.05	± 10 mV	± 0.2 °C	± 10% turbidity (if using a turbidity meter)

Analytes Sampled for:

Field Filtered:	Unfiltered:
DOC dissolved metals	see COC

Bottles Collected

	x 40 mL Vial (HCl)		x 60 mL Ferrous	2	x 60 mL metals (HNO_3)
3	x 40 mL Vial (H_2SO_4)	1	x 100 mL Amber	1	x 250 mL Plastic
1	1L p	1	125ml p	1	500ml p

QA/QC Information

—

Field Commets

Bore volume calculation, bore condition, fate of tubing, redox correction etc.

BV = (24.90-15.754) Rb
≈ 55L

MM checked with sampler re: pH & DO data 30/5/18 unclear. Check lab pH to confirm

* Development comment that pH connection to meter was unreliable (JT).

Approval and Distribution

[signature]	23/5/18	M. Mom [signature]	30/5/18
Fieldwork Staff Signature	Date	Checker Name and Signature	Date
for JR [signature]	30/5/18		
Project Manager Signature	Date	Distribution: Project Central File	

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FQM - Groundwater Sampling and Purging Record

WELL DEVELOPMENT AND SAMPLING RECORD

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Q4AN(EV)-405-FM1

Project Name:	NEWMF	Project Number:	60565376	PM Name:	James Rusk	Bore ID:	L04
Client:	OILS	Project Location:	LYNDHURST	Fieldwork Staff:	Tim Smith / Joe Tan	Sample Date:	22/5/18
						Well Development or Well Sampling Event? (circle)	

General Bore Information

- Date of GW Level: See below
- Depth to GW (m-pvc): 21.180
- Bore Depth (m-pvc): 24.45
- Depth to Product (m-pvc): –
- Product Thickness (m): –
- Calculated bore volume (L): 20L
- Bore Radius (mm): 0.0845
- Screen Interval (m): 18-24
- Casing Radius (mm): 0.025
- Cover Type (gatic/stick up):
- Bore Locked (YES/NO):
- Key Type (if applicable):
- Includes/excludes bore annulus (circle)

Parameter Info.

- Chem Kit Serial No.: SMARTS
- Chem Kit Model: SMARTROLL
- Corrected Redox: Y / N
- (The correction to apply is probe dependent)
- Parameter method: ☐ Downhole ☑ Retrieved
- # purge volumes removed: –

Decontamination

- ☐ Decontaminated
- ☐ Dedicated
- ☑ Disposable
- ☐ Other (specify)

Sampling Method

- ☐ Low Flow Pump rate:
- Intake depth: 23.5
- ☑ Bailer ☐ Hydrasleeve
- ☐ Peristaltic Pump ☐ Waterra
- ☐ Other (specify)
- Total purged volume (L): –

Hydrasleeve info.

- Hydrasleeve Size:
- Hydrasleeve Type:
- Sampling Depth (m-pvc):
- Hydrasleeve install time:
- Sampling Start Time:
- Monitoring sequence followed (number in order): Gauging, Hydrasleeve in, Hydrasleeve out, Parameters

Water Quality Parameters

Date	Time	Cumulative Vol. Removed (L)	SWL (m-pvc)	Pump Rate	DO (ppm or mg/L)	E.C. (mS/cm or µS/cm)	pH	Redox (mV)	Temp °C	Odour, Colour, Turbidity
17/5/18	12:20pm	-	24.38	-	4.58	35394	6.00*	56.7	18.78	bailed dry 9:30, 10:10 and 12:20 this day
18/5/18	8:30am	-	22.75	–	-	-	-	–	–	clear, bailed dry
										(air development then post development by bailer)
22/5/18	3:00pm	5	21.180	-	7.07	30541	7.98	7.00	20.88	slightly brown, very low turbidity, clear (bailer)
					SAMPLED					
Acceptable Parameter Range:					± 10%	± 3%	± 0.05	± 10 mV	± 0.2 °C	± 10% turbidity (if using a turbidity meter)

Analytes Sampled for:

- Field Filtered: DOC, dissolved metals, diss sulfide, diss nitrate
- Unfiltered: see COC

Bottles Collected

	x 40 mL Vial (HCl)		x 60 mL Ferrous	2	x 60 mL metals (HNO_3)
3	x 40 mL Vial (H_2SO_4)	1	x 100 mL Amber	1	x 250 mL Plastic
1	1L p	1	125mL p	1	500mL p

QA/QC Information

–

Field Comments

Bore volume calculation, bore condition, fate of tubing, redox correction etc.

BV = (24.45 - 21.180) x 6 ≈ 20 L

*potentially unreliable development pH (JT)

Approval and Distribution

Fieldwork Staff Signature	22/5/18 Date	M.Moms Checker Name and Signature	30/5/18 Date
For JR Project Manager Signature	30/5/18 Date	Distribution: Project Central File	

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FQM - Groundwater Sampling and Purging Record

AECOM

WELL DEVELOPMENT AND SAMPLING RECORD

Q4AN(EV)-405-FM1

Project Name:	NEWMF	Project Number:	60565376	PM Name:	James Rusk	Bore ID:	L05S
Client:	OIIS	Project Location:	LYNDHURST	Fieldwork Staff:	Tim Smith / Joe Tan	Sample Date:	23/5/18

Well Development or Well Sampling Event? (circle)

General Bore Information

Date of GW Level:	22/5/18	Bore Radius (mm):	0.0845
Depth to GW (m-pvc):	9.704	Screen Interval (m):	6-12
Bore Depth (m-pvc):	12.70	Casing Radius (mm):	0.025
Depth to Product (m-pvc):	-	Cover Type (gatic/stick up):	
Product Thickness (m):	-	Bore Locked (YES/NO):	
		Key Type (if applicable):	

Calculated bore volume (L): 18L | Includes/excludes bore annulus (circle) | # purge volumes removed: – | Total purged volume (L): –

Parameter Info.

Chem Kit Serial No.: SMART8
Chem Kit Model: SMARTROLL
Corrected Redox: Y / N
(The correction to apply is probe dependent)
Parameter method: Downhole / Retrieved ✓

Decontamination

☑ Decontaminated
☑ Dedicated
☑ Disposable
☐ Other (specify)

Sampling Method

☐ Low Flow Pump rate:
Intake depth:
☑ Bailer ☐ Hydrasleeve
☐ Peristaltic Pump ☐ Waterra
☐ Other (specify)

Hydrasleeve info.

Hydrasleeve Size:
Hydrasleeve Type:
Sampling Depth (m-pvc):
Hydrasleeve Install time:
Sampling Start Time:

Monitoring sequence followed (number in order):
Gauging
Hydrasleeve in
Hydrasleeve out
Parameters

Water Quality Parameters

Date	Time	Cumulative Vol. Removed (L)	SWL (m-pvc)	Pump Rate	DO (ppm or mg/L)	E.C. (mS/cm or µS/cm)	pH	Redox (mV)	Temp °C	Odour, Colour, Turbidity
8/5/18										
9/5/18	1:00pm	100	-	-	3.97	50576	6.21	68	19.63	Red, turbid (bailed)
17/5/18										
18/5/18	7:54am	-	9.73	-	4.59	36231	8.27*	5.0	18.83	muddy (bailed)
23/5/18	8:00am	5	12.70	-	0.90	32233	8.64	-234.7	18.16	brown moderate turbidity becoming reddish brown high turbidity, flocculated particles slowly settle out.
				SAMPLED						
Acceptable Parameter Range:					± 10%	± 3%	± 0.05	± 10 mV	± 0.2 °C	± 10% turbidity (if using a turbidity meter)

Analytes Sampled for:

Field Filtered:	Unfiltered:
dissolved metals DOC	see COC

Bottles Collected

	x 40 mL Vial (HCl)		x 60 mL Ferrous	2	x 60 mL metals (HNO_3)
3	x 40 mL Vial (H_2SO_4)	1	x 100 mL Amber	1	x 250 mL Plastic
1	1L p	1	125ml p	1	500ml p

QA/QC Information

–

Field Comments

Bore volume calculation, bore condition, fate of tubing, redox correction etc.

BV = (12.70 - 9.704) x ...
≈ 18L

* Potentially unreliable development pH reading (JT).

Approval and Distribution

[signature]	23/5/18	M. Morris [signature]	30/5/18
Fieldwork Staff Signature	Date	Checker Name and Signature	Date
For JR [signature]	30/5/18		
Project Manager Signature	Date	Distribution: Project Central File	

ANZ

FQM - Groundwater Sampling and Purging Record

WELL DEVELOPMENT AND SAMPLING RECORD

AECOM

Q4AN(EV)-405-FM1

Project Name:	NEWMF	Project Number:	60565376	PM Name:	James Rusk	Bore ID:	L05D
Client:	0115	Project Location:	LYNDHURST	Fieldwork Staff:	Tim Smith / Joe Tan	Sample Date:	23/5/18

Well Development or Well Sampling Event? (circle)

General Bore Information

- Date of GW Level: See below
- Depth to GW (m-pvc): 11.844
- Bore Depth (m-pvc): 74
- Depth to Product (m-pvc): -
- Product Thickness (m): -
- Bore Radius (mm): 0.0845
- Screen Interval (m): 73-67
- Casing Radius (mm): 0.025
- Cover Type (gatic/stick up):
- Bore Locked (YES/NO):
- Key Type (if applicable):
- Calculated bore volume (L): 146L
- Includes/ excludes bore annulus (circle)

Parameter Info.

- Chem Kit Serial No.:
- Chem Kit Model:
- Corrected Redox: Y / N
- (The correction to apply is probe dependent)
- Parameter method: ☐ Downhole ☑ Retrieved

Decontamination

- ☑ Decontaminated
- ☑ Dedicated
- ☑ Disposable
- ☐ Other (specify)

purge volumes removed: -

Sampling Method

- ☐ Low Flow Pump rate:
- Intake depth:
- ☑ Bailer ☐ Hydrasleeve
- ☐ Peristaltic Pump ☐ Waterra
- ☐ Other (specify)

Total purged volume (L): -

Hydrasleeve info.

- Hydrasleeve Size:
- Hydrasleeve Type:
- Sampling Depth (m-pvc):
- Hydrasleeve Install time:
- Sampling Start Time:

Monitoring sequence followed (number in order): Gauging, Hydrasleeve in, Hydrasleeve out, Parameters

Water Quality Parameters

Date	Time	Cumulative Vol. Removed (L)	SWL (m-pvc)	Pump Rate	DO (ppm or mg/L)	E.C. (mS/cm or µS/cm)	pH	Redox (mV)	Temp °C	Odour, Colour, Turbidity
8/5/18										
9/5/18	-	650L	-	-	2.89	165530	6.87	10	20.02	dark grey, turbid
16/5/18										
17/5/18										
18/5/18	7:43am	-	11.86	-	1.99	173428	4.75*	108.7	18.61	clear
23/5/18	8:40am	-	11.844	-	2.20	190309	8.07	-130.6	17.13	clear, colourless, very low turbidity
				SAMPLED						
Acceptable Parameter Range:					± 10%	± 3%	± 0.05	± 10 mV	± 0.2 °C	± 10% turbidity (if using a turbidity meter)

Analytes Sampled for:

- Field Filtered: dissolved metals, DOC
- Unfiltered: see COC

Bottles Collected

	x 40 mL Vial (HCl)		x 60 mL Ferrous	2	x 60 mL metals (HNO_3)
3	x 40 mL Vial (H_2SO_4)	1	x 100 mL Amber	1	x 250 mL Plastic
1	1L p	1	125mL p	1	500mL p

QA/QC Information

-

Field Comments

Bore volume calculation, bore condition, fate of tubing, redox correction etc

BV = (74 - 67) x 6 = 146L (total).

Bore screened section 6 L = 6 m of screen = 36 L

then for rest of water column = 2L/m

55m x 2L/m = 110 + 36 = 146L

* potentially unreliable pH readings during development (TT).

MM

Approval and Distribution

PWB	23/5/18	M. Mom MM	30/5/18
Fieldwork Staff Signature	Date	Checker Name and Signature	Date
for JR MM	30/5/18		
Project Manager Signature	Date		

Distribution: Project Central File

Groundwater Analytical Results - Lyndhurst

Reporting Group	Analyte	Unit	LOR	L01	L02			L03	L04	L05S	L05D	QC01
			Field ID	L01_22/05/18	L02_23/05/18	QC03_23/5/18	QC04_23/5/18	L03_23/05/18	L0_22/05/18	L05S_23/05/18	L05D_23/05/18	QC01_22/05/18
			Sample Type	Normal	Normal	Field Duplicate	Interlab Duplicate	Normal	Normal	Normal	Normal	Rinse blank
			Sample Date	22/05/018	23/05/2018	23/05/2018	23/05/2018	23/05/2018	22/05/2018	23/05/2018	23/05/2018	22/05/2018
			Lab Report	EM1808546	EM1808546	EM1808546	600238	EM1808546	EM1808546	EM1808546	EM1808546	EM1808546
General	pH	pH unit	0.01	6.74	4.19	4.22	4.1	4.63	7.22	8.72	6.68	4.65
	Electrical Conductivity (EC)	µS/cm	1	42800	43400	43800	48000	45800	31100	27400	168000	2
Radionuclides	Gross alpha	Bq/L	0.05	2.71	24.8	29.1	0.962*	30.4	1.22	1.44	10	-
	Gross beta activity - 40 K	Bq/L	0.1	8.98	93.4	98.1	85.1*	135	2.91	4.37	38.2	-
Dissolved Metals (15 NEPM)	Arsenic	mg/L	0.001	<0.002	0.002	0.003	0.002	<0.002	<0.001	0.002	<0.005	<0.001
	Boron	mg/L	0.05	2.46	1.52	1.5	2	1.88	1.7	0.19	3.05	<0.05
	Barium	mg/L	0.001	0.25	0.281	0.284	0.31	0.328	0.312	0.306	0.056	<0.001
	Beryllium	mg/L	0.001	<0.002	0.002	0.002	0.003	<0.002	<0.001	<0.001	<0.005	<0.001
	Cadmium	mg/L	0.0001	0.0012	0.0026	0.0027	0.0019	0.0023	0.0006	<0.0001	<0.0005	<0.0001
	Cobalt	mg/L	0.001	0.021	0.069	0.07	0.05	0.034	0.011	<0.001	<0.005	<0.001
	Chromium	mg/L	0.001	<0.002	0.009	0.009	0.008	<0.002	<0.001	0.001	<0.005	<0.001
	Copper	mg/L	0.001	0.002	0.007	0.008	0.005	0.002	0.002	0.001	<0.005	<0.001
	Manganese	mg/L	0.001	0.963	0.9	0.905	0.91	1.88	0.654	0.001	2.1	0.001
	Nickel	mg/L	0.001	0.087	0.086	0.086	0.068	0.095	0.045	0.004	0.009	<0.001
	Lead	mg/L	0.001	<0.002	0.015	0.017	0.014	0.004	<0.001	<0.001	<0.005	<0.001
	Selenium	mg/L	0.01	<0.02	<0.01	<0.01	-	<0.02	<0.01	<0.01	<0.05	<0.01
	Vanadium	mg/L	0.01	<0.02	<0.01	<0.01	<0.005	<0.02	<0.01	<0.01	<0.05	<0.01
	Zinc	mg/L	0.005	0.1	0.166	0.169	0.12	0.117	4.03	<0.005	0.038	<0.005
	Lithium	mg/L	0.001	0.054	0.039	0.037	0.045	0.035	0.029	0.021	0.195	<0.001
	Strontium	mg/L	0.001	4.18	2.87	2.88	2.7	2.54	2.33	3.9	11.2	<0.001
	Thorium	mg/L	0.001	<0.002	0.002	0.001	0.2	<0.002	0.001	<0.001	<0.005	<0.001
	Uranium	mg/L	0.001	<0.002	0.005	0.006	<0.005	<0.002	0.001	<0.001	<0.005	<0.001
	Mercury	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.001	<0.0001	<0.001
Bromine	Bromine	mg/L	0.1	51.8	40	40.1	<5^	42.4	25.6	23.9	216	<0.1
Iodine	Iodine	mg/L	0.1	0.7	0.4	0.2	<5^	0.3	3.6	0.9	0.6	<0.1
Total Metals	Manganese	mg/L	0.001	1.01	0.913	0.909	1	2.04	0.731	0.343	2.1	-
	Iron	mg/L	0.05	10.6	5.12	5.15	6.4	2.9	41.7	32.7	9.08	-
Nutrients	Nitrite as N	mg/L	0.01	0.02	<0.01	<0.01	-	<0.01	<0.01	0.1	0.01	-
	Nitrate as N	mg/L	0.01	0.22	0.09	0.12	0.14	0.09	<0.01	<0.01	<0.01	-
	Nitrate + Nitrite as N	mg/L	0.01	0.24	0.09	0.12	-	0.09	<0.01	0.06	<0.01	-
	Ammonia as N	mg/L	0.01	-	-	-	0.24	-	-	-	-	-
Fluoride	Fluoride	mg/L	0.1	0.4	0.1	0.1	<0.5	0.3	0.6	0.1	<0.1	<0.1
Silicon	Silicon	mg/L	0.05	18.4	23.5	25.2	27	19	14.9	0.89	2.93	<0.05
Dissolved Sulphide as	Dissolved Sulphide as S2-	mg/L	0.1	<0.1	<0.1	<0.1	<0.05	<0.1	<0.1	1.5	<0.1	-
Alkalinity	Hydroxide Alkalinity as CaCO3	mg/L	1	<1	<1	<1	-	<1	<1	<1	<1	<1
	Carbonate Alkalinity as CaCO3	mg/L	1	<1	<1	<1	<10	<1	<1	8	<1	<1
	Bicarbonate Alkalinity as CaCO3	mg/L	1	101	<1	<1	<20	<1	200	27	114	<1
	Total Alkalinity as CaCO3	mg/L	1	101	<1	<1	<20	<1	200	34	114	<1
Organic Matter	Dissolved Organic Carbon (DOC)	mg/L	1	4	4	4	<5	3	7	7	7	-
Major Ions	Calcium	mg/L	1	442	150	134	120	284	315	523	974	<1
	Magnesium	mg/L	1	1100	1020	931	870	792	733	328	5410	<1
	Sodium	mg/L	1	10100	10000	9070	9600	10200	7240	6120	48500	<1
	Potassium	mg/L	1	261	187	169	120	123	178	159	523	<1
	Sulphate (as SO4-)	mg/L	1	1470	1020	843	1300	1230	1220	1200	8780	<1
	Chloride	mg/L	1	16100	16400	16500	17000	16300	11800	10400	78800	<1
	Total Anions	meq/L	0.01	487	484	483	-	485	362	319	2410	<0.01
	Total Cations	meq/L	0.01	558	531	482	-	526	396	323	2620	<0.01
	Ionic Balance	%	0.01	6.87	4.66	0.09	-	4.03	4.39	0.67	4.16	-

Legend:
Not analysed/ not calculated
LOR: limit of reporting
Bq/L: Becquerals per litre with a conversion rate of 0.037 pCi/L (pico-curie per litre) for the secondary laboratory*
mg/L: milligrams per Litre
µg/L: micrograms per litre
meq/L: milliequivalents per litre
^ performed by an external on behalf of the secondary laboratory not NATA registered for the analysis
* performed by an external laboratory on behalf of the secondary laboratory and converted from reported units of pico-curie per litre (pCi/L)

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **EM1808546**	Page	: 1 of 6
Amendment	: **1**		
Client	: **AECOM SERVICES PTY LTD**	Laboratory	: Environmental Division Melbourne
Contact	: MELINDA MORRIS	Contact	: Peter Ravlic
Address	: Level 28, 91 King William Street ADELAIDE SA, AUSTRALIA 5000	Address	: 4 Westall Rd Springvale VIC Australia 3171
Telephone	: +61 08 83661000	Telephone	: +61-3-8549 9600
Project	: 60565376	Date Samples Received	: 25-May-2018 10:45
Order number	: 60565376.4.0	Date Analysis Commenced	: 25-May-2018
C-O-C number	: ----	Issue Date	: 14-Jun-2018 18:27
Sampler	: SYLVIA BRETHERTON		
Site	: NRWMF Site Characterisation		
Quote number	: EN/004/16		
No. of samples received	: 16		
No. of samples analysed	: 8		

ilac-MRA NATA

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

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

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

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

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

Ankit Joshi	Inorganic Chemist	Sydney Inorganics, Smithfield, NSW
Dilani Fernando	Senior Inorganic Chemist	Melbourne Inorganics, Springvale, VIC
Titus Vimalasiri	Metals Teamleader	Radionuclides, Fyshwick, ACT

General Comments

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

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

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

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

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

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

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

- EG020F: EM1808546-008 & 016 dissolved manganese results have been confirmed by re-preparation and re-analysis
- EG020F: EM1808546-001, 004, 006, 011 & 012 required dilution prior to dissolved metals analysis due to sample matrix interference. LOR values have been raised accordingly
- ED093F: EM1808546 #4, 6 and 14, the results for Cations have been confirmed by re-preparation and re-analysis.
- EA010-P: Electrical Conductivity @ 25°C was analysed by manual method (EA010).
- Gross Alpha and Beta Activity analyses are performed by ALS Fyshwick (NATA Accreditation number 992).
- It is recognised that Nitrite +Nitrate as N is less than Nitrite as N for samples #5 and #6. However, the difference is within experimental variation of the methods.
- ED045G: Results for EM1808546-016 have been confirmed by re-preparation and re-analysis.
- EK059G:EM1808546#5 and #6 results for Nitrite and Nitrate as N (NOx) have been confirmed by reanalysis.It is recognised that Nitrite and Nitrate as N (NOx) is less than Nitrites as N for sample #5 and #6. However, the difference is within experimental variation of the methods.
- EK057G: Results for EM1808546-005 and 006 have been confirmed by re-preparation and re-analysis.
- This report has been amended to re-issue the results as requested. 14/6/18.
- Ionic balances were calculated using: major anions - chloride, alkalinity and sulfate; and major cations - calcium, magnesium, potassium and sodium.
- ED045G: The presence of thiocyanate can positively contribute to the chloride result, thereby may bias results higher than expected. Results should be scrutinised accordingly.
- Sodium Adsorption Ratio (where reported): Where results for Na, Ca or Mg are <LOR, a concentration at half the reported LOR is incorporated into the SAR calculation. This represents a conservative approach for Na relative to the assumption that <LOR = zero concentration and a conservative approach for Ca & Mg relative to the assumption that <LOR is equivalent to the LOR concentration.

Analytical Results

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

				L01_22/5/18	L04_22/5/18	L02_23/5/18	L03_23/5/18	L05S_23/5/18
				22-May-2018 00:00	22-May-2018 00:00	23-May-2018 00:00	23-May-2018 00:00	23-May-2018 00:00
				EM1808546-001	**EM1808546-002**	**EM1808546-003**	**EM1808546-004**	**EM1808546-005**
				Result	Result	Result	Result	Result
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	**6.74**	**7.22**	**4.19**	**4.63**	**8.72**
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	**42800**	**31100**	**43400**	**45800**	**27400**
EA250: Gross Alpha and Beta Activity								
Gross alpha	----	0.05	Bq/L	**2.71**	**1.22**	**24.8**	**30.4**	**1.44**
Gross beta activity - 40K	----	0.10	Bq/L	**8.98**	**2.91**	**93.4**	**135**	**4.37**
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	<1	<1	**8**
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	**101**	**200**	<1	<1	**27**
Total Alkalinity as CaCO3	----	1	mg/L	**101**	**200**	<1	<1	**34**
ED040F: Dissolved Major Anions								
Silicon	7440-21-3	0.05	mg/L	**18.4**	**14.9**	**23.5**	**19.0**	**0.89**
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	**1470**	**1220**	**1020**	**1230**	**1200**
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	**16100**	**11800**	**16400**	**16300**	**10400**
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	**442**	**315**	**150**	**284**	**523**
Magnesium	7439-95-4	1	mg/L	**1100**	**733**	**1020**	**792**	**328**
Sodium	7440-23-5	1	mg/L	**10100**	**7240**	**10000**	**10200**	**6120**
Potassium	7440-09-7	1	mg/L	**261**	**178**	**187**	**123**	**159**
EG020F: Dissolved Metals by ICP-MS								
Arsenic	7440-38-2	0.001	mg/L	<0.002	<0.001	**0.002**	<0.002	**0.002**
Boron	7440-42-8	0.05	mg/L	**2.46**	**1.70**	**1.52**	**1.88**	**0.19**
Barium	7440-39-3	0.001	mg/L	**0.250**	**0.312**	**0.281**	**0.328**	**0.306**
Beryllium	7440-41-7	0.001	mg/L	<0.002	<0.001	**0.002**	<0.002	<0.001
Cadmium	7440-43-9	0.0001	mg/L	**0.0012**	**0.0006**	**0.0026**	**0.0023**	<0.0001
Cobalt	7440-48-4	0.001	mg/L	**0.021**	**0.011**	**0.069**	**0.034**	<0.001
Chromium	7440-47-3	0.001	mg/L	<0.002	<0.001	**0.009**	<0.002	**0.001**
Copper	7440-50-8	0.001	mg/L	**0.002**	**0.002**	**0.007**	**0.002**	**0.001**
Manganese	7439-96-5	0.001	mg/L	**0.963**	**0.654**	**0.900**	**1.88**	**0.001**
Nickel	7440-02-0	0.001	mg/L	**0.087**	**0.045**	**0.086**	**0.095**	**0.004**
Lead	7439-92-1	0.001	mg/L	<0.002	<0.001	**0.015**	**0.004**	<0.001

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				L01_22/5/18	L04_22/5/18	L02_23/5/18	L03_23/5/18	L05S_23/5/18
				22-May-2018 00:00	22-May-2018 00:00	23-May-2018 00:00	23-May-2018 00:00	23-May-2018 00:00
				EM1808546-001	EM1808546-002	EM1808546-003	EM1808546-004	EM1808546-005
				Result	Result	Result	Result	Result
EG020F: Dissolved Metals by ICP-MS - Continued								
Selenium	7782-49-2	0.01	mg/L	<0.02	<0.01	<0.01	<0.02	<0.01
Vanadium	7440-62-2	0.01	mg/L	<0.02	<0.01	<0.01	<0.02	<0.01
Zinc	7440-66-6	0.005	mg/L	**0.100**	**4.03**	**0.166**	**0.117**	<0.005
Lithium	7439-93-2	0.001	mg/L	**0.054**	**0.029**	**0.039**	**0.035**	**0.021**
Strontium	7440-24-6	0.001	mg/L	**4.18**	**2.33**	**2.87**	**2.54**	**3.90**
Thorium	7440-29-1	0.001	mg/L	<0.002	**0.001**	**0.002**	<0.002	<0.001
Uranium	7440-61-1	0.001	mg/L	<0.002	**0.001**	**0.005**	<0.002	<0.001
Bromine	7726-95-6	0.1	mg/L	**51.8**	**25.6**	**40.0**	**42.4**	**23.9**
Iodine	7553-56-2	0.1	mg/L	**0.7**	**3.6**	**0.4**	**0.3**	**0.9**
EG020T: Total Metals by ICP-MS								
Manganese	7439-96-5	0.001	mg/L	**1.01**	**0.731**	**0.913**	**2.04**	**0.343**
Iron	7439-89-6	0.05	mg/L	**10.6**	**41.7**	**5.12**	**2.90**	**32.7**
EG035F: Dissolved Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	**0.4**	**0.6**	**0.1**	**0.3**	**0.1**
EK057G: Nitrite as N by Discrete Analyser								
Nitrite as N	14797-65-0	0.01	mg/L	**0.02**	<0.01	<0.01	<0.01	**0.10**
EK058G: Nitrate as N by Discrete Analyser								
Nitrate as N	14797-55-8	0.01	mg/L	**0.22**	<0.01	**0.09**	**0.09**	<0.01
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								
Nitrite + Nitrate as N	----	0.01	mg/L	**0.24**	<0.01	**0.09**	**0.09**	**0.06**
EK085F: Dissolved Sulfide as S2-								
Dissolved Sulfide as S2-	18496-25-8	0.1	mg/L	<0.1	<0.1	<0.1	<0.1	**1.5**
EN055: Ionic Balance								
Total Anions	----	0.01	meq/L	**487**	**362**	**484**	**485**	**319**
Total Cations	----	0.01	meq/L	**558**	**396**	**531**	**526**	**323**
Ionic Balance	----	0.01	%	**6.87**	**4.39**	**4.66**	**4.03**	**0.67**
EP002: Dissolved Organic Carbon (DOC)								
Dissolved Organic Carbon	----	1	mg/L	**4**	**7**	**4**	**3**	**7**

Analytical Results

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

				L05D_23/5/18	QC03_23/5/18	QC01_22/5/18	----	----
				23-May-2018 00:00	23-May-2018 00:00	22-May-2018 00:00	----	----
				EM1808546-006	EM1808546-007	EM1808546-008	--------	--------
				Result	Result	Result	----	----
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	**6.68**	**4.22**	**4.65**	----	----
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	**168000**	**43800**	**2**	----	----
EA250: Gross Alpha and Beta Activity								
Gross alpha	----	0.05	Bq/L	**10.0**	**29.1**	----	----	----
Gross beta activity - 40K	----	0.10	Bq/L	**38.2**	**98.1**	----	----	----
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	<1	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	**114**	<1	<1	----	----
Total Alkalinity as CaCO3	----	1	mg/L	**114**	<1	<1	----	----
ED040F: Dissolved Major Anions								
Silicon	7440-21-3	0.05	mg/L	**2.93**	**25.2**	<0.05	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	**8780**	**843**	<1	----	----
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	**78800**	**16500**	<1	----	----
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	**974**	**134**	<1	----	----
Magnesium	7439-95-4	1	mg/L	**5410**	**931**	<1	----	----
Sodium	7440-23-5	1	mg/L	**48500**	**9070**	<1	----	----
Potassium	7440-09-7	1	mg/L	**523**	**169**	<1	----	----
EG020F: Dissolved Metals by ICP-MS								
Arsenic	7440-38-2	0.001	mg/L	<0.005	**0.003**	<0.001	----	----
Boron	7440-42-8	0.05	mg/L	**3.05**	**1.50**	<0.05	----	----
Barium	7440-39-3	0.001	mg/L	**0.056**	**0.284**	<0.001	----	----
Beryllium	7440-41-7	0.001	mg/L	<0.005	**0.002**	<0.001	----	----
Cadmium	7440-43-9	0.0001	mg/L	<0.0005	**0.0027**	<0.0001	----	----
Cobalt	7440-48-4	0.001	mg/L	<0.005	**0.070**	<0.001	----	----
Chromium	7440-47-3	0.001	mg/L	<0.005	**0.009**	<0.001	----	----
Copper	7440-50-8	0.001	mg/L	<0.005	**0.008**	<0.001	----	----
Manganese	7439-96-5	0.001	mg/L	**2.10**	**0.905**	**0.001**	----	----
Nickel	7440-02-0	0.001	mg/L	**0.009**	**0.086**	<0.001	----	----
Lead	7439-92-1	0.001	mg/L	<0.005	**0.017**	<0.001	----	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				L05D_23/5/18	QC03_23/5/18	QC01_22/5/18	----	----
				23-May-2018 00:00	23-May-2018 00:00	22-May-2018 00:00	----	----
				EM1808546-006	EM1808546-007	EM1808546-008	--------	--------
				Result	Result	Result	----	----
EG020F: Dissolved Metals by ICP-MS - Continued								
Selenium	7782-49-2	0.01	mg/L	<0.05	<0.01	<0.01	----	----
Vanadium	7440-62-2	0.01	mg/L	<0.05	<0.01	<0.01	----	----
Zinc	7440-66-6	0.005	mg/L	**0.038**	**0.169**	<0.005	----	----
Lithium	7439-93-2	0.001	mg/L	**0.195**	**0.037**	<0.001	----	----
Strontium	7440-24-6	0.001	mg/L	**11.2**	**2.88**	<0.001	----	----
Thorium	7440-29-1	0.001	mg/L	<0.005	**0.001**	<0.001	----	----
Uranium	7440-61-1	0.001	mg/L	<0.005	**0.006**	<0.001	----	----
Bromine	7726-95-6	0.1	mg/L	**216**	**40.1**	<0.1	----	----
Iodine	7553-56-2	0.1	mg/L	**0.6**	**0.2**	<0.1	----	----
EG020T: Total Metals by ICP-MS								
Manganese	7439-96-5	0.001	mg/L	**2.10**	**0.909**	----	----	----
Iron	7439-89-6	0.05	mg/L	**9.08**	**5.15**	----	----	----
EG035F: Dissolved Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	----	----
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	<0.1	**0.1**	<0.1	----	----
EK057G: Nitrite as N by Discrete Analyser								
Nitrite as N	14797-65-0	0.01	mg/L	**0.01**	<0.01	----	----	----
EK058G: Nitrate as N by Discrete Analyser								
Nitrate as N	14797-55-8	0.01	mg/L	<0.01	**0.12**	----	----	----
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								
Nitrite + Nitrate as N	----	0.01	mg/L	<0.01	**0.12**	----	----	----
EK085F: Dissolved Sulfide as S2-								
Dissolved Sulfide as S2-	18496-25-8	0.1	mg/L	<0.1	<0.1	----	----	----
EN055: Ionic Balance								
Total Anions	----	0.01	meq/L	**2410**	**483**	<0.01	----	----
Total Cations	----	0.01	meq/L	**2620**	**482**	<0.01	----	----
Ionic Balance	----	0.01	%	**4.16**	**0.09**	----	----	----
EP002: Dissolved Organic Carbon (DOC)								
Dissolved Organic Carbon	----	1	mg/L	**7**	**4**	----	----	----

Environmental

QUALITY CONTROL REPORT

Work Order	: **EM1808546**	Page	: 1 of 10
Amendment	: **1**		
Client	: **AECOM SERVICES PTY LTD**	Laboratory	: Environmental Division Melbourne
Contact	: MELINDA MORRIS	Contact	: Peter Ravlic
Address	: Level 28, 91 King William Street ADELAIDE SA, AUSTRALIA 5000	Address	: 4 Westall Rd Springvale VIC Australia 3171
Telephone	: +61 08 83661000	Telephone	: +61-3-8549 9600
Project	: 60565376	Date Samples Received	: 25-May-2018
Order number	: 60565376.4.0	Date Analysis Commenced	: 25-May-2018
C-O-C number	: ----	Issue Date	: 14-Jun-2018
Sampler	: SYLVIA BRETHERTON		
Site	: NRWMF Site Characterisation		
Quote number	: EN/004/16		
No. of samples received	: 16		
No. of samples analysed	: 8		

NATA

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

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

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Method Blank (MB) and Laboratory Control Spike (LCS) Report; Recovery and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits

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

Ankit Joshi	Inorganic Chemist	Sydney Inorganics, Smithfield, NSW
Dilani Fernando	Senior Inorganic Chemist	Melbourne Inorganics, Springvale, VIC
Titus Vimalasiri	Metals Teamleader	Radionuclides, Fyshwick, ACT

General Comments

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

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

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

Key : Anonymous = Refers to samples which are not specifically part of this work order but formed part of the QC process lot
CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
RPD = Relative Percentage Difference
# = Indicates failed QC

Laboratory Duplicate (DUP) Report

The quality control term Laboratory Duplicate refers to a randomly selected intralaboratory split. Laboratory duplicates provide information regarding method precision and sample heterogeneity. The permitted ranges for the Relative Percent Deviation (RPD) of Laboratory Duplicates are specified in ALS Method QWI-EN/38 and are dependent on the magnitude of results in comparison to the level of reporting: Result < 10 times LOR: No Limit; Result between 10 and 20 times LOR: 0% - 50%; Result > 20 times LOR: 0% - 20%.

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
EA005P: pH by PC Titrator (QC Lot: 1683366)									
EM1808546-013	N04_23/5/18	EA005-P: pH Value	----	0.01	pH Unit	6.63	6.62	0.151	0% - 20%
EM1808546-008	QC01_22/5/18	EA005-P: pH Value	----	0.01	pH Unit	4.65	4.64	0.215	0% - 20%
EA010P: Conductivity by PC Titrator (QC Lot: 1683364)									
EM1808541-001	Anonymous	EA010-P: Electrical Conductivity @ 25°C	----	1	µS/cm	2370	2280	3.79	0% - 20%
EM1808537-006	Anonymous	EA010-P: Electrical Conductivity @ 25°C	----	1	µS/cm	2	1	0.00	No Limit
EA010P: Conductivity by PC Titrator (QC Lot: 1683367)									
EM1808591-002	Anonymous	EA010-P: Electrical Conductivity @ 25°C	----	1	µS/cm	2910	2840	2.33	0% - 20%
EM1808546-008	QC01_22/5/18	EA010-P: Electrical Conductivity @ 25°C	----	1	µS/cm	2	2	0.00	No Limit
EA250: Gross Alpha and Beta Activity (QC Lot: 1690356)									
EM1808537-001	Anonymous	EA250-LSC: Gross alpha	----	0.05	Bq/L	0.48	0.49	2.38	No Limit
		EA250-LSC: Gross beta activity - 40K	----	0.1	Bq/L	0.36	0.62	53.5	No Limit
EM1808546-006	L05D_23/5/18	EA250-LSC: Gross alpha	----	0.05	Bq/L	10.0	10.4	3.41	No Limit
		EA250-LSC: Gross beta activity - 40K	----	0.1	Bq/L	38.2	38.6	1.06	No Limit
ED037P: Alkalinity by PC Titrator (QC Lot: 1683365)									
EM1808546-013	N04_23/5/18	ED037-P: Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	0.00	No Limit
		ED037-P: Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	0.00	No Limit
		ED037-P: Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	78	79	1.40	0% - 20%
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	78	79	1.40	0% - 20%
EM1808546-008	QC01_22/5/18	ED037-P: Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	0.00	No Limit
		ED037-P: Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	0.00	No Limit
		ED037-P: Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	<1	<1	0.00	No Limit
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	<1	<1	0.00	No Limit
ED040F: Dissolved Major Anions (QC Lot: 1681596)									
EM1808546-004	L03_23/5/18	ED040F: Silicon	7440-21-3	0.05	mg/L	19.0	18.5	2.98	0% - 20%

Sub-Matrix: **WATER**

Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
				Laboratory Duplicate (DUP) Report					
ED040F: Dissolved Major Anions (QC Lot: 1681596) - continued									
EM1808537-001	Anonymous	ED040F: Silicon	7440-21-3	0.05	mg/L	18.3	18.1	1.24	0% - 20%
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA (QC Lot: 1681595)									
EM1808546-004	L03_23/5/18	ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	1230	1240	0.497	0% - 20%
EM1808537-001	Anonymous	ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	603	602	0.00	0% - 20%
ED045G: Chloride by Discrete Analyser (QC Lot: 1681593)									
EM1807682-018	Anonymous	ED045G: Chloride	16887-00-6	1	mg/L	176	179	1.56	0% - 20%
EM1808537-005	Anonymous	ED045G: Chloride	16887-00-6	1	mg/L	1310	1310	0.355	0% - 20%
ED093F: Dissolved Major Cations (QC Lot: 1683420)									
EM1808537-002	Anonymous	ED093F: Calcium	7440-70-2	1	mg/L	151	141	6.58	0% - 20%
		ED093F: Magnesium	7439-95-4	1	mg/L	154	144	6.77	0% - 20%
		ED093F: Sodium	7440-23-5	1	mg/L	828	805	2.84	0% - 20%
		ED093F: Potassium	7440-09-7	1	mg/L	24	19	19.1	0% - 20%
EM1808546-004	L03_23/5/18	ED093F: Calcium	7440-70-2	1	mg/L	284	281	1.10	0% - 20%
		ED093F: Magnesium	7439-95-4	1	mg/L	792	782	1.30	0% - 20%
		ED093F: Sodium	7440-23-5	1	mg/L	10200	10000	1.46	0% - 20%
		ED093F: Potassium	7440-09-7	1	mg/L	123	120	2.52	0% - 20%
EG020F: Dissolved Metals by ICP-MS (QC Lot: 1683417)									
EM1808539-004	Anonymous	EG020A-F: Cadmium	7440-43-9	0.0001	mg/L	<0.0002	<0.0002	0.00	No Limit
		EG020A-F: Arsenic	7440-38-2	0.001	mg/L	0.012	0.012	0.00	No Limit
		EG020A-F: Beryllium	7440-41-7	0.001	mg/L	<0.002	<0.002	0.00	No Limit
		EG020A-F: Barium	7440-39-3	0.001	mg/L	0.098	0.098	0.00	0% - 20%
		EG020A-F: Chromium	7440-47-3	0.001	mg/L	0.004	0.004	0.00	No Limit
		EG020A-F: Cobalt	7440-48-4	0.001	mg/L	<0.002	<0.002	0.00	No Limit
		EG020A-F: Copper	7440-50-8	0.001	mg/L	0.002	0.002	0.00	No Limit
		EG020A-F: Lead	7439-92-1	0.001	mg/L	<0.002	<0.002	0.00	No Limit
		EG020A-F: Lithium	7439-93-2	0.001	mg/L	0.112	0.110	2.42	0% - 20%
		EG020A-F: Manganese	7439-96-5	0.001	mg/L	0.148	0.146	0.833	0% - 20%
		EG020A-F: Nickel	7440-02-0	0.001	mg/L	<0.002	<0.002	0.00	No Limit
		EG020A-F: Zinc	7440-66-6	0.005	mg/L	<0.010	<0.010	0.00	No Limit
		EG020A-F: Selenium	7782-49-2	0.01	mg/L	<0.02	<0.02	0.00	No Limit
		EG020A-F: Vanadium	7440-62-2	0.01	mg/L	<0.02	<0.02	0.00	No Limit
		EG020A-F: Boron	7440-42-8	0.05	mg/L	4.38	4.30	1.91	0% - 20%
		EG020A-F: Bromine	7726-95-6	0.1	mg/L	88.3	86.7	1.81	0% - 20%
		EG020A-F: Iodine	7553-56-2	0.1	mg/L	0.2	0.2	0.00	No Limit
EM1808537-001	Anonymous	EG020A-F: Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	0.00	No Limit
		EG020A-F: Arsenic	7440-38-2	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-F: Beryllium	7440-41-7	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-F: Barium	7440-39-3	0.001	mg/L	0.060	0.064	7.28	0% - 20%
		EG020A-F: Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	0.00	No Limit

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	***Client sample ID***	***Method: Compound***	***CAS Number***	***LOR***	***Unit***	***Original Result***	***Duplicate Result***	***RPD (%)***	***Recovery Limits (%)***
EG020F: Dissolved Metals by ICP-MS (QC Lot: 1683417) - continued									
EM1808537-001	Anonymous	EG020A-F: Cobalt	7440-48-4	0.001	mg/L	0.002	0.002	0.00	No Limit
		EG020A-F: Copper	7440-50-8	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-F: Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-F: Lithium	7439-93-2	0.001	mg/L	0.050	0.053	4.14	0% - 20%
		EG020A-F: Manganese	7439-96-5	0.001	mg/L	0.308	0.327	6.13	0% - 20%
		EG020A-F: Nickel	7440-02-0	0.001	mg/L	0.001	0.001	0.00	No Limit
		EG020A-F: Zinc	7440-66-6	0.005	mg/L	0.005	0.005	0.00	No Limit
		EG020A-F: Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	0.00	No Limit
		EG020A-F: Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	0.00	No Limit
		EG020A-F: Boron	7440-42-8	0.05	mg/L	0.66	0.69	5.15	0% - 50%
		EG020A-F: Bromine	7726-95-6	0.1	mg/L	1.5	1.7	9.69	0% - 50%
		EG020A-F: Iodine	7553-56-2	0.1	mg/L	0.2	0.3	0.00	No Limit
EG020F: Dissolved Metals by ICP-MS (QC Lot: 1683419)									
EM1808546-004	L03_23/5/18	EG020B-F: Strontium	7440-24-6	0.001	mg/L	2.54	2.60	2.44	0% - 20%
		EG020B-F: Thorium	7440-29-1	0.001	mg/L	<0.002	<0.002	0.00	No Limit
		EG020B-F: Uranium	7440-61-1	0.001	mg/L	<0.002	<0.002	0.00	No Limit
EM1808537-001	Anonymous	EG020B-F: Strontium	7440-24-6	0.001	mg/L	2.80	3.00	7.01	0% - 20%
		EG020B-F: Thorium	7440-29-1	0.001	mg/L	0.002	0.001	0.00	No Limit
		EG020B-F: Uranium	7440-61-1	0.001	mg/L	0.006	0.006	0.00	No Limit
EG020F: Dissolved Metals by ICP-MS (QC Lot: 1683422)									
EM1808546-006	L05D_23/5/18	EG020A-F: Cadmium	7440-43-9	0.0001	mg/L	<0.0005	<0.0005	0.00	No Limit
		EG020A-F: Arsenic	7440-38-2	0.001	mg/L	<0.005	<0.005	0.00	No Limit
		EG020A-F: Beryllium	7440-41-7	0.001	mg/L	<0.005	<0.005	0.00	No Limit
		EG020A-F: Barium	7440-39-3	0.001	mg/L	0.056	0.056	0.00	0% - 50%
		EG020A-F: Chromium	7440-47-3	0.001	mg/L	<0.005	<0.005	0.00	No Limit
		EG020A-F: Cobalt	7440-48-4	0.001	mg/L	<0.005	<0.005	0.00	No Limit
		EG020A-F: Copper	7440-50-8	0.001	mg/L	<0.005	<0.005	0.00	No Limit
		EG020A-F: Lead	7439-92-1	0.001	mg/L	<0.005	<0.005	0.00	No Limit
		EG020A-F: Lithium	7439-93-2	0.001	mg/L	0.195	0.186	4.44	0% - 20%
		EG020A-F: Manganese	7439-96-5	0.001	mg/L	2.10	2.11	0.153	0% - 20%
		EG020A-F: Nickel	7440-02-0	0.001	mg/L	0.009	0.008	0.00	No Limit
		EG020A-F: Zinc	7440-66-6	0.005	mg/L	0.038	0.039	2.76	No Limit
		EG020A-F: Selenium	7782-49-2	0.01	mg/L	<0.05	<0.05	0.00	No Limit
		EG020A-F: Vanadium	7440-62-2	0.01	mg/L	<0.05	<0.05	0.00	No Limit
		EG020A-F: Boron	7440-42-8	0.05	mg/L	3.05	2.94	3.53	0% - 20%
		EG020A-F: Bromine	7726-95-6	0.1	mg/L	216	220	1.62	0% - 20%
		EG020A-F: Iodine	7553-56-2	0.1	mg/L	0.6	0.6	0.00	No Limit
EM1808546-016	QC05_23/5/18	EG020A-F: Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	0.00	No Limit
		EG020A-F: Arsenic	7440-38-2	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-F: Beryllium	7440-41-7	0.001	mg/L	<0.001	<0.001	0.00	No Limit

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
EG020F: Dissolved Metals by ICP-MS (QC Lot: 1683422) - continued									
EM1808546-016	QC05_23/5/18	EG020A-F: Barium	7440-39-3	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-F: Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-F: Cobalt	7440-48-4	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-F: Copper	7440-50-8	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-F: Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-F: Lithium	7439-93-2	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-F: Manganese	7439-96-5	0.001	mg/L	0.002	0.001	0.00	No Limit
		EG020A-F: Nickel	7440-02-0	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-F: Zinc	7440-66-6	0.005	mg/L	<0.005	<0.005	0.00	No Limit
		EG020A-F: Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	0.00	No Limit
		EG020A-F: Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	0.00	No Limit
		EG020A-F: Boron	7440-42-8	0.05	mg/L	<0.05	<0.05	0.00	No Limit
		EG020A-F: Bromine	7726-95-6	0.1	mg/L	<0.1	<0.1	0.00	No Limit
		EG020A-F: Iodine	7553-56-2	0.1	mg/L	<0.1	<0.1	0.00	No Limit
EG020T: Total Metals by ICP-MS (QC Lot: 1683414)									
EM1808482-004	Anonymous	EG020A-T: Manganese	7439-96-5	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-T: Iron	7439-89-6	0.05	mg/L	<0.05	<0.05	0.00	No Limit
EM1808537-001	Anonymous	EG020A-T: Manganese	7439-96-5	0.001	mg/L	0.637	0.601	5.83	0% - 20%
		EG020A-T: Iron	7439-89-6	0.05	mg/L	3.70	3.97	7.09	0% - 20%
EG020T: Total Metals by ICP-MS (QC Lot: 1683415)									
EM1808546-003	L02_23/5/18	EG020A-T: Manganese	7439-96-5	0.001	mg/L	0.913	0.907	0.581	0% - 20%
		EG020A-T: Iron	7439-89-6	0.05	mg/L	5.12	5.22	1.86	0% - 20%
EM1808546-014	N05S_23/5/18	EG020A-T: Manganese	7439-96-5	0.001	mg/L	1.19	1.14	4.52	0% - 20%
		EG020A-T: Iron	7439-89-6	0.05	mg/L	6.86	7.00	2.01	0% - 20%
EG035F: Dissolved Mercury by FIMS (QC Lot: 1683418)									
EM1808539-004	Anonymous	EG035F: Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	0.00	No Limit
EM1808537-001	Anonymous	EG035F: Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	0.00	No Limit
EG035F: Dissolved Mercury by FIMS (QC Lot: 1683421)									
EM1808546-006	L05D_23/5/18	EG035F: Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	0.00	No Limit
EM1808546-016	QC05_23/5/18	EG035F: Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	0.00	No Limit
EK040P: Fluoride by PC Titrator (QC Lot: 1683363)									
EM1808537-006	Anonymous	EK040P: Fluoride	16984-48-8	0.1	mg/L	<0.1	<0.1	0.00	No Limit
EM1808546-008	QC01_22/5/18	EK040P: Fluoride	16984-48-8	0.1	mg/L	<0.1	<0.1	0.00	No Limit
EK057G: Nitrite as N by Discrete Analyser (QC Lot: 1681594)									
EM1808546-005	L05S_23/5/18	EK057G: Nitrite as N	14797-65-0	0.01	mg/L	0.10	0.10	0.00	No Limit
EM1808537-001	Anonymous	EK057G: Nitrite as N	14797-65-0	0.01	mg/L	0.01	<0.01	0.00	No Limit
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser (QC Lot: 1701843)									
EM1808546-001	L01_22/5/18	EK059G: Nitrite + Nitrate as N	----	0.01	mg/L	0.24	0.24	0.00	0% - 20%
EM1808546-012	N03_23/5/18	EK059G: Nitrite + Nitrate as N	----	0.01	mg/L	0.06	0.06	0.00	No Limit

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
EK085F: Dissolved Sulfide as S2- (QC Lot: 1683781)									
EM1808537-001	Anonymous	EK085F: Dissolved Sulfide as S2-	18496-25-8	0.1	mg/L	<0.1	<0.1	0.00	No Limit
EM1808546-005	L05S_23/5/18	EK085F: Dissolved Sulfide as S2-	18496-25-8	0.1	mg/L	1.5	1.8	18.7	No Limit
EP002: Dissolved Organic Carbon (DOC) (QC Lot: 1694024)									
EM1808537-001	Anonymous	EP002: Dissolved Organic Carbon	----	1	mg/L	2	2	0.00	No Limit
EM1808546-006	L05D_23/5/18	EP002: Dissolved Organic Carbon	----	1	mg/L	7	6	0.00	No Limit

Method Blank (MB) and Laboratory Control Spike (LCS) Report

The quality control term Method / Laboratory Blank refers to an analyte free matrix to which all reagents are added in the same volumes or proportions as used in standard sample preparation. The purpose of this QC parameter is to monitor potential laboratory contamination. The quality control term Laboratory Control Spike (LCS) refers to a certified reference material, or a known interference free matrix spiked with target analytes. The purpose of this QC parameter is to monitor method precision and accuracy independent of sample matrix. Dynamic Recovery Limits are based on statistical evaluation of processed LCS.

Sub-Matrix: **WATER**

				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Recovery Limits (%)	
Method: Compound	CAS Number	LOR	Unit	Result	Concentration	LCS	Low	High
EA010P: Conductivity by PC Titrator (QCLot: 1683364)								
EA010-P: Electrical Conductivity @ 25°C	----	1	µS/cm	<1	1412 µS/cm	99.5	85	119
EA010P: Conductivity by PC Titrator (QCLot: 1683367)								
EA010-P: Electrical Conductivity @ 25°C	----	1	µS/cm	<1	1412 µS/cm	99.5	85	119
EA250: Gross Alpha and Beta Activity (QCLot: 1690356)								
EA250-LSC: Gross alpha	----	0.05	Bq/L	<0.05	1751 Bq/L	99.4	70	130
EA250-LSC: Gross beta activity - 40K	----	0.1	Bq/L	<0.10	3342 Bq/L	99.8	70	130
ED037P: Alkalinity by PC Titrator (QCLot: 1683365)								
ED037-P: Total Alkalinity as CaCO3	----	----	mg/L	----	200 mg/L	103	88	109
ED040F: Dissolved Major Anions (QCLot: 1681596)								
ED040F: Silicon	7440-21-3	0.05	mg/L	<0.05	----	----	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA (QCLot: 1681595)								
ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	<1	25 mg/L	108	92	115
				<1	100 mg/L	106	92	115
ED045G: Chloride by Discrete Analyser (QCLot: 1681593)								
ED045G: Chloride	16887-00-6	1	mg/L	<1	10 mg/L	103	88	118
				<1	1000 mg/L	108	88	118
ED093F: Dissolved Major Cations (QCLot: 1683420)								
ED093F: Calcium	7440-70-2	1	mg/L	<1	5 mg/L	94.4	93	110
ED093F: Magnesium	7439-95-4	1	mg/L	<1	5 mg/L	95.2	91	110
ED093F: Sodium	7440-23-5	1	mg/L	<1	50 mg/L	98.0	90	109
ED093F: Potassium	7440-09-7	1	mg/L	<1	50 mg/L	95.8	89	109
EG020F: Dissolved Metals by ICP-MS (QCLot: 1683417)								
EG020A-F: Arsenic	7440-38-2	0.001	mg/L	<0.001	0.1 mg/L	97.5	91	107
EG020A-F: Beryllium	7440-41-7	0.001	mg/L	<0.001	0.1 mg/L	103	82	113
EG020A-F: Barium	7440-39-3	0.001	mg/L	<0.001	0.1 mg/L	87.6	84	106
EG020A-F: Cadmium	7440-43-9	0.0001	mg/L	<0.0001	0.1 mg/L	88.8	84	104
EG020A-F: Chromium	7440-47-3	0.001	mg/L	<0.001	0.1 mg/L	87.8	83	103
EG020A-F: Cobalt	7440-48-4	0.001	mg/L	<0.001	0.1 mg/L	96.6	83	106
EG020A-F: Copper	7440-50-8	0.001	mg/L	<0.001	0.1 mg/L	93.9	82	103
EG020A-F: Lead	7439-92-1	0.001	mg/L	<0.001	0.1 mg/L	92.2	83	105
EG020A-F: Lithium	7439-93-2	0.001	mg/L	<0.001	0.1 mg/L	106	82	110
EG020A-F: Manganese	7439-96-5	0.001	mg/L	<0.001	0.1 mg/L	90.6	83	105
EG020A-F: Nickel	7440-02-0	0.001	mg/L	<0.001	0.1 mg/L	94.2	82	106

Sub-Matrix: **WATER**

Method: Compound	CAS Number	LOR	Unit	Method Blank (MB) Report Result	Laboratory Control Spike (LCS) Report Spike Concentration	Spike Recovery (%) LCS	Recovery Limits (%) Low	Recovery Limits (%) High
EG020F: Dissolved Metals by ICP-MS (QCLot: 1683417) - continued								
EG020A-F: Selenium	7782-49-2	0.01	mg/L	<0.01	0.1 mg/L	96.8	82	109
EG020A-F: Vanadium	7440-62-2	0.01	mg/L	<0.01	0.1 mg/L	87.6	83	106
EG020A-F: Zinc	7440-66-6	0.005	mg/L	<0.005	0.1 mg/L	98.3	85	109
EG020A-F: Boron	7440-42-8	0.05	mg/L	<0.05	0.5 mg/L	100.0	84	116
EG020A-F: Bromine	7726-95-6	0.1	mg/L	<0.1	----	----	----	----
EG020A-F: Iodine	7553-56-2	0.1	mg/L	<0.1	----	----	----	----
EG020F: Dissolved Metals by ICP-MS (QCLot: 1683419)								
EG020B-F: Strontium	7440-24-6	0.001	mg/L	<0.001	0.1 mg/L	98.4	83	109
EG020B-F: Thorium	7440-29-1	0.001	mg/L	<0.001	0.1 mg/L	101	84	110
EG020B-F: Uranium	7440-61-1	0.001	mg/L	<0.001	0.1 mg/L	101	82	108
EG020F: Dissolved Metals by ICP-MS (QCLot: 1683422)								
EG020A-F: Arsenic	7440-38-2	0.001	mg/L	<0.001	0.1 mg/L	99.8	91	107
EG020A-F: Beryllium	7440-41-7	0.001	mg/L	<0.001	0.1 mg/L	96.4	82	113
EG020A-F: Barium	7440-39-3	0.001	mg/L	<0.001	0.1 mg/L	84.8	84	106
EG020A-F: Cadmium	7440-43-9	0.0001	mg/L	<0.0001	0.1 mg/L	97.1	84	104
EG020A-F: Chromium	7440-47-3	0.001	mg/L	<0.001	0.1 mg/L	94.7	83	103
EG020A-F: Cobalt	7440-48-4	0.001	mg/L	<0.001	0.1 mg/L	98.1	83	106
EG020A-F: Copper	7440-50-8	0.001	mg/L	<0.001	0.1 mg/L	91.2	82	103
EG020A-F: Lead	7439-92-1	0.001	mg/L	<0.001	0.1 mg/L	90.6	83	105
EG020A-F: Lithium	7439-93-2	0.001	mg/L	<0.001	0.1 mg/L	94.7	82	110
EG020A-F: Manganese	7439-96-5	0.001	mg/L	<0.001	0.1 mg/L	97.0	83	105
EG020A-F: Nickel	7440-02-0	0.001	mg/L	<0.001	0.1 mg/L	94.1	82	106
EG020A-F: Selenium	7782-49-2	0.01	mg/L	<0.01	0.1 mg/L	92.4	82	109
EG020A-F: Vanadium	7440-62-2	0.01	mg/L	<0.01	0.1 mg/L	96.0	83	106
EG020A-F: Zinc	7440-66-6	0.005	mg/L	<0.005	0.1 mg/L	100	85	109
EG020A-F: Boron	7440-42-8	0.05	mg/L	<0.05	0.5 mg/L	101	84	116
EG020A-F: Bromine	7726-95-6	0.1	mg/L	<0.1	----	----	----	----
EG020A-F: Iodine	7553-56-2	0.1	mg/L	<0.1	----	----	----	----
EG020T: Total Metals by ICP-MS (QCLot: 1683414)								
EG020A-T: Manganese	7439-96-5	0.001	mg/L	<0.001	0.1 mg/L	98.8	88	111
EG020A-T: Iron	7439-89-6	0.05	mg/L	<0.05	0.5 mg/L	101	80	120
EG020T: Total Metals by ICP-MS (QCLot: 1683415)								
EG020A-T: Manganese	7439-96-5	0.001	mg/L	<0.001	0.1 mg/L	97.8	88	111
EG020A-T: Iron	7439-89-6	0.05	mg/L	<0.05	0.5 mg/L	104	80	120
EG035F: Dissolved Mercury by FIMS (QCLot: 1683418)								
EG035F: Mercury	7439-97-6	0.0001	mg/L	<0.0001	0.01 mg/L	99.1	81	114
EG035F: Dissolved Mercury by FIMS (QCLot: 1683421)								
EG035F: Mercury	7439-97-6	0.0001	mg/L	<0.0001	0.01 mg/L	108	81	114

Sub-Matrix: **WATER**

Method: Compound	CAS Number	LOR	Unit	Method Blank (MB) Report Result	Laboratory Control Spike (LCS) Report Spike Concentration	Spike Recovery (%) LCS	Recovery Limits (%) Low	Recovery Limits (%) High
EK040P: Fluoride by PC Titrator (QCLot: 1683363)								
EK040P: Fluoride	16984-48-8	0.1	mg/L	<0.1	5 mg/L	109	85	112
EK057G: Nitrite as N by Discrete Analyser (QCLot: 1681594)								
EK057G: Nitrite as N	14797-65-0	0.01	mg/L	<0.01	0.5 mg/L	107	94	107
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser (QCLot: 1701843)								
EK059G: Nitrite + Nitrate as N	----	0.01	mg/L	<0.01	0.5 mg/L	100	89	114
EK085F: Dissolved Sulfide as S2- (QCLot: 1683781)								
EK085F: Dissolved Sulfide as S2-	18496-25-8	0.1	mg/L	<0.1	0.5 mg/L	99.4	82	116
EP002: Dissolved Organic Carbon (DOC) (QCLot: 1694024)								
EP002: Dissolved Organic Carbon	----	1	mg/L	<1	10 mg/L	97.3	71	121

Matrix Spike (MS) Report

The quality control term Matrix Spike (MS) refers to an intralaboratory split sample spiked with a representative set of target analytes. The purpose of this QC parameter is to monitor potential matrix effects on analyte recoveries. Static Recovery Limits as per laboratory Data Quality Objectives (DQOs). Ideal recovery ranges stated may be waived in the event of sample matrix interference.

Sub-Matrix: **WATER**

Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Matrix Spike (MS) Report Spike Concentration	SpikeRecovery(%) MS	Recovery Limits (%) Low	Recovery Limits (%) High
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA (QCLot: 1681595)							
EM1808537-002	Anonymous	ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	100 mg/L	# Not Determined	70	130
ED045G: Chloride by Discrete Analyser (QCLot: 1681593)							
EM1807682-019	Anonymous	ED045G: Chloride	16887-00-6	400 mg/L	99.9	70	130
EG020F: Dissolved Metals by ICP-MS (QCLot: 1683417)							
EM1808537-001	Anonymous	EG020A-F: Arsenic	7440-38-2	0.2 mg/L	110	85	131
		EG020A-F: Beryllium	7440-41-7	0.2 mg/L	102	73	141
		EG020A-F: Barium	7440-39-3	0.2 mg/L	103	75	127
		EG020A-F: Cadmium	7440-43-9	0.05 mg/L	96.4	81	133
		EG020A-F: Chromium	7440-47-3	0.2 mg/L	98.8	71	135
		EG020A-F: Cobalt	7440-48-4	0.2 mg/L	106	78	132
		EG020A-F: Copper	7440-50-8	0.2 mg/L	101	76	130
		EG020A-F: Lead	7439-92-1	0.2 mg/L	101	75	133
		EG020A-F: Manganese	7439-96-5	0.2 mg/L	119	64	134
		EG020A-F: Nickel	7440-02-0	0.2 mg/L	103	73	131
		EG020A-F: Vanadium	7440-62-2	0.2 mg/L	100	73	131
		EG020A-F: Zinc	7440-66-6	0.2 mg/L	106	75	131
EG020F: Dissolved Metals by ICP-MS (QCLot: 1683422)							
EM1808546-006	L05D_23/5/18	EG020A-F: Arsenic	7440-38-2	1 mg/L	95.8	85	131

Sub-Matrix: **WATER**

Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Matrix Spike (MS) Report Spike Concentration	SpikeRecovery(%) MS	Recovery Limits (%) Low	Recovery Limits (%) High
EG020F: Dissolved Metals by ICP-MS (QCLot: 1683422) - continued							
EM1808546-006	L05D_23/5/18	EG020A-F: Beryllium	7440-41-7	1 mg/L	88.6	73	141
		EG020A-F: Barium	7440-39-3	1 mg/L	90.8	75	127
		EG020A-F: Cadmium	7440-43-9	0.2 mg/L	104	81	133
		EG020A-F: Chromium	7440-47-3	1 mg/L	89.5	71	135
		EG020A-F: Cobalt	7440-48-4	1 mg/L	89.7	78	132
		EG020A-F: Copper	7440-50-8	1 mg/L	82.5	76	130
		EG020A-F: Lead	7439-92-1	1 mg/L	89.3	75	133
		EG020A-F: Manganese	7439-96-5	1 mg/L	86.9	64	134
		EG020A-F: Nickel	7440-02-0	1 mg/L	86.4	73	131
		EG020A-F: Vanadium	7440-62-2	1 mg/L	94.2	73	131
		EG020A-F: Zinc	7440-66-6	1 mg/L	81.3	75	131
EG020T: Total Metals by ICP-MS (QCLot: 1683414)							
EM1808482-004	Anonymous	EG020A-T: Manganese	7439-96-5	1 mg/L	90.9	73	123
EG020T: Total Metals by ICP-MS (QCLot: 1683415)							
EM1808546-003	L02_23/5/18	EG020A-T: Manganese	7439-96-5	1 mg/L	93.7	73	123
EG035F: Dissolved Mercury by FIMS (QCLot: 1683418)							
EM1808537-002	Anonymous	EG035F: Mercury	7439-97-6	0.01 mg/L	88.9	70	120
EG035F: Dissolved Mercury by FIMS (QCLot: 1683421)							
EM1808546-007	QC03_23/5/18	EG035F: Mercury	7439-97-6	0.01 mg/L	84.4	70	120
EK040P: Fluoride by PC Titrator (QCLot: 1683363)							
EM1808537-003	Anonymous	EK040P: Fluoride	16984-48-8	5 mg/L	123	70	130
EK057G: Nitrite as N by Discrete Analyser (QCLot: 1681594)							
EM1808537-002	Anonymous	EK057G: Nitrite as N	14797-65-0	0.5 mg/L	102	80	114
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser (QCLot: 1701843)							
EM1808546-002	L04_22/5/18	EK059G: Nitrite + Nitrate as N	----	0.5 mg/L	94.5	70	130
EP002: Dissolved Organic Carbon (DOC) (QCLot: 1694024)							
EM1808537-002	Anonymous	EP002: Dissolved Organic Carbon	----	100 mg/L	81.9	70	130

Environmental

QA/QC Compliance Assessment to assist with Quality Review

Work Order	: **EM1808546**	Page	: 1 of 10
Amendment	: **1**		
Client	: **AECOM SERVICES PTY LTD**	Laboratory	: Environmental Division Melbourne
Contact	: MELINDA MORRIS	Telephone	: +61-3-8549 9600
Project	: 60565376	Date Samples Received	: 25-May-2018
Site	: NRWMF Site Characterisation	Issue Date	: 14-Jun-2018
Sampler	: SYLVIA BRETHERTON	No. of samples received	: 16
Order number	: 60565376.4.0	No. of samples analysed	: 8

This report is automatically generated by the ALS LIMS through interpretation of the ALS Quality Control Report and several Quality Assurance parameters measured by ALS. This automated reporting highlights any non-conformances, facilitates faster and more accurate data validation and is designed to assist internal expert and external Auditor review. Many components of this report contribute to the overall DQO assessment and reporting for guideline compliance.

Brief method summaries and references are also provided to assist in traceability.

Summary of Outliers

Outliers : Quality Control Samples

This report highlights outliers flagged in the Quality Control (QC) Report.

- **NO Method Blank value outliers occur.**
- **NO Duplicate outliers occur.**
- **NO Laboratory Control outliers occur.**
- **Matrix Spike outliers exist - please see following pages for full details.**
- **For all regular sample matrices, NO surrogate recovery outliers occur.**

Outliers : Analysis Holding Time Compliance

- **Analysis Holding Time Outliers exist - please see following pages for full details.**

Outliers : Frequency of Quality Control Samples

- **Quality Control Sample Frequency Outliers exist - please see following pages for full details.**

Outliers : Quality Control Samples

Duplicates, Method Blanks, Laboratory Control Samples and Matrix Spikes

Matrix: **WATER**

Compound Group Name	Laboratory Sample ID	Client Sample ID	Analyte	CAS Number	Data	Limits	Comment
Matrix Spike (MS) Recoveries							
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA	EM1808537--002	Anonymous	**Sulfate as SO4 - Turbidimetric**	14808-79-8	Not Determined	----	**MS recovery not determined, background level greater than or equal to 4x spike level.**

Outliers : Analysis Holding Time Compliance

Matrix: **WATER**

Method	*Extraction / Preparation*			*Analysis*		
Container / Client Sample ID(s)	*Date extracted*	*Due for extraction*	***Days overdue***	*Date analysed*	*Due for analysis*	***Days overdue***
EA005P: pH by PC Titrator						
Clear Plastic Bottle - Natural L01_22/5/18, L04_22/5/18, QC01_22/5/18	----	----	----	29-May-2018	22-May-2018	**7**
Clear Plastic Bottle - Natural L02_23/5/18, L03_23/5/18, L05S_23/5/18, L05D_23/5/18, QC03_23/5/18	----	----	----	29-May-2018	23-May-2018	**6**
EK057G: Nitrite as N by Discrete Analyser						
Clear Plastic Bottle - Natural L01_22/5/18, L04_22/5/18	----	----	----	28-May-2018	24-May-2018	**4**

Outliers : Frequency of Quality Control Samples

Matrix: **WATER**

Quality Control Sample Type	Count		Rate (%)		Quality Control Specification
Method	QC	Regular	Actual	Expected	
Laboratory Control Samples (LCS)					
Major Anions - Dissolved	0	14	0.00	5.00	NEPM 2013 B3 & ALS QC Standard

Analysis Holding Time Compliance

If samples are identified below as having been analysed or extracted outside of recommended holding times, this should be taken into consideration when interpreting results.

This report summarizes extraction / preparation and analysis times and compares each with ALS recommended holding times (referencing USEPA SW 846, APHA, AS and NEPM) based on the sample container provided. Dates reported represent first date of extraction or analysis and preclude subsequent dilutions and reruns. A listing of breaches (if any) is provided herein.

Holding time for leachate methods (e.g. TCLP) vary according to the analytes reported. Assessment compares the leach date with the shortest analyte holding time for the equivalent soil method. These are: organics 14 days, mercury 28 days & other metals 180 days. A recorded breach does not guarantee a breach for all non-volatile parameters.

Holding times for ***VOC in soils*** vary according to analytes of interest. Vinyl Chloride and Styrene holding time is 7 days; others 14 days. A recorded breach does not guarantee a breach for all VOC analytes and should be verified in case the reported breach is a false positive or Vinyl Chloride and Styrene are not key analytes of interest/concern.

Matrix: **WATER**

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

Method	*Sample Date*	*Extraction / Preparation*			*Analysis*		
Container / Client Sample ID(s)		***Date extracted***	*Due for extraction*	*Evaluation*	***Date analysed***	*Due for analysis*	*Evaluation*

Matrix: **WATER**

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

Method Container / Client Sample ID(s)		Sample Date	Extraction / Preparation			Analysis		
			Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EA005P: pH by PC Titrator								
Clear Plastic Bottle - Natural (EA005-P) L01_22/5/18, QC01_22/5/18	L04_22/5/18,	**22-May-2018**	----	----	----	**29-May-2018**	22-May-2018	✘
Clear Plastic Bottle - Natural (EA005-P) L02_23/5/18, L05S_23/5/18, QC03_23/5/18	L03_23/5/18, L05D_23/5/18,	**23-May-2018**	----	----	----	**29-May-2018**	23-May-2018	✘
EA010P: Conductivity by PC Titrator								
Clear Plastic Bottle - Natural (EA010-P) L01_22/5/18, QC01_22/5/18	L04_22/5/18,	**22-May-2018**	----	----	----	**29-May-2018**	19-Jun-2018	✓
Clear Plastic Bottle - Natural (EA010-P) L02_23/5/18, L05S_23/5/18, QC03_23/5/18	L03_23/5/18, L05D_23/5/18,	**23-May-2018**	----	----	----	**29-May-2018**	20-Jun-2018	✓
EA250: Gross Alpha and Beta Activity								
Clear Plastic Bottle - Natural (EA250-LSC) L01_22/5/18,	L04_22/5/18	**22-May-2018**	----	----	----	**31-May-2018**	18-Nov-2018	✓
Clear Plastic Bottle - Natural (EA250-LSC) L02_23/5/18, L05S_23/5/18, QC03_23/5/18	L03_23/5/18, L05D_23/5/18,	**23-May-2018**	----	----	----	**31-May-2018**	19-Nov-2018	✓
ED037P: Alkalinity by PC Titrator								
Clear Plastic Bottle - Natural (ED037-P) L01_22/5/18, QC01_22/5/18	L04_22/5/18,	**22-May-2018**	----	----	----	**29-May-2018**	05-Jun-2018	✓
Clear Plastic Bottle - Natural (ED037-P) L02_23/5/18, L05S_23/5/18, QC03_23/5/18	L03_23/5/18, L05D_23/5/18,	**23-May-2018**	----	----	----	**29-May-2018**	06-Jun-2018	✓
ED040F: Dissolved Major Anions								
Clear Plastic Bottle - Natural (ED040F) L01_22/5/18, QC01_22/5/18	L04_22/5/18,	**22-May-2018**	----	----	----	**28-May-2018**	19-Jun-2018	✓
Clear Plastic Bottle - Natural (ED040F) L02_23/5/18, L05S_23/5/18, QC03_23/5/18	L03_23/5/18, L05D_23/5/18,	**23-May-2018**	----	----	----	**28-May-2018**	20-Jun-2018	✓

Matrix: **WATER**

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

Method / Container / Client Sample ID(s)		Sample Date	Extraction / Preparation			Analysis		
			Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Clear Plastic Bottle - Natural (ED041G) L01_22/5/18, QC01_22/5/18	L04_22/5/18,	**22-May-2018**	----	----	----	**29-May-2018**	19-Jun-2018	✓
Clear Plastic Bottle - Natural (ED041G) L02_23/5/18, L05S_23/5/18, QC03_23/5/18	L03_23/5/18, L05D_23/5/18,	**23-May-2018**	----	----	----	**29-May-2018**	20-Jun-2018	✓
ED045G: Chloride by Discrete Analyser								
Clear Plastic Bottle - Natural (ED045G) L01_22/5/18, QC01_22/5/18	L04_22/5/18,	**22-May-2018**	----	----	----	**29-May-2018**	19-Jun-2018	✓
Clear Plastic Bottle - Natural (ED045G) L02_23/5/18, L05S_23/5/18, QC03_23/5/18	L03_23/5/18, L05D_23/5/18,	**23-May-2018**	----	----	----	**29-May-2018**	20-Jun-2018	✓
ED093F: Dissolved Major Cations								
Clear Plastic Bottle - Filtered; Lab-acidified (ED093F) L01_22/5/18, QC01_22/5/18	L04_22/5/18,	**22-May-2018**	----	----	----	**29-May-2018**	19-Jun-2018	✓
Clear Plastic Bottle - Filtered; Lab-acidified (ED093F) L02_23/5/18, L05S_23/5/18, QC03_23/5/18	L03_23/5/18, L05D_23/5/18,	**23-May-2018**	----	----	----	**29-May-2018**	20-Jun-2018	✓
EG020F: Dissolved Metals by ICP-MS								
Clear Plastic Bottle - Filtered; Lab-acidified (EG020B-F) L01_22/5/18, QC01_22/5/18	L04_22/5/18,	**22-May-2018**	----	----	----	**29-May-2018**	18-Nov-2018	✓
Clear Plastic Bottle - Filtered; Lab-acidified (EG020B-F) L02_23/5/18, L05S_23/5/18, QC03_23/5/18	L03_23/5/18, L05D_23/5/18,	**23-May-2018**	----	----	----	**29-May-2018**	19-Nov-2018	✓
EG020T: Total Metals by ICP-MS								
Clear Plastic Bottle - Unfiltered; Lab-acidified (EG020A-T) L01_22/5/18,	L04_22/5/18	**22-May-2018**	**29-May-2018**	18-Nov-2018	✓	**29-May-2018**	18-Nov-2018	✓
Clear Plastic Bottle - Unfiltered; Lab-acidified (EG020A-T) L02_23/5/18, L05S_23/5/18, QC03_23/5/18	L03_23/5/18, L05D_23/5/18,	**23-May-2018**	**29-May-2018**	19-Nov-2018	✓	**29-May-2018**	19-Nov-2018	✓

Matrix: **WATER**

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

Method	**Sample Date**	Extraction / Preparation			Analysis		
Container / Client Sample ID(s)		**Date extracted**	Due for extraction	Evaluation	**Date analysed**	Due for analysis	Evaluation
EG035F: Dissolved Mercury by FIMS							
Clear Plastic Bottle - Filtered; Lab-acidified (EG035F) L01_22/5/18, L04_22/5/18, QC01_22/5/18	**22-May-2018**	**----**	----	----	**31-May-2018**	19-Jun-2018	✓
Clear Plastic Bottle - Filtered; Lab-acidified (EG035F) L02_23/5/18, L03_23/5/18, L05S_23/5/18, L05D_23/5/18, QC03_23/5/18	**23-May-2018**	**----**	----	----	**31-May-2018**	20-Jun-2018	✓
EK040P: Fluoride by PC Titrator							
Clear Plastic Bottle - Natural (EK040P) L01_22/5/18, L04_22/5/18, QC01_22/5/18	**22-May-2018**	**----**	----	----	**29-May-2018**	19-Jun-2018	✓
Clear Plastic Bottle - Natural (EK040P) L02_23/5/18, L03_23/5/18, L05S_23/5/18, L05D_23/5/18, QC03_23/5/18	**23-May-2018**	**----**	----	----	**29-May-2018**	20-Jun-2018	✓
EK057G: Nitrite as N by Discrete Analyser							
Clear Plastic Bottle - Natural (EK057G) L01_22/5/18, L04_22/5/18	**22-May-2018**	**----**	----	----	**28-May-2018**	24-May-2018	✗
Clear Plastic Bottle - Natural (EK057G) L02_23/5/18, L03_23/5/18, L05S_23/5/18, L05D_23/5/18, QC03_23/5/18	**23-May-2018**	**----**	----	----	**25-May-2018**	25-May-2018	✓
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser							
Clear Plastic Bottle - Sulfuric Acid (EK059G) L01_22/5/18, L04_22/5/18	**22-May-2018**	**----**	----	----	**05-Jun-2018**	19-Jun-2018	✓
Clear Plastic Bottle - Sulfuric Acid (EK059G) L02_23/5/18, L03_23/5/18, L05S_23/5/18, L05D_23/5/18, QC03_23/5/18	**23-May-2018**	**----**	----	----	**05-Jun-2018**	20-Jun-2018	✓
EK085F: Dissolved Sulfide as S2-							
Clear Plastic Bottle - Zn Acetate/NaOH-FLOCCULATED (EK085F) L01_22/5/18, L04_22/5/18	**22-May-2018**	**----**	----	----	**29-May-2018**	29-May-2018	✓
Clear Plastic Bottle - Zn Acetate/NaOH-FLOCCULATED (EK085F) L02_23/5/18, L03_23/5/18, L05S_23/5/18, L05D_23/5/18, QC03_23/5/18	**23-May-2018**	**----**	----	----	**29-May-2018**	30-May-2018	✓

Matrix: **WATER**

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

Method Container / Client Sample ID(s)		Sample Date	Extraction / Preparation			Analysis		
			Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EP002: Dissolved Organic Carbon (DOC)								
Amber DOC Filtered- Sulfuric Preserved (EP002)								
L01_22/5/18,	L04_22/5/18	**22-May-2018**	**----**	----	----	**01-Jun-2018**	19-Jun-2018	✓
Amber DOC Filtered- Sulfuric Preserved (EP002)								
L02_23/5/18, L05S_23/5/18, QC03_23/5/18	L03_23/5/18, L05D_23/5/18,	**23-May-2018**	**----**	----	----	**01-Jun-2018**	20-Jun-2018	✓

Quality Control Parameter Frequency Compliance

The following report summarises the frequency of laboratory QC samples analysed within the analytical lot(s) in which the submitted sample(s) was(were) processed. Actual rate should be greater than or equal to the expected rate. A listing of breaches is provided in the Summary of Outliers.

Matrix: **WATER**

Evaluation: ✗ = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	*Method*	*QC*	*Regular*	***Actual***	***Expected***	*Evaluation*	
Laboratory Duplicates (DUP)							
Alkalinity by PC Titrator	ED037-P	2	13	**15.38**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Chloride by Discrete Analyser	ED045G	2	18	**11.11**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Conductivity by PC Titrator	EA010-P	4	29	**13.79**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Mercury by FIMS	EG035F	4	25	**16.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Metals by ICP-MS - Suite A	EG020A-F	4	30	**13.33**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Metals by ICP-MS - Suite B	EG020B-F	2	14	**14.29**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Organic Carbon	EP002	2	15	**13.33**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Sulfide as S2-	EK085F	2	13	**15.38**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Fluoride by PC Titrator	EK040P	2	18	**11.11**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Gross Alpha and Beta Activity	EA250-LSC	2	14	**14.29**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Major Anions - Dissolved	ED040F	2	14	**14.29**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Major Cations - Dissolved	ED093F	2	14	**14.29**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	2	7	**28.57**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite as N by Discrete Analyser	EK057G	2	12	**16.67**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
pH by PC Titrator	EA005-P	2	13	**15.38**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	2	14	**14.29**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals by ICP-MS - Suite A	EG020A-T	4	29	**13.79**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Laboratory Control Samples (LCS)							
Alkalinity by PC Titrator	ED037-P	1	13	**7.69**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Chloride by Discrete Analyser	ED045G	2	18	**11.11**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Conductivity by PC Titrator	EA010-P	2	29	**6.90**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Mercury by FIMS	EG035F	2	25	**8.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Metals by ICP-MS - Suite A	EG020A-F	2	30	**6.67**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Metals by ICP-MS - Suite B	EG020B-F	1	14	**7.14**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Organic Carbon	EP002	1	15	**6.67**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Sulfide as S2-	EK085F	1	13	**7.69**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Fluoride by PC Titrator	EK040P	1	18	**5.56**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Gross Alpha and Beta Activity	EA250-LSC	2	14	**14.29**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Major Anions - Dissolved	ED040F	0	14	**0.00**	**5.00**	✗	NEPM 2013 B3 & ALS QC Standard
Major Cations - Dissolved	ED093F	1	14	**7.14**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	1	7	**14.29**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite as N by Discrete Analyser	EK057G	1	12	**8.33**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	2	14	**14.29**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals by ICP-MS - Suite A	EG020A-T	2	29	**6.90**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Method Blanks (MB)							
Chloride by Discrete Analyser	ED045G	1	18	**5.56**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard

Matrix: **WATER**

Evaluation: × = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	*Method*	*QC*	*Regular*	***Actual***	***Expected***	*Evaluation*	
Method Blanks (MB) - Continued							
Conductivity by PC Titrator	EA010-P	2	29	**6.90**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Mercury by FIMS	EG035F	2	25	**8.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Metals by ICP-MS - Suite A	EG020A-F	2	30	**6.67**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Metals by ICP-MS - Suite B	EG020B-F	1	14	**7.14**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Organic Carbon	EP002	1	15	**6.67**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Sulfide as S2-	EK085F	1	13	**7.69**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Fluoride by PC Titrator	EK040P	1	18	**5.56**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Gross Alpha and Beta Activity	EA250-LSC	1	14	**7.14**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Major Anions - Dissolved	ED040F	1	14	**7.14**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Major Cations - Dissolved	ED093F	1	14	**7.14**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	1	7	**14.29**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite as N by Discrete Analyser	EK057G	1	12	**8.33**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	1	14	**7.14**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals by ICP-MS - Suite A	EG020A-T	2	29	**6.90**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Matrix Spikes (MS)							
Chloride by Discrete Analyser	ED045G	1	18	**5.56**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Mercury by FIMS	EG035F	2	25	**8.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Metals by ICP-MS - Suite A	EG020A-F	2	30	**6.67**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Organic Carbon	EP002	1	15	**6.67**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Fluoride by PC Titrator	EK040P	1	18	**5.56**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	1	7	**14.29**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite as N by Discrete Analyser	EK057G	1	12	**8.33**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	1	14	**7.14**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals by ICP-MS - Suite A	EG020A-T	2	29	**6.90**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard

Brief Method Summaries

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the US EPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request. The following report provides brief descriptions of the analytical procedures employed for results reported in the Certificate of Analysis. Sources from which ALS methods have been developed are provided within the Method Descriptions.

Analytical Methods	Method	Matrix	Method Descriptions
pH by PC Titrator	EA005-P	WATER	In house: Referenced to APHA 4500 H+ B. This procedure determines pH of water samples by automated ISE. This method is compliant with NEPM (2013) Schedule B(3)
Conductivity by PC Titrator	EA010-P	WATER	In house: Referenced to APHA 2510 B. This procedure determines conductivity by automated ISE. This method is compliant with NEPM (2013) Schedule B(3)
Gross Alpha and Beta Activity	EA250-LSC	WATER	In house: Referenced to ASTM D7283-06: Determination of gross alpha and gross beta radioactivity in water samples by Liquid Scintillation Counting (LSC).
Alkalinity by PC Titrator	ED037-P	WATER	In house: Referenced to APHA 2320 B This procedure determines alkalinity by automated measurement (e.g. PC Titrate) using pH 4.5 for indicating the total alkalinity end-point. This method is compliant with NEPM (2013) Schedule B(3)
Major Anions - Dissolved	ED040F	WATER	In house: Referenced to APHA 3120. The 0.45µm filtered samples are determined by ICP/AES for Sulfur and/or Silcon content and reported as Sulfate and/or Silica after conversion by gravimetric factor.
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	WATER	In house: Referenced to APHA 4500-SO4. Dissolved sulfate is determined in a 0.45um filtered sample. Sulfate ions are converted to a barium sulfate suspension in an acetic acid medium with barium chloride. Light absorbance of the BaSO4 suspension is measured by a photometer and the SO4-2 concentration is determined by comparison of the reading with a standard curve. This method is compliant with NEPM (2013) Schedule B(3)
Chloride by Discrete Analyser	ED045G	WATER	In house: Referenced to APHA 4500 Cl - G.The thiocyanate ion is liberated from mercuric thiocyanate through sequestration of mercury by the chloride ion to form non-ionised mercuric chloride.in the presence of ferric ions the librated thiocynate forms highly-coloured ferric thiocynate which is measured at 480 nm APHA 21st edition seal method 2 017-1-L april 2003
Major Cations - Dissolved	ED093F	WATER	In house: Referenced to APHA 3120 and 3125; USEPA SW 846 - 6010 and 6020; Cations are determined by either ICP-AES or ICP-MS techniques. This method is compliant with NEPM (2013) Schedule B(3) Sodium Adsorption Ratio is calculated from Ca, Mg and Na which determined by ALS in house method QWI-EN/ED093F. This method is compliant with NEPM (2013) Schedule B(3) Hardness parameters are calculated based on APHA 2340 B. This method is compliant with NEPM (2013) Schedule B(3)
Dissolved Metals by ICP-MS - Suite A	EG020A-F	WATER	In house: Referenced to APHA 3125; USEPA SW846 - 6020, ALS QWI-EN/EG020. Samples are 0.45µm filtered prior to analysis. The ICPMS technique utilizes a highly efficient argon plasma to ionize selected elements. Ions are then passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to their measurement by a discrete dynode ion detector.
Total Metals by ICP-MS - Suite A	EG020A-T	WATER	In house: Referenced to APHA 3125; USEPA SW846 - 6020, ALS QWI-EN/EG020. The ICPMS technique utilizes a highly efficient argon plasma to ionize selected elements. Ions are then passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to their measurement by a discrete dynode ion detector.

Analytical Methods	Method	Matrix	Method Descriptions
Dissolved Metals by ICP-MS - Suite B	EG020B-F	WATER	In house: Referenced to APHA 3125; USEPA SW846 - 6020, ALS QWI-EN/EG020. Samples are 0.45µm filtered prior to analysis. The ICPMS technique utilizes a highly efficient argon plasma to ionize selected elements. Ions are then passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to their measurement by a discrete dynode ion detector.
Dissolved Mercury by FIMS	EG035F	WATER	In house: Referenced to AS 3550, APHA 3112 Hg - B (Flow-injection (SnCl2)(Cold Vapour generation) AAS) Samples are 0.45µm filtered prior to analysis. FIM-AAS is an automated flameless atomic absorption technique. A bromate/bromide reagent is used to oxidise any organic mercury compounds in the filtered sample. The ionic mercury is reduced online to atomic mercury vapour by SnCl2 which is then purged into a heated quartz cell. Quantification is by comparing absorbance against a calibration curve. This method is compliant with NEPM (2013) Schedule B(3)
Fluoride by PC Titrator	EK040P	WATER	In house: Referenced to APHA 4500-F C: CDTA is added to the sample to provide a uniform ionic strength background, adjust pH, and break up complexes. Fluoride concentration is determined by either manual or automatic ISE measurement. This method is compliant with NEPM (2013) Schedule B(3)
Nitrite as N by Discrete Analyser	EK057G	WATER	In house: Referenced to APHA 4500-NO2- B. Nitrite is determined by direct colourimetry by Discrete Analyser. This method is compliant with NEPM (2013) Schedule B(3)
Nitrate as N by Discrete Analyser	EK058G	WATER	In house: Referenced to APHA 4500-NO3- F. Nitrate is reduced to nitrite by way of a chemical reduction followed by quantification by Discrete Analyser. Nitrite is determined seperately by direct colourimetry and result for Nitrate calculated as the difference between the two results. This method is compliant with NEPM (2013) Schedule B(3)
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	WATER	In house: Referenced to APHA 4500-NO3- F. Combined oxidised Nitrogen (NO2+NO3) is determined by Chemical Reduction and direct colourimetry by Discrete Analyser. This method is compliant with NEPM (2013) Schedule B(3)
Dissolved Sulfide as S2-	EK085F	WATER	In house: Referenced to APHA 4500-S2- D. Water samples are flocculated in the field using AlCl3. The clear supernatant is and immediately precipitated when transferred to a predosed caustic/zinc acetate preserved sample container. After the supernatant is discarded, the resultant precipitate is then coloured using methylene blue indicator and measured using UV-VIS detection at 664nm. This method is compliant with NEPM (2013) Schedule B(3)
Ionic Balance by PCT DA and Turbi SO4 DA	EN055 - PG	WATER	In house: Referenced to APHA 1030F. This method is compliant with NEPM (2013) Schedule B(3)
Dissolved Organic Carbon	EP002	WATER	In house: Referenced to APHA 5310 B. This method is compliant with NEPM (2013) Schedule B(3) . Samples are combusted at high termperature in the presence of an oxidative catalyst. The evolved carbon dioxide is quantified using an IR detector.

Preparation Methods	Method	Matrix	Method Descriptions
Digestion for Total Recoverable Metals	EN25	WATER	In house: Referenced to USEPA SW846-3005. Method 3005 is a Nitric/Hydrochloric acid digestion procedure used to prepare surface and ground water samples for analysis by ICPAES or ICPMS. This method is compliant with NEPM (2013) Schedule B(3)

SAMPLE RECEIPT NOTIFICATION (SRN)

Work Order : **EM1808546**

Client	: **AECOM SERVICES PTY LTD**	Laboratory	: Environmental Division Melbourne
Contact	: MELINDA MORRIS	Contact	: Peter Ravlic
Address	: Level 28, 91 King William Street ADELAIDE SA, AUSTRALIA 5000	Address	: 4 Westall Rd Springvale VIC Australia 3171
E-mail	: melinda.morris@aecom.com	E-mail	: peter.ravlic@alsglobal.com
Telephone	: +61 08 83661000	Telephone	: +61-3-8549 9600
Facsimile	: +61 08 83661001	Facsimile	: +61-3-8549 9626
Project	: 60565376	Page	: 1 of 4
Order number	: 60565376.4.0	Quote number	: EM2017URSSA0002 (EN/004/16)
C-O-C number	: ----	QC Level	: NEPM 2013 B3 & ALS QC Standard
Site	: NRWMF Site Characterisation		
Sampler	: SYLVIA BRETHERTON		

Dates

Date Samples Received	: 25-May-2018 10:45	Issue Date	: 28-May-2018
Client Requested Due Date	: 12-Jun-2018	Scheduled Reporting Date	: **12-Jun-2018**

Delivery Details

Mode of Delivery	: Carrier	Security Seal	: Not Available
No. of coolers/boxes	: 5	Temperature	: 9.3°C - Ice present
Receipt Detail	:	No. of samples received / analysed	: 17 / 15

General Comments

- This report contains the following information:
  - Sample Container(s)/Preservation Non-Compliances
  - Summary of Sample(s) and Requested Analysis
  - Proactive Holding Time Report
  - Requested Deliverables
- **Please direct any queries related to sample condition / numbering / breakages to Client Services.**
- Sample Disposal - Aqueous (3 weeks), Solid (2 months) from receipt of samples.
- **Analytical work for this work order will be conducted at ALS Springvale, ALS Sydney & ALS Canberra.**
- **Please refer to the Proactive Holding Time Report table below which summarises breaches of recommended holding times that have occurred prior to samples/instructions being received at the laboratory. The absence of this summary table indicates that all samples have been received within the recommended holding times for the analysis requested.**
- Radiological analysis will be undertaken by ALS WRG Canberra, NATA accreditation no. 992, site no. 1531. The estimated TAT for this analysis is 15 working days.

Sample Container(s)/Preservation Non-Compliances

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

✓ **No sample container / preservation non-compliance exists.**

Summary of Sample(s) and Requested Analysis

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

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

Matrix: **WATER**

Laboratory sample ID	*Client sampling date / time*	*Client sample ID*	WATER - EA010P Electrical Conductivity (PCT)	WATER - EA250-LSC Gross Alpha and Beta Activity	WATER - EG020F Dissolved Metals by ICP/MS	WATER - EK085F Dissolved Sulfide as S2-	WATER - EP002 Dissolved Organic Carbon (DOC)	WATER - NT-01 & 02A Ca, Mg, Na, K, Cl, SO4, Alkalinity & Fluoride	WATER - W-03 15 Metals (NEPM Suite)
EM1808546-001	22-May-2018 00:00	L01_22/5/18	✓	✓	✓	✓	✓	✓	✓
EM1808546-002	22-May-2018 00:00	L04_22/5/18	✓	✓	✓	✓	✓	✓	✓
EM1808546-003	23-May-2018 00:00	L02_23/5/18	✓	✓	✓	✓	✓	✓	✓
EM1808546-004	23-May-2018 00:00	L03_23/5/18	✓	✓	✓	✓	✓	✓	✓
EM1808546-005	23-May-2018 00:00	L05S_23/5/18	✓	✓	✓	✓	✓	✓	✓
EM1808546-006	23-May-2018 00:00	L05D_23/5/18	✓	✓	✓	✓	✓	✓	✓
EM1808546-007	23-May-2018 00:00	QC03_23/5/18	✓	✓	✓	✓	✓	✓	✓
EM1808546-008	22-May-2018 00:00	QC01_22/5/18	✓		✓			✓	✓
EM1808546-010	23-May-2018 00:00	N01_23/5/18	✓	✓	✓	✓	✓	✓	✓
EM1808546-011	23-May-2018 00:00	N02_23/5/18	✓	✓	✓	✓	✓	✓	✓
EM1808546-012	23-May-2018 00:00	N03_23/5/18	✓	✓	✓	✓	✓	✓	✓
EM1808546-013	23-May-2018 00:00	N04_23/5/18	✓	✓	✓	✓	✓	✓	✓
EM1808546-014	23-May-2018 00:00	N05S_23/5/18	✓	✓	✓	✓	✓	✓	✓
EM1808546-015	23-May-2018 00:00	N05D_23/5/18	✓		✓			✓	✓
EM1808546-016	23-May-2018 00:00	QC05_23/5/18	✓		✓			✓	✓

Matrix: **WATER**

Laboratory sample ID	*Client sampling date / time*	*Client sample ID*	(On Hold) WATER No analysis requested	WATER - EA005P pH (PCT)	WATER - EG020T Total Metals by ICP/MS (including digestion)	WATER - EG052F Silicon Silicon by ICPAES (ED040F)	WATER - EK058G Nitrate as N by Discrete Analyser
EM1808546-001	22-May-2018 00:00	L01_22/5/18		✓	✓	✓	✓
EM1808546-002	22-May-2018 00:00	L04_22/5/18		✓	✓	✓	✓
EM1808546-003	23-May-2018 00:00	L02_23/5/18		✓	✓	✓	✓
EM1808546-004	23-May-2018 00:00	L03_23/5/18		✓	✓	✓	✓
EM1808546-005	23-May-2018 00:00	L05S_23/5/18		✓	✓	✓	✓
EM1808546-006	23-May-2018 00:00	L05D_23/5/18		✓	✓	✓	✓
EM1808546-007	23-May-2018 00:00	QC03_23/5/18		✓	✓	✓	✓
EM1808546-008	22-May-2018 00:00	QC01_22/5/18		✓		✓	
EM1808546-009	22-May-2018 00:00	QC02_22/5/18	✓				

			(On Hold) WATER No analysis requested	WATER - EA005P pH (PCT)	WATER - EG020T Total Metals by ICP/MS (including digestion)	WATER - EG052F Silicon Silicon by ICPAES (ED040F)	WATER - EK058G Nitrate as N by Discrete Analyser
EM1808546-010	23-May-2018 00:00	N01_23/5/18		▯	▯	▯	▯
EM1808546-011	23-May-2018 00:00	N02_23/5/18		▯	▯	▯	▯
EM1808546-012	23-May-2018 00:00	N03_23/5/18		▯	▯	▯	▯
EM1808546-013	23-May-2018 00:00	N04_23/5/18		▯	▯	▯	▯
EM1808546-014	23-May-2018 00:00	N05S_23/5/18		▯	▯	▯	▯
EM1808546-015	23-May-2018 00:00	N05D_23/5/18		▯		▯	
EM1808546-016	23-May-2018 00:00	QC05_23/5/18		▯		▯	
EM1808546-017	23-May-2018 00:00	QC06_23/5/18	▯				

Proactive Holding Time Report

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

Matrix: **WATER**

Evaluation: = Holding time breach ; ▯ = Within holding time.

Method **Client Sample ID(s)**	**Container**	**Due for extraction**	**Due for analysis**	**Samples Received**		**Instructions Received**	
				Date	**Evaluation**	**Date**	**Evaluation**
EA005-P: pH by PC Titrator							
L01_22/5/18	Clear Plastic Bottle - Natural	----	22-May-2018	25-May-2018		----	----
L02_23/5/18	Clear Plastic Bottle - Natural	----	23-May-2018	25-May-2018		----	----
L03_23/5/18	Clear Plastic Bottle - Natural	----	23-May-2018	25-May-2018		----	----
L04_22/5/18	Clear Plastic Bottle - Natural	----	22-May-2018	25-May-2018		----	----
L05D_23/5/18	Clear Plastic Bottle - Natural	----	23-May-2018	25-May-2018		----	----
L05S_23/5/18	Clear Plastic Bottle - Natural	----	23-May-2018	25-May-2018		----	----
N01_23/5/18	Clear Plastic Bottle - Natural	----	23-May-2018	25-May-2018		----	----
N02_23/5/18	Clear Plastic Bottle - Natural	----	23-May-2018	25-May-2018		----	----
N03_23/5/18	Clear Plastic Bottle - Natural	----	23-May-2018	25-May-2018		----	----
N04_23/5/18	Clear Plastic Bottle - Natural	----	23-May-2018	25-May-2018		----	----
N05D_23/5/18	Clear Plastic Bottle - Natural	----	23-May-2018	25-May-2018		----	----
N05S_23/5/18	Clear Plastic Bottle - Natural	----	23-May-2018	25-May-2018		----	----
QC01_22/5/18	Clear Plastic Bottle - Natural	----	22-May-2018	25-May-2018		----	----
QC03_23/5/18	Clear Plastic Bottle - Natural	----	23-May-2018	25-May-2018		----	----
QC05_23/5/18	Clear Plastic Bottle - Natural	----	23-May-2018	25-May-2018		----	----
EK057G: Nitrite as N by Discrete Analyser							
L01_22/5/18	Clear Plastic Bottle - Natural	----	24-May-2018	25-May-2018		----	----
L04_22/5/18	Clear Plastic Bottle - Natural	----	24-May-2018	25-May-2018		----	----

Requested Deliverables

ADELAIDE URS CORP		
- *AU Certificate of Analysis - NATA (COA)	Email	adelaide@ursCORP.com
- *AU Interpretive QC Report - DEFAULT (Anon QCI Rep) (QCI)	Email	adelaide@ursCORP.com
- *AU QC Report - DEFAULT (Anon QC Rep) - NATA (QC)	Email	adelaide@ursCORP.com
- A4 - AU Sample Receipt Notification - Environmental HT (SRN)	Email	adelaide@ursCORP.com
- Chain of Custody (CoC) (COC)	Email	adelaide@ursCORP.com
- EDI Format - ENMRG (ENMRG)	Email	adelaide@ursCORP.com
- EDI Format - ESDAT (ESDAT)	Email	adelaide@ursCORP.com
ALL INVOICES		
- A4 - AU Tax Invoice (INV)	Email	ap_customerservice.anz@aecom.com
MELINDA MORRIS		
- *AU Certificate of Analysis - NATA (COA)	Email	melinda.morris@aecom.com
- *AU Interpretive QC Report - DEFAULT (Anon QCI Rep) (QCI)	Email	melinda.morris@aecom.com
- *AU QC Report - DEFAULT (Anon QC Rep) - NATA (QC)	Email	melinda.morris@aecom.com
- A4 - AU Sample Receipt Notification - Environmental HT (SRN)	Email	melinda.morris@aecom.com
- A4 - AU Tax Invoice (INV)	Email	melinda.morris@aecom.com
- Chain of Custody (CoC) (COC)	Email	melinda.morris@aecom.com
- EDI Format - ENMRG (ENMRG)	Email	melinda.morris@aecom.com
- EDI Format - ESDAT (ESDAT)	Email	melinda.morris@aecom.com

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NP 25/5

FREIGHT

1 of 2
(please report only one lab batch for both pages)

AECOM PROJECT - CHAIN OF CUSTODY

CLIENT:	AECOM Services	LABORATORY:	ALS	All results to be provided in ESDAT format.	FOR LABORATORY USE ONLY
ADDRESS:	Level 28, 91 King William St Adelaide SA 5000	ADDRESS:	2-4 Westall Rd Springvale Vic, 3171	email address: adelaide@urscorp.com melinda.morris@aecom.com	
PHONE NO:	08 7100 6400	PHONE NO:	03 8549 9600	Quote Number:	
FAX NO:	08 7223 5499	FAX NO:			
PROJECT NAME:	NRWMF Site Characterisation	PROJECT MANAGER: melinda.morris@aecom.com 0408 387 495			
		SAMPLERS:	SYLVIA B.	SIGNED:	
PROJECT NO:	60565376.4.0				

COMMENTS: SPECIAL HANDLING/STORAGE

UPDATED COC BY MELINDA 17/05/18

Please forward QC field duplicates to ALS Sydney

ANALYSIS REQUIRED

LAB ID	SITE	LOCATION	MATRIX	SAMPLE TYPE	SAMPLE ID	Date	CONTAINER TYPE AND PRESERVATIVE	FIELD FILTERED?	TOTAL NUMBER OF CONTAINERS	pH, Electrical Conductivity, Major Anions & Cations, Si & Alkalinity & Iodine & Bromine & Fluorine – 500ml Green	Dissolved Metals – NEPM 15 (W-3) + Li, Sr, Th, U – 60ml Red/Green bottle (Field Filtered)	Dissolved Nitrate (as N) - 60ml Purple 2 day holding time	Dissolved Organic Carbon ~~40ml Purple~~ Vial (Field Filtered)	Total Metals (Fe, Mn) – 60ml Red/Green unfiltered	Dissolved Sulfide – 125ml Yellow	Gross alpha and Gross beta - 1 L Red/Green unpreserved	TRH/BTEXN/PAH/Phenols (W-24) + OC and OP (W-12) - 100ml Amber + 40 ml vials
1	LYNDHURST	KIMBA	W	PRIMARY	L01 22/5/18	22/5/18	P, VS, C, S	4	10	✓	✓	✓	✓	✓	✓	✓	HOLD
2	↓	↓	↓	↓	L04 22/5/18	22/5/18	↓	4	↓	✓	✓	✓	✓	✓	✓	✓	HOLD
3					L02 23/5/18	23/5/18		2		✓	✓	✓	✓	✓	✓	✓	HOLD
4					L03 23/5/18	23/5/18		2		✓	✓	✓	✓	✓	✓	✓	HOLD
5					L05S 23/5/18	23/5/18		2		✓	✓	✓	✓	✓	✓	✓	HOLD
6					L05D 23/5/18	23/5/18		2		✓	✓	✓	✓	✓	✓	✓	HOLD
7				QAQC	QC03 23/5/18	23/5/18		2		✓	✓	✓	—	—	✓	✓	HOLD
→				↓	QC04 23/5/18	23/5/18		2		please send to eurofins						✓	HOLD
8					QC01 22/5/18	22/5/18		N		✓	✓	HOLD	HOLD	HOLD	HOLD	HOLD	HOLD
9	↓	↓	↓	↓	QC02 22/5/18	22/5/18	↓	N	↓	HOLD	HOLD	HOLD	HOLD	HOLD	HOLD	HOLD	HOLD
																	HOLD
																	HOLD
																	HOLD
																	HOLD
																	HOLD
									TOTAL								

Custody Seal?	Y N NA	RELINQUISHED BY: SYLVIA B	CHE...
Samples Cold?	Y N NA	DATE: 24/5/18	
Comments:		RECEIVED BY:	
		DATE:	

...ERVATIVE CODES
...d Preserved; C = Sodium Hydroxide Preserved; J = Solvent Washed Acid Rinsed Jar
...ss Bottle; VC = Hydrochloric Acid Preserved Vial; VS Sulphuric Acid Preserved Glass Bottle;
... = EDTA Preserved Bottle; ST = Sterile Bottle; O = Other

Forwarded to Secondary Lab
Initials NP **Date** 25/5

Environmental Division
Melbourne
Work Order Reference
EM1808546

Telephone : + 61-3-8549 9600

Recieved by: Nisqla (ALS) 11:15 25/5/18

(please report both pages as one lab batch)

AECOM PROJECT - CHAIN OF CUSTODY

CLIENT:	AECOM Services	LABORATORY:	ALS	All results to be provided in ESDAT format. email address: adelaide@urscorp.com melinda.morris@aecom.com Quote Number:	FOR LABORATORY USE ONLY
ADDRESS:	Level 28, 91 King William St Adelaide SA 5000	ADDRESS:	2-4 Westall Rd Springvale Vic, 3171		
PHONE NO:	08 7100 6400	PHONE NO:	03 8549 9600		
FAX NO:	08 7223 5499	FAX NO:			
PROJECT NAME:	NRWMF Site Characterisation	PROJECT MANAGER:	melinda.morris@aecom.com 0408 387 495		
PROJECT NO:	60565376.4.0	SAMPLERS:	SYLVIA B	SIGNED:	

COMMENTS: SPECIAL HANDLING/STORAGE

UPDATED COC BY MELINDA 17/05/18

Please forward QC field duplicates to ALS Sydney

ANALYSIS REQUIRED

LAB ID	SITE	LOCATION	MATRIX	SAMPLE TYPE	SAMPLE ID	Date	CONTAINER TYPE AND PRESERVATIVE	FIELD FILTERED?	TOTAL NUMBER OF CONTAINERS	pH, Electrical Conductivity, Major Anions & Cations, Si & Alkalinity & Iodine & Bromine & Fluorine – 500ml Green	Dissolved Metals – NEPM 15 (W-3) + Li, Sr, Th, U – 60ml Red/Green bottle (Field Filtered)	Dissolved Nitrate (as N) - 60ml Purple 2 day holding time	Dissolved Organic Carbon – 40ml Purple vial (Field Filtered)	Total Metals (Fe, Mn) – 60ml Red/Green unfiltered	Dissolved Sulfide – 125ml Yellow	Gross alpha and Gross beta - 1 L Red/Green unpreserved	TRH/BTEXN/PAH/Phenols (W-24) + OC and OP (W-12) - 100ml Amber + 40 ml vials
10	NAPANDEE	KIMBA	W	PRIMARY	NO1 23/5/18	23/5/18	P,VS,C,S	2	10	✓	✓	✓	✓	✓	✓	✓	HOLD
11					NO2 23/5/18					✓	✓	✓	✓	✓	✓	✓	HOLD
12					NO3 23/5/18					✓	✓	✓	✓	✓	✓	✓	HOLD
13					NO4 23/5/18					✓	✓	✓	✓	✓	✓	✓	HOLD
14					NO5S 23/5/18					✓	✓	✓	✓	✓	✓	✓	HOLD
15					NO5D 23/5/18					✓	✓	HOLD					HOLD
16				QAQC	QC05 23/5/18			N		✓	✓	HOLD					HOLD
17				QAQC	QC06 23/5/18			N		HOLD							HOLD
																	HOLD
																	HOLD
																	HOLD
																	HOLD
																	HOLD
																	HOLD
																	HOLD
									TOTAL								

Custody Seal ? Y N NA	RELINQUISHED BY: SYLVIA B.	CHECKED:		CONTAINER TYPE AND PRESERVATIVE CODES
Samples Cold ? Y N NA	DATE: 24/5/18	TIME:		P = Natural Plastic; N = Nitric Acid Preserved; C = Sodium Hydroxide Preserved; J = Solvent Washed Acid Rinsed Jar
Comments:	RECEIVED BY:	CHECKED:		S = Solvent Washed Acid Rinsed Glass Bottle; VC = Hydrochloric Acid Preserved Vial; VS Sulphuric Acid Preserved Glass Bottle;
	DATE:	TIME:		Z = Zinc acetate Preserved Bottle; E = EDTA Preserved Bottle; ST = Sterile Bottle; O = Other

Recieved by ~~Nicole~~ [ALS] 11.15 25/5/18

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FREIGHT

1 of 2
(please report only one lab batch for both pages)

NP 2575

AECOM PROJECT - CHAIN OF CUSTODY

PAGE _1_ OF _1_

CLIENT:	AECOM Services	LABORATORY:	ALS	All results to be provided in ESDAT format.	FOR LABORATORY USE ONLY
ADDRESS:	Level 28, 91 King William St Adelaide SA 5000	ADDRESS:	2-4 Westall Rd Springvale Vic, 3171	email address: adelaide@urscorp.com melinda.morris@aecom.com	
PHONE NO:	08 7100 6400	PHONE NO:	03 8549 9600	Quote Number:	
FAX NO:	08 7223 5499	FAX NO:			
PROJECT NAME:	NRWMF Site Characterisation	PROJECT MANAGER:	melinda.morris@aecom.com 0408 387 495		
PROJECT NO:	60565376.4.0	SAMPLERS:	SYLVIA B.	SIGNED:	

COMMENTS: SPECIAL HANDLING/STORAGE

UPDATED COC BY MELINDA 17/05/18

Please forward QC field duplicates to ALS Sydney

ANALYSIS REQUIRED

LAB ID	SITE	LOCATION	MATRIX	SAMPLE TYPE	SAMPLE ID	Date	CONTAINER TYPE AND PRESERVATIVE	FIELD FILTERED?	TOTAL NUMBER OF CONTAINERS	pH, Electrical Conductivity, Major Anions & Cations, SI & Alkalinity & Iodine & Bromine & Fluorine - 500ml Green	Dissolved Metals – NEPM 15 (W-3) + Li, Sr, Th, U – 60ml Red/Green bottle (Field Filtered)	Dissolved Nitrate (as N) - 60ml Purple 2 day holding time	Dissolved Organic Carbon - 40ml Purple Vial (Field Filtered)	Total Metals (Fe, Mn) – 60ml Red/Green unfiltered	Dissolved Sulfide – 125ml Yellow	Gross alpha and Gross beta - 1 L Red/Green unpreserved	TRH/BTEXN/PAH/Phenols (W-24) + OC and OP (W-12) - 100ml Amber + 40 ml vials
1	LYNDHURST	KIMBA	W	PRIMARY	L01 - 22/5/18	22/5/18	P,VS,C S	4	10	✓	✓	✓	✓	✓	✓	✓	HOLD
2	↓	↓	↓	↓	L04 - 22/5/18	22/5/18	↓	4	↓	✓	✓	✓	✓	✓	✓	✓	HOLD
3					L02 - 23/5/18	23/5/18		2		✓	✓	✓	✓	✓	✓	✓	HOLD
4					L03 - 23/5/18	23/5/18		2		✓	✓	✓	✓	✓	✓	✓	HOLD
5					L05S - 23/5/18	23/5/18		2		✓	✓	✓	✓	✓	✓	✓	HOLD
6					L05D - 23/5/18	23/5/18		2		✓	✓	✓	✓	✓	✓	✓	HOLD
7				QAQC	QC03 - 23/5/18	23/5/18		2		✓	✓	✓	✓	✓	✓	✓	HOLD
→				↓	QC04 - 23/5/18	23/5/18		2		please send to eurofins							HOLD
8					QC01 - 22/5/18	22/5/18		N		✓	✓	HOLD	HOLD	HOLD	HOLD	HOLD	HOLD
9	↓	↓	↓	↓	QC02 - 22/5/18	22/5/18	↓	N	↓	HOLD	HOLD	HOLD	HOLD	HOLD	HOLD	HOLD	HOLD
																	HOLD
																	HOLD
																	HOLD
																	HOLD
																	HOLD
								TOTAL									

Custody Seal ? Y N NA
Samples Cold ? Y N NA
Comments:

RELINQUISHED BY: SYLVIA B
DATE: 24/5/18
RECEIVED BY:
DATE:

...RVATIVE CODES
...d Preserved; C = Sodium Hydroxide Preserved; J = Solvent Washed Acid Rinsed Jar
...ss Bottle; VC = Hydrochloric Acid Preserved Vial; VS Sulphuric Acid Preserved Glass Bottle;
... = EDTA Preserved Bottle; ST = Sterile Bottle; O = Other

Forwarded to Secondary Lab
Initials NP **Date** 25/5

Environmental Division
Melbourne
Work Order Reference
EM1808546

Telephone : + 61-3-8549 9600

Recieved by : Nisqa (ALS) 11:15 25/5/18

SCANNED

NP 2815

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FREIGHT

1 of 2 (please report only one lab batch for both pages)

NP 25/5

AECOM PROJECT - CHAIN OF CUSTODY

PAGE _1_ OF _1_

CLIENT:	AECOM Services	LABORATORY:	ALS	All results to be provided in ESDAT format.
ADDRESS:	Level 28, 91 King William St Adelaide SA 5000	ADDRESS:	2-4 Westall Rd Springvale Vic, 3171	email address: adelaide@urscorp.com melinda.morris@aecom.com
PHONE NO:	08 7100 6400	PHONE NO:	03 8549 9600	Quote Number:
FAX NO:	08 7223 5499	FAX NO:		
PROJECT NAME:	NRWMF Site Characterisation	PROJECT MANAGER: melinda.morris@aecom.com 0408 387 495		
PROJECT NO:	60565376.4.0	SAMPLERS:	SYLVIA B.	SIGNED:

FOR LABORATORY USE ONLY

COMMENTS: SPECIAL HANDLING/STORAGE

UPDATED COC BY MELINDA 17/05/18

Please forward QC field duplicates to ALS Sydney

ANALYSIS REQUIRED

LAB ID	SITE	LOCATION	MATRIX	SAMPLE TYPE	SAMPLE ID	Date	CONTAINER TYPE AND PRESERVATIVE	FIELD FILTERED?	TOTAL NUMBER OF CONTAINERS	pH, Electrical Conductivity, Major Anions & Cations, Si & Alkalinity & Iodine & Bromine & Fluorine – 500ml Green	Dissolved Metals – NEPM 15 (W-3) + Li, Sr, Th, U – 60ml Red/Green bottle (Field Filtered)	Dissolved Nitrate (as N) - 60ml Purple 2 day holding time	Dissolved Organic Carbon – 40ml Purple Vial (Field Filtered)	Total Metals (Fe, Mn) – 60ml Red/Green unfiltered	Dissolved Sulfide – 125ml Yellow	Gross alpha and Gross beta - 1 L Red/Green unpreserved	TRH/BTEXN/PAH/Phenols (W-24) + OC and OP (W-12) - 100ml Amber + 40 ml vials
1	LYNDHURST	KIMBA	W	PRIMARY	LO1 22/5/18	22/5/18	P,VS,C S	4	10	✓	✓	✓	✓	✓	✓	✓	HOLD
2					LO4 22/5/18	22/5/18		4		✓	✓	✓	✓	✓	✓	✓	HOLD
3					LO2 23/5/18	23/5/18		2		✓	✓	✓	✓	✓	✓	✓	HOLD
4					LO3 23/5/18	23/5/18		2		✓	✓	✓	✓	✓	✓	✓	HOLD
5					LO5S 23/5/18	23/5/18		2		✓	✓	✓	✓	✓	✓	✓	HOLD
6					LO5D 23/5/18	23/5/18		2		✓	✓	✓	✓	✓	✓	✓	HOLD
7				QAQC	QC03 23/5/18	23/5/18		2		✓	✓					✓	HOLD
→					QC04 23/5/18	23/5/18		2		please send		to	eurofins			✓	HOLD
8					QC01 22/5/18	22/5/18		N		✓	✓	HOLD	HOLD	HOLD	HOLD	HOLD	HOLD
9					QC02 22/5/18	22/5/18		N		HOLD	HOLD	HOLD	HOLD	HOLD	HOLD	HOLD	HOLD
																	HOLD
																	HOLD
																	HOLD
																	HOLD
																	HOLD
									TOTAL								

Custody Seal?	Y N NA	RELINQUISHED BY: SYLVIA B	CHE
Samples Cold?	Y N NA	DATE: 24/5/18	
Comments:		RECEIVED BY:	
		DATE:	

…RVATIVE CODES

d Preserved; C = Sodium Hydroxide Preserved; J = Solvent Washed Acid Rinsed Jar

ss Bottle; VC = Hydrochloric Acid Preserved Vial; VS Sulphuric Acid Preserved Glass Bottle;

= EDTA Preserved Bottle; ST = Sterile Bottle; O = Other

Forwarded to Secondary Lab

Initials NP **Date** 25/5

Environmental Division
Melbourne
Work Order Reference
EM1808546

Telephone : + 61-3-8549 9600

Recieved by: Nisqla (ALS) 11:15 25/5/18

2 of 2
(please report both pages as one lab batch)

AECOM PROJECT - CHAIN OF CUSTODY

PAGE _1_ OF _1_

CLIENT:	AECOM Services	LABORATORY:	ALS
ADDRESS:	Level 28, 91 King William St Adelaide SA 5000	ADDRESS:	2-4 Westall Rd Springvale Vic, 3171
PHONE NO:	08 7100 6400	PHONE NO:	03 8549 9600
FAX NO:	08 7223 5499	FAX NO:	
PROJECT NAME:	NRWMF Site Characterisation	PROJECT MANAGER:	melinda.morris@aecom.com 0408 387 495
PROJECT NO:	60565376.4.0	SAMPLERS:	SYLVIA B

SIGNED: SB

All results to be provided in ESDAT format.
email address: adelaide@urscorp.com
melinda.morris@aecom.com
Quote Number:

FOR LABORATORY USE ONLY

COMMENTS: SPECIAL HANDLING/STORAGE

UPDATED COC BY MELINDA 17/05/18

Please forward QC field duplicates to ALS Sydney

ANALYSIS REQUIRED

LAB ID	SITE	LOCATION	MATRIX	SAMPLE TYPE	SAMPLE ID	Date	CONTAINER TYPE AND PRESERVATIVE	FIELD FILTERED?	TOTAL NUMBER OF CONTAINERS	pH, Electrical Conductivity, Major Anions & Cations, Si & Alkalinity & Iodine & Bromine & Fluorine – 500ml Green	Dissolved Metals – NEPM 15 (W-3) + Li, Sr, Th, U – 60ml Red/Green bottle (Field Filtered)	Dissolved Nitrate (as N) - 60ml Purple 2 day holding time	Dissolved Organic ~~Carbon – 40ml~~ Purple Vial (Field Filtered)	Total Metals (Fe, Mn) – 60ml Red/Green unfiltered	Dissolved Sulfide – 125ml Yellow	Gross alpha and Gross beta - 1 L Red/Green unpreserved	TRH/BTEXN/PAH/Phenols (W-24) + OC and OP (W-12) - 100ml Amber + 40 ml vials
10	NAPANDEE	KIMBA	W	PRIMARY	N01 23/5/18	23/5/18	P,VS,C,S	2	10	✓	✓	✓	✓	✓	✓	✓	HOLD
11	↓	↓	↓	↓	N02 23/5/18	↓	↓	↓	↓	✓	✓	✓	✓	✓	✓	✓	HOLD
12					N03 23/5/18					✓	✓	✓	✓	✓	✓	✓	HOLD
13					N04 23/5/18					✓	✓	✓	✓	✓	✓	✓	HOLD
14					N05S 23/5/18					✓	✓	✓	✓	✓	✓	✓	HOLD
15					N05D 23/5/18					✓	✓	HOLD →					HOLD
16				QAQC	QC05 23/5/18			N		✓	✓	HOLD →					HOLD
17				QAQC	QC06 23/5/18			N		HOLD →							HOLD
																	HOLD
																	HOLD
																	HOLD
																	HOLD
																	HOLD
																	HOLD
																	HOLD
								TOTAL:									

Custody Seal ? Y N NA	RELINQUISHED BY: SYLVIA B.	CHECKED:		CONTAINER TYPE AND PRESERVATIVE CODES
Samples Cold ? Y N NA	DATE: 24/5/18	TIME:		P = Natural Plastic; N = Nitric Acid Preserved; C = Sodium Hydroxide Preserved; J = Solvent Washed Acid Rinsed Jar
Comments:	RECEIVED BY:	CHECKED:		S = Solvent Washed Acid Rinsed Glass Bottle; VC = Hydrochloric Acid Preserved Vial; VS Sulphuric Acid Preserved Glass Bottle;
	DATE:	TIME:		Z = Zinc acetate Preserved Bottle; E = EDTA Preserved Bottle; ST = Sterile Bottle; O = Other

Recieved by ~~Nicole~~ [ALS] 11.15
25/5/18

1

NP 2575

FREIGHT

1 of 2
(please report only one lab batch for both pages)

AECOM PROJECT - CHAIN OF CUSTODY

PAGE _1_ OF _1_

CLIENT:	AECOM Services	LABORATORY:	ALS
ADDRESS:	Level 28, 91 King William St Adelaide SA 5000	ADDRESS:	2-4 Westall Rd Springvale Vic, 3171
PHONE NO:	08 7100 6400	PHONE NO:	03 8549 9600
FAX NO:	08 7223 5499	FAX NO:	
PROJECT NAME:	NRWMF Site Characterisation	PROJECT MANAGER:	melinda.morris@aecom.com 0408 387 495
PROJECT NO:	60565376.4.0	SAMPLERS:	SYLVIA B.

All results to be provided in ESDAT format.
email address: adelaide@urscorp.com
melinda.morris@aecom.com
Quote Number:

SIGNED: [signature]

FOR LABORATORY USE ONLY

COMMENTS: SPECIAL HANDLING/STORAGE

UPDATED COC BY MELINDA 17/05/18

Please forward QC field duplicates to ALS Sydney

ANALYSIS REQUIRED

LAB ID	SITE	LOCATION	MATRIX	SAMPLE TYPE	SAMPLE ID		Date	CONTAINER TYPE AND PRESERVATIVE	FIELD FILTERED?	TOTAL NUMBER OF CONTAINERS	pH, Electrical Conductivity, Major Anions & Cations, Si & Alkalinity & Iodine & Bromine & Fluorine - 500ml Green	Dissolved Metals – NEPM 15 (W-3) + Li, Sr, Th, U – 60ml Red/Green bottle (Field Filtered)	Dissolved Nitrate (as N) - 60ml Purple 2 day holding time	Dissolved Organic Carbon – 40ml Purple Vial (Field Filtered)	Total Metals (Fe, Mn) – 60ml Red/Green unfiltered	Dissolved Sulfide – 125ml Yellow	Gross alpha and Gross beta - 1 L Red/Green unpreserved	TRH/BTEXN/PAH/Phenols (W-24) + OC and OP (W-12) - 100ml Amber + 40 ml vials
1	LYNDHURST	KIMBA	W	PRIMARY	L01	22/5/18	22/5/18	P,VS,C S	4	10	✓	✓	✓	✓	✓	✓	✓	HOLD
2					L04	22/5/18	22/5/18		4		✓	✓	✓	✓	✓	✓	✓	HOLD
3					L02	23/5/18	23/5/18		2		✓	✓	✓	✓	✓	✓	✓	HOLD
4					L03	23/5/18	23/5/18		2		✓	✓	✓	✓	✓	✓	✓	HOLD
5					L05S	23/5/18	23/5/18		2		✓	✓	✓	✓	✓	✓	✓	HOLD
6					L05D	23/5/18	23/5/18		2		✓	✓	✓	✓	✓	✓	✓	HOLD
7				QAQC	QC03	23/5/18	23/5/18		2		✓	✓	✓	✓	✓	✓	✓	HOLD
→					QC04	23/5/18	23/5/18		2		please send	to	eurofins				✓	HOLD
8					QC01	22/5/18	22/5/18		N		✓	✓	HOLD	HOLD	HOLD	HOLD	HOLD	HOLD
9					QC02	22/5/18	22/5/18		N		HOLD	HOLD	HOLD	HOLD	HOLD	HOLD	HOLD	HOLD
																		HOLD
																		HOLD
																		HOLD
																		HOLD
																		HOLD
										TOTAL								

Custody Seal ? Y N NA
Samples Cold ? Y N NA
Comments:

RELINQUISHED BY: SYLVIA B
DATE: 24/5/18
RECEIVED BY:
DATE:

...RVATIVE CODES
...d Preserved; C = Sodium Hydroxide Preserved; J = Solvent Washed Acid Rinsed Jar
...ss Bottle; VC = Hydrochloric Acid Preserved Vial; VS Sulphuric Acid Preserved Glass Bottle;
... = EDTA Preserved Bottle; ST = Sterile Bottle; O = Other

Forwarded to Secondary Lab
Initials NP Date 25/5

Environmental Division
Melbourne
Work Order Reference
EM1808546

Telephone : + 61-3-8549 9600

Recieved by : Nisga (ALS) 11:15 25/5/18

SCANNED

NP 2875

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30 years Testing For Life 1987–2017
Celebrating 30 years Testing and Protecting Human Health

Certificate of Analysis

AECOM Services P/L (fmly URS Aus P/L) SA
Level 28, 91 King William St
Adelaide
SA 5000

NATA Accredited
Accreditation Number 1261
Site Number 1254

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: **Melinda Morris**

Report	**600238-W**
Project name	NRWMF SITE CLASSIFICATION
Project ID	60565376.4.0
Received Date	May 25, 2018

Client Sample ID			**QC04_23/5/18**
Sample Matrix			**Water**
Eurofins | mgt Sample No.			**M18-My34071**
Date Sampled			**May 23, 2018**
Test/Reference	LOR	Unit	
Ammonia (as N)	0.01	mg/L	0.24
Chloride	1	mg/L	17000
Chromium (hexavalent)	0.001	mg/L	< 0.001
Chromium (trivalent filtered)	0.001	mg/L	0.008
Conductivity (at 25°C)	1	uS/cm	48000
Dissolved Organic Carbon	5	mg/L	< 5
Fluoride	0.5	mg/L	< 0.5
Nitrate (as N)	0.02	mg/L	0.14
pH (at 25°C)	0.1	pH Units	4.1
Sulphate (as SO4)	5	mg/L	1300
Sulphide (as S)	0.05	mg/L	< 0.05
Silicon (filtered)	0.5	mg/L	27
Radioactivity - gross Alpha & Beta			see attached
Bromine*	1	mg/L	see attached
Iodine*			see attached
Alkalinity (speciated)			
Bicarbonate Alkalinity (as CaCO3)	20	mg/L	< 20
Carbonate Alkalinity (as CaCO3)	10	mg/L	< 10
Total Alkalinity (as CaCO3)	20	mg/L	< 20
Heavy Metals			
Arsenic (filtered)	0.001	mg/L	0.002
Barium (filtered)	0.02	mg/L	0.31
Beryllium (filtered)	0.001	mg/L	0.003
Boron (filtered)	0.05	mg/L	2.0
Cadmium (filtered)	0.0002	mg/L	0.0019
Chromium (filtered)	0.001	mg/L	0.008
Cobalt (filtered)	0.001	mg/L	0.050
Copper (filtered)	0.001	mg/L	0.005
Iron	0.05	mg/L	6.4
Lead (filtered)	0.001	mg/L	0.014
Lithium (filtered)	0.005	mg/L	0.045
Manganese	0.005	mg/L	1.0
Manganese (filtered)	0.005	mg/L	0.91
Mercury (filtered)	0.0001	mg/L	< 0.0001
Nickel (filtered)	0.001	mg/L	0.068

eurofins | mgt

Client Sample ID			QC04_23/5/18
Sample Matrix			Water
Eurofins | mgt Sample No.			M18-My34071
Date Sampled			May 23, 2018
Test/Reference	LOR	Unit	
Heavy Metals			
Strontium (filtered)	0.005	mg/L	2.7
Thorium (filtered)*	0.001	mg/L	0.20
Uranium (filtered)	0.005	mg/L	< 0.005
Vanadium (filtered)	0.005	mg/L	< 0.005
Zinc (filtered)	0.005	mg/L	0.12
Alkali Metals			
Calcium	0.5	mg/L	120
Magnesium	0.5	mg/L	870
Potassium	0.5	mg/L	120
Sodium	0.5	mg/L	9600

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 (regarding both quality and NATA accreditation).

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
Eurofins | mgt Suite B11			
Ammonia (as N)	Melbourne	May 29, 2018	28 Day
- Method: APHA 4500-NH3 Ammonia Nitrogen by FIA			
Chloride	Melbourne	May 29, 2018	28 Day
- Method: LTM-INO-4090 Chloride by Discrete Analyser			
Nitrate (as N)	Melbourne	May 29, 2018	28 Day
- Method: APHA 4500-NO3 Nitrate Nitrogen by FIA			
Sulphate (as SO4)	Melbourne	May 29, 2018	28 Day
- Method: LTM-INO-4110 Sulfate by Discrete Analyser			
Alkalinity (speciated)	Melbourne	May 29, 2018	14 Day
- Method: APHA 2320 Alkalinity by Titration			
Alkali Metals	Melbourne	May 29, 2018	180 Day
- Method: USEPA 6010 Alkali Metals			
Chromium (hexavalent)	Melbourne	May 29, 2018	28 Day
- Method: Cr (VI) by MGT 1170A			
Heavy Metals (filtered)	Melbourne	May 29, 2018	180 Day
- Method: LTM-MET-3040 Metals in Waters, Soils & Sediments by ICP-MS			
Mobil Metals : Metals M15	Melbourne	May 29, 2018	28 Day
- Method: LTM-MET-3040 Metals in Waters, Soils & Sediments by ICP-MS			
Conductivity (at 25°C)	Melbourne	May 29, 2018	28 Day
- Method: LTM-INO-4030 Conductivity			
Dissolved Organic Carbon	Melbourne	May 30, 2018	28 Day
- Method: APHA 5310B Dissolved Organic Carbon			
Fluoride	Melbourne	May 29, 2018	28 Day
- Method: APHA 4500 F-C Fluoride by Ion Selective Electrode			
pH (at 25°C)	Melbourne	May 29, 2018	0 Hours
- Method: LTM-GEN-7090 pH in water by ISE			
Sulphide (as S)	Melbourne	May 29, 2018	7 Day
- Method: APHA 4500-S C & D - Sulphide			
Silicon (filtered)	Melbourne	May 29, 2018	28 Day
- Method: LTM-MET-3040 Metals in Waters, Soils & Sediments by ICP-MS			
Heavy Metals	Melbourne	May 29, 2018	180 Day
- Method: LTM-MET-3040 Metals in Waters, Soils & Sediments by ICP-MS			
Thorium (filtered)*	Melbourne	May 29, 2018	0 Day
- Method: LTM-MET-3040 Metals in Waters, Soils & Sediments by ICP-MS			

eurofins mgt

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web : www.eurofins.com.au

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2-5 Kingston Town Close
Oakleigh VIC 3166
Phone : +61 3 8564 5000
NATA # 1261
Site # 1254 & 14271

Sydney
Unit F3, Building F
16 Mars Road
Lane Cove West NSW 2066
Phone : +61 2 9900 8400
NATA # 1261 Site # 18217

Brisbane
1/21 Smallwood Place
Murarrie QLD 4172
Phone : +61 7 3902 4600
NATA # 1261 Site # 20794

Perth
2/91 Leach Highway
Kewdale WA 6105
Phone : +61 8 9251 9600
NATA # 1261
Site # 23736

Company Name: AECOM Aust Pty Ltd South Australia
Address: Level 28/91 King William Street
Adelaide
SA 5000

Project Name: NRWMF SITE CLASSIFICATION
Project ID: 60565376.4.0

Order No.:
Report #: 600238
Phone: 08 7100 6400
Fax: 08 7100 6499

Received: May 25, 2018 5:28 PM
Due: Jun 1, 2018
Priority: 5 Day
Contact Name: Melinda Morris

Eurofins | mgt Analytical Services Manager : Natalie Krasselt

Sample Detail						Bromine*	Conductivity (at 25°C)	Dissolved Organic Carbon	Fluoride	Gross Alpha and Beta (with K-40 correction)	Iodine*	Iron	Lithium (filtered)	Manganese	pH (at 25°C)	Silicon (filtered)	Strontium (filtered)	Sulphide (as S)	Thorium (filtered)*	Total Alkalinity (as CaCO3)	Uranium (filtered)	Eurofins | mgt Suite B11	NEPM 1999 Metals : Metals M15 (Filtered)
Melbourne Laboratory - NATA Site # 1254 & 14271							X	X	X			X	X	X	X	X	X	X	X	X	X	X	X
Sydney Laboratory - NATA Site # 18217																							
Brisbane Laboratory - NATA Site # 20794																							
Perth Laboratory - NATA Site # 23736																							
External Laboratory						X				X	X												
No	**Sample ID**	**Sample Date**	**Sampling Time**	**Matrix**	**LAB ID**																		
1	QC04_23/5/18	May 23, 2018		Water	M18-My34071	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Test Counts						1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Internal Quality Control Review and Glossary

General

1. Laboratory QC results for Method Blanks, Duplicates, Matrix Spikes, and Laboratory Control Samples are included in this QC report where applicable. Additional QC data may be available on request.
2. All soil 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. 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	Quality Systems Manual ver 5.1 US Department of Defense
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 50-150%-Phenols & PFASs

PFAS field samples that contain surrogate recoveries in excess of the QC limit designated in QSM 5.1 where no positive PFAS results have been reported have been reviewed and no data was affected.

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							
Ammonia (as N)	mg/L	< 0.01			0.01	Pass	
Chloride	mg/L	< 1			1	Pass	
Chromium (hexavalent)	mg/L	< 0.001			0.001	Pass	
Fluoride	mg/L	< 0.5			0.5	Pass	
Nitrate (as N)	mg/L	< 0.02			0.02	Pass	
Sulphate (as SO4)	mg/L	< 5			5	Pass	
Sulphide (as S)	mg/L	< 0.05			0.05	Pass	
Method Blank							
Alkalinity (speciated)							
Bicarbonate Alkalinity (as CaCO3)	mg/L	< 20			20	Pass	
Carbonate Alkalinity (as CaCO3)	mg/L	< 10			10	Pass	
Total Alkalinity (as CaCO3)	mg/L	< 20			20	Pass	
Method Blank							
Heavy Metals							
Arsenic (filtered)	mg/L	< 0.001			0.001	Pass	
Barium (filtered)	mg/L	< 0.02			0.02	Pass	
Beryllium (filtered)	mg/L	< 0.001			0.001	Pass	
Boron (filtered)	mg/L	< 0.05			0.05	Pass	
Cadmium (filtered)	mg/L	< 0.0002			0.0002	Pass	
Chromium (filtered)	mg/L	< 0.001			0.001	Pass	
Cobalt (filtered)	mg/L	< 0.001			0.001	Pass	
Copper (filtered)	mg/L	< 0.001			0.001	Pass	
Lead (filtered)	mg/L	< 0.001			0.001	Pass	
Lithium (filtered)	mg/L	< 0.005			0.005	Pass	
Manganese (filtered)	mg/L	< 0.005			0.005	Pass	
Mercury (filtered)	mg/L	< 0.0001			0.0001	Pass	
Nickel (filtered)	mg/L	< 0.001			0.001	Pass	
Strontium (filtered)	mg/L	< 0.005			0.005	Pass	
Uranium (filtered)	mg/L	< 0.005			0.005	Pass	
Vanadium (filtered)	mg/L	< 0.005			0.005	Pass	
Zinc (filtered)	mg/L	< 0.005			0.005	Pass	
Method Blank							
Alkali Metals							
Calcium	mg/L	< 0.5			0.5	Pass	
Magnesium	mg/L	< 0.5			0.5	Pass	
Potassium	mg/L	< 0.5			0.5	Pass	
Sodium	mg/L	< 0.5			0.5	Pass	
LCS - % Recovery							
Ammonia (as N)	%	99			70-130	Pass	
Chloride	%	108			70-130	Pass	
Chromium (hexavalent)	%	98			70-130	Pass	
Fluoride	%	94			70-130	Pass	
Nitrate (as N)	%	103			70-130	Pass	
Sulphate (as SO4)	%	104			70-130	Pass	
Sulphide (as S)	%	102			70-130	Pass	
LCS - % Recovery							
Alkalinity (speciated)							
Bicarbonate Alkalinity (as CaCO3)	%	93			70-130	Pass	
Carbonate Alkalinity (as CaCO3)	%	91			70-130	Pass	
Total Alkalinity (as CaCO3)	%	100			70-130	Pass	
LCS - % Recovery							

Test	Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Code
Heavy Metals							
Arsenic (filtered)	%	88			80-120	Pass	
Boron (filtered)	%	111			80-120	Pass	
Cadmium (filtered)	%	91			80-120	Pass	
Chromium (filtered)	%	86			80-120	Pass	
Cobalt (filtered)	%	87			80-120	Pass	
Copper (filtered)	%	86			80-120	Pass	
Lead (filtered)	%	93			80-120	Pass	
Lithium (filtered)	%	99			70-130	Pass	
Manganese (filtered)	%	89			80-120	Pass	
Mercury (filtered)	%	92			70-130	Pass	
Nickel (filtered)	%	89			80-120	Pass	
Strontium (filtered)	%	89			80-120	Pass	
Thorium (filtered)*	%	102			70-130	Pass	
Uranium (filtered)	%	90			70-130	Pass	
Zinc (filtered)	%	89			80-120	Pass	
LCS - % Recovery							
Alkali Metals							
Calcium	%	102			70-130	Pass	
Magnesium	%	109			70-130	Pass	
Potassium	%	91			70-130	Pass	
Sodium	%	104			70-130	Pass	

Test	Lab Sample ID	QA Source	Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Code
Spike - % Recovery									
				Result 1					
Ammonia (as N)	M18-My36481	NCP	%	93			70-130	Pass	
Chloride	M18-My36274	NCP	%	103			70-130	Pass	
Chromium (hexavalent)	M18-My33246	NCP	%	110			70-130	Pass	
Nitrate (as N)	M18-My36481	NCP	%	99			70-130	Pass	
Sulphate (as SO4)	M18-My34153	NCP	%	59			70-130	Fail	Q08
Spike - % Recovery									
Alkalinity (speciated)				Result 1					
Carbonate Alkalinity (as CaCO3)	M18-My33248	NCP	%	71			70-130	Pass	
Total Alkalinity (as CaCO3)	M18-My36883	NCP	%	59			70-130	Fail	Q08
Spike - % Recovery									
Heavy Metals				Result 1					
Arsenic (filtered)	M18-My32051	NCP	%	93			70-130	Pass	
Barium (filtered)	M18-My32051	NCP	%	95			75-125	Pass	
Beryllium (filtered)	M18-My32051	NCP	%	93			75-125	Pass	
Boron (filtered)	M18-My33200	NCP	%	95			75-125	Pass	
Cadmium (filtered)	M18-My32051	NCP	%	81			70-130	Pass	
Chromium (filtered)	M18-My32051	NCP	%	83			70-130	Pass	
Cobalt (filtered)	M18-My32051	NCP	%	84			75-125	Pass	
Copper (filtered)	M18-My32051	NCP	%	79			70-130	Pass	
Lead (filtered)	M18-My32051	NCP	%	84			70-130	Pass	
Lithium (filtered)	M18-My32051	NCP	%	99			75-125	Pass	
Manganese (filtered)	M18-My32051	NCP	%	92			70-130	Pass	
Mercury (filtered)	M18-My32051	NCP	%	93			70-130	Pass	
Nickel (filtered)	M18-My32051	NCP	%	82			70-130	Pass	
Strontium (filtered)	M18-My32051	NCP	%	88			75-125	Pass	
Uranium (filtered)	M18-My32051	NCP	%	86			70-130	Pass	
Vanadium (filtered)	M18-My32051	NCP	%	91			75-125	Pass	
Zinc (filtered)	M18-My32051	NCP	%	85			70-130	Pass	
Spike - % Recovery									

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Test	Lab Sample ID	QA Source	Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Code
Alkali Metals				Result 1					
Calcium	M18-My33593	NCP	%	102			70-130	Pass	
Magnesium	M18-My33593	NCP	%	104			70-130	Pass	
Potassium	M18-My33593	NCP	%	94			70-130	Pass	
Sodium	M18-My33593	NCP	%	102			70-130	Pass	
Test	**Lab Sample ID**	**QA Source**	**Units**	**Result 1**			**Acceptance Limits**	**Pass Limits**	**Qualifying Code**
Duplicate									
				Result 1	Result 2	RPD			
Ammonia (as N)	M18-My36481	NCP	mg/L	0.38	0.37	2.0	30%	Pass	
Chloride	M18-My34153	NCP	mg/L	1600	1600	1.0	30%	Pass	
Chromium (hexavalent)	M18-My33246	NCP	mg/L	< 0.001	< 0.001	<1	30%	Pass	
Conductivity (at 25°C)	M18-My33247	NCP	uS/cm	2100	2000	1.0	30%	Pass	
Dissolved Organic Carbon	M18-My34071	CP	mg/L	< 5	< 5	<1	30%	Pass	
Fluoride	M18-My34071	CP	mg/L	< 0.5	< 0.5	<1	30%	Pass	
Nitrate (as N)	M18-My36481	NCP	mg/L	0.08	0.08	4.0	30%	Pass	
pH (at 25°C)	M18-My33247	NCP	pH Units	8.3	8.3	pass	30%	Pass	
Sulphate (as SO4)	M18-My34153	NCP	mg/L	200	200	2.0	30%	Pass	
Sulphide (as S)	M18-My37190	NCP	mg/L	< 0.05	< 0.05	<1	30%	Pass	
Duplicate									
Alkalinity (speciated)				Result 1	Result 2	RPD			
Bicarbonate Alkalinity (as CaCO3)	M18-My33247	NCP	mg/L	750	770	3.0	30%	Pass	
Carbonate Alkalinity (as CaCO3)	M18-My33247	NCP	mg/L	< 10	< 10	<1	30%	Pass	
Total Alkalinity (as CaCO3)	M18-My33247	NCP	mg/L	750	770	3.0	30%	Pass	
Duplicate									
Heavy Metals				Result 1	Result 2	RPD			
Arsenic (filtered)	M18-My32051	NCP	mg/L	< 0.001	< 0.001	<1	30%	Pass	
Barium (filtered)	M18-My32051	NCP	mg/L	0.04	0.04	3.0	30%	Pass	
Beryllium (filtered)	M18-My32051	NCP	mg/L	< 0.001	< 0.001	<1	30%	Pass	
Boron (filtered)	M18-My32051	NCP	mg/L	1.3	1.3	1.0	30%	Pass	
Cadmium (filtered)	M18-My32051	NCP	mg/L	< 0.0002	< 0.0002	<1	30%	Pass	
Chromium (filtered)	M18-My32051	NCP	mg/L	< 0.001	< 0.001	<1	30%	Pass	
Cobalt (filtered)	M18-My32051	NCP	mg/L	0.002	0.002	6.0	30%	Pass	
Copper (filtered)	M18-My32051	NCP	mg/L	< 0.001	< 0.001	<1	30%	Pass	
Iron	M18-My37537	NCP	mg/L	< 0.5	0.13	93	30%	Fail	Q15
Lead (filtered)	M18-My32051	NCP	mg/L	< 0.001	< 0.001	<1	30%	Pass	
Lithium (filtered)	M18-My32051	NCP	mg/L	0.015	0.014	<1	30%	Pass	
Manganese (filtered)	M18-My32051	NCP	mg/L	1.2	1.1	4.0	30%	Pass	
Mercury (filtered)	M18-My32051	NCP	mg/L	< 0.0001	< 0.0001	<1	30%	Pass	
Nickel (filtered)	M18-My32051	NCP	mg/L	0.039	0.037	6.0	30%	Pass	
Strontium (filtered)	M18-My32051	NCP	mg/L	2.1	2.0	5.0	30%	Pass	
Uranium (filtered)	M18-My32051	NCP	mg/L	< 0.005	< 0.005	<1	30%	Pass	
Vanadium (filtered)	M18-My32051	NCP	mg/L	< 0.005	< 0.005	<1	30%	Pass	
Zinc (filtered)	M18-My32051	NCP	mg/L	0.031	0.029	5.0	30%	Pass	
Duplicate									
Alkali Metals				Result 1	Result 2	RPD			
Calcium	M18-My33593	NCP	mg/L	57	58	1.0	30%	Pass	
Magnesium	M18-My33593	NCP	mg/L	6.2	6.0	3.0	30%	Pass	
Potassium	M18-My33593	NCP	mg/L	54	53	<1	30%	Pass	
Sodium	M18-My36175	NCP	mg/L	1600	1500	2.0	30%	Pass	

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Comments

Bromine and Iodine analysed by: ACS Laboratories (Australia), report reference: ACS1817067

Gross Alpha/Beta Radiation: Eurofins | Eaton Analytical, NELAP accreditation number 01114CA, ISO17025 accredited, report reference 740885

Sample Integrity

Custody Seals Intact (if used)	N/A
Attempt to Chill was evident	No
Sample correctly preserved	Yes
Appropriate sample containers have been used	Yes
Sample containers for volatile analysis received with minimal headspace	Yes
Samples received within HoldingTime	Yes
Some samples have been subcontracted	Yes

Qualifier Codes/Comments

Code	Description
Q08	The matrix spike recovery is outside of the recommended acceptance criteria. An acceptable recovery was obtained for the laboratory control sample indicating a sample matrix interference
Q15	The RPD reported passes Eurofins | mgt's QC - Acceptance Criteria as defined in the Internal Quality Control Review and Glossary page of this report.

Authorised By

Natalie Krasselt	Analytical Services Manager
Alex Petridis	Senior Analyst-Metal (VIC)
Michael Brancati	Senior Analyst-Inorganic (VIC)

Glenn Jackson
National Operations 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.

750 Royal Oaks Drive, Suite 100
Monrovia, California 91016-3629
Tel: (626) 386-1100
Fax: (866) 988-3757
1 800 566 LABS (1 800 566 5227)

AT-1807

Laboratory Report

for

Eurofins-Mgt
2-5 Kingston Town Close
Oakleigh, VIC 3166
Attention: Tammy Lakeland

Utah ELCP CA00006

Date of Issue
06/13/2018

EUROFINS EATON
ANALYTICAL, LLC

Report: 740885
Project: SUBCONTRACT
Group: Radiochemistry w/Potassium

DST: David S Tripp

Project Manager

* Accredited in accordance with TNI 2009 and ISO/IEC 17025:2005.
* Laboratory certifies that the test results meet all **TNI 2009 and ISO/IEC 17025:2005** requirements unless noted under the individual analysis.
* Following the cover page are State Certification List, ISO 17025 Accredited Method List, Acknowledgement of Samples Received, Comments, Hits Report, Data Report, QC Summary, QC Report and Regulatory Forms, as applicable.
* Test results relate only to the sample(s) tested.

STATE CERTIFICATION LIST

State	Certification Number	State	Certification Number
Alabama	41060	**Mississippi**	Certified
Arizona	AZ0778	**Montana**	Cert 0035
Arkansas	Certified	**Nebraska**	Certified
California-Monrovia-ELAP	2813	**Nevada**	CA000062018
California-Colton- ELAP	2812	**New Hampshire ***	2959
Colorado	Certified	**New Jersey ***	CA 008
Connecticut	PH-0107	**New Mexico**	Certified
Delaware	CA 006	**New York ***	11320
Florida *	E871024	**North Carolina**	06701
Georgia	947	**North Dakota**	R-009
Guam	18-005R	**Oregon ***	CA200003-005
Hawaii	Certified	**Pennsylvania ***	68-565
Idaho	Certified	**Puerto Rico**	Certified
Illinois *	200033	**Rhode Island**	LAO00326
Indiana	C-CA-01	**South Carolina**	87016
Iowa - Asbestos	413	**South Dakota**	Certified
Kansas *	E-10268	**Tennessee**	TN02839
Kentucky	90107	**Texas ***	T104704230-17-13
Louisiana *	LA180000	**Utah (Primary AB) ***	CA00006
Maine	CA0006	**Vermont**	VT0114
Maryland	224	**Virginia ***	460260
Commonwealth of Northern Marianas Is.	MP0004	**Washington**	C838
Massachusetts	M-CA006	**EPA Region 5**	Certified
Michigan	9906	**Los Angeles County Sanitation Districts**	10264

* NELAP/TNI Recognized Accreditation Bodies

Eurofins Eaton Analytical, LLC
750 Royal Oaks Drive, Suite 100
Monrovia, CA 91016-3629
T | 626-386-1100
F | 866-988-3757
www.EurofinsUS.com/Eaton

ISO 17025 Accredited Method List

The tests listed below are accredited and meet the requirements of ISO 17025 as verified by the ANSI-ASQ National Accreditation Board/ANAB.
Refer to Certificate and scope of accreditation (AT 1807) found at: http://www.eatonanalytical.com

SPECIFIC TESTS	METHOD OR TECHNIQUE USED	Environ-mental (Drinking Water)	Environ-mental (Waste Water)	Water as a Component of Food and Bev/Bev/ Bottled Water
1,4-Dioxane	EPA 522	x		x
2,3,7,8-TCDD	Modified EPA 1613B	x		x
Acrylamide	In House Method (2440)	x		x
Alkalinity	SM 2320B	x	x	x
Ammonia	EPA 350.1		x	x
Ammonia	SM 4500-NH3 H		x	x
Anions and DBPs by IC	EPA 300.0	x	x	x
Anions and DBPs by IC	EPA 300.1	x		x
Asbestos	EPA 100.2	x	x	
Bicarbonate Alkalinity as HCO3	SM 2320B	x	x	x
BOD / CBOD	SM 5210B		x	x
Bromate	In House Method (2447)	x		x
Carbamates	EPA 531.2	x		x
Carbonate as CO3	SM 2330B	x	x	x
Carbonyls	EPA 556	x		x
COD	EPA 410.4 / SM 5220D		x	
Chloramines	SM 4500-CL G	x	x	x
Chlorinated Acids	EPA 515.4	x		x
Chlorinated Acids	EPA 555	x		x
Chlorine Dioxide	SM 4500-CLO2 D	x		x
Chlorine -Total/Free/ Combined Residual	SM 4500-Cl G	x	x	x
Conductivity	EPA 120.1		x	
Conductivity	SM 2510B	x	x	x
Corrosivity (Langelier Index)	SM 2330B	x		x
Cryptosporidium	EPA 1623	x		x
Cyanide, Amenable	SM 4500-CN G	x	x	
Cyanide, Free	SM 4500CN F	x	x	x
Cyanide, Total	EPA 335.4	x	x	x
Cyanogen Chloride (screen)	In House Method (2470)	x		x
Diquat and Paraquat	EPA 549.2	x		x
DBP/HAA	SM 6251B	x		x
Dissolved Oxygen	SM 4500-O G		x	x
DOC	SM 5310C	x		x
E. Coli	(MTF/EC+MUG)	x		x
E. Coli	CFR 141.21(f)(6)(i)	x		x
E. Coli	SM 9223		x	
E. Coli (Enumeration)	SM 9221B.1/ SM 9221F	x		x
E. Coli (Enumeration)	SM 9223B	x		x
EDB/DCBP	EPA 504.1	x		
EDB/DBCP and DBP	EPA 551.1	x		x
EDTA and NTA	In House Method (2454)	x		x
Endothall	EPA 548.1	x		x
Endothall	In-house Method (2445)	x		x
Enterococci	SM 9230B	x	x	
Fecal Coliform	SM 9221 E (MTF/EC)	x		
Fecal Coliform	SM 9221C, E (MTF/EC)		x	
Fecal Coliform (Enumeration)	SM 9221E (MTF/EC)	x		x
Fecal Coliform with Chlorine Present	SM 9221E		x	
Fecal Streptococci	SM 9230B	x	x	
Fluoride	SM 4500-F C	x	x	x
Giardia	EPA 1623	x		x
Glyphosate	EPA 547	x		x
Gross Alpha/Beta	EPA 900.0	x	x	x
Gross Alpha Coprecipitation	SM 7110 C	x	x	x
Hardness	SM 2340B	x	x	x
Heterotrophic Bacteria	In House Method (2439)	x		x
Heterotrophic Bacteria	SM 9215 B	x		x
Hexavalent Chromium	EPA 218.6	x	x	x

SPECIFIC TESTS	METHOD OR TECHNIQUE USED	Environ-mental (Drinking Water)	Environ-mental (Waste Water)	Water as a Component of Food and Bev/Bev/ Bottled Water
Hexavalent Chromium	EPA 218.7	x		x
Hexavalent Chromium	SM 3500-Cr B		x	
Hormones	EPA 539	x		x
Hydroxide as OH Calc.	SM 2330B	x		x
Kjeldahl Nitrogen	EPA 351.2		x	
Legionella	CDC Legionella	x		x
Mercury	EPA 245.1	x	x	x
Metals	EPA 200.7 / 200.8	x	x	x
Microcystin LR	ELISA (2360)	x		x
NDMA	EPA 521	x		x
NDMA	TQ In house method based on EPA 521 (2425)	x		x
Nitrate/Nitrite Nitrogen	EPA 353.2	x	x	x
OCL, Pesticides/PCB	EPA 505	x		x
Ortho Phosphate	EPA 365.1	x	x	x
Ortho Phosphate	SM 4500P E			x
Ortho Phosphorous	SM 4500P E	x		
Oxyhalides Disinfection Byproducts	EPA 317.0	x		x
Perchlorate	EPA 331.0	x		x
Perchlorate (low and high)	EPA 314.0	x		x
Perfluorinated Alkyl Acids	EPA 537	x		x
pH	EPA 150.1	x		
pH	SM 4500-H+B	x	x	x
Phenylurea Pesticides/ Herbicides	In House Method, based on EPA 532 (2448)	x		x
Pseudomonas	IDEXX Pseudalert (2461)	x		x
Radium-226	GA Institute of Tech	x		x
Radium-228	GA Institute of Tech	x		x
Radon-222	SM 7500RN	x		x
Residue, Filterable	SM 2540C	x	x	x
Residue, Non-filterable	SM 2540D		x	
Residue, Total	SM 2540B		x	x
Residue, Volatile	EPA 160.4		x	
Semi-VOC	EPA 525.2	x		x
Semi-VOC	EPA 625		x	x
Silica	SM 4500-Si D	x	x	
Silica	SM 4500-SiO2 C	x	x	
Sulfide	SM 4500-S$^{=}$ D		x	
Sulfite	SM 4500-SO^{3}B	x	x	x
Surfactants	SM 5540C	x	x	x
Taste and Odor Analytes	SM 6040E	x		x
Total Coliform (P/A)	SM 9221 A, B	x		x
Total Coliform (Enumeration)	SM 9221 A, B, C	x		x
Total Coliform / E. coli	Colisure SM 9223	x		x
Total Coliform	SM 9221B		x	
Total Coliform with Chlorine Present	SM 9221B		x	
Total Coliform / E.coli (P/A and Enumeration)	SM 9223	x		x
TOC	SM 5310C	x	x	x
TOX	SM 5320B		x	
Total Phenols	EPA 420.1		x	
Total Phenols	EPA 420.4	x	x	x
Total Phosphorous	SM 4500 P E		x	
Turbidity	EPA 180.1	x	x	x
Turbidity	SM 2130B	x	x	
Uranium by ICP/MS	EPA 200.8	x		x
UV 254	SM 5910B	x		
VOC	EPA 524.2/EPA 524.3	x		x
VOC	EPA 624		x	x
VOC	EPA SW 846 8260	x		x
VOC	In House Method (2411)	x		x
Yeast and Mold	SM 9610	x		x

Eurofins Eaton Analytical

Acknowledgement of Samples Received

Addr: **Eurofins-Mgt**
2-5 Kingston Town Close
OakleighVIC 3166

Client ID: EUROFINS-MGT
Folder #: 740885
Project: SUBCONTRACT
Sample Group: Radiochemistry w/Potassium

Attn: Tammy Lakeland
Phone: +61 3 8564 5000

Project Manager: David S Tripp
Phone: (626) 386-1158
PO #: 600238

The following samples were received from you on **May 30, 2018** at **1205**. They have been scheduled for the tests listed below each sample. If this information is incorrect, please contact your service representative. Thank you for using Eurofins Eaton Analytical, LLC.

Sample #	Sample ID	Sample Date
201805300363	M18-My34071	05/23/2018 0800

Variable ID: QC04_23/5/18

@BETA	Corrected Gross Beta	Gross Alpha by Co-precipitation
Potassium Total ICAP	Wire Fee	

Test Description

@BETA -- Gross Alpha/Beta Radiation

740885

eurofins | mgt

ABN 50 005 085 521

☒ MELBOURNE
Ph: +61 3 8564 5000
2-5 Kingston Town Close, Oakleigh, Vic 3184
Email: EnviroSampleVic@eurofins.com

☐ BRISBANE
Ph: +61 7 3902 4600
1/21 Smallwood Place Murarrie, Qld 4172
Email: EnviroSampleQLD@eurofins.com

☐ SYDNEY
Ph: +61 2 9900 8400
Unit F3, 16 Mars Road, Lane Cove West, NSW 2066
Email: EnviroSampleNSW@eurofins.com

☐ PERTH
Ph: +61 8 92519692
2/91 Leach Highway, Kewdale, WA 6027
Email: EnviroSampleWA@eurofins.com

Purchase Order for External Analysis

Eurofins | mgt Ref: 600238 **Eurofins | mgt Purchase Order:** 18-0221 600238 **Results Required:** STD

Receiving Laboratory: Eurofins Eaton Analytical California **Eurofins | mgt Contact:** Natalie Krasselt

Address: 750 Royal Oaks Dr#100
Monrovia CA 91016 United States

Telephone: +1 626-386-1100 **Fax:**

Report results to: EnviroReportsAU@eurofins.com ☒
Eurofins | mgt, P.O. Box 276, Oakleigh, Vic 3166, Australia ☐
Send invoices to: EnviroAP@eurofins.com ☒

Client ID	Eurofins | mgt ID	Matrix	Tests Required	Sampling Date	Comments
QC04_23/5/18	M18-My34071	Water	Radioactivity – Gross Alpha & Beta with Potassium 40 correction	23/5/18	

Total No. Samples: 1

Note: Please identify samples using Eurofins | mgt ID and Client ID

Chain of Custody

Relinquished by: Catherine Wilson Date/Time: 28/05/18
Received by: Mike Tibbitts Date/Time: 5/30/18 1205
Relinquished by: Date/Time:
Received by: Date/Time:

***Sample Receipt Advice** (Receiving Lab Use Only)*

All Samples Received in Good Condition ☐
All Documentation in Proper Order ☐
Samples Received with an Attempt to Chill ☐
Samples Received Within Holding Times ☐

Average sample temp on receipt: (°C)

For all enquires please quote Ref. No.

Please complete this section and email a scan copy to EnviroReportsAU@eurofins.com

Last modified on: 06 April 2017	Approved on: 06 April 2017	Version: QS3023_R5
Last modified by: C. Hasan	Approver: T. Lakeland	Page 1 of 1
Editorial Committee: Fran Sanjaya, Dr. Bob Symons, Cassie Hasan, Tammy Lakeland		Next required review date: 06 April 2020

eurofins | Eaton Analytical

INTERNAL CHAIN OF CUSTODY RECORD

EEA Folder Number: 740885

SAMPLE TEMP RECEIVED:

Note: If samples are out of temperature range, let the ASMs know. ASMs will determine whether to proceed with analysis or not.

SAMPLES REC'D DAY OF COLLECTION? Yes / No

IR Gun ID = 631 (Observation= 19.7 °C) (Corr.Factor -0.1 °C) (Final = 19.6 °C)

TYPE OF ICE: Real ____ Synthetic X No Ice ____ **CONDITION OF ICE:** Frozen ____ Partially Frozen ____ Thawed X N/A ____

METHOD OF SHIPMENT: Pick-Up / Walk-In / FedEx / UPS / DHL / Area Fast / Top Line / Other: ____________

Compliance Acceptance Criteria:

1) **Chemistry:** >0, ≤ 6°C, not frozen (NELAP) (if received after 24 hrs of sample collection)

2) **Microbiology, Distribution:** < 10°C, not frozen (can be ≥10°C if received on ice the same day as sample collection, within 8 hours)

3) **Microbiology, Surface Water:** < 10°C (if received after 2 hours of sample collection)

If out of temperature range for both Chemistry and Microbiology samples and temperature does not confirm, then measure the temperature of each quadrant and record each temperature of the quadrants

1 = (Observation= ____ °C) (Corr.Factor ____ °C) (Final = ____ °C)	2 = (Observation= ____ °C) (Corr.Factor ____ °C) (Final = ____ °C)
3 = (Observation= ____ °C) (Corr.Factor ____ °C) (Final = ____ °C)	4 = (Observation= ____ °C) (Corr.Factor ____ °C) (Final = ____ °C)

4 **Dioxin (1613 or 2,3,7,8 TCDD):** must be between 0-4 °C, not frozen (if received after 24 hrs of sample collection)

5) **pH Check.** Manufacturer: ____________ Lot Number: ________ pH strip type: 0 - 14 or ________ Expiration Date ________ Results: __

6) **Chlorine check.** Manufacturer: Sansafe. Lot No.: ________ Expiration Date: ________ Results ____________

7) **VOA Headspace:** **No Samples with Headspace:** ☐ **Samples with Headspace (see below):** ☐

Headspace Documentation (use additional VOC Internal COFC for additional bottles)

Exempt from headspace concerns: Methods 515.4, HAA(6251,552), 505, SPME, @CH, 532LCMS, 556, 536, Anatoxin, LCMS methods using 40 ml vials, International clients:

Samp ID	Bottle #	None/<6 mm	>6mm	Samp ID	Bottle #	None/<6 mm	>6mm	Samp ID	Bottle #	None/<6 mm	>6mm	Samp ID	Bottle #	None/<6 mm	>6mm

Note Sample IDs which have dissimilar headspace (i.e. potential sampling errors): ____________________

RECEIVED BY: SIGNATURE	PRINT NAME	COMPANY/TITLE	DATE	TIME
[signature]	Mark Tibbitts	Eurofins Eaton Analytical	5/30/18	1205

QA FO 0083.7 (QA FO-FRM5504) (5/23/18) Ver 7

eurofins | mgt

Name	Canh To
Company	Eurofins | mgt
Street	2-5 Kingston Town Close
Town	Oakleigh VIC 3166
Country	Australia

28 May 2018

EXPORT DECLARATION

Dear Sir/Madam,

We hereby certify that the samples exported from Australia:

- Are not radioactive
- Are not hazardous
- Sending to check for contamination
- Non-food article

The samples were shipped:

From: Eurofins | mgt, 5 Kingston Town Close, Oakleigh, VIC 3166, Australia

To: Eurofins Eaton Analytical California, 750 Royal Oaks Dr#100, Monrovia CA 91016 USA

Value for customs purposes - $25

Yours sincerely,

Canh To
-Sample receipt officer
-Laboratory Technician

Commercial Invoice

Shipper:
Eurofins Mgt Environmental Testing AUS
Mr Canh To
2-5 Kingston Town Close Oakleigh
Victoria - 3166 Australia

Oakleigh 3166 Australia

Phone: +6161385645045
VAT/GST No:

Receiver:
EUROFINS EATON ANALYTICAL CALIFORNIA
Mr ANDY EATON
750 ROYAL OAKS DR#100
MONROVIA CA 91016
USA
MONROVIA CA 91016 United States Of America

Phone: +116263861100
VAT/GST No:

Date: 2018-05-28

Invoice Number:

Shipment Reference:

Bill To Third Party:

Comments:

Airway Bill Number:

9901518815

	Full Description of Goods	QTY	UOM	Commodity Code	Unit Value	Subtotal Value	Unit Net Weight	Subtotal Weight	Origin
1	Environmental water samples for laboratory testing	1	N/A		25	25	3	3	Australia

Total Declared Value:	25	AUD	Total Net Weight:	3.0	kg
Total Pieces:	1		Total Gross Weight:	4	kg

Payer of GST/VAT: Receiver (No:)
Type of Export: Permanent
Terms of Payment:

Currency Code: AUD
Incoterm: DAP - Delivered At Place

I/We hereby certify that the information of this invoice is true and correct and that the contents of this shipment are as stated above.

Signature: CATo

Position in Company:

Shipping Consultant

Company Stamp:

eurofins | mgt

COMMERCIAL INVOICE/PROFORMA INVOICE

Ship to:	EUROFINS EATON ANALYTICAL CALIFORNIA	Date:	28 May 2018
Address:	750 ROYAL OAKS DR#100	Air Waybill No.:	
	MONROVIA CA 91016	Carrier:	DHL EXPRESS: 9901518815
	USA	Dimensions in cm	23 x 29 x 30cm
		No. of Pieces:	1
		Total Weight:	4 kg
Contact Name:	ANDY EATON	Phone:	+49 40 69 70 96 0
		Fax:	+49 40 69 70 96 99

Full Description of Goods	No. of Items	Unit Value (AUS $)	Total Value (AUS $)
Samples for analytical analysis	1	25	25
-Non Hazardous			
-Non restricted article			
-Non food article			
Glass jars			
Non radioactive			
Water Sample shipped under S.P. A197			
		Total Invoice Value	25

Name and Address of Manufacturer: EUROFINS ENVIRONMENT TESTING AUSTRALIA PTY LTD
2-5 KINGSTON TOWN CLOSE
OAKLEIGH VICTORIA 3166
Australia

Reason for Export: Samples for scientific analyses, not for sale or for human consumption
Harmonised Tariff: N/A
Authorization: N/A

I certify that the above information is correct and that in so far as any part of this consignment contains dangerous goods, such part is properly described by name and is in proper condition for carriage by air according to the IATA Dangerous Goods Regulations.

For and on behalf of the above named company.

Name (in print): Canh To

Contact Number: +61385645050

Signature CATo

Position Company SAMPLE RECEIPT OFFICER

EXPRESS WORLDWIDE **WPX** DHL

2018-05-28 DHL EmailShip 04.02.00 / *18-1407*

From : Eurofins Mgt Environmental Testing AUS
Mr Canh To
2-5 Kingston Town Close Oakleigh
Victoria - 3166 Australia
Oakleigh 3166
Australia

Origin:
MEL

Contact: Ph: +6161385645045

To : EUROFINS EATON ANALYTICAL CALIFORNIA
Mr ANDY EATON
750 ROYAL OAKS DR#100
MONROVIA CA 91016
USA

Contact Name:
Mr ANDY EATON
eMail:
Ph: +116263861100

MONROVIA CA 91016
United States Of America

US-ELA-ELA

C

Day	Time

Ref:

Pce/Shpt Weight	Piece
4.0 kg	**1 / 1**

Contents: Water samplesNon hazardousNon restricted article

WAYBILL 99 0151 8815

(2L)US91016+48000001

(J) JD01 4600 0056 3077 5804

eurofins | mgt

Name	Canh To
Company	Eurofins | mgt
Street	2-5 Kingston Town Close
Town	Oakleigh VIC 3166
Country	Australia

28 May 2018

EXPORT DECLARATION

Dear Sir/Madam,

We hereby certify that the samples exported from Australia:

- Are not radioactive
- Are not hazardous
- Sending to check for contamination
- Non-food article

The samples were shipped:

From: Eurofins | mgt, 5 Kingston Town Close, Oakleigh, VIC 3166, Australia

To: Eurofins Eaton Analytical California, 750 Royal Oaks Dr#100, Monrovia CA 91016 USA

Value for customs purposes - $25

Yours sincerely,

Canh To
-Sample receipt officer
-Laboratory Technician

Eurofins | mgt Laboratories :
Melbourne
Sydney
Brisbane

Melbourne Laboratory
2-5 Kingston Town Close
Oakleigh
Victoria 3166
Australia

T | +61 3 8564 5000
Offices :
Adelaide
Perth
Darwin
Newcastle

Shipper: Eurofins Mgt Environmental Testing AUS Mr Canh To 2-5 Kingston Town Close Oakleigh Victoria - 3166 Australia Oakleigh 3166 Australia Phone: +6161385645045 VAT/GST No:	# Commercial Invoice
Receiver: EUROFINS EATON ANALYTICAL CALIFORNIA Mr ANDY EATON 750 ROYAL OAKS DR#100 MONROVIA CA 91016 USA MONROVIA CA 91016 United States Of America Phone: +116263861100 VAT/GST No:	Date: 2018-05-28 Invoice Number: Shipment Reference:
Bill To Third Party:	Comments: Airway Bill Number: 9901518815

	Full Description of Goods	QTY	UOM	Commodity Code	Unit Value	Subtotal Value	Unit Net Weight	Subtotal Weight	Origin
1	Environmental water samples for laboratory testing	1	N/A		25	25	3	3	Australia

Total Declared Value:	25	AUD	Total Net Weight:	3.0	kg
Total Pieces:	1		Total Gross Weight:	4	kg

Payer of GST/VAT: Receiver (No:)
Type of Export: Permanent
Terms of Payment:

Currency Code: AUD
Incoterm: DAP - Delivered At Place

I/We hereby certify that the information of this invoice is true and correct and that the contents of this shipment are as stated above.

Signature:
Position in Company:
Shipping Consultant

Company Stamp:

eurofins

mgt

COMMERCIAL INVOICE/PROFORMA INVOICE

Ship to:	EUROFINS EATON ANALYTICAL CALIFORNIA	Date:	28 May 2018
Address:	750 ROYAL OAKS DR#100	Air Waybill No.:	
	MONROVIA CA 91016	Carrier:	DHL EXPRESS: 9901518815
	USA	Dimensions in cm	23 x 29 x 30cm
		No. of Pieces:	1
		Total Weight:	4 kg
Contact Name:	ANDY EATON	Phone:	+49 40 69 70 96 0
		Fax:	+49 40 69 70 96 99

Full Description of Goods	No. of Items	Unit Value (AUS $)	Total Value (AUS $)
Samples for analytical analysis	1	25	25
-Non Hazardous			
-Non restricted article			
-Non food article			
Glass jars			
Non radioactive			
Water Sample shipped under S.P. A197			
		Total Invoice Value	25

Name and Address of Manufacturer: EUROFINS ENVIRONMENT TESTING AUSTRALIA PTY LTD
2-5 KINGSTON TOWN CLOSE
OAKLEIGH VICTORIA 3166
Australia

Reason for Export: Samples for scientific analyses, not for sale or for human consumption
Harmonised Tariff: N/A
Authorization: N/A

I certify that the above information is correct and that in so far as any part of this consignment contains dangerous goods, such part is properly described by name and is in proper condition for carriage by air according to the IATA Dangerous Goods Regulations.

For and on behalf of the above named company.

Name (in print): Canh To

Contact Number: +61385645050

Signature

Position
Company SAMPLE RECEIPT OFFICER

eurofins | Eaton Analytical

Tel: (626) 386-1100
Fax: (866) 988-3757
1 800 566 LABS (1 800 566 5227)

Laboratory Comments

Report: 740885
Project: SUBCONTRACT
Group: Radiochemistry w/Potassium

Eurofins-Mgt
Tammy Lakeland
2-5 Kingston Town Close
Oakleigh, VIC 3166

The Comments Report may be blank if there are no comments for this report.

Laboratory Hits

Tel: (626) 386-1100
Fax: (866) 988-3757
1 800 566 LABS (1 800 566 5227)

Report: 740885
Project: SUBCONTRACT
Group: Radiochemistry w/Potassium

Eurofins-Mgt
Tammy Lakeland
2-5 Kingston Town Close
Oakleigh, VIC 3166

Samples Received on:
05/30/2018 1205

Analyzed	Analyte	Sample ID	Result	Federal MCL	Units	MRL
	201805300363	**M18-My34071**				
06/07/2018 15:02	Beta, Gross		2500		pCi/L	3
06/07/2018 19:59	Corrected Gross Beta		2300		pCi/L	3
06/10/2018 08:08	Gross Alpha + adjusted error		26		pCi/L	3
06/10/2018 08:08	Gross Alpha by Coprecipitation		26	15	pCi/L	3
06/04/2018 13:27	Potassium Total ICAP		190		mg/L	5

SUMMARY OF POSITIVE DATA ONLY

Eurofins Eaton Analytical

Tel: (626) 386-1100
Fax: (866) 988-3757
1 800 566 LABS (1 800 566 5227)

Laboratory Data

Report: 740885
Project: SUBCONTRACT
Group: Radiochemistry w/Potassium

Eurofins-Mgt
Tammy Lakeland
2-5 Kingston Town Close
Oakleigh, VIC 3166

Samples Received on:
05/30/2018 1205

Prepped	Analyzed	Prep Batch	Analytical Batch	Method	Analyte	Result	Units	MRL	Dilution
M18-My34071 (201805300363)						**Sampled on 05/23/2018 0800**			
	Variable ID: QC04_23/5/18								
		EPA 200.7 - ICP Metals							
05/31/18	06/04/18 13:27	1094266	1095324	(EPA 200.7)	Potassium Total ICAP	190	mg/L	5	5
		EPA 900.0 - Gross Alpha/Beta Radiation							
06/06/18	06/07/18 15:02	1096102	1096623	(EPA 900.0)	Beta, Gross	2500	pCi/L	3	1
06/06/18	06/07/18 15:02	1096102	1096623	(EPA 900.0)	Beta, Min Detectable Activity	53	pCi/L		1
06/06/18	06/07/18 15:02	1096102	1096623	(EPA 900.0)	Beta, Two Sigma Error	90	pCi/L		1
		EPA 900.0 - Corrected Gross Beta							
	06/07/18 19:59			(EPA 900.0)	Corrected Gross Beta	2300	pCi/L	3	1
		SM 7110C - Gross Alpha by Co-precipitation							
06/08/18	06/10/18 08:08	1096648	1097011	(SM 7110C)	Alpha, Min Detectable Activity	0.13	pCi/L		1
06/08/18	06/10/18 08:08	1096648	1097011	(SM 7110C)	Alpha, Two Sigma Error	0.63	pCi/L		1
06/08/18	06/10/18 08:08	1096648	1097011	(SM 7110C)	Gross Alpha + adjusted error	26	pCi/L	3	1
06/08/18	06/10/18 08:08	1096648	1097011	(SM 7110C)	Gross Alpha by Coprecipitation	26	pCi/L	3	1

Rounding on totals after summation.
(c) - indicates calculated results

eurofins Eaton Analytical

Tel: (626) 386-1100
Fax: (866) 988-3757
1 800 566 LABS (1 800 566 5227)

Laboratory QC Summary

Report: 740885
Project: SUBCONTRACT
Group: Radiochemistry w/Potassium

Eurofins-Mgt

ICP Metals

Prep Batch: 1094266 Analytical Batch: 1095324 — **Analysis Date: 06/04/2018**

201805300363 M18-My34071 — Analyzed by: NINA

Gross Alpha/Beta Radiation

Prep Batch: 1096102 Analytical Batch: 1096623 — **Analysis Date: 06/07/2018**

201805300363 M18-My34071 — Analyzed by: XI4C

Gross Alpha by Co-precipitation

Prep Batch: 1096648 Analytical Batch: 1097011 — **Analysis Date: 06/10/2018**

201805300363 M18-My34071 — Analyzed by: KA6E

Eurofins Eaton Analytical

Tel: (626) 386-1100
Fax: (866) 988-3757
1 800 566 LABS (1 800 566 5227)

Laboratory QC

Report: 740885
Project: SUBCONTRACT
Group: Radiochemistry w/Potassium

Eurofins-Mgt

QC Type	Analyte	Native	Spiked	Recovered	Units	Yield (%)	Limits (%)	RPDLimit (%)	RPD%
ICP Metals by EPA 200.7									
Analytical Batch: 1095324						**Analysis Date: 06/04/2018**			
LCS1	Potassium Total ICAP		20	20.2	mg/L	101	(85-115)		
LCS2	Potassium Total ICAP		20	20.0	mg/L	100	(85-115)	20	1
MBLK	Potassium Total ICAP			<0.5	mg/L				
MRL_CHK	Potassium Total ICAP		1	0.636	mg/L	64	(50-150)		
MS_201805300537	Potassium Total ICAP	4.3	20	25.9	mg/L	108	(70-130)		
MS2_201805240131	Potassium Total ICAP		20	21.8	mg/L	105	(70-130)		
MSD_201805300537	Potassium Total ICAP	4.3	20	26.5	mg/L	111	(70-130)	20	2.3
MSD2_201805240131	Potassium Total ICAP		20	21.3	mg/L	102	(70-130)	20	2.4
Gross Alpha/Beta Radiation by EPA 900.0									
Analytical Batch: 1096623						**Analysis Date: 06/07/2018**			
DUP1_201805311000	Beta, Gross	19		17.8	pCi/L		(0-20)	20	5.2
DUP2_201805240001	Beta, Gross	4.4		4.08	pCi/L		(0-20)		
LCS1	Beta, Gross		31	27.9	pCi/L	89	(80-120)		
LCS2	Beta, Gross		31	29.1	pCi/L	93	(80-120)	20	4.2
MBLK	Beta, Gross			<3	pCi/L				
MS_201805220416	Beta, Gross	ND	31	34.5	pCi/L	105	(70-130)		
Gross Alpha by Co-precipitation by SM 7110C									
Analytical Batch: 1097011						**Analysis Date: 06/10/2018**			
LCS1	Gross Alpha by Coprecipitation		29	26.4	pCi/L	90	(80-120)		
LCS2	Gross Alpha by Coprecipitation		29	27.3	pCi/L	93	(80-120)	20	3.4
MBLK	Gross Alpha by Coprecipitation			<3	pCi/L				
MS_201805240644	Gross Alpha by Coprecipitation	ND	29	62.3	pCi/L	104	(70-130)		

Spike recovery is already corrected for native results.
Spikes which exceed Limits and Method Blanks with positive results are highlighted by Underlining.
Criteria for MS and Dup are advisory only, batch control is based on LCS. Criteria for duplicates are advisory only, unless otherwise specified in the method.
RPD not calculated for LCS2 when different a concentration than LCS1 is used.
RPD not calculated for Duplicates when the result is not five times the MRL (Minimum Reporting Level).
(S) - Indicates surrogate compound.
(I) - Indicates internal standard compound.

ACS Laboratories (Australia)
ABN: 85 708 233 006

37 Stubbs Street
Kensington, VIC 3031

P.O. Box 1399, Kensington, VIC 3031

T +61 3 9220 0115
F +61 3 9220 0113
E info@acslab.com.au
W www.acslab.com.au

4 June 2018 **Report No: ACS1817067**

Mr Andrew Black
Eurofins MGT
3 Kingston Town Close
Oakleigh, VIC 3166

Dear Andrew,

Date of Sample Receipt: 28th May 2018
No. of Samples Received: 1
Eurofins Ref: 600238

Results (mg/L)

Analyte	**ID:M18-My3407102466**
	Lab No:17,067-1
Bromine	<5
Iodine(I_2)	<5

Method: Colorimetery/IC.

Yours faithfully,
ACS Laboratories (Australia)

Chris Gangemi
Analyst

eurofins mgt

ABN– 50 005 085 521
e.mail : EnviroSales@eurofins.com
web : www.eurofins.com.au

Melbourne
2-5 Kingston Town Close
Oakleigh VIC 3166
Phone : +61 3 8564 5000
NATA # 1261
Site # 1254 & 14271

Sydney
Unit F3, Building F
16 Mars Road
Lane Cove West NSW 2066
Phone : +61 2 9900 8400
NATA # 1261 Site # 18217

Brisbane
1/21 Smallwood Place
Murarrie QLD 4172
Phone : +61 7 3902 4600
NATA # 1261 Site # 20794

Perth
2/91 Leach Highway
Kewdale WA 6105
Phone : +61 8 9251 9600
NATA # 1261
Site # 23736

Company Name:	AECOM Aust Pty Ltd South Australia	**Order No.:**		**Received:**	May 25, 2018 5:28 PM
Address:	Level 28/91 King William Street	**Report #:**	600238	**Due:**	Jun 1, 2018
	Adelaide	**Phone:**	08 7100 6400	**Priority:**	5 Day
	SA 5000	**Fax:**	08 7100 6499	**Contact Name:**	Melinda Morris
Project Name:	NRWMF SITE CLASSIFICATION				
Project ID:	60565376.4.0				

Eurofins | mgt Analytical Services Manager : Natalie Krasselt

Sample Detail						Bromine*	Conductivity (at 25°C)	Dissolved Organic Carbon	Fluoride	Gross Alpha and Beta (with K-40 correction)	Iodine*	Iron	Lithium (filtered)	Manganese	pH (at 25°C)	Silicon (filtered)	Strontium (filtered)	Sulphide (as S)	Thorium (filtered)*	Total Alkalinity (as CaCO3)	Uranium (filtered)	Eurofins | mgt Suite B11	NEPM 1999 Metals : Metals M15 (Filtered)
Melbourne Laboratory - NATA Site # 1254 & 14271							X	X	X			X	X	X	X	X	X	X	X	X	X	X	X
Sydney Laboratory - NATA Site # 18217																							
Brisbane Laboratory - NATA Site # 20794																							
Perth Laboratory - NATA Site # 23736																							
External Laboratory						X				X	X												
No	**Sample ID**	**Sample Date**	**Sampling Time**	**Matrix**	**LAB ID**																		
1	QC04_23/5/18	May 23, 2018		Water	M18-My34071	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Test Counts						1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Melbourne
3-5 Kingston Town Close
Oakleigh Vic 3166
Phone : +61 3 8564 5000
NATA # 1261
Site # 1254 & 14271

Sydney
Unit F3, Building F
16 Mars Road
Lane Cove West NSW 2066
Phone : +61 2 9900 8400
NATA # 1261 Site # 18217

Brisbane
1/21 Smallwood Place
Murarrie QLD 4172
Phone : +61 7 3902 4600
NATA # 1261 Site # 20794

Perth
2/91 Leach Highway
Kewdale WA 6105
Phone : +61 8 9251 9600
NATA # 1261 Site # 23736

ABN – 50 005 085 521 e.mail : EnviroSales@eurofins.com web : www.eurofins.com.au

Sample Receipt Advice

Company name:	**AECOM Aust Pty Ltd South Australia**
Contact name:	Melinda Morris
Project name:	NRWMF SITE CLASSIFICATION
Project ID:	60565376.4.0
COC number:	Not provided
Turn around time:	5 Day
Date/Time received:	May 25, 2018 5:28 PM
Eurofins | mgt reference:	**600238**

Sample information

☑ A detailed list of analytes logged into our LIMS, is included in the attached summary table.

☑ All samples have been received as described on the above COC.

☑ COC has been completed correctly.

☑ Attempt to chill was evident.

☑ Appropriately preserved sample containers have been used.

☑ All samples were received in good condition.

☑ Samples have been provided with adequate time to commence analysis in accordance with the relevant holding times.

☑ Appropriate sample containers have been used.

☑ Sample containers for volatile analysis received with zero headspace.

☒ Split sample sent to requested external lab.

☑ Some samples have been subcontracted.

N/A Custody Seals intact (if used).

Contact notes

If you have any questions with respect to these samples please contact:

Natalie Krasselt on Phone : +61 3 8564 5000 or by e.mail: NatalieKrasselt@eurofins.com

Results will be delivered electronically via e.mail to Melinda Morris - melinda.morris@aecom.com.

#15

AECOM PROJECT - CHAIN OF CUSTODY

PAGE _1_ OF _1_

CLIENT:	AECOM Services	LABORATORY:	Eurofins MGT	All results to be provided in ESDAT format.	FOR LABORATORY USE ONLY
ADDRESS:	Level 28, 91 King William St Adelaide SA 5000	ADDRESS:		email address: adelaide@urscorp.com melinda.morris@aecom.com	
PHONE NO:	08 7100 6400	PHONE NO:		Quote Number:	
FAX NO:	08 7223 5499	FAX NO:			
PROJECT NAME:	NRWMF Site Characterisation	PROJECT MANAGER: melinda.morris@aecom.com 0408 387 495			
PROJECT NO:	60565376.4.0	SAMPLERS:		SIGNED:	

COMMENTS: SPECIAL HANDLING/STORAGE

UPDATED COC BY MELINDA 17/05/18

Please forward QC field duplicates to ALS Sydney

ANALYSIS REQUIRED

LAB ID	SITE	LOCATION	MATRIX	SAMPLE TYPE	SAMPLE ID	Date	CONTAINER TYPE AND PRESERVATIVE	FIELD FILTERED?	TOTAL NUMBER OF CONTAINERS	pH, Electrical Conductivity, Major Anions & Cations, Si & Alkalinity & Iodine & Bromine & Fluorine – 500ml Green	Dissolved Metals – NEPM 15 (W-3) + Li, Sr, Th, U – 60ml Red/Green bottle (Field Filtered)	Dissolved Nitrate (as N) - 60ml Purple 2 day holding time	Dissolved Organic Carbon – 40ml Purple Vial (Field Filtered)	Total Metals (Fe, Mn) – 60ml Red/Green unfiltered	Dissolved Sulfide – 125ml Yellow	Gross alpha and Gross beta - 1 L Red/Green unpreserved	TRH/BTEXN/PAH/Phenols (W-24) + OC and OP (W-12) - 100ml Amber + 40 ml vials
			W	QAQC	QC04_23/5/18	23/5/18	P,VS,C,S	2	9	✓	✓	✓	✓	✓	✓	✓	HOLD
					-												HOLD
					-												HOLD
					-												HOLD
					-												HOLD
					-												HOLD
					-												HOLD
					-												HOLD
					-												HOLD
					-												HOLD
					-												HOLD
					-												HOLD
					-												HOLD
					-												HOLD
									TOTAL								HOLD

Custody Seal ? Y N NA	RELINQUISHED BY: SYLV LAB.	CHECKED:	
Samples Cold ? Y N NA	DATE: 24/5/18	TIME:	
Comments:	RECEIVED BY:	CHECKED:	
	DATE:	TIME:	

CONTAINER TYPE AND PRESERVATIVE CODES

P = Natural Plastic; N = Nitric Acid Preserved; C = Sodium Hydroxide Preserved; J = Solvent Washed Acid Rinsed Jar

S = Solvent Washed Acid Rinsed Glass Bottle; VC = Hydrochloric Acid Preserved Vial; VS Sulphuric Acid Preserved Glass Bottle;

Z = Zinc acetate Preserved Bottle; E = EDTA Preserved Bottle; ST = Sterile Bottle; O = Other

Recieved by : ~~Afzaal~~ [ALS] 25/5/18 11.15

Catherine Ef/mgt 25/5 5.28pm

Relinquished by [illegible] 25/05/18 @ 4.40pm

600238

Soil Analytical Chemistry - Lyndhurst

		Sample ID	L07_0.0-0.2m	QC203-26042018	L07_0.5-0.6m	L07-1.6-1.7m	L07_2.1-2.2m	L08_0.0-0.2m	L08_1.0-1.1m	L08_2.2-2.3m	L10_0.0-0.2m	L10_1.0-1.1m	L10_2.0-2.1m
		Sample Date	26/04/2018	-	26/04/2018	26/04/2018	26/04/2018	26/04/2018	26/04/2018	26/04/2018	26/04/2018	26/04/2018	26/04/2018
		Description	Silty SAND topsoil	Field duplicate of L07_0.0-0.2	SAND	SAND	SAND	Clayey SAND	Clayey SAND	Clayey SAND	Silty SAND topsoil	SAND	SAND
		Lab Batch	EM1807699	EM1807699	EM1807699	EM1807699	EM1807699	EM1807699	EM1807699	EM1807699	EM1807699	EM1807699	EM1807699
Laboratory Analyte	**LOR**	**Unit**											
pH	0.1	pH unit	7.1	7.5	7.9	8.3	8.4	6.3	8.5	8.4	8	8.5	8.4
Electrical Conductivity	1	µS/cm	66	68	55	121	224	27	648	655	143	632	661
Electrical Conductivity (Saturated Paste)	1	µS/cm	148	160	123	200	409	119	1540	1610	505	1720	1990
Exchangeable Cations on Alkaline Soils													
Exchangeable Calcium	0.2	meq/100g	2.1	1.8	2.4	2.5	2.5	1.7	1.6	2	9.9	1.6	0.8
Exchangeable Magnesium	0.2	meq/100g	<0.2	<0.2	<0.2	1.5	1.5	0.4	3.4	2.9	2.2	2.8	2.2
Exchangeable Potassium	0.2	meq/100g	0.4	0.3	0.3	0.7	0.8	0.2	2	1.6	1.2	0.6	0.7
Exchangeable Sodium	0.2	meq/100g	<0.2	<0.2	<0.2	0.4	1.3	<0.1	5.4	5	0.3	1.9	2.5
Cation Exchange Capacity (CEC)	0.2	meq/100g	2.5	2.1	2.7	5	6.1	2.3	12.4	11.5	13.6	7	6.2
Exchangeable Sodium Percent (ESP)	0.2	%	<0.2	<0.2	<0.2	8	21.9	2.1	43.4	43.4	2.4	27.4	40.5

Legend:
Not analysed/ not calculated
LOR: limit of reporting
µs/cm: microseimens per centimetre
meq/100g: milliequivalents per 100 grams

AECOM Imagine it. Delivered.

Client Name: DIIS
Project Name: NRWMF Site Characterisation
Project No: 60565376

Analytical Summary - Soils Lyndhurst

		Sample ID	L01_21.0-21.4	L05S_13.5-13.6
		Sample Date	9/05/2018	17/05/2018
		Description	CLAY	Sandy CLAY
		Lab batch	EM1808010	EM1808425
Laboratory Analyte	LOR	Unit		
Moisture Content (dried @105-110^{0}C)		%	-	14.2
Particle sizing				
+75µm	1	%	42	54
+150µm	1	%	34	49
+300µm	1	%	24	38
+425µm	1	%	18	28
+600µm	1	%	12	18
+1180µm	1	%	4	8
+2.36mm	1	%	1	4
+4.75mm	1	%	<1	2
+9.5mm	1	%	<1	<1
+19.0mm	1	%	<1	<1
+37.5mm	1	%	<1	<1
+75.0mm	1	%	<1	<1
Soil Classification based on Particle Size	1	%		
Clay (<2 µm)	1	%	41	39
Silt (2-60 µm)	1	%	15	6
Sand (0.06-2.00 mm)	1	%	42	50
Gravel (>2mm)	1	%	2	5
Cobbles (>6cm)	1	%	<1	<1
Particle Density (Clay/Silt/Sand)	0.01	g/cm3	2.62	2.63
Exchangeable Cations on Alkaline Soils				
ø Exchangeable Calcium	0.2	meq/100g	-	0.4
ø Exchangeable Magnesium	0.2	meq/100g	-	1.6
ø Exchangeable Potassium	0.2	meq/100g	-	0.4
ø Exchangeable Sodium	0.2	meq/100g	-	1.4
ø Cation Exchange Capacity	0.2	meq/100g	-	3.8
ø Exchangeable Sodium Percent	0.2	%	-	37.4
Exchangeable Cations				
Exchangeable Calcium	0.1	meq/100g	-	-
Exchangeable Magnesium	0.1	meq/100g	-	-
Exchangeable Potassium	0.1	meq/100g	-	-
Exchangeable Sodium	0.1	meq/100g	-	-
Exchangeable Sodium Percent (ESP)	0.1	%	-	-
Cation Exchange Capacity (CEC)	0.1	meq/100g	-	-
Alkalinity (Total Alkalinity as CaCO3)	1	mg/kg	-	1
Bicarbonate Alkalinity as CaCO3	1	mg/kg	-	1
Carbonate Alkalinity as CaCO3	1	mg/kg	-	<1
Total Metals				
Arsenic	5	mg/kg	-	<5
Barium	10	mg/kg	-	50
Beryllium	1	mg/kg	-	<1
Boron	50	mg/kg	-	<50
Cadmium	1	mg/kg	-	<1
Chromium	2	mg/kg	-	12
Cobalt	2	mg/kg	-	<2
Copper	5	mg/kg	-	10
Iron	50	mg/kg	-	21600
Lead	5	mg/kg	-	<5
Manganese	5	mg/kg	-	14
Nickel	2	mg/kg	-	<2
Selenium	5	mg/kg	-	<5
Vanadium	5	mg/kg	-	46
Zinc	5	mg/kg	-	<5
Total Recoverable Mercury	0.1	mg/kg	-	<0.1
Organic Matter				
Organic Matter	0.5	%	-	<0.5
Total Organic Carbon	0.5	%	-	<0.5
Radionuclides / Activity				
Gross alpha	500	Bq/kg DW	-	1790
Gross beta	500	Bq/kg DW	-	840
XRD - Mineral or Mineral Group - ALS Perth Metallurgy			A19037 (MIN3344)	
Kaolinite	-	Mass %	9	-
Muscovite-illite	-	Mass %	1	-
Albite	-	Mass %	1	-
Microcline and/or rutile	-	Mass %	1	-
Alpha quartz	-	Mass %	86	-
Anatase	-	Mass %	1	
Illmenite and/or magnesite	-	Mass %	<1	-

Legend:
Not analysed/ not calculated
LOR: limit of reporting
g/cm3: grams per centimetre cubed
Meq/100g: milliequivalents per 100 grams
Bq/kg: Becquerals killogram

CERTIFICATE OF ANALYSIS

Work Order	: **EM1807699**	Page	: 1 of 5
Client	: **AECOM SERVICES PTY LTD**	Laboratory	: Environmental Division Melbourne
Contact	: MELINDA MORRIS	Contact	: Peter Ravlic
Address	: Level 28, 91 King William Street ADELAIDE SA, AUSTRALIA 5000	Address	: 4 Westall Rd Springvale VIC Australia 3171
Telephone	: +61 08 83661000	Telephone	: +61-3-8549 9600
Project	: 60565376	Date Samples Received	: 01-May-2018 09:45
Order number	: 60565376.4.0	Date Analysis Commenced	: 11-May-2018
C-O-C number	: ----	Issue Date	: 16-May-2018 14:48
Sampler	: ----		
Site	: NRWMF Site Characterisation		
Quote number	: EN/004/16		
No. of samples received	: 31		
No. of samples analysed	: 11		

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

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

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

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

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

Dilani Fernando	Senior Inorganic Chemist	Melbourne Inorganics, Springvale, VIC

General Comments

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

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

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

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

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

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

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

- pH analysis is done under non-stirring condition.
- EA032 (Saturated Paste EC): NATA accreditation does not cover the performance of this service.
- ALS is not NATA accredited for the analysis of Exchangeable Cations on Alkaline Soils when performed under ALS Method ED006.
- ED007 and ED008: When Exchangeable Al is reported from these methods, it should be noted that Rayment & Lyons (2011) suggests Exchange Acidity by 1M KCl - Method 15G1 (ED005) is a more suitable method for the determination of exchange acidity (H+ + Al3+).

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				L10_0-0.2	L10_1.0-1.1	L10_2.0-2.1	L07_0-0.2	L07_0.5-0.6
				26-Apr-2018 00:00	26-Apr-2018 00:00	26-Apr-2018 00:00	26-Apr-2018 00:00	26-Apr-2018 00:00
				EM1807699-007	EM1807699-008	EM1807699-009	EM1807699-010	EM1807699-011
				Result	Result	Result	Result	Result
EA001: pH in soil using 0.01M CaCl extract								
pH (CaCl2)	----	0.1	pH Unit	8.0	8.5	8.4	7.1	7.9
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	143	632	661	66	55
EA032: Electrical Conductivity (saturated paste)								
Electrical Conductivity (Saturated Paste)	----	1	µS/cm	505	1720	1990	148	123
ED006: Exchangeable Cations on Alkaline Soils								
ø Exchangeable Calcium	----	0.2	meq/100g	9.9	1.6	0.8	2.1	2.4
ø Exchangeable Magnesium	----	0.2	meq/100g	2.2	2.8	2.2	<0.2	<0.2
ø Exchangeable Potassium	----	0.2	meq/100g	1.2	0.6	0.7	0.4	0.3
ø Exchangeable Sodium	----	0.2	meq/100g	0.3	1.9	2.5	<0.2	<0.2
ø Cation Exchange Capacity	----	0.2	meq/100g	13.6	7.0	6.2	2.5	2.7
ø Exchangeable Sodium Percent	----	0.2	%	2.4	27.4	40.5	<0.2	<0.2

Analytical Results

Sub-Matrix: **SOIL** (Matrix: **SOIL**)				**L07_1.6-1.7**	**L07_2.1-2.2**	**L08_0-0.2**	**L08_1.0-1.1**	**L08_2.2-2.3**
				26-Apr-2018 00:00	26-Apr-2018 00:00	26-Apr-2018 00:00	26-Apr-2018 00:00	26-Apr-2018 00:00
				EM1807699-012	**EM1807699-013**	**EM1807699-017**	**EM1807699-019**	**EM1807699-020**
				Result	Result	Result	Result	Result
EA001: pH in soil using 0.01M CaCl extract								
pH (CaCl2)	----	0.1	pH Unit	**8.3**	**8.4**	**6.3**	**8.5**	**8.4**
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	**121**	**224**	**27**	**648**	**655**
EA032: Electrical Conductivity (saturated paste)								
Electrical Conductivity (Saturated Paste)	----	1	µS/cm	**200**	**409**	**119**	**1540**	**1610**
ED006: Exchangeable Cations on Alkaline Soils								
ø **Exchangeable Calcium**	----	0.2	meq/100g	**2.5**	**2.5**	----	**1.6**	**2.0**
ø **Exchangeable Magnesium**	----	0.2	meq/100g	**1.5**	**1.5**	----	**3.4**	**2.9**
ø **Exchangeable Potassium**	----	0.2	meq/100g	**0.7**	**0.8**	----	**2.0**	**1.6**
ø **Exchangeable Sodium**	----	0.2	meq/100g	**0.4**	**1.3**	----	**5.4**	**5.0**
ø **Cation Exchange Capacity**	----	0.2	meq/100g	**5.0**	**6.1**	----	**12.4**	**11.5**
ø **Exchangeable Sodium Percent**	----	0.2	%	**8.0**	**21.9**	----	**43.4**	**43.4**
ED007: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	----	----	**1.7**	----	----
Exchangeable Magnesium	----	0.1	meq/100g	----	----	**0.4**	----	----
Exchangeable Potassium	----	0.1	meq/100g	----	----	**0.2**	----	----
Exchangeable Sodium	----	0.1	meq/100g	----	----	<0.1	----	----
Cation Exchange Capacity	----	0.1	meq/100g	----	----	**2.3**	----	----
Exchangeable Sodium Percent	----	0.1	%	----	----	**2.1**	----	----

Analytical Results

Sub-Matrix: SOIL
(Matrix: SOIL)

				QC203_260418	----	----	----	----
				26-Apr-2018 00:00	----	----	----	----
				EM1807699-027	--------	--------	--------	--------
				Result	----	----	----	----
EA001: pH in soil using 0.01M CaCl extract								
pH (CaCl2)	----	0.1	pH Unit	**7.5**	----	----	----	----
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	**68**	----	----	----	----
EA032: Electrical Conductivity (saturated paste)								
Electrical Conductivity (Saturated Paste)	----	1	µS/cm	**160**	----	----	----	----
ED006: Exchangeable Cations on Alkaline Soils								
ø **Exchangeable Calcium**	----	0.2	meq/100g	**1.8**	----	----	----	----
ø **Exchangeable Magnesium**	----	0.2	meq/100g	<0.2	----	----	----	----
ø **Exchangeable Potassium**	----	0.2	meq/100g	**0.3**	----	----	----	----
ø **Exchangeable Sodium**	----	0.2	meq/100g	<0.2	----	----	----	----
ø **Cation Exchange Capacity**	----	0.2	meq/100g	**2.1**	----	----	----	----
ø **Exchangeable Sodium Percent**	----	0.2	%	<0.2	----	----	----	----

QUALITY CONTROL REPORT

Work Order	: **EM1807699**	Page	: 1 of 4
Client	: **AECOM SERVICES PTY LTD**	Laboratory	: Environmental Division Melbourne
Contact	: MELINDA MORRIS	Contact	: Peter Ravlic
Address	: Level 28, 91 King William Street ADELAIDE SA, AUSTRALIA 5000	Address	: 4 Westall Rd Springvale VIC Australia 3171
Telephone	: +61 08 83661000	Telephone	: +61-3-8549 9600
Project	: 60565376	Date Samples Received	: 01-May-2018
Order number	: 60565376.4.0	Date Analysis Commenced	: 11-May-2018
C-O-C number	: ----	Issue Date	: 16-May-2018
Sampler	: ----		
Site	: NRWMF Site Characterisation		
Quote number	: EN/004/16		
No. of samples received	: 31		
No. of samples analysed	: 11		

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

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

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Method Blank (MB) and Laboratory Control Spike (LCS) Report; Recovery and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits

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

Dilani Fernando	Senior Inorganic Chemist	Melbourne Inorganics, Springvale, VIC

General Comments

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

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

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

Key : Anonymous = Refers to samples which are not specifically part of this work order but formed part of the QC process lot
CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
RPD = Relative Percentage Difference
\# = Indicates failed QC

Laboratory Duplicate (DUP) Report

The quality control term Laboratory Duplicate refers to a randomly selected intralaboratory split. Laboratory duplicates provide information regarding method precision and sample heterogeneity. The permitted ranges for the Relative Percent Deviation (RPD) of Laboratory Duplicates are specified in ALS Method QWI-EN/38 and are dependent on the magnitude of results in comparison to the level of reporting: Result < 10 times LOR: No Limit; Result between 10 and 20 times LOR: 0% - 50%; Result > 20 times LOR: 0% - 20%.

Sub-Matrix: **SOIL**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
EA001: pH in soil using 0.01M CaCl extract (QC Lot: 1633541)									
EM1807699-007	L10_0-0.2	EA001: pH (CaCl2)	----	0.1	pH Unit	8.0	8.1	1.24	0% - 20%
EM1807699-020	L08_2.2-2.3	EA001: pH (CaCl2)	----	0.1	pH Unit	8.4	8.4	0.00	0% - 20%
EA010: Conductivity (QC Lot: 1633539)									
EM1807699-007	L10_0-0.2	EA010: Electrical Conductivity @ 25°C	----	1	µS/cm	143	141	0.916	0% - 20%
EM1807699-020	L08_2.2-2.3	EA010: Electrical Conductivity @ 25°C	----	1	µS/cm	655	682	4.04	0% - 20%
EA032: Electrical Conductivity (saturated paste) (QC Lot: 1637862)									
EM1807107-006	Anonymous	EA032: Electrical Conductivity (Saturated Paste)	----	1	µS/cm	405	407	0.493	0% - 20%
EM1807107-022	Anonymous	EA032: Electrical Conductivity (Saturated Paste)	----	1	µS/cm	454	470	3.46	0% - 20%
EA032: Electrical Conductivity (saturated paste) (QC Lot: 1637863)									
EM1807699-027	QC203_260418	EA032: Electrical Conductivity (Saturated Paste)	----	1	µS/cm	160	158	0.944	0% - 20%
ED006: Exchangeable Cations on Alkaline Soils (QC Lot: 1644175)									
EM1807107-007	Anonymous	ED006: Exchangeable Sodium Percent	----	0.2	%	41.4	41.4	0.00	0% - 20%
		ED006: Exchangeable Calcium	----	0.2	meq/100g	1.7	1.7	0.00	No Limit
		ED006: Exchangeable Magnesium	----	0.2	meq/100g	3.1	3.1	0.00	0% - 50%
		ED006: Exchangeable Potassium	----	0.2	meq/100g	1.3	1.3	0.00	No Limit
		ED006: Exchangeable Sodium	----	0.2	meq/100g	4.4	4.4	0.00	0% - 20%
		ED006: Cation Exchange Capacity	----	0.2	meq/100g	10.6	10.6	0.00	0% - 20%
EM1807645-015	Anonymous	ED006: Exchangeable Sodium Percent	----	0.2	%	23.4	23.3	0.435	0% - 20%
		ED006: Exchangeable Calcium	----	0.2	meq/100g	2.1	2.4	9.78	0% - 50%
		ED006: Exchangeable Magnesium	----	0.2	meq/100g	4.1	4.4	7.70	0% - 20%
		ED006: Exchangeable Potassium	----	0.2	meq/100g	1.5	1.6	0.00	No Limit
		ED006: Exchangeable Sodium	----	0.2	meq/100g	2.4	2.5	7.26	0% - 50%
		ED006: Cation Exchange Capacity	----	0.2	meq/100g	10.1	10.9	7.70	0% - 20%
ED006: Exchangeable Cations on Alkaline Soils (QC Lot: 1644176)									

Sub-Matrix: **SOIL**

Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Laboratory Duplicate (DUP) Report					
				LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
ED006: Exchangeable Cations on Alkaline Soils (QC Lot: 1644176) - continued									
EM1807699-027	QC203_260418	ED006: Exchangeable Sodium Percent	----	0.2	%	<0.2	<0.2	0.00	No Limit
		ED006: Exchangeable Calcium	----	0.2	meq/100g	1.8	1.9	0.00	No Limit
		ED006: Exchangeable Magnesium	----	0.2	meq/100g	<0.2	<0.2	0.00	No Limit
		ED006: Exchangeable Potassium	----	0.2	meq/100g	0.3	0.3	0.00	No Limit
		ED006: Exchangeable Sodium	----	0.2	meq/100g	<0.2	<0.2	0.00	No Limit
		ED006: Cation Exchange Capacity	----	0.2	meq/100g	2.1	2.2	0.00	0% - 50%
ED007: Exchangeable Cations (QC Lot: 1633572)									
EM1807699-017	L08_0-0.2	ED007: Exchangeable Sodium Percent	----	0.1	%	2.1	2.0	0.00	0% - 20%
		ED007: Exchangeable Calcium	----	0.1	meq/100g	1.7	1.7	0.00	0% - 50%
		ED007: Exchangeable Magnesium	----	0.1	meq/100g	0.4	0.4	0.00	No Limit
		ED007: Exchangeable Potassium	----	0.1	meq/100g	0.2	0.2	0.00	No Limit
		ED007: Exchangeable Sodium	----	0.1	meq/100g	<0.1	<0.1	0.00	No Limit
		ED007: Cation Exchange Capacity	----	0.1	meq/100g	2.3	2.3	0.00	0% - 20%

Method Blank (MB) and Laboratory Control Spike (LCS) Report

The quality control term Method / Laboratory Blank refers to an analyte free matrix to which all reagents are added in the same volumes or proportions as used in standard sample preparation. The purpose of this QC parameter is to monitor potential laboratory contamination. The quality control term Laboratory Control Spike (LCS) refers to a certified reference material, or a known interference free matrix spiked with target analytes. The purpose of this QC parameter is to monitor method precision and accuracy independent of sample matrix. Dynamic Recovery Limits are based on statistical evaluation of processed LCS.

Sub-Matrix: **SOIL**

				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Recovery Limits (%)	
Method: Compound	CAS Number	LOR	Unit	Result	Concentration	LCS	Low	High
EA010: Conductivity (QCLot: 1633539)								
EA010: Electrical Conductivity @ 25°C	----	1	µS/cm	<1	1413 µS/cm	99.6	95	105
EA032: Electrical Conductivity (saturated paste) (QCLot: 1637862)								
EA032: Electrical Conductivity (Saturated Paste)	----	1	µS/cm	<1	1413 µS/cm	100	70	130
EA032: Electrical Conductivity (saturated paste) (QCLot: 1637863)								
EA032: Electrical Conductivity (Saturated Paste)	----	1	µS/cm	<1	1413 µS/cm	100	70	130
ED006: Exchangeable Cations on Alkaline Soils (QCLot: 1644175)								
ED006: Exchangeable Calcium	----	0.2	meq/100g	<0.2	33 meq/100g	88.2	80	120
ED006: Exchangeable Magnesium	----	0.2	meq/100g	<0.2	32 meq/100g	91.4	80	120
ED006: Exchangeable Potassium	----	0.2	meq/100g	<0.2	2.2 meq/100g	115	80	120
ED006: Exchangeable Sodium	----	0.2	meq/100g	<0.2	5.6 meq/100g	83.6	80	120
ED006: Cation Exchange Capacity	----	0.2	meq/100g	<0.2	----	----	----	----
ED006: Exchangeable Sodium Percent	----	0.2	%	<0.2	----	----	----	----
ED006: Exchangeable Cations on Alkaline Soils (QCLot: 1644176)								
ED006: Exchangeable Calcium	----	0.2	meq/100g	<0.2	33 meq/100g	86.7	80	120
ED006: Exchangeable Magnesium	----	0.2	meq/100g	<0.2	32 meq/100g	90.9	80	120
ED006: Exchangeable Potassium	----	0.2	meq/100g	<0.2	2.2 meq/100g	114	80	120
ED006: Exchangeable Sodium	----	0.2	meq/100g	<0.2	5.6 meq/100g	81.5	80	120
ED006: Cation Exchange Capacity	----	0.2	meq/100g	<0.2	----	----	----	----
ED006: Exchangeable Sodium Percent	----	0.2	%	<0.2	----	----	----	----
ED007: Exchangeable Cations (QCLot: 1633572)								
ED007: Exchangeable Calcium	----	0.1	meq/100g	<0.1	3.45 meq/100g	102	80	120
ED007: Exchangeable Magnesium	----	0.1	meq/100g	<0.1	1.09 meq/100g	93.4	80	120
ED007: Exchangeable Potassium	----	0.1	meq/100g	<0.1	0.609 meq/100g	111	80	120
ED007: Exchangeable Sodium	----	0.1	meq/100g	<0.1	0.347 meq/100g	98.8	80	120
ED007: Cation Exchange Capacity	----	0.1	meq/100g	<0.1	----	----	----	----

Matrix Spike (MS) Report

The quality control term Matrix Spike (MS) refers to an intralaboratory split sample spiked with a representative set of target analytes. The purpose of this QC parameter is to monitor potential matrix effects on analyte recoveries. Static Recovery Limits as per laboratory Data Quality Objectives (DQOs). Ideal recovery ranges stated may be waived in the event of sample matrix interference.

- **No Matrix Spike (MS) or Matrix Spike Duplicate (MSD) Results are required to be reported.**

QA/QC Compliance Assessment to assist with Quality Review

Work Order	: **EM1807699**	Page	: 1 of 5
Client	: **AECOM SERVICES PTY LTD**	Laboratory	: Environmental Division Melbourne
Contact	: MELINDA MORRIS	Telephone	: +61-3-8549 9600
Project	: 60565376	Date Samples Received	: 01-May-2018
Site	: NRWMF Site Characterisation	Issue Date	: 16-May-2018
Sampler	: ----	No. of samples received	: 31
Order number	: 60565376.4.0	No. of samples analysed	: 11

This report is automatically generated by the ALS LIMS through interpretation of the ALS Quality Control Report and several Quality Assurance parameters measured by ALS. This automated reporting highlights any non-conformances, facilitates faster and more accurate data validation and is designed to assist internal expert and external Auditor review. Many components of this report contribute to the overall DQO assessment and reporting for guideline compliance.

Brief method summaries and references are also provided to assist in traceability.

Summary of Outliers

Outliers : Quality Control Samples

This report highlights outliers flagged in the Quality Control (QC) Report.

- **NO Method Blank value outliers occur.**
- **NO Duplicate outliers occur.**
- **NO Laboratory Control outliers occur.**
- **NO Matrix Spike outliers occur.**
- **For all regular sample matrices, NO surrogate recovery outliers occur.**

Outliers : Analysis Holding Time Compliance

- **Analysis Holding Time Outliers exist - please see following pages for full details.**

Outliers : Frequency of Quality Control Samples

- **NO Quality Control Sample Frequency Outliers exist.**

Outliers : Analysis Holding Time Compliance

Matrix: **SOIL**

Method		Extraction / Preparation			Analysis		
Container / Client Sample ID(s)		Date extracted	Due for extraction	Days overdue	Date analysed	Due for analysis	Days overdue
EA001: pH in soil using 0.01M CaCl extract							
Soil Glass Jar - Unpreserved							
L10_0-0.2,	L10_1.0-1.1,	11-May-2018	03-May-2018	**8**	----	----	----
L10_2.0-2.1,	L07_0-0.2,						
L07_0.5-0.6,	L07_1.6-1.7,						
L07_2.1-2.2,	L08_0-0.2,						
L08_1.0-1.1,	L08_2.2-2.3,						
QC203_260418							
EA010: Conductivity							
Soil Glass Jar - Unpreserved							
L10_0-0.2,	L10_1.0-1.1,	11-May-2018	03-May-2018	**8**	----	----	----
L10_2.0-2.1,	L07_0-0.2,						
L07_0.5-0.6,	L07_1.6-1.7,						
L07_2.1-2.2,	L08_0-0.2,						
L08_1.0-1.1,	L08_2.2-2.3,						
QC203_260418							

Analysis Holding Time Compliance

If samples are identified below as having been analysed or extracted outside of recommended holding times, this should be taken into consideration when interpreting results.

This report summarizes extraction / preparation and analysis times and compares each with ALS recommended holding times (referencing USEPA SW 846, APHA, AS and NEPM) based on the sample container provided. Dates reported represent first date of extraction or analysis and preclude subsequent dilutions and reruns. A listing of breaches (if any) is provided herein.

Holding time for leachate methods (e.g. TCLP) vary according to the analytes reported. Assessment compares the leach date with the shortest analyte holding time for the equivalent soil method. These are: organics 14 days, mercury 28 days & other metals 180 days. A recorded breach does not guarantee a breach for all non-volatile parameters.

Holding times for ***VOC in soils*** vary according to analytes of interest. Vinyl Chloride and Styrene holding time is 7 days; others 14 days. A recorded breach does not guarantee a breach for all VOC analytes and should be verified in case the reported breach is a false positive or Vinyl Chloride and Styrene are not key analytes of interest/concern.

Matrix: **SOIL**

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

Method		*Sample Date*	Extraction / Preparation			Analysis		
Container / *Client Sample ID(s)*			**Date extracted**	Due for extraction	Evaluation	**Date analysed**	Due for analysis	Evaluation
EA001: pH in soil using 0.01M CaCl extract								
Soil Glass Jar - Unpreserved (EA001)								
L10_0-0.2,	L10_1.0-1.1,	**26-Apr-2018**	**11-May-2018**	03-May-2018	×	**11-May-2018**	11-May-2018	✓
L10_2.0-2.1,	L07_0-0.2,							
L07_0.5-0.6,	L07_1.6-1.7,							
L07_2.1-2.2,	L08_0-0.2,							
L08_1.0-1.1,	L08_2.2-2.3,							
QC203_260418								

Matrix: **SOIL**

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

Method / Container / Client Sample ID(s)		Sample Date	Extraction / Preparation			Analysis		
			Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EA010: Conductivity								
Soil Glass Jar - Unpreserved (EA010)								
L10_0-0.2,	L10_1.0-1.1,	**26-Apr-2018**	**11-May-2018**	03-May-2018	×	**11-May-2018**	08-Jun-2018	✓
L10_2.0-2.1,	L07_0-0.2,							
L07_0.5-0.6,	L07_1.6-1.7,							
L07_2.1-2.2,	L08_0-0.2,							
L08_1.0-1.1,	L08_2.2-2.3,							
QC203_260418								
EA032: Electrical Conductivity (saturated paste)								
Soil Glass Jar - Unpreserved (EA032)								
L10_0-0.2,	L10_1.0-1.1,	**26-Apr-2018**	**----**	----	----	**14-May-2018**	23-Oct-2018	✓
L10_2.0-2.1,	L07_0-0.2,							
L07_0.5-0.6,	L07_1.6-1.7,							
L07_2.1-2.2,	L08_0-0.2,							
L08_1.0-1.1,	L08_2.2-2.3,							
QC203_260418								
ED006: Exchangeable Cations on Alkaline Soils								
Soil Glass Jar - Unpreserved (ED006)								
L10_0-0.2,	L10_1.0-1.1,	**26-Apr-2018**	**16-May-2018**	24-May-2018	✓	**16-May-2018**	24-May-2018	✓
L10_2.0-2.1,	L07_0-0.2,							
L07_0.5-0.6,	L07_1.6-1.7,							
L07_2.1-2.2,	L08_1.0-1.1,							
L08_2.2-2.3,	QC203_260418							
ED007: Exchangeable Cations								
Soil Glass Jar - Unpreserved (ED007)								
L08_0-0.2		**26-Apr-2018**	**11-May-2018**	24-May-2018	✓	**16-May-2018**	24-May-2018	✓
ED008: Exchangeable Cations								
Soil Glass Jar - Unpreserved (ED008)								
L08_0-0.2		**26-Apr-2018**	**11-May-2018**	24-May-2018	✓	**16-May-2018**	24-May-2018	✓

Quality Control Parameter Frequency Compliance

The following report summarises the frequency of laboratory QC samples analysed within the analytical lot(s) in which the submitted sample(s) was(were) processed. Actual rate should be greater than or equal to the expected rate. A listing of breaches is provided in the Summary of Outliers.

Matrix: **SOIL**

Evaluation: × = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	*Method*	*QC*	*Regular*	***Actual***	***Expected***	*Evaluation*	
Laboratory Duplicates (DUP)							
Electrical Conductivity (1:5)	EA010	2	11	**18.18**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Electrical Conductivity (Saturated Paste)	EA032	3	21	**14.29**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Exchangeable Cations	ED007	1	1	**100.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Exchangeable Cations on Alkaline Soils	ED006	3	26	**11.54**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
pH in soil using a 0.01M CaCl2 extract	EA001	2	11	**18.18**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Laboratory Control Samples (LCS)							
Electrical Conductivity (1:5)	EA010	1	11	**9.09**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Electrical Conductivity (Saturated Paste)	EA032	2	21	**9.52**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Exchangeable Cations	ED007	1	1	**100.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Exchangeable Cations on Alkaline Soils	ED006	2	26	**7.69**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Method Blanks (MB)							
Electrical Conductivity (1:5)	EA010	1	11	**9.09**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Electrical Conductivity (Saturated Paste)	EA032	2	21	**9.52**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Exchangeable Cations	ED007	1	1	**100.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Exchangeable Cations on Alkaline Soils	ED006	2	26	**7.69**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard

Brief Method Summaries

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the US EPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request. The following report provides brief descriptions of the analytical procedures employed for results reported in the Certificate of Analysis. Sources from which ALS methods have been developed are provided within the Method Descriptions.

Analytical Methods	*Method*	*Matrix*	*Method Descriptions*
pH in soil using a 0.01M CaCl2 extract	EA001	SOIL	In house: Referenced to Rayment and Lyons (2011) 4B3 (mod.) or 4B4 (mod.) 10 g of soil is mixed with 50 mL of 0.01M CaCl2 and tumbled end over end for 1 hour. pH is measured from the continuous suspension. This method is compliant with NEPM (2013) Schedule B(3)
Electrical Conductivity (1:5)	EA010	SOIL	In house: Referenced to Rayment and Lyons 3A1 and APHA 2510. Conductivity is determined on soil samples using a 1:5 soil/water leach. This method is compliant with NEPM (2013) Schedule B(3)
Electrical Conductivity (Saturated Paste)	EA032	SOIL	In house: Referenced to USEPA 600/2 - 78 - 054 - conductivity determined on a saturated paste.
Exchangeable Cations on Alkaline Soils	* ED006	SOIL	In house: Referenced to Soil Survey Test Method C5. Soluble salts are removed from the sample prior to analysis. Cations are exchanged from the sample by contact with alcoholic ammonium chloride at pH 8.5. They are then quantitated in the final solution by ICPAES and reported as meq/100g of original soil.
Exchangeable Cations	ED007	SOIL	In house: Referenced to Rayment & Lyons (2011) Method 15A1. Cations are exchanged from the sample by contact with Ammonium Chloride. They are then quantitated in the final solution by ICPAES and reported as meq/100g of original soil. This method is compliant with NEPM (2013) Schedule B(3) (Method 301)
Exchangeable Cations with pre-treatment	ED008	SOIL	In house: Referenced to Rayment & Higginson (2011) Method 15A2. Soluble salts are removed from the sample prior to analysis. Cations are exchanged from the sample by contact with Ammonium Chloride. They are then quantitated in the final solution by ICPAES and reported as meq/100g of original soil. This method is compliant with NEPM (2013) Schedule B(3) (Method 301)

Preparation Methods	*Method*	*Matrix*	*Method Descriptions*
pH in soil using a 0.01M CaCl2 extract	EA001-PR	SOIL	In house: Referenced to Rayment and Higginson 4B1, 10 g of soil is mixed with 50 mL of 0.01M CaCl2 and tumbled end over end for 1 hour. pH is measured from the continuous suspension. This method is compliant with NEPM (2013) Schedule B(3) (Method 103)
Exchangeable Cations Preparation Method (Alkaline Soils)	ED006PR	SOIL	In house: Referenced to Rayment and Lyons 2011 method 15C1.
Exchangeable Cations Preparation Method	ED007PR	SOIL	In house: Referenced to Rayment & Higginson (1992) method 15A1. A 1M NH4Cl extraction by end over end tumbling at a ratio of 1:20. There is no pretreatment for soluble salts. Extracts can be run by ICP for cations.
1:5 solid / water leach for soluble analytes	EN34	SOIL	10 g of soil is mixed with 50 mL of reagent grade water and tumbled end over end for 1 hour. Water soluble salts are leached from the soil by the continuous suspension. Samples are settled and the water filtered off for analysis.

AECOM PROJECT - CHAIN OF CUSTODY

CLIENT:	AECOM Services	LABORATORY:	ALS	All results to be provided in ESDAT format.	FOR LABORATORY USE ONLY
ADDRESS:	Level 28, 91 King William St Adelaide SA 5000	ADDRESS:	2-4 Westall Rd Springvale Vic, 3171	email address: adelaide@urscorp.com	
PHONE NO:	08 7100 6400	PHONE NO:	03 8549 9600	Quote Number:	
FAX NO:	08 7223 5499	FAX NO:			
PROJECT NAME:	NRWMF Site Characterisation	PROJECT MANAGER: melinda.morris@aecom.com 0408 387 495			
		SAMPLERS:		SIGNED:	
PROJECT NO:	60565376.4.0				

COMMENTS: SPECIAL HANDLING/STORAGE

ANALYSIS REQUIRED

LAB ID	SITE	LOCATION	MATRIX	SAMPLE TYPE	SAMPLE ID		Date	CONTAINER TYPE AND PRESERVATIVE	FIELD FILTERED?	TOTAL NUMBER OF CONTAINERS	Please hold for further analysis to be emailed	Cation Exchange Capacity, Exchangeable Cations (Ca, Mg, Na, K) plus Exchangeable Sodium Percentage (ESP)	Metals – NEPM 15 (S-3), Total Fe & Mn	TRH/BTEXN/PAH/Phenols Suite (S-24)	OC/OPs Suite (S-12)	Triazine Pesticides (Atrazine and Simazine)	Carbonate & Total Organic Carbon	NEPM Screen for Soil Classification Suite (P-22)	Gross alpha and Gross beta (50 g bag)	Particle Size Distribution (500 g bag)	XRD with clay extraction (sub-sampled from 500 g bag)
	NRWMF SCP	Napandee	Soil	Primary	H10	1.0-1.1	25/04/2018	1 Jar, 1 Bag	NA	2	1										
	NRWMF SCP	Napandee	Soil	Primary	H10	2.0-2.1	25/04/2018	1 Jar, 1 Bag	NA	2	1										
	NRWMF SCP	Napandee	Soil	Primary	H09	0-0.2	25/04/2018	1 Jar, 1 Bag	NA	2	1										
	NRWMF SCP	Napandee	Soil	Primary	H09	1.4-1.5	25/04/2018	1 Jar, 1 Bag	NA	2	1										
	NRWMF SCP	Napandee	Soil	Primary	H09	2.5-2.6	25/04/2018	1 Jar, 1 Bag	NA	2	1										
1	NRWMF SCP	Lyndhurst	Soil	Primary	L11	0-0.2	26/04/2018	1 Jar, 1 Bag	NA	2	1										
2	NRWMF SCP	Lyndhurst	Soil	Primary	L11	1.1-1.2	26/04/2018	1 Jar, 1 Bag	NA	2	1										
3	NRWMF SCP	Lyndhurst	Soil	Primary	L11	2.0-2.1	26/04/2018	1 Jar, 1 Bag	NA	2	1										
4	NRWMF SCP	Lyndhurst	Soil	Primary	L09	0-0.2	26/04/2018	1 Jar, 1 Bag	NA	2	1										
5	NRWMF SCP	Lyndhurst	Soil	Primary	L09	1.0-1.1	26/04/2018	1 Jar, 1 Bag	NA	2	1										
6	NRWMF SCP	Lyndhurst	Soil	Primary	L09	2.1-2.2	26/04/2018	1 Jar, 1 Bag	NA	2	1										
7	NRWMF SCP	Lyndhurst	Soil	Primary	L10	0-0.2	26/04/2018	1 Jar, 1 Bag	NA	2	1										
8	NRWMF SCP	Lyndhurst	Soil	Primary	L10	1.0-1.1	26/04/2018	1 Jar, 1 Bag	NA	2	1										
9	NRWMF SCP	Lyndhurst	Soil	Primary	L10	2.0-2.1	26/04/2018	1 Jar, 1 Bag	NA	2	1										
10	NRWMF SCP	Lyndhurst	Soil	Primary	L07	0-0.2	26/04/2018	1 Jar, 1 Bag	NA	2	1										
										TOTAL											

Moisture
NP 10/5

Custody Seal ? Y N NA	RELINQUISHED BY:		CHECKED:	
Samples Cold ? Y N NA	DATE:		TIME:	
Comments:	RECEIVED BY:	Bharathi (ALS)	CHECKED:	01/5/18
	DATE:		TIME:	10.15a

CONTAINER TYPE AND PRESERVATIVE CODES

P = Natural Plastic; N = Nitric Acid Preserved; C = Sodium Hydroxide Preserved; J = Solvent Washed Acid Rinsed Jar
S = Solvent Washed Acid Rinsed Glass Bottle; VC = Hydrochloric Acid Preserved Vial; VS Sulphuric Acid Preserved Glass Bottle;
Z = Zinc acetate Preserved Bottle; E = EDTA Preserved Bottle; ST = Sterile Bottle; O = Other

Environmental Division
Melbourne
Work Order Reference
EM1807699

Telephone : + 61-3-8549 9600

AECOM PROJECT - CHAIN OF CUSTODY

CLIENT:	AECOM Services	LABORATORY:	ALS	All results to be provided in ESDAT format.
ADDRESS:	Level 28, 91 King William St Adelaide SA 5000	ADDRESS:	2-4 Westall Rd Springvale Vic, 3171	email address: adelaide@urscorp.com
PHONE NO:	08 7100 6400	PHONE NO:	03 8549 9600	Quote Number:
FAX NO:	08 7223 5499	FAX NO:		
PROJECT NAME:	NRWMF Site Characterisation	PROJECT MANAGER: melinda.morris@aecom.com 0408 387 495		
		SAMPLERS:		SIGNED:
PROJECT NO:	60565376.4.0			

FOR LABORATORY USE ONLY

COMMENTS: SPECIAL HANDLING/STORAGE

ANALYSIS REQUIRED

LAB ID	SITE	LOCATION	MATRIX	SAMPLE TYPE	SAMPLE ID		Date	CONTAINER TYPE AND PRESERVATIVE	FIELD FILTERED?	TOTAL NUMBER OF CONTAINERS	Please hold for further analysis to be emailed	Cation Exchange Capacity, Exchangeable Cations (Ca, Mg, Na, K) plus Exchangeable Sodium Percentage (ESP)	Metals – NEPM 15 (S-3), Total Fe & Mn	TRH/BTEXN/PAH/Phenols Suite (S-24)	OC/OPs Suite (S-12)	Triazine Pesticides (Atrazine and Simazine)	Carbonate & Total Organic Carbon	NEPM Screen for Soil Classification Suite (P-22)	Gross alpha and Gross beta (50 g bag)	Particle Size Distribution (500 g bag)	XRD with clay extraction (sub-sampled from 500 g bag)
11	NRWMF SCP	Lyndhurst	Soil	Primary	L07	0.5-0.6	26/04/2018	1 Jar, 1 Bag	NA	2	1										
12	NRWMF SCP	Lyndhurst	Soil	Primary	L07	1.6-1.7	26/04/2018	[redacted]	NA	2	1	1 Bag	1	1 Jar							
13	NRWMF SCP	Lyndhurst	Soil	Primary	L07	2.1-2.2	26/04/2018	[redacted]	NA	2	1	〃		〃							
14	NRWMF SCP	Lyndhurst	Soil	Primary	L06	0-0.2	26/04/2018	1 Jar, 1 Bag	NA	2	1										
15	NRWMF SCP	Lyndhurst	Soil	Primary	L06	1.0-1.1	26/04/2018	1 Jar, 1 Bag	NA	2	1										
16	NRWMF SCP	Lyndhurst	Soil	Primary	L06	2.0-2.1	26/04/2018	1 Jar, 1 Bag	NA	2	1										
17	NRWMF SCP	Lyndhurst	Soil	Primary	L08	0-0.2	26/04/2018	1 Jar, 1 Bag	NA	2	1										
18	NRWMF SCP	Lyndhurst	Soil	Primary	L08	0.3-0.5	26/04/2018	1 Jar, 1 Bag	NA	2	1										
19	NRWMF SCP	Lyndhurst	Soil	Primary	L08	1.0-1.1	26/04/2018	1 Jar, 1 Bag	NA	2	1										
20	NRWMF SCP	Lyndhurst	Soil	Primary	L08	2.2-2.3	26/04/2018	1 Jar, 1 Bag	NA	2	1										
	NRWMF SCP	Napandee	Soil	QA\QC	QC100	250418	25/04/2018	1 Jar, 1 Bag	NA	2	1										
	NRWMF SCP	Napandee	Soil	QA\QC	QC101	250418	25/04/2018	1 Jar, 1 Bag	NA	2	1										
	NRWMF SCP	Napandee	Soil	QA\QC	QC102	250418	25/04/2018	1 Jar, 1 Bag	NA	2	1										
	NRWMF SCP	Napandee	Soil	QA\QC	QC103	250418	25/04/2018	1 Jar, 1 Bag	NA	2	1										
	NRWMF SCP	Napandee	Soil	QA\QC	QC104	250418	25/04/2018	1 Jar, 1 Bag	NA	2	1										
										TOTAL											

Custody Seal?	Y N NA	RELINQUISHED BY:	CHECKED:	CONTAINER TYPE AND PRESERVATIVE CODES
Samples Cold?	Y N NA	DATE:	TIME:	P = Natural Plastic; N = Nitric Acid Preserved; C = Sodium Hydroxide Preserved; J = Solvent Washed Acid Rinsed Jar
Comments:		RECEIVED BY: Bharathi (ALS)	CHECKED:	S = Solvent Washed Acid Rinsed Glass Bottle; VC = Hydrochloric Acid Preserved Vial; VS Sulphuric Acid Preserved Glass Bottle;
		DATE:	TIME: 01/5/18 10.15 am	Z = Zinc acetate Preserved Bottle; E = EDTA Preserved Bottle; ST = Sterile Bottle; O = Other

AECOM PROJECT - CHAIN OF CUSTODY

CLIENT:	AECOM Services	LABORATORY:	ALS
ADDRESS:	Level 28, 91 King William St Adelaide SA 5000	ADDRESS:	2-4 Westall Rd Springvale Vic, 3171
PHONE NO:	08 7100 6400	PHONE NO:	03 8549 9600
FAX NO:	08 7223 5499	FAX NO:	
PROJECT NAME:	NRWMF Site Characterisation	PROJECT MANAGER:	melinda.morris@aecom.com 0408 387 495
PROJECT NO:	60565376.4.0	SAMPLERS:	SIGNED:

All results to be provided in ESDAT format.
email address: adelaide@urscorp.com
Quote Number:

FOR LABORATORY USE ONLY

COMMENTS: SPECIAL HANDLING/STORAGE

ANALYSIS REQUIRED

LAB ID	SITE	LOCATION	MATRIX	SAMPLE TYPE	SAMPLE ID	Date	CONTAINER TYPE AND PRESERVATIVE	FIELD FILTERED?	TOTAL NUMBER OF CONTAINERS	Please hold for further analysis to be emailed	Cation Exchange Capacity, Exchangeable Cations (Ca, Mg, Na, K) plus Exchangeable Sodium Percentage (ESP)	Metals – NEPM 15 (S-3), Total Fe & Mn	TRH/BTEXN/PAH/Phenols Suite (S-24)	OC/OPs Suite (S-12)	Triazine Pesticides (Atrazine and Simazine)	Carbonate & Total Organic Carbon	NEPM Screen for Soil Classification Suite (P-22)	Gross alpha and Gross beta (50 g bag)	Particle Size Distribution (500 g bag)	XRD with clay extraction (sub-sampled from 500 g bag)
	NRWMF SCP	Napandee	Soil	QA\QC	QC105_250418	25/04/2018	1 Jar, 1 Bag	NA	2	1										
	NRWMF SCP	Napandee	Soil	QA\QC	QC106_250418	25/04/2018	1 Jar, 1 Bag	NA	2	1										
	NRWMF SCP	Napandee	Soil	QA\QC	QC107_250418	25/04/2018	1 Jar, 1 Bag	NA	2	1										
	NRWMF SCP	Napandee	Soil	QA\QC	QC108_250418	25/04/2018	1 Jar, 1 Bag	NA	2	1										
	NRWMF SCP	Napandee	Soil	QA\QC	QC109_250418	25/04/2018	1 Jar, 1 Bag	NA	2	1										
	NRWMF SCP	Napandee	Soil	QA\QC	QC110_250418	25/04/2018	1 Jar, 1 Bag	NA	2	1										
	NRWMF SCP	Napandee	Soil	QA\QC	QC111_250418	25/04/2018	1 Jar, 1 Bag	NA	2	1										
21	NRWMF SCP	Lyndhurst	Soil	QA\QC	QC209_260418	26/04/2018	1 Jar, 1 Bag	NA	2	1										
22	NRWMF SCP	Lyndhurst	Soil	QA\QC	QC210_260418	26/04/2018	1 Jar, 1 Bag	NA	2	1										
23	NRWMF SCP	Lyndhurst	Soil	QA\QC	QC207_260418	26/04/2018	1 Jar, 1 Bag	NA	2	1										
24	NRWMF SCP	Lyndhurst	Soil	QA\QC	QC208_260418	26/04/2018	1 Jar, 1 Bag	NA	2	1										
25	NRWMF SCP	Lyndhurst	Soil	QA\QC	QC205_260418	26/04/2018	1 Jar, 1 Bag	NA	2	1										
26	NRWMF SCP	Lyndhurst	Soil	QA\QC	QC206_260418	26/04/2018	1 Jar, 1 Bag	NA	2	1										
27	NRWMF SCP	Lyndhurst	Soil	QA\QC	QC203_260418	26/04/2018	1 Jar, 1 Bag	NA	2	1										
28	NRWMF SCP	Lyndhurst	Soil	QA\QC	QC204_260418	26/04/2018	1 Jar, 1 Bag	NA	2	1										
									TOTAL											

Custody Seal ? Y N NA	RELINQUISHED BY:	CHECKED:	
Samples Cold ? Y N NA	DATE:	TIME:	
Comments:	RECEIVED BY: Bharati (ALS)	CHECKED: 01/5/16	
	DATE:	TIME: 10.15	

CONTAINER TYPE AND PRESERVATIVE CODES
P = Natural Plastic; N = Nitric Acid Preserved; C = Sodium Hydroxide Preserved; J = Solvent Washed Acid Rinsed Jar
S = Solvent Washed Acid Rinsed Glass Bottle; VC = Hydrochloric Acid Preserved Vial; VS Sulphuric Acid Preserved Glass Bottle;
Z = Zinc acetate Preserved Bottle; E = EDTA Preserved Bottle; ST = Sterile Bottle; O = Other

AECOM PROJECT - CHAIN OF CUSTODY

CLIENT:	AECOM Services	LABORATORY:	ALS	All results to be provided in ESDAT format.	FOR LABORATORY USE ONLY
ADDRESS:	Level 28, 91 King William St Adelaide SA 5000	ADDRESS:	2-4 Westall Rd Springvale Vic, 3171	email address: adelaide@urscorp.com	
PHONE NO:	08 7100 6400	PHONE NO:	03 8549 9600	Quote Number:	
FAX NO:	08 7223 5499	FAX NO:			
PROJECT NAME:	NRWMF Site Characterisation	PROJECT MANAGER: melinda.morris@aecom.com 0408 387 495			
		SAMPLERS:		SIGNED:	
PROJECT NO:	60565376.4.0				

COMMENTS: SPECIAL HANDLING/STORAGE

ANALYSIS REQUIRED

LAB ID	SITE	LOCATION	MATRIX	SAMPLE TYPE	SAMPLE ID	Date	CONTAINER TYPE AND PRESERVATIVE	FIELD FILTERED?	TOTAL NUMBER OF CONTAINERS	Please hold for further analysis to be emailed	Cation Exchange Capacity, Exchangeable Cations (Ca, Mg, Na, K) plus Exchangeable Sodium Percentage (ESP)	Metals – NEPM 15 (S-3), Total Fe & Mn	TRH/BTEXN/PAH/Phenols Suite (S-24)	OC/OPs Suite (S-12)	Triazine Pesticides (Atrazine and Simazine)	Carbonate & Total Organic Carbon	NEPM Screen for Soil Classification Suite (P-22)	Gross alpha and Gross beta (50 g bag)	Particle Size Distribution (500 g bag)	XRD with clay extraction (sub-sampled from 500 g bag)
29	NRWMF SCP	Lyndhurst	Soil	QA\QC	QC201 260418	26/04/2018	1 Jar, 1 Bag	NA	2	1										
30	NRWMF SCP	Lyndhurst	Soil	QA\QC	QC202 260418	26/04/2018	2 Jar, 1 Bag	NA	3	1										
31	NRWMF SCP	Lyndhurst	Soil	QA\QC	QC211 260418	26/04/2018	3 Jar, 1 Bag	NA	4	1										
32	NRWMF SCP	Lyndhurst	Soil	QA\QC	QC212 260418	26/04/2018	4 Jar, 1 Bag	NA	5	1										
									TOTAL											

Custody Seal ? Y N NA	RELINQUISHED BY:	CHECKED:		CONTAINER TYPE AND PRESERVATIVE CODES
Samples Cold ? Y N NA	DATE:	TIME:		P = Natural Plastic; N = Nitric Acid Preserved; C = Sodium Hydroxide Preserved; J = Solvent Washed Acid Rinsed Jar
Comments:	RECEIVED BY: Bharathi (ALS)	CHECKED:	01/5/18	S = Solvent Washed Acid Rinsed Glass Bottle; VC = Hydrochloric Acid Preserved Vial; VS Sulphuric Acid Preserved Glass Bottle;
	DATE:	TIME:	10.15am	Z = Zinc acetate Preserved Bottle; E = EDTA Preserved Bottle; ST = Sterile Bottle; O = Other

Peter Ravlic

From: Rusk, James <james.rusk@aecom.com>
Sent: Wednesday, 9 May 2018 2:31 PM
To: Peter Ravlic
Cc: Morris, Melinda
Subject: URGENT: analysis of soil samples from batch EM1807107 for AECOM project 60565376 task 4.0
Attachments: 01052018132833-0001.pdf

Importance: High

Hi Peter,

As discussed, please find requested analysis for samples from batch EM1807107 for urgent scheduling within the table below

Batch	Lab ID	Site	Sample ID^	Analysis	Date Sampled	Holding Time
EM1807107	Not assigned	Napandee	N07_0-0.2	pH, EC 1:5, EC saturated paste(EA032) CEC + exchangeable cations, ESP	25/4/18	pH, EC outside of holding times (7 days)
			QC104_250418			
			N07_1.5-1.6			
			N07_2.5-2.6			
			N11_0-0.2			
			N11_1.0-1.1			
			N11_2.0-2.1			
			N09_0-0.2			
			N09_1.4-1.5			
			N09_2.5-2.6			
EM1807107	Not assigned	Lyndhurst	10 L07_0-0.2	pH, EC 1:5, EC saturated paste,(EA032) CEC + exchangeable cations, ESP	26/4/18	pH, EC outside of holding times (7 days)
			11 L07_0.5-0.6			
			12 L07_1.5-1.6 1.6-1.7			
			13 L07_2.1-2.2			
			27 QC203_260418			
			17 L08_0-0.2			
			19 L08_1.0-1.1			
			20 L08_2.2-2.3			
			7 L10_0-0.2			
			8 L10_1.0-1.1			
			9 L10_2.0-2.2 2.1			

^ Within batch EM, before issuing the SRN please add a note to the COC and amend the sample IDs with Hxx_depth-depth to Nxx_depth-depth e.g. H06_0-0.2 to N06_0-0.2.

Can you please separate out the samples from Napandee (N) and Lyndhurst (L) and report in separate batches.

The QC samples relevant to each site are:
- Napandee QC100_250418 to QC111_250418
- Lyndhurst QC201_260418 to QC212_260418

Thanks and Regards,

James Rusk
Team Leader - Environment
D +61 8 7223 5531 M +61 411 778 163
james.rusk@aecom.com

AECOM
Level 28, 91 King William Street, Adelaide, SA 5000

AECOM PROJECT - CHAIN OF CUSTODY

CLIENT: AECOM Services	LABORATORY: ALS	All results to be provided in ESDAT format.	FOR LABORATORY USE ONLY
ADDRESS: Level 28, 91 King William St, Adelaide, SA 5000	ADDRESS: 2-4 Westall Rd, Springvale, Vic, 3171	email address: adelaide@urscorp.com	
PHONE NO: 08 7100 6400	PHONE NO: 03 8549 9600	Quote Number:	
FAX NO: 08 7223 5499	FAX NO:		
PROJECT NAME: NRWMF Site Characterisation	PROJECT MANAGER: melinda.morris@aecom.com 0408 387 495		
	SAMPLERS:	SIGNED:	
PROJECT NO: 60565376.4.0			

COMMENTS: SPECIAL HANDLING/STORAGE

ANALYSIS REQUIRED

LAB ID	SITE	LOCATION	MATRIX	SAMPLE TYPE	SAMPLE ID		Date	CONTAINER TYPE AND PRESERVATIVE	FIELD FILTERED?	TOTAL NUMBER OF CONTAINERS	Please hold for further analysis to be emailed	Cation Exchange Capacity, Exchangeable Cations (Ca, Mg, Na, K) plus Exchangeable Sodium Percentage (ESP)	Metals – NEPM 15 (S-3), Total Fe & Mn	TRH/BTEXN/PAH/Phenols Suite (S-24)	OC/OPs Suite (S-12)	Triazine Pesticides (Atrazine and Simazine)	Carbonate & Total Organic Carbon	NEPM Screen for Soil Classification Suite (P-22)	Gross alpha and Gross beta (50 g bag)	Particle Size Distribution (500 g bag)	XRD with clay extraction (sub-sampled from 500 g bag)
	NRWMF SCP	Napandee	Soil	Primary	H10	1.0-1.1	25/04/2018	1 Jar, 1 Bag	NA	2	1										
	NRWMF SCP	Napandee	Soil	Primary	H10	2.0-2.1	25/04/2018	1 Jar, 1 Bag	NA	2	1										
	NRWMF SCP	Napandee	Soil	Primary	H09	0-0.2	25/04/2018	1 Jar, 1 Bag	NA	2	1										
	NRWMF SCP	Napandee	Soil	Primary	H09	1.4-1.5	25/04/2018	1 Jar, 1 Bag	NA	2	1										
	NRWMF SCP	Napandee	Soil	Primary	H09	2.5-2.6	25/04/2018	1 Jar, 1 Bag	NA	2	1										
1	NRWMF SCP	Lyndhurst	Soil	Primary	L11	0-0.2	26/04/2018	1 Jar, 1 Bag	NA	2	1										
2	NRWMF SCP	Lyndhurst	Soil	Primary	L11	1.1-1.2	26/04/2018	1 Jar, 1 Bag	NA	2	1										
3	NRWMF SCP	Lyndhurst	Soil	Primary	L11	2.0-2.1	26/04/2018	1 Jar, 1 Bag	NA	2	1										
4	NRWMF SCP	Lyndhurst	Soil	Primary	L09	0-0.2	26/04/2018	1 Jar, 1 Bag	NA	2	1										
5	NRWMF SCP	Lyndhurst	Soil	Primary	L09	1.0-1.1	26/04/2018	1 Jar, 1 Bag	NA	2	1										
6	NRWMF SCP	Lyndhurst	Soil	Primary	L09	2.1-2.2	26/04/2018	1 Jar, 1 Bag	NA	2	1										
7	NRWMF SCP	Lyndhurst	Soil	Primary	L10	0-0.2	26/04/2018	1 Jar, 1 Bag	NA	2	1										
8	NRWMF SCP	Lyndhurst	Soil	Primary	L10	1.0-1.1	26/04/2018	1 Jar, 1 Bag	NA	2	1										
9	NRWMF SCP	Lyndhurst	Soil	Primary	L10	2.0-2.1	26/04/2018	1 Jar, 1 Bag	NA	2	1										
10	NRWMF SCP	Lyndhurst	Soil	Primary	L07	0-0.2	26/04/2018	1 Jar, 1 Bag	NA	2	1										
										TOTAL											

Moisture
NP 10/5

Custody Seal? Y N NA	RELINQUISHED BY:	CHECKED:	CONTAINER TYPE AND PRESERVATIVE CODES
Samples Cold? Y N NA	DATE:	TIME:	P = Natural Plastic; N = Nitric Acid Preserved; C = Sodium Hydroxide Preserved; J = Solvent Washed Acid Rinsed Jar
Comments:	RECEIVED BY: Bharath (ALS)	CHECKED: 01/5/18	S = Solvent Washed Acid Rinsed Glass Bottle; VC = Hydrochloric Acid Preserved Vial; VS Sulphuric Acid Preserved Glass Bottle;
	DATE:	TIME: 10.15a	Z = Zinc acetate Preserved Bottle; E = EDTA Preserved Bottle; ST = Sterile Bottle; O = Other

Environmental Division
Melbourne
Work Order Reference
EM1807699

Telephone : + 61-3-8549 9600

An 10/5

AECOM PROJECT - CHAIN OF CUSTODY

CLIENT:	AECOM Services	LABORATORY:	ALS	All results to be provided in ESDAT format.
ADDRESS:	Level 28, 91 King William St Adelaide SA 5000	ADDRESS:	2-4 Westall Rd Springvale Vic, 3171	email address: adelaide@urscorp.com
PHONE NO:	08 7100 6400	PHONE NO:	03 8549 9600	Quote Number:
FAX NO:	08 7223 5499	FAX NO:		
PROJECT NAME:	NRWMF Site Characterisation	PROJECT MANAGER: melinda.morris@aecom.com 0408 387 495		
		SAMPLERS:		SIGNED:
PROJECT NO:	60565376.4.0			

FOR LABORATORY USE ONLY

COMMENTS: SPECIAL HANDLING/STORAGE

ANALYSIS REQUIRED

LAB ID	SITE	LOCATION	MATRIX	SAMPLE TYPE	SAMPLE ID		Date	CONTAINER TYPE AND PRESERVATIVE	FIELD FILTERED?	TOTAL NUMBER OF CONTAINERS	Please hold for further analysis to be emailed	Cation Exchange Capacity, Exchangeable Cations (Ca, Mg, Na, K) plus Exchangeable Sodium Percentage (ESP)	Metals – NEPM 15 (S-3), Total Fe & Mn	TRH/BTEXN/PAH/Phenols Suite (S-24)	OC/OPs Suite (S-12)	Triazine Pesticides (Atrazine and Simazine)	Carbonate & Total Organic Carbon	NEPM Screen for Soil Classification Suite (P-22)	Gross alpha and Gross beta (50 g bag)	Particle Size Distribution (500 g bag)	XRD with clay extraction (sub-sampled from 500 g bag)
11	NRWMF SCP	Lyndhurst	Soil	Primary	L07	0.5-0.6	26/04/2018	1 Jar, 1 Bag	NA	2	1										
12	NRWMF SCP	Lyndhurst	Soil	Primary	L07	1.6-1.7	26/04/2018	[redacted]	NA	2	1	1 Bag	1	Jar							
13	NRWMF SCP	Lyndhurst	Soil	Primary	L07	2.1-2.2	26/04/2018	[redacted]	NA	2	1										
14	NRWMF SCP	Lyndhurst	Soil	Primary	L06	0-0.2	26/04/2018	1 Jar, 1 Bag	NA	2	1										
15	NRWMF SCP	Lyndhurst	Soil	Primary	L06	1.0-1.1	26/04/2018	1 Jar, 1 Bag	NA	2	1										
16	NRWMF SCP	Lyndhurst	Soil	Primary	L06	2.0-2.1	26/04/2018	1 Jar, 1 Bag	NA	2	1										
17	NRWMF SCP	Lyndhurst	Soil	Primary	L08	0-0.2	26/04/2018	1 Jar, 1 Bag	NA	2	1										
18	NRWMF SCP	Lyndhurst	Soil	Primary	L08	0.3-0.5	26/04/2018	1 Jar, 1 Bag	NA	2	1										
19	NRWMF SCP	Lyndhurst	Soil	Primary	L08	1.0-1.1	26/04/2018	1 Jar, 1 Bag	NA	2	1										
20	NRWMF SCP	Lyndhurst	Soil	Primary	L08	2.2-2.3	26/04/2018	1 Jar, 1 Bag	NA	2	1										
	NRWMF SCP	Napandee	Soil	QA\QC	QC100	250418	25/04/2018	1 Jar, 1 Bag	NA	2	1										
	NRWMF SCP	Napandee	Soil	QA\QC	QC101	250418	25/04/2018	1 Jar, 1 Bag	NA	2	1										
	NRWMF SCP	Napandee	Soil	QA\QC	QC102	250418	25/04/2018	1 Jar, 1 Bag	NA	2	1										
	NRWMF SCP	Napandee	Soil	QA\QC	QC103	250418	25/04/2018	1 Jar, 1 Bag	NA	2	1										
	NRWMF SCP	Napandee	Soil	QA\QC	QC104	250418	25/04/2018	1 Jar, 1 Bag	NA	2	1										
										TOTAL											

Custody Seal? Y N NA	RELINQUISHED BY:	CHECKED:	CONTAINER TYPE AND PRESERVATIVE CODES
Samples Cold? Y N NA	DATE:	TIME:	P = Natural Plastic; N = Nitric Acid Preserved; C = Sodium Hydroxide Preserved; J = Solvent Washed Acid Rinsed Jar
Comments:	RECEIVED BY: Bharathi (ALS)	CHECKED:	S = Solvent Washed Acid Rinsed Glass Bottle; VC = Hydrochloric Acid Preserved Vial; VS Sulphuric Acid Preserved Glass Bottle;
	DATE:	TIME: 01/5/18 10.15 am	Z = Zinc acetate Preserved Bottle; E = EDTA Preserved Bottle; ST = Sterile Bottle; O = Other

AECOM PROJECT - CHAIN OF CUSTODY

CLIENT:	AECOM Services	LABORATORY:	ALS	All results to be provided in ESDAT format.	FOR LABORATORY USE ONLY
ADDRESS:	Level 28, 91 King William St Adelaide SA 5000	ADDRESS:	2-4 Westall Rd Springvale Vic, 3171	email address: adelaide@urscorp.com	
PHONE NO:	08 7100 6400	PHONE NO:	03 8549 9600	Quote Number:	
FAX NO:	08 7223 5499	FAX NO:			
PROJECT NAME:	NRWMF Site Characterisation	PROJECT MANAGER: melinda.morris@aecom.com 0408 387 495			
		SAMPLERS:		SIGNED:	
PROJECT NO:	60565376.4.0				

COMMENTS: SPECIAL HANDLING/STORAGE

ANALYSIS REQUIRED

LAB ID	SITE	LOCATION	MATRIX	SAMPLE TYPE	SAMPLE ID	Date	CONTAINER TYPE AND PRESERVATIVE	FIELD FILTERED?	TOTAL NUMBER OF CONTAINERS	Please hold for further analysis to be emailed	Cation Exchange Capacity, Exchangeable Cations (Ca, Mg, Na, K) plus Exchangeable Sodium Percentage (ESP)	Metals – NEPM 15 (S-3), Total Fe & Mn	TRH/BTEXN/PAH/Phenols Suite (S-24)	OC/OPs Suite (S-12)	Triazine Pesticides (Atrazine and Simazine)	Carbonate & Total Organic Carbon	NEPM Screen for Soil Classification Suite (P-22)	Gross alpha and Gross beta (50 g bag)	Particle Size Distribution (500 g bag)	XRD with clay extraction (sub-sampled from 500 g bag)
	NRWMF SCP	Napandee	Soil	QA\QC	QC105_250418	25/04/2018	1 Jar, 1 Bag	NA	2	1										
	NRWMF SCP	Napandee	Soil	QA\QC	QC106_250418	25/04/2018	1 Jar, 1 Bag	NA	2	1										
	NRWMF SCP	Napandee	Soil	QA\QC	QC107_250418	25/04/2018	1 Jar, 1 Bag	NA	2	1										
	NRWMF SCP	Napandee	Soil	QA\QC	QC108_250418	25/04/2018	1 Jar, 1 Bag	NA	2	1										
	NRWMF SCP	Napandee	Soil	QA\QC	QC109_250418	25/04/2018	1 Jar, 1 Bag	NA	2	1										
	NRWMF SCP	Napandee	Soil	QA\QC	QC110_250418	25/04/2018	1 Jar, 1 Bag	NA	2	1										
	NRWMF SCP	Napandee	Soil	QA\QC	QC111_250418	25/04/2018	1 Jar, 1 Bag	NA	2	1										
21	NRWMF SCP	Lyndhurst	Soil	QA\QC	QC209_260418	26/04/2018	1 Jar, 1 Bag	NA	2	1										
22	NRWMF SCP	Lyndhurst	Soil	QA\QC	QC210_260418	26/04/2018	1 Jar, 1 Bag	NA	2	1										
23	NRWMF SCP	Lyndhurst	Soil	QA\QC	QC207_260418	26/04/2018	1 Jar, 1 Bag	NA	2	1										
24	NRWMF SCP	Lyndhurst	Soil	QA\QC	QC208_260418	26/04/2018	1 Jar, 1 Bag	NA	2	1										
25	NRWMF SCP	Lyndhurst	Soil	QA\QC	QC205_260418	26/04/2018	1 Jar, 1 Bag	NA	2	1										
26	NRWMF SCP	Lyndhurst	Soil	QA\QC	QC206_260418	26/04/2018	1 Jar, 1 Bag	NA	2	1										
27	NRWMF SCP	Lyndhurst	Soil	QA\QC	QC203_260418	26/04/2018	1 Jar, 1 Bag	NA	2	1										
28	NRWMF SCP	Lyndhurst	Soil	QA\QC	QC204_260418	26/04/2018	1 Jar, 1 Bag	NA	2	1										
									TOTAL											

Custody Seal?	Y N NA	RELINQUISHED BY:		CHECKED:	
Samples Cold?	Y N NA	DATE:		TIME:	
Comments:		RECEIVED BY:	Bharath (ALS)	CHECKED:	01/5/16
		DATE:		TIME:	10.15am

CONTAINER TYPE AND PRESERVATIVE CODES

P = Natural Plastic; N = Nitric Acid Preserved; C = Sodium Hydroxide Preserved; J = Solvent Washed Acid Rinsed Jar

S = Solvent Washed Acid Rinsed Glass Bottle; VC = Hydrochloric Acid Preserved Vial; VS Sulphuric Acid Preserved Glass Bottle;

Z = Zinc acetate Preserved Bottle; E = EDTA Preserved Bottle; ST = Sterile Bottle; O = Other

AECOM PROJECT - CHAIN OF CUSTODY

CLIENT:	AECOM Services	LABORATORY:	ALS	All results to be provided in ESDAT format.
ADDRESS:	Level 28, 91 King William St Adelaide SA 5000	ADDRESS:	2-4 Westall Rd Springvale Vic, 3171	email address: adelaide@urscorp.com
PHONE NO:	08 7100 6400	PHONE NO:	03 8549 9600	Quote Number:
FAX NO:	08 7223 5499	FAX NO:		
PROJECT NAME:	NRWMF Site Characterisation	PROJECT MANAGER: melinda.morris@aecom.com 0408 387 495		
		SAMPLERS:		SIGNED:
PROJECT NO:	60565376.4.0			

FOR LABORATORY USE ONLY

COMMENTS: SPECIAL HANDLING/STORAGE

ANALYSIS REQUIRED

LAB ID	SITE	LOCATION	MATRIX	SAMPLE TYPE	SAMPLE ID		Date	CONTAINER TYPE AND PRESERVATIVE	FIELD FILTERED?	TOTAL NUMBER OF CONTAINERS	Please hold for further analysis to be emailed	Cation Exchange Capacity, Exchangeable Cations (Ca, Mg, Na, K) plus Exchangeable Sodium Percentage (ESP)	Metals – NEPM 15 (S-3), Total Fe & Mn	TRH/BTEXN/PAH/Phenols Suite (S-24)	OC/OPs Suite (S-12)	Triazine Pesticides (Atrazine and Simazine)	Carbonate & Total Organic Carbon	NEPM Screen for Soil Classification Suite (P-22)	Gross alpha and Gross beta (50 g bag)	Particle Size Distribution (500 g bag)	XRD with clay extraction (sub-sampled from 500 g bag)
29	NRWMF SCP	Lyndhurst	Soil	QA\QC	QC201	260418	26/04/2018	1 Jar, 1 Bag	NA	2	1										
30	NRWMF SCP	Lyndhurst	Soil	QA\QC	QC202	260418	26/04/2018	2 Jar, 1 Bag	NA	3	1										
31	NRWMF SCP	Lyndhurst	Soil	QA\QC	QC211	260418	26/04/2018	3 Jar, 1 Bag	NA	4	1										
32	NRWMF SCP	Lyndhurst	Soil	QA\QC	QC212	260418	26/04/2018	4 Jar, 1 Bag	NA	5	1										
										TOTAL											

Custody Seal ?	Y N NA	RELINQUISHED BY:		CHECKED:	CONTAINER TYPE AND PRESERVATIVE CODES
Samples Cold ?	Y N NA	DATE:		TIME:	P = Natural Plastic; N = Nitric Acid Preserved; C = Sodium Hydroxide Preserved; J = Solvent Washed Acid Rinsed Jar
Comments:		RECEIVED BY:	Bharathi (ALS)	CHECKED: 01/5/18	S = Solvent Washed Acid Rinsed Glass Bottle; VC = Hydrochloric Acid Preserved Vial; VS Sulphuric Acid Preserved Glass Bottle;
		DATE:		TIME: 10.15	Z = Zinc acetate Preserved Bottle; E = EDTA Preserved Bottle; ST = Sterile Bottle; O = Other

Peter Ravlic

From:	Rusk, James <james.rusk@aecom.com>
Sent:	Wednesday, 9 May 2018 2:31 PM
To:	Peter Ravlic
Cc:	Morris, Melinda
Subject:	URGENT: analysis of soil samples from batch EM1807107 for AECOM project 60565376 task 4.0
Attachments:	01052018132833-0001.pdf
Importance:	High

Hi Peter,

As discussed, please find requested analysis for samples from batch EM1807107 for urgent scheduling within the table below

Batch	Lab ID	Site	Sample ID^	Analysis	Date Sampled	Holding Time
EM1807107	Not assigned	Napandee	N07_0-0.2	pH, EC 1:5, EC saturated paste(EA032) CEC + exchangeable cations, ESP	25/4/18	pH, EC outside of holding times (7 days)
			QC104_250418			
			N07_1.5-1.6			
			N07_2.5-2.6			
			N11_0-0.2			
			N11_1.0-1.1			
			N11_2.0-2.1			
			N09_0-0.2			
			N09_1.4-1.5			
			N09_2.5-2.6			
EM1807107	Not assigned	Lyndhurst	10 L07_0-0.2	pH, EC 1:5, EC saturated paste,(EA032) CEC + exchangeable cations, ESP	26/4/18	pH, EC outside of holding times (7 days)
			11 L07_0.5-0.6			
			12 L07_1.5-1.6 1.6-1.7			
			13 L07_2.1-2.2			
			27 QC203_260418			
			17 L08_0-0.2			
			19 L08_1.0-1.1			
			20 L08_2.2-2.3			
			7 L10_0-0.2			
			8 L10_1.0-1.1			
			9 L10_2.0-2.2 2.1			

^ Within batch EM, before issuing the SRN please add a note to the COC and amend the sample IDs with Hxx_depth-depth to Nxx_depth-depth e.g. H06_0-0.2 to N06_0-0.2.

Can you please separate out the samples from Napandee (N) and Lyndhurst (L) and report in separate batches.

The QC samples relevant to each site are:
- Napandee QC100_250418 to QC111_250418
- Lyndhurst QC201_260418 to QC212_260418

Thanks and Regards,

James Rusk
Team Leader - Environment
D +61 8 7223 5531 M +61 411 778 163
james.rusk@aecom.com

AECOM
Level 28, 91 King William Street, Adelaide, SA 5000

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **EM1808010**	Page	: 1 of 3
Client	: **AECOM SERVICES PTY LTD**	Laboratory	: Environmental Division Melbourne
Contact	: MELINDA MORRIS	Contact	: Peter Ravlic
Address	: Level 28, 91 King William Street ADELAIDE SA, AUSTRALIA 5000	Address	: 4 Westall Rd Springvale VIC Australia 3171
Telephone	: +61 08 83661000	Telephone	: +61-3-8549 9600
Project	: 60565376	Date Samples Received	: 15-May-2018 14:15
Order number	: 60565376.4.0	Date Analysis Commenced	: 04-Jun-2018
C-O-C number	: ----	Issue Date	: 13-Jul-2018 16:41
Sampler	: TIM SMITH		
Site	: Lyndhurst		
Quote number	: EN/004/16		
No. of samples received	: 8		
No. of samples analysed	: 1		

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

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

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

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

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

Nathan Webb	Asbestos Identifier	Newcastle - Inorganics, Mayfield West, NSW

General Comments

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

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

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

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

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

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

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

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				L01_21.0-21.4	----	----	----	----
				09-May-2018 00:00	----	----	----	----
				EM1808010-008	--------	--------	--------	--------
				Result	----	----	----	----
EA150: Particle Sizing								
+75µm	----	1	%	42	----	----	----	----
+150µm	----	1	%	34	----	----	----	----
+300µm	----	1	%	24	----	----	----	----
+425µm	----	1	%	18	----	----	----	----
+600µm	----	1	%	12	----	----	----	----
+1180µm	----	1	%	4	----	----	----	----
+2.36mm	----	1	%	1	----	----	----	----
+4.75mm	----	1	%	<1	----	----	----	----
+9.5mm	----	1	%	<1	----	----	----	----
+19.0mm	----	1	%	<1	----	----	----	----
+37.5mm	----	1	%	<1	----	----	----	----
+75.0mm	----	1	%	<1	----	----	----	----
EA150: Soil Classification based on Particle Size								
Clay (<2 µm)	----	1	%	41	----	----	----	----
Silt (2-60 µm)	----	1	%	15	----	----	----	----
Sand (0.06-2.00 mm)	----	1	%	42	----	----	----	----
Gravel (>2mm)	----	1	%	2	----	----	----	----
Cobbles (>6cm)	----	1	%	<1	----	----	----	----
EA152: Soil Particle Density								
ø Soil Particle Density (Clay/Silt/Sand)	----	0.01	g/cm3	2.62	----	----	----	----

Environmental

QUALITY CONTROL REPORT

Work Order	: **EM1808010**	Page	: 1 of 3
Client	: **AECOM SERVICES PTY LTD**	Laboratory	: Environmental Division Melbourne
Contact	: MELINDA MORRIS	Contact	: Peter Ravlic
Address	: Level 28, 91 King William Street ADELAIDE SA, AUSTRALIA 5000	Address	: 4 Westall Rd Springvale VIC Australia 3171
Telephone	: +61 08 83661000	Telephone	: +61-3-8549 9600
Project	: 60565376	Date Samples Received	: 15-May-2018
Order number	: 60565376.4.0	Date Analysis Commenced	: 04-Jun-2018
C-O-C number	: ----	Issue Date	: 13-Jul-2018
Sampler	: TIM SMITH		
Site	: Lyndhurst		
Quote number	: EN/004/16		
No. of samples received	: 8		
No. of samples analysed	: 1		

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

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

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Method Blank (MB) and Laboratory Control Spike (LCS) Report; Recovery and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits

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

Nathan Webb	Asbestos Identifier	Newcastle - Inorganics, Mayfield West, NSW

General Comments

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

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

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

Key : Anonymous = Refers to samples which are not specifically part of this work order but formed part of the QC process lot
CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
RPD = Relative Percentage Difference
# = Indicates failed QC

Laboratory Duplicate (DUP) Report

The quality control term Laboratory Duplicate refers to a randomly selected intralaboratory split. Laboratory duplicates provide information regarding method precision and sample heterogeneity. The permitted ranges for the Relative Percent Deviation (RPD) of Laboratory Duplicates are specified in ALS Method QWI-EN/38 and are dependent on the magnitude of results in comparison to the level of reporting: Result < 10 times LOR: No Limit; Result between 10 and 20 times LOR: 0% - 50%; Result > 20 times LOR: 0% - 20%.

- **No Laboratory Duplicate (DUP) Results are required to be reported.**

Method Blank (MB) and Laboratory Control Spike (LCS) Report

The quality control term Method / Laboratory Blank refers to an analyte free matrix to which all reagents are added in the same volumes or proportions as used in standard sample preparation. The purpose of this QC parameter is to monitor potential laboratory contamination. The quality control term Laboratory Control Spike (LCS) refers to a certified reference material, or a known interference free matrix spiked with target analytes. The purpose of this QC parameter is to monitor method precision and accuracy independent of sample matrix. Dynamic Recovery Limits are based on statistical evaluation of processed LCS.

- **No Method Blank (MB) or Laboratory Control Spike (LCS) Results are required to be reported.**

Matrix Spike (MS) Report

The quality control term Matrix Spike (MS) refers to an intralaboratory split sample spiked with a representative set of target analytes. The purpose of this QC parameter is to monitor potential matrix effects on analyte recoveries. Static Recovery Limits as per laboratory Data Quality Objectives (DQOs). Ideal recovery ranges stated may be waived in the event of sample matrix interference.

- **No Matrix Spike (MS) or Matrix Spike Duplicate (MSD) Results are required to be reported.**

QA/QC Compliance Assessment to assist with Quality Review

Work Order	: **EM1808010**	Page	: 1 of 4
Client	: **AECOM SERVICES PTY LTD**	Laboratory	: Environmental Division Melbourne
Contact	: MELINDA MORRIS	Telephone	: +61-3-8549 9600
Project	: 60565376	Date Samples Received	: 15-May-2018
Site	: Lyndhurst	Issue Date	: 13-Jul-2018
Sampler	: TIM SMITH	No. of samples received	: 8
Order number	: 60565376.4.0	No. of samples analysed	: 1

This report is automatically generated by the ALS LIMS through interpretation of the ALS Quality Control Report and several Quality Assurance parameters measured by ALS. This automated reporting highlights any non-conformances, facilitates faster and more accurate data validation and is designed to assist internal expert and external Auditor review. Many components of this report contribute to the overall DQO assessment and reporting for guideline compliance.

Brief method summaries and references are also provided to assist in traceability.

Summary of Outliers

Outliers : Quality Control Samples

This report highlights outliers flagged in the Quality Control (QC) Report.

- **NO Method Blank value outliers occur.**
- **NO Duplicate outliers occur.**
- **NO Laboratory Control outliers occur.**
- **NO Matrix Spike outliers occur.**
- **For all regular sample matrices, NO surrogate recovery outliers occur.**

Outliers : Analysis Holding Time Compliance

- **NO Analysis Holding Time Outliers exist.**

Outliers : Frequency of Quality Control Samples

- **NO Quality Control Sample Frequency Outliers exist.**

Analysis Holding Time Compliance

If samples are identified below as having been analysed or extracted outside of recommended holding times, this should be taken into consideration when interpreting results.

This report summarizes extraction / preparation and analysis times and compares each with ALS recommended holding times (referencing USEPA SW 846, APHA, AS and NEPM) based on the sample container provided. Dates reported represent first date of extraction or analysis and preclude subsequent dilutions and reruns. A listing of breaches (if any) is provided herein.

Holding time for leachate methods (e.g. TCLP) vary according to the analytes reported. Assessment compares the leach date with the shortest analyte holding time for the equivalent soil method. These are: organics 14 days, mercury 28 days & other metals 180 days. A recorded breach does not guarantee a breach for all non-volatile parameters.

Holding times for ***VOC in soils*** vary according to analytes of interest. Vinyl Chloride and Styrene holding time is 7 days; others 14 days. A recorded breach does not guarantee a breach for all VOC analytes and should be verified in case the reported breach is a false positive or Vinyl Chloride and Styrene are not key analytes of interest/concern.

Matrix: **SOIL**

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

Method	*Sample Date*	*Extraction / Preparation*			*Analysis*		
Container / Client Sample ID(s)		*Date extracted*	*Due for extraction*	*Evaluation*	*Date analysed*	*Due for analysis*	*Evaluation*
EA150: Particle Sizing							
Snap Lock Bag (EA150H)							
L01_21.0-21.4	**09-May-2018**	**----**	----	----	**04-Jun-2018**	05-Nov-2018	✓
EA150: Soil Classification based on Particle Size							
Snap Lock Bag (EA150H)							
L01_21.0-21.4	**09-May-2018**	**----**	----	----	**04-Jun-2018**	05-Nov-2018	✓
EA152: Soil Particle Density							
Snap Lock Bag (EA152)							
L01_21.0-21.4	**09-May-2018**	**----**	----	----	**04-Jun-2018**	05-Nov-2018	✓

Quality Control Parameter Frequency Compliance

- **No Quality Control data available for this section.**

Brief Method Summaries

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the US EPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request. The following report provides brief descriptions of the analytical procedures employed for results reported in the Certificate of Analysis. Sources from which ALS methods have been developed are provided within the Method Descriptions.

Analytical Methods	Method	Matrix	Method Descriptions
Particle Size Analysis by Hydrometer	EA150H	SOIL	Particle Size Analysis by Hydrometer according to AS1289.3.6.3 - 2003
Soil Particle Density	* EA152	SOIL	Soil Particle Density by AS 1289.3.5.1-2006 : Methods of testing soils for engineering purposes - Soil classification tests - Determination of the soil particle density of a soil - Standard method

Preparation Methods	Method	Matrix	Method Descriptions
Dry and Pulverise (up to 100g)	GEO30B	SOIL	Samples are oven dried and pulverised to nominal 90% passing 75 µm.

ALS Environmental

SAMPLE RECEIPT NOTIFICATION (SRN)

Work Order	: **EM1808010**		
Client	: **AECOM SERVICES PTY LTD**	Laboratory	: Environmental Division Melbourne
Contact	: MELINDA MORRIS	Contact	: Peter Ravlic
Address	: Level 28, 91 King William Street ADELAIDE SA, AUSTRALIA 5000	Address	: 4 Westall Rd Springvale VIC Australia 3171
E-mail	: melinda.morris@aecom.com	E-mail	: peter.ravlic@alsglobal.com
Telephone	: +61 08 83661000	Telephone	: +61-3-8549 9600
Facsimile	: +61 08 83661001	Facsimile	: +61-3-8549 9626
Project	: 60565376	Page	: 1 of 2
Order number	: 60565376.4.0	Quote number	: EM2017URSSA0002 (EN/004/16)
C-O-C number	: ----	QC Level	: NEPM 2013 B3 & ALS QC Standard
Site	: Lyndhurst		
Sampler	: TIM SMITH		

Dates

Date Samples Received	: 15-May-2018 14:15	Issue Date	: 17-May-2018
Client Requested Due Date	: 18-Jun-2018	Scheduled Reporting Date	: **18-Jun-2018**

Delivery Details

Mode of Delivery	: Carrier	Security Seal	: Intact.
No. of coolers/boxes	: 2	Temperature	: 7.3°C - Ice present
Receipt Detail	:	No. of samples received / analysed	: 8 / 1

General Comments

- This report contains the following information:
  - Sample Container(s)/Preservation Non-Compliances
  - Summary of Sample(s) and Requested Analysis
  - Proactive Holding Time Report
  - Requested Deliverables
- **Please direct any queries related to sample condition / numbering / breakages to Client Services.**
- Sample Disposal - Aqueous (3 weeks), Solid (2 months) from receipt of samples.
- **Analytical work for this work order will be conducted at ALS Newcastle and ALS Perth (Minerals Division).**
- **Please refer to the Proactive Holding Time Report table below which summarises breaches of recommended holding times that have occurred prior to samples/instructions being received at the laboratory. The absence of this summary table indicates that all samples have been received within the recommended holding times for the analysis requested.**

Sample Container(s)/Preservation Non-Compliances

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

- **No sample container / preservation non-compliance exists.**

Summary of Sample(s) and Requested Analysis

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

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

Matrix: **SOIL**

Laboratory sample ID	Client sampling date / time	Client sample ID	(On Hold) SOIL No analysis requested	SOIL - EA150H/EA152 Particle Sizing with Hydrometer + Soil Particle	SOIL - MIS-SOL (Subcontracted) Miscellaneous Subcontracted Analysis (Solid)
EM1808010-001	05-May-2018 00:00	L05D_0.0-0.1	✓		
EM1808010-002	05-May-2018 00:00	L05D_4.0-4.1	✓		
EM1808010-003	05-May-2018 00:00	L05D_11.8-11.9	✓		
EM1808010-004	05-May-2018 00:00	L05D_24.0-24.1	✓		
EM1808010-005	05-May-2018 00:00	L05D_35.0-35.1	✓		
EM1808010-006	05-May-2018 00:00	L05D_50-50.1	✓		
EM1808010-007	05-May-2018 00:00	L05D_72-72.1	✓		
EM1808010-008	09-May-2018 00:00	L01_21.0-21.4		✓	✓

Proactive Holding Time Report

Sample(s) have been received within the recommended holding times for the requested analysis.

Requested Deliverables

ADELAIDE URS CORP

- *AU Certificate of Analysis - NATA (COA)	Email	adelaide@ursCORP.com
- *AU Interpretive QC Report - DEFAULT (Anon QCI Rep) (QCI)	Email	adelaide@ursCORP.com
- *AU QC Report - DEFAULT (Anon QC Rep) - NATA (QC)	Email	adelaide@ursCORP.com
- A4 - AU Sample Receipt Notification - Environmental HT (SRN)	Email	adelaide@ursCORP.com
- Attachment - Report (SUBCO)	Email	adelaide@ursCORP.com
- Chain of Custody (CoC) (COC)	Email	adelaide@ursCORP.com
- EDI Format - ENMRG (ENMRG)	Email	adelaide@ursCORP.com
- EDI Format - ESDAT (ESDAT)	Email	adelaide@ursCORP.com

ALL INVOICES

- A4 - AU Tax Invoice (INV)	Email	ap_customerservice.anz@aecom.com

MELINDA MORRIS

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

SAMPLE RECEIPT NOTIFICATION (SRN)

Work Order	: **EM1808010**		
Client	: **AECOM SERVICES PTY LTD**	Laboratory	: Environmental Division Melbourne
Contact	: MELINDA MORRIS	Contact	: Peter Ravlic
Address	: Level 28, 91 King William Street ADELAIDE SA, AUSTRALIA 5000	Address	: 4 Westall Rd Springvale VIC Australia 3171
E-mail	: melinda.morris@aecom.com	E-mail	: peter.ravlic@alsglobal.com
Telephone	: +61 08 83661000	Telephone	: +61-3-8549 9600
Facsimile	: +61 08 83661001	Facsimile	: +61-3-8549 9626
Project	: 60565376	Page	: 1 of 2
Order number	: 60565376.4.0	Quote number	: EM2017URSSA0002 (EN/004/16)
C-O-C number	: ----	QC Level	: NEPM 2013 B3 & ALS QC Standard
Site	: Lyndhurst		
Sampler	: TIM SMITH		

Dates

Date Samples Received	: 15-May-2018 14:15	Issue Date	: 22-Jun-2018
Client Requested Due Date	: 18-Jun-2018	Scheduled Reporting Date	: **13-Jul-2018**

Delivery Details

Mode of Delivery	: Carrier	Security Seal	: Intact.
No. of coolers/boxes	: 2	Temperature	: 7.3°C - Ice present
Receipt Detail	:	No. of samples received / analysed	: 8 / 1

General Comments

- This report contains the following information:
  - Sample Container(s)/Preservation Non-Compliances
  - Summary of Sample(s) and Requested Analysis
  - Proactive Holding Time Report
  - Requested Deliverables
- **The SRA date for this workorder has been extended due to pending results from Perth Minerals**
- **Please direct any queries related to sample condition / numbering / breakages to Client Services.**
- Sample Disposal - Aqueous (3 weeks), Solid (2 months) from receipt of samples.
- **Analytical work for this work order will be conducted at ALS Newcastle and ALS Perth (Minerals Division).**
- **Please refer to the Proactive Holding Time Report table below which summarises breaches of recommended holding times that have occurred prior to samples/instructions being received at the laboratory. The absence of this summary table indicates that all samples have been received within the recommended holding times for the analysis requested.**

Sample Container(s)/Preservation Non-Compliances

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

- **No sample container / preservation non-compliance exists.**

Summary of Sample(s) and Requested Analysis

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

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

Matrix: **SOIL**

Laboratory sample ID	Client sampling date / time	Client sample ID	(On Hold) SOIL No analysis requested	SOIL - EA150H/EA152 Particle Sizing with Hydrometer + Soil Particle	SOIL - GEO30B Dry and Pulverise @ 80-85C	SOIL - MIS-SOL (Subcontracted) Miscellaneous Subcontracted Analysis (Solid)
EM1808010-001	05-May-2018 00:00	L05D_0.0-0.1	✓			
EM1808010-002	05-May-2018 00:00	L05D_4.0-4.1	✓			
EM1808010-003	05-May-2018 00:00	L05D_11.8-11.9	✓			
EM1808010-004	05-May-2018 00:00	L05D_24.0-24.1	✓			
EM1808010-005	05-May-2018 00:00	L05D_35.0-35.1	✓			
EM1808010-006	05-May-2018 00:00	L05D_50-50.1	✓			
EM1808010-007	05-May-2018 00:00	L05D_72-72.1	✓			
EM1808010-008	09-May-2018 00:00	L01_21.0-21.4		✓	✓	✓

Proactive Holding Time Report

Sample(s) have been received within the recommended holding times for the requested analysis.

Requested Deliverables

ADELAIDE URS CORP		
- *AU Certificate of Analysis - NATA (COA)	Email	adelaide@ursCORP.com
- *AU Interpretive QC Report - DEFAULT (Anon QCI Rep) (QCI)	Email	adelaide@ursCORP.com
- *AU QC Report - DEFAULT (Anon QC Rep) - NATA (QC)	Email	adelaide@ursCORP.com
- A4 - AU Sample Receipt Notification - Environmental HT (SRN)	Email	adelaide@ursCORP.com
- Attachment - Report (SUBCO)	Email	adelaide@ursCORP.com
- Chain of Custody (CoC) (COC)	Email	adelaide@ursCORP.com
- EDI Format - ENMRG (ENMRG)	Email	adelaide@ursCORP.com
- EDI Format - ESDAT (ESDAT)	Email	adelaide@ursCORP.com
ALL INVOICES		
- A4 - AU Tax Invoice (INV)	Email	ap_customerservice.anz@aecom.com
MELINDA MORRIS		
- *AU Certificate of Analysis - NATA (COA)	Email	melinda.morris@aecom.com
- *AU Interpretive QC Report - DEFAULT (Anon QCI Rep) (QCI)	Email	melinda.morris@aecom.com
- *AU QC Report - DEFAULT (Anon QC Rep) - NATA (QC)	Email	melinda.morris@aecom.com
- A4 - AU Sample Receipt Notification - Environmental HT (SRN)	Email	melinda.morris@aecom.com
- A4 - AU Tax Invoice (INV)	Email	melinda.morris@aecom.com
- Attachment - Report (SUBCO)	Email	melinda.morris@aecom.com
- Chain of Custody (CoC) (COC)	Email	melinda.morris@aecom.com
- EDI Format - ENMRG (ENMRG)	Email	melinda.morris@aecom.com
- EDI Format - ESDAT (ESDAT)	Email	melinda.morris@aecom.com

~~FREIGHT~~

AECOM PROJECT - CHAIN OF CUSTODY

CLIENT:	AECOM Services	LABORATORY:	ALS	All results to be provided in ESDAT format.	FOR LABORATORY USE ONLY
ADDRESS:	Level 28, 91 King William St, Adelaide, SA 5000	ADDRESS:	2-4 Westall Rd, Springvale, Vic, 3171	email address: adelaide@urscorp.com	
PHONE NO:	08 7100 6400	PHONE NO:	03 8549 9600	Quote Number:	
FAX NO:	08 7223 5499	FAX NO:			
PROJECT NAME:	NRWMF Site Characterisation	PROJECT MANAGER:	melinda.morris@aecom.com 0408 387 495		
		SAMPLERS:	Tim Smith	SIGNED: JR	
PROJECT NO:	60565376.4.0				

COMMENTS: SPECIAL HANDLING/STORAGE: Please separate Wyandee + Lyndhurst into separate batches

ANALYSIS REQUIRED

LAB ID	SITE	LOCATION	MATRIX	SAMPLE TYPE	SAMPLE ID		Date	CONTAINER TYPE AND PRESERVATIVE	FIELD FILTERED?	TOTAL NUMBER OF CONTAINERS	Cation Exchange Capacity, Exchangeable Cations (Ca, Mg, Na, K) plus Exchangeable Sodium Percentage (ESP)	Metals – NEPM 15 (S-3), Total Fe & Mn	TRH/BTEXN/PAH/Phenols Suite (S-24)	OC/OPs Suite (S-12)	Triazine Pesticides (Atrazine and Simazine)	Carbonate & Total Organic Carbon	NEPM Screen for Soil Classification Suite (P-22)	Gross alpha and Gross beta (50 g bag)	Particle Size Distribution (500 g bag)	XRD with clay extraction (sub-sampled from 500 g bag)	HOLD
	NAPANDEE	KIMBA	SOIL	PRIMARY	N03	0.0-0.1	1-5-18	1J, 2B	–	3											X
	"	"	"	"	N03	27-27.4	2-5-18	1J, 1B	–	2									X	X	
	"	"	"	"	N04	0.0-0.1	2-5-18	1J, 2B	–	3											X
	[illegible]	"	"	"	N04	1.0-1.1	2-5-18	1J, 1B	–	2											X
	LYNDHURST	"	"	"	L05D	0.0-0.1	5-5-18	1J, 2B	–	3											X
	"	"	"	"	L05D	4.0-4.1	5-5-18	1J, 1B	–	2											X
	"	"	"	"	L05D	11.3-11.9	5-5-18	1J, 1B	–	2											X
	"	"	"	"	L05D	24.0-24.1	5-5-18	1J, 1B	–	2											X
	"	"	"	"	L05D	35.0-35.1	5-5-18	1J, 1B	–	2											X
	"	"	"	"	L05D	50-50.1	5-5-18	1J, 1B	–	2											X
	"	"	"	"	L05D	72-72.1	5/5	1J, 1B	–	2											X
	"	"	"	"	L01	21.0-21.4	9/5	1J, 1B	–	2									X	X	
										TOTAL											

RELINQUISHED BY: JR		CHECKED: JR	
DATE: 14/5/18		TIME: 0900	
RECEIVED BY:		CHECKED:	
DATE:		TIME:	

CONTAINER TYPE AND PRESERVATIVE CODES
P = Natural Plastic; N = Nitric Acid Preserved; C = Sodium Hydroxide Preserved; J = Solvent Washed Acid Rinsed Jar
S = Solvent Washed Acid Rinsed Glass Bottle; VC = Hydrochloric Acid Preserved Vial; VS Sulphuric Acid Preserved Glass Bottle;
Z = Zinc acetate Preserved Bottle; E = EDTA Preserved Bottle; ST = Sterile Bottle; O = Other

Marvin (ALS)
15/5, 14:45

J = JAR
B = BAG LARGE & SMALL

Environmental Division
Melbourne
Work Order Reference
EM1808010

Telephone : + 61-3-8549 9600

~~FREIGHT~~

AECOM PROJECT - CHAIN OF CUSTODY

CLIENT:	AECOM Services	LABORATORY:	ALS
ADDRESS:	Level 28, 91 King William St Adelaide SA 5000	ADDRESS:	2-4 Westall Rd Springvale Vic, 3171
PHONE NO:	08 7100 6400	PHONE NO:	03 8549 9600
FAX NO:	08 7223 5499	FAX NO:	
PROJECT NAME:	NRWMF Site Characterisation	PROJECT MANAGER:	melinda.morris@aecom.com 0408 387 495
PROJECT NO:	60565376.4.0	SAMPLERS:	Tim Smith
		SIGNED:	JR

All results to be provided in ESDAT format.
email address: adelaide@urscorp.com
Quote Number:

FOR LABORATORY USE ONLY

COMMENTS: SPECIAL HANDLING/STORAGE: Please separate Napandee + Lyndhurst into separate batches

ANALYSIS REQUIRED

SITE	LOCATION	MATRIX	SAMPLE TYPE	SAMPLE ID		Date	CONTAINER TYPE AND PRESERVATIVE	FIELD FILTERED?	TOTAL NUMBER OF CONTAINERS	Cation Exchange Capacity, Exchangeable Cations (Ca, Mg, Na, K) plus Exchangeable Sodium Percentage (ESP)	Metals – NEPM 15 (S-3), Total Fe & Mn	TRH/BTEXN/PAH/Phenols Suite (S-24)	OC/OPs Suite (S-12)	Triazine Pesticides (Atrazine and Simazine)	Carbonate & Total Organic Carbon	NEPM Screen for Soil Classification Suite (P-22)	Gross alpha and Gross beta (50 g bag)	Particle Size Distribution (500 g bag)	XRD with clay extraction (sub-sampled from 500 g bag)	HOLD
NAPANDEE	KIMBA	SOIL	PRIMARY	N03	0.0-0.1	1-5-18	J, 2B	–	3											X
"	"	"	"	N03	27-27.4	2-5-18	J, 1B	–	2									X	X	
"	"	"	"	N04	0.0-0.1	2-5-18	J, 2B	–	3											X
"	"	"	"	N04	1.0-1.1	2-5-18	J, 1B	–	2											X
LYNDHURST	"	"	"	L05D	0.0-0.1	5-5-18	J, 2B	–	3											X
"	"	"	"	L05D	4.0-4.1	5-5-18	J, 1B	–	2											X
"	"	"	"	L05D	11.8-11.9	5-5-18	J, 1B	–	2											X
"	"	"	"	L05D	24.0-24.1	5-5-18	J, 1B	–	2											X
"	"	"	"	L05D	35.0-35.1	5-5-18	J, 1B	–	2											X
"	"	"	"	L05D	50-50.1	5-5-18	J, 1B	–	2											X
"	"	"	"	L05D	72-72.1	5/5	J, 1B	–	2											X
"	"	"	"	L01	21.0-21.4	9/5	J, 1B	–	2									X	X	

TOTAL

RELINQUISHED BY: JR	CHECKED: JR	RECEIVED BY:	CHECKED:
DATE: 14/5/18	TIME: 0900	DATE:	TIME:

CONTAINER TYPE AND PRESERVATIVE CODES
P = Natural Plastic; N = Nitric Acid Preserved; C = Sodium Hydroxide Preserved; J = Solvent Washed Acid Rinsed Jar
S = Solvent Washed Acid Rinsed Glass Bottle; VC = Hydrochloric Acid Preserved Vial; VS Sulphuric Acid Preserved Glass Bottle;
Z = Zinc acetate Preserved Bottle; E = EDTA Preserved Bottle; ST = Sterile Bottle; O = Other

Marra (ALS)
15/5, 14:45

J = JAR
B = BAG LARGE + SMALL

Environmental Division
Melbourne
Work Order Reference
EM1808010

Telephone : + 61-3-8549 9600

Peter Ravlic

From:	Morris, Melinda <melinda.morris@aecom.com>
Sent:	Thursday, 17 May 2018 12:13 PM
To:	Peter Ravlic
Cc:	Smith, Tim (Adelaide); Kieren Burns
Subject:	RE: NRWMF Site
Follow Up Flag:	Follow up
Flag Status:	Flagged

Hi Peter,

Please get both analyses done. Can we get PSD + Hydrometer if there is enough sample and the XRD (not clay content with QUT which was ridiculously expensive).

Call me if you need further clarification.

Thanks heaps for checking.

M.

Melinda Morris
Associate Director – Hydrogeologist
D +61 8 7223 5543 M +61 408 387 495
melinda.morris@aecom.com

AECOM
Level 28, 91 King William Street, Adelaide, SA 5000
T +61 8 7223 5400 F +61 8 7223 5499
aecom.com

From: Peter Ravlic [mailto:peter.ravlic@alsglobal.com]
Sent: Thursday, 17 May 2018 11:36 AM
To: Morris, Melinda
Cc: Smith, Tim (Adelaide); Kieren Burns
Subject: NRWMF Site

Hi Melinda

We rec'd another batch of samples (2 soils) attached for PSD & XRD analysis

Are we just to proceed with the PSD analysis for now

Thanks

Regards

Peter Ravlic
Client Services – Springvale

Certificate of Analysis

ALS Laboratory Group Pty Ltd
5/585 Maitland Road
Mayfield West, NSW 2304
pH 02 4014 2500
fax 02 4968 0349
samples.newcastle@alsenviro.com

ALS Environmental

Newcastle, NSW

CLIENT: Melinda Morris

DATE REPORTED: 12-Jun-2018

COMPANY: AECOM Services Pty Ltd

DATE RECEIVED: 15-May-2018

ADDRESS: Level 28, 91 King William Street
Adelaide
SA, Australia 5000

REPORT NO: EM1808010-008 / PSD

PROJECT: 60565376

SAMPLE ID: L01_21.0-21.4

Particle Size Distribution

Particle Size (mm)	Percent Passing
4.75	100%
2.36	99%
1.18	96%
0.600	88%
0.425	82%
0.300	76%
0.150	66%
0.075	58%
Particle Size (microns)	
70	57%
49	54%
37	52%
18	49%
9	45%
5	43%
1	41%

Samples analysed as received.

Median Particle Size (mm)*	0.026

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

Sample Comments:

Analysed: 1-Jun-18

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description: FINES, SAND, STONE

Dispersion Method Shaker

Test Method: AS1289.3.6.3 2003

Hydrometer Type ASTM E100

Soil Particle Density (<2.36mm) 2.62 g/cm3

Nathan Webb
Laboratory Coordinator
Authorised Signatory

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **EM1808425**	Page	: 1 of 4
Client	: **AECOM SERVICES PTY LTD**	Laboratory	: Environmental Division Melbourne
Contact	: MELINDA MORRIS	Contact	: Peter Ravlic
Address	: Level 28, 91 King William Street ADELAIDE SA, AUSTRALIA 5000	Address	: 4 Westall Rd Springvale VIC Australia 3171
Telephone	: +61 08 83661000	Telephone	: +61-3-8549 9600
Project	: 60565376	Date Samples Received	: 23-May-2018 11:40
Order number	: 60565376.4.0	Date Analysis Commenced	: 25-May-2018
C-O-C number	: ----	Issue Date	: 04-Jul-2018 10:31
Sampler	: JT		
Site	: NRWMF Site Charcterisation		
Quote number	: EN/004/16		
No. of samples received	: 1		
No. of samples analysed	: 1		

NATA

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

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

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

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

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

Dilani Fernando	Senior Inorganic Chemist	Melbourne Inorganics, Springvale, VIC
Nathan Webb	Asbestos Identifier	Newcastle - Inorganics, Mayfield West, NSW
Nikki Stepniewski	Senior Inorganic Instrument Chemist	Melbourne Inorganics, Springvale, VIC
Sarah Ashworth	Laboratory Manager - Brisbane	Brisbane External Subcontracting, Stafford, QLD

General Comments

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

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

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

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

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

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

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

- Radiological work undertaken by ALS Laboratory Group (Ceska Lipa) under CAI accreditation No. L1163. Report No. PR1859388. NATA and CAI accreditations' are both recognised under ILAC.
- ED037 (Alkalinity): NATA accreditation does not cover the performance of this service.
- Radiological work undertaken by ALS Laboratory Group (Ceska Lipa) under CAI accreditation No. L1163. Report No. $$. NATA and CAI accreditations' are both recognised under ILAC.
- ED007 and ED008: When Exchangeable Al is reported from these methods, it should be noted that Rayment & Lyons (2011) suggests Exchange Acidity by 1M KCl - Method 15G1 (ED005) is a more suitable method for the determination of exchange acidity (H+ + Al3+).

Analytical Results

Sub-Matrix: **SOIL** (Matrix: **SOIL**)			[illegible]	**L05S_13.5-13.6**	----	----	----	----
			[illegible]	17-May-2018 00:00	----	----	----	----
[illegible]	[illegible]	[illegible]	[illegible]	**EM1808425-001**	--------	--------	--------	--------
				Result	----	----	----	----
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	1.0	%	**14.2**	----	----	----	----
EA150: Particle Sizing								
+75µm	----	1	%	**54**	----	----	----	----
+150µm	----	1	%	**49**	----	----	----	----
+300µm	----	1	%	**38**	----	----	----	----
+425µm	----	1	%	**28**	----	----	----	----
+600µm	----	1	%	**18**	----	----	----	----
+1180µm	----	1	%	**8**	----	----	----	----
+2.36mm	----	1	%	**4**	----	----	----	----
+4.75mm	----	1	%	**2**	----	----	----	----
+9.5mm	----	1	%	<1	----	----	----	----
+19.0mm	----	1	%	<1	----	----	----	----
+37.5mm	----	1	%	<1	----	----	----	----
+75.0mm	----	1	%	<1	----	----	----	----
EA150: Soil Classification based on Particle Size								
Clay (<2 µm)	----	1	%	**39**	----	----	----	----
Silt (2-60 µm)	----	1	%	**6**	----	----	----	----
Sand (0.06-2.00 mm)	----	1	%	**50**	----	----	----	----
Gravel (>2mm)	----	1	%	**5**	----	----	----	----
Cobbles (>6cm)	----	1	%	<1	----	----	----	----
EA152: Soil Particle Density								
ø **Soil Particle Density (Clay/Silt/Sand)**	----	0.01	g/cm3	**2.63**	----	----	----	----
ED008: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	**0.4**	----	----	----	----
Exchangeable Magnesium	----	0.1	meq/100g	**1.6**	----	----	----	----
Exchangeable Potassium	----	0.1	meq/100g	**0.4**	----	----	----	----
Exchangeable Sodium	----	0.1	meq/100g	**1.4**	----	----	----	----
Exchangeable Sodium Percent	----	0.1	%	**37.4**	----	----	----	----
Cation Exchange Capacity	----	0.1	meq/100g	**3.8**	----	----	----	----
ED037: Alkalinity								
Total Alkalinity as CaCO3	----	1	mg/kg	**1**	----	----	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/kg	**1**	----	----	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/kg	<1	----	----	----	----
EG005T: Total Metals by ICP-AES								

Analytical Results

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

				L05S_13.5-13.6	----	----	----	----
				17-May-2018 00:00	----	----	----	----
				EM1808425-001	--------	--------	--------	--------
				Result	----	----	----	----
EG005T: Total Metals by ICP-AES - Continued								
Arsenic	7440-38-2	5	mg/kg	<5	----	----	----	----
Barium	7440-39-3	10	mg/kg	**50**	----	----	----	----
Beryllium	7440-41-7	1	mg/kg	<1	----	----	----	----
Boron	7440-42-8	50	mg/kg	<50	----	----	----	----
Cadmium	7440-43-9	1	mg/kg	<1	----	----	----	----
Chromium	7440-47-3	2	mg/kg	**12**	----	----	----	----
Cobalt	7440-48-4	2	mg/kg	<2	----	----	----	----
Copper	7440-50-8	5	mg/kg	**10**	----	----	----	----
Iron	7439-89-6	50	mg/kg	**21600**	----	----	----	----
Lead	7439-92-1	5	mg/kg	<5	----	----	----	----
Manganese	7439-96-5	5	mg/kg	**14**	----	----	----	----
Nickel	7440-02-0	2	mg/kg	<2	----	----	----	----
Selenium	7782-49-2	5	mg/kg	<5	----	----	----	----
Vanadium	7440-62-2	5	mg/kg	**46**	----	----	----	----
Zinc	7440-66-6	5	mg/kg	<5	----	----	----	----
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.1	mg/kg	<0.1	----	----	----	----
EP004: Organic Matter								
Organic Matter	----	0.5	%	<0.5	----	----	----	----
Total Organic Carbon	----	0.5	%	<0.5	----	----	----	----
Radionuclides / Activity								
Gross alpha	----	500	Bq/kg DW	**1790**	----	----	----	----
Gross beta	----	500	Bq/kg DW	**840**	----	----	----	----

ALS Environmental

QUALITY CONTROL REPORT

Work Order	: **EM1808425**	Page	: 1 of 5
Client	: **AECOM SERVICES PTY LTD**	Laboratory	: Environmental Division Melbourne
Contact	: MELINDA MORRIS	Contact	: Peter Ravlic
Address	: Level 28, 91 King William Street ADELAIDE SA, AUSTRALIA 5000	Address	: 4 Westall Rd Springvale VIC Australia 3171
Telephone	: +61 08 83661000	Telephone	: +61-3-8549 9600
Project	: 60565376	Date Samples Received	: 23-May-2018
Order number	: 60565376.4.0	Date Analysis Commenced	: 25-May-2018
C-O-C number	: ----	Issue Date	: 04-Jul-2018
Sampler	: JT		
Site	: NRWMF Site Charcterisation		
Quote number	: EN/004/16		
No. of samples received	: 1		
No. of samples analysed	: 1		

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

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

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Method Blank (MB) and Laboratory Control Spike (LCS) Report; Recovery and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits

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

Dilani Fernando	Senior Inorganic Chemist	Melbourne Inorganics, Springvale, VIC
Nathan Webb	Asbestos Identifier	Newcastle - Inorganics, Mayfield West, NSW
Nikki Stepniewski	Senior Inorganic Instrument Chemist	Melbourne Inorganics, Springvale, VIC
Sarah Ashworth	Laboratory Manager - Brisbane	Brisbane External Subcontracting, Stafford, QLD

General Comments

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

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

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

Key : Anonymous = Refers to samples which are not specifically part of this work order but formed part of the QC process lot
CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
RPD = Relative Percentage Difference
\# = Indicates failed QC

Laboratory Duplicate (DUP) Report

The quality control term Laboratory Duplicate refers to a randomly selected intralaboratory split. Laboratory duplicates provide information regarding method precision and sample heterogeneity. The permitted ranges for the Relative Percent Deviation (RPD) of Laboratory Duplicates are specified in ALS Method QWI-EN/38 and are dependent on the magnitude of results in comparison to the level of reporting: Result < 10 times LOR: No Limit; Result between 10 and 20 times LOR: 0% - 50%; Result > 20 times LOR: 0% - 20%.

Sub-Matrix: **SOIL**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
EA055: Moisture Content (Dried @ 105-110°C) (QC Lot: 1677106)									
EM1808425-001	L05S_13.5-13.6	EA055: Moisture Content	----	0.1	%	14.2	15.9	11.6	0% - 50%
EM1808522-001	Anonymous	EA055: Moisture Content	----	0.1	%	5.4	5.4	0.00	No Limit
ED008: Exchangeable Cations (QC Lot: 1680782)									
EM1808425-001	L05S_13.5-13.6	ED008: Exchangeable Sodium Percent	----	0.1	%	37.4	36.3	2.96	0% - 20%
		ED008: Exchangeable Calcium	----	0.1	meq/100g	0.4	0.4	0.00	No Limit
		ED008: Exchangeable Magnesium	----	0.1	meq/100g	1.6	1.5	0.00	0% - 50%
		ED008: Exchangeable Potassium	----	0.1	meq/100g	0.4	0.3	0.00	No Limit
		ED008: Exchangeable Sodium	----	0.1	meq/100g	1.4	1.3	10.5	0% - 50%
		ED008: Cation Exchange Capacity	----	0.1	meq/100g	3.8	3.5	7.53	0% - 20%
ED037: Alkalinity (QC Lot: 1683641)									
EM1808425-001	L05S_13.5-13.6	ED037: Total Alkalinity as CaCO3	----	1	mg/kg	1	<1	0.00	No Limit
EG005T: Total Metals by ICP-AES (QC Lot: 1704069)									
EM1808425-001	L05S_13.5-13.6	EG005T: Barium	7440-39-3	10	mg/kg	50	30	60.4	No Limit
EM1808425-001	L05S_13.5-13.6	EG005T: Beryllium	7440-41-7	1	mg/kg	<1	<1	0.00	No Limit
		EG005T: Cadmium	7440-43-9	1	mg/kg	<1	<1	0.00	No Limit
		EG005T: Chromium	7440-47-3	2	mg/kg	12	13	0.00	No Limit
		EG005T: Cobalt	7440-48-4	2	mg/kg	<2	<2	0.00	No Limit
		EG005T: Nickel	7440-02-0	2	mg/kg	<2	<2	0.00	No Limit
		EG005T: Arsenic	7440-38-2	5	mg/kg	<5	<5	0.00	No Limit
		EG005T: Copper	7440-50-8	5	mg/kg	10	9	0.00	No Limit
		EG005T: Lead	7439-92-1	5	mg/kg	<5	<5	0.00	No Limit
		EG005T: Manganese	7439-96-5	5	mg/kg	14	12	19.2	No Limit
		EG005T: Selenium	7782-49-2	5	mg/kg	<5	<5	0.00	No Limit
		EG005T: Vanadium	7440-62-2	5	mg/kg	46	59	23.5	0% - 50%

Sub-Matrix: **SOIL**

Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
				Laboratory Duplicate (DUP) Report					
EG005T: Total Metals by ICP-AES (QC Lot: 1704069) - continued									
EM1808425-001	L05S_13.5-13.6	EG005T: Zinc	7440-66-6	5	mg/kg	<5	<5	0.00	No Limit
		EG005T: Boron	7440-42-8	50	mg/kg	<50	<50	0.00	No Limit
		EG005T: Iron	7439-89-6	50	mg/kg	21600	24200	11.4	0% - 20%
EM1808830-032	Anonymous	EG005T: Beryllium	7440-41-7	1	mg/kg	<1	<1	0.00	No Limit
		EG005T: Cadmium	7440-43-9	1	mg/kg	<1	<1	0.00	No Limit
		EG005T: Barium	7440-39-3	10	mg/kg	180	130	38.1	0% - 50%
		EG005T: Chromium	7440-47-3	2	mg/kg	7	5	25.0	No Limit
		EG005T: Cobalt	7440-48-4	2	mg/kg	8	6	26.6	No Limit
		EG005T: Nickel	7440-02-0	2	mg/kg	9	7	26.4	No Limit
		EG005T: Arsenic	7440-38-2	5	mg/kg	<5	<5	0.00	No Limit
		EG005T: Copper	7440-50-8	5	mg/kg	30	24	21.7	No Limit
		EG005T: Lead	7439-92-1	5	mg/kg	265	219	19.1	0% - 20%
		EG005T: Manganese	7439-96-5	5	mg/kg	278	252	9.99	0% - 20%
		EG005T: Selenium	7782-49-2	5	mg/kg	<5	<5	0.00	No Limit
		EG005T: Vanadium	7440-62-2	5	mg/kg	24	19	23.3	No Limit
		EG005T: Zinc	7440-66-6	5	mg/kg	174	160	8.31	0% - 20%
		EG005T: Boron	7440-42-8	50	mg/kg	<50	<50	0.00	No Limit
		EG005T: Iron	7439-89-6	50	mg/kg	19300	17600	9.49	0% - 20%
EG035T: Total Recoverable Mercury by FIMS (QC Lot: 1704070)									
EM1808425-001	L05S_13.5-13.6	EG035T: Mercury	7439-97-6	0.1	mg/kg	<0.1	<0.1	0.00	No Limit
EM1808830-032	Anonymous	EG035T: Mercury	7439-97-6	0.1	mg/kg	1.3	1.4	8.82	0% - 50%
EP004: Organic Matter (QC Lot: 1698378)									
EM1808772-029	Anonymous	EP004: Organic Matter	----	0.5	%	<0.5	0.5	0.00	No Limit
		EP004: Total Organic Carbon	----	0.5	%	<0.5	<0.5	0.00	No Limit
EM1808772-036	Anonymous	EP004: Organic Matter	----	0.5	%	<0.5	<0.5	0.00	No Limit
		EP004: Total Organic Carbon	----	0.5	%	<0.5	<0.5	0.00	No Limit

Method Blank (MB) and Laboratory Control Spike (LCS) Report

The quality control term Method / Laboratory Blank refers to an analyte free matrix to which all reagents are added in the same volumes or proportions as used in standard sample preparation. The purpose of this QC parameter is to monitor potential laboratory contamination. The quality control term Laboratory Control Spike (LCS) refers to a certified reference material, or a known interference free matrix spiked with target analytes. The purpose of this QC parameter is to monitor method precision and accuracy independent of sample matrix. Dynamic Recovery Limits are based on statistical evaluation of processed LCS.

Sub-Matrix: **SOIL**

				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Recovery Limits (%)	
Method: Compound	CAS Number	LOR	Unit	Result	Concentration	LCS	Low	High
ED008: Exchangeable Cations (QCLot: 1680782)								
ED008: Exchangeable Calcium	----	0.1	meq/100g	<0.1	3.45 meq/100g	102	80	120
ED008: Exchangeable Magnesium	----	0.1	meq/100g	<0.1	1.09 meq/100g	92.5	80	120
ED008: Exchangeable Potassium	----	0.1	meq/100g	<0.1	0.609 meq/100g	109	80	120
ED008: Exchangeable Sodium	----	0.1	meq/100g	<0.1	0.347 meq/100g	92.8	80	120
ED008: Cation Exchange Capacity	----	0.1	meq/100g	<0.1	----	----	----	----
ED037: Alkalinity (QCLot: 1683641)								
ED037: Total Alkalinity as CaCO3	----	----	mg/kg	----	200 mg/kg	97.0	92	107
EG005T: Total Metals by ICP-AES (QCLot: 1704069)								
EG005T: Arsenic	7440-38-2	5	mg/kg	<5	21.7 mg/kg	92.1	79	113
EG005T: Barium	7440-39-3	10	mg/kg	<10	143 mg/kg	96.0	79	110
EG005T: Beryllium	7440-41-7	1	mg/kg	<1	5.63 mg/kg	100	85	120
EG005T: Boron	7440-42-8	50	mg/kg	<50	33.2 mg/kg	117	82	126
EG005T: Cadmium	7440-43-9	1	mg/kg	<1	4.64 mg/kg	85.6	85	109
EG005T: Chromium	7440-47-3	2	mg/kg	<2	43.9 mg/kg	90.6	83	109
EG005T: Cobalt	7440-48-4	2	mg/kg	<2	16 mg/kg	91.1	78	112
EG005T: Copper	7440-50-8	5	mg/kg	<5	32 mg/kg	85.9	78	108
EG005T: Iron	7439-89-6	50	mg/kg	<50	8400 mg/kg	99.5	90	110
EG005T: Lead	7439-92-1	5	mg/kg	<5	40 mg/kg	88.4	78	106
EG005T: Manganese	7439-96-5	5	mg/kg	<5	130 mg/kg	94.4	82	107
EG005T: Nickel	7440-02-0	2	mg/kg	<2	55 mg/kg	93.0	82	111
EG005T: Selenium	7782-49-2	5	mg/kg	<5	5.37 mg/kg	97.0	93	109
EG005T: Vanadium	7440-62-2	5	mg/kg	<5	29.6 mg/kg	91.1	80	109
EG005T: Zinc	7440-66-6	5	mg/kg	<5	60.8 mg/kg	90.7	82	111
EG035T: Total Recoverable Mercury by FIMS (QCLot: 1704070)								
EG035T: Mercury	7439-97-6	0.1	mg/kg	<0.1	2.57 mg/kg	82.2	77	104
EP004: Organic Matter (QCLot: 1698378)								
EP004: Organic Matter	----	0.5	%	<0.5	77 %	81.7	81	112
EP004: Total Organic Carbon	----	0.5	%	<0.5	43.5 %	83.8	83	114

Matrix Spike (MS) Report

The quality control term Matrix Spike (MS) refers to an intralaboratory split sample spiked with a representative set of target analytes. The purpose of this QC parameter is to monitor potential matrix effects on analyte recoveries. Static Recovery Limits as per laboratory Data Quality Objectives (DQOs). Ideal recovery ranges stated may be waived in the event of sample matrix interference.

Sub-Matrix: **SOIL**

Matrix Spike (MS) Report

Sub-Matrix: **SOIL**

				Matrix Spike (MS) Report			
				Spike	SpikeRecovery(%)	Recovery Limits (%)	
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Concentration	MS	Low	High
EG005T: Total Metals by ICP-AES (QCLot: 1704069)							
EM1808830-024	Anonymous	EG005T: Arsenic	7440-38-2	50 mg/kg	95.9	78	124
		EG005T: Barium	7440-39-3	50 mg/kg	77.6	71	135
		EG005T: Beryllium	7440-41-7	50 mg/kg	99.9	85	125
		EG005T: Cadmium	7440-43-9	50 mg/kg	90.7	84	116
		EG005T: Chromium	7440-47-3	50 mg/kg	90.4	79	121
		EG005T: Copper	7440-50-8	50 mg/kg	97.1	82	124
		EG005T: Lead	7439-92-1	50 mg/kg	105	76	124
		EG005T: Manganese	7439-96-5	50 mg/kg	# Not Determined	68	136
		EG005T: Nickel	7440-02-0	50 mg/kg	90.2	78	120
		EG005T: Selenium	7782-49-2	50 mg/kg	86.2	71	125
		EG005T: Vanadium	7440-62-2	50 mg/kg	93.9	76	124
		EG005T: Zinc	7440-66-6	50 mg/kg	105	74	128
EG035T: Total Recoverable Mercury by FIMS (QCLot: 1704070)							
EM1808830-024	Anonymous	EG035T: Mercury	7439-97-6	5 mg/kg	89.0	76	116
EP004: Organic Matter (QCLot: 1698378)							
EM1808772-030	Anonymous	EP004: Organic Matter	----	1.05 %	70.8	70	120
		EP004: Total Organic Carbon	----	0.61 %	70.5	70	120

QA/QC Compliance Assessment to assist with Quality Review

Work Order	: **EM1808425**	Page	: 1 of 6
Client	: **AECOM SERVICES PTY LTD**	Laboratory	: Environmental Division Melbourne
Contact	: MELINDA MORRIS	Telephone	: +61-3-8549 9600
Project	: 60565376	Date Samples Received	: 23-May-2018
Site	: NRWMF Site Charcterisation	Issue Date	: 04-Jul-2018
Sampler	: JT	No. of samples received	: 1
Order number	: 60565376.4.0	No. of samples analysed	: 1

This report is automatically generated by the ALS LIMS through interpretation of the ALS Quality Control Report and several Quality Assurance parameters measured by ALS. This automated reporting highlights any non-conformances, facilitates faster and more accurate data validation and is designed to assist internal expert and external Auditor review. Many components of this report contribute to the overall DQO assessment and reporting for guideline compliance.

Brief method summaries and references are also provided to assist in traceability.

Summary of Outliers

Outliers : Quality Control Samples

This report highlights outliers flagged in the Quality Control (QC) Report.

- **NO Method Blank value outliers occur.**
- **NO Duplicate outliers occur.**
- **NO Laboratory Control outliers occur.**
- **Matrix Spike outliers exist - please see following pages for full details.**
- **For all regular sample matrices, NO surrogate recovery outliers occur.**

Outliers : Analysis Holding Time Compliance

- **NO Analysis Holding Time Outliers exist.**

Outliers : Frequency of Quality Control Samples

- **NO Quality Control Sample Frequency Outliers exist.**

Outliers : Quality Control Samples

Duplicates, Method Blanks, Laboratory Control Samples and Matrix Spikes

Matrix: **SOIL**

Compound Group Name	Laboratory Sample ID	Client Sample ID	Analyte	CAS Number	Data	Limits	Comment
Matrix Spike (MS) Recoveries							
EG005T: Total Metals by ICP-AES	EM1808830--024	Anonymous	**Manganese**	7439-96-5	Not Determined	----	**MS recovery not determined, background level greater than or equal to 4x spike level.**

Analysis Holding Time Compliance

If samples are identified below as having been analysed or extracted outside of recommended holding times, this should be taken into consideration when interpreting results.

This report summarizes extraction / preparation and analysis times and compares each with ALS recommended holding times (referencing USEPA SW 846, APHA, AS and NEPM) based on the sample container provided. Dates reported represent first date of extraction or analysis and preclude subsequent dilutions and reruns. A listing of breaches (if any) is provided herein.

Holding time for leachate methods (e.g. TCLP) vary according to the analytes reported. Assessment compares the leach date with the shortest analyte holding time for the equivalent soil method. These are: organics 14 days, mercury 28 days & other metals 180 days. A recorded breach does not guarantee a breach for all non-volatile parameters.

Holding times for ***VOC in soils*** vary according to analytes of interest. Vinyl Chloride and Styrene holding time is 7 days; others 14 days. A recorded breach does not guarantee a breach for all VOC analytes and should be verified in case the reported breach is a false positive or Vinyl Chloride and Styrene are not key analytes of interest/concern.

Matrix: **SOIL**

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

Method	*Sample Date*	*Extraction / Preparation*			*Analysis*		
Container / Client Sample ID(s)		*Date extracted*	*Due for extraction*	*Evaluation*	*Date analysed*	*Due for analysis*	*Evaluation*
EA055: Moisture Content (Dried @ 105-110°C)							
Soil Glass Jar - Unpreserved (EA055) L05S_13.5-13.6	**17-May-2018**	----	----	----	**25-May-2018**	31-May-2018	✓
EA150: Particle Sizing							
Snap Lock Bag (EA150H) L05S_13.5-13.6	**17-May-2018**	----	----	----	**04-Jun-2018**	13-Nov-2018	✓
EA150: Soil Classification based on Particle Size							
Snap Lock Bag (EA150H) L05S_13.5-13.6	**17-May-2018**	----	----	----	**04-Jun-2018**	13-Nov-2018	✓
EA152: Soil Particle Density							
Snap Lock Bag (EA152) L05S_13.5-13.6	**17-May-2018**	----	----	----	**04-Jun-2018**	13-Nov-2018	✓
ED008: Exchangeable Cations							
Soil Glass Jar - Unpreserved (ED008) L05S_13.5-13.6	**17-May-2018**	**28-May-2018**	14-Jun-2018	✓	**01-Jun-2018**	14-Jun-2018	✓
ED037: Alkalinity							
Soil Glass Jar - Unpreserved (ED037) L05S_13.5-13.6	**17-May-2018**	**29-May-2018**	13-Nov-2018	✓	**31-May-2018**	13-Nov-2018	✓
EG005T: Total Metals by ICP-AES							
Soil Glass Jar - Unpreserved (EG005T) L05S_13.5-13.6	**17-May-2018**	**07-Jun-2018**	13-Nov-2018	✓	**07-Jun-2018**	13-Nov-2018	✓

Matrix: **SOIL**

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

Method	Sample Date	Extraction / Preparation			Analysis		
Container / Client Sample ID(s)		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EG035T: Total Recoverable Mercury by FIMS							
Soil Glass Jar - Unpreserved (EG035T)							
L05S_13.5-13.6	**17-May-2018**	**07-Jun-2018**	14-Jun-2018	✓	**08-Jun-2018**	14-Jun-2018	✓
EP004: Organic Matter							
Soil Glass Jar - Unpreserved (EP004)							
L05S_13.5-13.6	**17-May-2018**	**06-Jun-2018**	14-Jun-2018	✓	**06-Jun-2018**	14-Jun-2018	✓

Quality Control Parameter Frequency Compliance

The following report summarises the frequency of laboratory QC samples analysed within the analytical lot(s) in which the submitted sample(s) was(were) processed. Actual rate should be greater than or equal to the expected rate. A listing of breaches is provided in the Summary of Outliers.

Matrix: **SOIL**

Evaluation: × = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	*Method*	*QC*	*Regular*	***Actual***	***Expected***	*Evaluation*	
Laboratory Duplicates (DUP)							
Alkalinity in Soil	ED037	1	1	**100.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Exchangeable Cations with pre-treatment	ED008	1	7	**14.29**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Moisture Content	EA055	2	19	**10.53**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Organic Matter	EP004	2	11	**18.18**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Mercury by FIMS	EG035T	2	20	**10.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals by ICP-AES	EG005T	3	20	**15.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Laboratory Control Samples (LCS)							
Alkalinity in Soil	ED037	1	1	**100.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Exchangeable Cations with pre-treatment	ED008	1	7	**14.29**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Organic Matter	EP004	1	11	**9.09**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Mercury by FIMS	EG035T	1	20	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals by ICP-AES	EG005T	1	20	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Method Blanks (MB)							
Exchangeable Cations with pre-treatment	ED008	1	7	**14.29**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Organic Matter	EP004	1	11	**9.09**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Mercury by FIMS	EG035T	1	20	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals by ICP-AES	EG005T	1	20	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Matrix Spikes (MS)							
Organic Matter	EP004	1	11	**9.09**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Mercury by FIMS	EG035T	1	20	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals by ICP-AES	EG005T	1	20	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard

Brief Method Summaries

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the US EPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request. The following report provides brief descriptions of the analytical procedures employed for results reported in the Certificate of Analysis. Sources from which ALS methods have been developed are provided within the Method Descriptions.

Analytical Methods	Method	Matrix	Method Descriptions
Moisture Content	EA055	SOIL	In house: A gravimetric procedure based on weight loss over a 12 hour drying period at 105-110 degrees C. This method is compliant with NEPM (2013) Schedule B(3) Section 7.1 and Table 1 (14 day holding time).
Particle Size Analysis by Hydrometer	EA150H	SOIL	Particle Size Analysis by Hydrometer according to AS1289.3.6.3 - 2003
Soil Particle Density	* EA152	SOIL	Soil Particle Density by AS 1289.3.5.1-2006 : Methods of testing soils for engineering purposes - Soil classification tests - Determination of the soil particle density of a soil - Standard method
Gross Alpha and Beta activity in solids	EA250	SOIL	In house: Referenced to ISO 9697 / CSN 757611. Determination of Gross Alpha and Beta activity in soil and sediment by Thick Source method. An appropriate mass of sample is dried and pulverised prior to direct activity counting. (If required, Potassium may be determined separately and results corrected accordingly for 40K.) Analysis is performed by ALS (Czech Republic) who hold technical accreditation #1163 for Gross alpha and beta activity under CAI. CAI are a European accreditation body, equivalent to NATA in Australila and recognised internationally by NATA under ILAC.
Exchangeable Cations with pre-treatment	ED008	SOIL	In house: Referenced to Rayment & Higginson (2011) Method 15A2. Soluble salts are removed from the sample prior to analysis. Cations are exchanged from the sample by contact with Ammonium Chloride. They are then quantitated in the final solution by ICPAES and reported as meq/100g of original soil. This method is compliant with NEPM (2013) Schedule B(3) (Method 301)
Alkalinity in Soil	ED037	SOIL	In house: Referenced to APHA 2320 B Alkalinity is determined and reported on a 1:5 soil/water leach.
Total Metals by ICP-AES	EG005T	SOIL	In house: Referenced to APHA 3120; USEPA SW 846 - 6010. Metals are determined following an appropriate acid digestion of the soil. The ICPAES technique ionises samples in a plasma, emitting a characteristic spectrum based on metals present. Intensities at selected wavelengths are compared against those of matrix matched standards. This method is compliant with NEPM (2013) Schedule B(3)
Total Mercury by FIMS	EG035T	SOIL	In house: Referenced to AS 3550, APHA 3112 Hg - B (Flow-injection (SnCl2) (Cold Vapour generation) AAS) FIM-AAS is an automated flameless atomic absorption technique. Mercury in solids are determined following an appropriate acid digestion. Ionic mercury is reduced online to atomic mercury vapour by SnCl2 which is then purged into a heated quartz cell. Quantification is by comparing absorbance against a calibration curve. This method is compliant with NEPM (2013) Schedule B(3)
Organic Matter	EP004	SOIL	In house: Referenced to AS1289.4.1.1 - 1997. Dichromate oxidation method after Walkley and Black. This method is compliant with NEPM (2013) Schedule B(3).

Preparation Methods	Method	Matrix	Method Descriptions
Exchangeable Cations Preparation Method	ED007PR	SOIL	In house: Referenced to Rayment & Higginson (1992) method 15A1. A 1M NH4Cl extraction by end over end tumbling at a ratio of 1:20. There is no pretreatment for soluble salts. Extracts can be run by ICP for cations.
1:5 solid / water leach for soluble analytes	EN34	SOIL	10 g of soil is mixed with 50 mL of reagent grade water and tumbled end over end for 1 hour. Water soluble salts are leached from the soil by the continuous suspension. Samples are settled and the water filtered off for analysis.

Preparation Methods	Method	Matrix	Method Descriptions
Hot Block Digest for metals in soils sediments and sludges	EN69	SOIL	In house: Referenced to USEPA 200.2. Hot Block Acid Digestion 1.0g of sample is heated with Nitric and Hydrochloric acids, then cooled. Peroxide is added and samples heated and cooled again before being filtered and bulked to volume for analysis. Digest is appropriate for determination of selected metals in sludge, sediments, and soils. This method is compliant with NEPM (2013) Schedule B(3) (Method 202)
Organic Matter	EP004-PR	SOIL	In house: Referenced to AS1289.4.1.1 - 1997. Dichromate oxidation method after Walkley and Black. This method is compliant with NEPM (2013) Schedule B(3) (Method 105)

FREIGHT

Environmental Division
Melbourne
Work Order Reference
EM1808425

Telephone : + 61-3-8549 9600

X HOLD (MW to send COC in email 22/5/18)

AECOM PROJECT - CHAIN OF CUSTODY

CLIENT:	AECOM Services	LABORATORY:	ALS	All results to be provided in ESDAT format.
ADDRESS:	Level 28, 91 King William St Adelaide SA 5000	ADDRESS:	2-4 Westall Rd Springvale Vic, 3171	email address: adelaide@urscorp.com
PHONE NO:	08 7100 6400	PHONE NO:	03 8549 9600	Quote Number:
FAX NO:	08 7223 5499	FAX NO:		
PROJECT NAME:	NRWMF Site Characterisation	PROJECT MANAGER: melinda.morris@aecom.com 0408 387 495		
		SAMPLERS: JOE TAN		SIGNED:
PROJECT NO:	60565376.4.0			

COMMENTS: SPECIAL HANDLING/STORAGE

ANALYSIS REQUIRED

SITE	LOCATION	MATRIX	SAMPLE TYPE	SAMPLE ID	Date	CONTAINER TYPE AND PRESERVATIVE	FIELD FILTERED?	TOTAL NUMBER OF CONTAINERS	Cation Exchange Capacity, Exchangeable Cations (Ca, Mg, Na, K) plus Exchangeable Sodium Percentage (ESP)	Metals – NEPM 15 (S-3), Total Fe & Mn	TRH/BTEXN/PAH/Phenols Suite (S-24)	OC/OPs Suite (S-12)	Triazine Pesticides (Atrazine and Simazine)	Carbonate & Total Organic Carbon	NEPM Screen for Soil Classification Suite (P-22)	Gross alpha and Gross beta (50 g bag)	Particle Size Distribution (500 g bag)	XRD with clay extraction (sub-sampled from 500 g bag)
NRWMF	LYNDHURST	SOIL		LOSS 13·5-13·6	17/5/18			JAR/BAC										

RELINQUISHED BY:		CHECKED:	
DATE:		TIME:	
RECEIVED BY:	MANU (AM)	CHECKED:	
DATE:	23/5	TIME:	11:00

CONTAINER TYPE AND PRESERVATIVE CODES
P = Natural Plastic; N = Nitric Acid Preserved; C = Sodium Hydroxide Preserved; J = Solvent Washed Acid Rinsed Jar
S = Solvent Washed Acid Rinsed Glass Bottle; VC = Hydrochloric Acid Preserved Vial; VS Sulphuric Acid Preserved Glass Bottle;
Z = Zinc acetate Preserved Bottle; E = EDTA Preserved Bottle; ST = Sterile Bottle; O = Other

FREIGHT

Environmental Division
Melbourne
Work Order Reference
EM1808425

Telephone : + 61-3-8549 9600

X HOLD (MM to send coc in email 22/5/18)

AECOM PROJECT - CHAIN OF CUSTODY

CLIENT:	AECOM Services	LABORATORY:	ALS	All results to be provided in ESDAT format.
ADDRESS:	Level 28, 91 King William St Adelaide SA 5000	ADDRESS:	2-4 Westall Rd Springvale Vic, 3171	email address: adelaide@urscorp.com
PHONE NO:	08 7100 6400	PHONE NO:	03 8549 9600	Quote Number:
FAX NO:	08 7223 5499	FAX NO:		
PROJECT NAME:	NRWMF Site Characterisation	PROJECT MANAGER: melinda.morris@aecom.com 0408 387 495		
		SAMPLERS: JOE TAN		SIGNED:
PROJECT NO:	60565376.4.0			

COMMENTS: SPECIAL HANDLING/STORAGE

ANALYSIS REQUIRED

LAB ID	SITE	LOCATION	MATRIX	SAMPLE TYPE	SAMPLE ID	Date	CONTAINER TYPE AND PRESERVATIVE	FIELD FILTERED?	TOTAL NUMBER OF CONTAINERS	Cation Exchange Capacity, Exchangeable Cations (Ca, Mg, Na, K) plus Exchangeable Sodium Percentage (ESP)	Metals – NEPM 15 (S-3), Total Fe & Mn	TRH/BTEXN/PAH/Phenols Suite (S-24)	OC/OPs Suite (S-12)	Triazine Pesticides (Atrazine and Simazine)	Carbonate & Total Organic Carbon	NEPM Screen for Soil Classification Suite (P-22)	Gross alpha and Gross beta (50 g bag)	Particle Size Distribution(500 g bag)	XRD with clay extraction (sub-sampled from 500 g bag)
	NRWMF	LYNDHURST	SOIL		LOSS [redacted] 13.5-13.6	17/5/18			JAR/BAC										

RELINQUISHED BY:		CHECKED:	
DATE:		TIME:	
RECEIVED BY:	KANNI (AM)	CHECKED:	
DATE:	23/5, 11:00	TIME:	

CONTAINER TYPE AND PRESERVATIVE CODES
P = Natural Plastic; N = Nitric Acid Preserved; C = Sodium Hydroxide Preserved; J = Solvent Washed Acid Rinsed Jar
S = Solvent Washed Acid Rinsed Glass Bottle; VC = Hydrochloric Acid Preserved Vial; VS Sulphuric Acid Preserved Glass Bottle;
Z = Zinc acetate Preserved Bottle; E = EDTA Preserved Bottle; ST = Sterile Bottle; O = Other

COC rec'd 24/5/18 19:24 - ALS PR

AECOM PROJECT - CHAIN OF CUSTODY

CLIENT:	AECOM Services	LABORATORY:	ALS	All results to be provided in ESDAT format.	FOR LABORATORY USE ONLY
ADDRESS:	Level 28, 91 King William St Adelaide SA 5000	ADDRESS:	2-4 Westall Rd Springvale Vic, 3171	email address: adelaide@urscorp.com	
PHONE NO:	08 7100 6400	PHONE NO:	03 8549 9600	Quote Number:	
FAX NO:	08 7223 5499	FAX NO:			
PROJECT NAME:	NRWMF Site Characterisation	PROJECT MANAGER:	melinda.morris@aecom.com 0408 387 495		
		SAMPLERS:	Joseph Tan	SIGNED:	
PROJECT NO:	60565376.4.0				

COMMENTS: SPECIAL HANDLING/STORAGE

UPDATED COC BY
MELINDA MORRIS
22/05/18

ALS Batch No.ES1812429

ANALYSIS REQUIRED

LAB ID	SITE	LOCATION	MATRIX	SAMPLE TYPE	SAMPLE ID		Date	CONTAINER TYPE AND PRESERVATIVE	FIELD FILTERED?	TOTAL NUMBER OF CONTAINERS	Cation Exchange Capacity, Exchangeable Cations (Ca, Mg, Na, K) plus Exchangeable Sodium Percentage (ESP)	Metals – NEPM 15 (S-3), Total Fe & Mn	Carbonate & Total Organic Carbon	NEPM Screen for Soil Classification Suite (P-22)	Gross alpha and Gross beta (50 g bag)	Particle Size Distribution + hydrometer (500 g bag)	HOLD	XRD with clay extraction (sub-sampled from 500 g bag)
		Lyndhurst	Soil		L05S	13.5-13.6	17/05/18	Bag + jar	NA	2	1	1	1		1	1		
										TOTAL								

Custody Seal ? Y N NA	RELINQUISHED BY:	CHECKED:		CONTAINER TYPE AND PRESERVATIVE CODES
Samples Cold ? Y N NA	DATE:	TIME:		P = Natural Plastic; N = Nitric Acid Preserved; C = Sodium Hydroxide Preserved; J = Solvent Washed Acid Rinsed Jar
Comments:	RECEIVED BY:	CHECKED:		S = Solvent Washed Acid Rinsed Glass Bottle; VC = Hydrochloric Acid Preserved Vial; VS Sulphuric Acid Preserved Glass Bottle;
	DATE:	TIME:		Z = Zinc acetate Preserved Bottle; E = EDTA Preserved Bottle; ST = Sterile Bottle; O = Other

(1)

CERTIFICATE OF ANALYSIS

Work Order	: **PR1859388**	Issue Date	: 03-Jul-2018
Customer	: **ALS ENVIRONMENTAL**	Laboratory	: ALS Czech Republic, s.r.o.
Contact	: results address	Contact	: Client Service
Address	: 2 Byth Street 4051 Stafford QLD Australia	Address	: Na Harfe 336/9 Prague 9 - Vysocany 190 00 Czech Republic
E-mail	: subresults.bri@alsglobal.com	E-mail	: customer.support@alsglobal.com
Telephone	: ----	Telephone	: +420 226 226 228
Facsimile	: ----	Facsimile	: +420 284 081 635
Project	: EM1808425	Page	: 1 of 2
Order number	: 503512	Date Samples Received	: 18-Jun-2018
C-O-C number	: ----	Quote number	: PR2015ALSEN-AU0002 (CZ-251-15-0965)
Site	: ----	Date of test	: 19-Jun-2018 - 03-Jul-2018
Sampled by	: Client	QC Level	: ALS CR Standard Quality Control Schedule

General Comments

This report shall not be reproduced except in full, without prior written approval from the laboratory.
The laboratory declares that the test results relate only to the listed samples.

Responsible for accuracy

Testing Laboratory No. 1163
Accredited by CAI according to
CSN EN ISO/IEC 17025:2005

Signatories	*Position*
Zdeněk Jirák	Environmental Business Unit Manager

L 1163

Analytical Results

Sub-Matrix: **SOIL**				Client sample ID	**L05S.13.5-13.6.**		**----**		**----**	
				Laboratory sample ID	PR1859388-001		----		----	
				Client sampling date / time	17-May-2018 00:00		----		----	
Parameter	*Method*	*LOR*	*Unit*		**Result**	**MU**	**Result**	**MU**	**Result**	**MU**
Physical Parameters										
Dry matter @ 105°C	S-DRY-GRCI	0.10	%		**98.0**	± 6.0%	**----**	----	**----**	----
Radiological Parameters										
Gross alpha activity	S-GAA-PRO	500	Bq/kg DW		**1790**	± 23.9%	**----**	----	**----**	----
Gross beta activity	S-GBA-PRO	500	Bq/kg DW		**840**	± 42.4%	**----**	----	**----**	----

If no sampling time is provided, the sampling time will default 00:00 on the date of sampling. If no sampling date is provided, delivery date in brackets without a time component will be displayed instead. Measurement uncertainty is expressed as expanded measurement uncertainty with coverage factor k = 2, representing 95% confidence level.
Key: LOR = Limit of reporting; MU = Measurement Uncertainty

The end of result part of the certificate of analysis

Brief Method Summaries

Analytical Methods	*Method Descriptions*
Location of test performance: Bendlova 1687/7 Ceska Lipa Czech Republic 470 01	
S-DRY-GRCI	CZ_SOP_D06_01_045 (CSN ISO 11465, CSN EN 12880, CSN EN 14346), CZ_SOP_D06_07_046 (CSN ISO 11465, CSN EN 12880, CSN EN 14346, CSN 46 5735) Determination of dry matter by gravimetry and determination of moisture by calculation from measured values.
S-GAA-PRO	CZ_SOP_D06_07_368 (CSN 75 7611 and ISO 9696) Determination of gross alpha mass activity by direct measurement of the sample by means of alpha radiation analyzer.
S-GBA-PRO	CZ_SOP_D06_07_369 (CSN 75 7612, CSN EN ISO 9697) Determination of gross beta mass activity by direct measurement of the sample by means of beta radiation analyzer.

Preparation Methods	*Method Descriptions*
Location of test performance: Bendlova 1687/7 Ceska Lipa Czech Republic 470 01	
* S-PPHOM.07	CZ_SOP_D06_07_P01 Preparation of solid samples for analysis (crushing, milling and pulverizing).

A `*` symbol preceding any method indicates laboratory or subcontractor non-accredited test. In the case when a procedure belonging to an accredited method was used for non-accredited matrix, would apply that the reported results are non-accredited. Please refer to General Comment section on front page for information. If the report contains subcontracted analysis, those are made in a subcontracted laboratory outside the laboratories ALS Czech Republic, s.r.o.
The calculation methods of summation parameters are available on request in the client service.

Sydney Laboratory
Unit 5/43 Herbert St
Artarmon NSW 2064
email: artarmon@ghd.com.au
web: www.ghd.com.au/ghdgeotechnics
Tel: (02) 9462 4860
Fax:(02) 9462 4710

Aggregate/Soil Test Report

Report No: SYD1801233
Issue No: 1
This report replaces all previous issues of report no 'SYD1801233'.

Client:
SMS Geotechnical Pty Ltd
Unit 9 / 21 Beafield Rd
Para Hills West SA 5096

Project: 2126797

Accredited for compliance with ISO / IEC 17025 - Testing

NATA Accredited Laboratory Number: 679

Approved Signatory: D.P Brooke (Sydney Laboratory Manager)

Date of Issue: 2/07/2018

Sample Details

GHD Sample No	SYD18-0241-04
Date Sampled	08/05/2018
Sampled By	Supplied by Client
Location	SMS.G18135
BH / TP No.	LO5S
Depth (m)	13.5 - 13.9
Soil Description	CLAY: with sand grey

Test Results

Description	Method	Result	Limits
Coef of Permeability (m/sec)	AS 1289.6.7.3	4 e -11	
Mean Stress Level (kPa)		30	
Permeant Used		tap water	
Length (mm)		77.6	
Diameter (mm)		63.5	
Length/Diameter Ratio		1.22	
Laboratory Moisture Ratio (%)		0.0	
Laboratory Density Ratio (%)		0.0	
CompactiveEffort		n/a	
Method of Compaction		Undisturbed	
Surcharge Applied (Kg)		0.0	
Pressure Applied (Kpa)		10	
Oversize Sieve (mm)		6.3	
Percentage Oversize (%)		0.0	
Moisture Content (%)		19.2	
Date Tested		20/06/2018	

Comments

Moisture and Density Ratio's not applicable. Undisturbed sample.
initial moisture content = 18.3% , Initial dry density = 1.792 t/m³

Sydney Laboratory
Unit 5/43 Herbert St
Artarmon NSW 2064
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web: www.ghd.com.au/ghdgeotechnics
Tel: (02) 9462 4860
Fax:(02) 9462 4710

Aggregate/Soil Test Report

Report No: SYD1801231
Issue No: 1
This report replaces all previous issues of report no 'SYD1801231'.

Client:
SMS Geotechnical Pty Ltd
Unit 9 / 21 Beafield Rd
Para Hills West SA 5096

Project: 2126797

Accredited for compliance with ISO / IEC 17025 - Testing

NATA Accredited Laboratory Number: 679

Approved Signatory: D.P Brooke (Sydney Laboratory Manager)

Date of Issue: 2/07/2018

Sample Details

GHD Sample No	SYD18-0241-02
Date Sampled	09/05/2018
Sampled By	Supplied by Client
Location	SMS.G18135
BH / TP No.	LO1
Depth (m)	21.0 - 21.4
Soil Description	Sandy CLAY / clay SAND: grey

Test Results

Description	Method	Result	Limits
Coef of Permeability (m/sec)	AS 1289.6.7.3	1 e -09	
Mean Stress Level (kPa)		30	
Permeant Used		tap water	
Length (mm)		77.3	
Diameter (mm)		62.7	
Length/Diameter Ratio		1.23	
Laboratory Moisture Ratio (%)		0.0	
Laboratory Density Ratio (%)		0.0	
CompactiveEffort		n/a	
Method of Compaction		Undisturbed	
Surcharge Applied (Kg)		0.0	
Pressure Applied (Kpa)		10	
Oversize Sieve (mm)		6.3	
Percentage Oversize (%)		0.0	
Moisture Content (%)		19.1	
Date Tested		15/06/2018	

Comments

Moisture and Density Ratio's not applicable. Undisturbed sample.
Initial moisture content = 17.1% , initial dry density = 1.81 t/m³

CHAIN OF CUSTODY

ALS Laboratory: please tick →

☐ Sydney: 277 Woodpark Rd, Smithfield NSW 2176 Ph: 02 8784 8555 E:samples.sydney@alsenviro.com
☐ Newcastle: 5 Rosegum Rd, Warabrook NSW 2304 Ph:02 4968 9433 E:samples.newcastle@alsenviro.com
☐ Brisbane: 32 Shand St, Stafford QLD 4053 Ph:07 3243 7222 E:samples.brisbane@alsenviro.com
☐ Townsville: 14-15 Desma Ct, Bohle QLD 4818 Ph:07 4796 0600 E: townsville.environmental@alsenviro.com
☐ Melbourne: 2-4 Westall Rd, Springvale VIC 3171 Ph:03 8549 9600 E: samples.melbourne@alsenviro.com
☐ Adelaide: 2-1 Burma Rd, Pooraka SA 5095 Ph: 08 8359 0890 E:adelaide@alsenviro.com
☐ Perth: 10 Hod Way, Malaga WA 6090 Ph: 08 9209 7655 E: samples.perth@alsenviro.com
☐ Launceston: 27 Wellington St, Launceston TAS 7250 Ph: 03 6331 2158 E: launceston@alsenviro.com

CLIENT:	AECOM	TURNAROUND REQUIREMENTS : (Standard TAT may be longer for some tests e.g.. Ultra Trace Organics)	☐ Standard TAT (List due date): ☐ Non Standard or urgent TAT (List due date):
OFFICE:	Level 28, 91 King William Street, Adelaide, SA 5000		
PROJECT:	60565376 / 4-0	ALS QUOTE NO.:	COC SEQUENCE NUMBER (Circle)
ORDER NUMBER:			COC: 1 2 3 4 5 6 7
PROJECT MANAGER:	Melinda Morris	CONTACT PH: 08 7223 5543	OF: 1 2 3 4 5 6 7
SAMPLER:		SAMPLER MOBILE: 0408 387 495	
COC emailed to ALS? (YES / NO)		EDD FORMAT (or default):	
Email Reports to:	melinda.morris@aecom.com 0408 387 495		
Email Invoice to:			

FOR LABORATORY USE ONLY (Circle)
Custody Seal Intact? Yes No N/A
Free ice / frozen ice bricks present upon receipt? Yes No N/A
Random Sample Temperature on Receipt: °C
Other comment:

RELINQUISHED BY:	RECEIVED BY:	RELINQUISHED BY:	RECEIVED BY:
DATE/TIME:	DATE/TIME:	DATE/TIME:	DATE/TIME:

COMMENTS/SPECIAL HANDLING/STORAGE OR DISPOSAL:

ALS USE ONLY	SAMPLE DETAILS MATRIX: Solid(S) Water(W)			CONTAINER INFORMATION		ANALYSIS REQUIRED including SUITES (NB. Suite Codes must be listed to attract suite price) Where Metals are required, specify Total (unfiltered bottle required) or Dissolved (field filtered bottle required).								Additional Information
LAB ID	SAMPLE ID	DATE / TIME	MATRIX	TYPE & PRESERVATIVE (refer to codes below)	TOTAL BOTTLES	Permeability								Comments on likely contaminant levels, dilutions, or samples requiring specific QC analysis etc.
1	W02C 36.9-37.3	13/05/2018	S		1	X								
2	L01 21.0_21.4	9/05/2018	S		1	X								
3	N03 27.0-27.4	7/05/2018	S		1	X								
4	L05S 13.5-13.9	8/05/2018	S		1	X								
				TOTAL										

Environmental Division
Melbourne
Work Order Reference
EM1808346

Telephone : + 61-3-8549 9600

Water Container Codes: P = Unpreserved Plastic; N = Nitric Preserved Plastic; ORC = Nitric Preserved ORC; SH = Sodium Hydroxide/Cd Preserved; S = Sodium Hydroxide Preserved Plastic; AG = Amber Glass Unpreserved; AP - Airfreight Unpreserved Plastic
V = VOA Vial HCl Preserved; VB = VOA Vial Sodium Bisulphate Preserved; VS = VOA Vial Sulfuric Preserved; AV = Airfreight Unpreserved Vial SG = Sulfuric Preserved Amber Glass; H = HCl preserved Plastic; HS = HCl preserved Speciation bottle; SP = Sulfuric Preserved Plastic; F = Formaldehyde Preserved Glass;
Z = Zinc Acetate Preserved Bottle; E = EDTA Preserved Bottles; ST = Sterile Bottle; ASS = Plastic Bag for Acid Sulphate Soils; B = Unpreserved Bag.

A19037 (MIN3344)
ALS Environmental

SAMPLES RECEIVED

One sample was submitted to ALS Metallurgy for semi-quantitative XRD analysis.

Sample 1	L01_21.0-21.4

SAMPLE PREPARATION

The sample was pressed into a back-packed sample holder to minimize preferred orientation of the particles. Powder X-ray diffraction (XRD) was used to analyse the sample and a combination of matrix flushing and reference intensity ratio (RIR) derived constants was used in the quantification of the minerals identified in the sample.

ANALYTICAL PROCEDURES

The XRD traces were collected under the following instrument conditions:

XRD	Panalytical Empyrean
Radiation	Co Kα 1.789
Generator	40 kV 40 mA
Angular Range	5° to 77° 2θ
Time/Step	120 s
Step Size	0.0131° 2θ
Divergence Slit	0.5 °
Anti-Scatter Slit	7.5 mm
Slit Type	Fixed
Detector	PIXcel in linear mode
Rotation Speed	60 rpm

SAMPLES SUBMITTED BY

Peter Ravlic (ALS Environmental)

ANALYSIS UNDERTAKEN BY

Jiamin Liu (ALS Metallurgy Mineralogy)

REPORTED BY

Jiamin Liu (ALS Metallurgy Mineralogy)

REPORT DATE

27 June 2018

Adelaide Laboratory

Coffey Services Australia Pty Ltd
ABN 55 139 460 521
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Keswick ADELAIDE SA 5035

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coffey
A TETRA TECH COMPANY

Material Test Report

Report No: ADEL18S-02164-1
Issue No: 2
This report replaces all previous issues of report no 'ADEL18S-02164-1'.

Client:	AECOM Services Pty Ltd Level 8, 540 Wickham Street Fortitude Valley QLD 4006
Principal:	Department of Industry, Innovation & Science
Project No.:	754-ADEL00342AA
Project Name:	NRWMF#60565376
Lot No.:	**TRN:**

NATA
WORLD RECOGNISED ACCREDITATION

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.

Approved Signatory: Marie Edwards
(Geotechnician)
NATA Accredited Laboratory Number:431
Date of Issue: 5/06/2018

Sample Details

Sample ID:	ADEL18S-02164
Client Sample:	
Date Sampled:	
Source:	
Material:	
Specification:	No Specification
Sampling Method:	Submitted by client
Project Location:	South Australia
Sample Location:	L08, 0.30-0.50m

Other Test Results

Description	Method	Result	Limits
Moisture Content (%)	AS 1289.2.1.1	4.0	
Sample History	AS 1289.1.1	Oven-dried	
Preparation	AS 1289.1.1	Dry Sieved	
Linear Shrinkage (%)	AS 1289.3.4.1	3.0	
Mould Length (mm)		254	
Liquid Limit (%)	AS 1289.3.1.1	24	
Method		Four Point	
Plastic Limit (%)	AS 1289.3.2.1	14	
Plasticity Index (%)	AS 1289.3.3.1	10	
Date Tested		31/05/2018	
Emerson Class Number	AS 1289.3.8.1	4	
Soil Description		Sandy Clay, Orange/ Brown	
Type of Water		Distilled	
Temperature of Water (°C)		18.0	
Date Tested		1/06/2018	

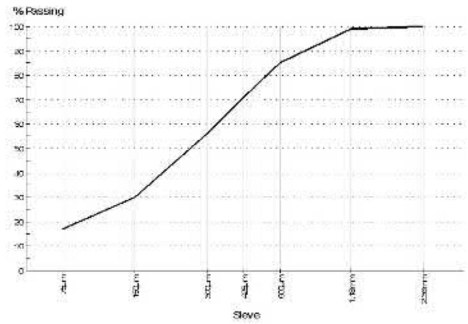
Particle Size Distribution

Method: AS 1289.3.6.1
Drying by: Oven
Date Tested: 29/05/2018

Note: Sample Washed

Sieve Size	% Passing	Limits
2.36mm	100	
1.18mm	99	
600µm	85	
425µm	71	
300µm	56	
150µm	30	
75µm	17	

Chart



Comments

N/A

Adelaide Laboratory

Coffey Services Australia Pty Ltd
ABN 55 139 460 521
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Keswick ADELAIDE SA 5035

Phone: +61 8 8375 4400
Fax: +61 8 8375 4499

coffey
A TETRA TECH COMPANY

Material Test Report

Report No: ADEL18S-02167-1
Issue No: 1

Client:	AECOM Services Pty Ltd Level 8, 540 Wickham Street Fortitude Valley QLD 4006
Principal:	Department of Industry, Innovation & Science
Project No.:	754-ADEL00342AA
Project Name:	NRWMF#60565376
Lot No.:	**TRN:**

NATA
WORLD RECOGNISED ACCREDITATION

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.

Approved Signatory: Marie Edwards (Geotechnician)
NATA Accredited Laboratory Number:431
Date of Issue: 1/06/2018

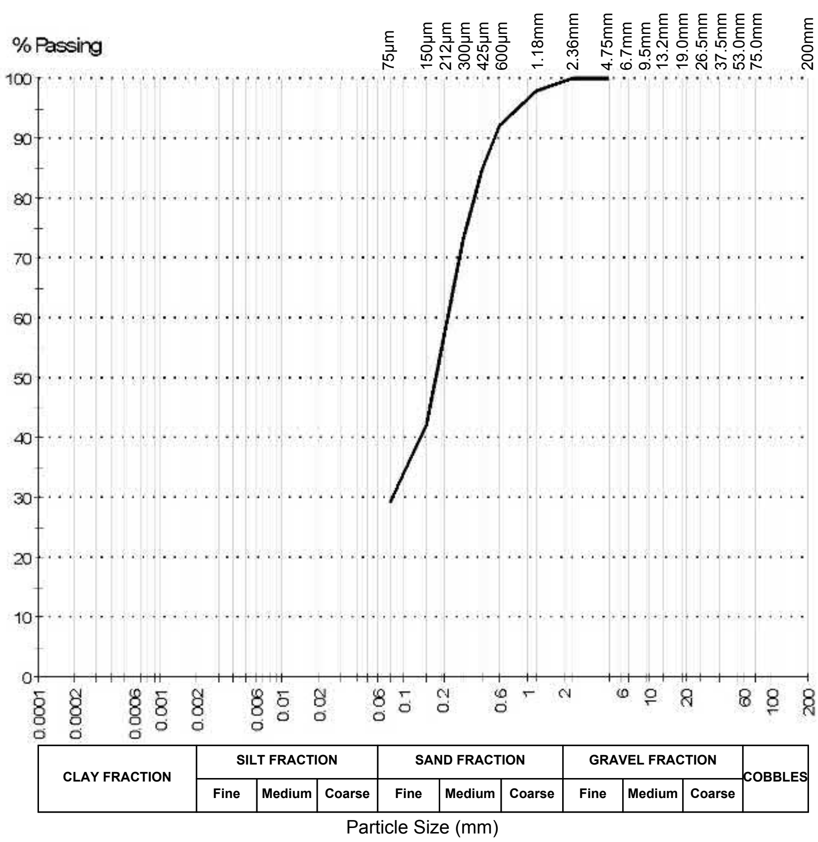
Sample Details

Sample ID:	ADEL18S-02167
Client Sample:	
Date Sampled:	
Source:	
Material:	
Specification:	No Specification
Sampling Method:	Submitted by client
Project Location:	South Australia
Sample Location:	LD05,6.0-6.40m

Other Test Results

Description	Method	Result	Limits
Moisture Content (%)	AS 1289.2.1.1	13.9	
Sample History	AS 1289.1.1	Oven-dried	
Preparation	AS 1289.1.1	Dry Sieved	
Linear Shrinkage (%)	AS 1289.3.4.1	9.5	
Mould Length (mm)		250	
Liquid Limit (%)	AS 1289.3.1.1	39	
Method		Four Point	
Plastic Limit (%)	AS 1289.3.2.1	18	
Plasticity Index (%)	AS 1289.3.3.1	21	
Date Tested		31/05/2018	

Particle Size Distribution



Method: AS 1289.3.6.1

Drying by: Oven
Date Tested: 29/06/2018

Note: Sample Washed

Sieve Size	% Passing	Limits
4.75mm	100	
2.36mm	100	
1.18mm	98	
600µm	92	
425µm	85	
300µm	73	
150µm	42	
75µm	29	

Comments

N/A

Adelaide Laboratory

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California Bearing Ratio Test Report

Report No: CBR:ADEL18S-02164
Issue No: 1

Client:	AECOM Services Pty Ltd Level 8, 540 Wickham Street Fortitude Valley QLD 4006
Principal:	Department of Industry, Innovation & Science
Project No.:	754-ADEL00342AA
Project Name:	NRWMF#60565376
Lot No.:	**TRN:**

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.

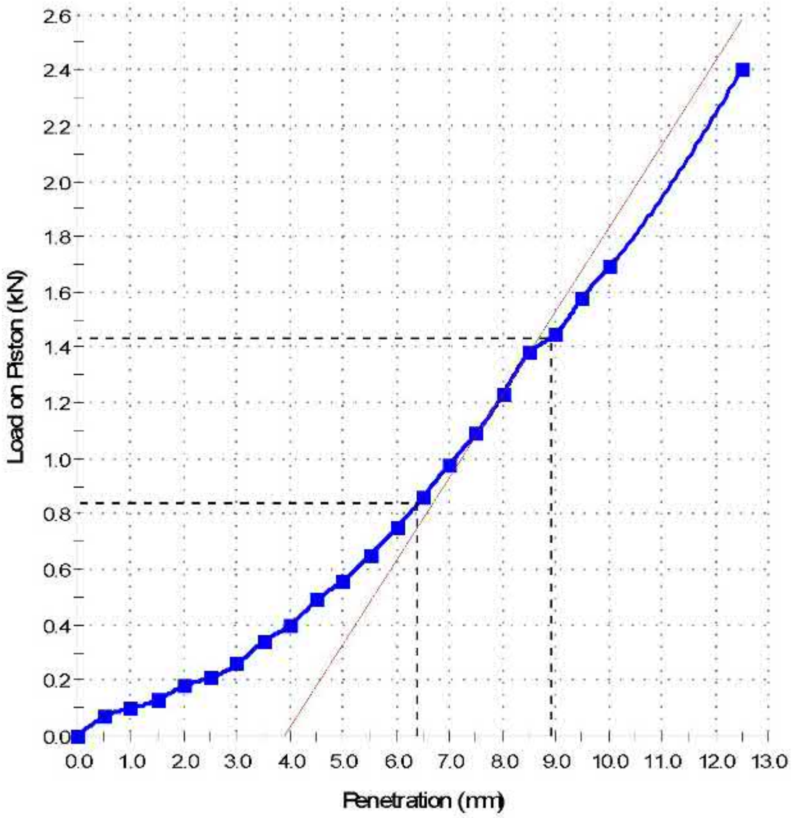
NATA WORLD RECOGNISED ACCREDITATION

Approved Signatory: Marie Edwards (Geotechnician)
NATA Accredited Laboratory Number:431
Date of Issue: 5/06/2018

Sample Details

Sample ID:	ADEL18S-02164	**Sampling Method:**	Submitted by client
Date Sampled:		**Material:**	
Date Submitted:	28/05/2018	**Source:**	
Date Tested:	31/05/2018	**Specification:**	No Specification
Project Location:	South Australia		
Sample Location:	L08, 0.30-0.50m		

Load vs Penetration



Test Results

AS 1289.6.1.1

CBR At 5.0mm (%):	**7**
Maximum Dry Density (t/m³):	1.90
Optimum Moisture Content (%):	10.2
Dry Density before Soaking (t/m³):	1.86
Density Ratio before Soaking (%):	98
Moisture Content before Soaking (%):	10.5
Moisture Ratio before Soaking (%):	102
Dry Density after Soaking (t/m³):	1.86
Density Ratio after Soaking (%):	98
Swell (%):	0.0
Moisture Content of Top 30mm (%):	13.1
Moisture Content of Remaining Depth (%):	12.7
Compactive Effort:	Standard
Surcharge Mass (kg):	4.50
Period of Soaking (Days):	4
Oversize Material (%):	0.0

—— AS 1289.2.1.1 ——

Field Moisture Content (%):	4.0
Curing Time (Hrs):	12.0
Plasticity Level Method:	Linear Shrinkage

Comments

AECOM

AECOM Contact: Kylie Schmidt & Joseph Tan
Tel: 08 7223 5538 **Fax:** 08 7223 5499

Level 28, 91 King William Street
Adelaide, SA 5000
email: kylie.schmidt@aecom.com
joseph.tan@aecom.com

Requisition for Testing - Soil Samples

Client: Department of Industry, Innovation and Science
Project: NRWMF
Number: 60565376
Date of Request:
Results Required By:

NOTES: 1. Retain sub-samples of all samples tested
2. Retain all samples until further notice
3. Supply PDF versions of lab certificates

Location	Depth (m)		Field Description	Sample Type e.g Bag [SPT, Spn], Tube [U63, U75], Core	Comments	Testing Required																										
						Moisture Content (AS1289 .2.1.1, 4133.4.2)	Atterberg limits (AS1289 .3.1.1, .3.2.1, .3.3.1, .3.4.1, .2.1.1)	Particle Size Distribution - 75mm to 75microns (AS1289 3.6.2)	Shrink/Swell Index (AS 1289.7.1.1)	Compaction (Standard - AS1289 5.1.1)	4 days soaked CBR @ 98%SMDD	Emerson Class																				
L11	3.00	3.20		Bag																												
L09	2.00	2.20		Bag																												
L10	0.40	0.60		Bag																												
L07	1.00	1.20		Bag																												
L06	0.50	0.70		Bag																												
L08	0.30	0.50		Bag		1	1	1		1	1	1																				
L05D	6.00	6.40		U63		1	1	1																								
Number of tests						2	2	2	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Dynamic Cone Penetrometer (9 kg) Test

AECOM

Project: NRWMF

Project Number: 60565376

Client: DIIS

Tested By: JT

Location: L06

Date: 23/04/2018

Results:

Penetration (mm)	Number of Blows per 100 mm Penetration	Penetration (mm)	Number of Blows per 100 mm Penetration	Penetration (mm)	Number of Blows per 100 mm Penetration
100	**2**	1100	**8**	2100	**6**
200	**18**	1200	**6**	2200	**4**
300	**27**	1300	**4**	2300	**4**
400	**13**	1400	**3**	2400	**4**
500	**7**	1500	**4**	2500	**6**
600	**4**	1600	**5**	2600	**7**
700	**3**	1700	**2**	2700	**7**
800	**4**	1800	**12**	2800	**7**
900	**15**	1900	**11**	2900	**7**
1000	**18**	2000	**5**	3000	**7**
Test Procedure: AS 1289.6.3.2					

Comments:

DCP terminated at depth 3.0 mbgl.

Ground Moisture Condition: Dry

Testing Depth (mm): GL

Dynamic Cone Penetrometer (9 kg) Test

AECOM

Project: NRWMF	**Project Number:** 60565376
Client: DIIS	**Tested By:** JT
Location: L07	**Date:** 26/04/2018

Results:

Penetration (mm)	Number of Blows per 100 mm Penetration	Penetration (mm)	Number of Blows per 100 mm Penetration	Penetration (mm)	Number of Blows per 100 mm Penetration
100	**2**	1100	**3**	2100	**R**
200	**7**	1200	**4**	2200	
300	**4**	1300	**5**	2300	
400	**2**	1400	**6**	2400	
500	**3**	1500	**7**	2500	
600	**2**	1600	**7**	2600	
700	**3**	1700	**5**	2700	
800	**3**	1800	**6**	2800	
900	**4**	1900	**7**	2900	
1000	**3**	2000	**8**	3000	
Test Procedure: AS 1289.6.3.2					

Comments:

DCP refusal (bouncing and eight consecutive blows gave less than 20mm penetration) at depth 2.1m.

Ground Moisture Condition: Dry

Testing Depth (mm): GL

Dynamic Cone Penetrometer (9 kg) Test

AECOM

Project:	**Project Number:**
NRWMF	60565376
Client:	**Tested By:**
DIIS	JT
Location:	**Date:**
L08	26/04/2018

Results:

Penetration (mm)	Number of Blows per 100 mm Penetration	Penetration (mm)	Number of Blows per 100 mm Penetration	Penetration (mm)	Number of Blows per 100 mm Penetration
100	**2**	1100	**6**	2100	
200	**7**	1200	**12**	2200	
300	**5**	1300	**6**	2300	
400	**6**	1400	**10**	2400	
500	**7**	1500	**R**	2500	
600	**6**	1600		2600	
700	**5**	1700		2700	
800	**20**	1800		2800	
900	**11**	1900		2900	
1000	**6**	2000		3000	
Test Procedure: AS 1289.6.3.2					

Comments:

DCP refusal (bouncing and eight consecutive blows gave less than 20mm penetration) at depth 1.5m.

Ground Moisture Condition:	Dry
Testing Depth (mm):	GL

Dynamic Cone Penetrometer (9 kg) Test

AECOM

Project: NRWMF

Project Number: 60565376

Client: DIIS

Tested By: JT

Location: L09

Date: 26/04/2018

Results:

Penetration (mm)	Number of Blows per 100 mm Penetration	Penetration (mm)	Number of Blows per 100 mm Penetration	Penetration (mm)	Number of Blows per 100 mm Penetration
100	**3**	1100		2100	
200	**7**	1200		2200	
300	**R**	1300		2300	
400		1400		2400	
500		1500		2500	
600		1600		2600	
700		1700		2700	
800		1800		2800	
900		1900		2900	
1000		2000		3000	
Test Procedure: AS 1289.6.3.2					

Comments:

DCP refusal (bouncing and eight consecutive blows gave less than 20mm penetration) at depth 0.3m.

Ground Moisture Condition: Dry

Testing Depth (mm): GL

Dynamic Cone Penetrometer (9 kg) Test

AECOM

Project: NRWMF

Project Number: 60565376

Client: DIIS

Tested By: JT

Location: L10

Date: 23/04/2018

Results:

Penetration (mm)	Number of Blows per 100 mm Penetration	Penetration (mm)	Number of Blows per 100 mm Penetration	Penetration (mm)	Number of Blows per 100 mm Penetration
100	**5**	1100	**R**	2100	
200	**6**	1200		2200	
300	**10**	1300		2300	
400	**10**	1400		2400	
500	**6**	1500		2500	
600	**6**	1600		2600	
700	**8**	1700		2700	
800	**9**	1800		2800	
900	**14**	1900		2900	
1000	**22**	2000		3000	
Test Procedure: AS 1289.6.3.2					

Comments:

DCP refusal (bouncing and eight consecutive blows gave less than 20mm penetration) at depth 1.1m.

Ground Moisture Condition: Dry

Testing Depth (mm): GL

Dynamic Cone Penetrometer (9 kg) Test

AECOM

Project: NRWMF

Project Number: 60565376

Client: DIIS

Tested By: JT

Location: L11

Date: 26/04/2018

Results:

Penetration (mm)	Number of Blows per 100 mm Penetration	Penetration (mm)	Number of Blows per 100 mm Penetration	Penetration (mm)	Number of Blows per 100 mm Penetration
100	**2**	1100	**8**	2100	**12**
200	**5**	1200	**4**	2200	**7**
300	**3**	1300	**4**	2300	**15**
400	**3**	1400	**4**	2400	**22**
500	**2**	1500	**6**	2500	**26**
600	**3**	1600	**5**	2600	**15**
700	**3**	1700	**8**	2700	**14**
800	**3**	1800	**15**	2800	**14**
900	**3**	1900	**14**	2900	**14**
1000	**3**	2000	**11**	3000	**16**
Test Procedure: AS 1289.6.3.2					

Comments:

DCP terminated at depth 3.0 mbgl.

Ground Moisture Condition: Dry

Testing Depth (mm): GL

DATA VALIDATION REPORT

Project number:	60565376	**Validation by:**	Sylvia Bretherton	**Date:**	16/07/2018
Client:	Department of Industry, Innovation and Science				
Site:	Lyndhurst	**Data verified by:**	Jodie Castlehow	**Date:**	18/07/2018
Matrix type:	Water				
Primary samples:	6	**Project Manager:**	James Rusk	**Date:**	19/07/2018
Laboratory:	ALS; Eurofins|MGT				
Lab reference:	EM1808546				

Key Findings:

No major QA/QC issues were identified in the field or laboratory datasets that could have a material implication to decision-making on the project.

However, based on the DVAL below, the following should be considered during data interpretation:

- Samples were analysed outside recommended holding times for pH (all) and nitrite as N (L01 and L04) and potential under reporting should be taken into consideration when interpreting data for these analytes.
- Elevated RPDs should be taken into consideration when using the data quantitatively for gross alpha, nitrate as N, ionic balance, and filtered cadmium, cobalt, zinc, thorium, potassium and bromine.
- The presence of thiocyanate can positively contribute to the chloride result, therefore may bias results higher than expected. Results should be scrutinised accordingly.
- The manganese concentration reported in the rinsate blank sample is likely to be attributed to the rinsate water; however results should be scrutinised accordingly where manganese is close to LOR.

Quality Assurance/Quality Control Measures – AS 4482-1

Measurement	Soil	Water	Frequency	RPD (%)	Recovery (%)
Type of Quality Control Samples to be Prepared or Taken On-Site					
Rinsate Blanks	-	✓	1 per day per field piece of equipment	-	-
Trip Blanks (VOC analysis only)	-	✓	1 per esky or 1 per batch	-	-
Intra Laboratory Duplicates	✓	✓	1 in 20 samples collected or 1 per batch	30 - 50	-
Inter Laboratory Duplicates	✓	✓	1 in 20 samples collected or 1 per batch	30 - 50	-
Quality Control Samples to be Prepared by Laboratory					
Laboratory Blanks	✓	✓	1 per batch	-	-
Laboratory Duplicates	✓	✓	1 in 10 samples collected or 1 per batch (whichever is smaller)	30	-
Matrix Spike Recoveries	✓	✓	1 in 20 samples collected or 1 per batch	-	70 - 130
Spike Recoveries	✓	✓	1 in 20 samples collected or 1 per batch	-	70 - 130

Surrogates	✓	✓	Each analysis done by GC-MS (all organics except C10+ TPH)	-	70 - 130

Field Quality Assurance and Quality Control

Sampling Personnel	All sampling was conducted by Sylvia Bretherton on 22 and 23 of May 2018.
Sampling Methodology	Grab samples were collected using a disposable bailer.
Chain of Custody (COC)	Chain of custody (COC) documents were completed by Sylvia Bretherton.
Analysis Request	Laboratory analysis request and sample receipt notification were reviewed and approved by Melinda Morris.
Field Blank	As concentrations were generally reported below (or close to) the limit of reporting (LOR) in the rinsate blank sample, the field blank sample was not analysed.
Rinsate Blank	As per project specifications, rinsate blank samples were not analysed at a frequency of one per day per piece of equipment. One rinsate sample, collected from the interface probe, was analysed over the two days of sampling. A minor concentration of manganese (1 ug/L) and electrical conductivity of 2 µS/cm were reported in the rinsate blank sample. Further investigation indicates the manganese concentration is attributed to the rinsate water; however results should be scrutinised accordingly where manganese is close to LOR. The electrical conductivity for the rinsate blank sample is approximately four orders of magnitude below electrical conductivities reported for primary samples, therefore this not considered to affect the interpretation of results. Given that all sampling equipment was either dedicated, disposable or decontaminated with a solution of water and Decon 90 between sampling locations, the decontamination methods and field staff were consistent over the course of the sampling event, and concentrations were generally reported below the LOR in the rinsate sample analysed; the decontamination methods are assessed as acceptable and the potential for cross contamination via sampling methods is considered unlikely.
Trip Blank	NA - no volatile analytes were analysed.
Frequency of Field QC	Field duplicate and triplicate (inter-laboratory duplicate) samples were collected at a frequency of one in twenty primary samples (one of each in total). Due to discrepancies in standard analytical suites between the primary and secondary laboratories, the inter-laboratory duplicate sample was not analysed for selenium, nitrite as N, nitrate & nitrite as N and hydroxide alkalinity as $CaCO_3$. The precision of the data for these analytes can be assessed as acceptable based on the intra-laboratory duplicate RPDs for these analytes (which were reported at or the required frequency within control limits) and laboratory duplicate RPDs (which were reported above the required frequency and within control limits).
Handling and Preservation	Primary, duplicate and triplicate groundwater samples were received preserved and chilled at the laboratories. Sample receipt temperature (9.3°C) was outside of the recommended range (≤6°C) in primary batch EM1808546. The triplicate sample was received at the secondary laboratory with an evident attempt to chill noted on the sample receipt notification. As the samples were immediately cooled upon collection and during transit to the laboratories, the samples are unlikely to have degraded more in these conditions than in ambient groundwater conditions at the time of sampling (approximately 17-18ºC). The primary and inter-laboratory RPDs were generally within control limits, therefore potential for under or over reporting is not considered to materially affect the interpretation of results. All samples were received at the laboratories in appropriate sample containers.

Laboratory QA/QC	
Tests Requested/Reported	Samples were analysed and reported as requested on the COC, except nutrients, which were not requested however were analysed by the laboratory. Results of the broader Kimba sampling program (including Lyndhurst and Napandee) were initially reported as one laboratory batch, however were subsequently reported as two separate batches.
Holding Time Compliance	Samples were analysed 6-7 days outside recommended holding times for pH (EA005P). Samples L01 and L04 were analysed 4 days outside recommended holding times for nitrite as N (EK057G). There is the potential for these analytes to have degraded over time and not be truly representative of field conditions. This potential under reporting should be taken into consideration when interpreting data for these analytes.
Laboratory Accreditation	The primary laboratory analysis was conducted by ALS Environmental Pty Ltd (Melbourne). Gross alpha and gross beta were subcontracted to ALS Fyshwick. Both laboratories are accredited by the National Association of Testing Authorities Australia (NATA) for the analyses undertaken. The triplicate sample was analysed at Eurofins-MGT (Melbourne), which is NATA accredited for the analyses undertaken. Bromine and iodine analysis was subcontracted by Eurofins MGT to ACS Laboratories in Kensington, Victoria (not NATA accredited). Gross alpha and beta analysis was subcontracted to Eurofins EATON Analytical in California, USA (NELAP accredited).
Frequency of Laboratory QC	Matrix spikes were not reported at the required frequencies for silicon (ED040F) and sulphide as S2- (EK085F). The accuracy of the data can be assessed as acceptable based on method blanks and available LCS, which were reported at the required frequencies and within control limits. Laboratory control spikes (LCS) were not reported for silicon, iodine and bromine. The accuracy of the data can be assessed as acceptable based on the method blanks which were reported at or above the required frequency and within control limits.
Method Blank	Method blank concentrations were reported below the LOR for all analytes tested.
Laboratory Duplicate RPDs	Laboratory duplicate relative percentage differences (RPDs) were within control limits. The laboratory duplicate RPDs are presented in the laboratory Quality Control Report.
Laboratory Control Spike Recovery	Laboratory control spike (LCS) recoveries were within control limits.
Matrix Spike Recovery	Matrix spike (MS) recoveries (where reported) were within control limits. The following recoveries were not determined: **Analyte** / **Recovery (%)** / **Comment**: Sulphate as SO4- turbimetric / Not determined / MS recovery not determined, background level greater than or equal to 4x spike level This non-determination does not reflect method bias and does not affect data interpretation. This MS sample was an anonymous sample and is therefore not representative of the sample matrix within the laboratory batch. The accuracy of the data can be assessed as acceptable based on method blanks and LCS, which were reported at or above the required frequencies and within control limits.
Surrogate Spike Recovery	NA

QA/QC Data Evaluation	
Comparison of Field Observations and Laboratory Results	No anomalous results between field observations and analysis results were noted, with the exception of differences between field pH readings and laboratory reported pH for two groundwater wells (L02 reported a laboratory pH of 4.2 and a field pH of 7.2, and L05D reported a laboratory pH of 6.7 and a field pH of 8.1). Field pH is considered to be more representative of field conditions given that laboratory pH was analysed outside of holding times.
Data Transcription	A random 10% check of the laboratory results identified no anomalies within the electronic data, the laboratory reports, and tables generated by AECOM.
Limits of Reporting	NA
Field Duplicate RPDs	Field duplicate RPDs were reported within control limits, with the exception of the following sample analysis (the samples with the higher reported concentrations are in bold): • L02_23/5/18 and **QC03_23/5/18** for filtered arsenic (40%) • **L02_23/5/18** and QC03_23/5/18 for filtered thorium (67%) • **L02_23/5/18** and QC03_23/5/18 for ionic balance (192%) As concentrations of filtered arsenic are less than 10 x LOR, where precision is low and actual differences minor, the data is considered to be of an acceptable precision and these elevated RPDs are not considered to affect the interpretation of results. As there are no adopted guideline values for filtered thorium and ionic balance the elevated RPDs only need to be taken into consideration when using the data quantitatively.
Field Triplicate RPDs	Field duplicate RPDs were reported within control limits, with the exception of the following sample analysis (the samples with the higher reported concentrations are in bold): • **L02_23/5/18** and QC04_23/5/18 for gross alpha (196%) • L02_23/5/18 and **QC04_23/5/18** for filtered beryllium (40%) • **L02_23/5/18** and QC04_23/5/18 for filtered cadmium (31%) • **L02_23/5/18** and QC04_23/5/18 for filtered cobalt (32%) • **L02_23/5/18** and QC04_23/5/18 for filtered copper (33%) • **L02_23/5/18** and QC04_23/5/18 for filtered zinc (32%) • L02_23/5/18 and **QC04_23/5/18** for filtered thorium (196%) • **L02_23/5/18** and **QC04_23/5/18** for nitrate as N (43%) • **L02_23/5/18** and QC04_23/5/18 for filtered potassium (44%) • **L02_23/5/18** and QC04_23/5/18 for filtered bromine (156%) As concentrations of filtered beryllium and filtered copper are less than 10 x LOR, where precision is low and actual differences minor, the data is considered to be of an acceptable precision and these elevated RPDs are not considered to affect the interpretation of results. As there are no adopted guideline values for gross alpha, nitrate as N, and filtered cadmium, cobalt, zinc, thorium, potassium and bromine, the elevated RPDs only need to be taken into consideration when using the data quantitatively.
Other	
Ionic Balance	Acceptable
Sum Totals	Total alkalinity as CaCO3, ionic balance, total anions and total cations were laboratory reported.
General Comments	ALS laboratory noted the following comments: - **EG020F**: QC01 dissolved manganese results have been confirmed by re-preparation and re-analysis - **EG020F**: L01, L03, L05D required dilution prior to dissolved metals analysis due to sample matrix interference. LOR values have been raised accordingly - **ED093F**: L03 and L05D results for cations have been confirmed by re-

	preparation and re-analysis. - **EA010-P**: Electrical Conductivity @ 25°C was analysed by manual method (EA010). - **EK059G**: L05S and L05D results for Nitrite and Nitrate as N (NOx) have been confirmed by reanalysis. It is recognised that Nitrite and Nitrate as N (NOx) is less than Nitrites as N for sample L05S and L05D. However, the difference is within experimental variation of the methods. - **EK057G**: Results for L05S and L05D have been confirmed by re-preparation and re-analysis. - This report has been amended to re-issue the results as requested. 14/6/18. - Ionic balances were calculated using: major anions - chloride, alkalinity and sulfate; and major cations - calcium, magnesium, potassium and sodium. - **ED045G**: The presence of thiocyanate can positively contribute to the chloride result, thereby may bias results higher than expected. Results should be scrutinised accordingly. - Sodium Adsorption Ratio (where reported): Where results for Na, Ca or Mg are <LOR, a concentration at half the reported LOR is incorporated into the SAR calculation. This represents a conservative approach for Na relative to the assumption that <LOR = zero concentration and a conservative approach for Ca & Mg relative to the assumption that <LOR is equivalent to the LOR concentration.

Lyndhurst Groundwater Rinsate Blank Sample Analysis

Lab Report	EM1808546
Field ID	QC01_22/5/18
Sample Date	22/05/2018
Sample Type	Rinsate blank

Reporting Group	Analyte	Units	LOR	
Physio-Chemical Parameters	pH (Lab)	pH Units	0.01	**4.65**
	Electrical conductivity (lab)	µS/cm	1	**2**
Radioactivity	Gross alpha	Bq/L	0.05	-
	Gross beta	Bq/L	0.1	-
Metals	Arsenic (Filtered)	ug/L	1	<1
	Barium (Filtered)	ug/L	1	<1
	Beryllium (Filtered)	ug/L	1	<1
	Boron (Filtered)	ug/L	50	<50
	Cadmium (Filtered)	ug/L	0.1	<0.1
	Chromium (Filtered)	ug/L	1	<1
	Cobalt (Filtered)	ug/L	1	<1
	Copper (Filtered)	ug/L	1	<1
	Iron	ug/L	50	-
	Lead (Filtered)	ug/L	1	<1
	Lithium (Filtered)	ug/L	1	<1
	Manganese	ug/L	1	
	Manganese (Filtered)	ug/L	1	**1**
	Mercury (Filtered)	ug/L	0.1	<0.1
	Nickel (Filtered)	ug/L	1	<1
	Selenium (Filtered)	ug/L	10	<10
	Strontium (Filtered)	ug/L	1	<1
	Uranium (Filtered)	ug/L	1	<1
	Vanadium (Filtered)	ug/L	10	<10
	Zinc (Filtered)	ug/L	5	<5
	Thorium (Filtered)	ug/L	1	<1
Inorganics	Bromine (Filtered)	mg/L	0.1	<0.1
	Iodine (Filtered)	mg/L	0.1	<0.1
	Dissolved Organic Carbon	mg/L	1	-
Nutrients	Nitrate (as N)	mg/L	0.01	-
	Nitrite (as N)	mg/L	0.01	-
	Nitrate & Nitrite (as N)	mg/L	0.01	-
Alkalinity	Bicarbonate Alkalinity as CaCO3	mg/L	1	<1
	Carbonate Alkalinity as CaCO3	mg/L	1	<1
	Hydroxide Alkalinity as CaCO3	mg/L	1	<1
	Total Alkalinity as CaCO3	mg/L	1	<1
Major Ions	Silicon (Filtered)	mg/L	0.05	<0.05
	Chloride	mg/L	1	<1
	Calcium (Filtered)	mg/L	1	<1
	Fluoride	mg/L	0.1	<0.1
	Magnesium (Filtered)	mg/L	1	<1
	Potassium (Filtered)	mg/L	1	<1
	Sodium (Filtered)	mg/L	1	<1
	Sulphide (as S2-) (Filtered)	mg/L	0.1	-
	Total Anions	meq/L	0.01	<0.01
	Total Cations	meq/L	0.01	<0.01
	Sulfate (as SO4-) (Filtered)	mg/L	1	<1
	Ionic Balance	%	0.01	-

Legend
LOR = limit of reporting
ug/L= micrograms per litre
mg/L = millograms per litre
µS/cm = microseimens per centimetre
meq/L = milliequivalents per litre
Bq/L = becquerel per litre

Groundwater Relative Percent Differences EM1808546 and 600238

Analyte	Units	LOR	EM1808546 L02_23/5/18 23/05/2018	EM1808546 QC03_23/5/18 23/05/2018	RPD	EM1808546 L02_23/5/18 23/05/2018	600238 QC04_23/5/18 23/05/2018	RPD
Physio-Chemical Parameters								
pH (Lab)	pH Units	0.01 : 0.1 (Interlab)	4.19	4.22	1	4.19	4.1	2
Electrical conductivity (lab)	µS/cm	1	43400	43800	1	43400	48000	10
Radioactivity								
Gross alpha	Bq/L	0.05	24.8	29.1	16	**24.8**	**0.962**	**196**
Gross beta	Bq/L	0.1	93.4	98.1	5	93.4	85.1	9
Metals								
Arsenic (Filtered)	ug/L	1	**2**	**3**	**40**	2	2	0
Barium (Filtered)	ug/L	1 : 20 (Interlab)	281	284	1	281	310	10
Beryllium (Filtered)	ug/L	1	2	2	0	**2**	**3**	**40**
Boron (Filtered)	ug/L	50	1520	1500	1	1520	2000	27
Cadmium (Filtered)	ug/L	0.1 : 0.2 (Interlab)	2.6	2.7	4	**2.6**	**1.9**	**31**
Chromium (Filtered)	ug/L	1	9	9	0	9	8	12
Cobalt (Filtered)	ug/L	1	69	70	1	**69**	**50**	**32**
Copper (Filtered)	ug/L	1	7	8	13	**7**	**5**	**33**
Iron	ug/L	50	5120	5150	1	5120	6400	22
Lead (Filtered)	ug/L	1	15	17	13	15	14	7
Lithium (Filtered)	ug/L	1 : 5 (Interlab)	39	37	5	39	45	14
Manganese	ug/L	1 : 5 (Interlab)	913	909	0	913	1000	9
Manganese (Filtered)	ug/L	1 : 5 (Interlab)	900	905	1	900	910	1
Mercury (Filtered)	ug/L	0.1	<0.1	<0.1	0	<0.1	<0.1	0
Nickel (Filtered)	ug/L	1	86	86	0	86	68	23
Selenium (Filtered)	ug/L	10	<10	<10	0	<10	-	-
Strontium (Filtered)	ug/L	1 : 5 (Interlab)	2870	2880	0	2870	2700	6
Uranium (Filtered)	ug/L	1 : 5 (Interlab)	5	6	18	5	<5	0
Vanadium (Filtered)	ug/L	10 : 5 (Interlab)	<10	<10	0	<10	<5	0
Zinc (Filtered)	ug/L	5	166	169	2	**166**	**120**	**32**
Thorium (Filtered)	ug/L	1	**2**	**1**	**67**	**2**	**200**	**196**
Inorganics								
Bromine (Filtered)	mg/L	0.1	40	40.1	0	**40**	**<5**	**156**
Iodine (Filtered)	mg/L	0.1	**0.4**	**0.2**	**67**	0.4	<5	170
Dissolved Organic Carbon	mg/L	1 : 5 (Interlab)	4	4	0	4	<5	0
Nutrients								
Nitrate (as N)	mg/L	0.01 : 0.02 (Interlab)	0.09	0.12	29	**0.09**	**0.14**	**43**
Nitrite (as N)	mg/L	0.01	<0.01	<0.01	0	<0.01	-	-
Nitrate & Nitrite (as N)	mg/L	0.01	0.09	0.12	29	0.09	-	-
Alkalinity								
Bicarbonate Alkalinity as CaCO3	mg/L	1 : 20 (Interlab)	<1	<1	0	<1	<20	0
Carbonate Alkalinity as CaCO3	mg/L	1 : 10 (Interlab)	<1	<1	0	<1	<10	0
Hydroxide Alkalinity as CaCO3	mg/L	1	<1	<1	0	<1	-	-
Total Alkalinity as CaCO3	mg/L	1 : 20 (Interlab)	<1	<1	0	<1	<20	0
Major Ions								
Silicon (Filtered)	mg/L	0.05 : 0.5 (Interlab)	23.5	25.2	7	23.5	27	14
Chloride	mg/L	1	16400	16500	1	16400	17000	4
Calcium (Filtered)	mg/L	1	150	134	11	150	120	22
Fluoride	mg/L	0.1 : 0.5 (Interlab)	0.1	0.1	0	0.1	<0.5	0
Magnesium (Filtered)	mg/L	1	1020	931	9	1020	870	16
Potassium (Filtered)	mg/L	1	187	169	10	**187**	**120**	**44**
Sodium (Filtered)	mg/L	1	10000	9070	10	10000	9600	4
Sulphide (as S2-) (Filtered)	mg/L	0.1	<0.1	<0.1	0	<0.1	<0.05	0
Total Anions	meq/L	0.01	484	483	0	484	-	-
Total Cations	meq/L	0.01	531	482	10	531	-	-
Sulfate (as SO4-) (Filtered)	mg/L	1	1020	843	19	1020	1300	24
Ionic Balance	%	0.01	**4.66**	**0.09**	**192**	4.66	-	-

High RPDs are in bold (Acceptable RPDs for each LOR multiplier range are: 30 (1-10 x LOR); 30 (10-20 x LOR); 30 (> 20 x LOR))
Interlab Duplicates are matched on a per compound basis as methods vary between laboratories.
Any methods in the row header relate to those used in the primary laboratory.

Legend
RPD = relative percent difference
LOR = limit of reporting
ug/L= micrograms per litre
mg/L = millograms per litre
µS/cm = microseimens per centimetre
meq/L = milliequivalents per litre
Bq/L = becquerel per litre

AECOM

Client Name: DIIS
Project Name: NRWMF Site Characterisation Project
Project No: 60565376

Lyndhurst Groundwater Frequency Table

Site Name	NRWMF
Project No.	60565376
Project Manager	Melinda Morris
Matrix	WATER
Laboratory	ALS and Eurofins|MGT
Batch File Number	EM1808546 & 600238

NOTES:
(a) ✓ - holding times are within project guideline limits.
× - holding times exceed project guideline limits.
(b) ✓ - Limits of reporting (LORs) comply with project specifications.
× - LORs do not comply with project specifications.
NA - Not Applicable

Analytical Method	Analytical Parameter	Number of Tests Requested	Number of Tests Reported	Number of Primary Samples	Holding Times (a)	Limits of Reporting (b)	Field Blank (1 per day)		Rinsate Blank (1 per day)		Method Blank (1 per batch)		Intra-Laboratory Duplicate Sample (1 in 20)		Inter-Laboratory Duplicate Sample (1 in 20)		Lab Duplicate (1 in 10)		Matrix Spike (1 in 20)		LCS (1 per batch)		Surrogates (GC-MS organics)	
							Number Required	Number Reported	Number Required	Number Reported	Number Required	Number Reported	Number Required	Number Reported	Number Required	Number Reported	Number Required	Number Reported	Number Required	Number Reported	Number Required	Number Reported	Reported	OK
EA005P: pH by PC Titrator	pH (Lab)	8	8	6	×	✓	2	0	2	1	0	0	1	1	1	1	1	2	0	0	0	0	-	-
EA010P: Conductivity by PC Titrator	Electrical conductivity (lab)	8	8	6	✓	✓	2	0	2	1	1	2	1	1	1	1	1	4	0	0	1	2	-	-
EA250: Gross Alpha and Beta Activity	Gross alpha	7	7	6	✓	✓	2	0	2	0	1	1	1	1	1	1	1	2	0	0	1	1	-	-
	Gross beta	7	7	6	✓	✓	2	0	2	0	1	1	1	1	1	1	1	2		0	1	1	-	-
ED041G: Sulfate (Turbidimetric) as SO4 2- by D	Sulfate (as SO4-)	8	8	6	✓	✓	2	0	2	1	1	1	1	1	1	1	1	2	1	1	1	2	-	-
EG020F: Dissolved Metals by ICP-MS	Arsenic	8	8	6	✓	✓	2	0	2	1	1	2	1	1	1	1	1	3	1	2	1	2	-	-
	Boron	8	8	6	✓	✓	2	0	2	1	1	2	1	1	1	1	1	3		0	1	2	-	-
	Barium	8	8	6	✓	✓	2	0	2	1	1	2	1	1	1	1	1	3		2	1	2	-	-
	Beryllium	8	8	6	✓	✓	2	0	2	1	1	2	1	1	1	1	1	3		2	1	2	-	-
	Cadmium	8	8	6	✓	✓	2	0	2	1	1	2	1	1	1	1	1	3		2	1	2	-	-
	Cobalt	8	8	6	✓	✓	2	0	2	1	1	2	1	1	1	1	1	3		2	1	2	-	-
	Chromium	8	8	6	✓	✓	2	0	2	1	1	2	1	1	1	1	1	3		2	1	2	-	-
	Copper	8	8	6	✓	✓	2	0	2	1	1	2	1	1	1	1	1	3		2	1	2	-	-
	Manganese	8	8	6	✓	✓	2	0	2	1	1	2	1	1	1	2	1	4		2	1	2	-	-
	Nickel	8	8	6	✓	✓	2	0	2	1	1	2	1	1	1	1	1	3		2	1	2	-	-
	Lead	8	8	6	✓	✓	2	0	2	1	1	2	1	1	1	1	1	3		2	1	2	-	-
	Selenium	8	8	6	✓	✓	2	0	2	1	1	2	1	1	1	0	1	3		0	1	2	-	-
	Vanadium	8	8	6	✓	✓	2	0	2	1	1	2	1	1	1	1	1	3		2	1	2	-	-
	Zinc	8	8	6	✓	✓	2	0	2	1	1	2	1	1	1	1	1	3		2	1	2	-	-
	Lithium	8	8	6	✓	✓	2	0	2	1	1	2	1	1	1	1	1	3		0	1	2	-	-
	Strontium	8	8	6	✓	✓	2	0	2	1	1	1	1	1	1	1	1	2		0	1	1	-	-
	Thorium	8	8	6	✓	✓	2	0	2	1	1	1	1	1	1	1	1	2		0	1	1	-	-
	Uranium	8	8	6	✓	✓	2	0	2	1	1	1	1	1	1	1	1	2		0	1	1	-	-
	Iodine	8	8	6	✓	✓	2	0	2	1	1	2	1	1	1	1	1	3		0	1	0	-	-
	Bromine	8	8	6	✓	✓	2	0	2	1	1	2	1	1	1	1	1	4		0	1	0	-	-
EG035F: Dissolved Mercury by FIMS	Mercury	8	8	6	✓	✓	2	0	2	1	1	2	1	1	1	1	1	4	1	2	1	2	-	-
EG020T: Total Metals by ICP-MS	Manganese	7	7	6	✓	✓	2	0	2	0	1	2	1	1	1	2	1	4	1	2	1	2	-	-
	Iron	7	7	6	✓	✓	2	0	2	0	1	2	1	1	1	1	1	4		0	1	2	-	-
EK057G: Nitrite as N by Discrete Analyser	Nitrite (as N)	7	7	6	×	✓	2	0	2	0	1	1	1	1	1	0	1	2	1	1	1	1	-	-
EK058G: Nitrate as N by Discrete Analyser	Nitrate (as N)	7	7	6	✓	✓	2	0	2	0	0	0	1	1	1	1	0	0	0	0	0	0	-	-
EK059G: Nitrite plus Nitrate as N (NOx) by Dis	Nitrate & Nitrite (as N)	7	7	6	✓	✓	2	0	2	0	1	1	1	1	1	0	1	2	1	1	1	1	-	-
EK040P: Fluoride by PC Titrator	Fluoride	8	8	6	✓	✓	2	0	2	1	1	1	1	1	1	1	1	2	1	1	1	1	-	-
ED040F: Dissolved Major Anions	Silicon	8	8	6	✓	✓	2	0	2	1	1	1	1	1	1	1	1	2	1	0	1	0	-	-
EK085F: Dissolved Sulfide as S2-	Sulphide (as S2-)	7	7	6	✓	✓	2	0	2	0	1	1	1	1	1	1	1	2	1	0	1	1	-	-
ED037P: Alkalinity by PC Titrator	Hydroxide Alkalinity as CaCO3	8	8	6	✓	✓	2	0	2	1	0	0	1	1	1	0	1	2	0	0	0	0	-	-
	Carbonate Alkalinity as CaCO3	8	8	6	✓	✓	2	0	2	1	0	0	1	1	1	1	1	2		0	0	0	-	-
	Bicarbonate Alkalinity as CaCO3	8	8	6	✓	✓	2	0	2	1	0	0	1	1	1	1	1	2		0	0	0	-	-
	Total Alkalinity as CaCO3	8	8	6	✓	✓	2	0	2	1	0	0	1	1	1	1	1	2		0	1	1	-	-
EP002: Dissolved Organic Carbon (DOC)	Dissolved Organic Carbon	7	7	6	✓	✓	2	0	2	0	1	1	1	1	1	1	1	2	1	1	1	1	-	-
ED093F: Dissolved Major Cations	Calcium	8	8	6	✓	✓	2	0	2	1	1	1	1	1	1	1	1	2	0	0	1	1	-	-
	Magnesium	8	8	6	✓	✓	2	0	2	1	1	1	1	1	1	1	1	2		0	1	1	-	-
	Sodium	8	8	6	✓	✓	2	0	2	1	1	1	1	1	1	1	1	2		0	1	1	-	-
	Potassium	8	8	6	✓	✓	2	0	2	1	1	1	1	1	1	1	1	2		0	1	1	-	-
ED045G: Chloride by Discrete Analyser	Chloride	8	8	6	✓	✓	2	0	2	1	1	1	1	1	1	1	1	2	1	1	1	2	-	-
EN055: Ionic Balance	Ionic Balance	7	7	6	✓	✓	2	0	2	0	0	0	1	1	1	0	0	0	0	0	0	0	-	-
	Total Anions	8	8	6	✓	✓	2	0	2	1	0	0	1	1	1	0	0	0		0	0	0	-	-
	Total Cations	8	8	6	✓	✓	2	0	2	1	0	0	1	1	1	0	0	0		0	0	0	-	-

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