Site Characterisation - Technical Report

NAPANDEE

NATIONAL RADIOACTIVE WASTE MANAGEMENT FACILITY

Technical Report - Site Characterisation, Napandee

Client: Commonwealth Department of Industry, Innovation and Science

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Table of Contents

List of Tables

List of Figures

Limitations Statement

Limitations Statement

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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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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) was 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 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 Napandee 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 *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.

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 Napandee site has no threatened ecological communities and only around 7% of the area is vegetated, with degraded vegetation within cropped and grazed paddocks and some good condition linear corridors along roadways. 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. If vegetation clearance is required for development then linear native vegetation corridors linking areas of remnant vegetation shall preferably be maintained, and further field surveys will be required to determine the likelihood and significance of impacts on 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/ Reserves, Recreational Parks, Wilderness Protected Areas), native vegetation Heritage Agreements, Aboriginal or State and Local heritage sites on or adjacent the site	The Napandee site has no Aboriginal heritage sites or State and Local Heritage sites within the Site. Pinkawillinie 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 (to inform possible licence application) 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 Safety Requirements NS-R-3 (Rev.1) Site Evaluations for Nuclear Installations.	Background radiation levels within the ARPANSA Action Levels for workplaces Background radiation levels are not sufficiently elevated to impact on the effectiveness of 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. AS1170.2:2011 Structural design Wind actions.	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, and more frequent 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 should it proceed at this site.
Bushfire Risks	Characterise bushfire threat from factors including vegetation hazard at local and landscape level, slopes, bushfire weather frequency/ severity and assess likelihood and nature of bushfire impact (ignition potential, development, approach).	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 (large patches of grassland and Mallee Mulga vegetation are sufficiently distant and small vegetation patches on and around the site, are unlikely to sustain a fully developed 100m wide fire front) if setbacks/ 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 measures	IAEA SSG-18 Meteorological and Hydrological Hazards in Site Evaluation for Nuclear Installations. Ball J, Babister M, Nathan R, Weeks W, Weinmann E, Retallick M, Testoni I, (Editors), 2016, Australian Rainfall and Runoff (ARR): A Guide to Flood Estimation, Commonwealth of Australia	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 however drainage lines exist in the vicinity of the site and local drainage paths exist through the site. A larger local catchment (upstream approximately 150 km2) drains past the south-western corner of the site. There is no recent anecdotal evidence of waterlogging or runoff from localised or upstream catchments. Hydraulic and hydrological modelling would be required to estimate flood risks for a range of events of varying magnitude. 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 Napandee site. If these tenements proceed to production, the associated activities may have the potential to impact the NRWMF.

Site Characteristic	Objective of Assessment	Key Legislation, Standards and Guidelines	Preferred Site Characteristics	Assessment Findings
Geology, hydrogeology & geochemistry	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 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 >20 m below ground surface and such would not impact on NRWMF buildings or their foundations, and is of no realistic beneficial use due to its high salinity and low yield. The relative high vertical difference over a short distance suggests there is poor hydraulic connection between the watertable and deeper aquifers. The subsurface clays and kaolin within the lithology exhibit chemical attenuation properties. These clays however, if exposed or use as fill, may have due to their moderately salinity and strongly sodicity lead to surface hardening/ crusting and waterlogging, and be limiting to plant growth. Geohazards are unlikely present at the site, with the exception of soils of low expansive potential at surface and medium depth (3 metres) which can be mitigated in design standards (AS2870). These findings are based on current data but further investigations would be required for site specific aspects such as design of footings and structures.

Site Characteristic	Objective of Assessment	Key Legislation, Standards and Guidelines	Preferred Site Characteristics	Assessment Findings
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 Napandee 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 locally or in upwind areas. The dunes overlie occasional shallow silcrete, and deeper kaolin and weathered bedrock. The potential for slope and mass movement processes need to be considered during times of high rainfall or seismic activity.
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, near-surface faults that could cause folding or other deformation, 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 Napandee 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)

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 & Vehicle Certification Rules, National Heavy Vehicle Regulator, 2017.	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 site is well served by major road networks with several unsealed local site access options which would require upgrades and sealing up to 44 kilometres to accommodate frequent B-double movements and infrequency ODOM movements. There does not appear to be the need to acquire land to accommodate new road reserves nor likely be the need for roadside vegetation clearance.
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 (23 km west of 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, stormwater)	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. The site is approximately 65 km from the closest transmission substation and 50 km from any transmission line. Connection can be made with booster pumping stations to a 150mm diameter potable water main, 2.6 km east from the site property boundary, for construction of the facility while a permanent connection is made to the existing 375 mm diameter main much further away in Kimba. 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 in place).
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 Napandee 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 Napandee that would likely require mitigation or management should the proposed NRWMF be further considered at the site. These include bushfire , local catchment flooding along an interdune swale in the south-western corner of the site and wind erosion, slope erosion or mass movement of sands from longitudinal dunes.

Groundwater in the water table aquifer is present at depths exceeding 20 m from the surface across the site which would provide good separation between the base of any proposed facility 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 Napandee 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 Napandee 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 Napandee study area and surrounds. Linear corridors of vegetation in good condition present along roadways, with only degraded vegetation present elsewhere within the study area. 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.

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 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 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, of which 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.

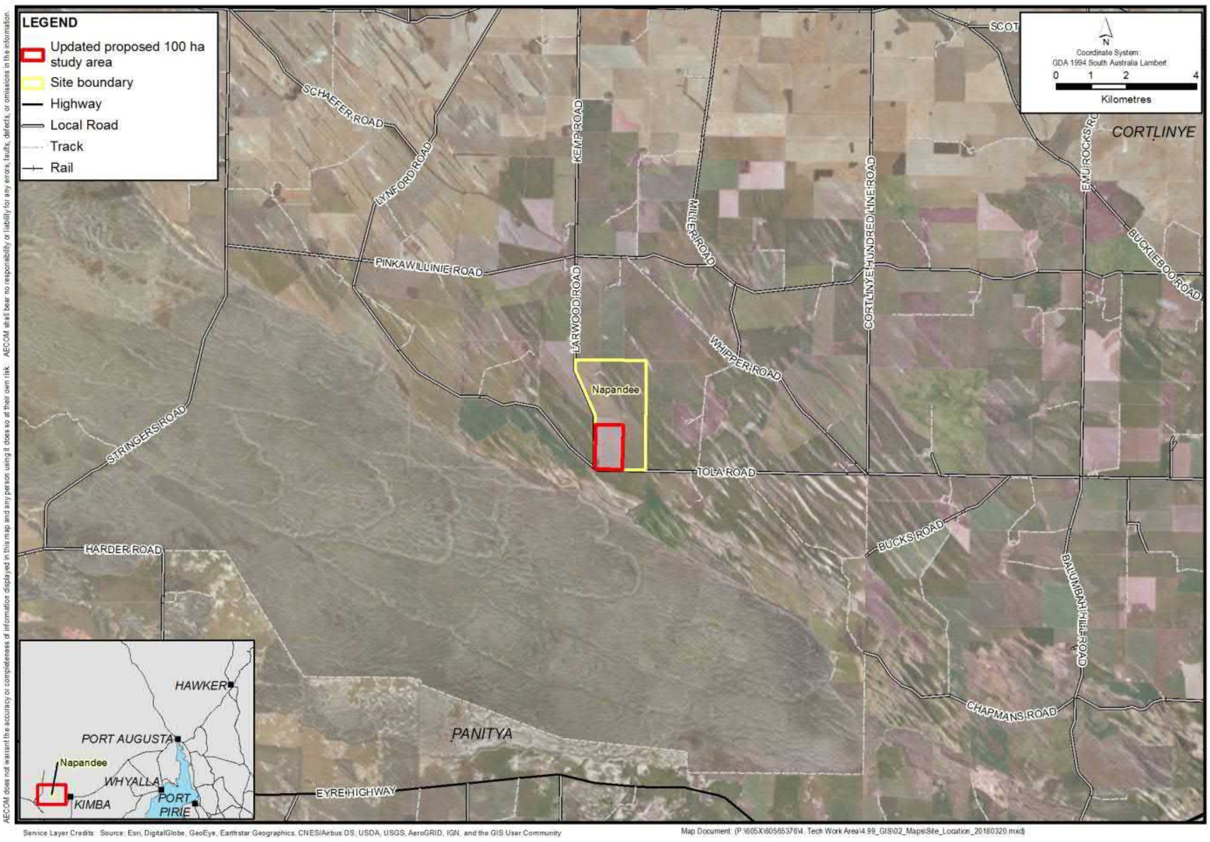
The Department has a comprehensive and ongoing stakeholder communications and engagement program underway within each local community.

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 Napandee site. The location of the site and study area contained within the site is displayed in Figure 1 below and described in the Table 1 below. The study area hereafter referred to as 'the site'.

Table 1 Site Identification Details

Site Name	Napandee
Site Description	Larwood Road, Hundred of Pinkawilinie Country of Buxton District Council of Kimba
Land Parcel	Part 1 parcel described as: Hundred Plan 500100, Parcel 94 (Portion of Certificate of Title Volume 5937 Folio 542) Total approximate nominated site area is 218 ha

Figure 1 Site Location Plan



The general site setting can be summarised:

- The site is located approximately 20 km east of the township of Kimba;
- The site is located within a 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 typically of north-west to south-east orientation, which have historically been extensive cleared for cropping;
- 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 along interdune swales;

- Pinkawillinie Conservation Park is located approximately 2 km south of the site, an area of parabolic dunes covered in native bushland;
- There is a linear corridor of native vegetation (open Mallee woodland) in good condition present along the western boundary of the study area adjoining Larwood Road and degraded open shrubland with isolated Mallee present along fence lines;
- The site can be accessed via existing formed unsealed roads, Tola Road and Larwood Road;
- The site is well separated from adversely affecting development and sensitive land uses; and
- The nearest dwelling located approximately 1.8 km to the east of 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 Napandee 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 site selection and 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 study area 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 radiation (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 2. 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/or
- Republic of Korea-Australia Migratory Bird Agreement (ROKAMBA).

Table 2 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 3 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 4 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. The study area around Napandee was expanded to 10 km for 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 Environment and Energy (DoEE) *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;
- The 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 Napandee 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 Napandee site and the Buffer Zone and within the site. 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 the 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 the 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 the expanded Study Area.
- **High**: Suitable habitat is present. Several recent records of species/community in the expanded Study Area.
- **Present**: Species known to be present, confirmed records in the expanded Study Area.

Desktop Results – Commonwealth Listed Species

The Protected Matters Search Tool (PMST) search for the Napandee site identified 11 threatened species and 12 Marine and/or Migratory species protected under the EPBC Act that may potentially occur. This includes five threatened flora species, five threatened bird species, one threatened mammal, and 12 Marine and/or Migratory bird species. The PMST report is provided in its entirety in Appendix A.

There were no Threatened Ecological Communities (TECs) identified as potentially occurring within the expanded Study Area. It can therefore be confidently assumed that no TECs occur within the Napandee Site or the Buffer Zone.

Five threatened flora species were identified in the desktop review as potentially occurring within the Napandee site or Buffer Zone, including four identified in the PMST report and one from the BDBSA database. Two of the five threatened flora species have been recorded in the expanded Study Area (Figure 2), including Yellow Swainson-pea (*Swainsona pyrophila*) and Granite Mudwort (*Limosella granitica*). Both species are listed as Vulnerable under the EPBC Act. The Granite Mudword is associated with seasonally wet rock-pools and is therefore considered Unlikely to occur. The Yellow Swainson-pea prefers disturbed sites and has a Moderate likelihood of occurrence. The remaining three species are considered Unlikely to occur. Lack of historical records and suitable habitat has led to this conclusion.

Six fauna species listed as Threatened under the EPBC Act were identified during the desktop assessment including five bird species and one mammal species. One species, the Malleefowl, has been recorded in the Buffer Zone. The Malleefowl and Sandhill Dunnart have a Moderate likelihood of occurrence within the Buffer Zone. These species may be present within fragments of Mallee Woodland and scrublands present but are considered unlikely to utilise cropped areas. Malleefowl may extend into such habitat on an occasional or rare basis. The Malleefowl record from the Buffer Zone dates back to 1967 (Figure 2), therefore its location data may be an inaccurate reflection or it may represent an historical nesting mound.

The PMST identified nine fauna species listed as Migratory under the EPBC Act that may occur within the Napandee site, Buffer Zone and/or expanded Study Area. Of these, two are listed as Critically Endangered and are therefore not discussed further in this section. The remaining seven species are birds and are associated with a variety of habitats commonly including wetlands, rivers, ocean and coastlines. Such habitat is not identified within the site or the Buffer Zone and as such these species are considered unlikely to have a low to unlikely likelihood of occurrence.

The PMST identified five bird species listed as Marine under the EPBC Act. An additional seven species are listed as Migratory and Marine and are not further discussed in this section. None of these species are Known to occur within the Buffer Zone. A review of their habitat indicates that four species are considered Unlikely to occur within the Napandee site and Buffer Zone. One species, the Blue-winged Parrot (*Neophema chrysostoma*) has a Low likelihood of occurrence within the Napandee site and a Moderate likelihood of occurrence within the Buffer Zone.

Desktop Results – State Ecological Values

Six threatened flora species protected under the NPW Act have been recorded in the expanded Study Area (Figure 3). Of these, two are also listed under the EPBC Act and are not further discussed in this section. The remaining four flora species are considered Unlikely to occur. Records are all from 1959 to 1998 and limited preferred habitat information is available. It is unlikely that suitable habitat is present given the extensive clearing in the area. Location data is also unlikely to be correct given the date of records. Conservation listed species are tabulated in the field methods and results section.

One species, *Ceratogyne obionoides* has a Low likelihood of occurrence within the Buffer Zone due to potential presence of suitable habitat. Four threatened fauna species listed under the NPW Act have been recorded within the expanded Study Area. Of these, one is listed as Threatened under the EPBC Act and is not further discussed in this section. None of the State listed fauna species are considered Likely or Moderately likely to occur within the Napandee site. All species have a Moderate likelihood of occurrence within the Buffer Zone. The White-winged Chough, Gilberts Whistler and Dwarf Four-toed Slider are considered to have a Moderate likelihood of occurrence within the Mallee woodland corridors. The White winged Chough, Four Toed Slider have been historically recoded as recently as

2002. Gilberts Whistler has not been historically recorded however the site is considered to occur in the species range.

The BDBSA search identified one weed species, the African Love-grass (*Eragrostis curvula)*, Declared under the *Natural Resource Management Act* (NRM Act) which has been recorded in the expanded Study Area.

Conservation and Special Use Areas

One Conservation Park is present within the expanded Study Area, namely the Pinkawillinie Conservation Park. The Park, described in DEWNR (2016) is located approximately 2 km southwest of the Napandee site (Figure 4) and extends for 130,130 ha. The Park includes 4WD tracks and bushwalking trails that visitors are able to use to photograph wildflowers and observe the abundant native wildlife that inhabits the area. The park consists of white sandhills and porcupine grass, eucalypts and sand pine, with a variety of shrubs and wildflowers. Animals found in the area include many bird species, small rodents and lizard species.

Other Parks identified within the broader region as identified in (DEWNR, 2018b) include:

- Tola Conservation Reserve is located approximately 12 km east of the project area and covers an area of 30 hectares;
- Caralue Bluff Conservation Park is located approximately 12 km south of the proposed site and covers an area of 2,157 hectares; and
- Cortlinye Conservation Reserve is located approximately 14km north east of the proposed site and covers an area of 208 hectares.

The PMST search for the Napandee site did not identify any World Heritage properties or National Heritage places protected under the EPBC Act within the expanded Study Area.

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).

NatureMaps indicates there are no Heritage Agreements (native vegetation) within close proximity of the Napandee site.

There are no Aboriginal Sites protected under the AH Act within the Buffer Area (DSD, 2018). The Napandee 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.

Figure 2 Records of Commonwealth Listed Flora and Fauna Species

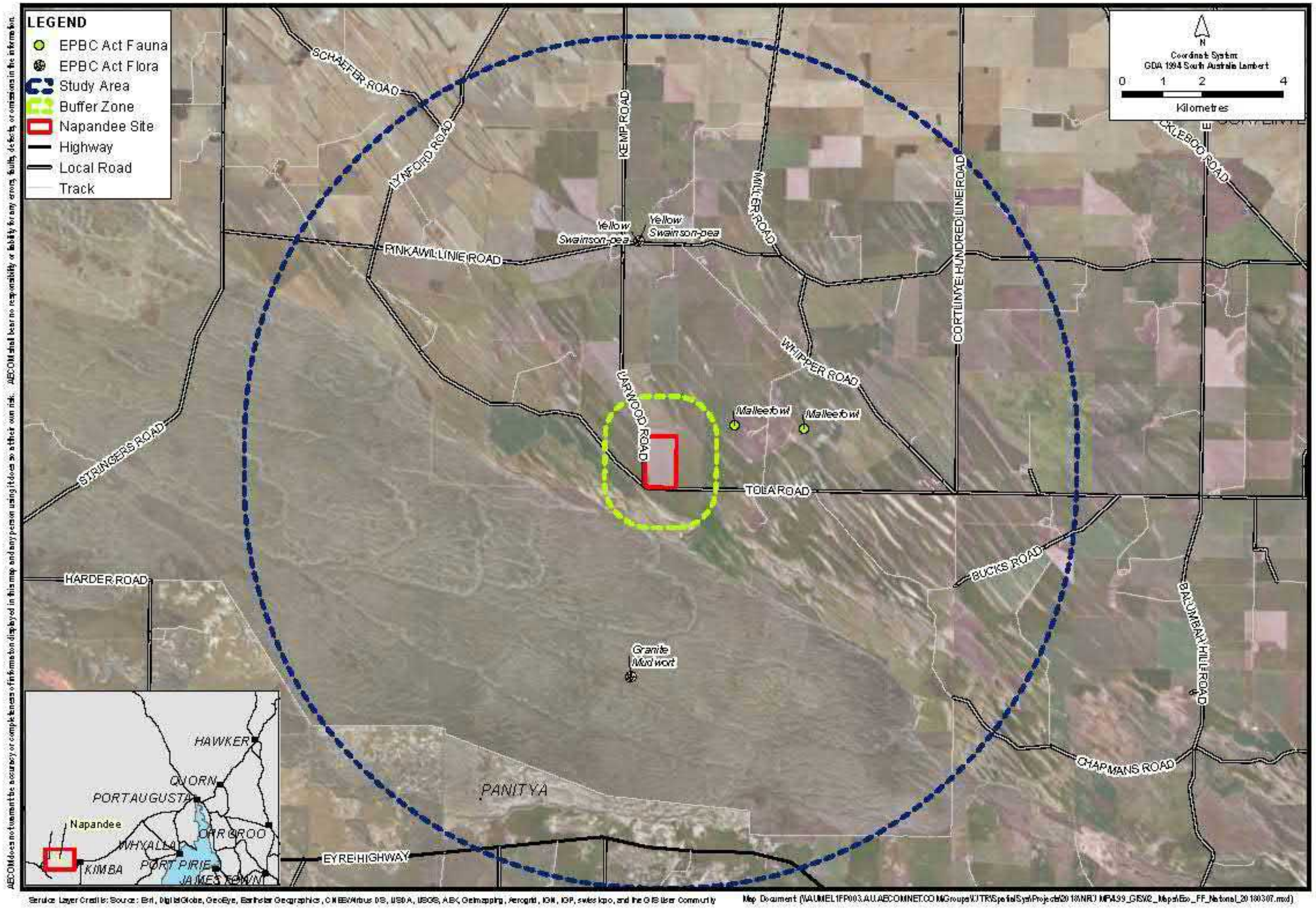
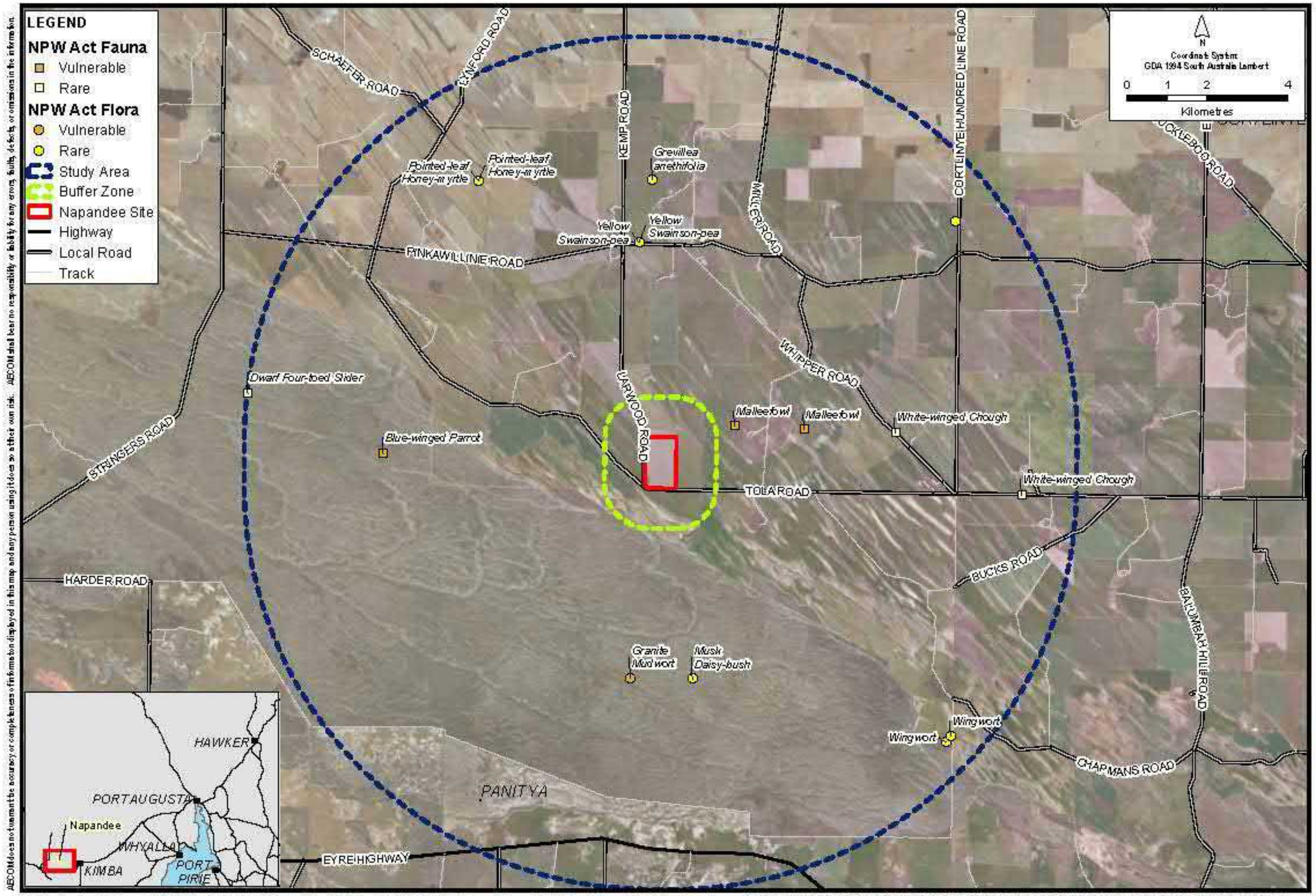
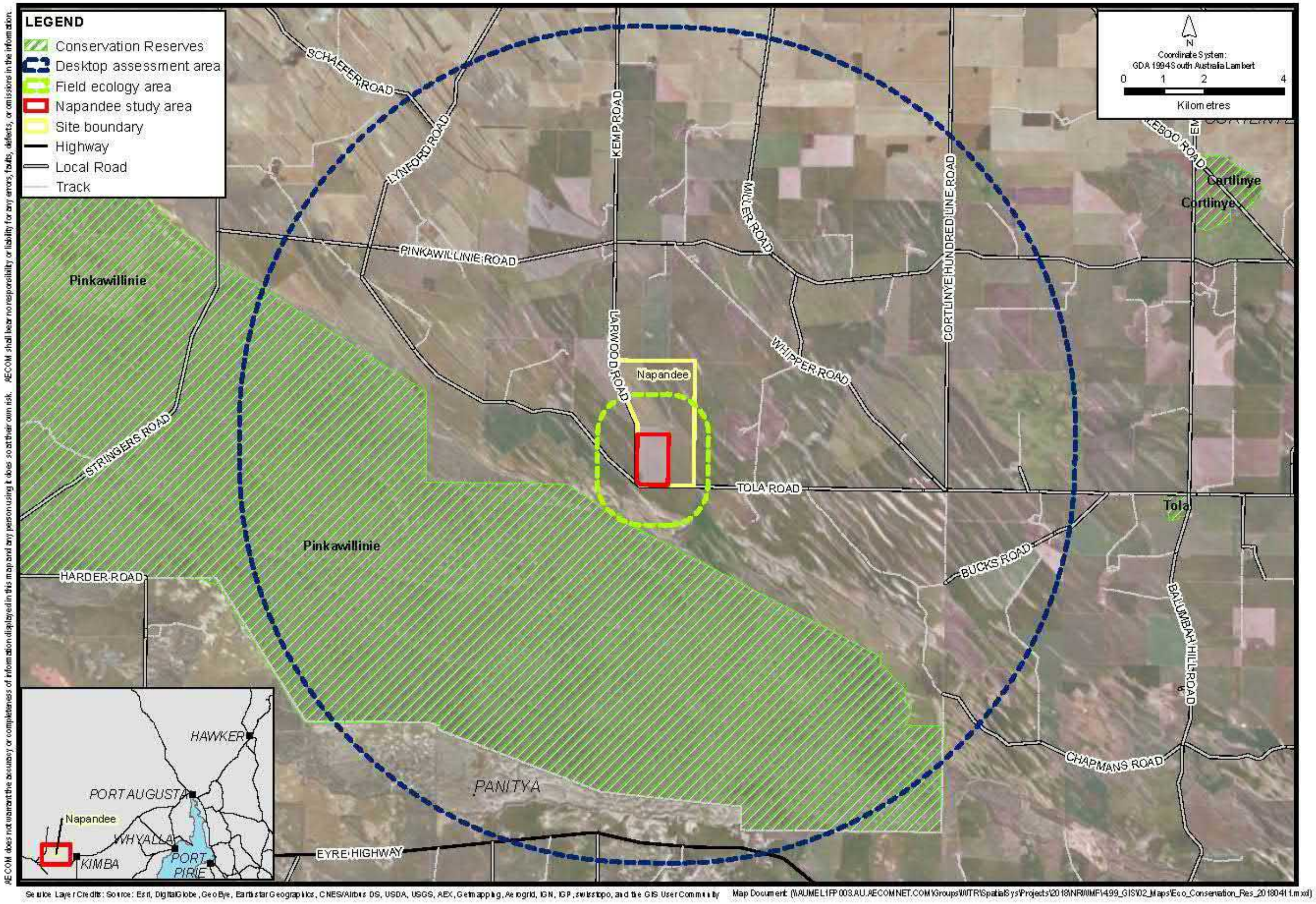


Figure 3 Records of State Listed Flora and Fauna Species



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

Figure 4 Conservation Reserves



2.1.1.3 Field Methods and Results

Flora and Vegetation

Native vegetation within the Napandee site is restricted to linear corridors of Eucalypt mallee woodland and shrubland. Condition of vegetation varies dependent on the exposure to grazing, historical clearing, erosion and invasion of weed species. The linear native vegetation form important fauna habitat corridors linking areas of remnant native vegetation in the local and regional area. They also act as wind barriers which prevent erosion.

Mallee Woodland and understory species along the western site boundary

Linear corridor of native vegetation (Mallee trees) along eastern site boundary

A field survey was undertaken by an AECOM Botanist with experience undertaking field surveys in South Australia and Western Australia. The survey area including a 1km buffer around the site was 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

The desktop assessment identified no Threatened Ecological Communities (TECs) in the vicinity of the survey area. None were recorded during the field survey.

Vegetation descriptions and photographs are provided in Table 5 and supported by floristic data collected in the field (Appendix A).

As displayed in Figure 5, two vegetation types were recorded within the survey area including open Mallee woodland recorded on undulating plains with minimal understorey, and tall open shrubland situated on linear dune formations.

Figure 5 Vegetation types within the site and Buffer Zone

Table 5 Vegetation types Napandee recorded within the survey area including code, description and photograph

Code	Vegetation Description	Photograph
A1	Open mallee woodland over sparse sclerophyllous shrubs Mallee woodland of *Eucalyptus oleosa, Eucalyptus brachycalyx* and *Eucalyptus calycogona* subsp. *calycogona* over *Scaevola spinescens, Pimelea microcephala* subsp. *microcephala, Acacia ancistrophylla* var. *lissophylla* and *Alyxia buxifolia* mid to tall open shrubland over *Lomandra leucocephala* subsp. *robusta,* and other dead grasses unable to be identified. Comprising linear corridors and two larger areas of remnant native vegetation. Species richness a direct reflection of size and impacts of historical grazing. Likely to have more weeds than recorded. Vegetation type represented by Nap 1, 2 and 3.	
A2	Tall open shrubland with isolated mallee *Melaleuca uncinata* and *Santalum acuminatum* tall open shrubland with *Eucalyptus socialis* subsp. *viridans* isolated mallee over *Triodia* species and *Enneapogon avenaceus*. Recorded on linear sand dunes. Vegetation type significantly impacted from historical clearing, isolation, grazing, and erosion. Vegetation type represented by Nap 4.	
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 (Table 6)

Condition of vegetation varied dependent on the exposure to grazing, historical clearing, erosion and invasion of weed species. Condition ranged from Excellent to Completely Degraded. Excellent vegetation is restricted to the Pinkawillinie Conservation Park. The majority of linear corridors of vegetation were mapped in Good condition. Understorey strata appear degraded as a result of grazing and biodiversity is likely to have been reduced. Degraded vegetation included lower biodiversity and signs that all strata have been impacted.

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

Five threatened flora species listed under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) were identified in the desktop assessment (Table 7, Figure 2). Of these, four species were considered unlikely to occur due to lack of suitable habitat and lack of historical records in the vicinity of the survey area. One species, *Swainsona pyrophila* (Yellow Swainsona) was considered to have a Moderate likelihood of occurrence. This species is listed as Vulnerable under the EPBC Act. The Yellow Swainsona is found only after a fire event. For this reason, the presence of this species in the expanded Study Area will remain uncertain. Historical location data has shown this species to occur along firebreaks, roadsides, clayplans and edges of fire ash.

It is possible that the Yellow Swainsona may occur within the survey area. Suitable habitat, which includes mallee scrub on red loam to sandy soils, is present in the survey area. It therefore continues to have a Moderate likelihood of occurrence.

Four flora species listed as Rare under the *National Parks and Wildlife Act 1972* (NPW Act) were identified during the desktop assessment (Table 7). Of these, three were considered unlikely to occur due to lack of suitable habitat and location data (i.e. they had not been previously recorded in the vicinity of the survey area). One species, *Ceratogyne obionoides* (Wingwort) had a Low likelihood of occurrence. This species prefers sand hills along drainage lines. One shallow drainage line is present in the southwest corner of the survey area, adjacent to a linear sand dune system. This may present potential habitat.

Table 7 Threatened Flora Species including Conservation Status, Habitat and Likelihood of Occurrence

Taxon	EPBC Act	NPW Act	Habitat	Desktop Assessment	Field Survey Assessment
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	Unlikely	Unlikely
Hibbertia crispula Ooldea Guinea-flower	VU	VU	Ooldea Guinea-flower is known from only two disjunct locations, the Lake Everard region and the Ooldea region of South Australia, growing on red sand	Unlikely	Unlikely
Limosella granitica Granite Mudwort	VU	VU	Granite Mudwort occurs in a small number of disjunct sub-populations across northern Eyre Peninsula, South Australia, where it is confined to seasonally wet rock-pools (gnamma holes) on the top of granite inselbergs and outcrops.	Unlikely	Unlikely
Pterostylis mirabilis Nodding Rufoushood	VU	VU	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 known from *Callitris* and *Eucalypt* woodland	Unlikely	Unlikely
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.	Moderate	Moderate
Ceratogyne obionoides Wingwort		R	Found on the upper Eyre Peninsula in South Australia, growing on sandhills.	Unlikely	Low
Grevillea anethifolia		R	Grows on sandy loam and gravel soils, sometimes along water courses.	Unlikely	Unlikely
Melaleuca oxyphylla Pointed-leaf Honey-myrtle		R	No habitat information available. No known records of this species within the expanded Study Area.	Unlikely	Unlikely

Taxon	EPBC Act	NPW Act	Habitat	Desktop Assessment	Field Survey Assessment
Olearia adenolasia Musk Daisy-bush		R	Grows on grey sand over laterite, and sandy loams. Plains and sandhills.	Unlikely	Unlikely

<u>Fauna and Fauna Habitat</u>

The field survey was undertaken by an AECOM Zoologist with experience conducting surveys in similar environments. Fauna surveys occurred concurrently with the aforementioned flora surveys. As per the flora survey, the fauna survey area was traversed by on foot and by 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 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 zone 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

Several habitat types were identified during the field assessment. These habitat types consisted of various compositions of Mallee Eucalypt Woodland and open farmland.

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 farming activities were identified. This area was not observed to support any fauna species, and in its observed condition, would be of negligible habitat value. Discussion with the landholder / managers revealed that, in recent times, the land had been subject to cropping, intense grazing (sheep) and finally spraying to kill off all vegetation and suppress weeds. This land use approach is understood to be used across cropped land within the farmers land holding.

Open farmland

Figure 6 Threatened flora records within the expanded study area

Whilst the centre of the paddock itself was devoid of habitat, the south-west corner of the paddock and its perimeter consisted of Mallee vegetation (referred to as A1 in Table 5). Mallee vegetation in the southwest corner of the paddock formed a block of vegetation approximately two and a half hectares in size and is included within the site footprint. This area of vegetation which aligns with vegetation code A1 was continuous with road side vegetation connecting to potential wildlife corridors to the north and east of the site. The area was dominated by tall, and in many cases, large old hollow bearing Mallee eucalypts. However, understorey was disturbed with prevalent bare ground and a sparse cover of saltbush and sedges. Grass cover and soil crust was sparse to absent. Habitat features of this area included the aforementioned tree hollows, peeling bark, large woody debris and logs (some of which contained hollows) and organic leaf litter with the area providing good opportunities for foraging and breeding birds and some habitat value for ground dwelling fauna such as reptiles and small mammals. Whilst not present in the paddock at the time, signs of past livestock access (sheep) were prevalent and grazing is likely to have compromised understorey diversity and thus habitat values.

Mallee vegetation to the south west corner of the subject paddock

To the south of the site's boundary and along roadsides, vegetation was similar to that described above with minor differences. For instance, an assessment of vegetation to the south-west of the subject paddock and to the south of the intersection of Tola Road and Larwood Road, revealed a similar canopy cover but increased understorey diversity with soil crust and additional lifeforms such as the presence of spinifex grass and Broombush adding additional habitat complexity with an absence of grazing by livestock the likely cause of these differences. Whilst vegetation lining the boundary of the site was typically more disturbed with these thin linear areas often completely devoid of understorey lifeforms and habitat complexities.

Intact Mallee vegetation showing shrub and spinifex cover

The final habitat type was aligned with mapping of vegetation denoted as A2 and described as Tall Open Shrubland with scattered Mallee. This vegetation type was of notably lower habitat value than Mallee woodland earlier described. Typically lacking understorey and more exposed to wind due to its position in the landscape, the area through an absence of old Mallee trees typically lacked hollows and the same foraging and nesting opportunities provided by other vegetation types assessed. Woody debris in the form of fallen shrubs were present providing potential cover for ground dwelling fauna however there were signs of stock access. This vegetation was also notably more isolated that other areas assessed and its long and linear nature means it is more likely to be adversely impacted by fringe effects.

Dune habitat

Fauna Diversity

No threatened fauna species were recorded within the survey area of the Napandee site and the Buffer Zone. A total of 18 species were identified with the majority comprising common birds. Species recorded included White-browed Babbler Pomatostomus superciliosus, Pallid Cuckoo *Cacomantis pallidus*, Singing Honey-eater Gavicalis virescens, White-eared Honeyeater, Grey Butcher Bird *Cracticus torquatus*, Nankeen Kestral *Falco cenchroides* and Yellow-rumped Thornbill *Acanthiza chrysorrhoa*. In addition, the remains of a Shingleback Lizard *Tiliqua rugose* and scats and tracks consistent with Western Grey Kangaroo *Macropus fuliginosus* were also detected. Of the species detected all are considered native. A complete list of fauna species identified during the assessment is presented in Table 8. This includes birds species identified during bird census and opportunistic sightings. The greatest faunal activity noted corresponded with Mallee vegetation in the south-west corner of the subject paddock.

Fauna observed on site, foraging Mulga Parrots (left) and a deceased Shingleback (right)

Table 8 Fauna species recorded

Common Name	Scientific Name	EPBC	NPW	Bird census
Birds				
Australian Magpie	*Gymnorhina tibicen*			1, 2
Australian Raven	*Corvus coronoides*			1
Crested pigeon	*Ocyphaps lophotes*			1, 2
Galah	*Eolophus roseicapilla*			1, 3
Grey Butcherbird	*Cracticus torquatus*			1
Grey-fantail	*Rhipidura albiscapa*			1
Grey Shrike-thrush	*Colluricincla harmonica*			2
Inland Thornbill	*Acanthiza apicalis*			1
Jacky Winter	*Microeca fascinans*			1
Mulga Parrot	*Psephotus varius*			1, 2, 3
Nankeen Kestrel	*Falco cenchroides*			2
Pallid Cuckoo	*Cacomantis pallidus*			
Singing Honeyeater	*Gavicalis virescens*			1
Striated Thorn-bill	*Acanthiza lineata*			1
Welcome Swallow	*Hirundo neoxena*			2
White-browed Babbler	*Pomatostomus superciliosus*			1
White-eared Honeyeater	*Lichenostomus leucotis*			
Yellow-rumped Thornbill	*Acanthiza chrysorrhoa*			1
Yellow-throated Miner	*Manorina flavigula*			1, 2, 3
Mammals				
Western Grey Kangaroo	*Macropus fuliginosus*			
Reptiles				
Shingleback Lizard	*Tiliqua rugosa*			

Threatened Fauna Species

Species identified as being potentially present at the site during the desktop assessment consisted of six fauna species listed as Threatened, under the EPBC Act, nine species listed as migratory and marine and five species listed as marine under the EPBC Act and nine species listed under the NPW Act. Of these species only Malleefowl *Leipoa ocellata* , Blue Winged Parrot *Neophema chrysostoma*, White-winged Chough *Corcorax melanorhamphos*, and Dwarf Four-toed Slider *Lerista distinguenda* have been recorded in the expanded Study Area (Figure 7). Gilberts Whistler has not been historically recorded however the Napandee site is considered to occur in the species range.

The likelihood of threatened fauna was reassessed following completion of the field survey and is provided in the tables below. This likelihood is informed by the outcomes of the field assessment and supersedes that presented in the desktop assessment.

Threatened species habitat within the site footprint is restricted to Mallee vegetation in the south- west corner of the subject Paddock. As described above, this vegetation has experienced past disturbance and ground cover was sparse, however did maintain some habitat values with large wood debris, logs, hollows and peeling bark identified. This habitat is considered to provide low quality habitat for the EPBC Act listed Malleefowl and low habitat potential for Sandhill Dunnart *Sminthopsis psammophila*.

Given the isolated nature and lack of habitat corridors connecting to Periwinkle Conservation Park, habitat is unlikely to be of critical importance to either species. Habitat within the site is considered suboptimal due to its small size and lack of shrub and hummock grass cover both of which are considered likely habitat requirements of Malleefowl (Benshemesh, 2007). If utilised by Malleefowl, this area would only represent a small component of the species overall foraging range and if lost would be unlikely to impact the species. Fauna surveys did not find any signs of Malleefowl presence. As such, no further assessment for the species is recommended.

The lack of understorey vegetation is likely to have compromised habitat suitability within the site for Sandhill Dunnart with the presence of Hummock Grass thought to be a key component of species habitat. However, detailed guidance on species habitat is lacking and the species presence cannot be ruled out based on current survey effort (Churchill, 2007). If present, the species would likely be impacted if its habitat is impacted with only limited ability to disperse should vegetation on the site be impacted. The species has not been recorded in the expanded Study Area and was identified via the PMST search, however recent communication with local ecologists from Ecological Horizons Pty Ltd has confirmed records within the Periwinkle Conservation Park.

State listed species that may be present within the site and have the potential to be impacted by the proposed NRWMF are limited to Dwarf Four-toed Slider. This species would require further assessment should vegetation in the south- west corner of the site be cleared.

Outside of the site footprint but within the Buffer Zone, a number of species are still considered to have a moderate likelihood of occurrence, particularly in areas of vegetation identified to contain hummock grasses and shrub cover. Species considered to have a moderate likelihood of occurrence include the EPBC Act listed Mallee Fowl, EPBC Act listed Sandhill Dunnart EPBC Act marine and NPW Act listed Blue Winged-Parrot, and NPW Act listed White Winged Chough, Dwarf Four-toed slider and Gilbert’s Whistler.

It should be noted that whilst such species are considered likely within the buffer zone, and such habitat may potentially support individuals and small populations of such species, it is unlikely to form core habitat. The nearest core habitat for the species and the location of many of the historical records is the Periwinkle Conservation Park. The Periwinkle Conservation Park is located entirely outside the buffer zone to the south of the subject area and is not directly linked (through continuous remnant vegetation cover) to any of the habitats identified in the buffer zone.

The residual likelihood of threatened fauna is provided in the table below.

Table 9 Threatened Fauna and Likelihood of Occurrence

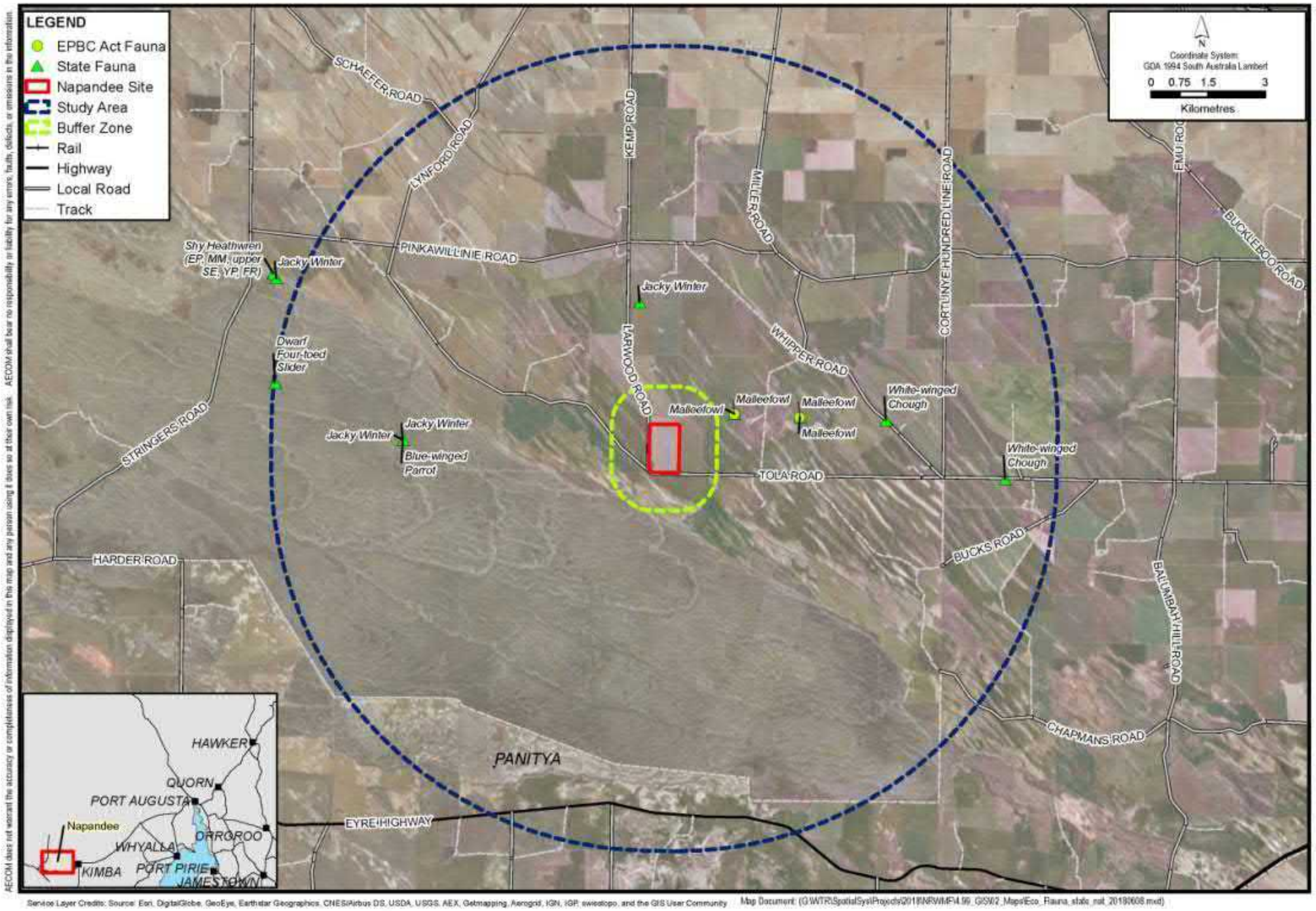
Common Name	EPBC	NPW	Habitat	Within Site	Within Buffer Zone
Actitis hypoleucos Common Sandpiper	Mi, Ma		Edges of saltwater to fresh waterbodies and wetlands, including estuaries, lakes, drainage lines, tidal watercourses and mudflats; occasionally beaches and rocky headlands; mainly spring-summer non-breeding migrant	Unlikely	Unlikely
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		Freshwater wetlands and watercourses, pastures and croplands, especially where drainage is poor. Occasionally also tidal flats and estuaries.	Unlikely	Unlikely
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

Common Name	EPBC	NPW	Habitat	Within Site	Within Buffer Zone
Corcorax melanorhamphos White-winged Chough		R	White-winged Choughs are found in open forests and woodlands. They tend to prefer wetter areas, with lots of leaf-litter, for feeding, and available mud for nest building.	Low	Moderate
Haliaeetus leucogaster White-bellied Sea-Eagle	Ma		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 areas, including farmland and clearing amongst mallee.	Low	Moderate
Lerista distinguenda Dwarf Four-toed Slider		R	This species inhabits coastal heaths and woodlands, including mallee and jarrah woodland, where animals shelter under rocks, logs and leaf litter. They are often found in abandoned stick ant nests.	Low – moderate	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
Neophema chrysostoma Blue-winged Parrot	Ma	VU	The Blue-winged Parrot inhabits a range of habitats from coastal, sub-coastal and inland areas, right through to semi-arid zones. Throughout their range they favour grasslands and grassy woodlands. They are often found near wetlands both near the coast and in semi-arid zones. Blue-winged Parrots can also be seen in altered environments such as airfields, golf-courses and paddocks.	Low	Moderate

Common Name	EPBC	NPW	Habitat	Within Site	Within Buffer Zone
Numenius madagascariensis Eastern Curlew	CR, Mi, Ma	VU	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
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.	Unlikely	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	Low
Sminthopsis psammophila Sandhill Dunnart	EN	VU	On the Eyre Peninsula, the Sandhill Dunnart occupies sand ridges covered by hummock grassland and mallee-broombush shrub.	Low	Moderate

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

Figure 7 Threatened fauna records within the study area



2.1.2 Assessment Against Criteria

An assessment against the site characteristic criteria is provided in Table 10 below based the desktop and field investigations.

Table 10 Assessment against Flora, Fauna and Conservation Site Characteristic Criteria

Key Criteria	Site Conditions	Constraints / hazards
Presence and condition of native vegetation Approximately 4.5 ha of native vegetation in the form of linear corridors within the site (100 ha), and 103 ha present in survey area (820 ha).		
Presence and condition of native vegetation	Approximately 4.5 ha of native vegetation of variable condition is present within the site. Linear native vegetation corridors provide important fauna habitat connecting areas of remnant vegetation in the local area.	Clearing of native vegetation should be avoided. Linear corridors provide habitat refuge and connectivity.
Presence of Commonwealth listed threatened species and habitat No Threatened Ecological Communities (TECs) present. One threatened flora and two threatened fauna species may be present. Detailed surveys of the site and Buffer Zone, including vegetation community, condition and importance for fauna should be verified during a field survey.		
Presence of Threatened Ecological Communities	None present.	None identified.
Presence of threatened flora species	The Yellow Swainson-pea prefers disturbed sites and has been recorded in the expanded Study Area. This species may be found along disturbed corridors of native vegetation within the site. Only occurs after fire.	Yellow Swainson-pea may be present within Site however its presence can only be verified following a fire. If vegetation clearing is required a risk assessment should be completed to determine the likelihood and significance of impact on this species.
Presence of threatened fauna species	Malleefowl has been recorded in the expanded Study Area. This species and the Sandhill Dunnart may utilise native vegetation corridors present within the site and/or Buffer Zone.	None identified provided suitable mitigation. Sandhill Dunnart may be present, would be unable to flee and requires further assessment should vegetation clearance be proposed.
Presence of Threatened fauna habitat	Native vegetation corridors present important fauna habitat linkage. It is unknown whether it could be considered critical habitat for threatened species.	None identified provided suitable mitigation.
Presence of Migratory species	No suitable habitat is present.	None identified.

Key Criteria	Site Conditions	Constraints / hazards
Presence of State listed threatened species and habitat Three fauna species with a Moderate likelihood of occurrence. Detailed surveys of the site and Buffer Zone including the assessment of the importance of habitats for fauna should be verified during a field survey.		
Presence of threatened flora species	No species likely to be present within site, one species may be present in adjacent area.	None identified provided there are suitable mitigations.
Presence of threatened fauna species	The White-winged Chough, Gilberts Whistler and Dwarf Four-toed Slider are considered to have a Moderate likelihood of occurrence within the site and Buffer Zone.	Dwarf Four-toed Slider may be present, would be unable to flee and requires further assessment should vegetation clearance be proposed
Proximity and value of Parks (National Parks, Conservation Parks, Conservation Reserves, Recreational Parks and Wilderness Protected areas) Pinkawillinie Conservation Park is 2 km from the Napandee Site. Implementation of appropriate management actions will mitigate potential impacts on the part as a result of development.		
Proximity and value of Parks	Pinkawillinie Conservation Park in expanded Study Area.	None
Proximity of Aboriginal heritage sites There are no known Aboriginal Heritage Sites located within the Study Area.		
Proximity of Aboriginal heritage sites	None present in expanded Study Area	None
Proximity of Commonwealth, state and local heritage sites No Commonwealth, state, or local heritage sites within Study Area.		
State and Local Heritage Sites	None present in expanded Study Area	None

2.1.3 Design Issues and Mitigation Measures

The Napandee site includes approximately 4.5 ha of native vegetation in linear corridors along the north border and tracking north-south in the eastern quarter. Clearing of native vegetation should be avoided where possible. The corridors provide fauna habitat linkages, refuge, and wind barriers. Access to the site is possible using the existing Tola Road and Larwood Road.

Appreciable land degradation in adjacent vegetation as a result of development should be managed, including erosion, dust, spread of weeds, surface water runoff, and clearing beyond approved boundaries.

2.1.4 Data Gaps and Recommendations for Stage 2 Work Program

The status of annual flora species and weeds is unknown. Lack of rainfall for months leading up to the survey will have affected species presence and vigour. Further vegetation survey may be required to gain a complete understanding of flora composition and the ability to assess significance of remnant native vegetation and condition. Absence of detailed survey data limits the ability to assess vegetation significance, biodiversity and suitability as habitat for threatened flora and fauna species.

With the exception of Sandhill Dunnart, all fauna species identified have a potential to utilise the Site and buffer zone would be expected to be able to relocated without significant impact were the site to be selected for the NRWMF. The dispersal ability of Sandhill Dunnart however is limited and a survey for the species is required to determine its status should suitable habitat for the species be proposed for clearance.

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.

If vegetation in south-west corner of site may be cleared for development of the site, targeted assessment for Sandhill Dunnart and Dwarf Four-toed Slider shall be undertaken. Several methods are 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.

2.2 Radiation, Background and Risks

2.2.1 Methodology and Results

2.2.1.1 Site Characteristic Criteria

This desktop assessment of radiation, background and risks, address the key site characteristic 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 the NRWMF.

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 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 NRWMF 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).

This desktop assessment has compared current published background conditions at each of the sites, allowing early identification of sites where elevated background conditions could potentially already exist.

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 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).

This site reported Q_{hem} (Quaternary aeolian sands also known as Holocene estuarine basin sands) with Moornaba Sands containing significant surface dune structures which are likely to concentrate radioactive elements.

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 10Bq/m^3.

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 survey used combined magnetic and radiometric survey techniques to assess baseline conditions for the site. The aerial survey consisted of use of a Cessna U206F registered to Geosurvey Pty Ltd (Murray Bridge, SA).

The 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 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.

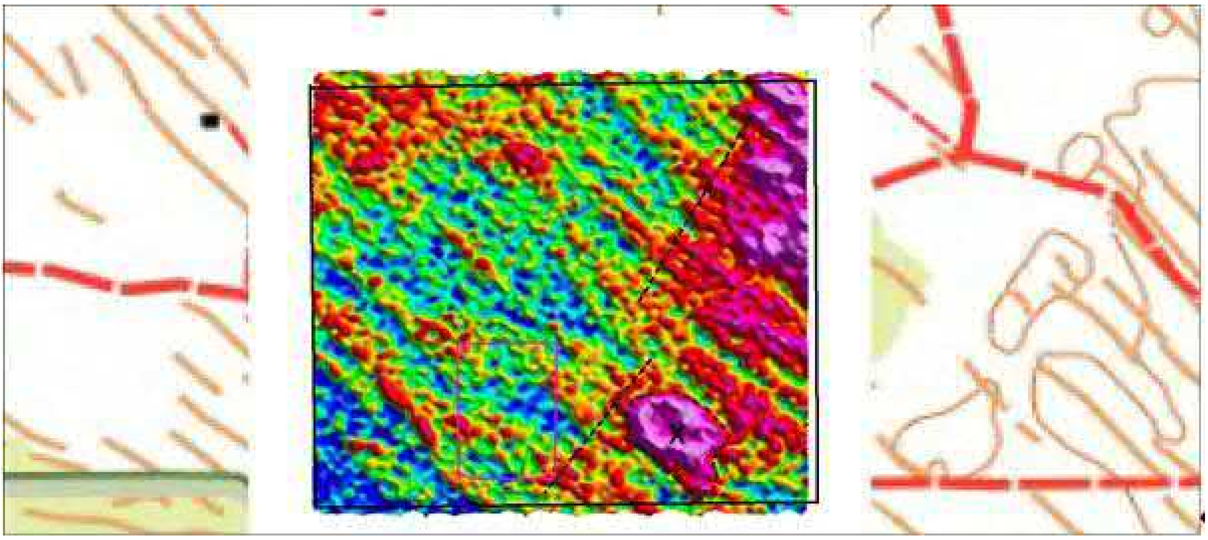
The aircraft (with a cruising speed of about 260 kph) gathered data on 50 m line spacing from a north-south survey height of around 50 m running survey lines spacing of 50 m (tied on an east-west basis at 500 m). Radiometric data was processed using standard radiometric correction procedures including 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 site of 1 square kilometre was subsequently sub-sampled. The techniques were consistent with current industry practice for these kinds of investigations and the 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 Napandee site, which appears to be associated with elevated background Potassium levels arising from weathering of K-Feldspar (commonly described as $KAlSi_3O_8$ $NaAlSi_3O_8$ –$CaAl_2Si_2O_8$).

The desktop data and subsequent supplementary field survey have not indicated the presence of elevated background radiation conditions within the site that could affect safety of personnel or impact future environmental monitoring. An elevated Thorium anomaly to the east of the site, within the aerial survey area, is displayed in the figure below.

Figure 8 Thorium Anomaly to East of Site (extract from Daishsat report).



The Thorium anomaly is displayed in purple and the broken vertical line running approximately SSw to NNE is estimated by Daishsat (2018) to be a “domain change” in terms of both radiometric and surface terrain.

This anomaly was to the east and in a different domain so its radiological impact to the site was considered to be negligible.

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 a targeted aerial radiometric survey undertaken as part of this assessment do not indicate the presence of elevated background radiation conditions 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 NRWMF, nor require detailed mapping and material testing to establish the baseline conditions prior to construction and operation of the NRWMF.

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, especially given the elevated thorium levels to the east of the site, 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.

Details of the proposed scope and methodology for this field survey works will 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 NRWMF.

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 11.

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 impacts assessed by other site characterisation studies and that the identified impacts should be considered in the assessment of the site and the design of the future NRWMF 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 NRWMF. The following steps were taken: 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.

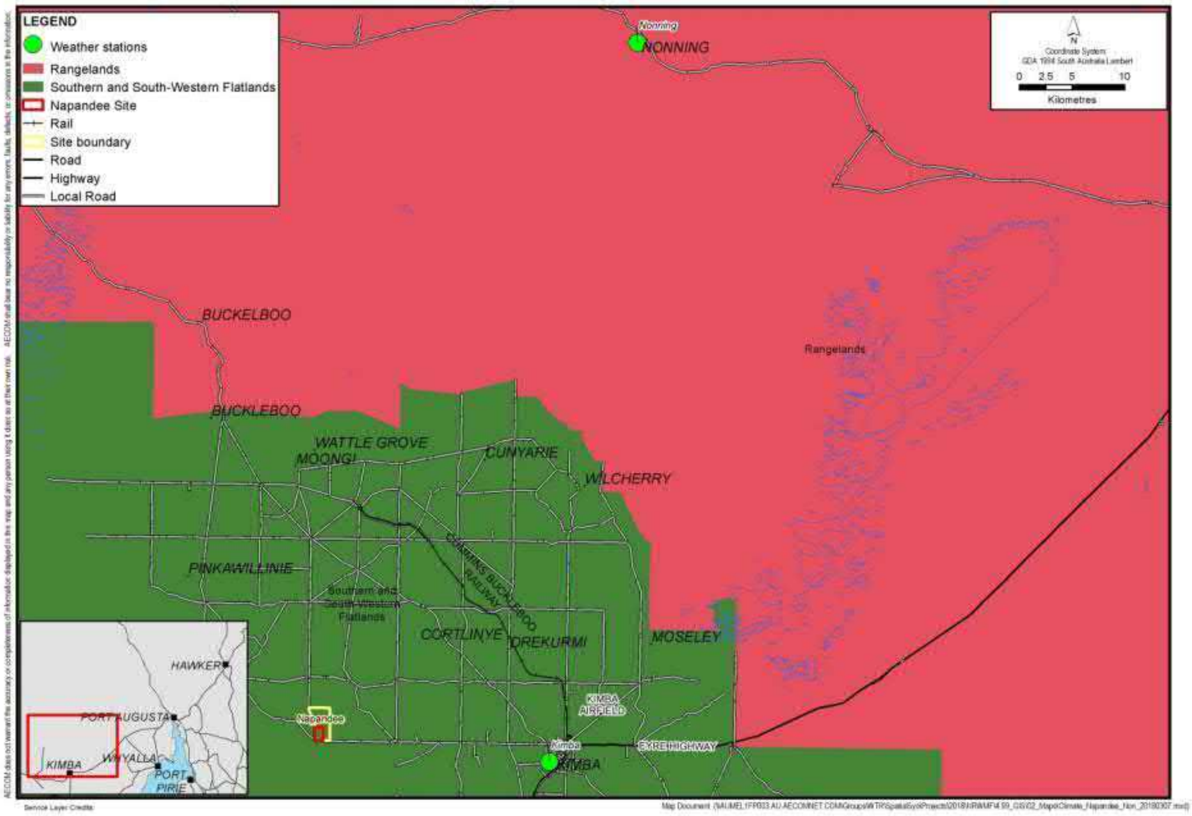
To determine potential impacts to the site and the future NRWMF arising from those hazards, the project team drew on its experience in undertaking climate change risk assessments for infrastructure projects and communities. The potential impacts arising from hazards were then discussed with specialists addressing other site 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 9). 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 divided into sub clusters, with the Napandee site located in the Eastern Sub - Cluster as seen in Figure 9

Figure 9 Location of the Napandee 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 (refer to Figure 9), 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 70 km to the northeast 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 12 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:

- the level of confidence in specific, absolute or percentage changes in climate variables. 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 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

[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.

'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 13 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

Given the high level nature of the desktop assessment, the following two assessment criteria have been identified for the climate change:

- Key hazards that could impact the future NRWMF and workers: identification of the hazards, their impact and the site characteristic or enabling infrastructure element they relate to.
- Change in frequency or intensity of climate hazards: The projected change in climate hazards that may affect the site or future NRWMF. 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 11 outlines the potential impacts to the site and future NRWMF 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 NRWMF and development of operational management practices.

Table 11 Impacts arising from climate hazards and relevant thematic areas

Impact	Climate Hazard/s	Significance and Potential Ability to Manage the Impact	Relevant Site Characteristic
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 NRWMF 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 NRWMF. 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 Characteristic
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 NRWMF 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 NRWMF 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 Characteristic
Erosion of landscape and vegetation	Extreme Rainfall	Material concern to the safe operation of the NRWMF 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 NRWMF 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 NRWMF Impact can be managed operational management practices	- Water - Capacity to deal with NRWMF 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 Characteristic
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 NRWMF 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 NRWMF 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 Characteristic
Increased maintenance costs of NRWMF 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 NRWMF 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 NRWMF 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
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 NRWMF. 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 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 12 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 13, no projections are available for changes in lightning or hail.

Differences between the 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.

On the basis of the climate change projections, the site should not be precluded from further consideration as potential hazards could be managed by design or operational considerations. 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 in other site characterisation studies.

Table 12 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)	20 (1995 baseline)	47 (38 to 57)	
Frost (days with min. temp. <2 °C)	1.1 / 3.3 (1981-2010 baseline) [1]	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 11 summarises the potential impacts to the site and future NRWMF to be considered in the design and operational phases. The table identifies the site characteristics or enabling infrastructure 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 under each site characteristic or enabling infrastructure element 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 NRWMF, 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 13. The projections included in this report are limited to the end of the century. The lifespan of the future NRWMF and closure requirements (e.g. capping) may extend beyond this period.

Table 13 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 assessments of the relevant site characteristics 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 detailed 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 NRWMF, 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 23). 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 10).

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

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.

2.4.1.2.1 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).

2.4.1.2.2 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 1m and 10m contour intervals.

2.4.1.2.3 Weather

Terramatrix obtained synoptic weather data for the Bureau of Meteorology (BOM) weather stations 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).

2.4.1.2.4 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 10 shows the extent of potentially classifiable vegetation, within the 200m assessment zone around the Napandee 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 10), 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).

This also accords with SA native vegetation mapping, which identifies the 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, 2017)*.

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

[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).

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.

A number of major vegetation subgroups (MVS) are identified as components of MVG 14 where it occurs on and around the site. These include MVS Mallee with hummock grass and MVS Mallee heath and shrublands (Location SA Map Viewer, 2018).

Two large patches of vegetation are located in the surrounding landscape, however, they are more than 1km from the site (see Figure 11). They comprise extensive tracts of native vegetation associated with the Pinkawillinie Conservation Park to the southwest of the Napandee site, and a patch of vegetation on private land to the northeast. These are also identified as MVG 14 Mallee Woodland and Shrubland (Location SA Map Viewer, 2018).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). Figure 2 shows two fires recorded in the publically available fire history data, both of which occurred in the Pinkawilline Conservation Park and appear to have burnt out from the park towards the site.

The Pinkawillinie Conservation Park comprises the largest hazard in the surrounding landscape and is approximately 6.5km wide (north to south) and extends more than 50km from the southeast to the northwest (see Figure 12). The rest of the surrounding landscape 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 (n.b. it appears not to, based on the AECOM photographs and descriptions), 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.

Figure 10 Napandee –site assessment zone for bushfire hazard assessment.

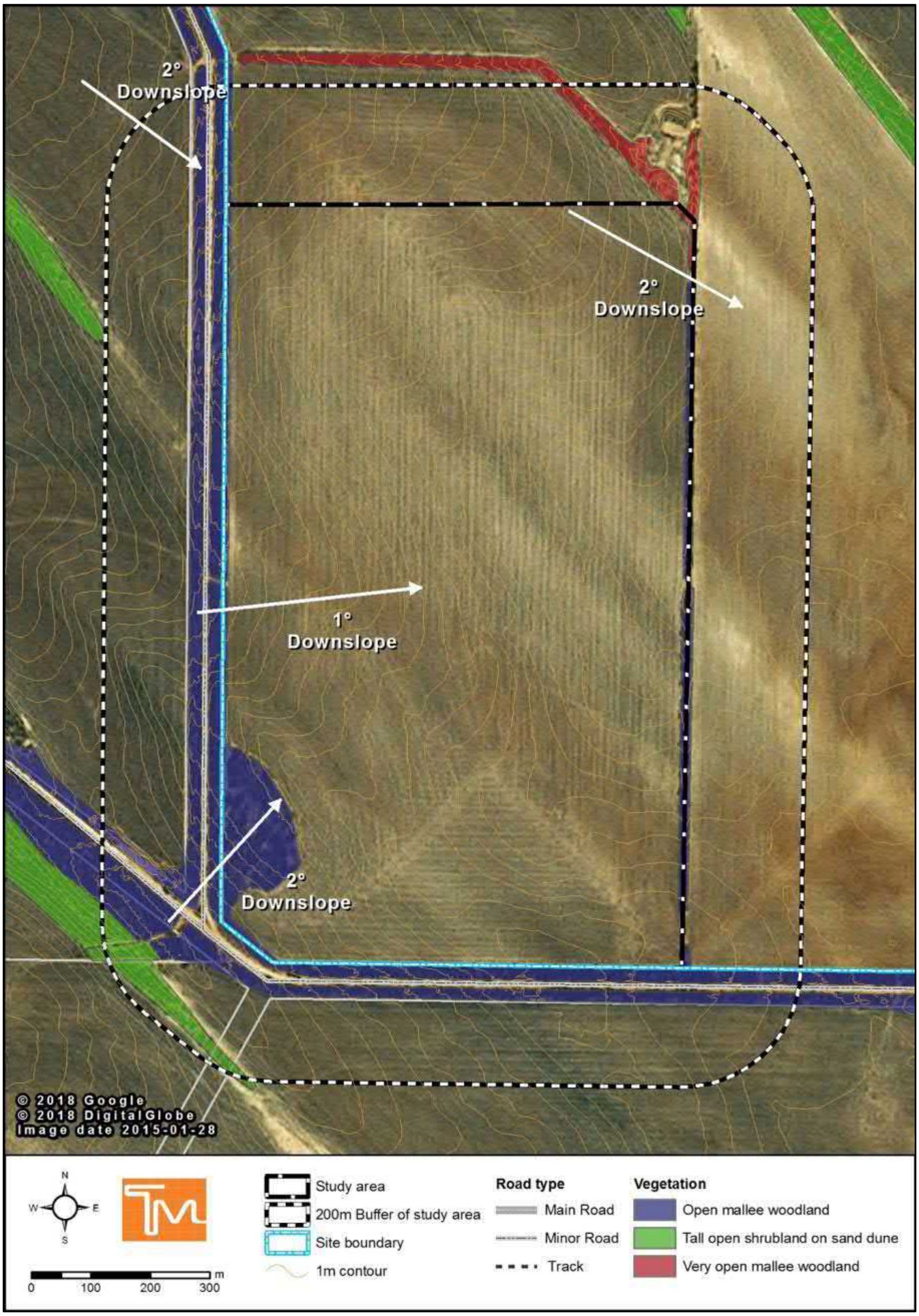
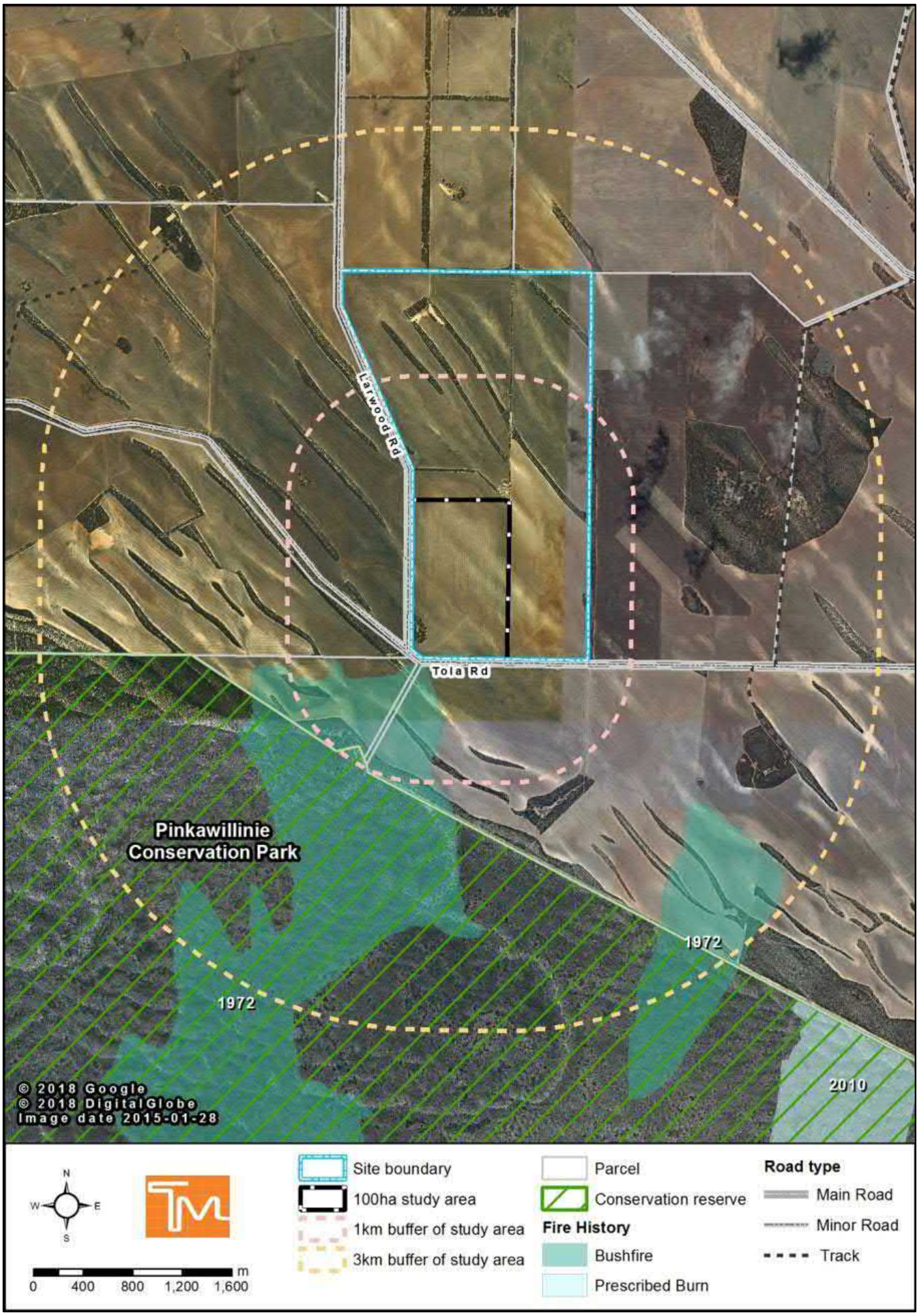


Figure 11 Napandee landscape assessment to 3km.



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 Map 1 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 12 The landscape surrounding the Napandee 100ha site (shown 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 Section 2.4.2.3). Green circles identify the locations of the nearest CFS brigades (see Section 2.4.2.4.4).

2.4.2.1.4 Non-hazardous vegetation

Due to their 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 east-west along the northern boundary, if they are sufficiently distant from future buildings (i.e. >20m).

Depending on where the NRWMF was to be located within the site, most of the other vegetation patches shown in Map 1 may be excludable. Irrespective of classification, 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.

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 Napandee, likely best accords with the Mallee-Mulga (Group E) classification under AS 3959-2009. Two large patches of this vegetation are located in the surrounding landscape; however, they are more than 1km from the site, comprising the extensive tracts of native vegetation associated with the Pinkawillinie Conservation Park to the southwest of the site, and a patch of vegetation on private land to the northeast. However, a fire in the Pinkawillanie Conservation Park would have to travel more than 1km through the pasture between the Park and the site, before impacting as a grassfire.

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 (it appears not to be, based on the AECOM photographs and descriptions), 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.

Due to their limited size and connectivity, patches of tree and shrub vegetation may also meet one or more of the exclusion criteria in AS 3959-2009 for low threat vegetation, depending on their distance from, and orientation to, any future buildings. This vegetation is likely to include the narrow bands of vegetation running north-south through the site and east-west along the northern boundary, if they are sufficiently distant from future buildings (i.e. >20m).

Large patches of vegetation in the surrounding landscape are sufficiently distant that they do not pose a significant threat or appreciably influence the location of the NRWMF within the site. The Grassland and Mallee-Mulga vegetation on and within 200m of the site does not pose a significant threat due to its relatively low fuel hazard. The setback of the NRWMF within the 100ha site, from remnant patches of vegetation, should be commensurate with the desired radiant heat flux safety thresholds for, and construction standards of, assets and buildings. The NRWMF would likely only be exposed to a grassfire that should not pose an unacceptable risk if appropriate bushfire protection measures are provided commensurate with the vulnerability of the NRWMF.

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˚.

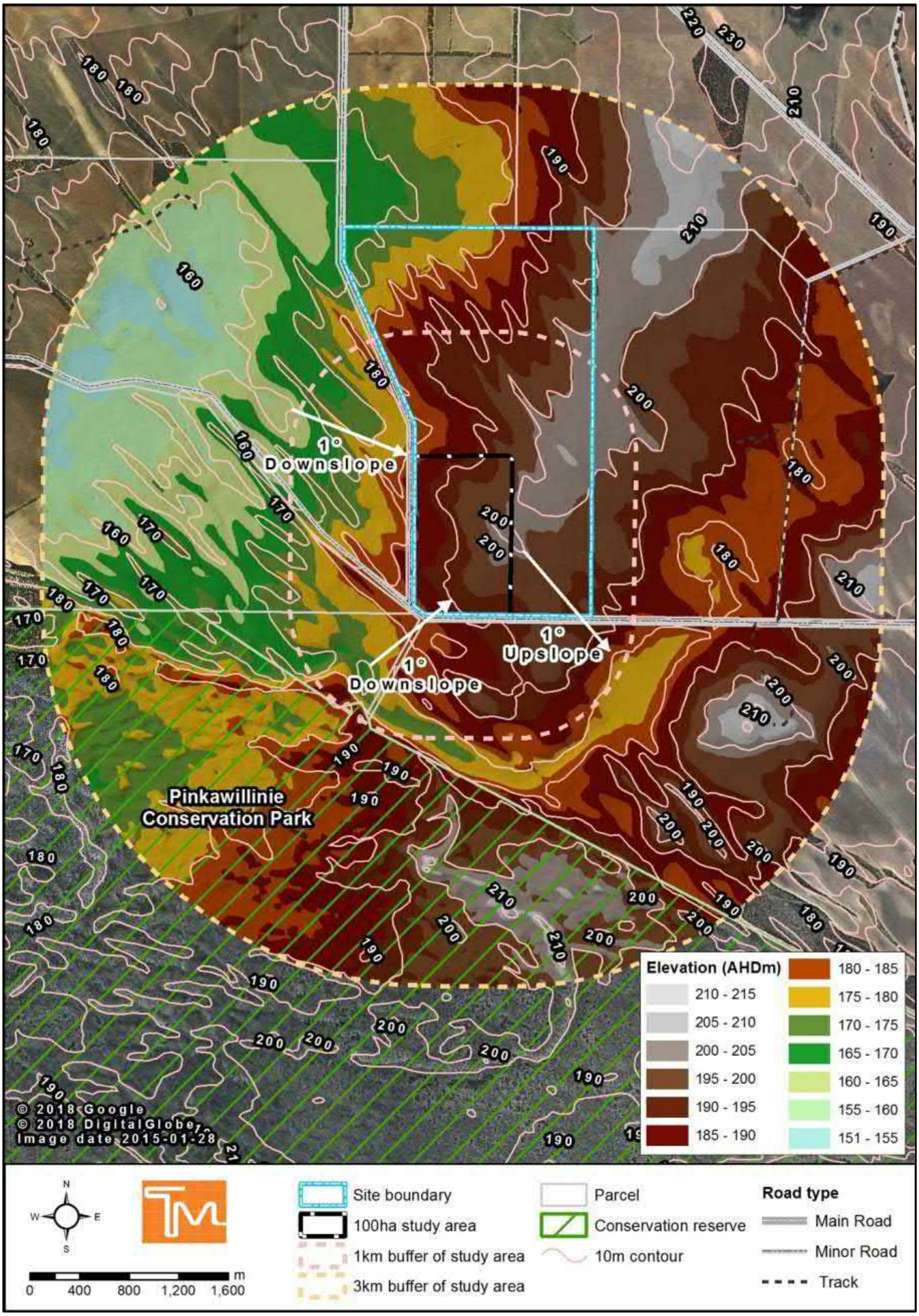
Figure 10 shows that a slight downslope of up to 2˚ occurs from the west extending across to the east of site and the assessment zone, and from the southwest. This slight slope will not significantly influence bushfire behaviour. Figure 13 shows the elevation of the land across the site and for 3 km around it.

Whilst fire spread and flame lengths might surge slightly if a fire burns up dune crests and ridges, 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 NRWMF will be located within the 100ha 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 Napandee.

Figure 13 Elevation map for Napandee based on 1m contours.



2.4.2.3 Weather

The analysis in this section is a comparative assessment, and therefore references all three sites.

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 14 displays the FDRs, their FFDI range and the description of conditions for each FDR.

Table 14 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.

Table 15 summarises the attributes of the closest BOM stations at Kimba, selected as being most representative of fire weather that may be experienced at the stations.

Table 15 Summary of BOM station attributes.

Attribute	Kimba
Distance and direction from Napandee	22km to east-southeast
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 FFDI. 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.

Table 16 Record of the six years with the highest GFDI for the Kimba station.

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 17 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 16 and Table 17 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 every18.7 years at Kimba. A day of 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 mean wind speed varies from around 8 to 13 km/hr.

Table 18 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

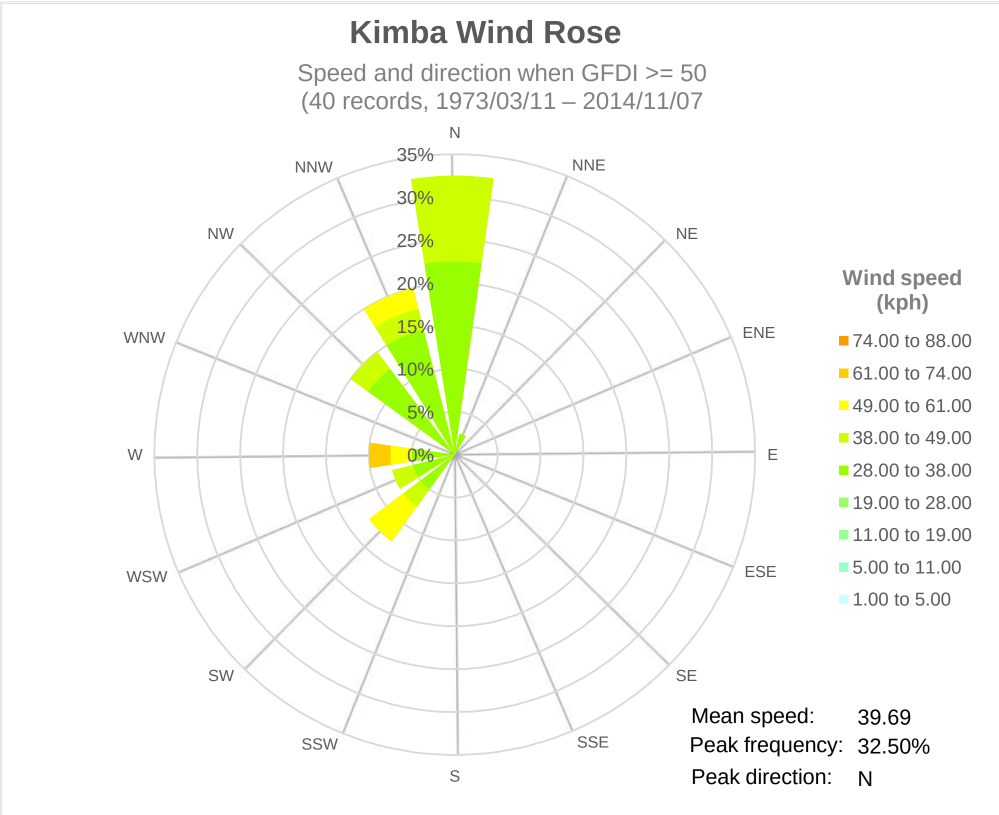
As wind speed and direction is a major influence on fire behaviour in grass and shrub and heath (Mallee-mulga) fuels, further analysis of wind data was undertaken to compare wind data for the two BOM sites.

[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 14.

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. Note that for Napandee, the 1972 wildfires that spread towards the site from the Pinkawillinie Conservation Park (see Figure 11) were likely to have been under a south-westerly wind.

Figure 14 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 19.

Table 19 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 Napandee, 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 22km east-southeast of Napandee), identifies that a day of Severe fire danger is likely to occur approximately once every 4 years at Napandee, 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 correlate poorly 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 Grassfire

Weather analysis for Kimba, shows a significant likelihood at Napandee of winds from the north to northwest under elevated fire danger conditions. The landscape in these directions is however, overwhelmingly pastoral, dominated by lesser hazard grass fuels that may be grazed and/or cropped in a relatively low fuel state for at least the later months of the fire danger period. A fire approach from the east to the southeast is less likely during the fire danger period and would also be through a pastoral landscape.

The rate and direction of fire spread would be determined by the wind speed and direction, with topography a negligible influence. Whilst the fire could be fast moving, it would likely be a lesser intensity grassfire and 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.

2.4.2.4.2 Mallee-Woodland (Shrub and Heath) bushfire

This is the type of fire that could develop in the Pinkawillanie Conservation Park to the southwest or occur in Mallee-Woodland vegetation on private land to the northwest or on and around site.

The wind analysis for Kimba, shows higher winds speeds are often from the southwest, which would drive a fire in the Park directly towards the site as likely occurred in 1972 (see Figure 11).

Notwithstanding, any fire in the Pinkawillanie Conservation Park would have to travel more than 1km through the pasture between the site and the Park before impacting the site as a grassfire. As noted previously, the topography is benign and not conducive to severe fire behaviour.

The tree and shrub vegetation along the roadside to the west of the site and the other small patches on and around the site, are unlikely to sustain a fully developed 100m wide fire front as presumed by AS 3959-2009 but could result in increased flame lengths and increased RHF exposure if assets are not provided with appropriate setbacks.

2.4.2.4.3 Bushfire impacts

Rate of spread, flame length and RHF

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 Napandee 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 20.

Table 20 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 23).

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 NRWMF 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 Napandee is part of (2006 data (Location SA Map Viewer, 2018)). As displayed in 2.6.1.3.4 the nearest dwelling 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 likely fire threat is from a grassfire caused by an accidental ignition on the site or in the surrounding landscape. It would most likely impact the site from those directions typically associated with days of elevated fire danger in south-eastern Australia (i.e. from the north, northwest, west or southwest). The rate and direction of fire approach and spread 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.

The tree and shrub vegetation along the roadside to the west of the site and the other small patches on and around the site, are unlikely to sustain a fully developed 100m wide fire front as presumed by AS 3959-2009 but could result in increased flame lengths and increased RHF exposure if assets are not provided with appropriate setbacks.

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 NRWMF 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 NRWMF were to ignite, they may be a significant local source of embers.

The bushfire hazard at Napandee is relatively low and should not preclude the development occurring, due to the lesser hazard nature of the vegetation on and around the site and the benign topography.

A fire threatening a NRWMF at Napandee could be fast moving, however, it would likely be a lesser intensity grassfire and should not pose a significant or 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. Table 21 outlines the four CFA brigades located around the site.

Data were analysed for the period 1 May 2009 to 30 June 2015. The results are provided in Table 22. Note that other incident types not selected may also generate fires that could threaten the site e.g. building, vehicle or rubbish fires.

Table 21 CFS brigades closest to (within 20-30km of) Napandee.

Brigade	Distance and direction from site
Buckleboo	21km to north
Kimba	22km to east-southeast
Waddikee	23km to south-southeast
Cootra	25km to southwest

Table 22 CFS incident data for brigades within 20-30km of the sites.

Site	Napandee
Incident/Brigade	**Kimba, Waddikee, Buckleboo, Cootra**
Grass or Stubble Fire	43
Scrub and Grass Fire	15
Tree Fire	1
Haystack	0
Grain / Crop Fire	3
Lightning (No Fire)	0
Forest Fire	0
Unauthorised Burning	0
Attempt to Burn	0
Total	**62**

Grass, grass stubble, scrub, grain and crop fires are the most common in the landscape surrounding the site, reflecting the 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 identified as 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 Napandee site would likely only be exposed to a grassfire that should not pose a significant hazard if appropriate bushfire protection measures are provided.

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. One possible exception may be the provision of an adequate water supply for fighting if water supply is a constraint.

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 23. 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 20 and discussed in Section 2.4.2.4.3).

Table 23 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.

Bushfire Attack Level (BAL)	Risk Level	Construction elements are expected to be exposed to…	Comment
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).
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

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.

2.4.5 Recommendations for Stage 2 Work Program

Future works by a specialist bushfire consultant shall include a site visit and an assessment to determine BALs and extent of APZs once the concept design and asset layout plan is established. Appropriate design fire inputs and RHF safety thresholds will also 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 Napandee site focused on Surface Water.

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 Napandee 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 NRWMF 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
- 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 Napandee 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.

- 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)

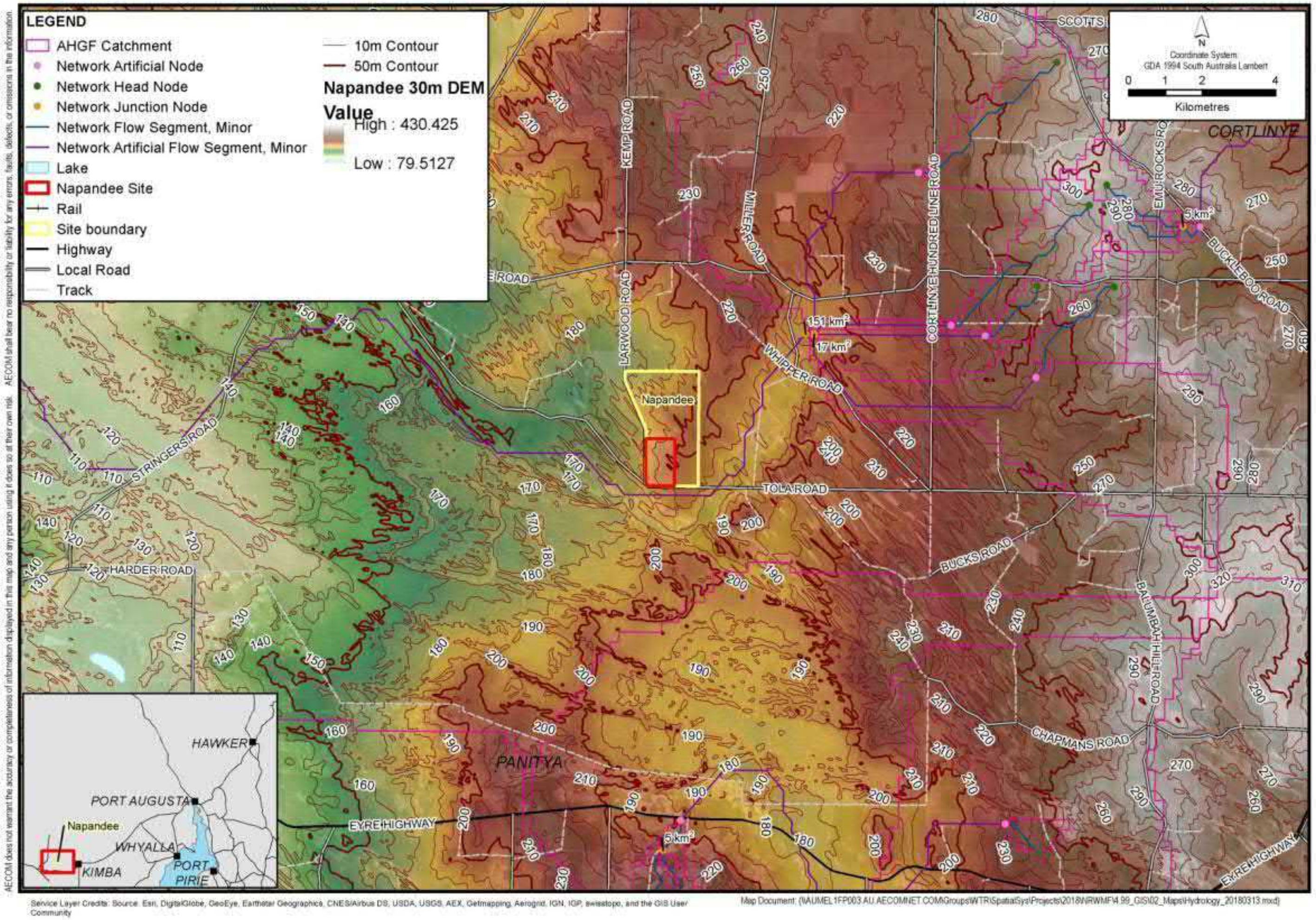
The available topographic and Geofabric information are illustrated in Figure 15 and Figure 16. From Figure 15 it can be seen that the Geofabric data indicates a non-perennial drainage depression located approximately 1 km from the southern and eastern site boundaries. The Geofabric data lists the upstream catchment for the watercourse in the order of 150 km^2. Figure 16 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. These serve relatively small localised catchments and are therefore considered minor. The slopes are typically in the order of 2%. 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 no known localised flooding or water logging issues (source: Jeff Baldock, 22 Feb 2018). This is based on approximately 6 years of experience at the property. More extreme events may produce waterlogging and runoff. 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 24 through to Table 27. 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 desktop information for soils (contained in the subsequent chapter) 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 39.6 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. 4.54 mm for the 1%AEP 24 hour storm), hence it is likely it would retain significant water and could cause water logging. Although the landowner has not experienced waterlogging of the site, more extreme events than those experienced by the owner during his six years of occupation of the site, may lead to waterlogging.

Figure 15 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

Figure 16 Drainage lines from LiDAR data

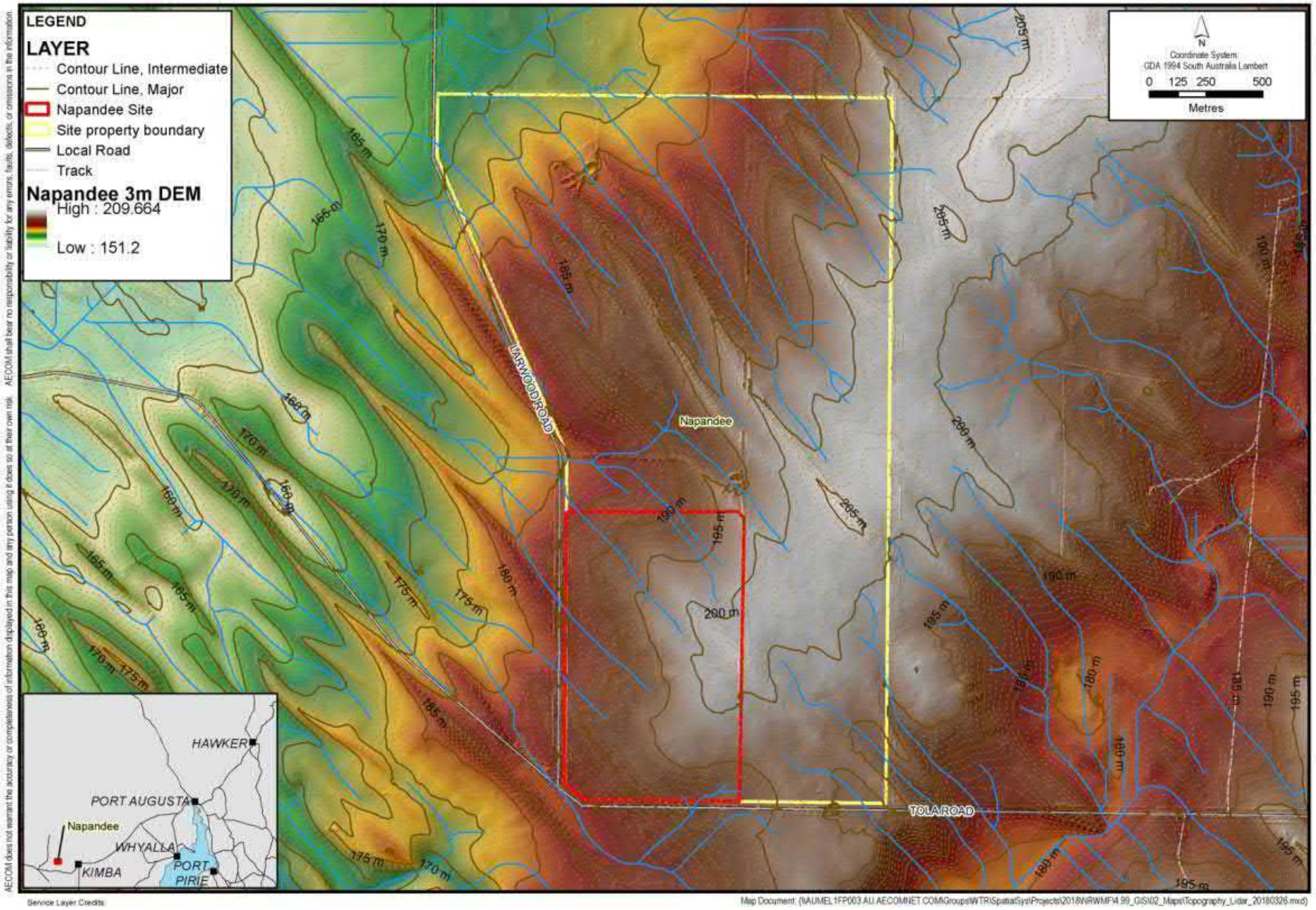


Table 24 Rainfall depths for frequent to infrequent events (mm)

Duration	Annual Exceedance Probability (AEP)						
	63.20%	50%	20%	10%	5%	2%	1%
1 min	1.11	1.28	1.87	2.32	2.8	3.5	4.08
2 min	1.97	2.27	3.31	4.1	4.94	6.07	7
3 min	2.64	3.04	4.43	5.49	6.61	8.15	9.43
4 min	3.18	3.67	5.35	6.63	7.98	9.88	11.5
5 min	3.64	4.2	6.13	7.59	9.15	11.4	13.2
10 min	5.26	6.08	8.9	11	13.3	16.6	19.5
15 min	6.35	7.34	10.7	13.3	16.1	20.1	23.6
30 min	8.45	9.76	14.3	17.7	21.3	26.7	31.2
1 hour	11	12.6	18.4	22.7	27.4	34	39.6
2 hour	14	16.1	23.3	28.7	34.5	42.8	49.7
3 hour	16	18.4	26.6	32.8	39.3	48.7	56.7
6 hour	20.1	23	33.1	40.8	48.9	60.9	71.1
12 hour	24.5	28.1	40.5	50.1	60.4	75.8	88.9
24 hour	29	33.2	48.2	60.1	73.2	92.5	109
48 hour	33.2	38	55.4	69.7	85.9	109	128
72 hour	35.6	40.6	59.2	74.5	92	116	137
96 hour	37.3	42.5	61.7	77.4	95.2	120	142
120 hour	38.7	44.1	63.6	79.3	96.9	122	144
144 hour	40.1	45.6	65.1	80.6	97.6	123	145
168 hour	41.4	47	66.5	81.5	97.7	123	145

Table 25 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	109	124	149	170	194
48 hour	128	155	193	225	263
72 hour	137	163	200	234	271
96 hour	142	165	202	235	271
120 hour	144	166	202	236	272
144 hour	145	168	204	239	276
168 hour	145	170	207	244	282

Table 26 Rainfall intensities for frequent to infrequent events (mm/hr)

Duration	Annual Exceedance Probability (AEP)						
	63.20%	50%	20%	10%	5%	2%	1%
1 min	66.6	77	112	139	168	210	245
2 min	59.2	68.2	99.3	123	148	182	210
3 min	52.8	60.9	88.7	110	132	163	189
4 min	47.7	55.1	80.3	99.4	120	148	172
5 min	43.7	50.4	73.6	91.1	110	136	159
10 min	31.6	36.5	53.4	66.1	79.8	99.9	117
15 min	25.4	29.3	42.9	53.2	64.2	80.5	94.3
30 min	16.9	19.5	28.5	35.3	42.6	53.3	62.3
1 hour	11	12.6	18.4	22.7	27.4	34	39.6
2 hour	7	8.05	11.6	14.4	17.2	21.4	24.8
3 hour	5.35	6.15	8.87	10.9	13.1	16.2	18.9
6 hour	3.34	3.83	5.52	6.8	8.15	10.2	11.8
12 hour	2.04	2.34	3.38	4.17	5.03	6.32	7.41
24 hour	1.21	1.38	2.01	2.5	3.05	3.85	4.54
48 hour	0.692	0.792	1.16	1.45	1.79	2.26	2.67
72 hour	0.494	0.564	0.822	1.04	1.28	1.61	1.9
96 hour	0.388	0.443	0.643	0.806	0.992	1.25	1.48
120 hour	0.323	0.368	0.53	0.661	0.808	1.02	1.2
144 hour	0.278	0.317	0.452	0.56	0.678	0.853	1.01
168 hour	0.246	0.28	0.396	0.485	0.582	0.732	0.865

Table 27 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	4.54	5.15	6.2	7.1	8.09
48 hour	2.67	3.24	4.02	4.69	5.47
72 hour	1.9	2.26	2.78	3.24	3.77
96 hour	1.48	1.72	2.1	2.45	2.83
120 hour	1.2	1.39	1.69	1.97	2.27
144 hour	1.01	1.17	1.42	1.66	1.92
168 hour	0.865	1.01	1.23	1.45	1.68

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 15. From Figure 15 it can be seen that the Geofabric data indicates a non-perennial drainage depression located approximately 1 km from the southern and eastern site boundaries. The Geofabric data lists the upstream catchment for the watercourse in the order of 150 km^2. Figure 16 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, with a larger local catchment draining past the south-western corner. There are no significant dams or reservoirs in proximity to the site.

Based on a review of all of the available data sources, there is no flood information available for the non-perennial drainage depression. The catchment is quite large, and therefore likely to produce significant runoff during infrequent and rare flood events. There is evidence from the aerial photos and available terrain data that linear sand dunes cross the depression, forming closed depressions that would fill with water and spill to adjacent flow paths. During a flood, the dunes would be subject to potential erosion, although no evidence is evident within the site boundary suggesting it is not subject to frequent flooding and erosion. To determine flood extents and flood levels, this would require hydrological and hydraulic modelling as part of the Stage Two assessment to quantify the risks of flooding should the Napandee 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 Tola Road. There is anecdotal evidence that Tola Road is an all-weather access road (source: Jeff Baldock, 22 Feb 2018). The aerial photography and terrain data show no evidence of significant scour or overtopping of Tola Road near the site. There is no 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 Napandee, 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 Napandee, 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 would require hydrological and hydraulic modelling as part of the Stage Two assessment should the Napandee site be further considered for the NRWMF.

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 flood hazards at the site. These are summarised in Table 28.

Table 28 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 south and east of the site, other than areas of gully floor erosion that support that the depression is subject to flooding. 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)
- 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
  - 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 Napandee 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 NRWMF located at the Napandee 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 subject 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 subject land 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 subject land 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 was obtained during the hydrological/ flood risk assessment.

2.6.1.1 Site Characteristic Criteria

The following Site Characteristic Criteria have been determined to be relevant to 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 proposed NRWMF.

For the purpose of the assessment development that may adversely affect the NRWMF 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 NRWMF.

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 to be developed, and as such, they 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 current sensitive land uses and potential for future sensitive land uses 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 ongoing operations of the proposed NRWMF.

For the purposes of the assessment, sensitive land uses considered under this criterion 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;
- 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 data review 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 properties and other parcels of land throughout the wider locality.

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:

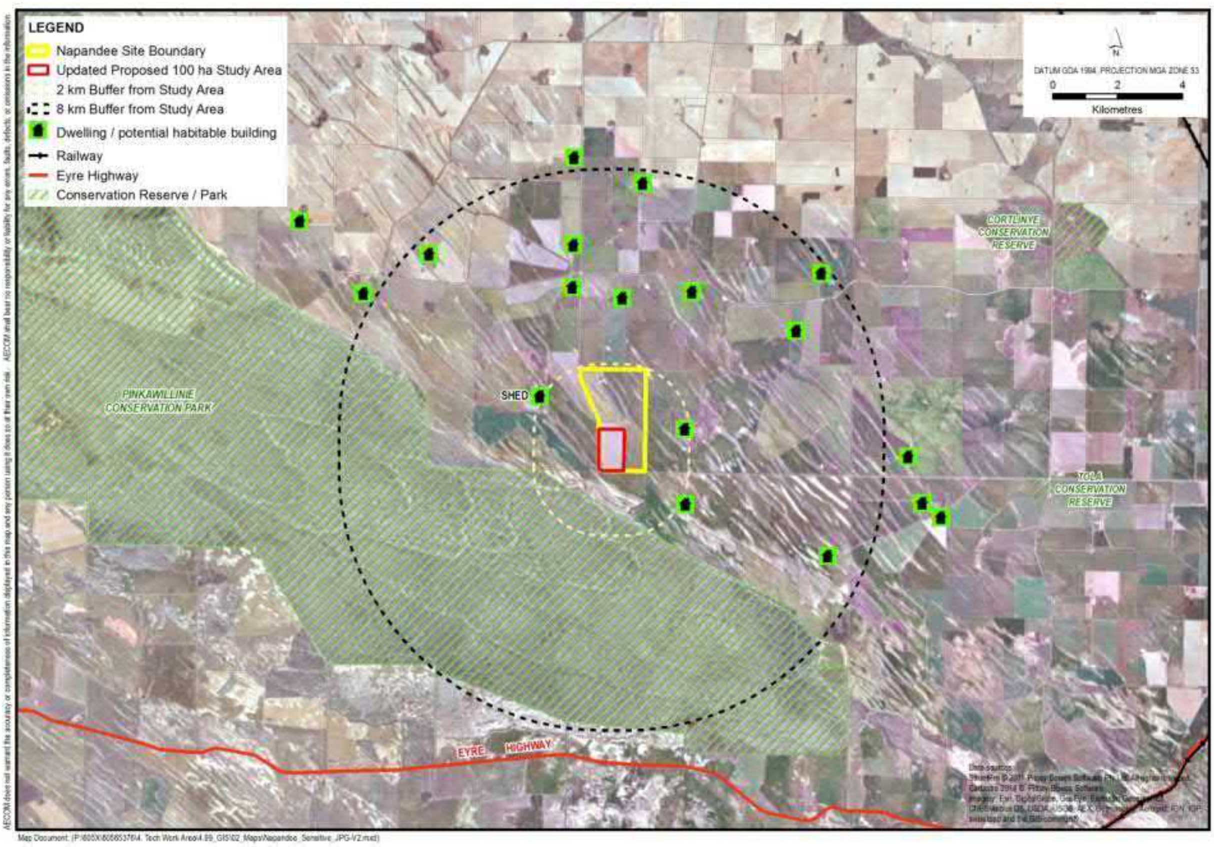
- A dwelling located approximately 1.8 kilometres to the east of the site. A further eleven dwellings are located within 8 kilometres of the site boundary. These dwellings are mainly to the north and east of the site.
- Kimba, the closest township to the site which is located approximately 22 kilometres east of the site.

Other sensitive land uses in the area include:

- The Pinkawillinie Conservation Park which is located approximately 1.5 kilometres to the south of the site. The park contains numerous 4WD tracks and bushwalking trails. Tourist facilities within the park are limited and camping is not permitted within the park.

The key existing features within the locality as described above are depicted in Figure 17 below. The uses identified in the figure have been confirmed by staff from the District Council of Kimba

Figure 17 Key existing features within the 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 development plan also contains council wide policy which guides development generally across the council area. Relevant council wide policy encourages non-rural development to be established within and adjacent existing townships or within other appropriate zones.

Based on the current development plan policy, the likelihood of any urban development adversely affecting the potential future use of the Napandee site for a low level radioactive waste NRWMF 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.

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

2.6.1.3.4 Population Assessment

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

- The Napandee site is located in the Local Government Area (LGA) of Kimba and is situated in the suburb of Pinkawilinie.
- The Kimba LGA has experienced a slight decrease in population from 1,088 in 2011 to 1,067 in 2016.
- The suburb of Pinkawilinie recorded a population of 54 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 Pinkawiline.
- 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 a 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.

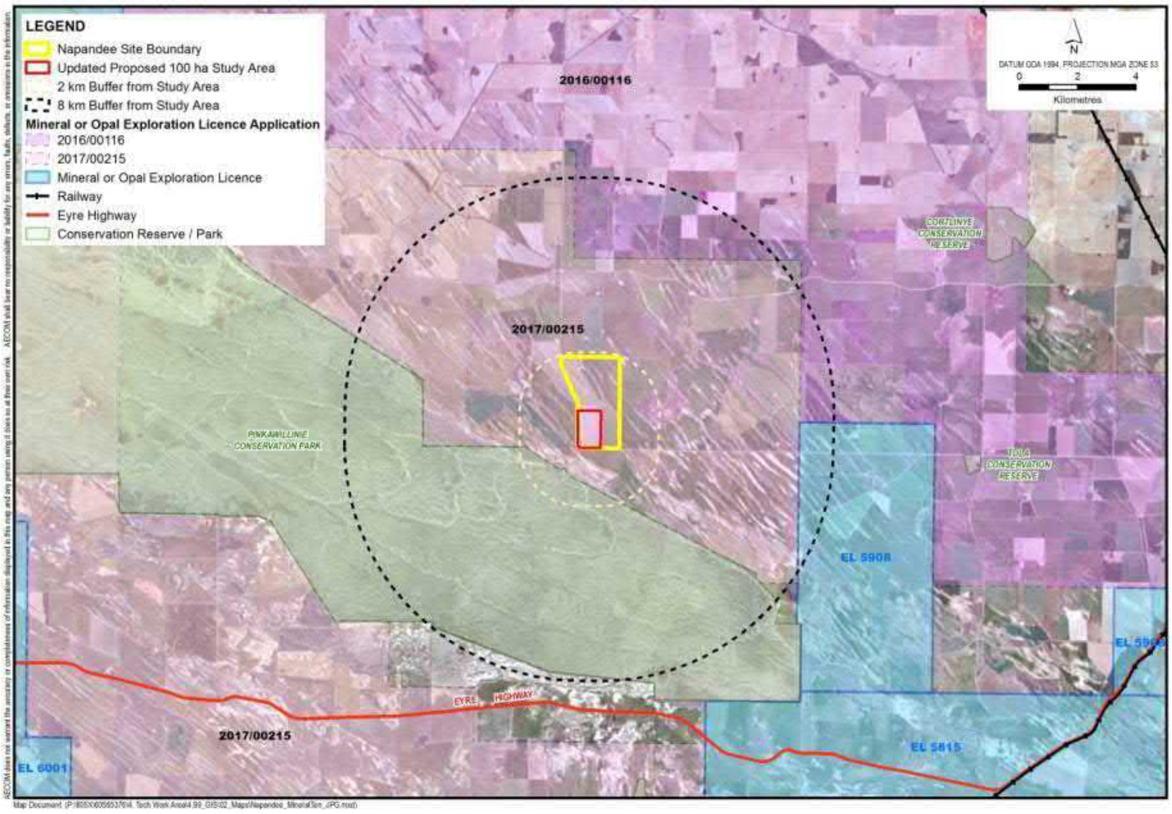
Based on the review, there is one mineral exploration licence application which exists over the site and a number of applications and licences within 8 kilometres of the site. Table 29 provides detail of each application and license identified, and Figure 18 below illustrates the location of each tenement with respect to the site.

Table 29 Leases and Tenements

Tenement No.	Tenement Owner	Tenement Type	Distance from Site
2017/00215	Lady Alice Mines Pty Ltd	Application Exploration Licence – Mineral (Silver, Gold & Copper)	Covers the site and associated allotment
2016/00116	Atlas Geophysics	Application Exploration Licence – Mineral (Silver, Gold & Copper)	5km to the north & 6.5km to the east
5908	Investigator Resources Limited	Exploration Licence – Mineral (Silver, Graphite, Gold, Zinc, Copper & Lead) Expiry Date: 05/11/2018	6.5 km to the east
5815	Pirie Resources Pty Ltd	Exploration Licence – Mineral (Graphite) Expiry Date: 31/01/2018	10km to the south east

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

Figure 18 Location of each tenement



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

Development of these land uses that may adversely affect the facility was not identified within 8 kilometres of the site.

Current and future potential for mines and mineral deposits is addressed in section 2.6.1.4.5

It is noted that the nearest military facility is located at Cultana which is approximately 90 kilometres to the east of the site.

2.6.1.3.7 Major Transport Infrastructure

Transport infrastructure identified within the locality of the site consists of:

- Eyre Highway located approximately 9.5 kilometres to the south
- Kimba Aerodrome located approximately 26.5 kilometres to the east

2.6.1.3.8 Flight Path and Crash Data

The Kimba Aerodrome is located approximately 26.5 kilometres to the east of the site and is approximately 28.50 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.

The Kimba runway is orientated northeast-southwest, and as such, aircraft approach and take-off movements would unlikely be aligned towards the site which is located to the west of the airstrip.

No flight path data was available, however, given the characteristics the locality and nature and use of the airfield, it is not anticipated that the site would be located within a major flight path area.

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.

2.6.1.3.9 Water extraction and Water Retention Structures

These issues have been investigated as part of Flora, Fauna and Conservation (2.1) and Climatic Conditions and Climate Change (2.3) – 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 and 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 site indicate that:

- No development that may adversely affect the facility was identified on the subject land or within 8 kilometres of the site.
- 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 Eyre Highway which is located approximately 9.5 kilometres to the south of the site. The site is well separated from other major transport infrastructure including railway lines and airfields.
- A number of mineral tenements exist within and in close proximity of the site. The existence of these tenements could result 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 assessment 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 1.8 kilometres to the east of the site. The dwellings exist at a very low density with 12 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 the 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 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 Napandee site. The potential for mineral tenement 2017/0025 which overlaps the site to proceed to production, will be reviewed by the Department in the future.

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 if the Napandee site is considered further.

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.

3.0

Subsurface Environment

3.0 Subsurface Environment

A desktop and field assessment of the subsurface environmental conditions within the study area 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 Criteria

Subsurface characteristics favourable for meeting the four assessment objectives and a range of criteria for this assessment are as follows:

Table 30 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)[11]
	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 are 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[10]
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	Deep (>10m)[11] regional watertable & piezometric surfaces
		No perched watertable
	Potential for vertical migration of solutes through sediments or bedrock	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] 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).
[11] 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

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 Napandee site is tabulated below.

Table 31 Natural Resource Management zones for Napandee

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 relevant soils and geotechnical conditions at the Napandee site, as specified in the references section.

There is currently no published site specific information on the soil or geochemical profile underlying the site or the broader Napandee property.

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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[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.

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

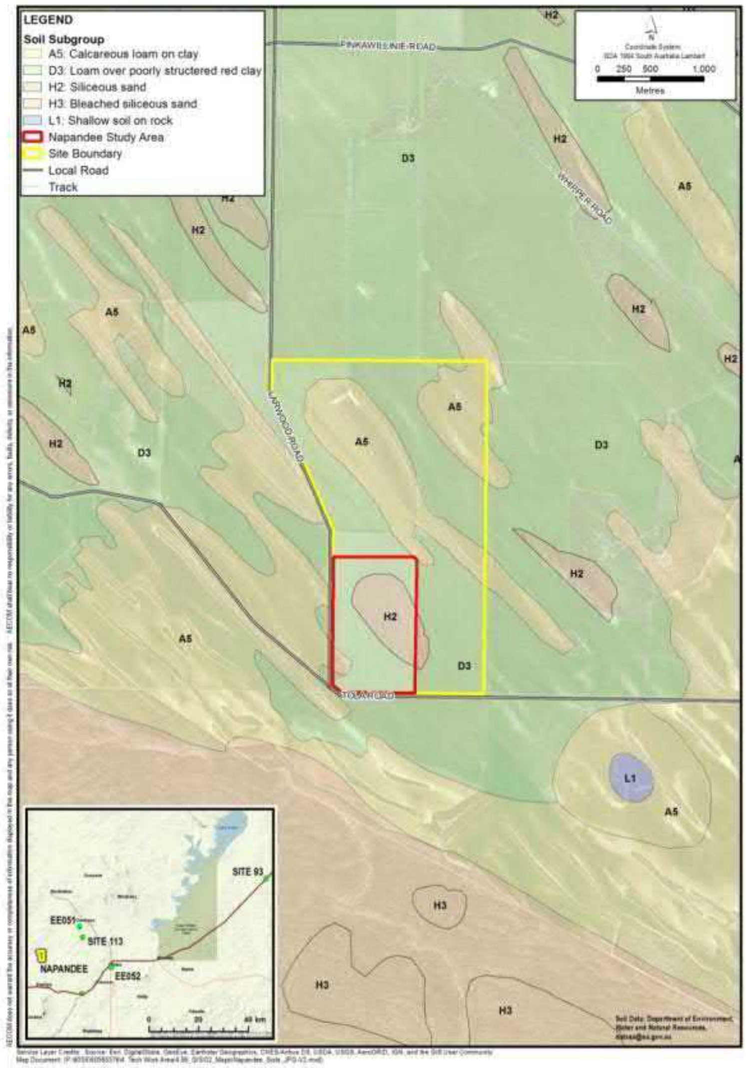
ASRIS map view provides mapped extents based on area weighted averages for a given unit.

The units shown on are described below: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

The landforms are described by ASRIS as low hills and ridges; plains with 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 overall slight slope across the site is in a general north-westerly direction
- The local landscape comprises a series of sand ridges (some parts of the broader Napandee site have vegetation, although no vegetated ridges observed within site)
- A minor sand ridge exists in the northern portion of the site (i.e. forms the edge of the A5 soil type boundary)
- Soil types within the site are inferred by mapping to comprise siliceous sand (H2, fine material) with loam over a red clay (D3), along with a small section around the topographic depression that the landholder identifies as a dam comprising a calcareous loam on clay (A5)
- Anecdotal information from the landholder suggests that no waterlogging issues are present across the site.
- It is possible that the dam (featured below) collects runoff from the seepage of water accumulating above shallow cemented calcrete layers in the soil profile within this locality (outside the site)

Figure 19 Soil distribution map for Napandee



Site reconnaissance photographs that were taken by AECOM on 22 February 2018 show the two most common landforms within the site.

Sand ridge and dam in north-western portion of the site (inferred A5 soil subgroup).

Majority of site showing red-brown soils (D3 soil subgroup). Vegetated dunes in the distance. Mallee along fence line.

Within the site properties of the mapped soil types include:

- D3, a surface loam over 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 underlying clay likely to have a saturated hydraulic conductivity at 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
- A5, a 'calcareous loam over clay' comprising a shallow loam underlain at clay to depth, 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 low/ poor drainage in underlying clayey soils at depth
  - neutral pH soil at surface underlain by slightly alkaline clayey soils
  - non-saline shallow loam underlain by slightly to moderate saline clay
  - non-sodic shallow loam underlain by an increasingly highly sodic clayey with depth
  - potentially highly dispersive clays at depth

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 mapped at the Napandee 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 32 summarises the assessment based on 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 Napandee progress as a potential site.

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

Table 32 Desktop Assessment of Potential Geohazards

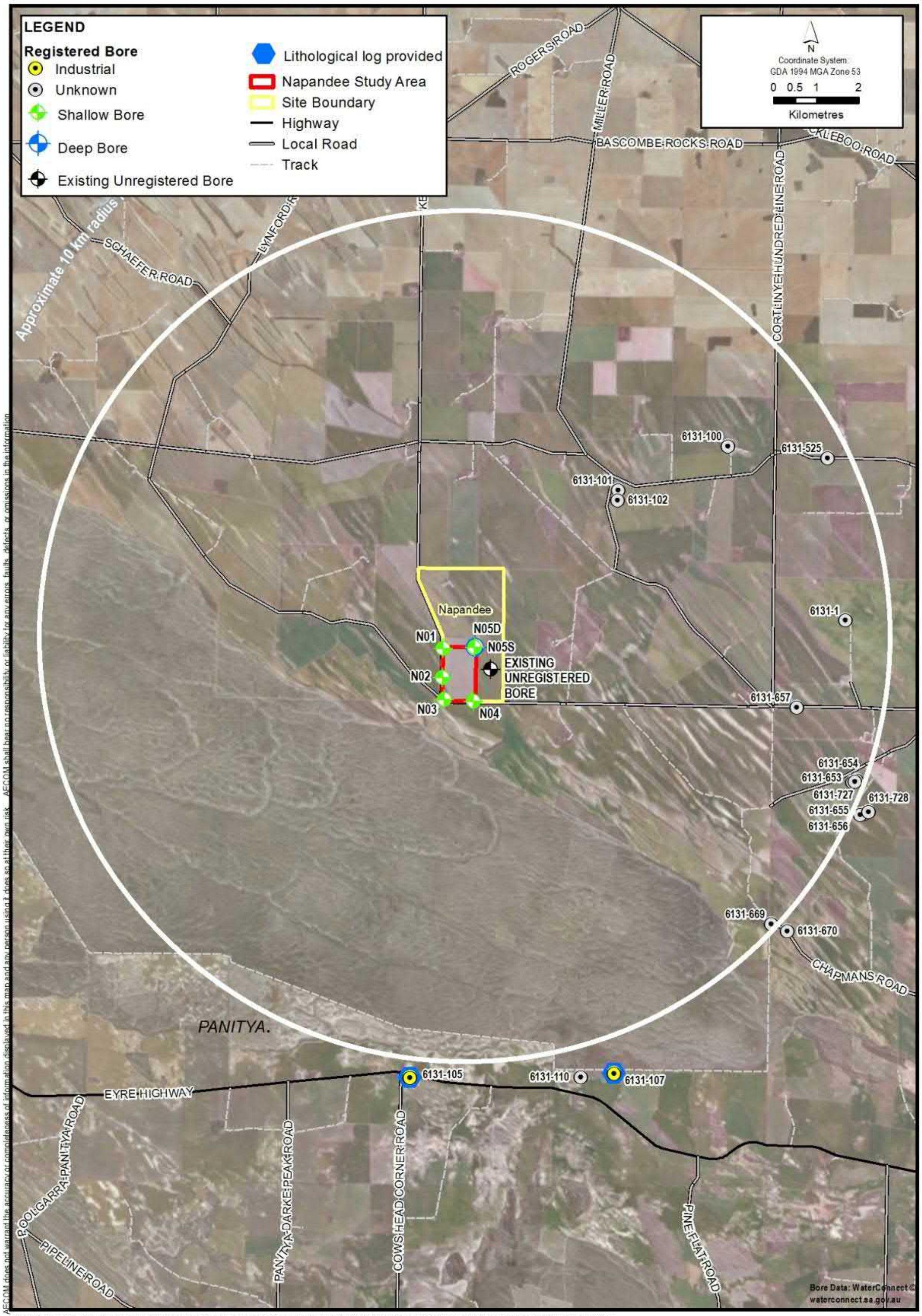
Geohazard / Characteristic Criteria	Likelihood	Findings
Slope instability	Unlikely	Based on the ground elevation data from NatureMaps (Feb, 2018), the proposed site is located on a relatively flat area with an elevation of approximately 220 mAHD.
Soil liquefaction	Unlikely	Generally, soils susceptible to liquefaction are non-cohesive soils such as sands and gravels, occurring in loosely deposited conditions below the water table (IAEA Safety Guide No. NS-G-3.6). Based on the desktop data 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 levels (> 20 m bgs) present at the site as identified based on the review of registered well data from WaterConnect.
Presence of collapsing or expansive soil	Collapsing – Possible Expansive - unlikely	Based on the surface geology information indicating the presence of sands across the majority of 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 Kimba Sheet SI 53-7 in the SA Geological Atlas Series, there are no natural features such as caverns and review of topographic maps and SARIG database 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 seif dunes on-site are cleared of vegetation then the sandy material will be more susceptible to wind erosion.

Geology and Hydrogeology Desktop 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 Napandee 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 20 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 m of unconsolidated sediments over a weathered gneiss which becomes fresher and more indurated with depth. Figure 20 also shows the location of an unregistered bore east of the study identified during drilling works conducted between April and May 2018. Bores installed as part intrusive work program are also shown on the plan. These bores are discussed in greater detail in Section 3.1.1.3.

Figure 20 Napandee –Bores within a 10 km radius (including an unregistered borehole and newly installed bores)



Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Map Document: (P:\605X\60565376\4. Tech Work Area\4.99_GIS\02_Maps\Napandee_Bores_JPG-V3.mxd)

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**.

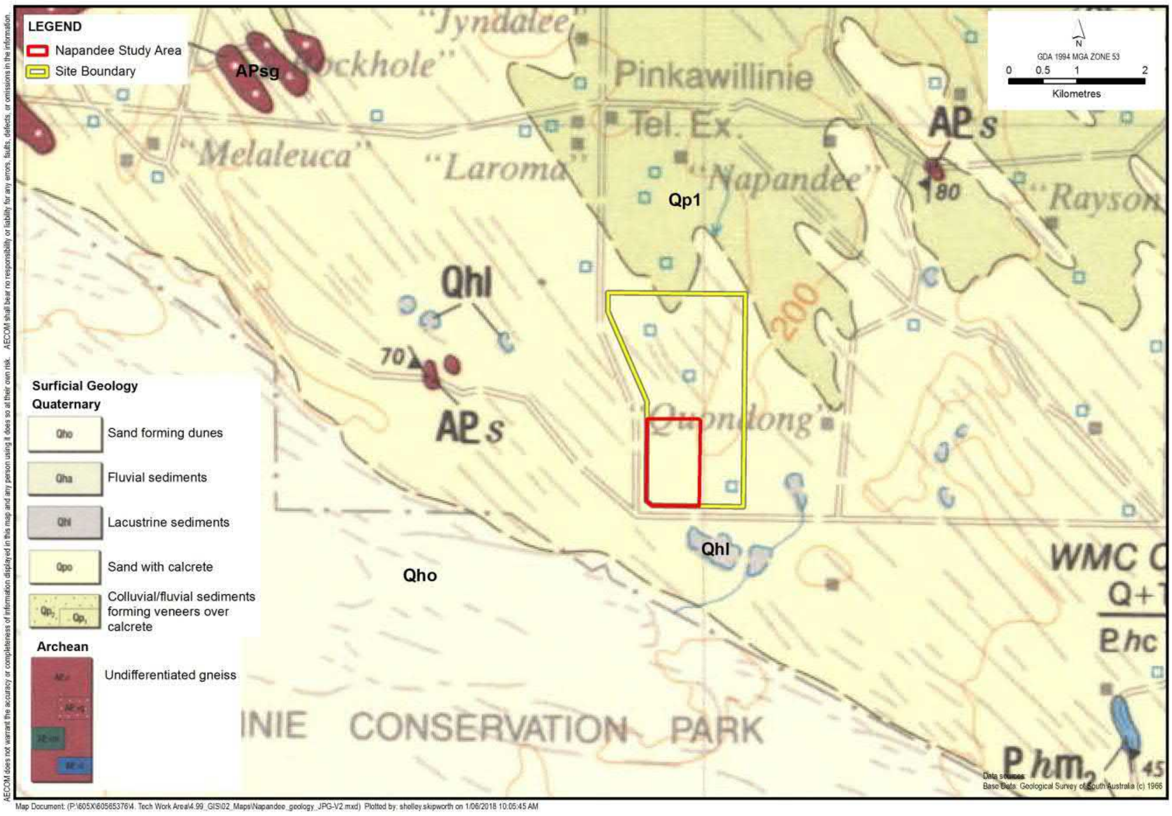
In addition, Daishsat Pty Ltd (Daishsat), was commissioned by AECOM to undertake an airborne geophysical survey of magnetics and radiometrics for the Napandee site. As part of the commissioned work, a staff geophysicist with over 40 years' experience undertook a preliminary desktop assessment of the 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 (5th to 6th 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 (see radiation section for more information).

Inferred Geological and Hydrogeological Profile from Desktop Assessment

Information on the surficial geological cover has been sourced from the Kimba Sheet SI 53-7 Geological Map Series 1:250,000 scale.

Figure 21 shows the location of the Napandee 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 fluvial origin gravelly clay, sand, silt and clay present in the northern portion of the site.

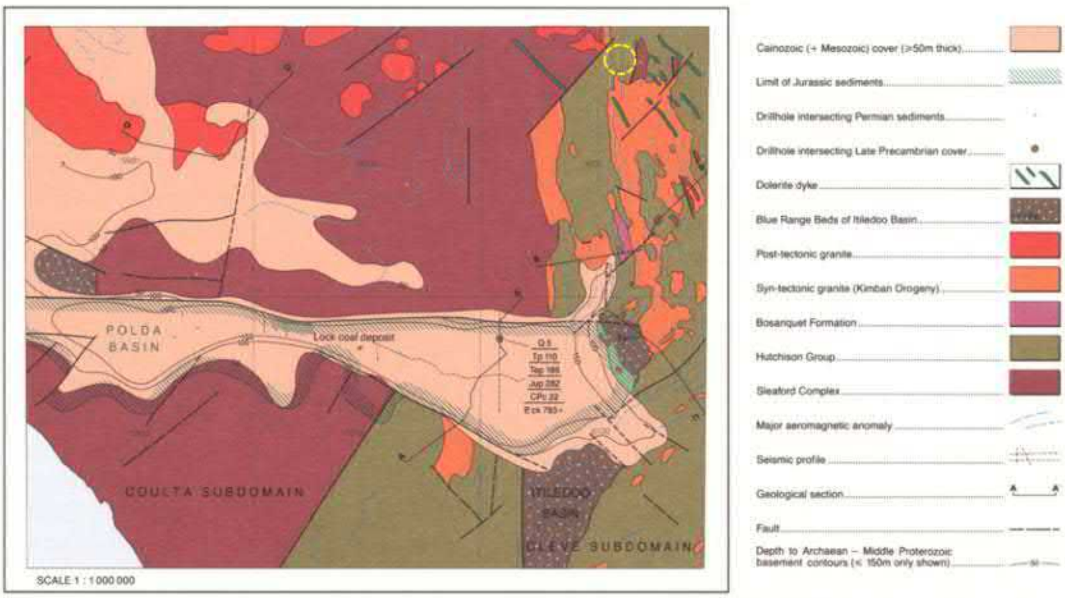
Figure 21 Napandee Geology Map 1:250,000 Kimba Sheet SA 53-7



Precambrian Archean-aged outcrops comprising metasediments, undifferentiated gneiss and granites from the Sleaford Complex are mapped to the north and west of the site surrounds.

The tectonic sketch from the Kimba 1:250,000 geological map sheet is reproduced as Figure 22 below with the approximate area of the Napandee site and surrounds shown as a yellow circle. Regionally there are northeast- southwest trending faults in the vicinity of the site with nearby major aeromagnetic anomalies. Doleritic dykes occur regionally in a northwest-southeast orientation within both the Hutchinson Group and Sleaford Complex basement rocks.

Figure 22 Tectonic Sketch excerpt from Kimba SI 53-7 1:250 000 Geological Map Sheet



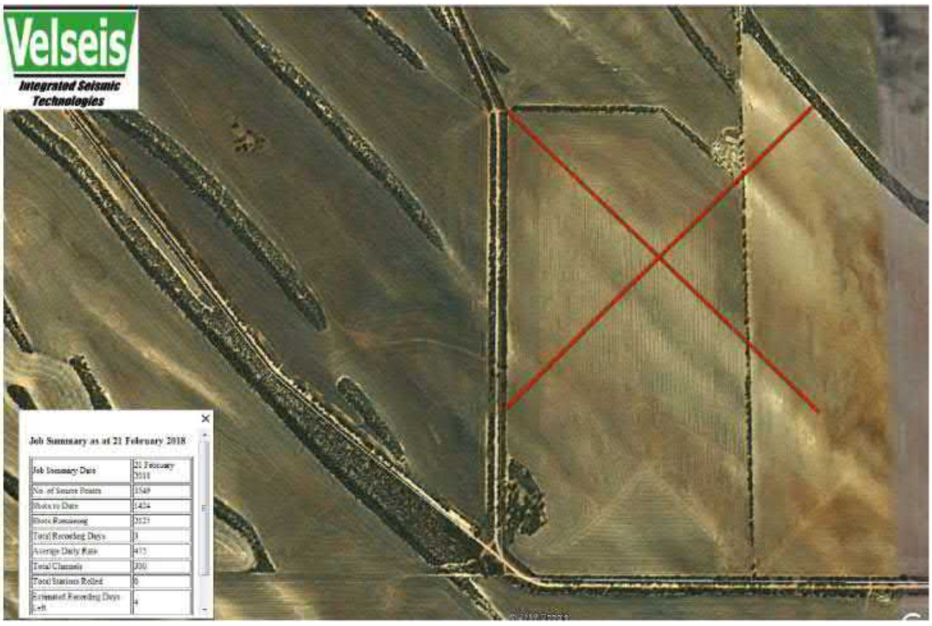
The findings of the Daishsat investigation indicate that:

- There is no general trend evident in the gravity data and inferred low gravity response indicates limited possibility of shallow mafic basement rocks occurring within the survey area. There is no evidence of regional scale, shallow subsurface structures in the gravity image.
- South Australian regional magnetic data reviewed indicates that the site is located in the north of a north-south oval structure, typical of a granite body. The north-west trending structure on the image is typical of mafic dykes that are the dominant feature of this area of South Australia and most likely occur at considerable depth below the ground surface. It is likely that the mafic dykes comprise part of the Neoproterozoic Gairdner Dykes (B. Stockill *pers. comm.).*
- 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 Napandee. Magnetic models indicate that crystalline basement rocks are at least 1300 m deep under the target area, and that a shallow dyke runs north west – south east across the survey area.
- No faults have been inferred from the enhanced magnetic images, however, the modelled dyke may be fault controlled and more reliable results would be obtained by the inclusion of detailed gravity data over the survey area.
- The predominance of dunes in the Napandee investigation area indicates that for the most part, radiometric images are influenced by wind 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 overprinted by the north-west dune response.
- The overall radiometric response changes in the east of the survey area, with generally higher response from all three elements.

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 Napandee site were completed by Velseis on the 21st of February 2018 (see **Figure 23** below).

Figure 23 Napandee seismic line 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:

- existence of multiple shallow faults within the top portion of the crystalline basement rock (approximately 60 to 200 m bgs) possibly indicative of reactivated graben style structures with deeper potential reverse style structures inferred to extend up to 320 m bgs
- in general the deeper inferred fault structures do not appear to intersect the shallower structural faults, however, at least one potential reverse style feature was interpreted to extend from the top of the crystalline basement to approximately 250 m bgs
- base of weathering inferred to be equivalent to the thickness of unconsolidated sediments estimated to occur between 25 and 35 m below ground surface (bgs) with some shallower reflectors at 15 to 20 m potentially representing more indurated layers
- top of the crystalline basement rock is estimated to occur around 60 m suggesting a potential weathered top of basement in the order of 20 to 30 m.

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

The interpretation of the sub-surface lithological profile was found to be consistent with the available lithological data presented in Appendix C.

Database bore summary information for bores within a 10 km radius of the Napandee site is tabulated and presented in Appendix C. Little data is available for the identified registered bores and the purpose of bores drilled within the search area is rarely identified. Given the lack of identified groundwater use and the availability of reticulated water in the Kimba region a reconnaissance survey of the existing bores in the vicinity of the site was not incorporated into the planned drilling program. It is noted however that discussions with the landholder while working on site did identify an unregistered bore in close proximity to the site (refer to Table 33).

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

On the basis of the information gathered and reviewed as part of the desktop assessment, the drilling program for Napandee 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 water bearing zones between the watertable aquifer and groundwater intersected within the basement rock.

3.1.1.3 Field Methods and Results

The location of each investigation bore and test pit within the Napandee site is displayed within Figure 24 below.

Drilling, Sampling and Bore Construction Program

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

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

Borehole Drilling

The intrusive work was conducted under the National Radioactive Waste Management Act 2012. The Act overrides all State based licensing and approvals requirements.

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

The drilling program commenced on 17th April 2018 with completion of the last bore on the 3rd 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 N01 to N05. Two bores are installed at site N05; N05D (Deep) and N05S (Shallow). Investigation bore locations in relation to the existing bores are shown in

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, shallow bores typically used between 1 – 6 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 in general accordance with Australian Standard AS1726. Bore logs are provided in Appendix C.

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[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 24 Location of investigation bores and test pits within Napandee site

Geotechnical Testing from Bores

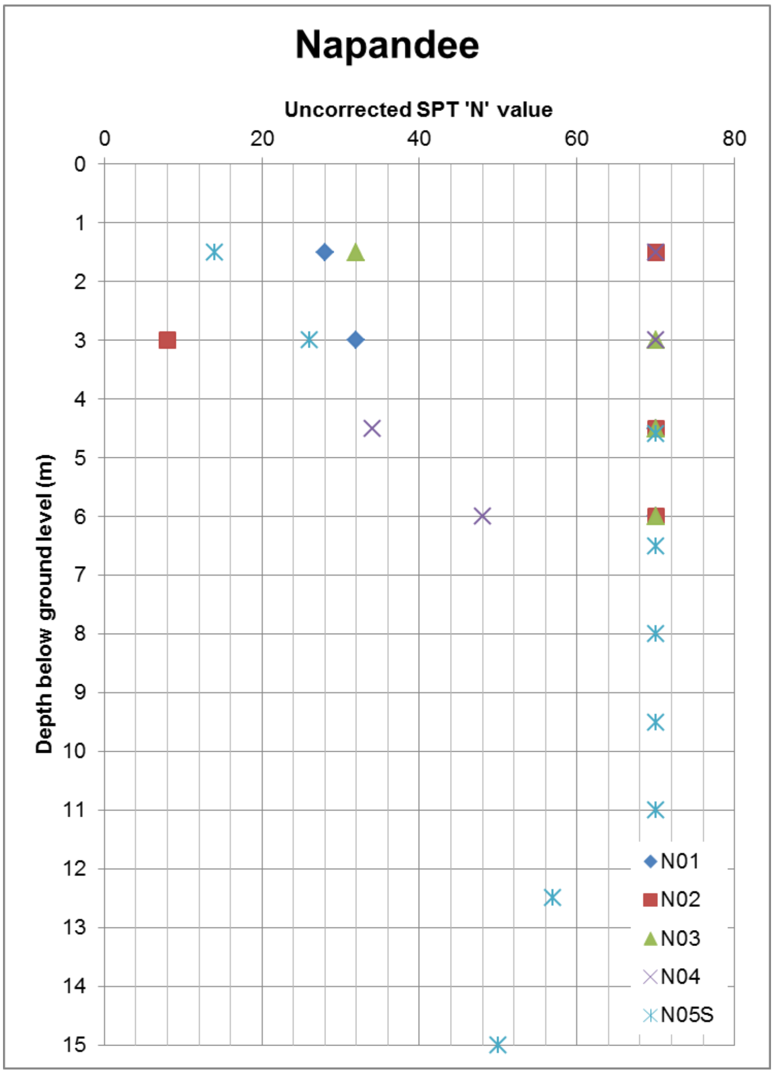
Geotechnical information was collected throughout the borehole drilling, mainly focused on the ground profile for top 15 m depth. The geotechnical investigation methods included geotechnical logging of soils, in-situ testing and collection of samples for laboratory testing.

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; and
- Collecting of disturbed samples recovered from top 15 m depth.

It is noted that laboratory results for U63 samples selected for permeability testing were not available at the time of reporting. Figure 25 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. It is noted that due to ground conditions at Napandee, SPTs were terminated in most holes at 6 m depth due to refusal and encountering rock conditions.

Figure 25 Uncorrected SPT Values with Depth



Geophysical Logging of Bores

Downhole geophysics (wireline logging) was conducted in all holes to refine lithologies 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 – N05D (Completed 20 April 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 (5 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 33.

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

Table 33 Bore Construction Details – Napandee

						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**
N01	25/04/2018	609162.92	6335603.15	169	50	34	28.0-34.0	27.0-34.0	184.74	183.97	184.83
N02	26/04/2018	609155.12	6334916.24	169	50	31	25.0-31.0	24.0-33.0	185.53	184.99	185.63
N03	2/05/2018	609195.29	6334408.71	169	50	34	28.0-34.0	27.0-34.5	184.59	183.83	184.73
N04	3/05/2018	609880.58	6334361.97	169	50	32	26.0-32.0	25.0-32.0	194.01	193.56	194.09
N05S	23/04/2018	609917.14	6335617.58	169	50	36	30.0-36.0	29.0-36.5	198.81	198.60	199.22
N05D	21/04/2018	609901.94	6335632.68	169	50	64	58.0-64.0	57.0-64.0	199.08	198.23	198.88

Notes:

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

Discussions with the landholder during the drilling program identified an abandoned unregistered bore located west of the site within the adjacent paddock (refer Figure 24).

The history of the bore was unknown (by landholder), however, it had been installed before the current owner had purchased the property (>10 years). Inspection of the bore site showed remnants of a concrete water tank / storage. Condition of the bore was open to environment (no cap, no pumping infrastructure installed, essentially abandoned). Bore construction was a 4" steel collar, bore oxidised. EC was greater than 50,000 µS/cm (unconfirmed due to inconsistency with water quality meter).

Depth to water: 34.46 mbgs
Total Depth: 65.0mbgl

A photograph of the surface around the unregistered bore is provided.

Test Pit Excavation and DCP and Laboratory Testing

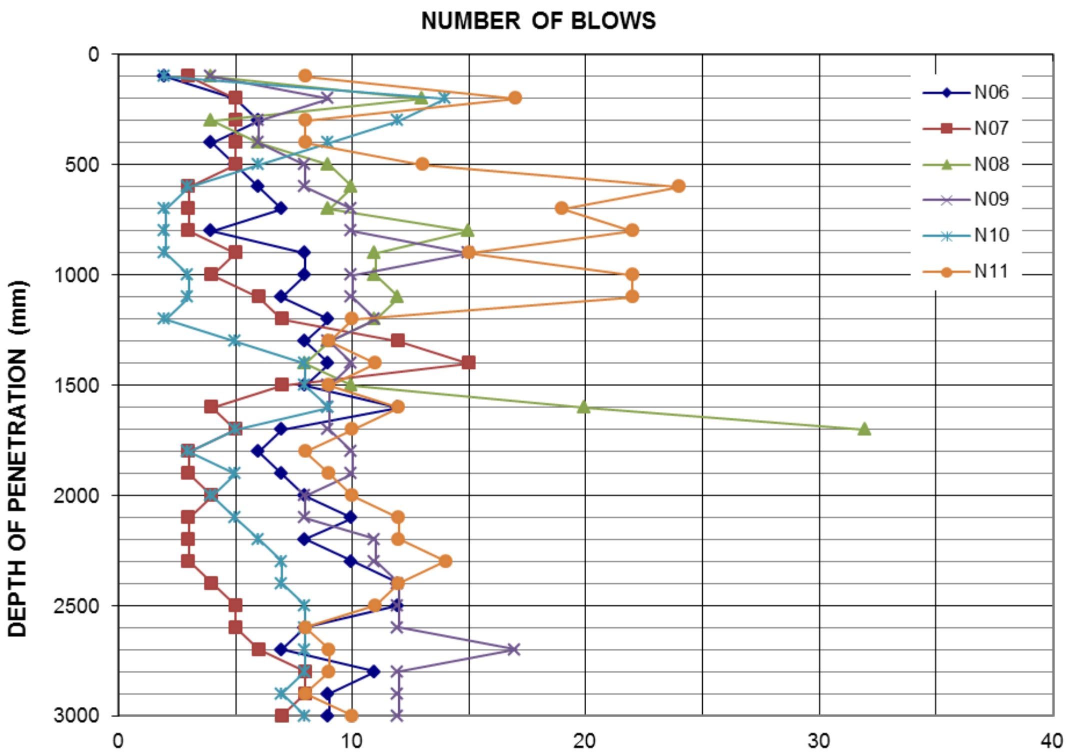
Six (6) test pits were excavated within the footprint of the 100 hectare site at Napandee. A 30 tonne excavator was used for the test pit excavation on site. All the test pits were excavated to a nominal depth of 3.0 m (with the exception of N08 where refusal was met at 2.1 m) and generally one bulk 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 24 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, with the exception of N08 where refusal was met at 1.7 m (correlating with the test pit refusal at this location).. Blows were measured every 100 mm of penetration. Figure 26 shows a summary of recorded number of blows per 100 mm with depth.

Figure 26 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 soil and geological profile for the site, as typified by the deep bore N05D is as follows:

Table 34 Representative Stratigraphy – Bore N05D

Depth From (m bgs)	Depth To (m bgs)	Strata	Relative Permeability (H/M/L)
0.0	0.6	Sand	H
0.6	2.2	Silty Sand	H
2.2	6.0	Sandy Clay	L
6.0	21.4	Kaolin (Clay) Weathered Bedrock	L
21.1	45.4	Bedrock (Weathered)	L
45.5	48.6	Sand Weathered Bedrock	M/H
48.6	50.1	Gravel Weathered Bedrock	M/H
50.1	51.6	Bedrock (Weathered)	M
51.6	64.6	Bedrock (Unweathered)	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 the table below.

Table 35 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/aquiclude material were collected during the investigation borehole drilling program and submitted for laboratory permeability testing. Two samples were collected and tested from boreholes on the site.

Table 36 Laboratory Testing Results – Undisturbed Aquitard / Aquiclude Permeability

Borehole	Depth (m)	Strata	K (cm/sec)	K (m/d)	Testing Laboratory	Testing Standard
N06	3.2 - 3.6	Sandy Clay	3×10^{-9}	2.6×10^{-6}	GroundScience	AS1289.6.7.3
N03	27.0 - 27.4	Silt/Clay	1×10^{-8}	8.6×10^{-6}	GHD	AS1289.6.7.3

The results for this site confirm the literature estimated relative permeabilities for the low permeability strata at the depths indicated and based on the representative stratigraphic sequence adopted from investigation borehole N05D.

Some silcrete and/or calcrete (around 1-2 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. 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 dominated by weathered bedrock as kaolin (extremely weathered) granite or weathered metamorphic rock (gneiss). Fine grained weathered rock tends to have low permeability properties and was encountered near ground surface (around 6 m below surface).

The shallow soil profile is similar that described in the desktop assessment as soil type D3, 'a surface loam overlain by a poorly structured clay', inferred by landscape scale mapping to be dominant across the site. The north-east corner of the site is located along a north-west south-east running sand ridge. The soil profile at this investigation location (N05S/D) comprises sandy to 2.1 m underlain by a sandy clay to 3.8 m. It is inferred likely to be soil type H2, a 'siliceous soil' at this location.

In general the sub-surface profile may be summarised as alluvial sediment overlying silcrete (potentially residual weathered gneiss), grading to weathered gneiss.

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

- Partially saturated sediments in sandy clays units found near surface and also perched on the gneiss found at around 187 mAHD.
- Water table at around 31 m depth (around 167 mAHD), found in the gneiss that is present from approximately178 mAHD. Gneiss comprises initially low permeability, extremely weathered material (partially saturated) approximately 6 m thick, then transitions to highly weathered, high permeability material from approximately 174 mAHD.

The environmental laboratory analytical results for soil samples from test pits N07, N09 and N11, all inferred of a similar soil profile to soil type D3, has been interpreted[16] to provide the following information about soil chemical quality properties within the profile from surface to around 2 to 2.5 m depth:

- of acidic pH at surface becoming moderately alkaline thereafter
- is non-saline at surface becoming slightly to moderate saline within the clay at depth
- varies from a very low to low cation exchange capacity
- is non-sodic at surface with sodicity increasing with depth and becoming strongly sodic and dispersive by within the clayey sand and underlying clay

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.

Standing groundwater levels recorded in the bores immediately prior to sampling tabulated below:

Table 37 Gauging Data for Napandee Investigation Bores

Bore No	Reduced Level (Top of casing mAHD) 23/5/18	Groundwater Level (m below top of casing)	Reduced Groundwater Level (mAHD)
N01	184.74	26.57	158.17
N02	185.53	24.39	161.14
N03	184.59	23.95	160.64
N04	194.01	28.05	165.96
N05S	198.81	31.61	167.20
N05D	199.08	32.65	166.43

The watertable bore is below surface level at between approximately 24 to 32 metres below ground surface (m bgs). The top of casing elevation level variation is due to surface topography which changes by approximately 14 m between the N05 location and the N01, N02 and N03 locations.

The reduced levels of groundwater in the shallow aquifer, based on water levels reported in 23 May 2018, range from 158.17 mAHD in Bore N01 on the north western portion of the site to 167.20 mAHD at Bore N05S in the north-eastern portion of the site. The inferred groundwater contour map across the site based on the above data is shown as Figure 27. The inferred direction of horizontal groundwater flow in the watertable aquifer is east to west at a hydraulic gradient of around 0.008.

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

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 of flow-path distance) is considered very low and would represent a regional groundwater flow pattern. The inferred horizontal hydraulic gradient on this site at 0.0008 is approaching an order of magnitude between the two, neither high nor very low. 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, an hydraulic gradient of a lower order or orders of magnitude would be preferable.

Figure 27 Interpreted Groundwater Contours and Inferred Flow Direction 23/05/18 – Watertable Aquifer Napandee

The direction of vertical groundwater flow between the weathered bedrock watertable aquifer and the unweathered bedrock aquifer is downward (i.e. the water level is higher in the watertable aquifer). A 0.8 m vertical head difference exists between the two aquifers over a vertical distance of around 15 m equating to a vertical hydraulic gradient of around 0.02. The relative high vertical difference over a short distance suggests there is poor hydraulic connection between the two aquifers. This is consistent with the assumed relative low permeability of the kaolin (clay) weathered bedrock profile.

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**). Work conducted by Gilfedder *et al* (2015) indicates that substantial variability and undulation in hydrochemistry suggests that local groundwater flow systems dominate over any regional groundwater flow-paths and that 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.

The inferred direction of groundwater flow from site derived groundwater level data suggests that local watertable groundwater flow is to the west. This flow direction is consistent with topography and inferred surface drainage is towards the northwestern portion of the site. It is unknown how regionally extensive this flow direction is or where the local or regional discharge point lies in relation to the site.

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;
- 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 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.

[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

Table 38 Groundwater Quality vs National Guidelines for Beneficial Uses of Water – Selected Analytes: Napandee

		National Quality Guideline					Laboratory Reported Groundwater Quality (by borehole)					
	Analyte	1	2	3	4	5	N01	N02	N03	N04	N05 S	N05 D
Major Parameters	TDS*	1,200	3,000 to 13,000	400 to 7,800	65 to 3,250	1,000	28,990	31,915	34,125	13,650	26.780	48,200
	pH	6.5 to 8.5	-	-	6.5 to 9.0	5.0 to 9.0	4.54	6.98	5.94	6.63	4.41	7.72
	SO_4	250	2,000	-	-	400	2,100	2,240	2.590	1,090	2,190	2,610
	Cl	5.0	-	40 to 700	-	400	15,600	16,400	19,800	7,500	14,400	17,800
Metals	Fe	0.3	-	0.2	-	0.3	16.8	0.72	0.97	12.0	6.86	-
	As	0.01	0.5 to 5.0	0.1	0.013 to 0.024	0.05	0.003	<0.002	<0.002	<0.001	0.003	<0.001
	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	0.48	0.53	0.17	0.31	0.26	-

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, the groundwater is dominantly saline and based on the salinity as reported in most bores, beneficial uses for consumptive and recreational use would be precluded. The low pH (4-5) reported in groundwater from several bores across the site could result from oxidation in sulphides in the mafic basement (observed in the region) resulting in some acidification of groundwater. Use of groundwater from this site for most applications would require extensive pre-treatment.

3.1.2 Assessment Against Criteria

The assessment criteria for geological, hydrogeological and geochemical characteristic criteria are tabulated in Section 3.1.1.1. Data collected during the recent field investigations has allowed AECOM to assess site suitability against each criteria. The assessment is as follows:

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 Napandee is located on a flat area with a moderately sloped ground surfaces were 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 considered unlikely to be constrained by slope instability.

Preferred Characteristic: Watertable at depth (>10 m)

Groundwater in the watertable aquifer was found to be present at depths >20 m below ground surface and is considered generally favourable for the proposed facility.

Preferred Characteristic: Cohesive soil profile

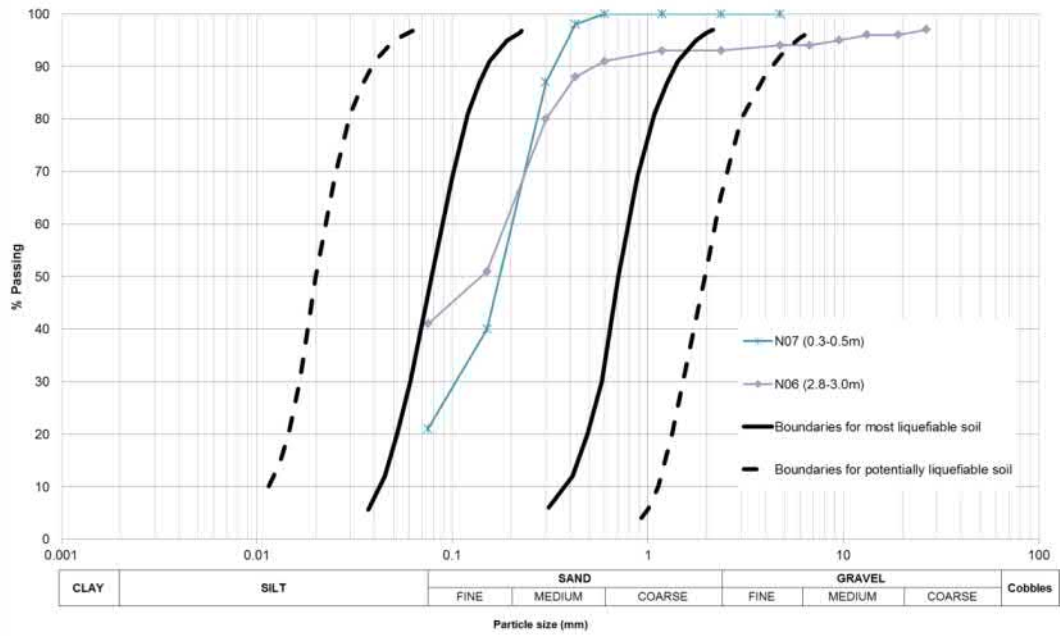
Liquefaction

Liquefiable soils create a significant hazard for infrastructure during the seismic event. 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 28 shows the boundaries suggested in 1985 by USNRC with particle size distribution of tested materials.

Figure 28 Particle Size Distribution of Tested Materials



Based on the above figure, most of the site materials can be characterised as liquefiable soil considering particle size only. The cohesionless soil materials encountered onsite were predominantly medium dense with localised loose layers encountered. The soils observed on site generally were cohesionless to 2 m depth, underlain by cohesive or weathered residual soil materials.

However, based on the site investigation observations, deep groundwater level (>20 m depth) was found. Although the materials are classified as liquefiable soils due to their particle size, most of the key conditions for soil to liquefy are not present most notably the presence of saturated soils. Therefore, it is unlikely that the soil encountered onsite become liquefied during an 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 2 m of soils consisted of cohesionless material of aeolian origin, underlain by cohesive or weathered residual soil 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 identification of collapsing soil. Table 39 shows the criteria for identification of collapsible soils using physical properties developed by several authors.

Table 39 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 site soils using indicated criteria in Table 39 are presented in Table 40. Based on empirical assessment, the materials found onsite were classified as non-collapsible soils.

Table 40 Results of Collapse Identification and Classification based on the Physical Parameters

Sample	**Parameter**		**Classification**	
	Kd	K	Kd	K
N07 (0.3-0.5m)	1.6	17.0*	Non-collapsible	Non-collapsible
N06 (2.8-3.0m)	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 2 m depth) throughout the borehole drilling and test pitting. These materials found onsite were generally in dry conditions and groundwater levels were generally found in a deeper depth (>20 m depth). As a result, it is not expected that the cohesive materials encountered are unlikely to 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 41 shows the criteria for identification of expansive soils using physical properties developed by several authors.

Table 41 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 29 presents the plasticity chart for the soils tested from site. Classification to determine the swell potential of the tested soils using indicated criteria are presented in Table 42. Based on empirical assessment, the shallow/near surface materials found onsite were classified as low swell potential and the deeper soil materials (3 m depth) were classified as medium swell potential.

Figure 29 Plasticity Chart for Tested Materials

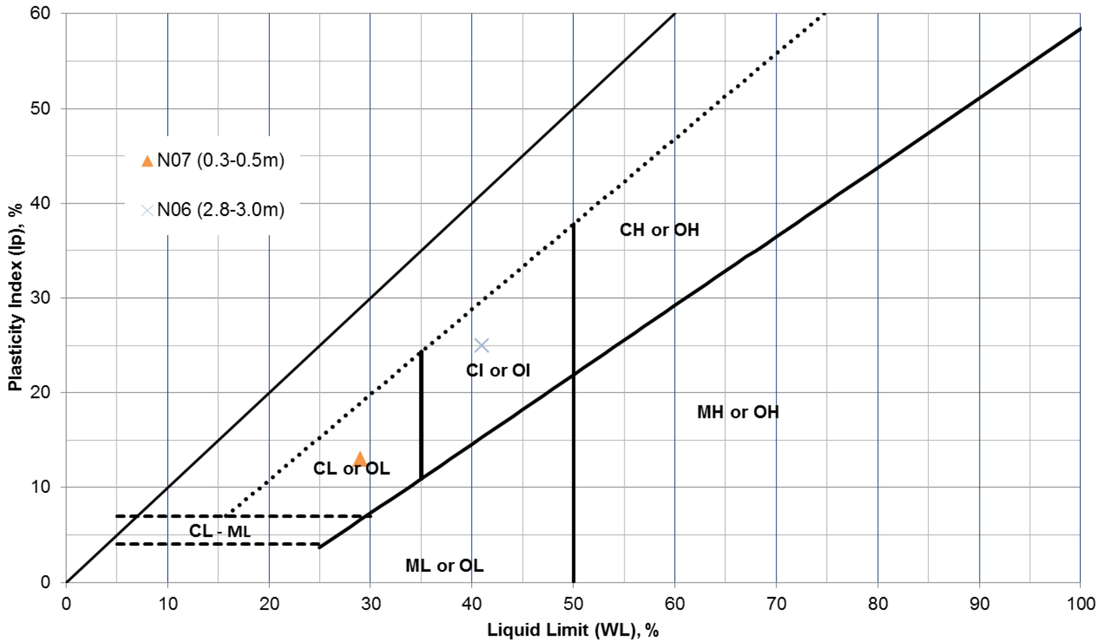


Table 42 Results of Swell Potential Classification based on the Physical Parameters

Sample	Swell Potential Classification		
	[1]	[2]	[3]
N07 (0.3-0.5m)	Low	Low	Low
N06 (2.8-3.0m)	Medium	Medium to high	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 Napandee 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 represents 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 agriculture land use. No signs of ground subsidence were observed during the site investigation works.

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 and desktop review, 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 areas 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, and are not prone to waterlogging

The sandy surface and clayey subsurface soil profile was typically present across the site with the exception of a sand ridge that intersects the north-eastern corner. These soils are inferred likely to be relatively free-draining at surface with decreasing hydraulic conductivity with depth as soils becoming clayey. The soils are non-saline and non-sodic at surface but slightly to moderately saline and sodic to strongly sodic within the underlying clays. The clay subsurface is indicated to be potentially dispersive in nature. The soil profile is neither aggressive in acidity or alkalinity.

Calcrete or silcrete bands were described within a number of investigations locations in the southern section of the site starting from around 1 m depth. The depth of these cemented layers is not likely to be shallow enough to lead to ponding under wet winter conditions.

Strongly sodic and/ or slightly to moderately 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 clayey soils 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

The yield potential of watertable aquifer (kaolin clay – weathered bedrock) and bedrock aquifer is inferred to be unfavourable.

Preferred Characteristic: Potable to brackish salinity groundwater

Groundwater quality in watertable and bedrock aquifers is highly saline and therefore not suitable for use beneficial uses.

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

Water table and deep aquifer piezometric surfaces are reported at depths exceeding 20m across the site

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: Few or widely (vertical) separated aquifers

Two aquifers within top 60 m of ground surface – low permeable kaolin clay and bedrock aquifer. Small vertical depth separation between the aquifers (15m)

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

The presence of clay, low salinity and generally 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, as are horizons with relatively low pH (< ~ 5.5). Attenuation studies, developing distribution coefficients and cation exchange/surface sorption models, will provide a greater level of detail.

Characteristic 2: Horizontal Migration Potential Mitigation

Preferred Characteristic: Low horizontal hydraulic gradient

The horizontal hydraulic gradient value is not considered low, at around 0.01

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

There are no identified groundwater uses or ecological receptors within 10km of site in the down hydraulic gradient direction of the site.

The above findings are summarised in the table below.

Table 43 Summary of Findings: Site Characteristic Criteria Assessment

<table>
<tr><th>Assessment Objective</th><th>Site Characteristic Criteria</th><th>Preferred Characteristic</th><th>Assessment Against Preferred Characteristic</th></tr>
<tr><td rowspan="7">Infrastructure Foundation Stability</td><td>Presence of collapsing or expansive soils</td><td rowspan="7">Relatively flat topography
Cohesive soil profile
Watertable at depth (>10m)</td><td rowspan="7">Unlikely, with exception of collapsing soils, low expansive soils at surface, medium at a depth of 3 m</td></tr>
<tr><td>Slope instability</td></tr>
<tr><td>Subsidence due to ground features</td></tr>
<tr><td>Long-term settlement</td></tr>
<tr><td>Scour and erosion processes</td></tr>
<tr><td>Potential of soil liquefaction</td></tr>
<tr><td>Presence of collapsing or expansive soils</td></tr>
<tr><td>Soil Quality</td><td>Detrimental soil quality properties that may lead to degradation and hydraulic properties that may increase the severity of flooding or erosion</td><td>Soils that are not saline, sodic, dispersive, do not have an aggressive pH, nor prone are waterlogging</td><td>The subsurface clayey soils, if exposed may be prone to crusting, waterlogging and dispersion of clay fines as they are moderately saline and strongly sodic</td></tr>
<tr><td>Ground Water Supply</td><td>Current of potential beneficial uses of groundwater</td><td>Presence of a pumpable groundwater supply aquifer (Yield min. 175 m^3/d or 2 L/s)</td><td>Absent</td></tr>
</table>

Assessment Objective	Site Characteristic Criteria	Preferred Characteristic	Assessment Against Preferred Characteristic
		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	Absent
		Thick, impermeable to low permeability aquitards	Present
	Potential for horizontal migration of solutes through saturated sediments or bedrock	Low horizontal hydraulic gradient	Absent
		No, few or distant third-party groundwater users/receptors	Present

3.1.3 Design Issues and Mitigation Measures

Geology and Hydrogeology

There was no observed evidence of a shallow water table aquifer that could impact on building footings or require dewatering during 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.

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 and Geochemistry

Should Napandee be selected as the preferred site, the aim of any subsequent Stage 2 field program would be to fill remaining data gaps and 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.

The Stage 2 field work shall target the 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 each 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.
  - Conduct a series of batch tests to assess chemical attenuation of the materials for use in the modelling of reactive transport and attenuation using industry-leading software such as PHREEQC

Geotechnical

Additional detailed and targeted geotechnical site investigation will be required with consideration of the proposed site layouts, structural loadings and nature of infrastructure proposed for the site.

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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.

Geotechnical in-situ 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. If the depth of the overlying soils is reduced then such cemented layers could 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.

3.2 Landform Stability

3.2.1 Methodology and Results

A desktop assessment of the geomorphology of the site within the short-listed Napandee 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 also undertaken 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 characteristic 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 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 Napandee 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 flows 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. However, over geological timescales, large changes in sea level are possible. For example, around 20,000 years ago, sea level was around 125 m below present (Lewis et al. 2012).

Key Geomorphological Processes

Key geomorphological processes were identified based on:

- Inferences from landforms and geomorphological drivers; and
- Relevant geomorphological literature as cited.

Geology and Landforms

A review of Figure 16 the digital elevation model (DEM) output from an acquired LiDAR (Light Detection And Ranging) airborne topographic survey, the surficial geology map from Figure 21 is from the 1:250,000 Kimba Map Sheet (SH53-8) and aerial imagery for the Napandee site and surrounds was undertaken.

Geologically, the Eyre Peninsula is underlain by the Gawler Craton (Berens et al. 2011) which consists of ancient (Pre-Cambrian) granitic rocks. The surface geology of the north-eastern Eyre Peninsula, where the Napandee site is located, consists of Quaternary deposits including sand plains, dune systems and inter-dunal clay pans that overly the older rocks of the Gawler Craton.

The geological mapping shows that the surficial geology of the Napandee site consists of Pleistocene longitudinal (seif) dunes draped with the Holocene sand veneers of the Moornaba Sand formation consistent with aerial imagery and the DEM which also show the longitudinal dunes (Refer Figure 21). The Pleistocene seif dunes are formed of orange quartz sand and clayey sand containing soft, biscuity calcrete. The calcrete is considered to have been derived from aeolian sources (Twidale, 2008). The Moornaba Sand formation consists of white, pale grey and orange sand. The land has been extensively cleared and is used for dryland agriculture. There are outcrops of Archaean granitic gneiss in the vicinity of the Napandee site but the geological mapping does not show any outcrops at the site or on the subject property.

The site inspection by the geomorphologist confirmed the ridge and swale topography. At the time of the inspection the crops had emerged within the paddocks. This combined with cultivation of the paddocks would have obscured any small-scale features that would have provided further evidence regarding geomorphological processes.

To the south-west of the Napandee site is the Pinkawillinie Conservation Park, an area of parabolic dunes associated with a Tertiary age palaeochannel (Corrobinnie Depression) that is covered in native bushland.

Soil Conditions

Information on the subsurface conditions beneath the site was reviewed from logs (Appendix C) obtained from the drilling of six boreholes and excavation of six shallow test pits across the site. The boreholes are situated around the perimeter of the site while the test pits are set out across the site. The data from the boreholes show a layer of sand (generally 1 to 2 m deep) at the top of the profile, which is underlain by 1 to 2 m of sandy clay in some boreholes (e.g. N01, N05S and N05D) and calcrete is also present in N03. These materials are consistent with the Quaternary (Holocene and Pleistocene) dunefield deposits shown on the 1:250,000 geological map.

The borehole logs suggest that the dunefield deposits are underlain by a layer of silcrete at a depth of 1-4 m below ground level. The silcrete, in turn, overlies kaolin and weathered bedrock (Gneiss). The kaolin appears to be derived from weathered gneiss bedrock. The elevation at which silcrete and kaolin is encountered is higher on the eastern side of the Napandee site than on the western side, indicating that the surface topography of the site (Figure 16) reflects the topography of an ancient surface carved into the underlying bedrock.

The test pits extend to a depth of approximately 3 m below ground level, or refusal, and did not encounter the underlying silcrete, kaolin or gneiss bedrock shown by the bores. They show sand deposits of variable depth overlying sandy clay or clay. Test pit N08 was terminated at refusal at a depth of 2.1 m in a calcrete layer. Cobbles and gravels were also encountered in test pit N11. The formations exposed in the test pits are all consistent with the Quaternary dunefield deposits, suggesting that these deposits are generally at least 3 m deep across the Napandee site.

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 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

Seismic activity in the Eyre Peninsula is highlighted within Geoscience Australia's National Earthquake Hazard Map of Australia (Burbidge et al 2012), 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 higher seismic activity in Australia.

Geomorphological Processes

Fluvial

There are no creeks at or in close proximity of the Napandee site however, there are indications of a minor surface water flow paths at the northern and southern ends of the property.

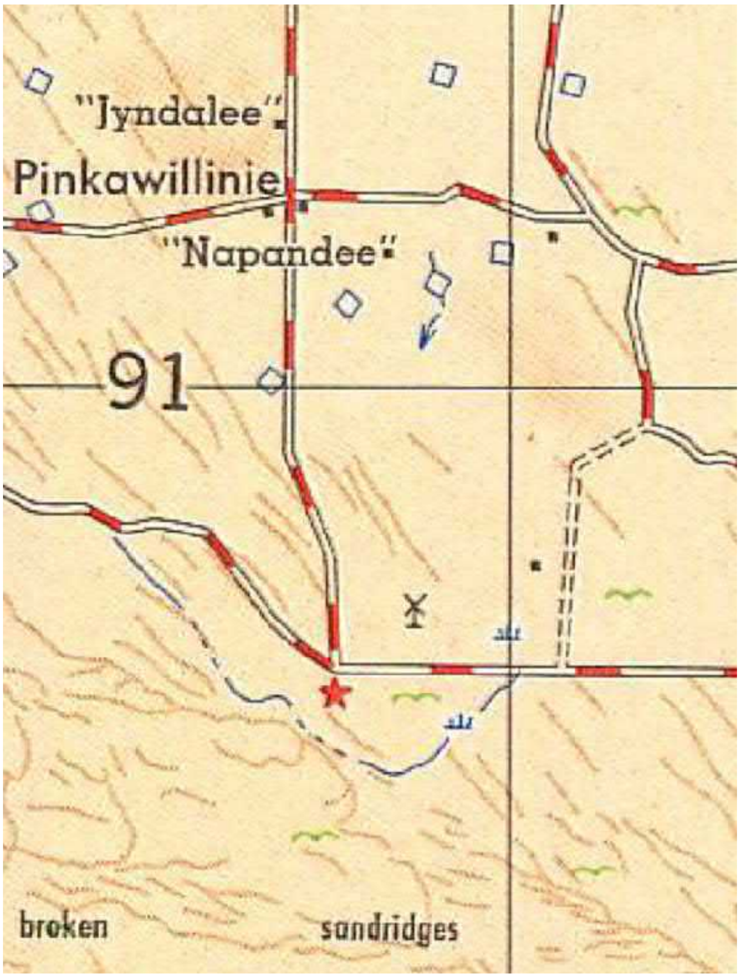
The geological map shows a minor drainage line flowing toward the site, also another minor drainage line draining away from the south of the site. The same drainage lines are also shown on the historical 1:250,000 Kimba topographic mapsheet (Figure 30). The northern drainage line is shown as being ephemeral spring-fed while the drainage line to the south is shows as being in part a swampy depression.

Whilst there are no major rivers or streams flowing through or past the Napandee site, the drainage line discussed above may carry runoff in times of intense rainfall. The AECOM hydrology assessment (Section 2.5.2.2) indicates that the catchment area is around 150 km^2) and likely to produce significant flows during rare large flood events. The AECOM hydrology assessment recommended investigation of this issue via hydraulic and hydrological modelling in second phase of Site Characterisation.

Flows may potentially occur along the interdune swales (Twidale, 2008). The interdune swales were observed by the geomorphologist during the site inspection. The presence of any shallow calcrete and clay in the dune deposits has the potential to limit infiltration and lead to waterlogging and increased surface water runoff. Flow in the minor watercourse or dune swales may cause fluvial scour or deposition. Further information on surface water hydrology, including flow paths and hydraulic loadings, is required to assess the likelihood of fluvial erosion or sedimentation at the Napandee site.

AECOM's soil assessment identified sodic and potentially dispersive clay subsoils at the Napandee site based on regional soil characteristics. If sodic, dispersive or slaking clays are present and become exposed they would be at risks of erosion, via rill, tunnel and gully erosion.

Figure 30 Excerpt from historical 1:250,000 topographic map for the Napandee site (from Kimba SI 53-7 Edition 1, Series R 502)



Slope/Mass Movement

The sand deposits including the dune slopes are susceptible to erosion and mass movement, especially at times of high rainfall or flood, even if vegetated. Processes include sapping, collapse, surface wash and gullying (Twidale 2008). The DEM indicates significant local relief at the Napandee study area (over 20 m vertical range) (Figure 16). The east-west fall across the site is associated with a hillside carved into the underlying Archean gneiss bedrock, as indicated by the bore data. This is overlain by relatively shallow Quaternary aeolian deposits including seif dunes. This is overlain by relatively shallow Quaternary aeolian deposits including seif dunes. Slope erosion risks may potentially be exacerbated by tectonic activity.

Aeolian

The topsoil and surface deposits across the Napandee study site are sandy and longitudinal dunes are a prominent feature. 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). However, the sandy ground surface at Napandee is potentially at risk of wind erosion (deflation), dune reactivation or transgressive dune development if the vegetation cover or the ground surface is disturbed. Transgressive dunes are a prominent feature of the adjacent Pinkawillinie Conservation Park.

The transgressive sand dunes in the Pinkawillinie Conservation Park are currently extensively vegetated with native bushland, but if the vegetation cover is disturbed (e.g. by fire) these dunes may potentially be reactivated and migrate towards the Napandee study site or provide a sediment source for additional deposition on the Napandee site.

3.2.1.3 Assessment against Criteria

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

The Napandee study site is situated on a landform consisting of Quaternary dunes overlying a hillside carved into the underlying Archean gneiss basement rock. The basement rock is deeply weathered with deep kaolin deposits overlain by silcrete. The Quaternary dunes 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 locally or in upwind areas.

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 landforms are not stabilized through maintenance of vegetation cover and appropriate management of surface water runoff.

3.2.2 Design Issues and Mitigation Measures

The potential for episodic flooding has the potential to lead to erosion and/or deposition of material within the site. This should be should be appropriately modelled and assessed for geomorphological implications. The potential for slope mass movement triggered by high rainfall events or seismic activity should be addressed for the civil design for the NRWMF, including geotechnical assessments with appropriate measures implemented.

3.2.3 Data Gaps and Recommendations for Stage 2 Field Program

Further assessment of likely fluvial processes requires hydrologic and hydraulic modelling to define surface flow paths and hydraulic loadings

Further testing of the subsurface clays for sodicity, slaking and dispersiveness should be undertaken to assess erosion risks if this material becomes exposed.

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 those 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 Napandee. This information is being used to evaluate sites for siting of the NRWMF, 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 31 through Figure 35. 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 Napandee 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 35. 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 35, with the topography of the Flinders and Mount Lofty Ranges shown in Figure 36, 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 31) 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 32 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 33 shows identified neotectonic features (potential active faults) in the same region from Clark et al. (2011), and Figure 35 shows the superposition of these features on the earthquake epicentre map. There is a clear association of faults and historical earthquakes, shown in Figure 35, with the topography of the Flinders and Mount Lofty Ranges shown in Figure 36.Use was made of topographic maps to assess the potential for topographic amplification of ground motions at the site.

Figure 31 Map of neotectonic features and site locations. Source: Clark, 2018b

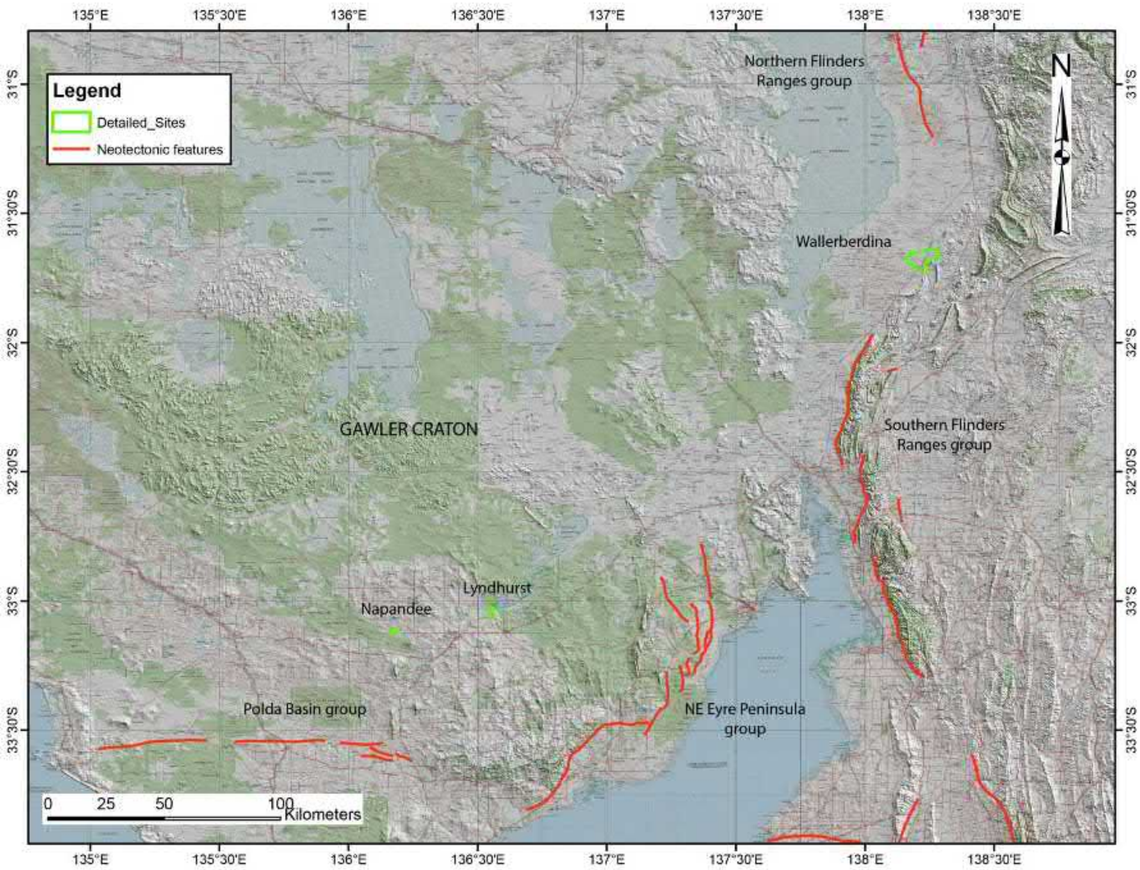


Figure 32 Historical seismicity within about 300 km of the site locations, shown by the yellow stars, based on the Geoscience Australia (2018) revised earthquake catalogue.

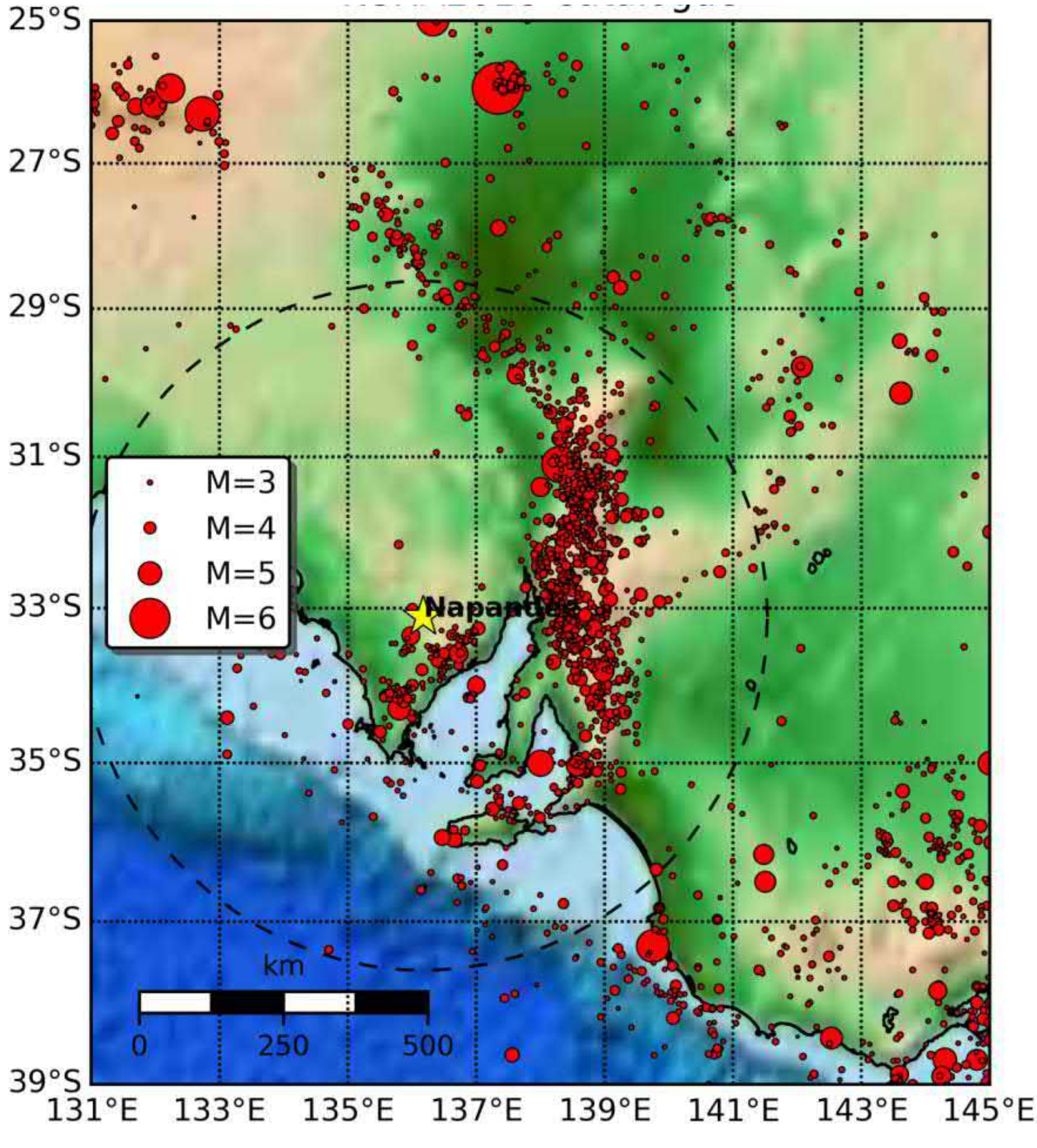


Figure 33 Neotectonic features in the study region based on Clark et al. (2011).

The top edges of the faults are shown by dark lines and their surface projections are shown by the coloured bands.

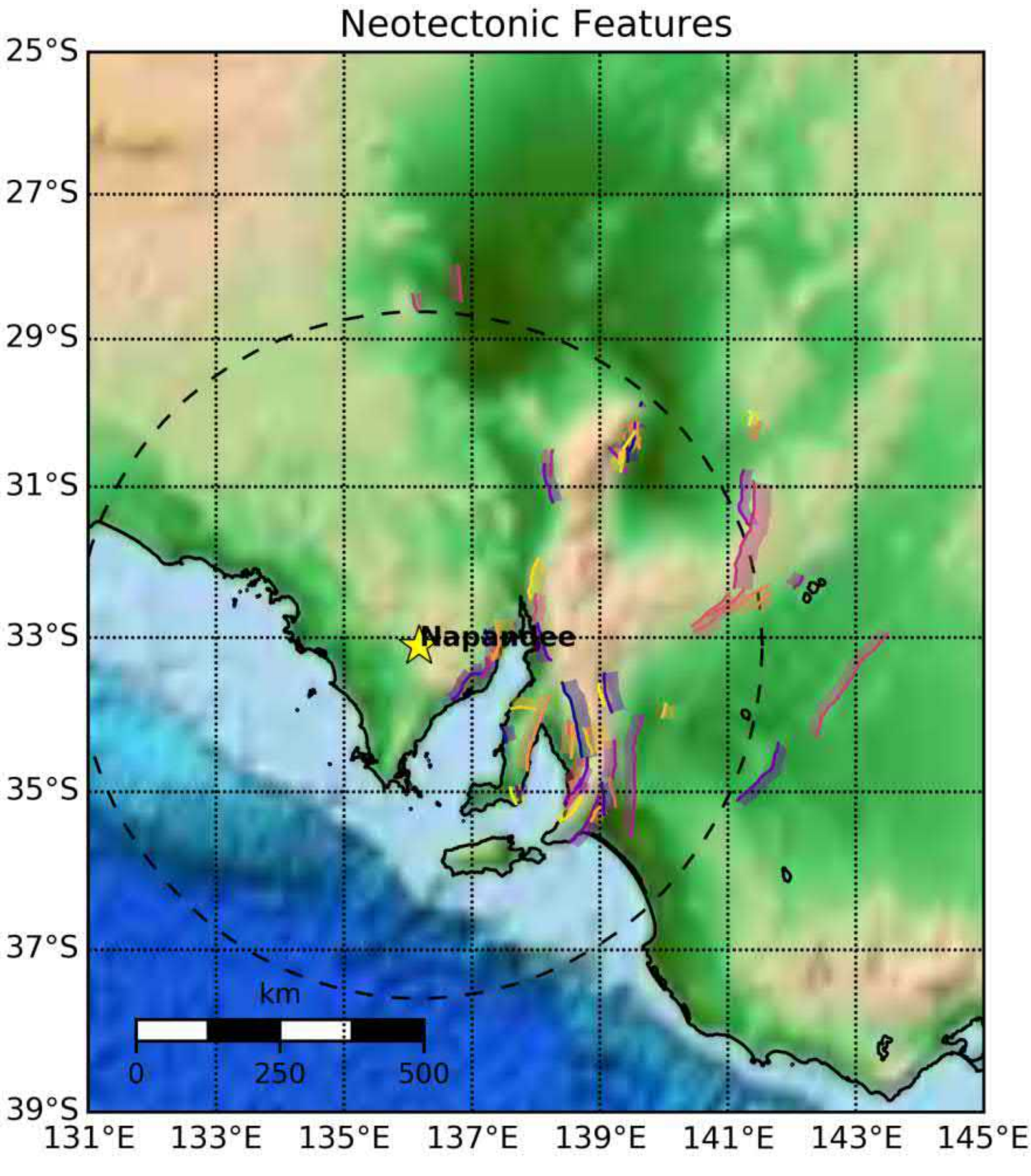


Figure 34 Legend for neotectonic features in the study region based on Clark et al. (2011).

Figure 35 Neotectonic features and historical earthquakes for the study region based on Clark et al. (2011) and Geoscience Australia (2018) respectively.

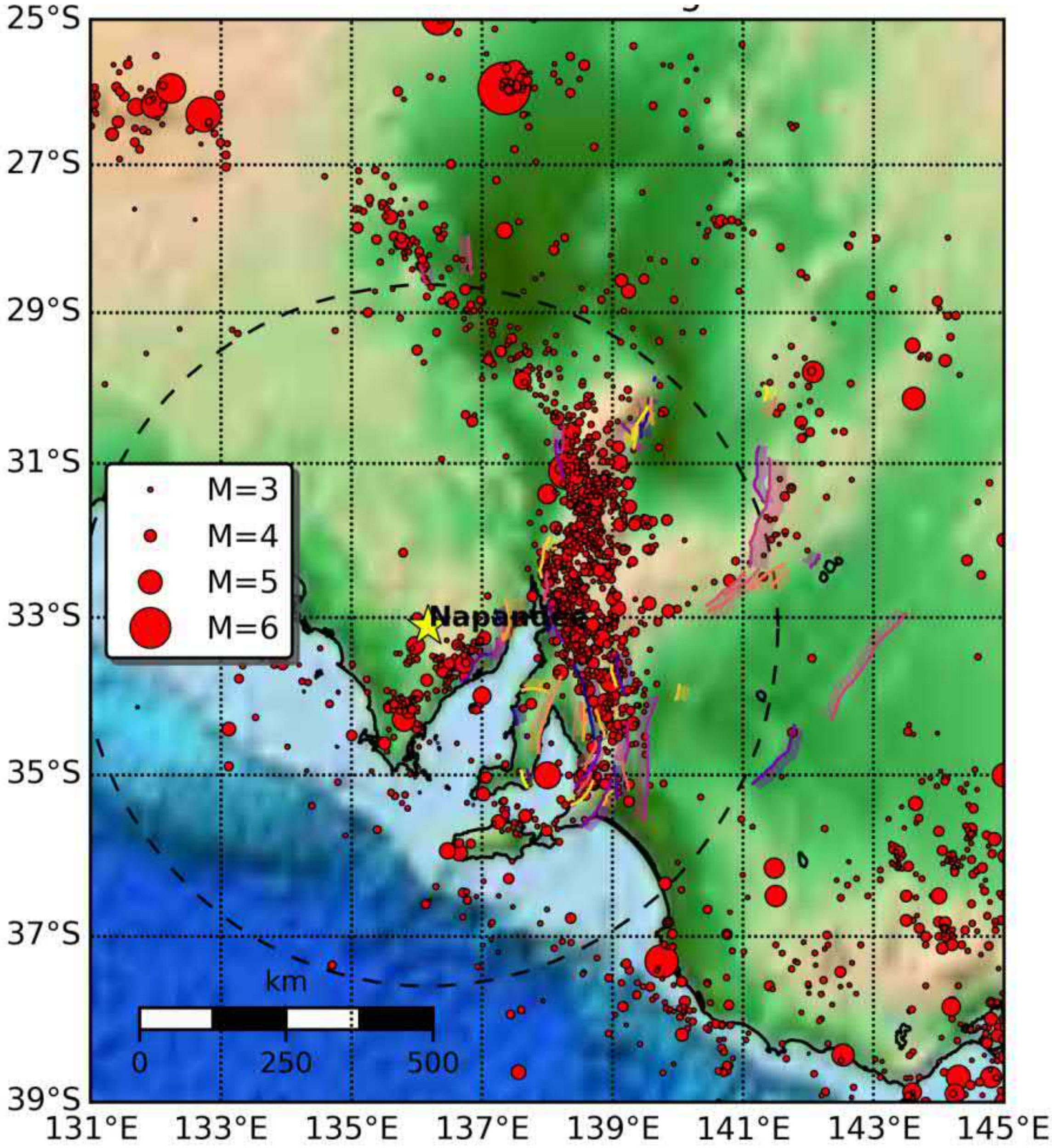
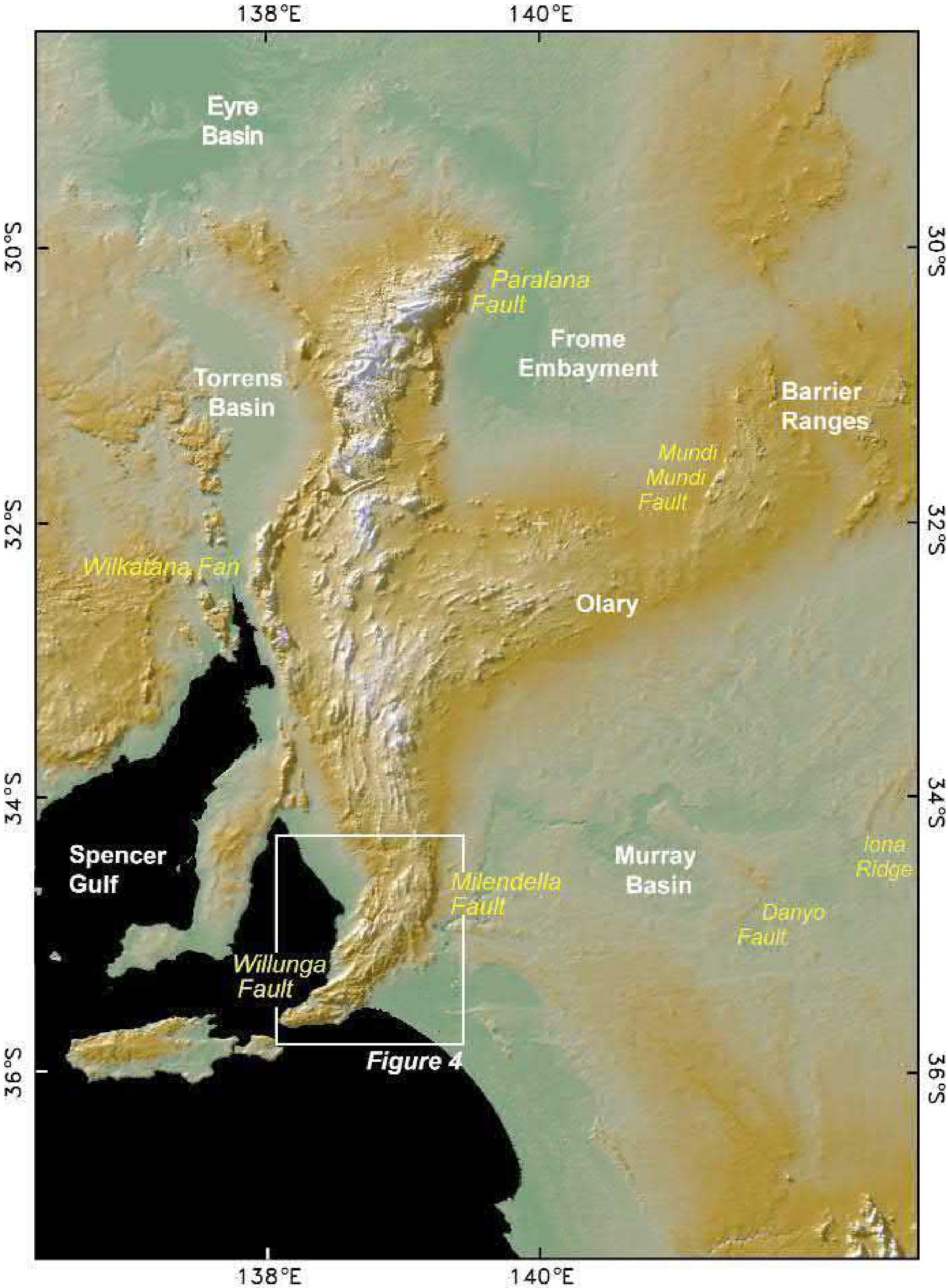


Figure 36 Topography of the Flinders and Mount Lofty Ranges. Source: Sandiford et al., 2013.



3.3.1.3 Field Data

Two shallow seismic reflection profiles together with a preliminary interpretation, described below, were obtained at Napandee by Velseis Pty Ltd (Velseis).

Daishsat Pty Ltd (Daishsat), undertook an airborne survey of magnetics and radiometrics for the Napandee site, and a preliminary desktop assessment of the available geophysical data sets at the site.

Reports on these surveys are provided in Appendix C

3.3.2 Review Against Criteria

Clark (2018a) states:

> *"The Kimba sites (which include Napandee) 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 Napandee 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 Napandee site are shown in Figure 37 , 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 38 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 37.

Figure 37 Geological setting, mapped scarps and historical seismicity. The Napandee site is the green rectangle in the right centre of the map. Source: Clark (2018b).

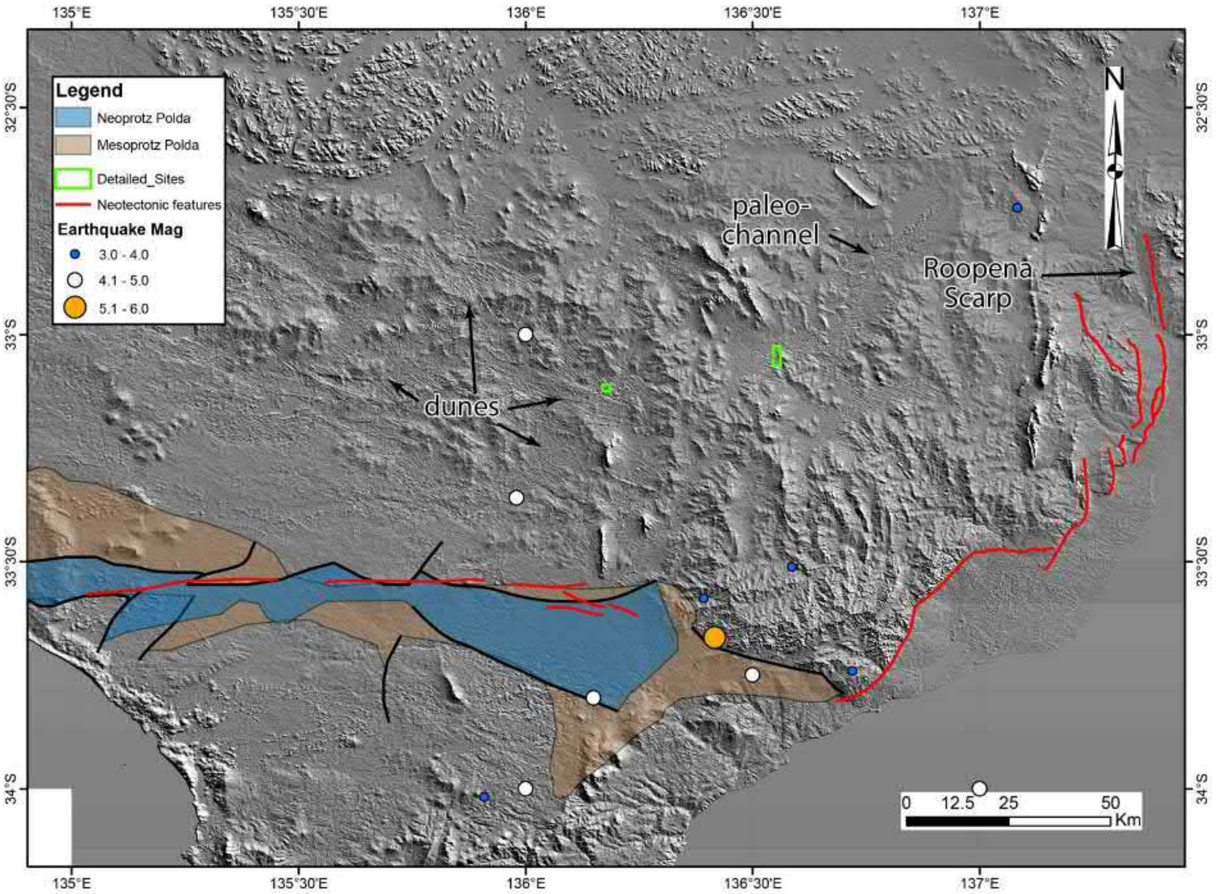
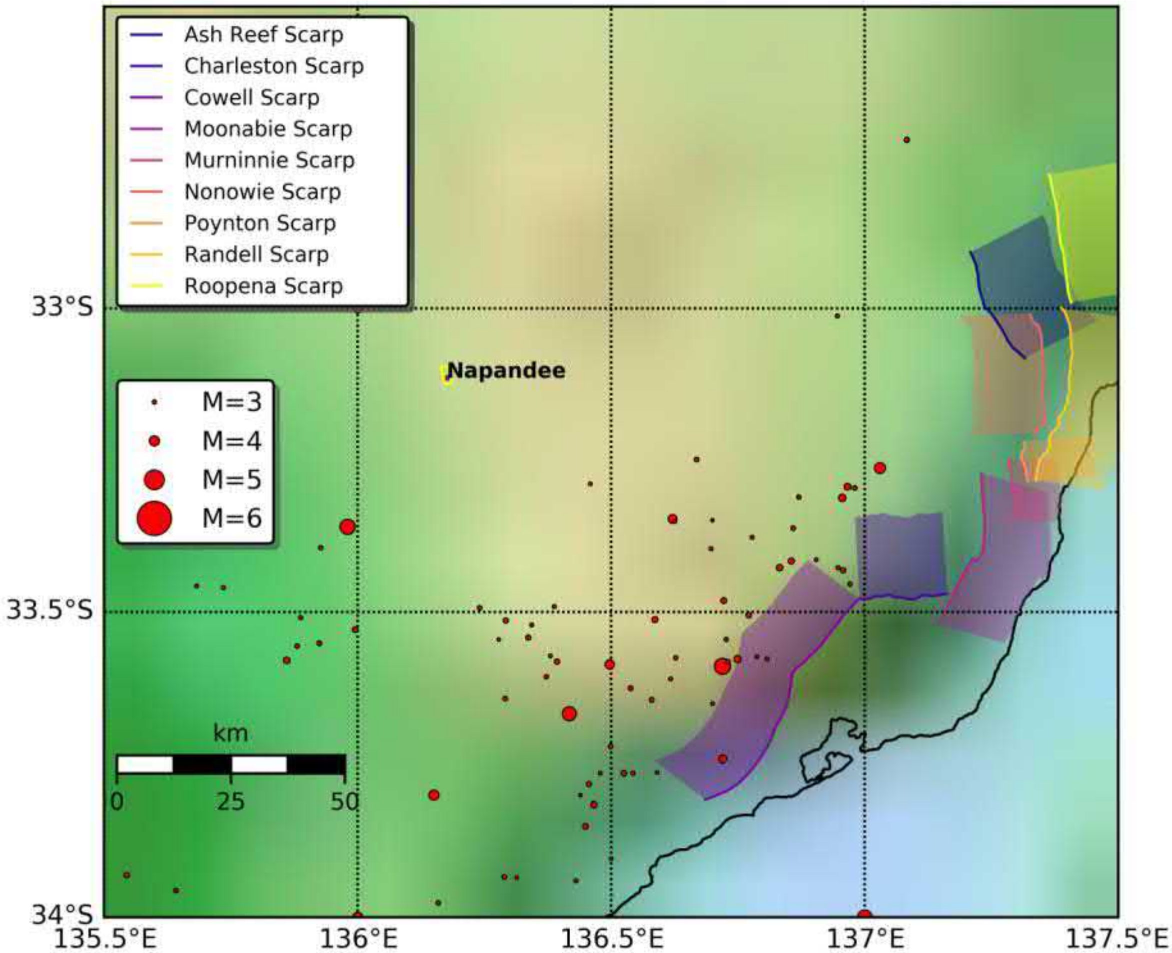


Figure 38 Neotectonic features and historical seismicity near the Napandee site based on Clark et al. (2011) and Geoscience Australia (2018).

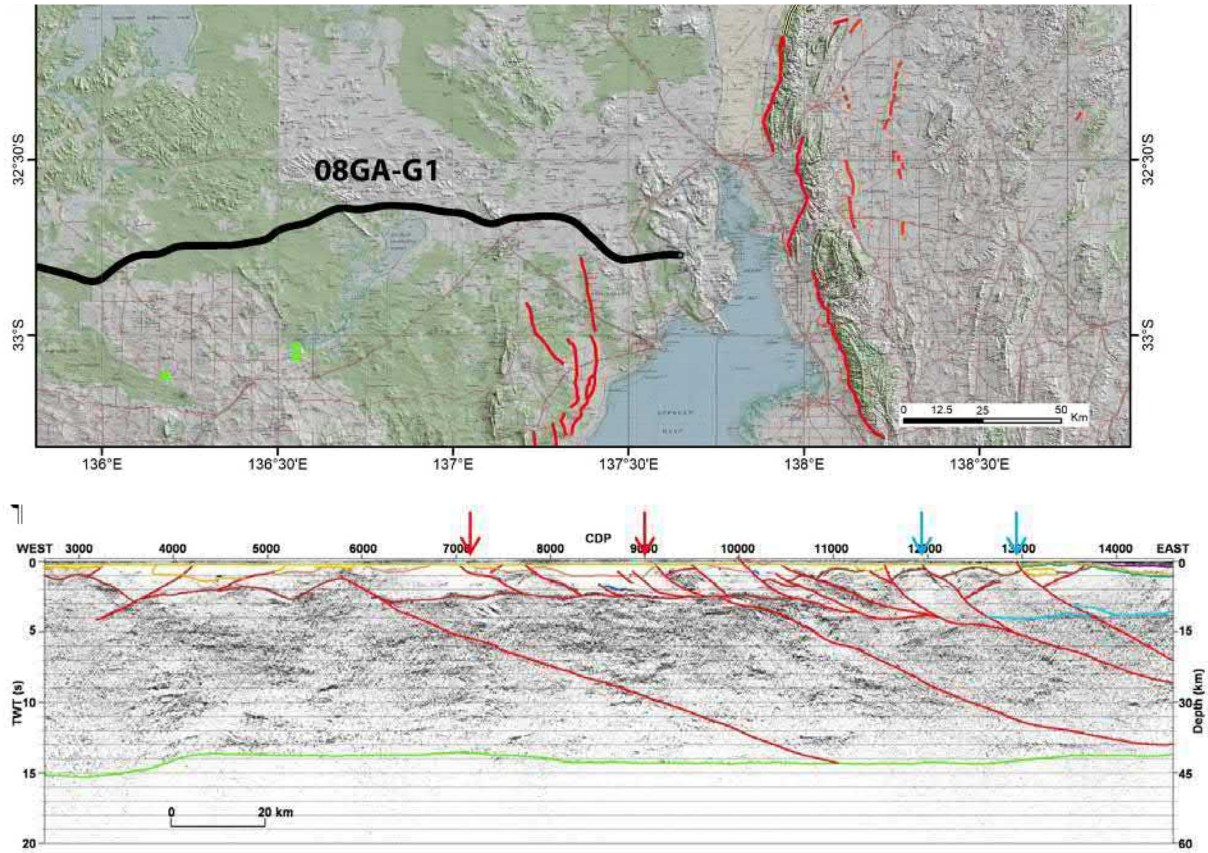
The top edges of the faults are shown by dark lines and their surface projections are shown by the coloured bands.



A deep crustal seismic reflection profile to the north of the Kimba sites (which include Napandee) is shown in Figure 39. 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 39). 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 Napandee.

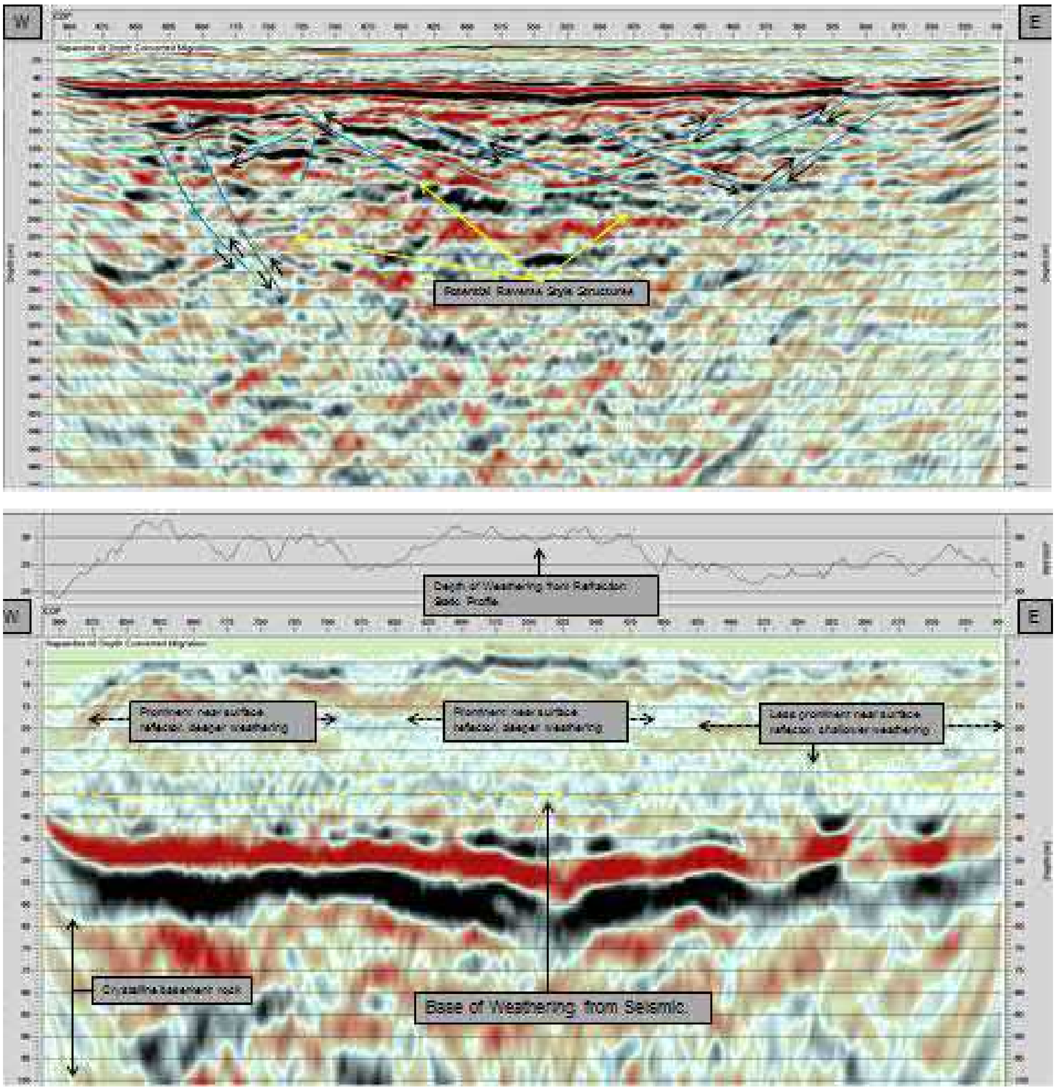
Figure 39 Top: Location and Bottom: Interpretation of deep crustal seismic line 08GA-G1 (from Fraser et al. 2010). Source: Clark (2018a).



Two shallow seismic reflection profiles were obtained at Napandee by Velseis Pty Ltd (Velseis). In Profile 2, shown in Figure 40 interpreted faults are shown by blue lines that extend down to depths of 280 m, and where possible, interpreted slip direction is indicated. The second interpreted fault from the eastern 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). These interpreted faults do not appear to displace the depth of weathering from refraction statics profile, indicating the absence of faulting in recent geological time. This indicates that, at the resolution available in these profiles, there is no evidence for geologically recent surface faulting at the site. The vertical resolution of the refraction statics profile should be assessed against the vertical resolution of the reflection profile to determine if further processing or filtering of the upper section of the seismic is desirable.

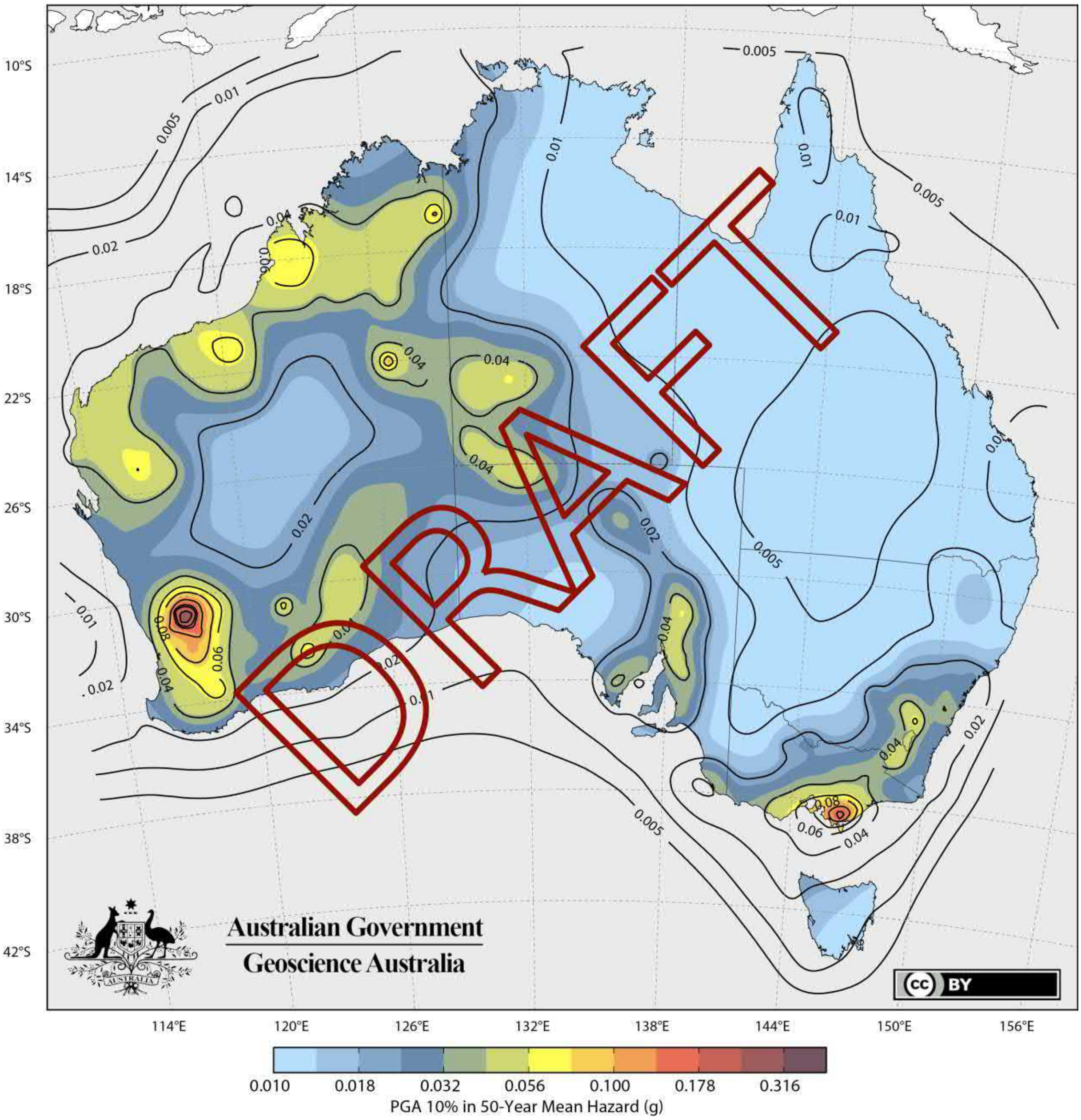
Daishsat (2018) concluded that although only regional data have been examined from the existing 1:250 000 geology map, drill-holes, gravity and magnetic data, there is no evidence to suggest the presence of shallow basement or structures at Napandee.

Figure 40 Napandee 02 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 41. The map shows peak acceleration having a 10% probability of exceedance in 50 years for site class B_e. The hazard value at the Napandee site is approximately 2.5%g, which is well below the damage threshold for ordinary structures.

Figure 41 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, to suggest reactivation of any faults in the foundation of the Napandee site during the last several hundred thousand years. 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 Napandee site displays absence of potentially active faults in the foundation.

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. There is no evidence, at the resolution of the SRTM DEM, LiDAR topographical and the on-ground seismic survey, to suggest reactivation of any near-surface faults beneath or near the foundation of the Napandee site during the last several hundred thousand years, subject to further assessment of a potential fault in the east of seismic line #2. Subject to this and 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 resolution of the SRTM DEM, LiDAR topographical and the on-ground seismic survey, to suggest reactivation of any faults within 20 km of the Napandee site during the last several hundred thousand years. 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 41, 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 Napandee 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 Assessment Against Criteria

The table below provides a summary of the qualitative desktop assessment against the site characteristic criteria.

Table 44 Desktop Assessment Summary of Site Conditions against Seismic Criteria

Assessment Criterion	Site Condition Assessment	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 Napandee. 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 Napandee 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

Several seismic ‘smiles’ near the faults interpreted in seismic line #2 suggest that the section may have been locally over-migrated. Examination of the raw seismic stacks, and/or reprocessing the data at lower migration velocity may clarify whether these features are real, or if they are processing artefacts. If processing artefacts, the interpretation of the section should be revised with an appropriate migration velocity. Should a fault interpretation remain a possibility, the potential for reprocessing or filtering the seismic to enhance reflections in the upper ~50 m of section might also be explored.

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 study of the Napandee site was undertaken to investigate site access, possible transport routes to the proposed site and any key constraints arising from 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. Accordingly, this 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 were 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 as Australian and local road design guidelines. International safety standards for radioactive materials were also considered.

4.1.1.1 Site Characteristic Criteria

The primary objective of the desktop assessment for the Napandee site was to evaluate 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 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 17/05/2018 and 18/05/2018)

4.1.2 Assessment Against Criteria

The proposed Napandee site with the potential to house the waste facility is located 23 km west of Kimba, SA (see Figure 42) and 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. This study will broadly consider the impact of this facility on the surrounding road network during both the construction and operation phases.

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). 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.

Figure 42 Napandee site

4.1.2.1 Existing conditions

The Napandee site is located approximately 23 km west of the Eyre Highway (part of the National Land Transport Network on private land and is serviced by unsealed local roads.

Arterial road network

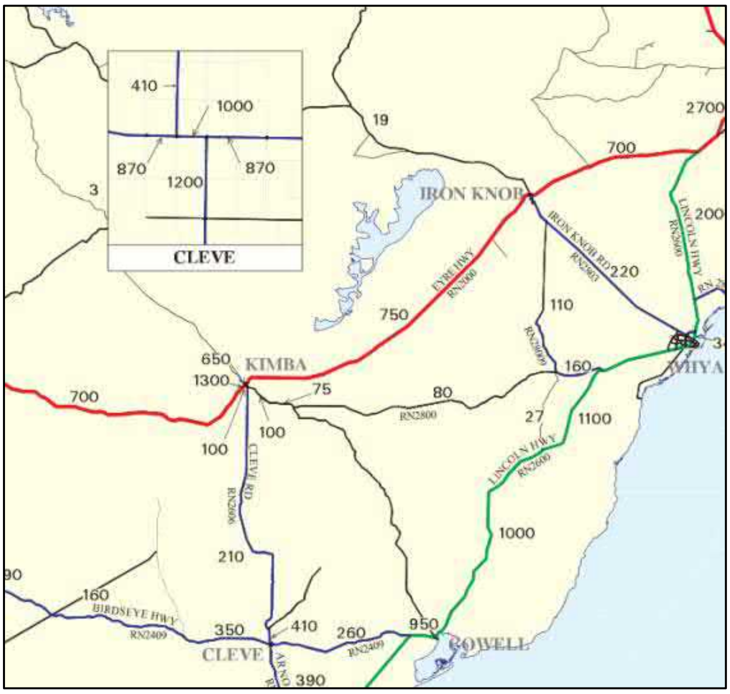
The Eyre Highway is the arterial road that will provide primary access to the local road network (subsequently the site) and is shown in Table 45.

Table 45 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/hr. Annual Average Daily Traffic (AADT) estimates are provided for the state-managed arterial roads in the vicinity of the site, as shown in Figure 43. The Eyre Highway has a low estimated AADT, with traffic flows of 750 vehicles / day along the section between Iron Knob and Kimba.

Figure 43 Annual Average Daily Traffic Estimate 24 hour two way flows (Department of Planning, Transport and Infrastructure, 2015)



4.1.2.1.1 Approved heavy vehicle routes

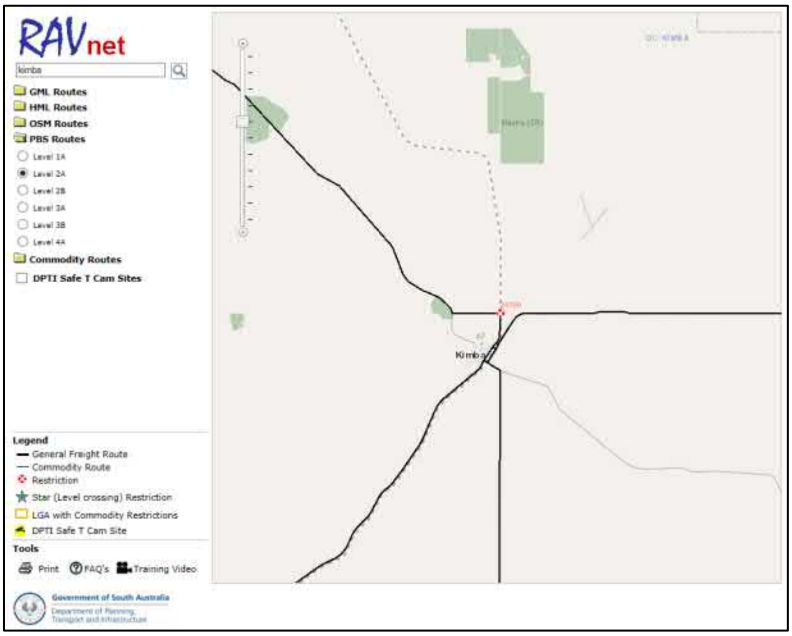
The Performance Based Standards (PBS) scheme provides the operating environment for the vehicles that fit within the specified PBS categories. In turn they provide limits and restrictions for the categories of vehicles on the road network as a way of maintaining safety, vehicle productivity and infrastructure quality standards. The performance levels are classified according the vehicle length as shown in Table 46 and RAVnet, accessed via the DPTI website (2016a), identifies the approved routes for each class.

Figure 44 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 46 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 44 Approved restricted access vehicle routes approved under PBS Level 2A – 26m B-double (Department of Planning, Transport and Infrastructure, 2018)



4.1.2.1.2 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 suitable for carrying heavy loads during the winter months as a result of rainfall. The Napandee site is bounded to the south by Tola Road and to the west by Larwood Road; refer to Figure 45 and Figure 46 below.

Figure 45 Tola Road

Figure 46 Larwood Road

4.1.2.1.3 Townships

Kimba

Kimba is located 16 km southwest of the site with a population of approximately 636. Eyre Highway runs through the middle of the town meaning the 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

4.1.2.1.4 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.

4.1.2.1.5 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 likely 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 has 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 Napandee site is located approximately 370 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.

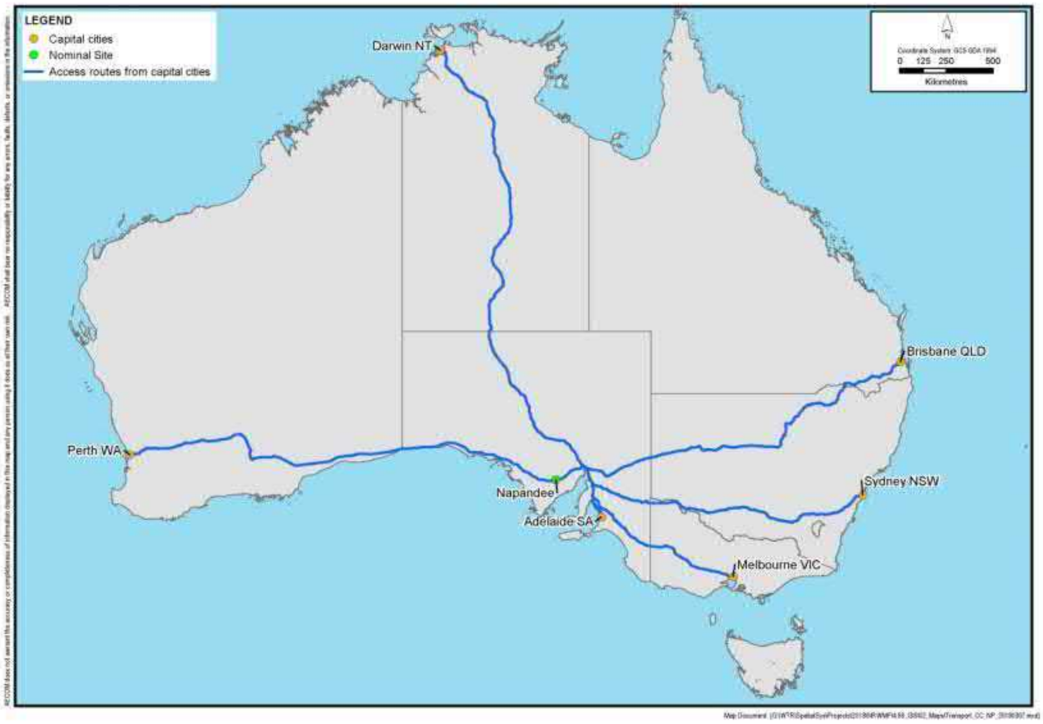
Lucas Heights, NSW

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 Napandee site is located approximately 1710 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 47.

Figure 47 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 47 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 possible that a temporary batching plant would 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 sourced 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 suitable 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 48 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 49 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 49, 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 48 TN81 Container being transported (Department of Industry, Innovation and Science, 2016)

Further investigations into the type of vehicle required and suitable transport routes will be performed as part of the Stage 2 works. As shown in Figure 48, 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 Napandee. This is mainly due to there being no approved B-double routes that do not run through Port Augusta between Woomera and Napandee, and Olympic Dam Highway terminating north of Woomera at Olympic Dam.

Figure 49 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 50 Access routes from Lucas Heights

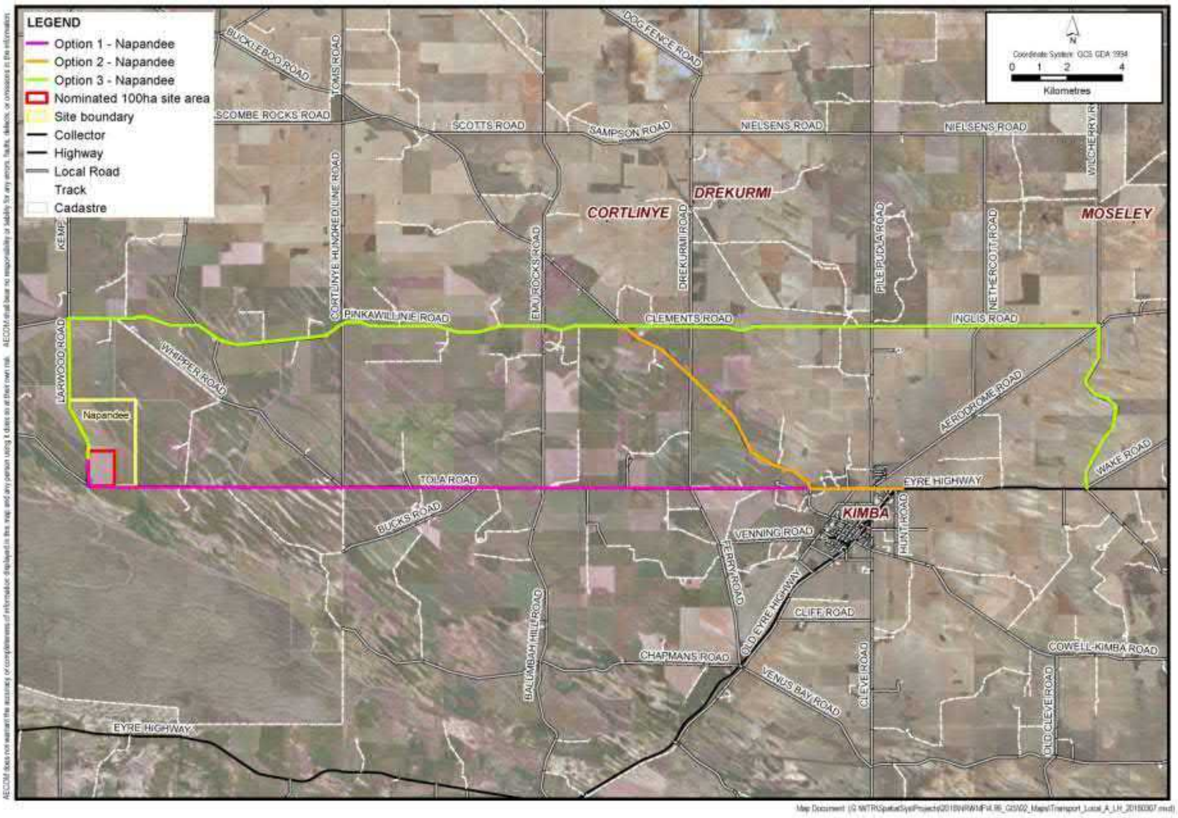
Further investigations will need to consider the local road network through key towns and cities along this route to determine if there are approved heavy vehicle routes that will allow shipments to bypass these towns. Future investigations will further narrow down this route to minimise the number of 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 Napandee site. These options are described below and shown in Figure 51. It should be noted that this not an exhaustive list and additional options may be considered in future investigations.

- Option 1: Tola Road
- Option 2: Buckleboo Road / Pinkawillinie Road
- Option 3: Wilcherry Road / Clements Road / Pinkawillinie Road

Figure 51 Local access routes



As can be seen in Figure 51 there is not a substantial difference in length for each of the proposed 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 should the Napandee site be considered further. 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 50 below:

Table 50 Option comparison

Option	Description	Advantages	Disadvantages
Option 1	Tola Road	• Shortest route from Eyre Highway to the site (26 km)	• Waste shipments will pass close to Kimba
Option 2	Buckleboo Road / Pinkawillinie Road	• Provides an alternate access route should Tola Road be unsuitable to community concerns etc.	• Is a less 'efficient' route than Option 1 while still needing to pass close to Kimba
Option 3	Wilcherry Road / Clements Road / Pinkawillinie Road	• Allows shipments to bypass Kimba	• The longest of the proposed routes (44 km)

Additional commentary on the site's performance against the characterisation criteria is included in following sections.

4.1.2.6 Assessment Criteria 1 – Proximity to waste source locations

Given the location of the Napandee site 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 1710 km from Lucas Heights and 370 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 or 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 Napandee 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 Napandee 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 infrequent over-dimensional and over-mass vehicles necessary to transport the TN81 containers. This would result in up to 44 km of sealed roads needing to be constructed. The sealing of these roads is also recommended as it would mitigate any damage that large rainfall events may cause to an unsealed road network.

While the Eyre Peninsula railway network is isolated from the rest of Australia's railway network, if the option of using this rail 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 Napandee 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

A qualitative assessment of the site has been undertaken against the above criteria and is summarised in Table 51. 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 51 Site performance against characteristic criteria

Assessment Criteria	Criteria Satisfied	Comments
Proximity of Waste Source Locations	✓	Sites 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 any potential access road is upgraded to accommodate these 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 desktop data for the site characteristic criteria 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 recommended to be undertaken as part of the Stage 2 site characterisation works on the preferred site include:

- Detailed survey and site investigations to determine the geometry and quality of the road network;
- Refining of access routes through the National Highway Network and local road network.

4.2 Waste

During the National Radioactive Waste Management Facility (NRWMF) site characterisation desktop assessment, AECOM investigated considerations that are likely to pose constraints for the future use of the potential site at Napandee for the NRWMF. Following the desktop study, AECOM contacted 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. This report outlines the methodology and results obtained.

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 recorded the number of existing licenced waste infrastructure around the proposed Napandee site location. The major types of waste infrastructure 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 Napandee site in relation to potential waste infrastructure locations.

The built facility general arrangement obtained from the current reference design enabled the identification of typical waste streams anticipated at the NRWMF. This information was critical in assessing any potential on site and off site waste management/disposal options. Approximate

[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].

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]

4.2.1.2.2 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 NRWMF progresses*.

Construction Works Waste Types

Construction activities are anticipated to generate the following waste streams (Table 52)

Table 52 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 Generation

Radioactive wastes to be managed at the NRWMF have not been described or considered in this assessment as this waste stream will not be disposed of to an off-site facility. 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 NRWMF 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 53 shows the types of infrastructure and associated types of waste to be generated.

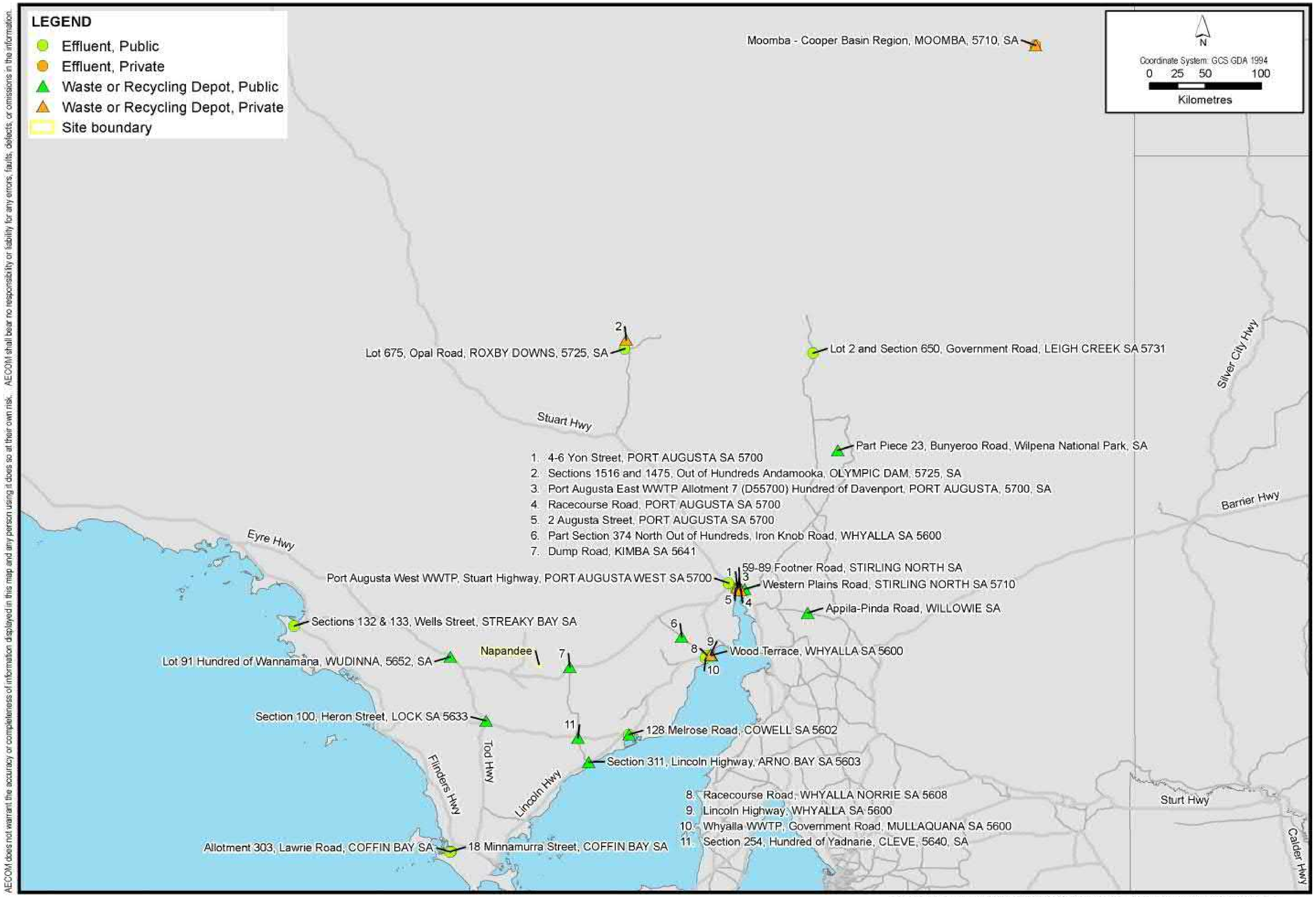
Table 53 Potential Waste Generating Areas - NRWMF

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
Stormwater Detention Basin (Drainage & Treatment)	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 52shows the different waste and recycling facilities that would potentially accept waste from the Napandee site and Table 54 shows further details of waste types, license details and approximate distances of facilities within 200 km from the potential site.

Figure 52 Identified waste, effluent and resource recovery facilities



Map Document: (G:\WTR\SpatialSys\Projects\2018\NRWMF\4.99_GIS\02_Maps\Waste_WB_20180322.mxd)

Table 54 Licensed waste infrastructure within 200km of the proposed Napandee site and types of waste accepted

License Holder	District Council of Kimba	District Council of Wudinna (Wannamana)	District Council of Cleve (Cleve)	District Council of Cleve (Arno Bay)	District Council of Elliston (Lock)	District Council of Franklin Harbour (Cowell)	City of Whyalla
Licensed Activities	Waste recycling depot (waste for resource recovery) Waste or recycling depots (solid waste for on-site disposal)	Waste or recycling depots (Solid waste for on-site disposal)	Waste recycling depot (Waste for resource recovery or transfer)	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)	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)
Site Address	Dump Road, KIMBA SA 5641	Lot 91 Hundred of Wannamana, WUDINNA, 5652, SA	Section 254, Hundred of Yadnarie, CLEVE, 5640, SA	Section 311, Lincoln Highway, ARNO BAY SA 5603	Section 100, Heron Street, LOCK SA 5633	128 Melrose Road, COWELL SA 5602	Part Section 374 North Out of Hundreds, Iron Knob Road, WHYALLA SA 5600
Friable asbestos	No	No	No	No	No	No	Yes
Non-friable asbestos	No	No	No	No	No	No	Yes
CDL - Containers	No	No	No	No	Yes	No	No
Construction and Demolition Waste (C&D) (Inert)	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Construction and Demolition Waste (C&D) (Mixed)	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Commercial and Industrial Waste (C&I) (General)	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Compostable Organic Waste	No	No	No	No	No	No	Yes
E-waste	No	Yes	No	Yes	Yes	Yes	Yes
Ferrous and non-ferrous metals	No	No	Yes	No	No	No	Yes
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	No	Yes	Yes
Listed Waste	No	No	No	No	No	No	No
Scrap Metal	Yes	Yes	No	Yes	No	Yes	No
Used Tyres	Yes	No	Yes	Yes	Yes	Yes	Yes
Waste Fuel	Yes	No	No	No	No	Yes	No
Waste Fill	Yes	Yes	No	Yes	No	Yes	Yes
Waste Oil	Yes	Yes	Yes	No	Yes	Yes	Yes
Other Parameters							
License Expiry Date	31 July 2022	31 July 2021	30 September 2020	31 July 2021	31 July 2022	31 July 2022	30 April 2021
Approximate distance to proposed site	28 km	80 km	100 km	125 km	130 km	140 km	160 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 54, there are waste streams which would potentially be generated at the Napandee 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 55 shows a summary of potential waste management options for waste generated at the Napandee site.

Table 55 Details of waste management at the proposed Napandee 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. 28km)
Construction and Demolition Waste (C&D) (Inert)	To off-site facilities	District Council of Kimba (Approx. 28km)
Construction and Demolition Waste (C&D) (Mixed)	To off-site facilities	District Council of Kimba (Approx. 28km)
E-waste	To off-site facilities	District Council of Wudinna (Wannamana) (Approx. 80km)
Friable and non-friable asbestos	To off-site facilities	City of Whyalla (Approx. 160km)
Ferrous and Non-ferrous metal	To off-site facilities	District Council of Cleve (Cleve) (Approx. 100km)
Green Waste	On-site processing (composting/worm farms)	District Council of Kimba (Approx. 28km)
Hazardous Waste	Pre-treatment prior to off-site disposal	No site within (at least) 160km
Listed Waste	Pre-treatment prior to off-site disposal	No site within (at least) 160km
Scrap metal	To off-site facilities	District Council of Kimba (Approx. 28km)
Whole Used Tyres	To off-site facilities	District Council of Kimba (Approx. 28km)
Waste Fuel	To off-site facilities	District Council of Kimba (Approx. 28km)
Waste Fill	If suitable, use on site as fill material or sent to an off-site facility	District Council of Kimba (Approx. 28km)
Waste Oil	To off-site facilities	District Council of Kimba (Approx. 28km)

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 but would need to be considered in the context of the relevant regulatory requirements.

4.2.1.3 Field Methods and Results

4.2.1.3.1 Methodology

AECOM contacted (via telephone and email) the existing licensed waste facilities within 200km of the Napandee 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 included local councils and some private waste contractors operating the facilities.

4.2.1.3.2 Results

Additional information obtained during this phase of the assessment is presented in Table 56.

Table 56 Waste Management Facilities within 200km of the Napandee site – Additional Information from councils

<table>
<tr><th>Operator/License Holder</th><th>Waste Management Facility</th><th>Approximate Distance from potential site</th><th>Types of waste accepted/not accepted</th><th>Estimated remaining life/Capacity/Notes</th></tr>
<tr><td>District Council of Kimba</td><td>Landfill and waste recycling centre</td><td>28 km</td><td>As per licence
• Accepted – C&I waste, C&D waste, MSW
• Not accepted – Listed waste, Hazardous waste, Radioactive waste, tyres</td><td>50 years (Expected)</td></tr>
<tr><td rowspan="2">District Council of Cleve</td><td>Transfer Station (Cleve)</td><td>100 km</td><td rowspan="2">• All rubbish
• No asbestos</td><td>TBC</td></tr>
<tr><td>Landfill (Arno Bay)</td><td>125 km</td><td>Closing at the end of June 2018. This will be operated as a waste transfer station</td></tr>
<tr><td>District Council of Elliston</td><td>Awaiting information from the District Council of Elliston</td><td>130 km</td><td>TBC</td><td>TBC</td></tr>
<tr><td rowspan="2">District Council of Franklin Harbour</td><td>Landfill</td><td>140 km</td><td rowspan="2">• As per license (Listed in Table 54) Asbestos waste and liquid waste not accepted.</td><td rowspan="2">20 years</td></tr>
<tr><td>Waste Transfer Station</td><td>140 km</td></tr>
<tr><td>City of Whyalla</td><td>Landfill</td><td>160 km</td><td>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</td><td>3 years. New site proposed (exact location TBC)</td></tr>
</table>

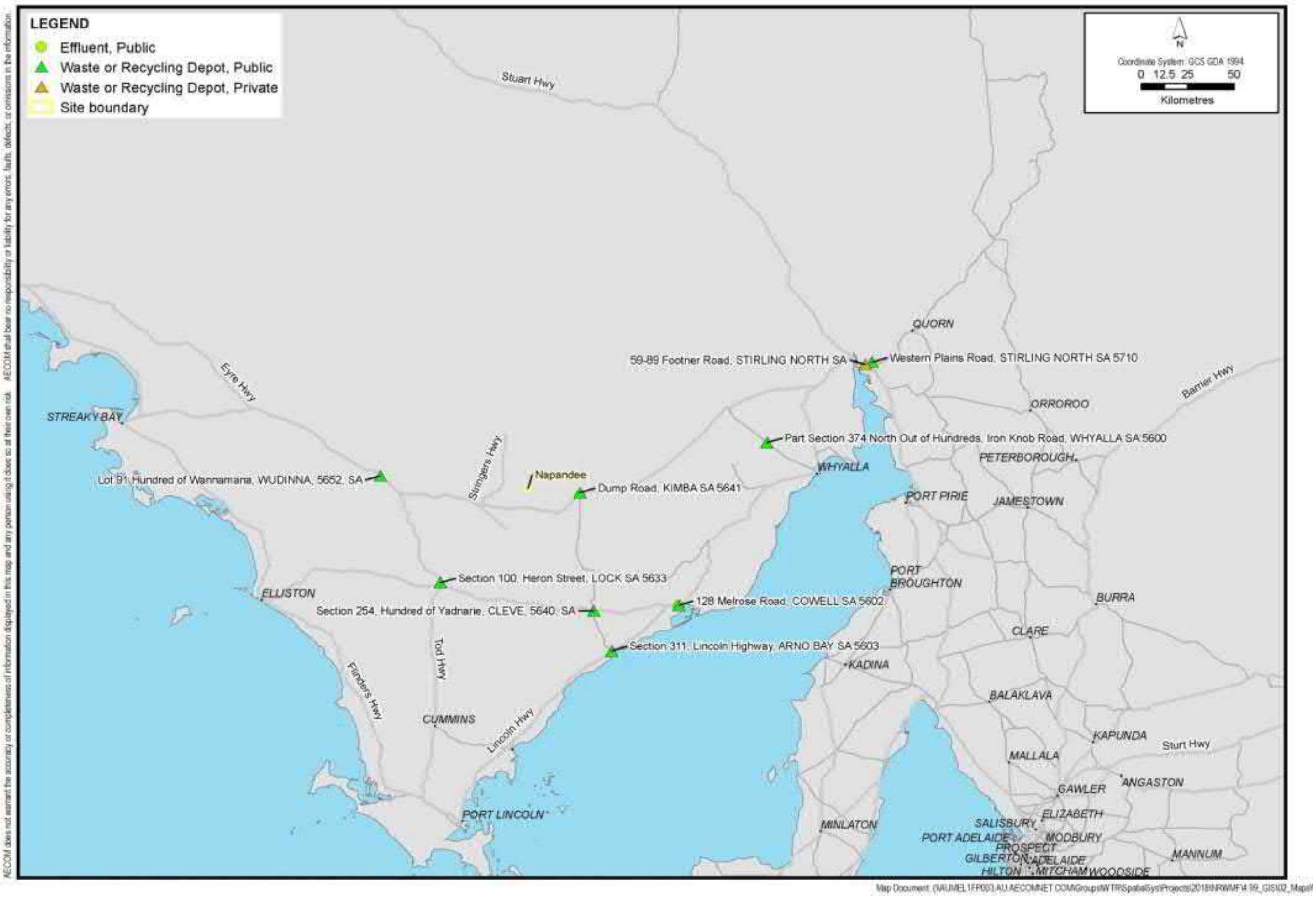
C&I – Commercial and Industrial

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 53 indicates the location of the waste management facilities within 200 km of the potential Napandee site.

Figure 53 Identified waste and resource recovery facilities within 200km of the Napandee site



The potential waste management facilities to potentially receive waste generated from the Project have been presented in Table 56. Among these, no facility has been confirmed to receive hazardous or listed waste that could potentially be generated from the Project.

The closest waste facility is a landfill and recycling centre located approximately 28 km from the proposed Napandee 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 125 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. 140 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 has a landfill which is located 160 km from the proposed Napandee 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 confirmed to remain operational for the next 20 years, and these facilities are within 150km from the proposed site.
- It should be noted that further discussions and arrangements with Councils could be warranted to affirm acceptance of waste generated from the Project at the potential facilities**.**
- There appears to be no potential waste facilities within 200km of the Napandee site that accepts 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 Napandee 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 Napandee 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 Napandee site are based on the site characteristic criteria discussed in Section 4.2.2, and may include:

- constructing a waste management facility at the Napandee 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 site characterisation assessments elsewhere in this report. As a result, reference would be made to design and mitigation measures identified in these sections.

Table 57 Possible Design Impacts of Climate Change Hazards on Site Characteristics or Enabling Infrastructure

Site Characteristic / Enabling Infrastructure Element	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 the site	• 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 (e.g. mixed solid wastes) generated by the NRWMF 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 NRWMF.
- Details on new or proposed waste facilities in the region as presented in Table 56.
- 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 NRWMF 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 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 58 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, capability and 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 Napandee 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) 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.
- Google Maps – accessed 7th March to 14th March 2018

The various sources of information that were accessed were assumed to be correct at the time and have been cross referenced to verify their authenticity where possible.

4.3.2 Assessment Against Criteria

4.3.2.1 Utility/Service Assessment

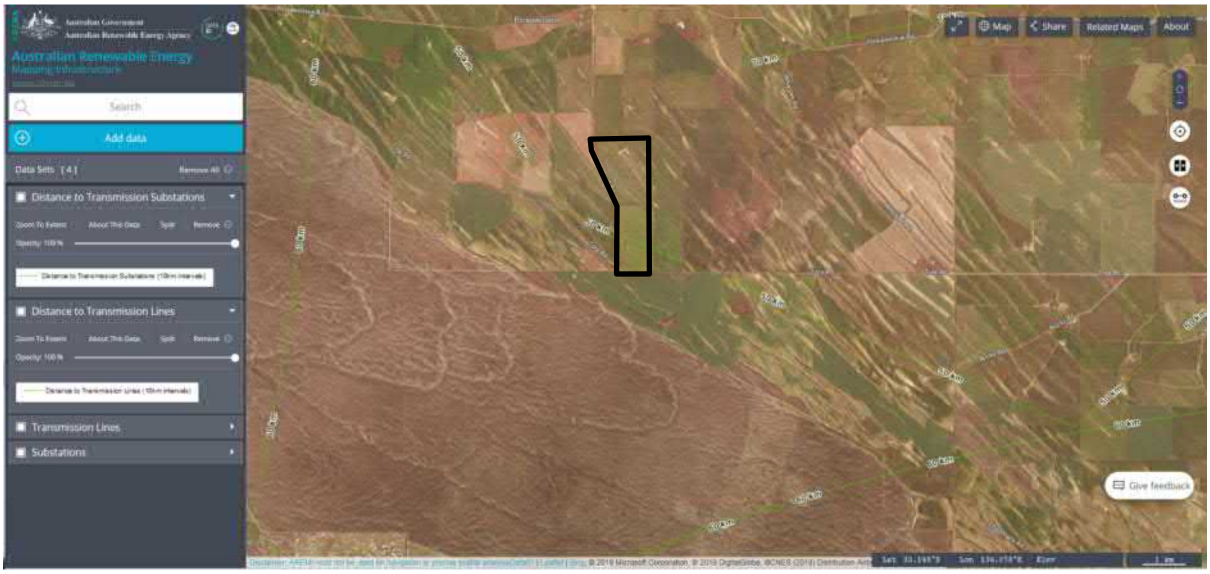
An assessment was undertaken for each of the utilities/services listed below by reviewing the data sources listed in Section 4.3.1.2. The following describes the infrastructure which is assessed to be available within a distance to the site that is deemed feasible for connection.

4.3.2.1.1 Power

<u>Assessment Criterion 1 Proximity to site</u>

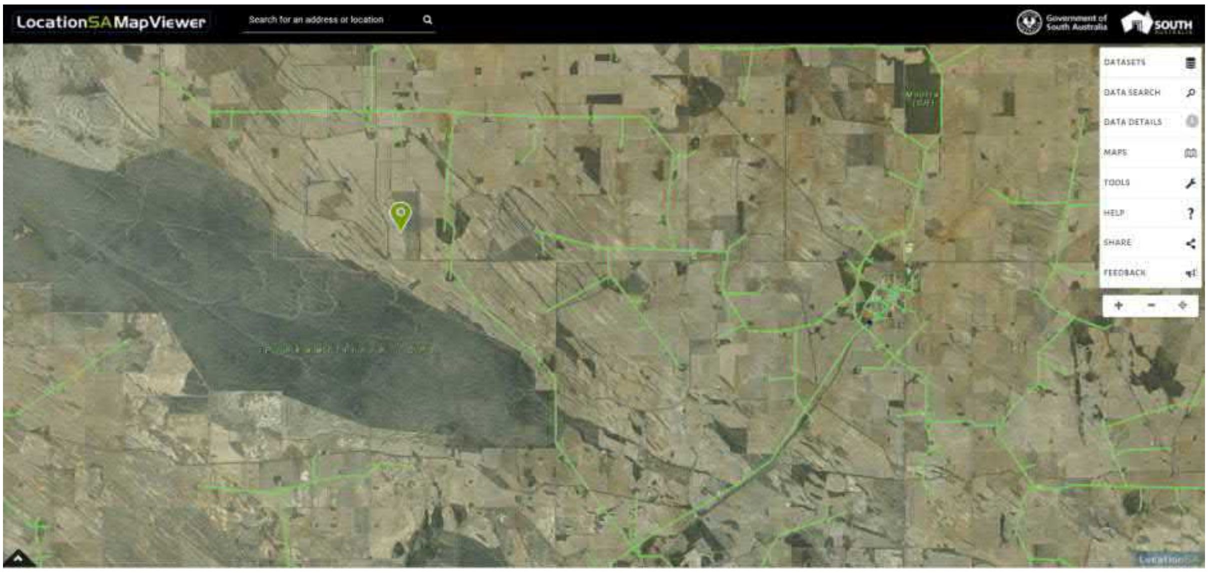
The Napandee site is approximately 65km from the closest transmission substation (Yadnarie or Wudinna) and approximately 50km from any transmission line (132kV Yadnarie to Wudinna). This can be seen in the image below from AREMI showing in green both the distances from the 132kV transmission line and the transmission substation.

Figure 54 AREMI – Site Map



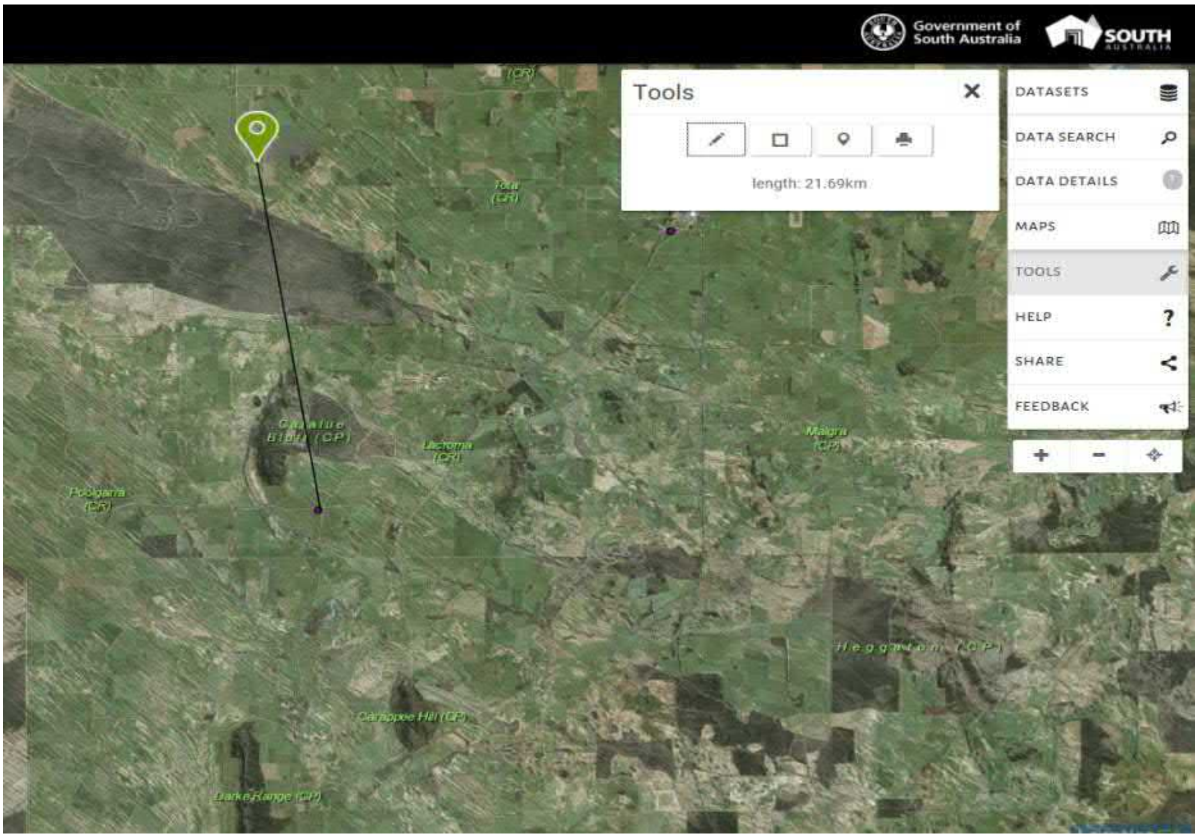
Most of the region surrounding the Napandee site is serviced via a single phase network, shown in green below. A single phase network is not suitable for connection of the NRWMF.

Figure 55 Location SA MapViewer screenshot showing local power network



The closest substation to the Napandee site is to the Caralue Substation, which is approximately 22km from the proposed site. The Caralue Substation operates at 66/11kV.

Figure 56 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 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 on the 11kV side if full load was required from the grid without supporting the augmentation of the network in the area.

Based on this constraint, another connection option is to connect on the 66kV side. The 66kV line between Darke Peak and Caralue has a rating of 10.3 MVA, with 2MVA being forecast for use of the next five years. This 66kV Darke Peak to Caralue line would have capacity for the anticipated load of the NRWMF.

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 Caralue 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

Assessment Criterion 1 – Proximity of water supply infrastructure to site

A 150mm diameter potable water main is located to the East of the site and is approximately 2.6km from the site property boundary. The water main is an Asbestos Cement (AC) pipe and was laid in 1974. Figure 57 below indicates the location the potable water main in relation to the site property boundary. Due to the age of the water main and material type the next stage of investigation would require that the water supply reliability by burst history and pipe integrity be established.

Characteristic Criteria 2 - Nature of service, capacity and constraints

Future construction and operational water supply needs are yet to be defined by the facility requirements. 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 150mm diameter water main for construction purposes while a permanent connection is made to the 375mm diameter main in Kimba. This would 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 of the concept and agreed with SA Water and the requirement for any additional pumping mains would also be discussed at this time.

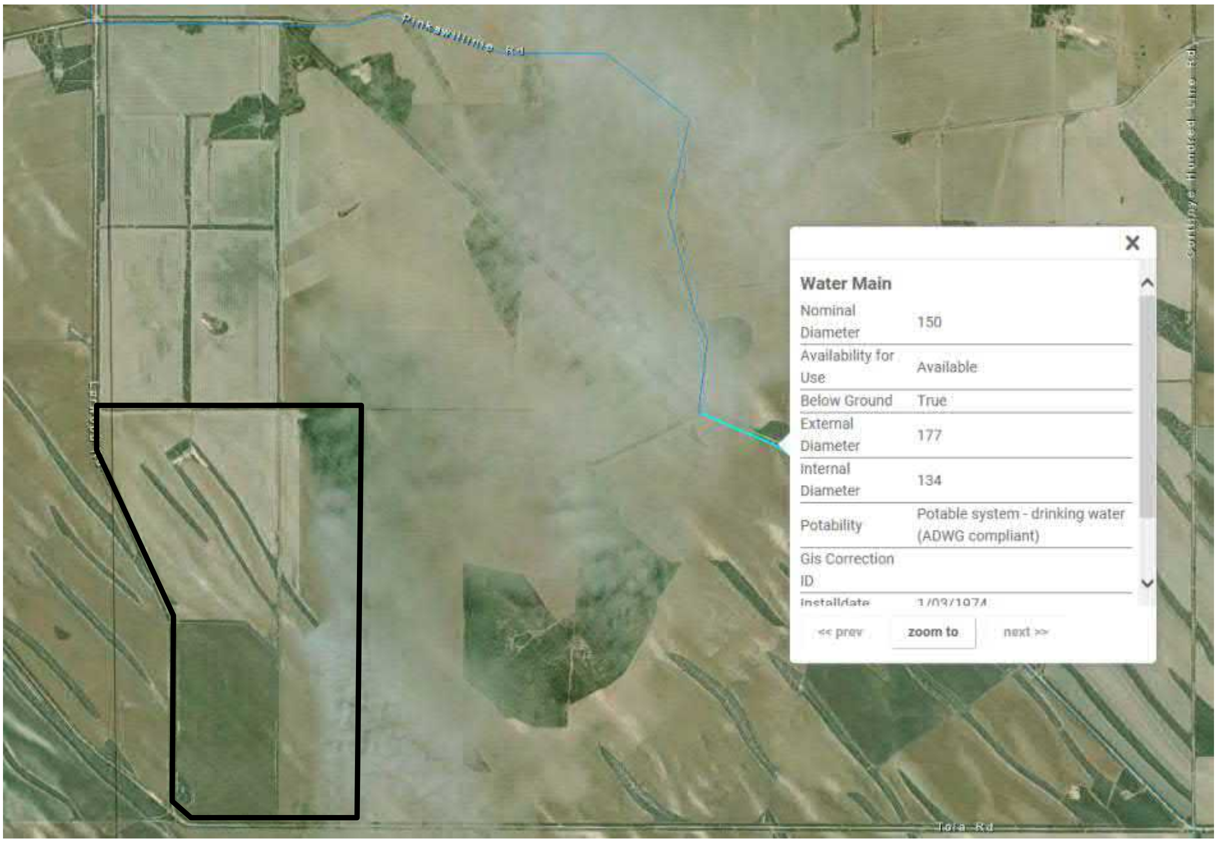
The water main would require booster pumping stations along the route due to the distance of the connection. Prior to entering site the water main will require to be connected to a backflow prevention system. The internal network should consider stormwater and rainwater collection reuse.

The SA Water potable water supply line is expected 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 potentially be utilised as an alternate supply of water (in non-potable form) but would require further detailed hydrogeological investigations to assess feasibility. 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.

Figure 57 Location SA MapViewer screenshot showing the site location in relation to the nearest watermain



4.3.2.1.3 Wastewater

Assessment Criterion 1 – Proximity of wastewater infrastructure to site

There is no wastewater infrastructure within 20km of the site location. The nearest facilities would be in the town of Kimba which is located 21km directly east of the site. Due to the distance between the site and Kimba no further investigation into connecting into the town's wastewater infrastructure was undertaken. 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.

Assessment Criterion 2 - Nature of service, capacity and constraints

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 if 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 Criteria 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 2km from the site. This connection would be inadequate for the requirements of the proposed NRWMF.

Assessment Criteria 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 Napandee 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 could be achieved and therefore provide data connection derives 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 21km to the East 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, etc.

Assessment Criterion 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 implementing design mitigations

Table 59 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 59 Existing Site Utility Assessment (prior to implementing any mitigation measures)

Service / Utility	Criteria 1 - Proximity	Criteria 2 - Capacity	Comments
Power	×	×	The site is approximately 65km from the closest transmission substation and approximately 50km from any transmission line.
Water Supply Main	×	×	150mm diameter potable water main is approximately 2.6 km east from the site property boundary. Booster pumping stations will be required along the route due to the distance from the connection.
Wastewater	×	×	There is no wastewater infrastructure within 20 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 detail the potential design issues with the various services/utilities and the potential mitigation measures which could be deployed to overcome the various issues. The mitigation measures are based on the data available at the time of writing and other options may require further investigated during the concept design stage of the project.

4.3.3.1 Power

The Napandee 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 for an 11kV connection. Connection at the 66kV line could be considered, however the costs associated with 66kV lines would need further investigation.

Supplementing the load with generation on site (e.g. renewables and/or batteries) should be considered for reducing the load as well as increasing stability in the region. 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 site is located approximately 2.6km to the West of an existing SA Water 150mm diameter water main and approximately 23km to the West of a 375mm diameter water main in the town of Kimba. Therefore connection to the existing water supply network is available to the site.

The proposal for the water supply of the site would be to connect to the 150mm diameter water main for construction purposes while a permanent connection is made to the 375mm diameter main in Kimba. 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 that 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. Utilising the Reference Design supplied by ANSTO it can be established that there will likely be two separate waste networks on site. The wastewater outputs should 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 Napandee site installation of additional equipment will be required. Through investigation of Government websites and data there are two suitable options for providing the communications requirement which are set out in Section 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 (22km to the East 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 derives 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 60 below indicates whether the site satisfies the characterization criteria after the proposed design mitigation measures. After the construction of suitable enabling utility infrastructure, both the proximity and capacity criteria will be satisfied.

Table 60 Proposed Site Utility Characteristic Criteria upon implementation of design 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 150 mm main for construction while a permanent connection is made to the existing 375 mm diameter main in Kimba.
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 Napandee. 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.

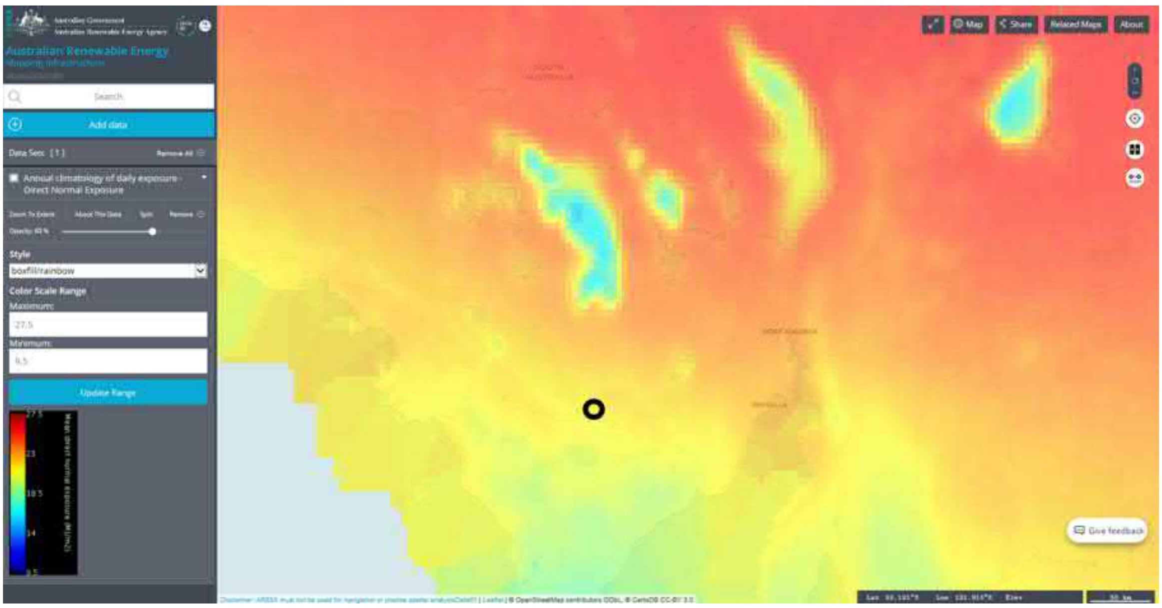
Solar PV technology has the added benefit of modularisation. Different sized solar farms can be designed and built to suit available land area. The modularity of the system also reduces down-time of the system, as some components can be repaired or replaced without affecting the other parts of the system (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.

Napandee resource

South Australia is known for having a high solar resource. In Figure 58 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 Napandee site (shown circled in black) is not in an area with the highest exposure (~20 MJ/m2/year), it still has typically more exposure than most of the state of Victoria.

Figure 58 Solar Resource in Napandee 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 Napandee Site) average over 30^{o}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 61 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 Napandee

Solar PV technology is relatively low cost compared to other forms of renewable generation and has the benefit of scalability. The Napandee 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.

Napandee 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 58 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 Napandee site (shown circled in black), is in an area of moderate/high solar exposure as shown in Figure 58.

Table 62 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 Napandee

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.

Napandee resource

The area for Napandee shows a moderate wind resource area as outlined Figure 59 (Napandee is the black circle below). Napandee is in a region of yellow colour (moderate). This resource is typical in the region surrounding Napandee. 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 taken into account when considering annual output.

Figure 59 Wind resource at Napandee sites [1]

Wind metrics

Table 63 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 Napandee

Wind turbines are a well-established technology and comparatively low cost for renewable technologies. The resource in the direct vicinity of the Napandee 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.

[29] Time to market includes development and design, approval, construction, commissioning

4.4.1.2.4 Geothermal

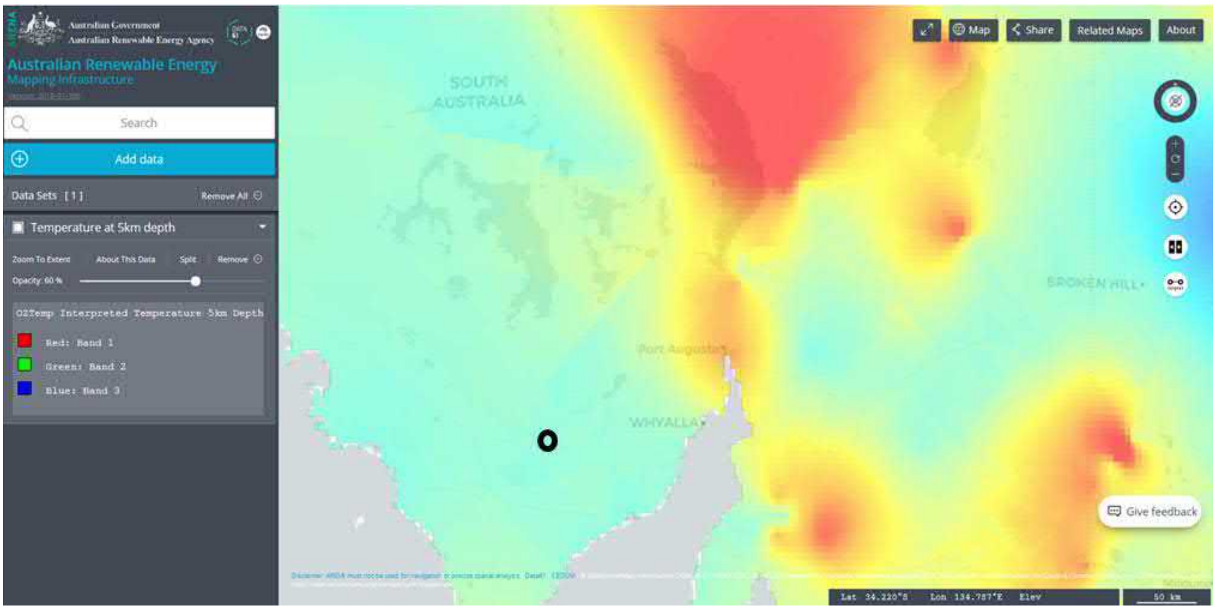
Geothermal power production is based on using the heat of the earth as an energy source. Geothermal energy can be drawn from the hot water circulating among rocks below the earth's surface, or by pumping cold water into the hot rocks and returning the heated water to the surface. This can drive steam 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].

Napandee Resource

The area for Napandee shows a low/medium geothermal resource area as outlined in Figure 60 below (the black circle shows the Napandee site). The Napandee 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]

Figure 60 Geothermal resource at Napandee 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 Napandee

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.

Napandee Resource

The area for Napandee 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 Napandee site.

Hydro (pumped hydro – storage) Metrics

Table 64 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 (LCOE)	$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

[30] Time to market includes development and design, approval, construction, commissioning

Assessment of Hydro for Napandee

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 yielded 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. Also, it 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.
- **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 technologies assessed above are summarised in Table 65 below.

Table 65 Renewable technologies for Napandee

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 Napandee sites (network 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 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 Napandee that would likely require mitigation or management should the proposed NRWMF be further considered at the site. These include bushfire within in the landscape, local catchment flooding along an interdune swale in the south-western corner of the site, and wind erosion or mass movement of sands from longitudinal dunes.

Groundwater in the water table aquifer is present at depths exceeding 20 m from the surface across the site which would provide good separation between the base of any proposed facility 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 Napandee 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 Napandee 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 Napandee study area and surrounds. Linear corridors of vegetation in good condition present along roadways, with only degraded vegetation present elsewhere within the study area. 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 facility. A hospital is located within Kimba, approximately 20 km drive east from the site. An aerodrome operated by the District Council of Kimba is located approximately 10 km east of Kimba or 30 km east of the site, from which an air ambulance (Royal Flying Doctor Service) can provide medical evacuation to a major hospital in Adelaide.

The site characteristic hazards and constraints of enabling infrastructure can often be mitigated by the facility 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 facility 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 facility on the preferred site. The safety case will consider not only site characteristics with potential safety impacts, but also the facility 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 66 Site Assessment Summary

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 Napandee site has no threatened ecological communities and only around 7% of the area is vegetated, with degraded vegetation within cropped and grazed paddocks and some good condition linear corridors along roadways. 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. If vegetation clearance is required for development then linear native vegetation corridors linking areas of remnant vegetation shall preferably be maintained, and further field surveys will be required to determine the likelihood and significance of impacts on 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/ Reserves, Recreational Parks, Wilderness Protected Areas), native vegetation Heritage Agreements, Aboriginal or State and Local heritage sites on or adjacent the site	The Napandee site has no Aboriginal heritage sites or State and Local Heritage sites within the Site. Pinkawillinie Conservation Park is 2 km from the site.

Radiation, background and risks	Establish a baseline for future environmental monitoring (to inform possible licence application) 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 Safety Requirements NS-R-3 (Rev.1) Site Evaluations for Nuclear Installations.	Background radiation levels within the ARPANSA Action Levels for workplaces Background radiation levels are not sufficiently elevated to impact on the effectiveness of 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. AS1170.2:2011 Structural design Wind actions.	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, and more frequent 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 should it proceed at this site.
Bushfire Risks	Characterise bushfire threat from factors including vegetation hazard at local and landscape level, slopes, bushfire weather frequency/ severity and assess likelihood and nature of bushfire impact (ignition potential, development, approach).	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 (large patches of grassland and Mallee Mulga vegetation are sufficiently distant and small vegetation patches on and around the site, are unlikely to sustain a fully developed 100m wide fire front) if setbacks/ areas of cleared vegetation are established around assets commensurate with their vulnerability to bushfire attack and provision of firefighting infrastructure.

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 measures	IAEA SSG-18 Meteorological and Hydrological Hazards in Site Evaluation for Nuclear Installations. Ball J, Babister M, Nathan R, Weeks W, Weinmann E, Retallick M, Testoni I, (Editors), 2016, Australian Rainfall and Runoff (ARR): A Guide to Flood Estimation, Commonwealth of Australia	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 however drainage lines exist in the vicinity of the site and local drainage paths exist through the site. A larger local catchment (upstream approximately 150 km2) drains past the south-western corner of the site. There is no recent anecdotal evidence of waterlogging or runoff from localised or upstream catchments. Hydraulic an hydrological modelling would be required to estimate flood risks for a range of events of varying magnitude. 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 Napandee site. If these tenements proceed to production, the associated activities may have the potential to impact the NRWMF.

Geology, hydrogeology & geochemistry	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 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 >20 m below ground surface and such would not impact on NRWMF buildings or their foundations, and is of no realistic beneficial use due to its high salinity and low yield. The relative high vertical difference over a short distance suggests there is poor hydraulic connection between the watertable and deeper aquifers. The subsurface clays and kaolin within the lithology exhibit chemical attenuation properties. These clays however, if exposed or use as fill, may have due to their moderately salinity and strongly sodicity lead to surface hardening/ crusting and waterlogging, and be limiting to plant growth. Geohazards are unlikely present at the site, with the exception of soils of low expansive potential at surface and medium depth (3 metres) which can be mitigated in design standards (AS2870). These findings are based on current data but further investigations would be 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 Napandee 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 locally or in upwind areas. The dunes overlie occasional shallow silcrete, and deeper kaolin and weathered bedrock. The potential for slope and mass movement processes need to be considered during times of high rainfall or seismic activity.
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, near-surface faults that could cause folding or other deformation, 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 Napandee 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)

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 & Vehicle Certification Rules, National Heavy Vehicle Regulator, 2017.	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 site is well served by major road networks with several unsealed local site access options which would require upgrades and sealing up to 44 kilometres to accommodate frequent B-double movements and infrequency ODOM movements. There does not appear to be the need to acquire land to accommodate new road reserves nor likely be the need for roadside vegetation clearance.
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 (23 km west of 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.

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, stormwater)	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. The site is approximately 65 km from the closest transmission substation and 50 km from any transmission line. Connection can be made with booster pumping stations to a 150mm diameter potable water main, 2.6 km east from the site property boundary, for construction of the facility while a permanent connection is made to the existing 375 mm diameter main much further away in Kimba. 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 in place).
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 Napandee 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

6.0

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6.0 References

6.1 Surface Environment

6.1.1 Flora, Fauna and Conservation

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Appendix A

Flora, Fauna and Conservation

Australian Government

Department of the Environment and Energy

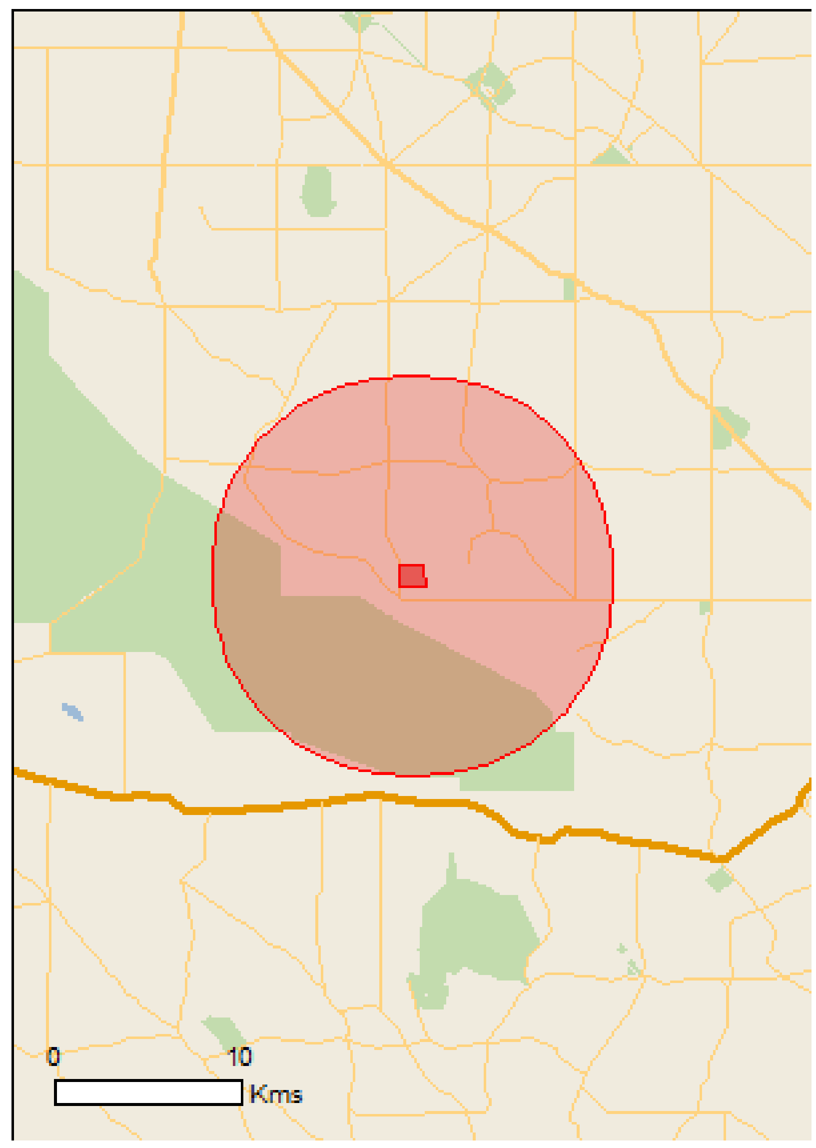
EPBC Act Protected Matters Report

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.

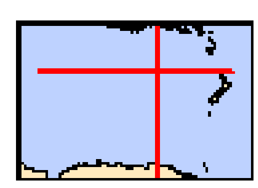
Information is available about Environment Assessments and the EPBC Act including significance guidelines, forms and application process details.

Report created: 15/02/18 17:04:01



Coordinates

Buffer: 10.0Km



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:	10
Listed Migratory Species:	9

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:	13
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:	1
Regional Forest Agreements:	None
Invasive Species:	15
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		
Calidris ferruginea		
Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
Leipoa ocellata		
Malleefowl [934]	Vulnerable	Species or species habitat likely 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		
Caladenia tensa		
Greencomb Spider-orchid, Rigid Spider-orchid [24390]	Endangered	Species or species habitat likely to occur within area
Hibbertia crispula		
Ooldea Guinea-flower [15222]	Vulnerable	Species or species habitat may occur within area
Pterostylis mirabilis		
Nodding Rufoushood [86228]	Vulnerable	Species or species habitat likely 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		
Apus pacificus		
Fork-tailed Swift [678]		Species or species habitat likely to occur within area

Name	Threatened	Type of Presence
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
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 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

Name	Threatened	Type of Presence
		area
Charadrius veredus Oriental Plover, Oriental Dotterel [882]		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
Pinkawillinie	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
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		

Name	Status	Type of Presence
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 may 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

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

-33.110431 136.169587,-33.110431 136.181217,-33.119381 136.181432,-33.119345 136.169759,-33.110431 136.169587,-33.110431 136.169587,-33.110431 136.169587

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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Napandee Flora Data

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	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)	2
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)	4
<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

Napandee Flora Data

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)				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

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)	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)	4
<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

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	Nap 2		Date:	17-Apr-18		Zone	
	Datum	GDA	E:	609043	N:	6334436	Ph dir'n:	

d=dominant, v=voucher, p=planted, R=regen (perennials).

Native spp.	Ht (cm)	Cover (%)				**Weed spp.**	Ht (cm)	Cover (%)
Acacia merrallii	50	0.1						
Acacia ancistrophylla var. lissophylla	50	1						
Alyxia buxifolia	120	1						
Atriplex stipitata	60	0.5						
Dianella revoluta	30	0.1						
Enchylaena tomentosa var. tomentosa	30	0.5						
Eremophila scoparia	200	0.1						
Eucalyptus leptophylla	300	0.1						
Eucalyptus oleosa	600	20						
Eucalyptus calycogona subsp calycogona	350	0.1						
Exocarpus aphyllus	100	0.2						
Gramineae sp.	40	0.5						
Grevillea huegelii	30	0.01						
Lomandra leucocephala subsp. robusta	30	0.1						
Maireana erioclada	20	0.5						
Maireana pyramidata								
Santalum acuminatum	200	0.5						
Zygophyllum glaucum	30	0.1						

Napandee Flora Data

Native Plant Life form	
All strata of vegetation heavily impacted and native vegetation represented by only scattered plants	X
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	

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)				0.5
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

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)	2
<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	Nap 3		Date:	17-Apr-18		Zone	
	Datum	GDA	E:	609872	N:	6335684	Ph dir'n:	

d=dominant, v=voucher, p=planted, R=regen (perennials).

Native spp.	Ht (cm)	Cover (%)				Weed spp.	Ht (cm)	Cover (%)
Melaleuca uncinata	300	3				Citrullus colocynthis	pr	0.01
Enneapogon avenaceus	5	0.1						
Eucalyptus socialis subsp. viridans	800	5						

Napandee Flora Data

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	X
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	

"Treeless in its natural state (refer to manual)? Y/N	Y

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

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	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)	4
<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	
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	Nap 4		Date:	17-Apr-18		Zone	
	Datum	GDA	E:	608913	N:	6335468	Ph dir'n:	

d=dominant, v=voucher, p=planted, R=regen (perennials).								
Native spp.						**Weed spp.**		
	Ht (cm)	Cover (%)					Ht (cm)	Cover (%)
Melaleuca uncinata	300	14				Citrullus colocynthis*		
Enneapogon avenaceus	5	0.1						
Eucalyptus socialis subsp. viridans	400	2						
Lomandra leucocephala subsp. robusta	20	0.1						
Maireana erioclada	25	0.1						
Minuria cunninghamii								
Rhagodia preissii subsp. preissii								
Salsola australis	30	0.1						
Santalum acuminatum	250	0.5						
Triodia sp.	30	0.2						

Appendix B

Climatic Conditions and Climate Change

Appendix B Climatic Conditions and Climate Change

Climate Data: Kimba Weather Station and SSW Flatlands Cluster 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

<table>
<tr><th>Variable</th><th>Annual historic trend</th><th>Climate change projections</th><th colspan="2">RCP 8.5
2030 scenario</th><th colspan="2">RCP 4.5
2090 Scenario</th><th colspan="2">RCP 8.5
2090 scenario</th></tr>
<tr><th colspan="3">Weather station: Kimba</th><th>Most likely – 50th percentile (10th- 90th percentile)</th><th>Degree of confidence</th><th>Most likely – 50th percentile (10th- 90th percentile)</th><th>Degree of confidence</th><th>Most likely – 50th percentile (10th- 90th percentile)</th><th>Degree of confidence</th></tr>
<tr><td>Mean 9 am relative humidity (%) [1]</td><td>55</td><td>Percentage change</td><td rowspan="2">-0.5 (-1.1 to 0.3)</td><td rowspan="2">High model agreement on little change</td><td rowspan="2">-0.8 (-2 to -0.1)</td><td rowspan="2">Medium model agreement on little change</td><td rowspan="2">-1.6 (-3.2 to -0.3)</td><td rowspan="2">High model agreement on substantial decrease</td></tr>
<tr><td>Mean 3 pm relative humidity (%) [1]</td><td>30</td><td>Percentage change</td></tr>
<tr><td>Mean 9 am wind speed (km/h) [1]</td><td>20.3</td><td>Percentage change</td><td rowspan="2">-0.5 (-3.1 to +0.7)</td><td rowspan="2">High model agreement on little change</td><td rowspan="2">-1.4 (-3.8 to +0.1)</td><td rowspan="2">Medium model agreement on substantial decrease</td><td rowspan="2">-1.8 (-4.4 to 0)</td><td rowspan="2">Medium model agreement on substantial decrease</td></tr>
<tr><td>Mean 3 pm wind speed (km/h) [1]</td><td>12.8</td><td>Percentage change</td></tr>
<tr><td>Solar radiation (%) [1]</td><td>N/A</td><td>Percentage change</td><td>+0.5 (-0.5 to +1.4)</td><td>Medium model agreement on little change</td><td>+1.1 (+0.1 to +2.3)</td><td>Medium model agreement on substantial increase</td><td>+1.5 (-0.1 to +3.6)</td><td>Medium model agreement on substantial increase</td></tr>
<tr><td>Soil moisture (%) [1]</td><td>N/A</td><td>Percentage change</td><td>-1.3 (-4.7 to +0)</td><td>Medium model agreement on substantial decrease</td><td>-1.8 (-5.6 to +1)</td><td>Medium model agreement on substantial decrease</td><td>-4.4 (-8.7 to -0.9)</td><td>High model agreement on substantial decrease</td></tr>
</table>

[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.

Section 2.3 Climate Data: Nonning weather station and Rangelands Cluster 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 – 50^{th} percentile (10^{th}- 90^{th} percentile)	Degree of confidence	Most likely – 50^{th} percentile (10^{th}- 90^{th} percentile)	Degree of confidence	Most likely – 50^{th} percentile (10^{th}- 90^{th} 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.					
Evapotrans-piration (%) [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, Geochemistry, Geotechnical and Soil

Appendix C Geology, Hydrogeology, Geochemistry, Soils and Geotechnical

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. **Napandee 10km radius registered well search results – WaterConnect query 06/03/18** (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.

Registered Groundwater Bores & Summary Data – 10 km Radius of Site (source WaterConnect dated 6/03/18)

Downloaded lithological and stratigraphic for 6131-105 information is provided below.

The lithological description of a brownish grey clay with abundant quartz grit, mica and fragments of highly weathered gneiss suggests that the top of the weathered surface of the consolidated bedrock as is encountered at approximately 30 m below ground surface.

The stratigraphic description indicates that the inferred basement rock was identified as being Early Proterozoic Hutchinson Group.

The limited lithological information for registered well 6131-105 supports the preliminary interpretations of the site specific seismic data; specifically:

- inferred undifferentiated Quaternary sediments to a depth of approximately 11 m bgs overlying a weathered basement to approximately 32 m bgs.
- the presence of a more indurated sandstone layer logged between approximately 3 and 10 m bgs may be the equivalent of a shallower reflector such as calcrete or alternatively the shallow

reflector may be indicative of the shallow unconfined water table which may occur at similar depths in the vicinity of the site.

It is noted however that the lithological and stratigraphic logs presented for 6131-107 located approximately 4 km east of 6131-105 provided below indicate a greater thickness of unconsolidated sediments extending from ground surface to the top of a weathered schist at approximately 60 m bgs. It is further noted that the WaterConnect stratigraphic description appears inconsistent with the lithological description.

Lithological Log for Bore 6131-105 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		Brown slightly clayey fine sand	
0.3	1.22	CLYU		Mottled red brown sandy clay with nodules of soft lime	
1.22	3.05	SDST	GRIT	Light brown medium grained friable sandstone with rounded quartz grit	
3.05	6.1	SDST		Red brown medium grained friable sandstone	
6.1	9.14	SDST		Light pink fine grained friable sandstone	
9.14	10.67	SDST	GRIT	Buff fine grained friable sandstone with abundant subangular quartz grit	
10.67	21.64	CLYU		Cream slightly gritty clay with minor quantities of mica	
21.64	29.26	CLYU		Light grey slightly gritty clay with mica and fragments of highly weathered gneiss	
29.26	32.31	CLYW	GNSS	Brownish grey clay with abundant quartz grit, mica and fragments of highly weathered gneiss	
32.31	35.36	GNSS		Grey fine grained gneiss (weathered)	
35.36	35.81	GNSS		Greyish pink dense banded gneiss	

Note:

AECOM inferred changes in broad rock type key:

Unconsolidated sediments

Weathered basement

Basement

Stratigraphic Log for Bore 6131-105 downloaded from WaterConnect 06/03/18

Stratigraphic Depth from	Stratigraphic Depth to	Stratigraphic Name
0	3.05	Unnamed GIS Unit
3.05	10.67	Unnamed GIS Unit
10.67	32.31	Unnamed GIS Unit
32.31	36	Hutchison Group

Lithological Log for Bore 6131-107 downloaded from WaterConnect 19/04/18

Lithology Depth from	Lithology Depth to	Major lithology code	Minor lithology code	Description
0	0.61	SAND		Grey slightly clayey fine sand
0.61	18.29	CLYU	GRIT	Brownish grey sandy clay with quartz grit
18.29	23.77	CLYU	GRVL	Red brown and grey sandy and gritty clay with some lateritic gravel
23.77	28.96	SAND	GRIT	Grey clayey fine sand with subangular quartz grit and gravel
28.96	31.7	CLYU	GRIT	Grey clay with abundant subangular grit and gravel
31.7	33.53	SAND	GRIT	Light brown medium-coarse grained sand and subangular grit
33.53	35.36	SAND	GRIT	Buff clayey fine sand with subangular grit
35.36	37.19	SAND	GRIT	Buff medium grained sand and subangular quartz grit and gravel
37.19	45.11	SAND	GRIT	Dark grey lignitic fine-coarse sand and grit
45.11	46.94	SAND	-	Black fine lignitic sand with mica
46.94	48.16	GRIT	GRVL	Light grey fine-coarse quartz grit and gravel partly cemented with pyrite
48.16	48.46	GRIT	GRVL	Brownish grey fine-coarse angular quartz grit and gravel
48.46	49.38	SAND	GRIT	Light grey fine-coarse sand and grit partly cemented with pyrite
49.38	52.43	GRVL	SAND	Light grey slightly clayey angular quartzitic gravel with some fine sand
52.43	54.86	GRIT	GRVL	Grey fine-coarse quartzitic grit and gravel
54.86	58.22	GRVL	-	Grey coarse subangular quartzite gravel and boulders up to 76cm long
58.22	59.13	SCHT	-	Green highly weathered mica schist with quartz veins

Stratigraphic Log for Bore 6131-107 downloaded from WaterConnect 19/04/18

Stratigraphic Depth from	Stratigraphic Depth to	Stratigraphic Name
0	18.29	Pooraka Formation - Quaternary
18.29	59.13	Poelpena Formation - Tertiary

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 Napandee site is provided below.

Natural Resource Management zones for Napandee

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

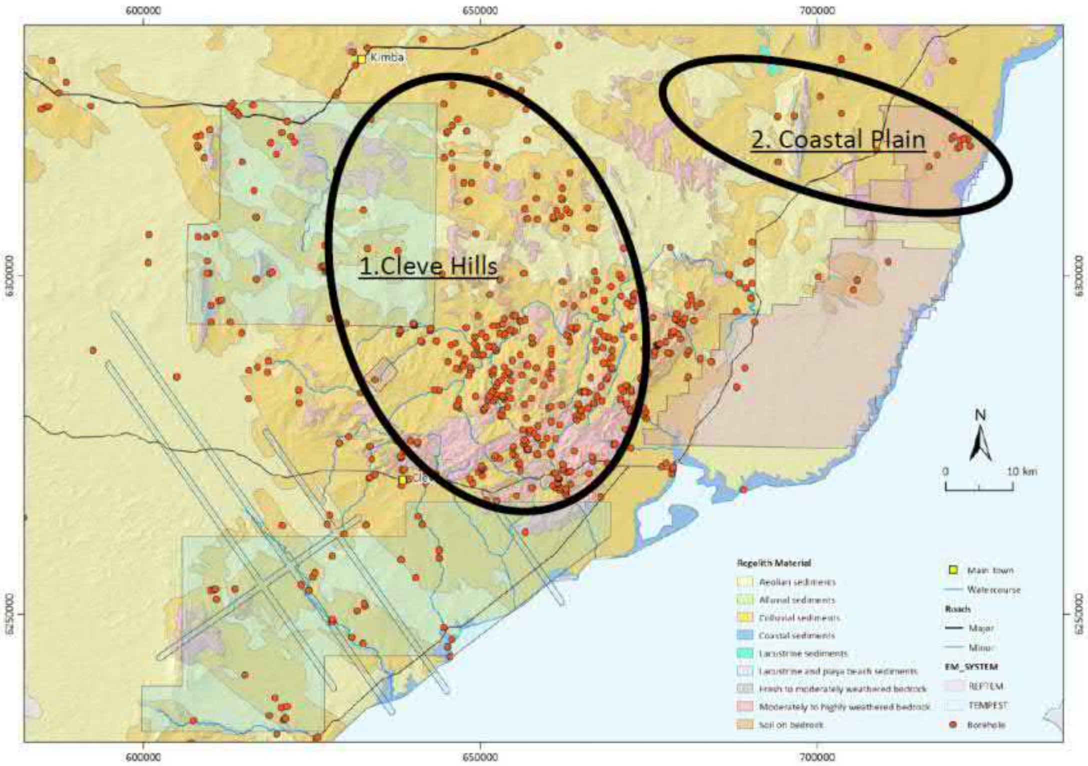
The Napandee location is situated within the Eyre Peninsula NRM (EPNRM) Region. DEWNR Tech Report 2011/16 (Berens *et al*, 2011) indicates the following:

- 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 of the Napandee 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.

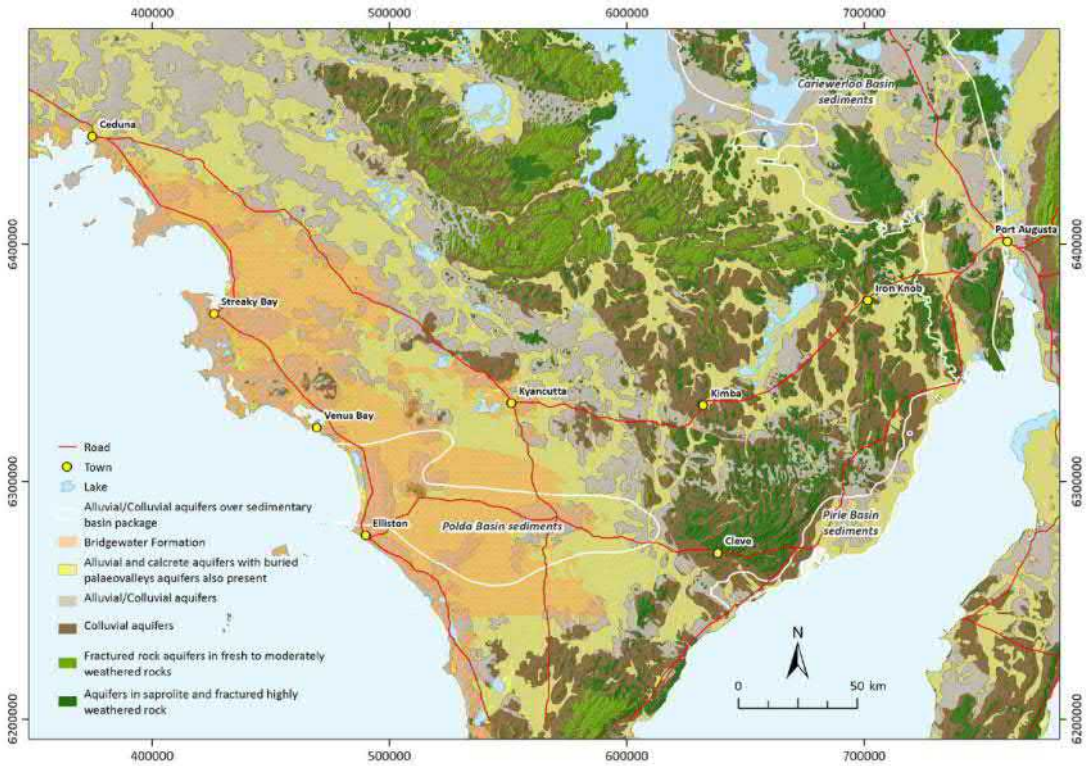
Understanding of the hydrogeological framework in northern Eyre Peninsula has been improved by completion of Goyder Institute for Water Research funded project *Facilitating Long-term Outback Water Solutions* (referred to as G-FLOWS Stage-2). The research used a combination of regional geophysical data (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 sites in the Cleve Hills and Coastal Plain areas presents the refined hydrogeological framework.

G-Flows Stage 2 case sites (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 Napandee 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 Napandee 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.
- Well 6131-102 was drilled to approximately 24 m bgs with a salinity of approximately18,700 mg/L TDS however no standing water level information was provided.
- Well 6131-110 indicates a standing water level of approximately 20 m bgs.
- Well 6131-105 provides lithological and stratigraphic information. The well was installed for industrial purposes in 1961 to a depth of 35.81 m bgs however salinity and water level information is not provided and it is listed as abandoned.
- Well 6131-107 also provides lithological and stratigraphic information. The well was installed for industrial purposes in 1961 to a depth of 59.13 m bgs with a salinity of 18,070 mg/L TDS and a water level of 17.68 m bgl. The status of this well is listed as operational with a yield of 2.53 L/s. Water cut information suggests lower yielding water bearing horizons may have been intersected at 22.37 m, 35.36 m and 48.16 m bgs (the salinity information being from a sample collected from the final water cut depth).

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 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. No available data on aquifer yield available.
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 Napandee 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.

Napandee 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
15831	6131-1		WW														
15930	6131-100		WW							ABD							
15931	6131-101		WW														
15932	6131-102		WW							UKN					18702	30500	
15935	6131-105		WW		35.81	7/02/1961			IND	ABD	7/02/1961			7/02/1961			
15940	6131-110		WW									20.12		17/07/1961			
138855	6131-525		MW		10	30/09/1981				UKN	30/09/1981						
138997	6131-653		MW		102	11/02/1985				UKN	11/02/1985						
138998	6131-654		MW		120	12/02/1985				UKN	12/02/1985						
138999	6131-655		MW		88	13/02/1985				UKN	13/02/1985						
139000	6131-656		MW		86	13/02/1985				UKN	13/02/1985						
139001	6131-657		MW		136	14/02/1985				UKN	14/02/1985						
139013	6131-669		MW		48	21/02/1985				UKN	21/02/1985						
139014	6131-670		MW		48	21/02/1985				UKN	21/02/1985						
154666	6131-727		MW		86	12/02/1985											
154667	6131-728		MW		90	13/02/1985											

Drill Hole No.	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
15831					618624	6336269	136.271	-33.1058	N	N	N	N	N	N
15930					615854	6340374	136.241	-33.069	N	N	N	N	N	N
15931					613277	6339342	136.214	-33.0786	N	N	N	N	N	N
15932					613267	6339096	136.214	-33.0808	N	Y	N	N	N	N
15935					608373	6325506	136.163	-33.2039	Y	N	N	N	N	Y
15940					612400	6325520	136.206	-33.2034	Y	N	N	N	N	N
138855					618204	6340096	136.266	-33.0713	N	N	N	N	N	N
138997					618789	6332461	136.274	-33.1401	N	N	N	N	N	N
138998					618889	6332496	136.275	-33.1398	N	N	N	N	N	N
138999					619079	6331721	136.277	-33.1467	N	N	N	N	N	N
139000					618979	6331691	136.276	-33.147	N	N	N	N	N	N
139001					617479	6334221	136.259	-33.1244	N	N	N	N	N	N
139013					616879	6329121	136.254	-33.1704	N	N	N	N	N	N
139014					617254	6328951	136.258	-33.1719	N	N	N	N	N	N
154666					618849	6332471	136.274	-33.14	N	N	N	N	N	N
154667					619169	6331761	136.278	-33.1464	N	N	N	N	N	N

DAISHSAT
GEODETIC SURVEYORS

Napandee

Geophysical Data Interpretation NRWMF Site Characterisation Project

Geophysical Data Interpretation
NRWMF Site Characterisation Project

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 Napandee.

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 Napandee site in the Kimba area of South Australia This survey was flown over two days in April, 2018 and consisted of a total of 365 line kilometres of airborne surveying at 50 metre line spacing.

This report provides an interpretation of the geophysical data collected over the Napandee 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.

2.0 Geology

2.1 Overview

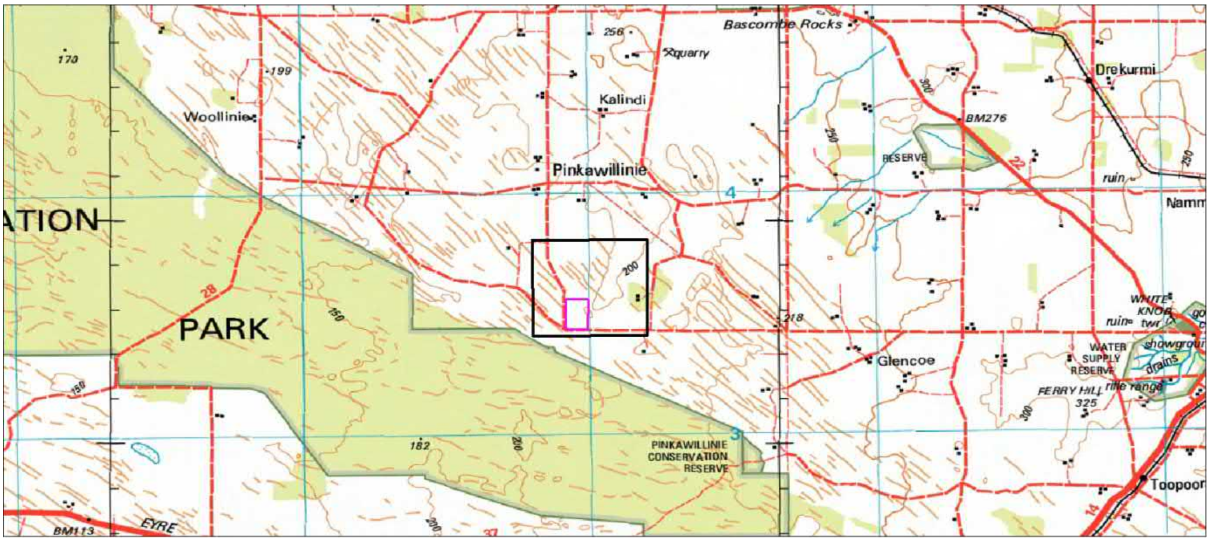


Image 1 Napandee Survey Site outline on topographic background

The area under consideration at Napandee is shown above. The main target area is approximately 1km^2 (magenta rectangle) and is located on recent surface sediments adjacent to the Pinkawillinie Conservation Park about 22 kilometres west 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.

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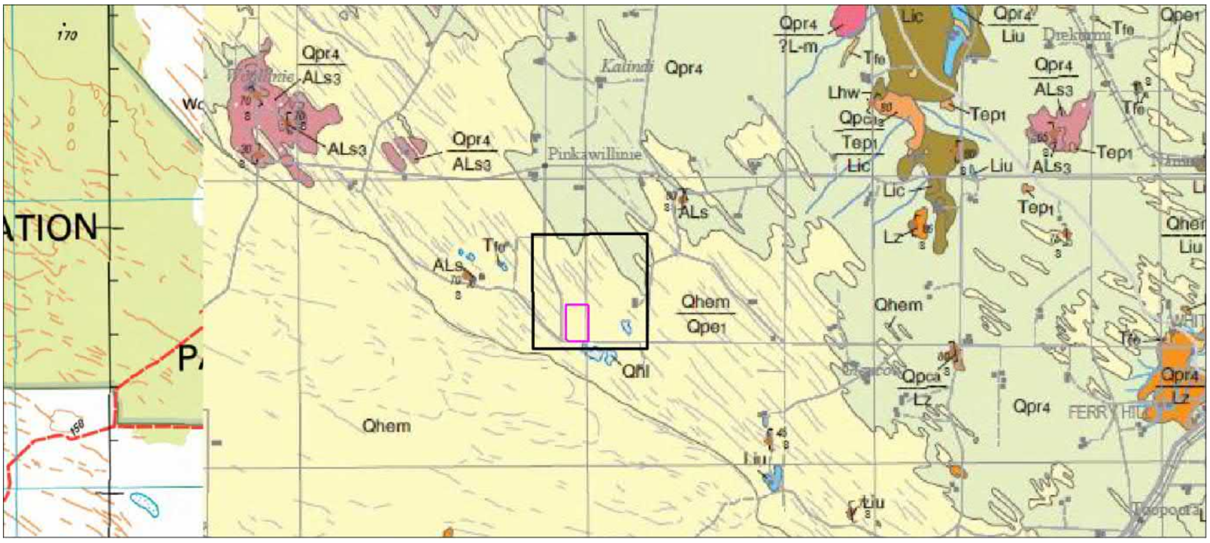


Image 2 Napandee Survey Site on the 1:250 000 geology map

2.2 Geology of the Napandee area

Surface cover is shown as Qhem, Moornaba Sand and consists of aeolian quartz sands with carbonates. These sediments form a belt of dunes over most of the survey area. There are no outcropping rocks within the study area. Metamorphic rocks (Cook Gap Schist) occur within 12 kilometres to the east.

There is nothing obvious from the surface geology to indicate rock type or structures in the geological basement rocks. The general trend of surface sand dunes is to the north west.

3.0 Gravity

3.1 Overview

The Napandee area is partly covered by a 1 kilometre station interval grid of publically available regional gravity stations collected in 2008. This data consists of accurate GPS controlled stations and because of the limited coverage, provides a poor regional perspective of gravity response over the area.

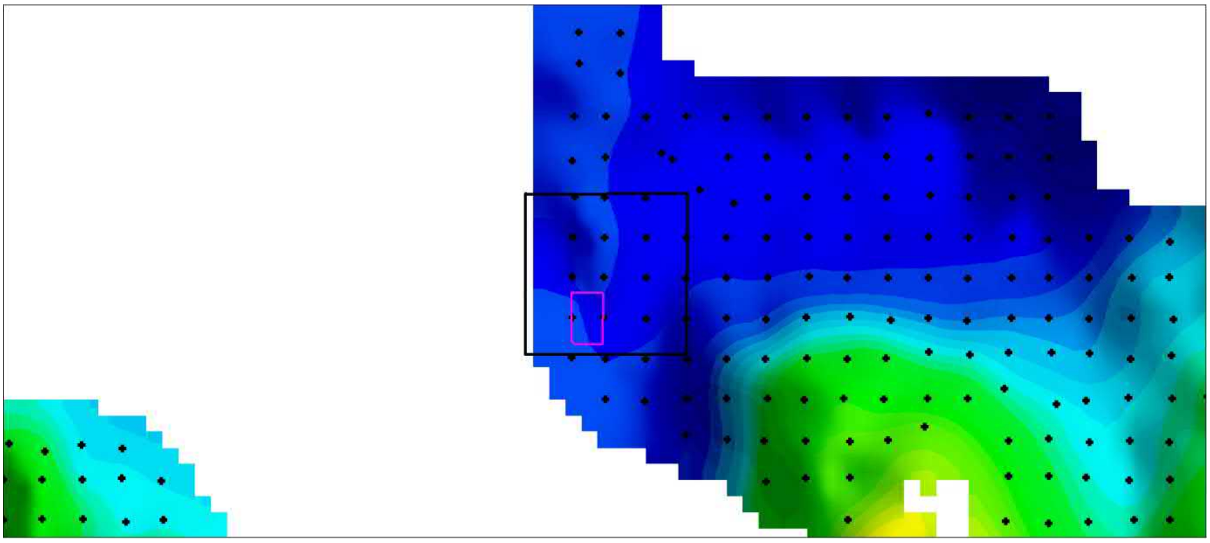


Image 3. Napandee regional gravity image with station plot.

3.2 Regional Gravity in the Napandee area

The 1 kilometre station interval does not provide any detail on short wavelength anomalous responses and is of very little use at the site target scale. Because of the limited coverage available, a regional assessment would provide very little information also. Given that the magnetic image indicates the presence of shallow intrusive rocks, detailed gravity data would be expected to provide significant additional constraints on the geological models presented 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.

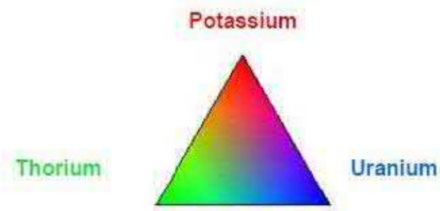
Correspondingly, rocks or surface sediments containing low concentrations of these elements will display "cool" colours, such as blue and green.

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).

Potassium = Red

Thorium = Green

Uranium = Blue



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 no rocks outcropping at the Napandee site. Relevant images have been reproduced here (Images 4 to 8) and detailed images accompany this report. The predominance of dunes in the Napandee investigation area indicates that for the most part, radiometric images are influenced by wind 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 overprinted by the north-west dune response.

The overall radiometric response changes in the east of the survey area, with generally higher response from all three elements. An approximate boundary marking this change has been drawn from the thorium image (dotted lines Image 4.)

as well as a roughly oval area enclosing a zone of marked high thorium. The centre of the oval thorium high is marked with an **X** so that the location can be identified on subsequent images. The lines marking this east-west change in response have been superimposed on all images to demonstrate the relative location of the change. Increased thorium response is to the east of the dotted lines.

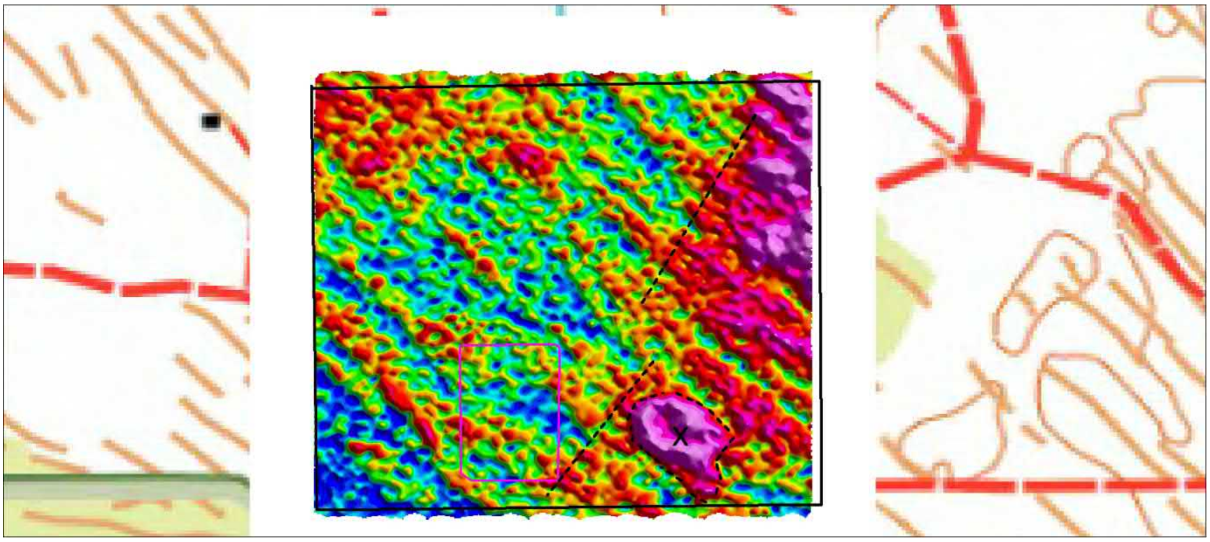


Image 4. Napandee surface thorium radiometric image.

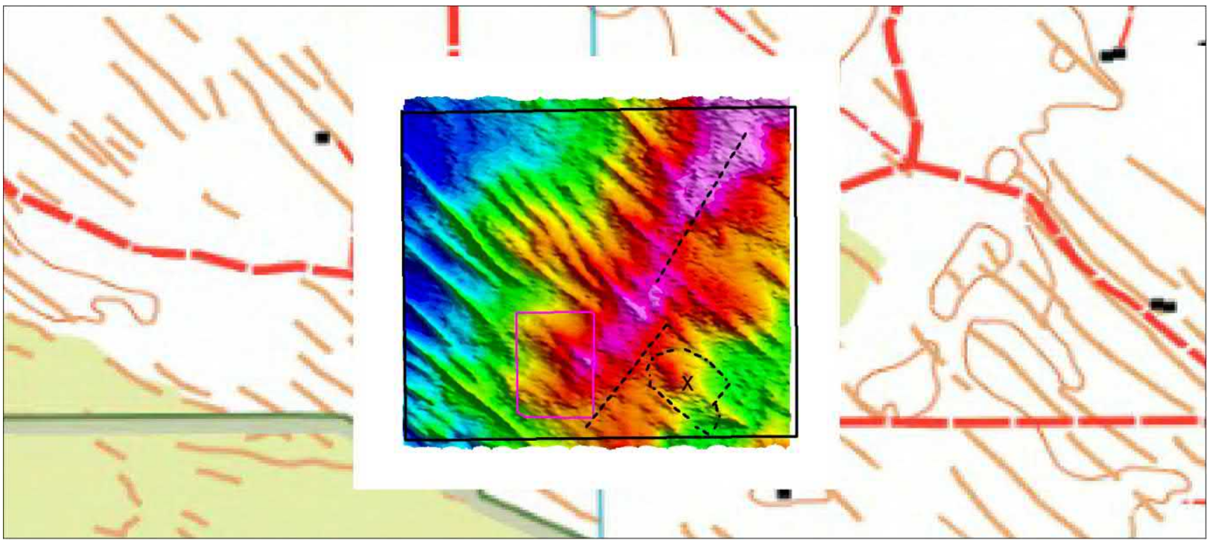


Image 5. Napandee surface elevation image.

The change in thorium response also corresponds with a north east ridge (topographic high) running through the survey area, with the apparent higher radiometric response to the east of this ridge (Image 5).

The uranium channel also displays an increased response to the east of the line indicated and is coincident with the thorium response (Image 6.). However the potassium channel while corresponding in part, is not as definitive (Image 7).

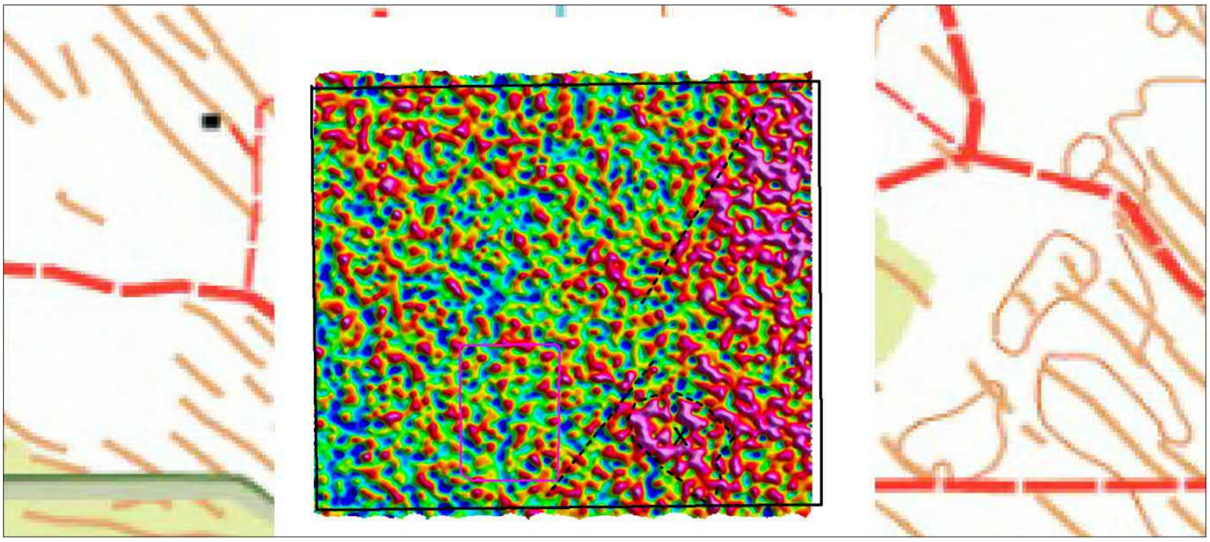


Image 6. Napandee surface uranium radiometric image.

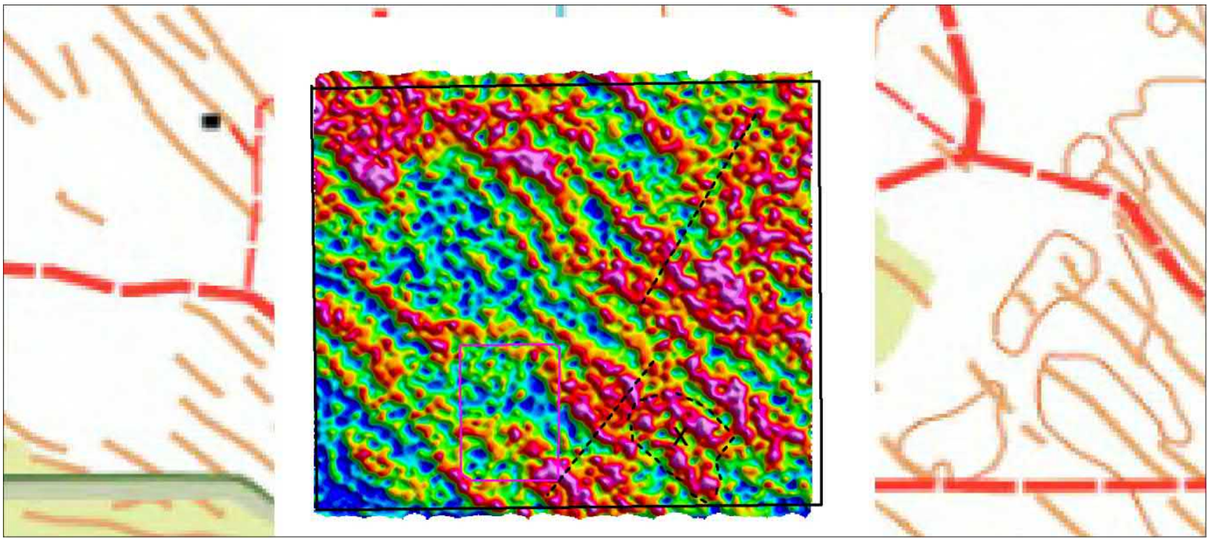


Image 7. Napandee surface potassium radiometric image.

Author: Bernie Stockill **Date:** 25/04/2018

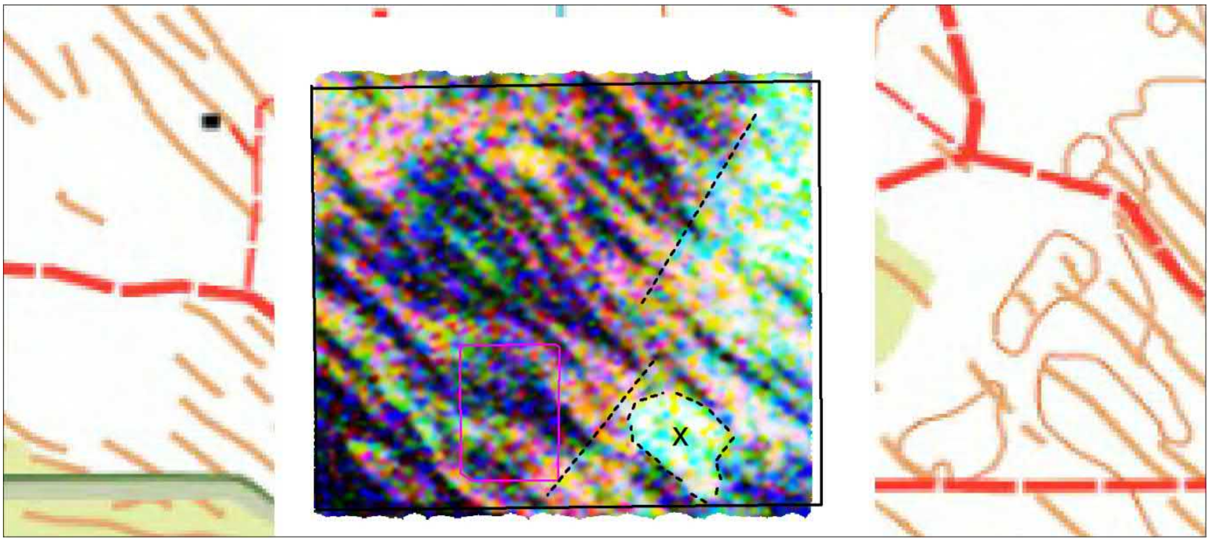


Image 8. Napandee surface rgb Ternary radiometric image.

Although not covering the 1 km^2 target area, and likely to have little or no consequence to the site, the change may possibly be explained by:

a) a variation in sub-surface geology east of the ridge,
b) a change in surface moisture content (with subsequent masking effect on the radiometric response) to the north west of the north easterly trending ridge,
c) a result of windblown surface sediments high in thorium and uranium (the dunes indicate a predominant north westerly direction) being blocked by the north easterly trending ridge,
d) Or, the area to the west of the ridge is partially covered by quartz sands which tend to mask the radiometric signal.

Although any of the above four are possible, the change in sub-surface geology would provide the strongest argument for the high thorium occurrence in the area marked by the **X** on the images.

There is no physical indication on the Google Earth image at this location (Image 9.) that shows any change in surface conditions. However, it should be noted that the break indicated between the two north easterly dotted lines corresponds with the prominent magnetic feature (interpreted as a mafic (Gairdner) Dyke) shown on Image 10).

Image 9. Napandee satellite Google Earth image (X marks the thorium high).

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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 Napandee in the Kimba area of South Australia. This survey was flown over two days from 5^{th} to 6^{th} April, 2018 and consisted of a total of 365 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 north-south 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 Napandee 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 Total Magnetic Intensity (TMI) image on Napandee is shown in Image 10. The interpretation report includes a series of modelled sections and the location of interpreted bodies relevant to the Napandee 1km^2 target area is shown in Image 11 below.

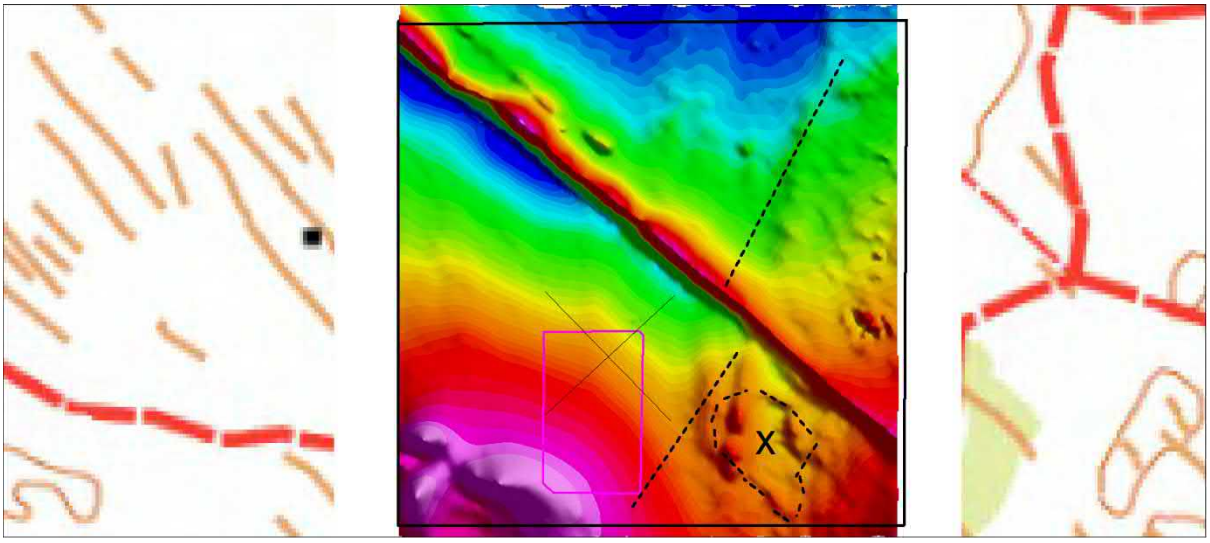

Image 10. Napandee TMI image with seismic lines and radiometric interpretation.

The revised target area is shown as a magenta rectangle, the seismic lines as light black crossed lines (original target area diagonals) and the lines generated from the thorium radiometric image as the dotted lines. The black **X** marks the centre of an elevated thorium and uranium response area.

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.

The image is dominated by two strong magnetic features, an intense broad high in the south west, and a thin magnetic high running north west – south east across the image. Minor magnetic anomalies occur elsewhere and interestingly in the vicinity of the thorium high.

The top of the broad magnetic high in the south west is modelled at around 1300 metres deep, and has been shown as several discrete bodies. At this depth, the magnetic rocks would have very little influence on the target area.

The north west – south east magnetic high has been interpreted as a mafic dyke, highly likely one of the many in this region that are recognised as Gairdner Dykes. This body has been modelled as very shallow, thin, vertical and continuous to hundreds of metres deep.

It is interesting to note that the bounding lines drawn from the thorium image break at the dyke, suggesting that it may have an influence on the surface sediments. It is also worth noting that the thorium high (**X**) does correspond with relatively shallow modelled magnetic bodies (100 metres deep) in an area of minor magnetic response.

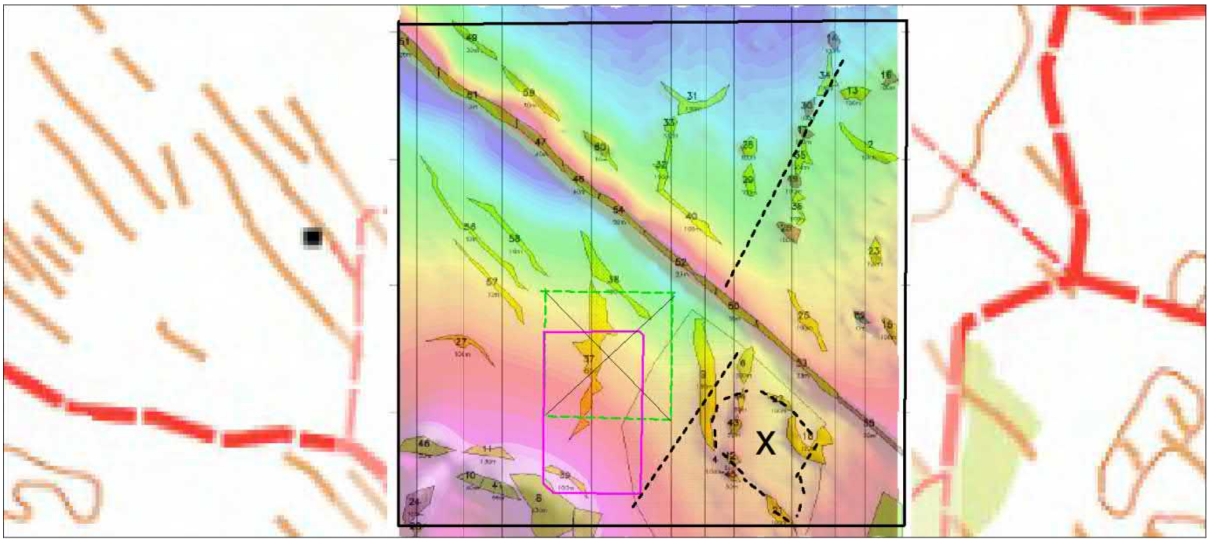

Image 11. Napandee TMI image (50% transparent) with study area (old-green and revised-magenta), seismic lines, radiometric interpretation and Hanneson modelled bodies.

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 Napandee. Magnetic models outlined in the interpretation report indicate that basement rocks are at least 1300 metres deep under the target area, and that a shallow dyke runs north west – south east across the survey area.

No faults have been inferred from the enhanced magnetic images, however, the modelled dyke may be fault controlled and more reliable results would 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 change in surface sediment composition in the east. While the cause of this difference may not be clear, a change in the underlying rocks is possible. 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 Napandee. 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_07 Kimba 1:250 000 Geology Map	PDF	SARIG Digital Download	10.929Mb		Jan-18
SH53_07 DHGeochem	CSV: XL Spreadsheets	SARIG Digital Download	23.8Mb		Feb-18
SH53_07 drillholeDetail	CSV: XL Spreadsheets	SARIG Digital Download	3.46Mb		Feb-18
SH53_07 rockSamples	CSV: XL Spreadsheets	SARIG Digital Download	7.96Mb		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
Ancilliary Reports:ENV03583; ENV08865; ENV09143; ENV09628; ENV10624; ENV11033; ENV11284; ENV12543; ENV12669; ENV12897	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
Napandee magnetic and radiometric High Resolution images	tiff images	Daishsat	130Mb	Apr-18	Apr-18
Napandee Model	PDF	Daishsat/Hanneson	1.23Mb	Apr-18	Apr-18

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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.

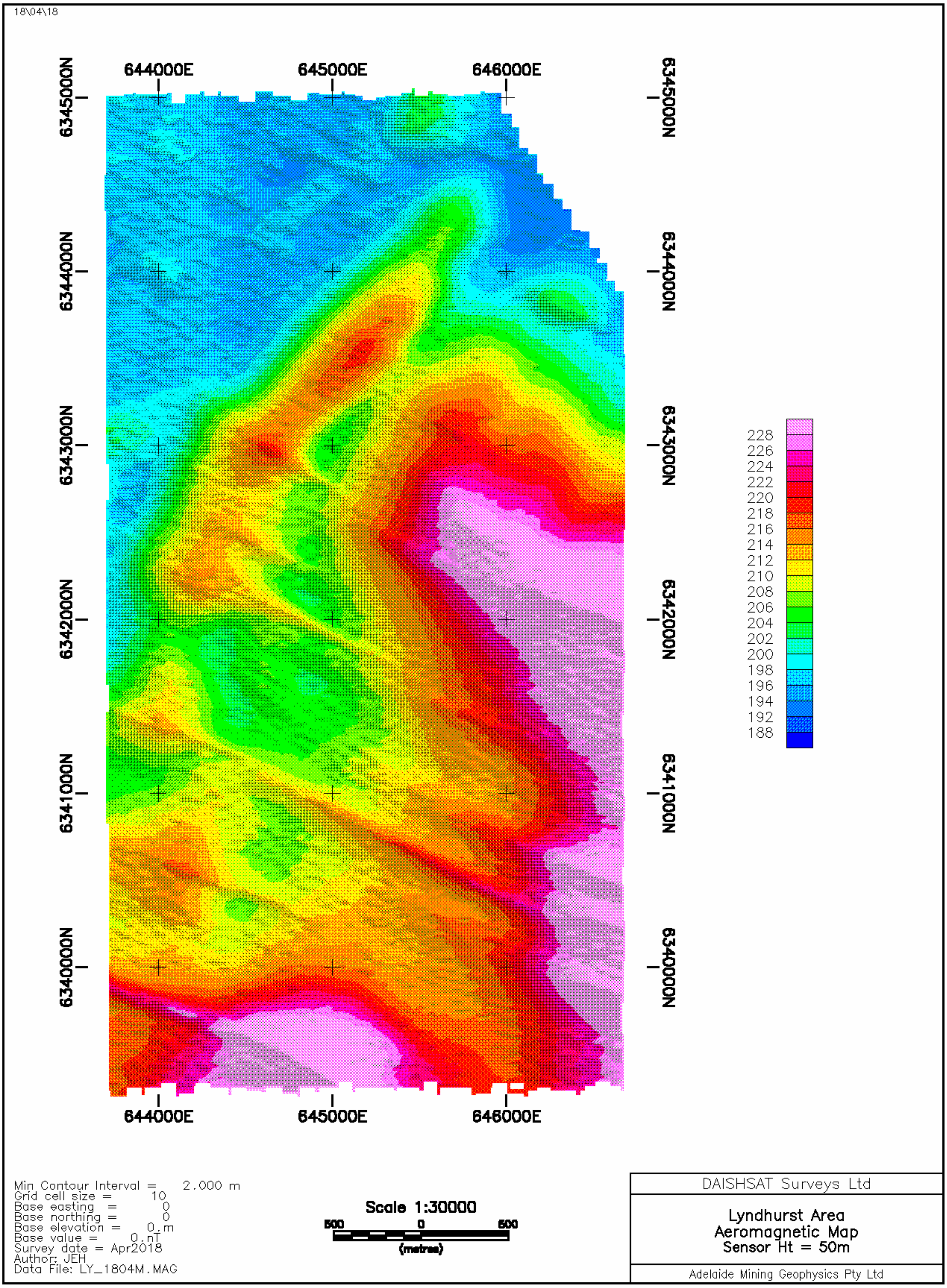
No magnetic remanence is evident in the observed responses, and the dominant magnetic features exhibit lows to the south (and west) as expected for a local Earth's field having inclination -65 and declination 7 degrees, respectively.

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.


18\04\18
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645000E
646000E
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6341000N
6340000N
228
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204
202
200
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196
194
192
188
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Base northing = 0
Base elevation = 0.m
Base value = 0.nT
Survey date = Apr2018
Author: JEH
Data File: LY_1804M.MAG
Scale 1:30000
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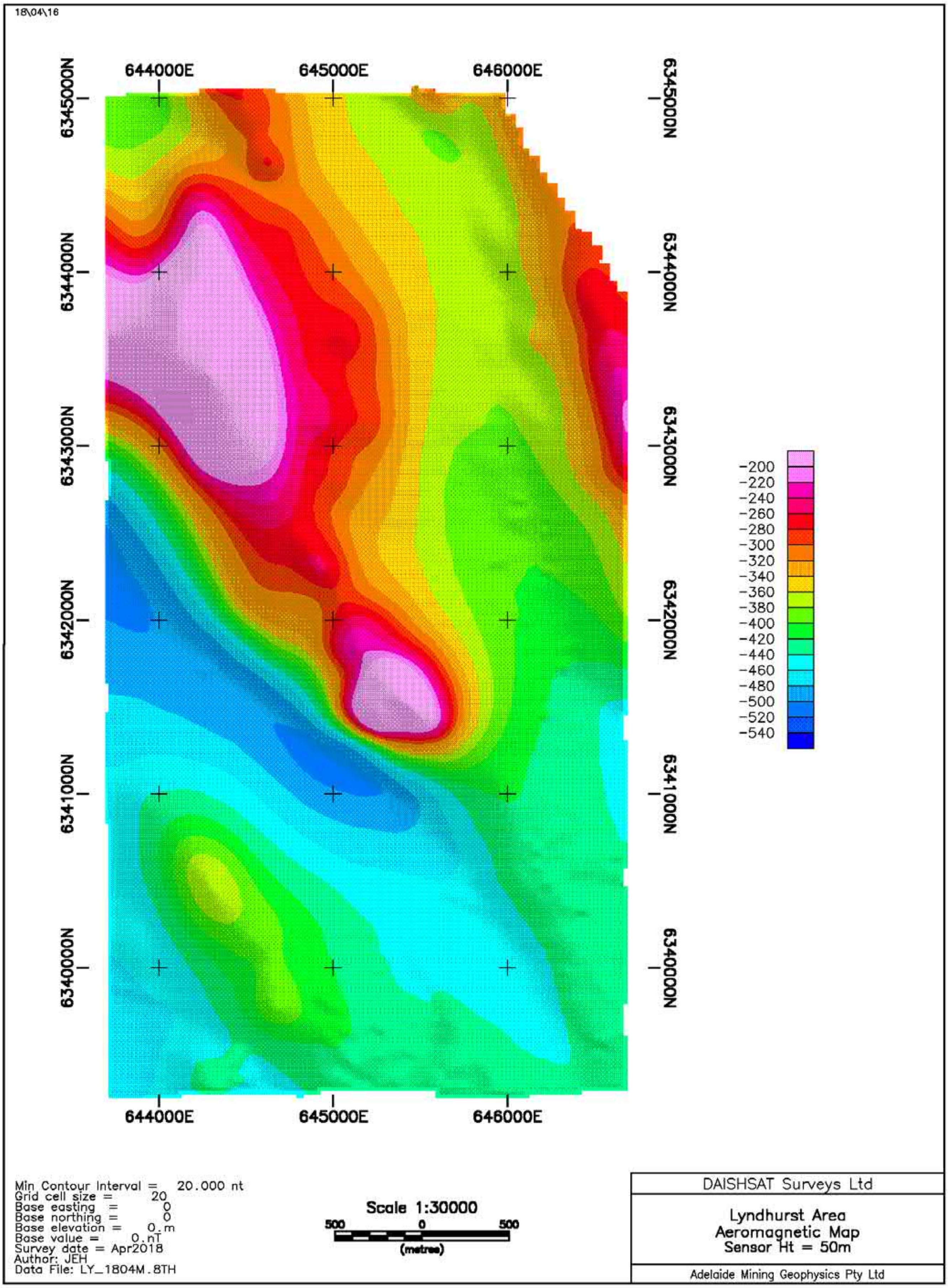
(metres)
DAISHSAT Surveys Ltd
Lyndhurst Area
Aeromagnetic Map
Sensor Ht = 50m
Adelaide Mining Geophysics Pty Ltd

Figure 1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645000E
646000E
6345000N
6344000N
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6340000N
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-260
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-380
-400
-420
-440
-460
-480
-500
-520
-540
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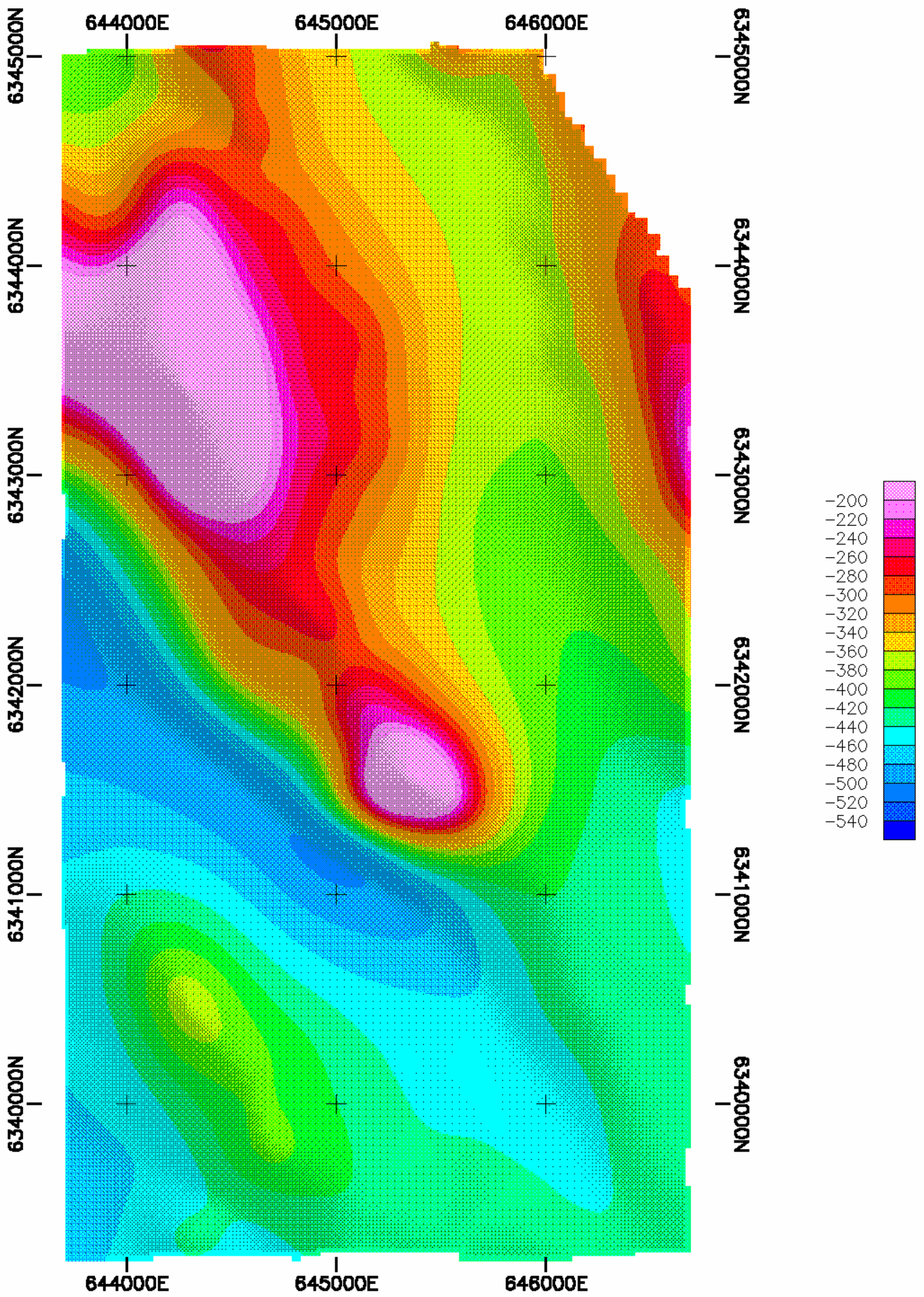
Grid cell size = 20
Base easting = 0
Base northing = 0
Base elevation = 0 m
Base value = 0 nT
Survey date = Apr2018
Author: JEH
Data File: LY_1804M.8TH
Scale 1:30000
500 0 500
(metres)
DAISHSAT Surveys Ltd
Lyndhurst Area
Aeromagnetic Map
Sensor Ht = 50m
Adelaide Mining Geophysics Pty Ltd

Figure 2.1

18\04\17



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Survey date = Apr2018
Author: JEH
Data File: LY_1804M.8TH

Scale 1:30000

500 0 500

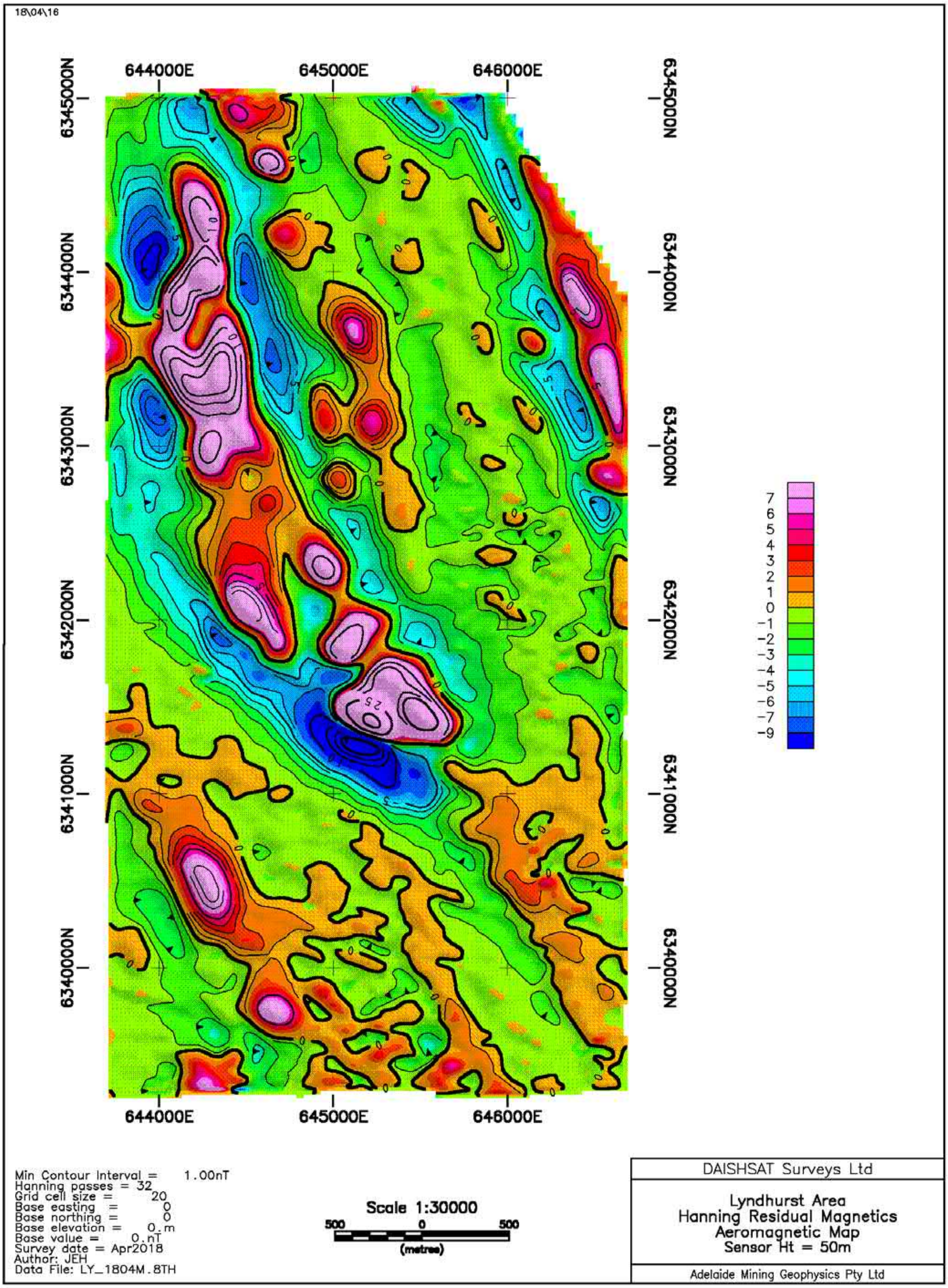
(metres)

DAISHSAT Surveys Ltd

Lyndhurst Area
Hanning Regional Magnetics
Aeromagnetic Map
Sensor Ht = 50m

Adelaide Mining Geophysics Pty Ltd

Figure 2.2


18\04\16
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646000E
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6343000N
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6341000N
6340000N
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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

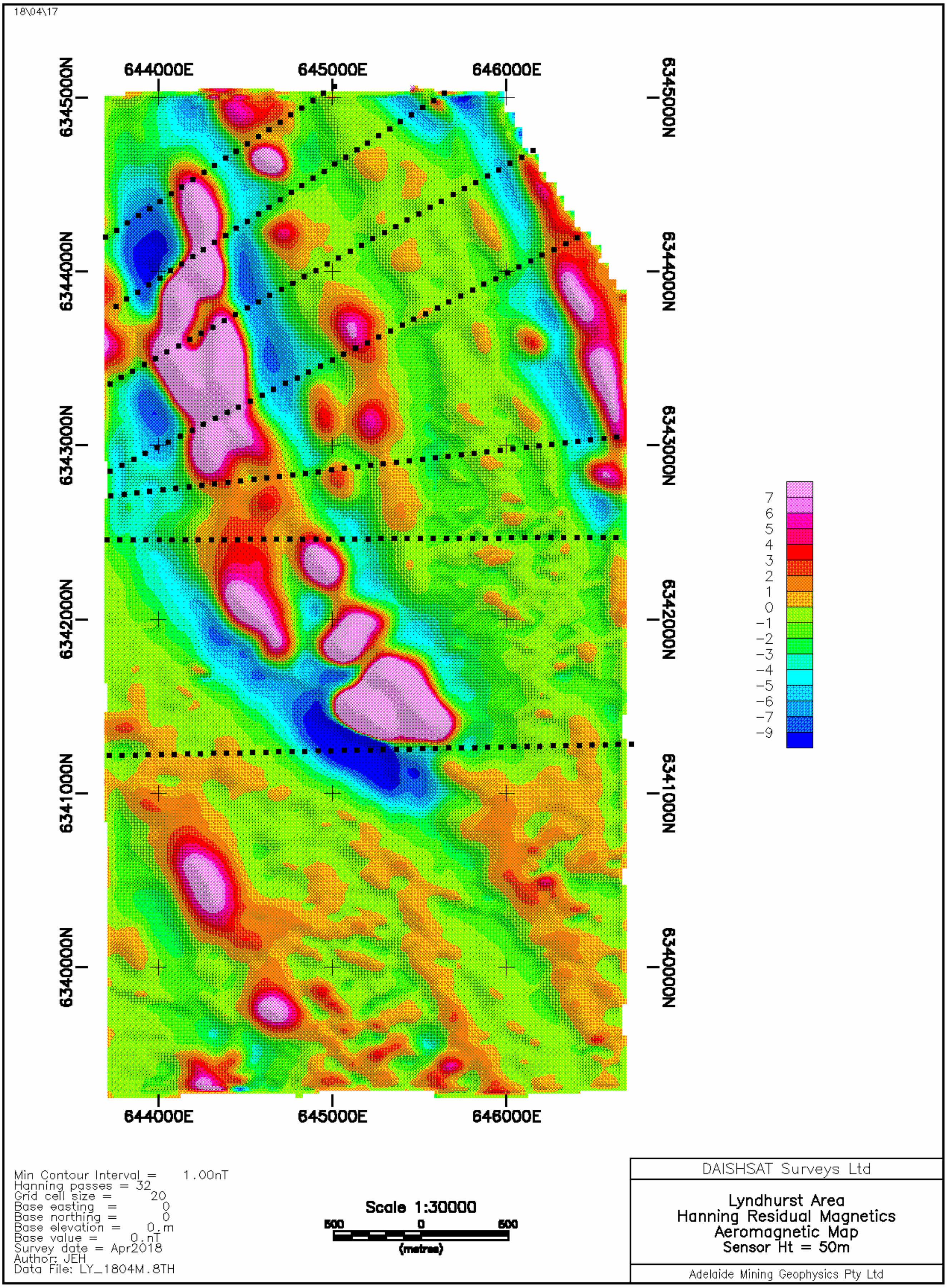
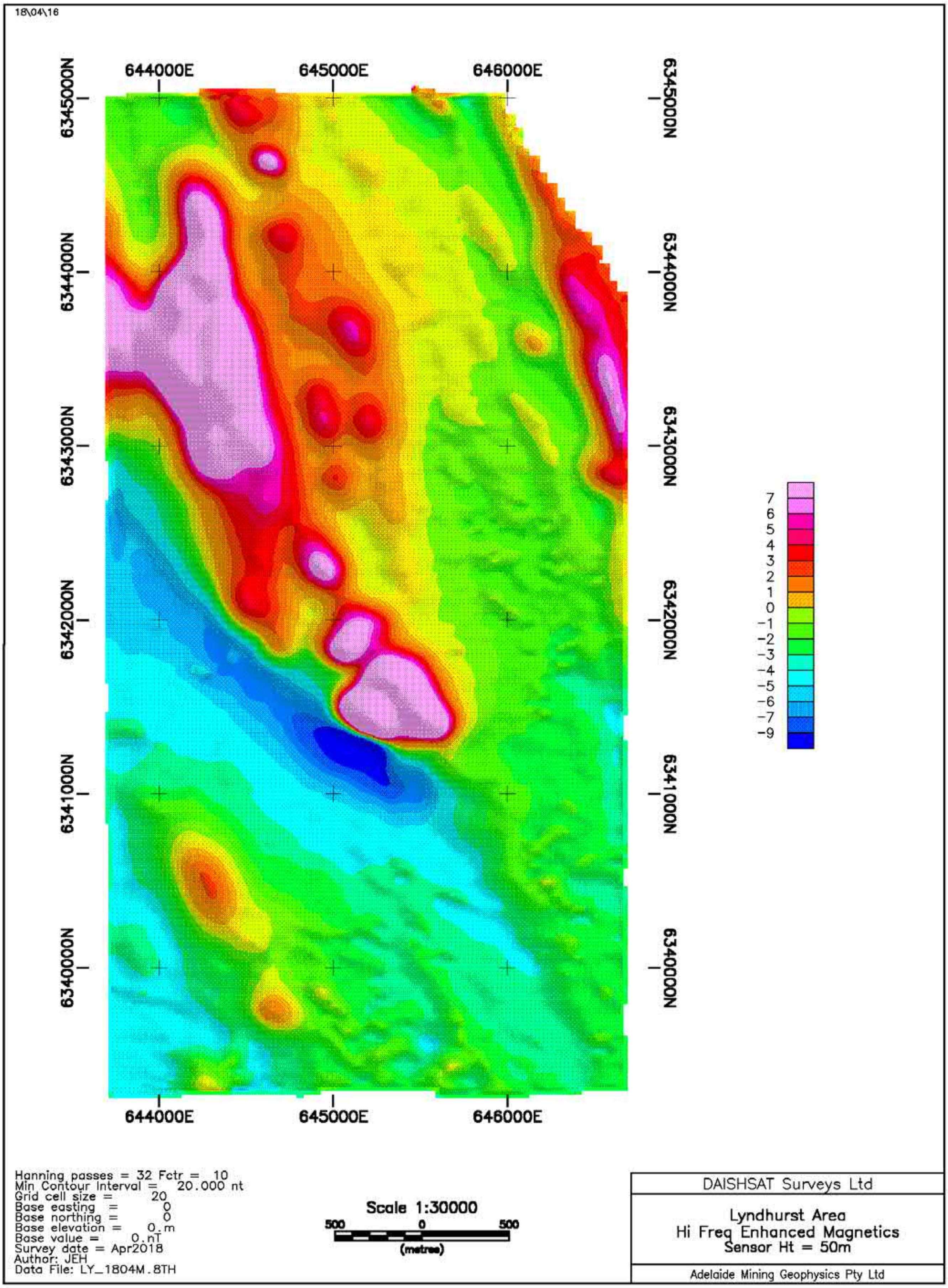


Figure 2.3b Dotted lines suggest possible faults based on truncations and discontinuities.


18\04\16
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1
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Author: JEH
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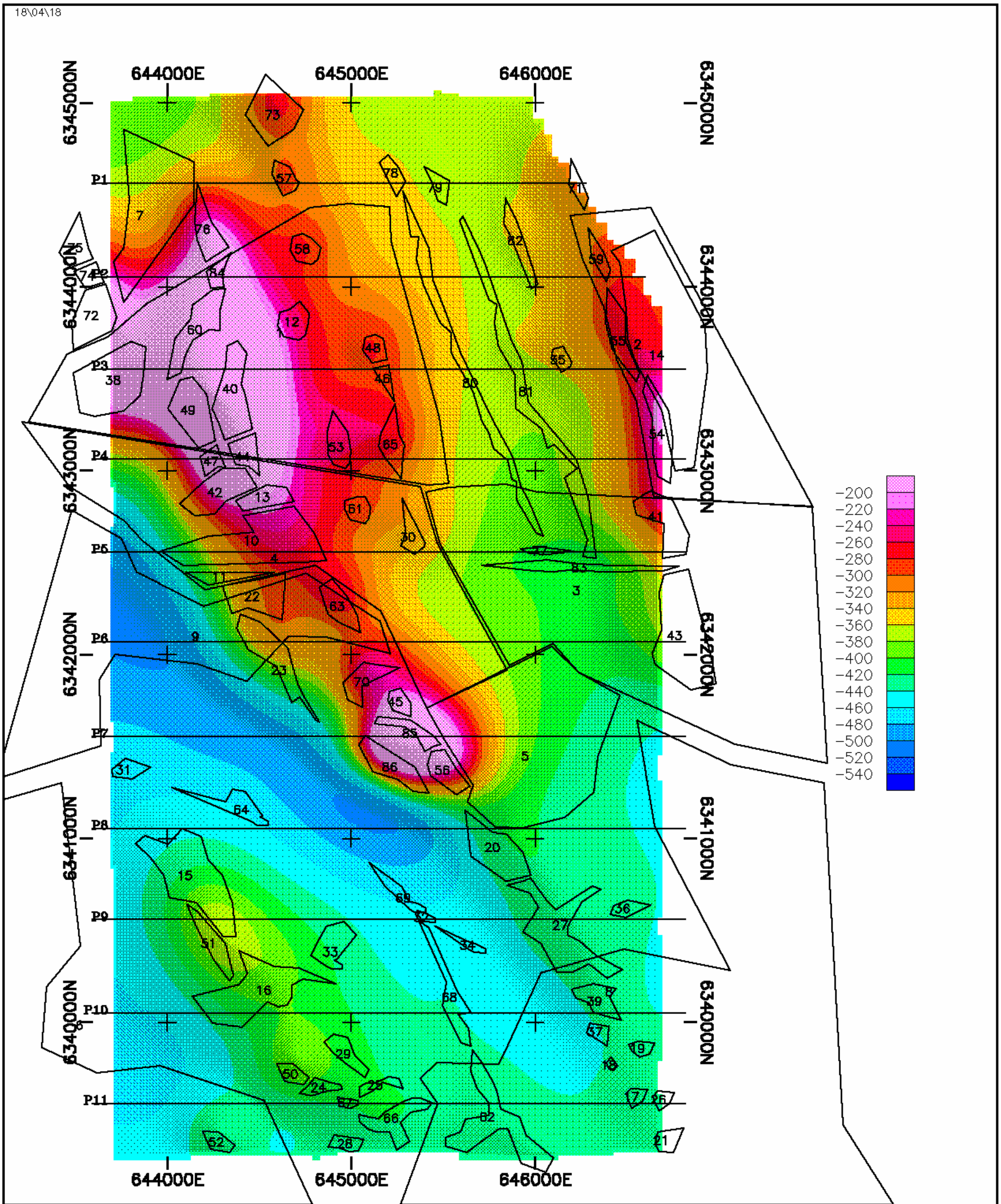
(metres)
DAISHSAT Surveys Ltd
Lyndhurst Area
Hi Freq Enhanced Magnetics
Sensor Ht = 50m
Adelaide Mining Geophysics Pty Ltd

Figure 2.4



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Author: JEH
Data File: maggrav.mag

Scale 1:30000

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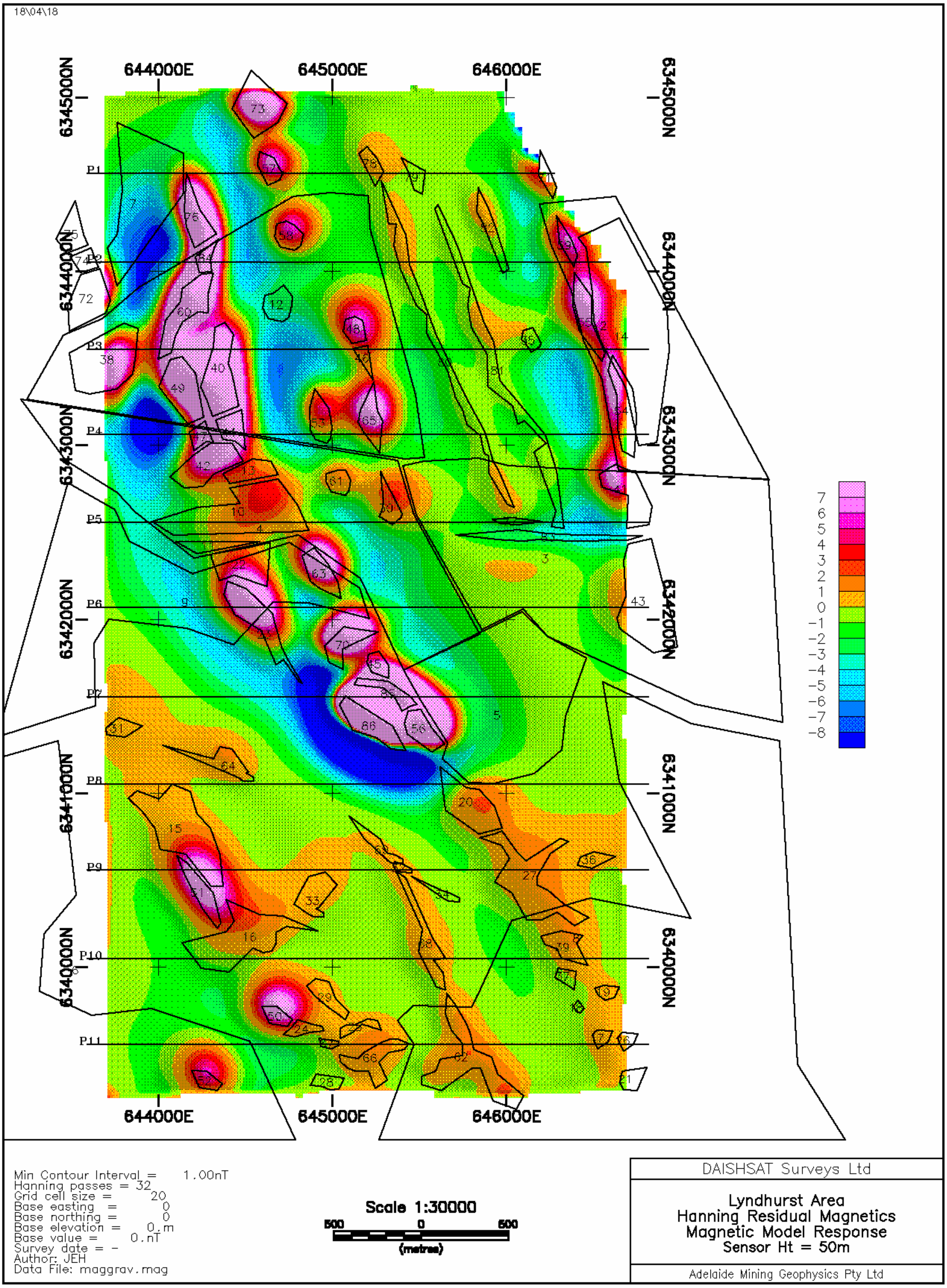
(metres)

DAISHSAT Surveys Ltd

Lyndhurst Area
Magnetic Model Response
Sensor Ht = 50m

Adelaide Mining Geophysics Pty Ltd

Figure 3.1



18\04\18
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6342000N
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6340000N
P1
P2
P3
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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
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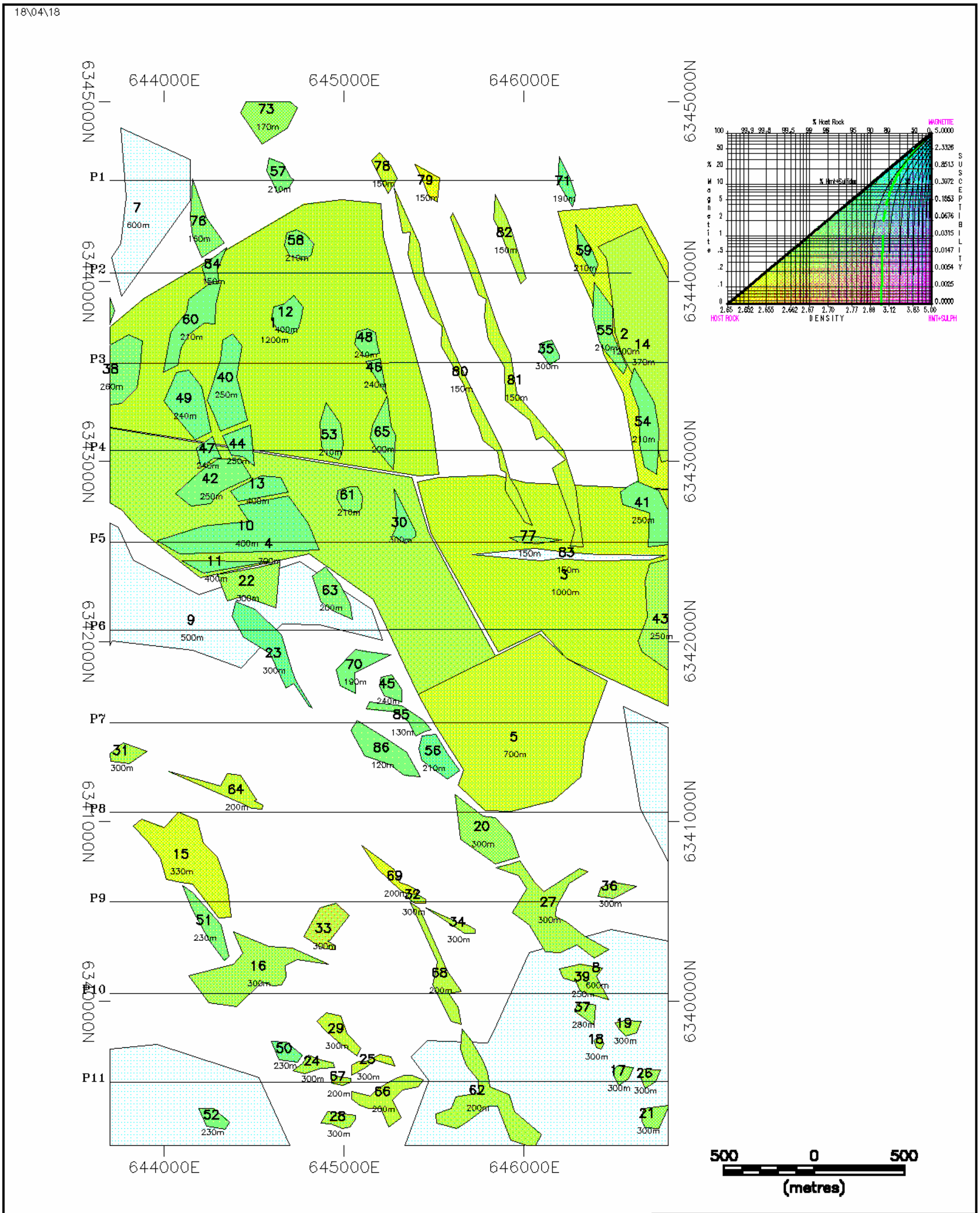
(metres)
DAISHSAT Surveys Ltd
Lyndhurst Area
Hanning Residual Magnetics
Magnetic Model Response
Sensor Ht = 50m
Adelaide Mining Geophysics Pty Ltd

Figure 3.2



Daishsat Geodetic Surveyors

Lyndhurst Area
Model Body Tops
Attributes: Phase diagram

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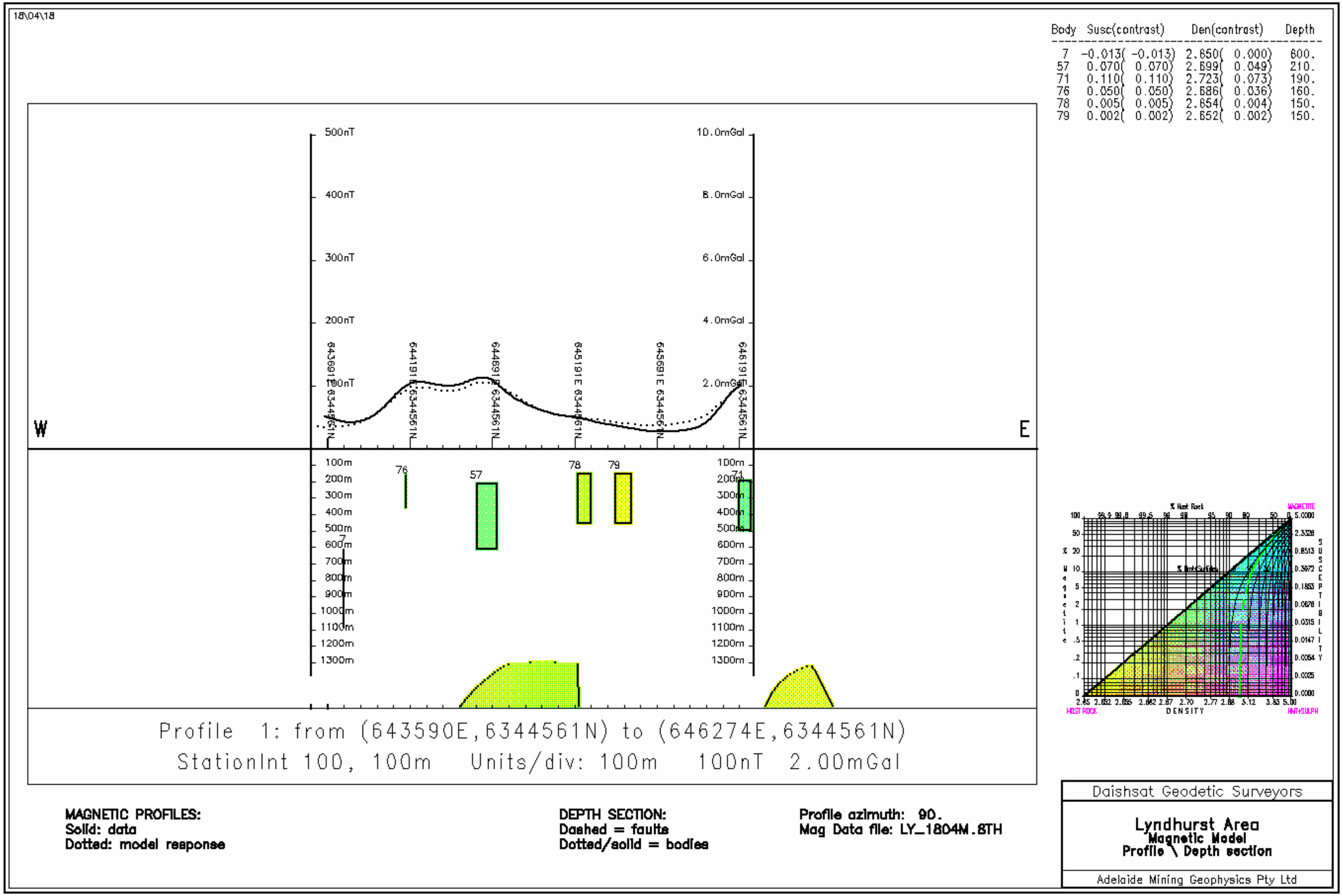
Figure 4.



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
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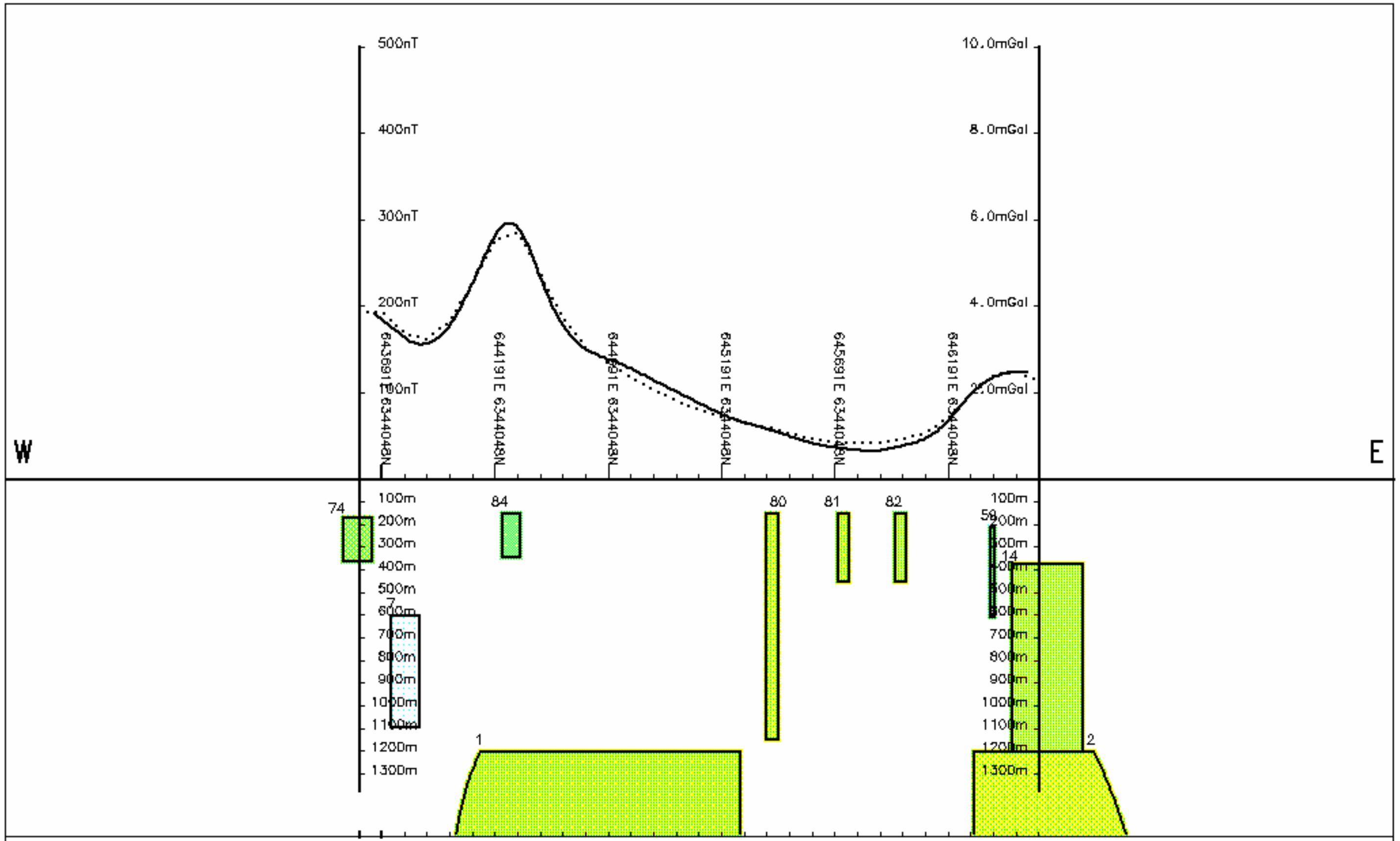
Solid: data
Dotted: model response
DEPTH SECTION:
Dashed = faults
Dotted/solid = bodies
Profile azimuth: 90.
Mag Data file: LY_1804M.8TH
Daishsat Geodetic Surveyors
Lyndhurst Area
Magnetic Model
Profile \ Depth section
Adelaide Mining Geophysics Pty Ltd
DENSITY
HOST ROCK

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.



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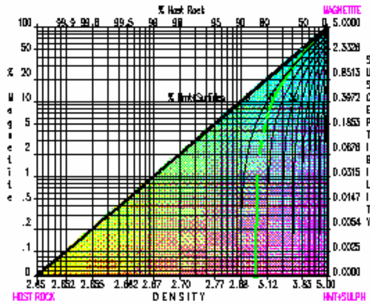


MAGNETIC PROFILES:
Solid: data
Dotted: model response

DEPTH SECTION:
Dashed = faults
Dotted/solid = bodies

Profile azimuth: 90.
Mag Data file: LY_1804M.8TH

Daishsat Geodetic Surveyors

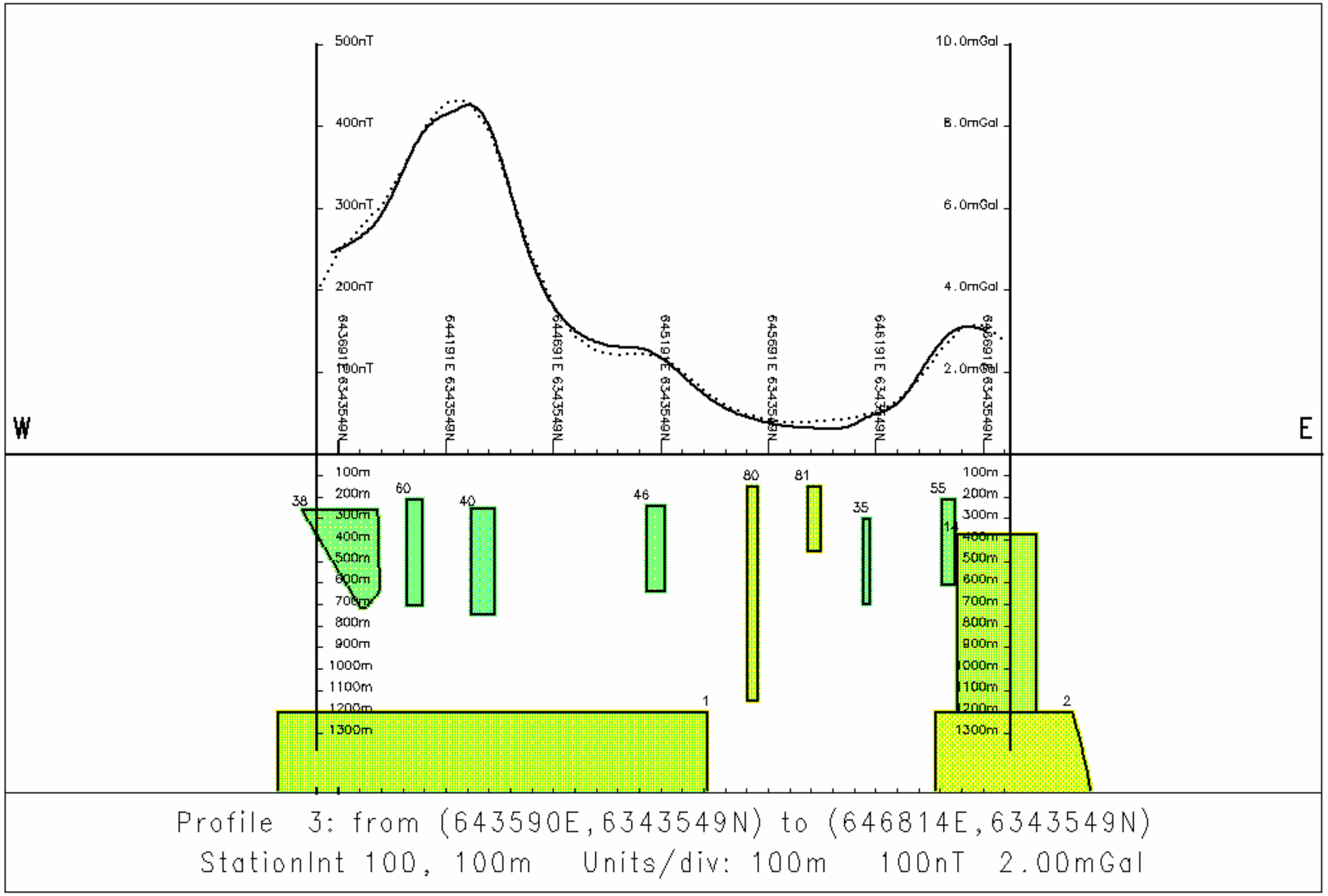
Lyndhurst Area
Magnetic Model
Profile \ Depth section

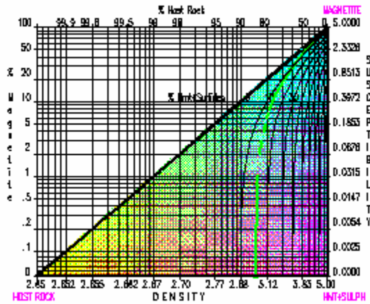
Adelaide Mining Geophysics Pty Ltd

Figure 5.2

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.





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

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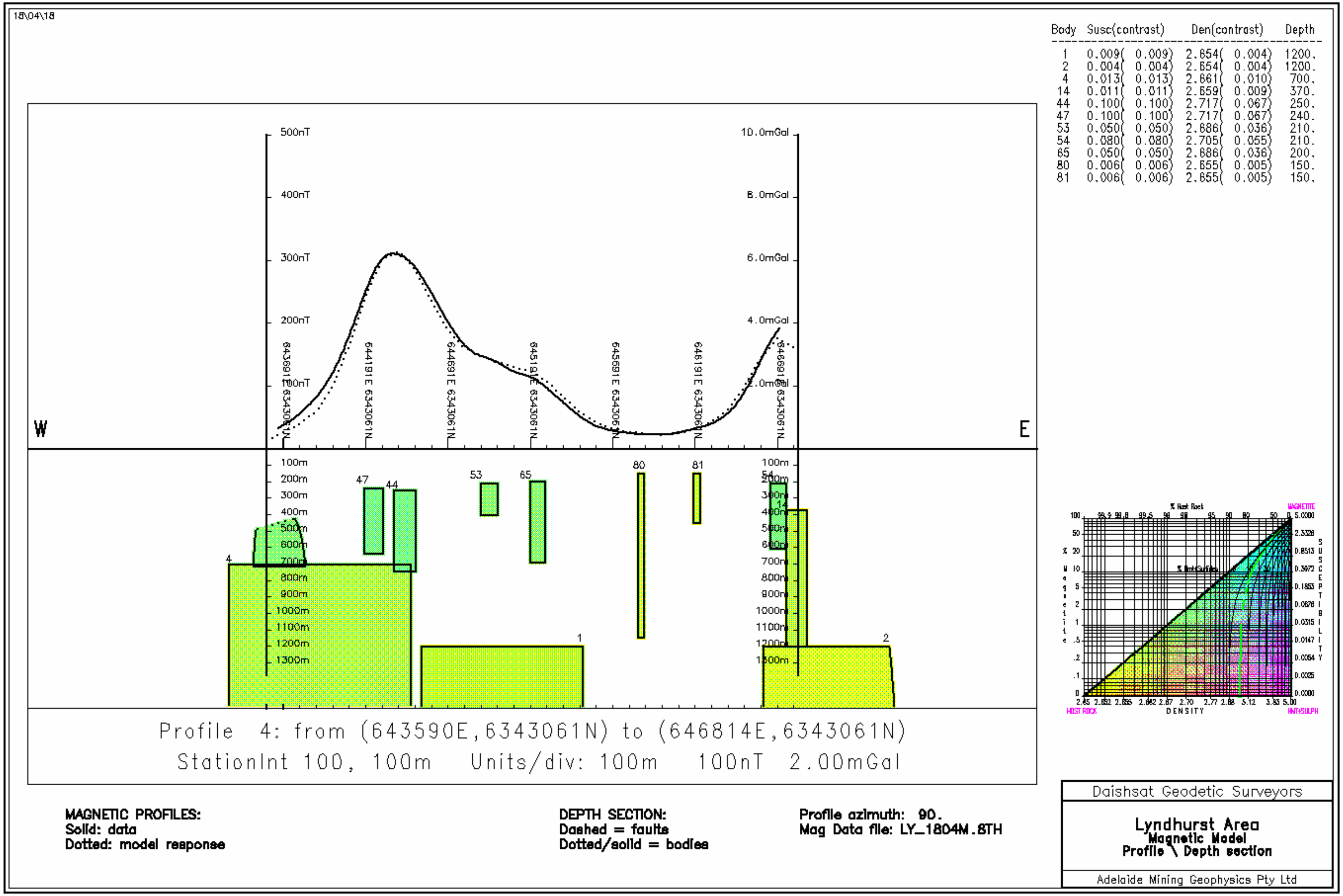
Figure 5.3


18\04\18
Body Susc(contrast) Den(contrast) Depth
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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.
500nT
400nT
300nT
200nT
100nT
10.0mGal
8.0mGal
6.0mGal
4.0mGal
2.0mGal
W
E
643691E 6343061N
644191E 6343061N
644691E 6343061N
645191E 6343061N
645691E 6343061N
646191E 6343061N
646691E 6343061N
100m
200m
300m
400m
500m
600m
700m
800m
900m
1000m
1100m
1200m
1300m
47
44
53
65
80
81
54
14
4
1
2
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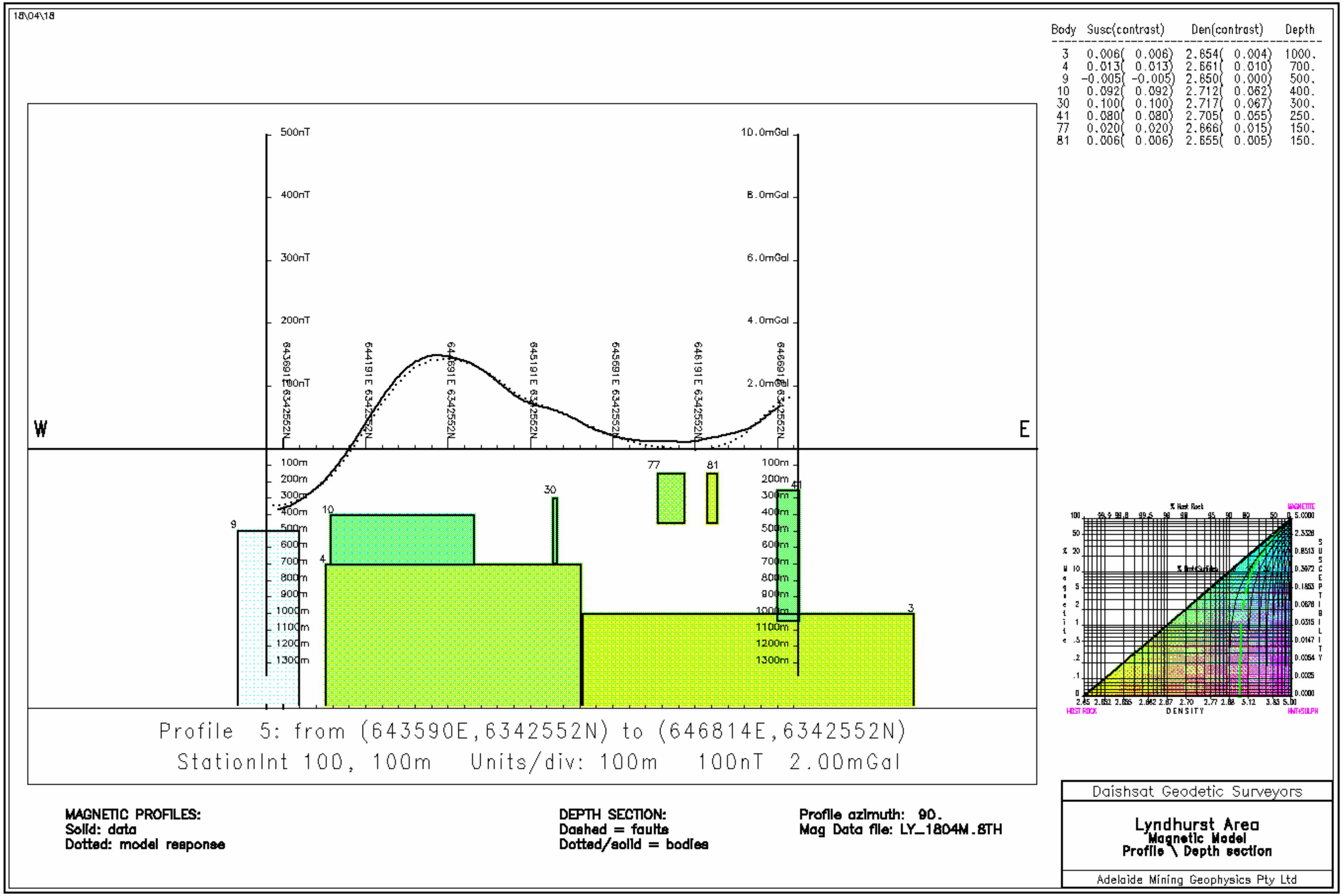
% Host Rock
MAGNETITE
DENSITY
HOST ROCK
HNT+SULPH
MAGNETIC PROFILES:
Solid: data
Dotted: model response
DEPTH SECTION:
Dashed = faults
Dotted/solid = bodies
Profile azimuth: 90.
Mag Data file: LY_1804M.STH
Daishsat Geodetic Surveyors
Lyndhurst Area
Magnetic Model
Profile \ Depth section
Adelaide Mining Geophysics Pty Ltd

Figure 5.4



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
Profile 5: from (643590E,6342552N) to (646814E,6342552N)
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
HOST ROCK
DENSITY
Daishsat Geodetic Surveyors
Lyndhurst Area
Magnetic Model
Profile \ Depth section
Adelaide Mining Geophysics Pty Ltd

Figure 5.5

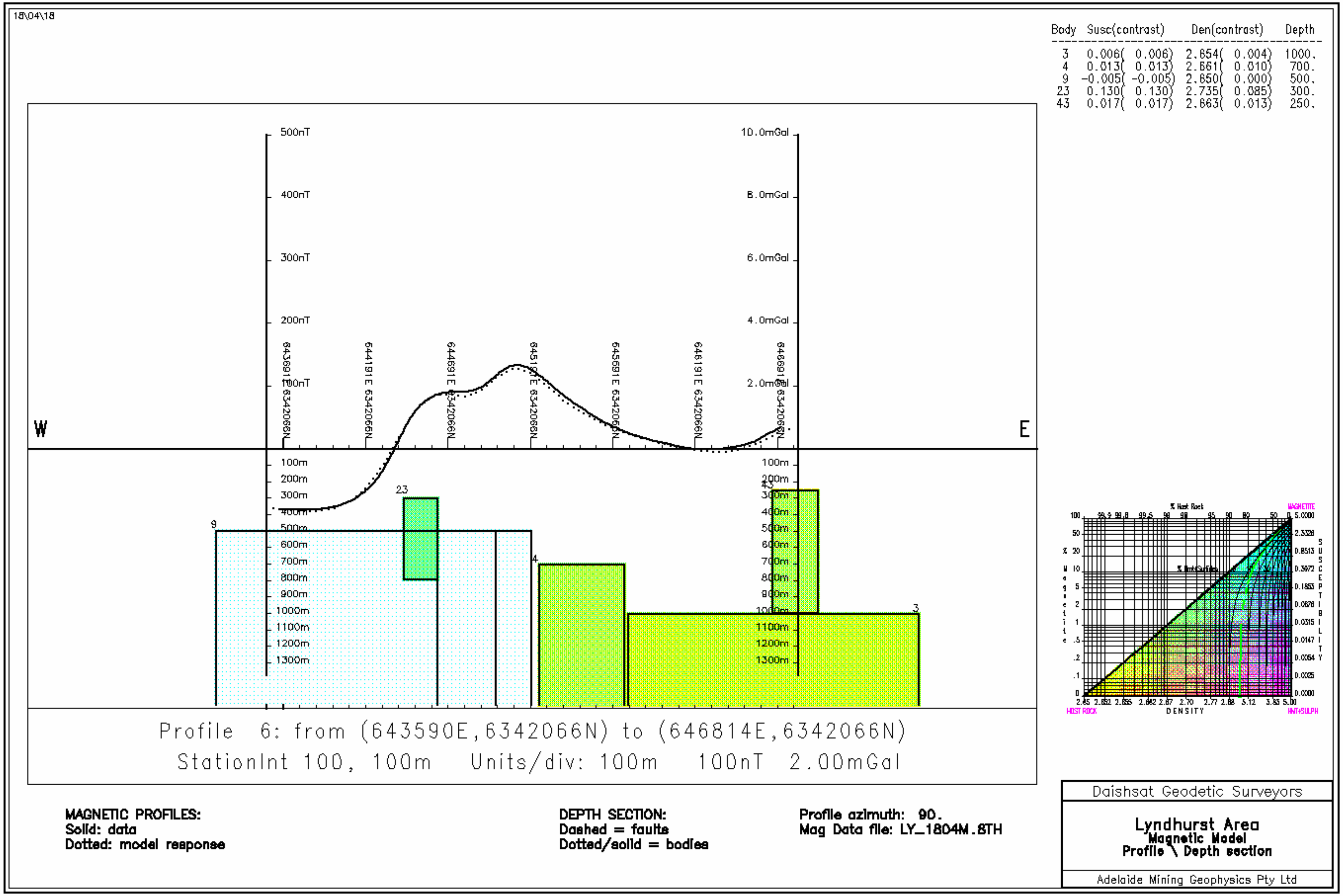

18\04\18
Body Susc(contrast) Den(contrast) Depth
3 0.006(0.006) 2.654(0.004) 1000.
4 0.013(0.013) 2.661(0.010) 700.
9 -0.005(-0.005) 2.650(0.000) 500.
23 0.130(0.130) 2.735(0.085) 300.
43 0.017(0.017) 2.663(0.013) 250.
Profile 6: from (643590E,6342066N) to (646814E,6342066N)
StationInt 100, 100m Units/div: 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 5.6

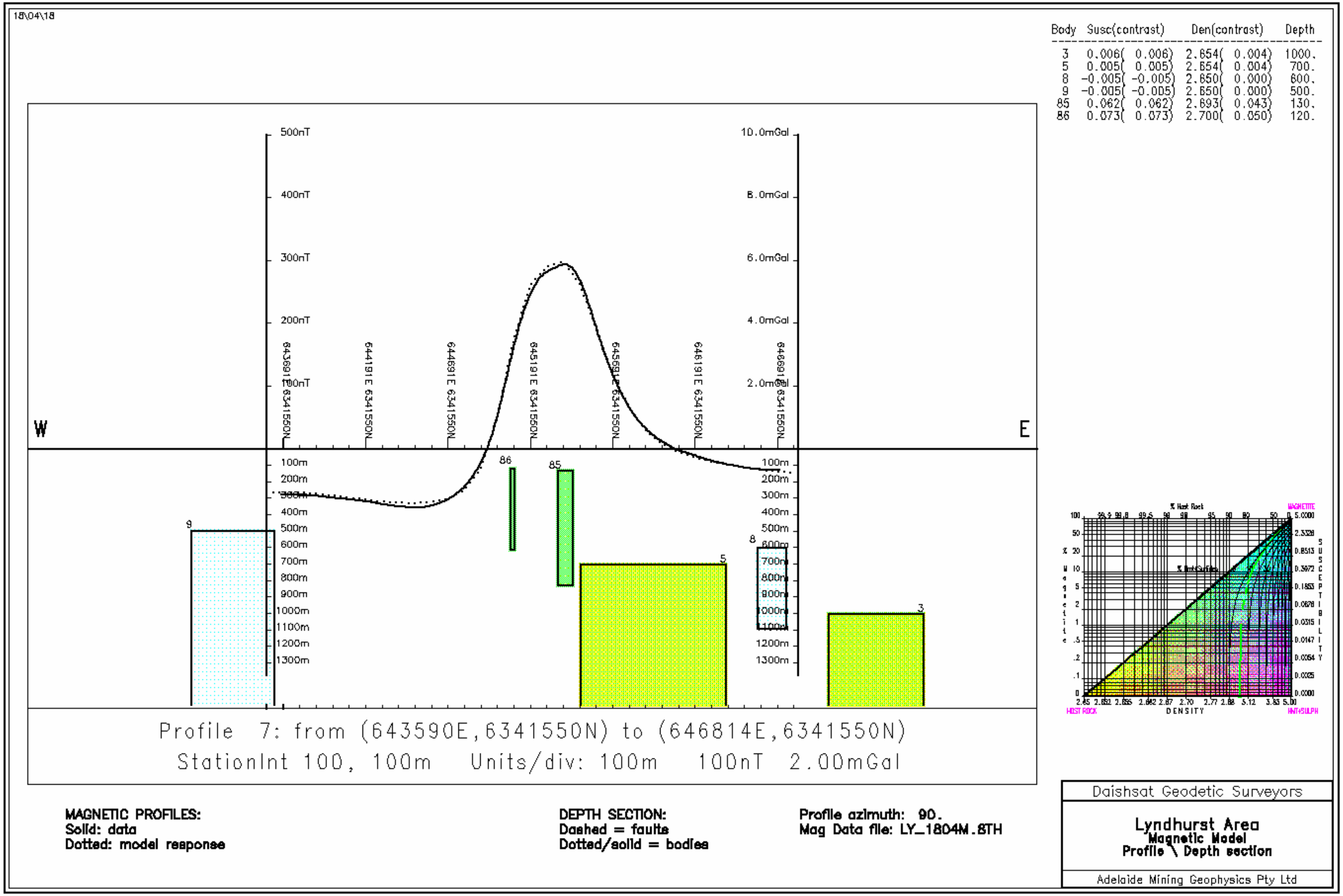

18\04\18
Body Susc(contrast) Den(contrast) Depth
3 0.006(0.006) 2.654(0.004) 1000.
5 0.005(0.005) 2.654(0.004) 700.
8 -0.005(-0.005) 2.650(0.000) 600.
9 -0.005(-0.005) 2.650(0.000) 500.
85 0.062(0.062) 2.693(0.043) 130.
86 0.073(0.073) 2.700(0.050) 120.
500nT
400nT
300nT
200nT
100nT
10.0mGal
8.0mGal
6.0mGal
4.0mGal
2.0mGal
643691E 6341550N
644191E 6341550N
644691E 6341550N
645191E 6341550N
645691E 6341550N
646191E 6341550N
646691E 6341550N
W
E
100m
200m
300m
400m
500m
600m
700m
800m
900m
1000m
1100m
1200m
1300m
86
85
9
5
8
3
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.8TH
% Host Rock
MAGNETITE
DENSITY
HOST ROCK
HMT+SULPH
Daishsat Geodetic Surveyors
Lyndhurst Area
Magnetic Model
Profile \ Depth section
Adelaide Mining Geophysics Pty Ltd

Figure 5.7

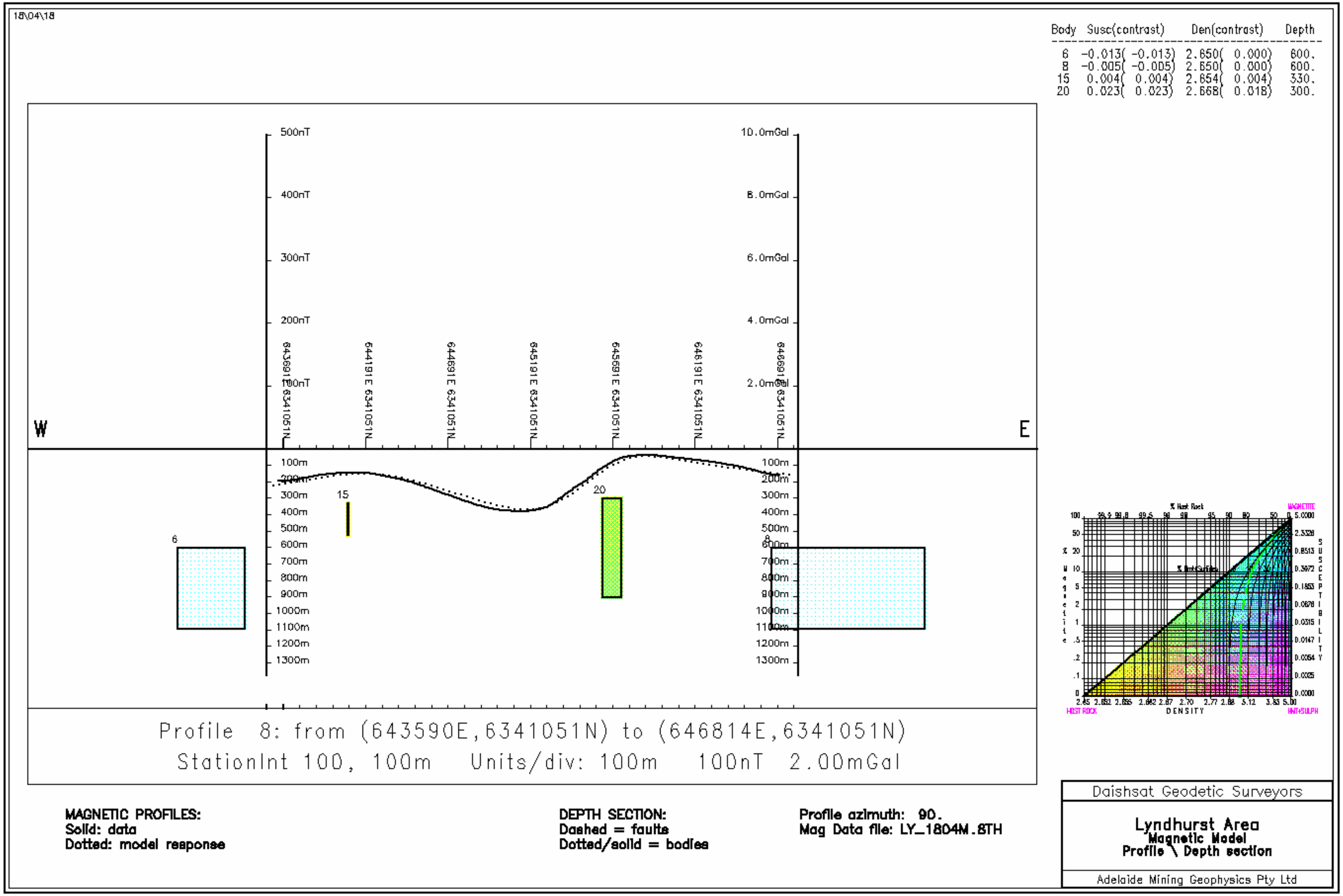

18\04\18
Body Susc(contrast) Den(contrast) Depth
6 -0.013(-0.013) 2.650(0.000) 600.
8 -0.005(-0.005) 2.650(0.000) 600.
15 0.004(0.004) 2.654(0.004) 330.
20 0.023(0.023) 2.668(0.018) 300.
W
E
Profile 8: from (643590E,6341051N) to (646814E,6341051N)
StationInt 100, 100m Units/div: 100m 100nT 2.00mGal
MAGNETIC PROFILES:
Solid: data
Dotted: model response
DEPTH SECTION:
Dashed = faults
Dotted/solid = bodies
Profile azimuth: 90.
Mag Data file: LY_1804M.8TH
Daishsat Geodetic Surveyors
Lyndhurst Area
Magnetic Model
Profile \ Depth section
Adelaide Mining Geophysics Pty Ltd

Figure 5.8

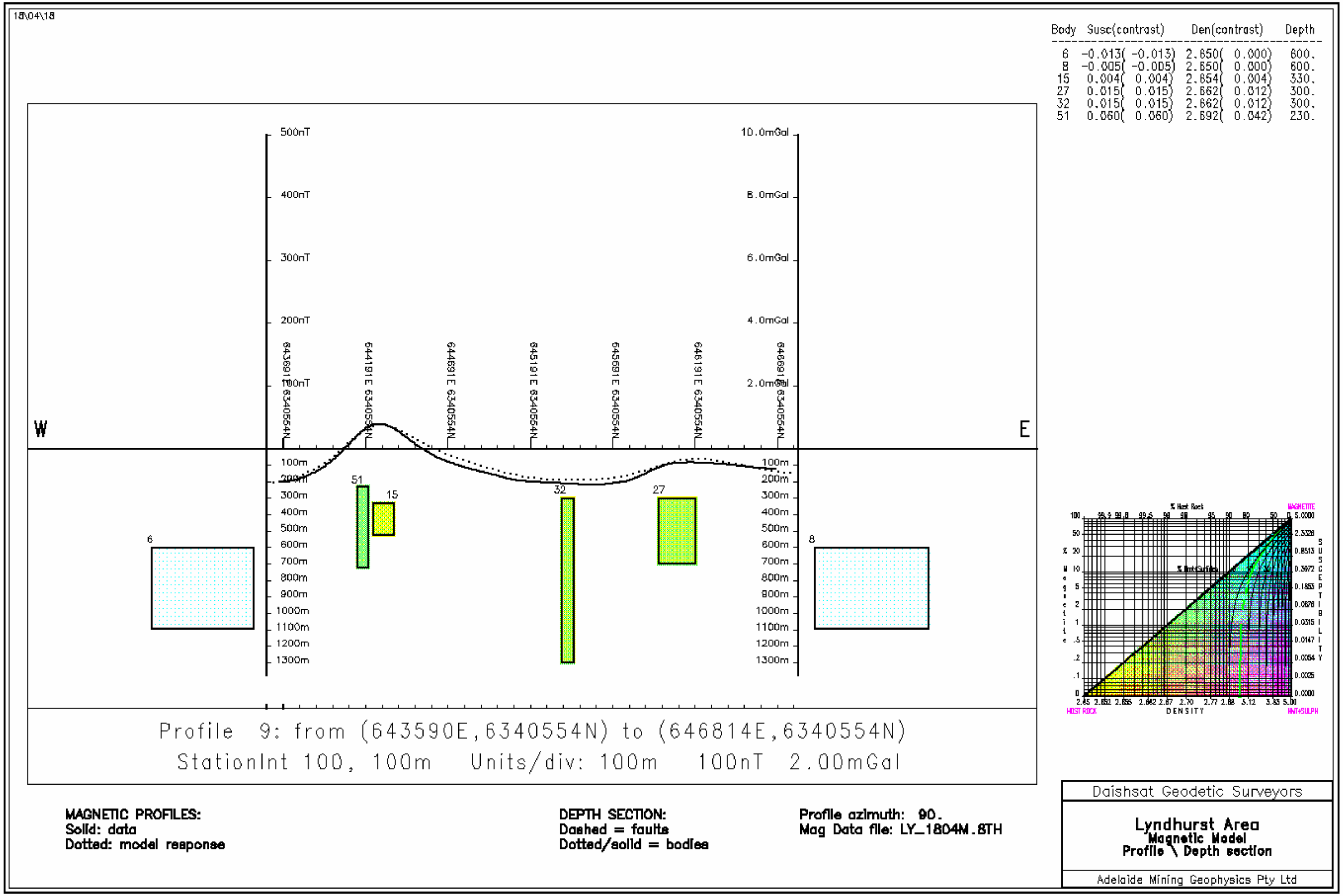

18\04\18
Body Susc(contrast) Den(contrast) Depth
6 -0.013(-0.013) 2.650(0.000) 600.
8 -0.005(-0.005) 2.650(0.000) 600.
15 0.004(0.004) 2.654(0.004) 330.
27 0.015(0.015) 2.662(0.012) 300.
32 0.015(0.015) 2.662(0.012) 300.
51 0.060(0.060) 2.692(0.042) 230.
500nT
400nT
300nT
200nT
100nT
10.0mGal
8.0mGal
6.0mGal
4.0mGal
2.0mGal
W
E
643691E 6340554N
644191E 6340554N
644691E 6340554N
645191E 6340554N
645691E 6340554N
646191E 6340554N
646691E 6340554N
100m
200m
300m
400m
500m
600m
700m
800m
900m
1000m
1100m
1200m
1300m
51
15
32
27
6
8
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.8TH
% Host Rock
MAGNETITE
DENSITY
HOST ROCK
SUSCEPTIBILITY
Daishsat Geodetic Surveyors
Lyndhurst Area
Magnetic Model
Profile \ Depth section
Adelaide Mining Geophysics Pty Ltd

Figure 5.9

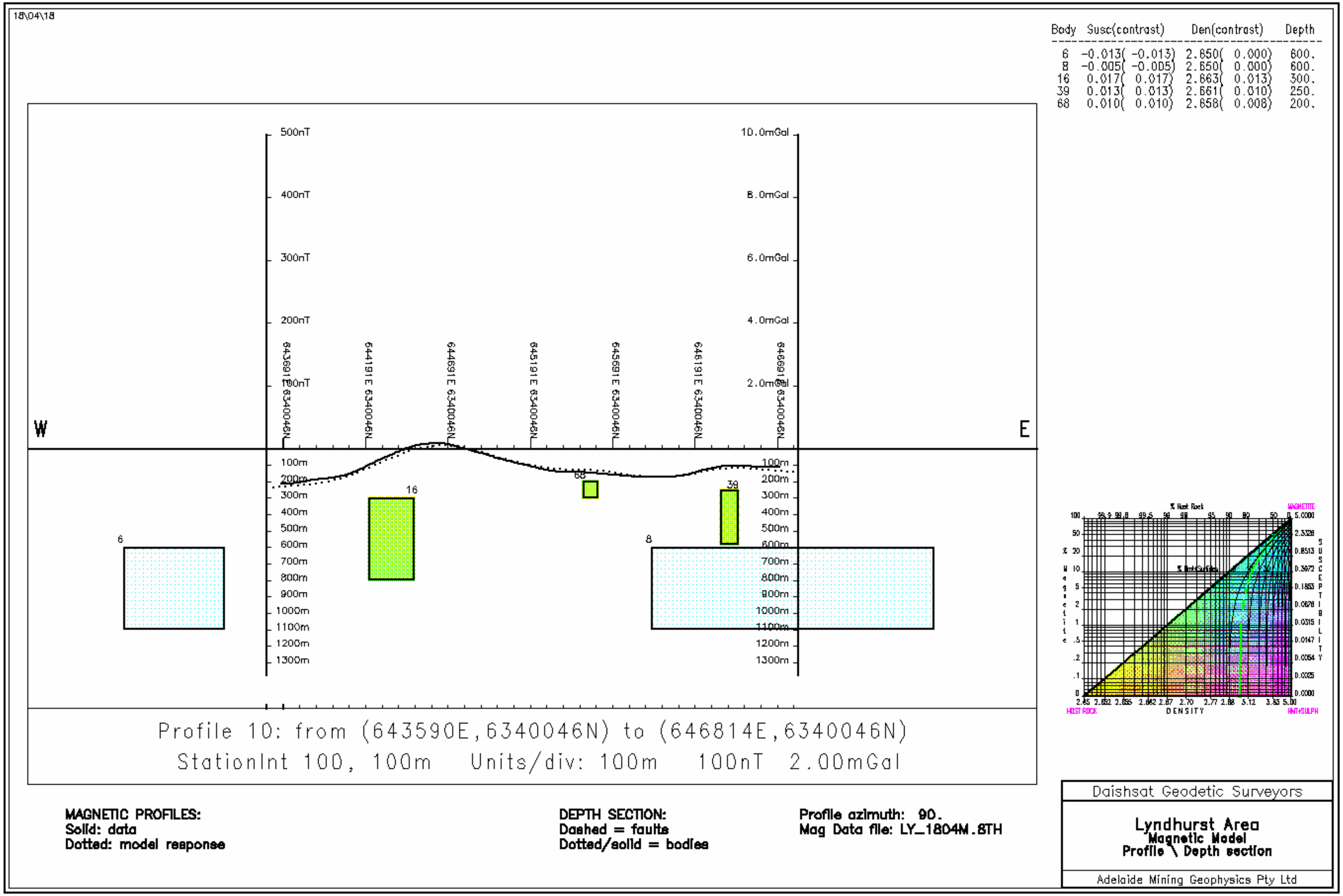
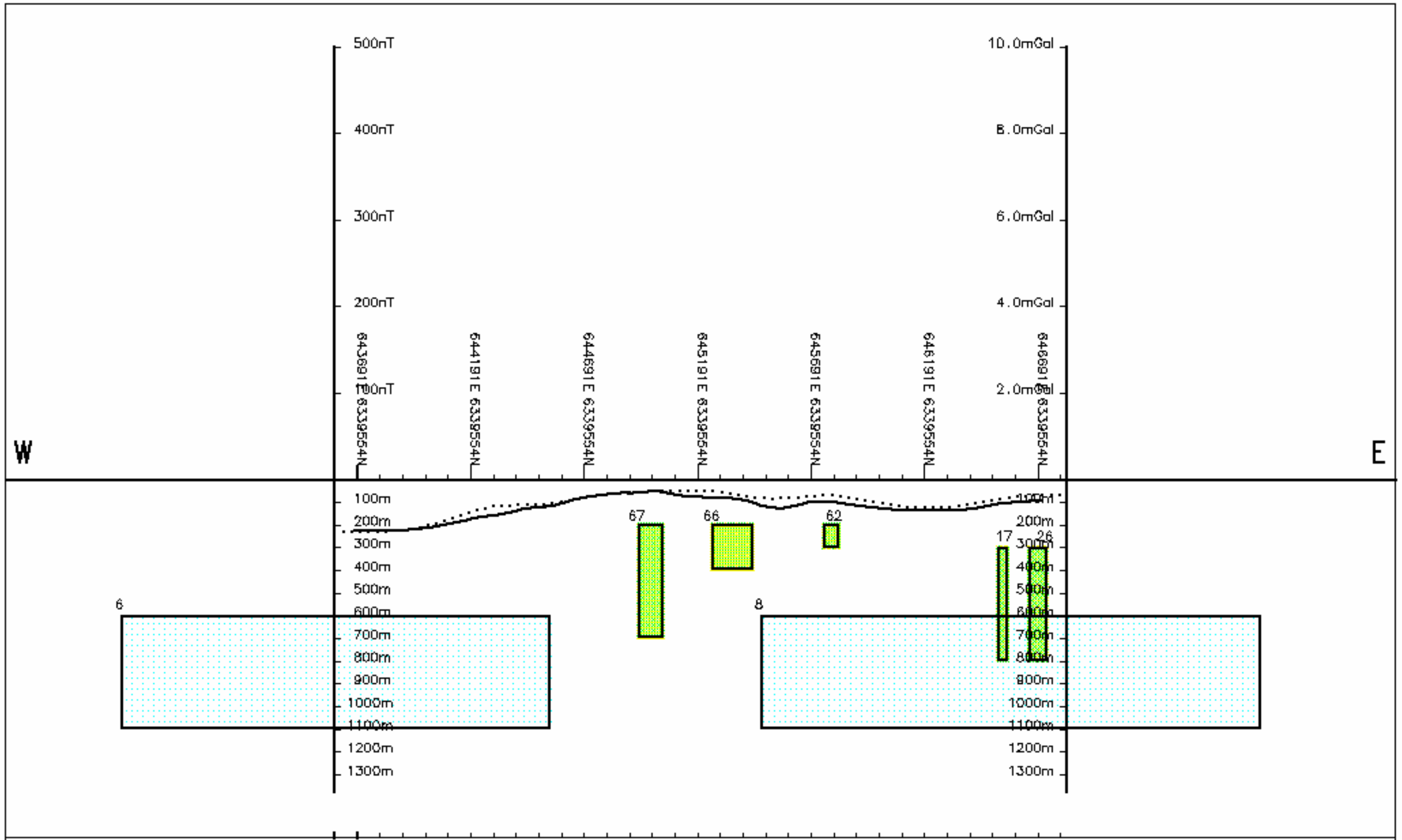

18\04\18
Body Susc(contrast) Den(contrast) Depth
6 -0.013(-0.013) 2.650(0.000) 600.
8 -0.005(-0.005) 2.650(0.000) 600.
16 0.017(0.017) 2.663(0.013) 300.
39 0.013(0.013) 2.661(0.010) 250.
68 0.010(0.010) 2.658(0.008) 200.
W
E
Profile 10: from (643590E,6340046N) to (646814E,6340046N)
StationInt 100, 100m 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

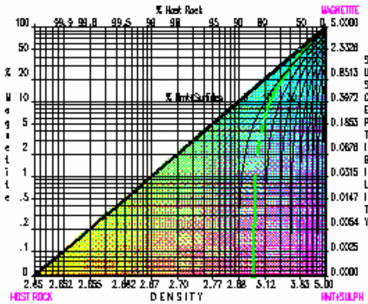
Figure 5.10

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.



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

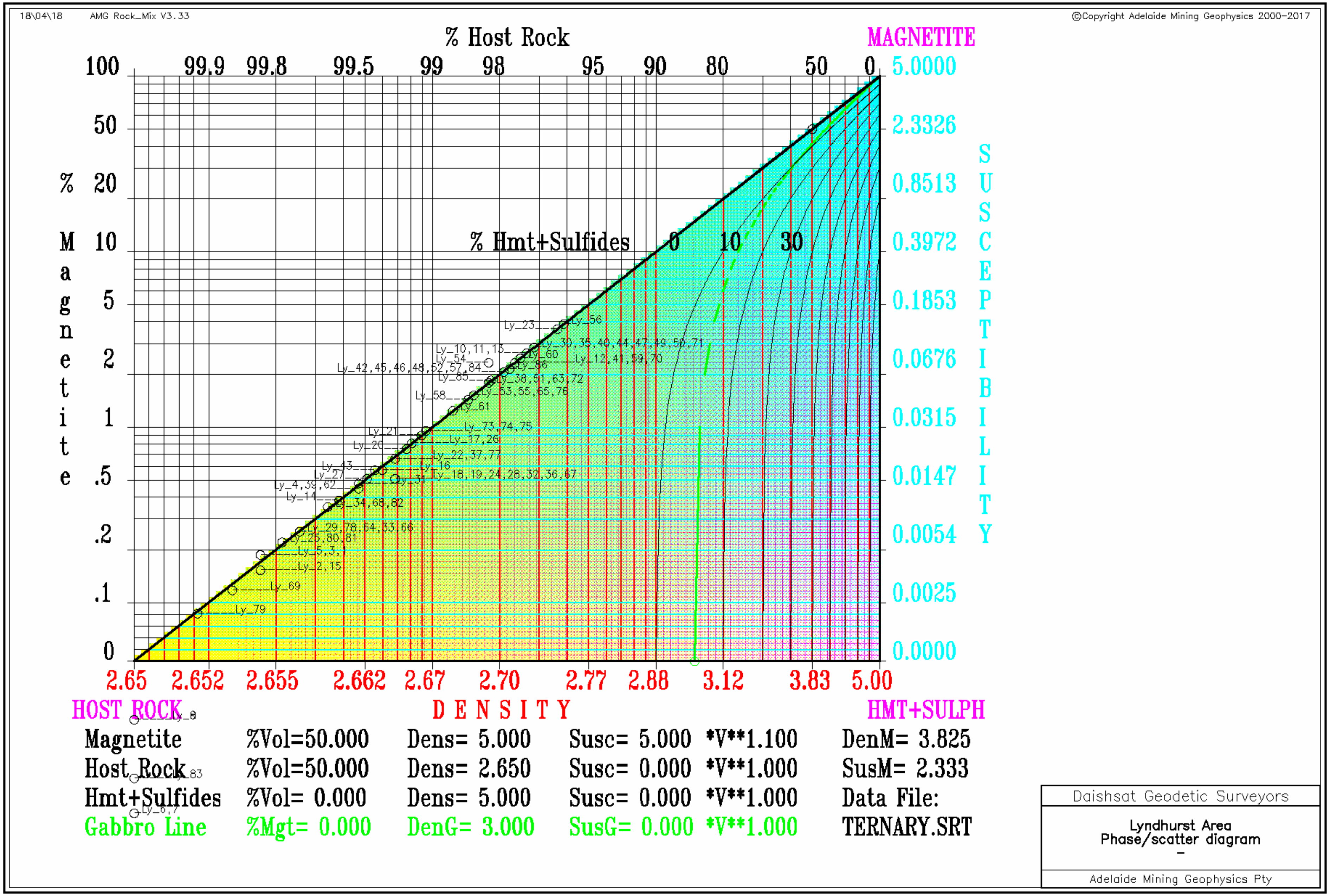
Profile azimuth: 90.
Mag Data file: LY_1804M.8TH

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
% Magnetite
100 50 20 10 5 2 1 .5 .2 .1 0
SUSCEPTIBILITY
% 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

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Napandee 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.

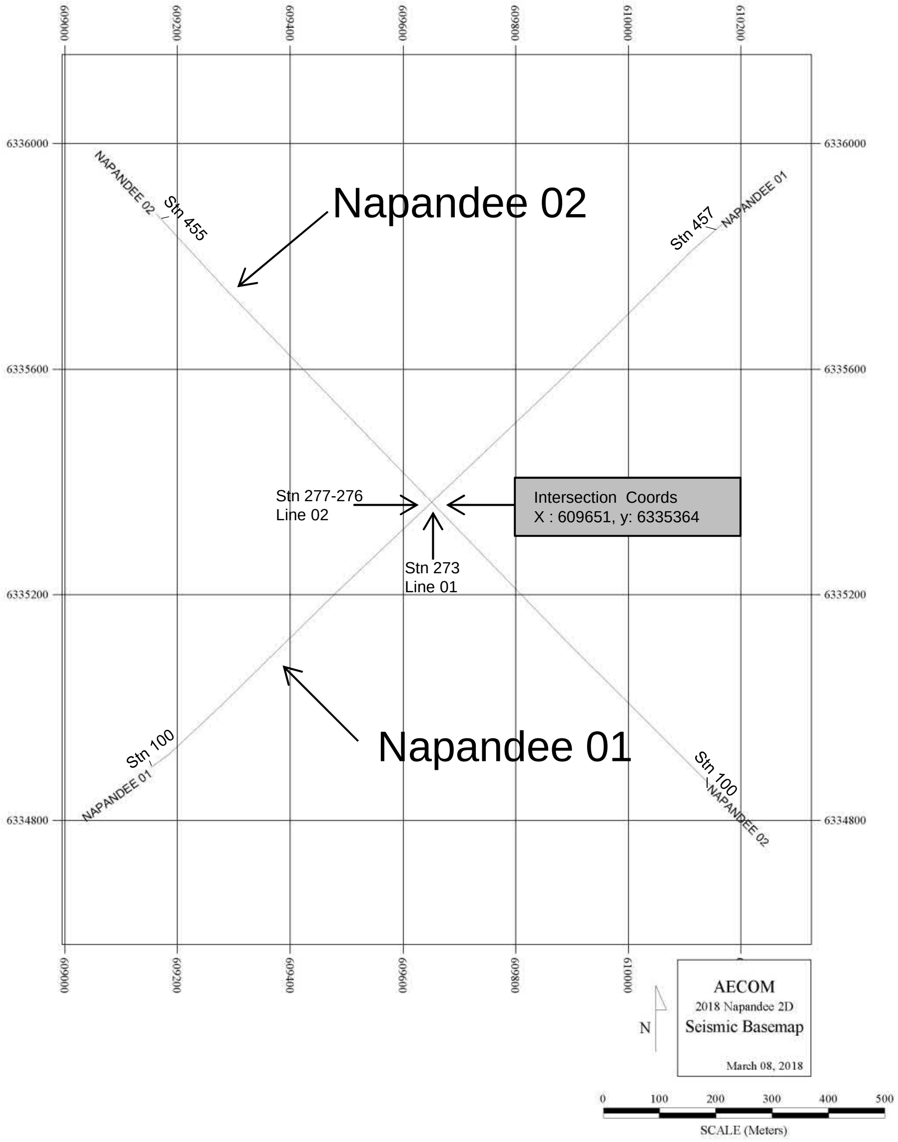
Depth of Weathering profiles, derived from refraction statics, have been annotated across the top of each interpreted section. Slides 6 & 9 zoom in on the shallow areas of each line and provide more detail on depth of weathering along each section, including the approximate position of the top of the 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.

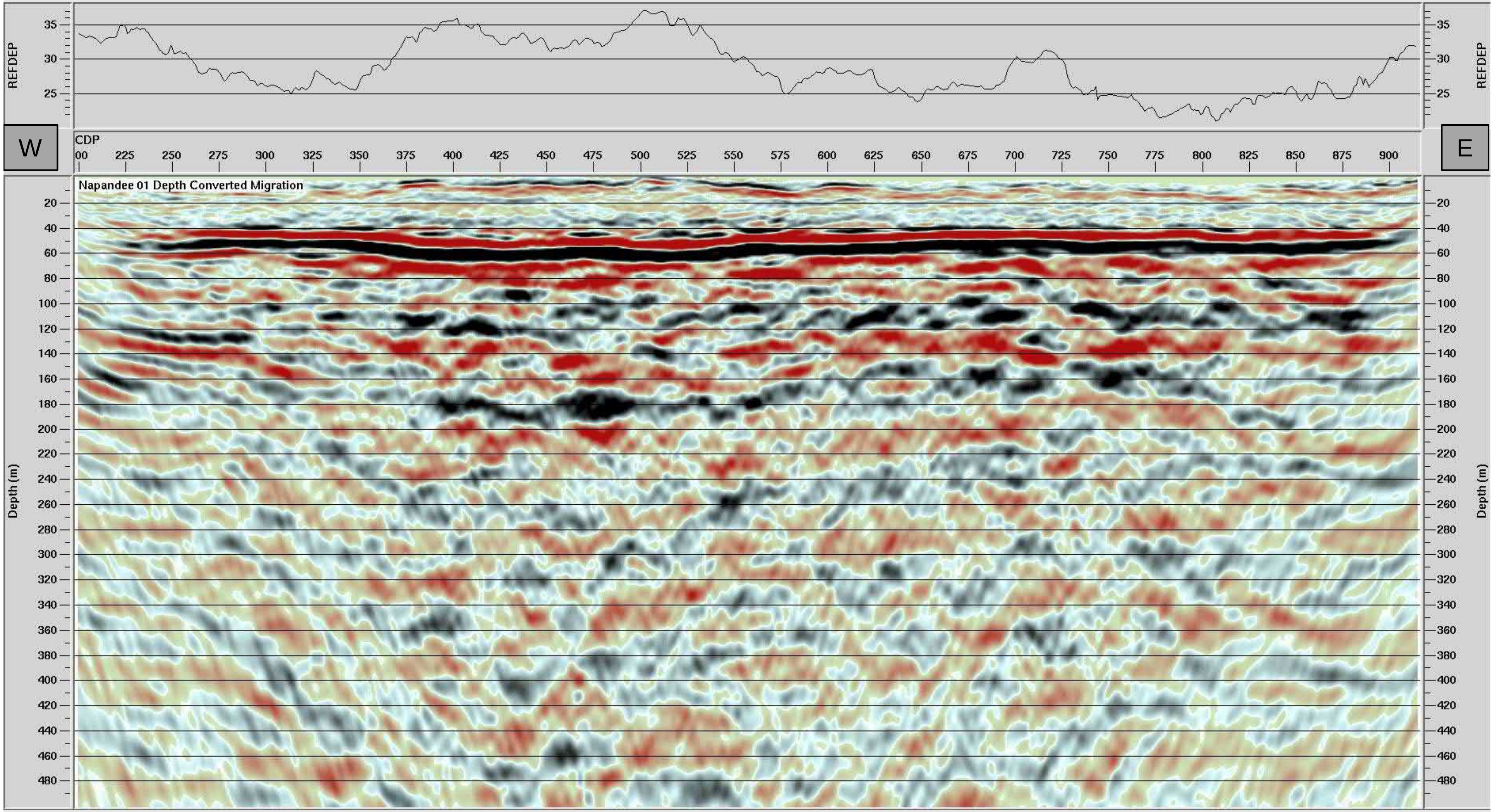
Where possible, stratigraphic horizons have been interpreted across some interpreted structures and are indicated by the aqua horizons.

It must be noted that until online borehole data becomes available, these interpreted sections are preliminary, and may alter with further information.



Napandee 02
Napandee 01
NAPANDEE 02
NAPANDEE 01
Stn 455
Stn 457
Stn 100
Stn 100
Stn 277-276
Line 02
Stn 273
Line 01
Intersection Coords
X : 609651, y: 6335364
6336000
6335600
6335200
6334800
609000
609200
609400
609600
609800
610000
610200
N
AECOM
2018 Napandee 2D
Seismic Basemap
March 08, 2018
0 100 200 300 400 500
SCALE (Meters)

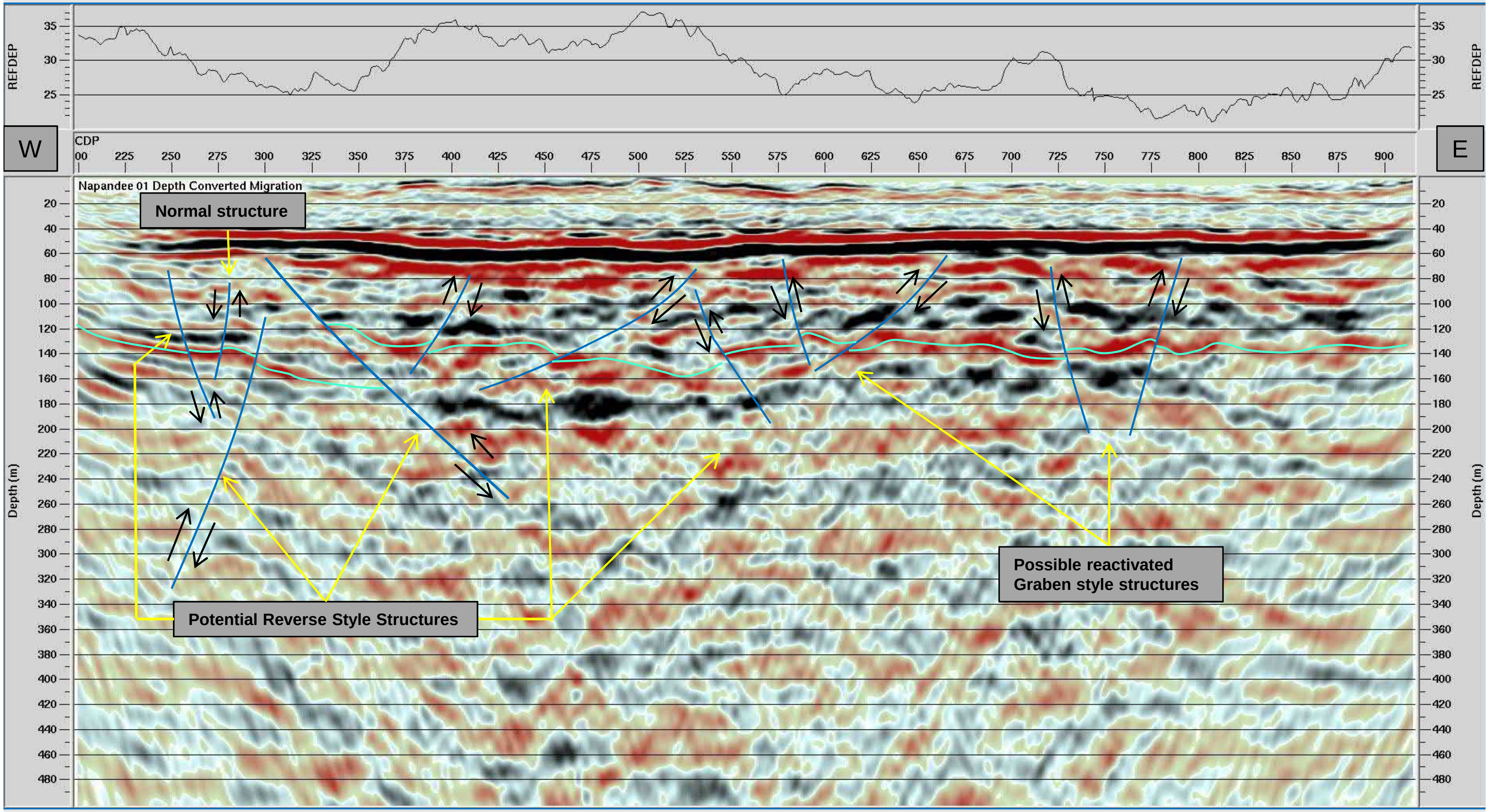
Napandee 01 Depth Converted Migrated Stack
No Interpretation



14 March, 2018
Velseis Processing

AECOM
2018 2D Seismic Program

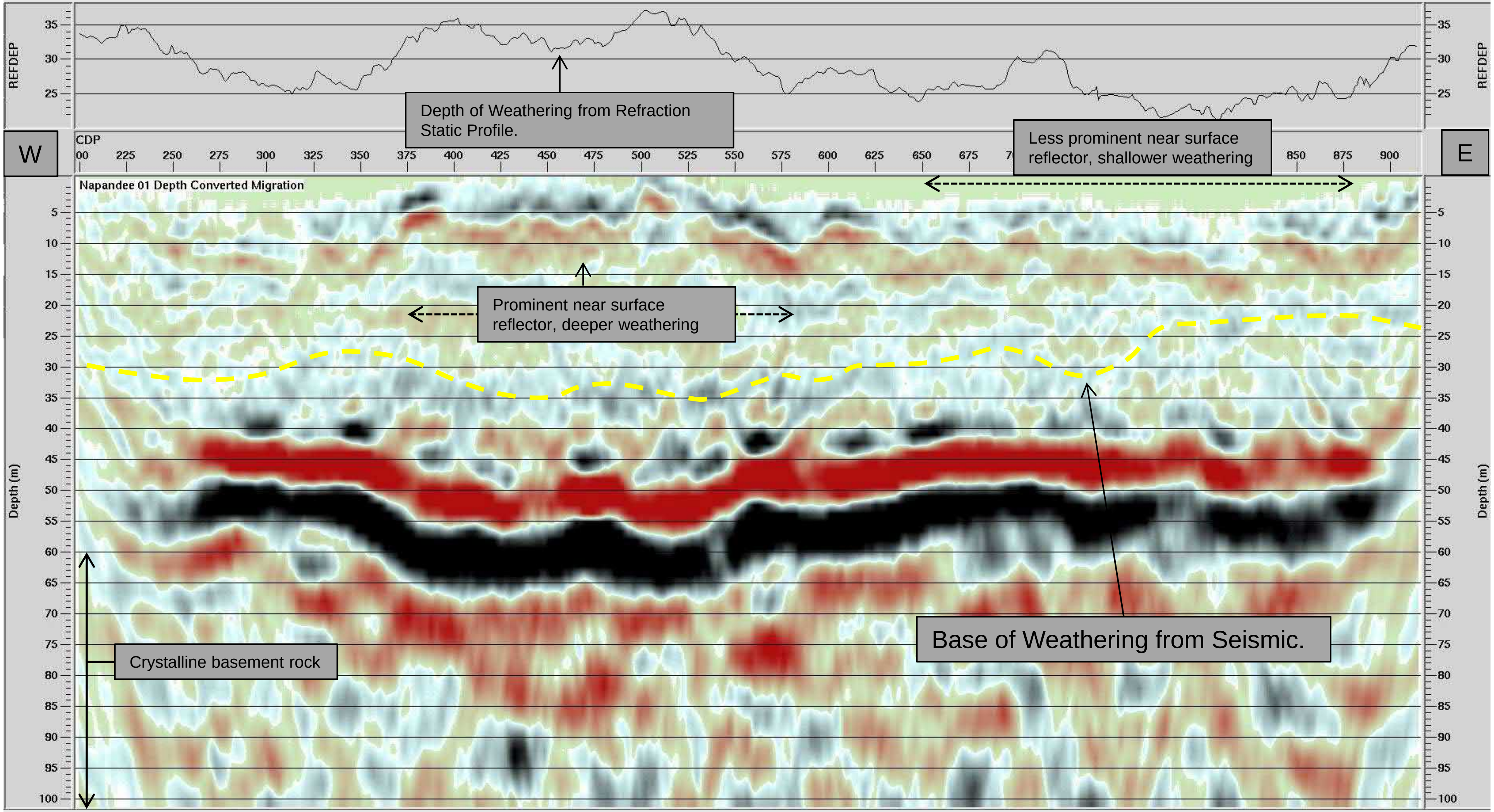
Napandee 01 Depth Converted Migrated Stack
Interpreted Structure



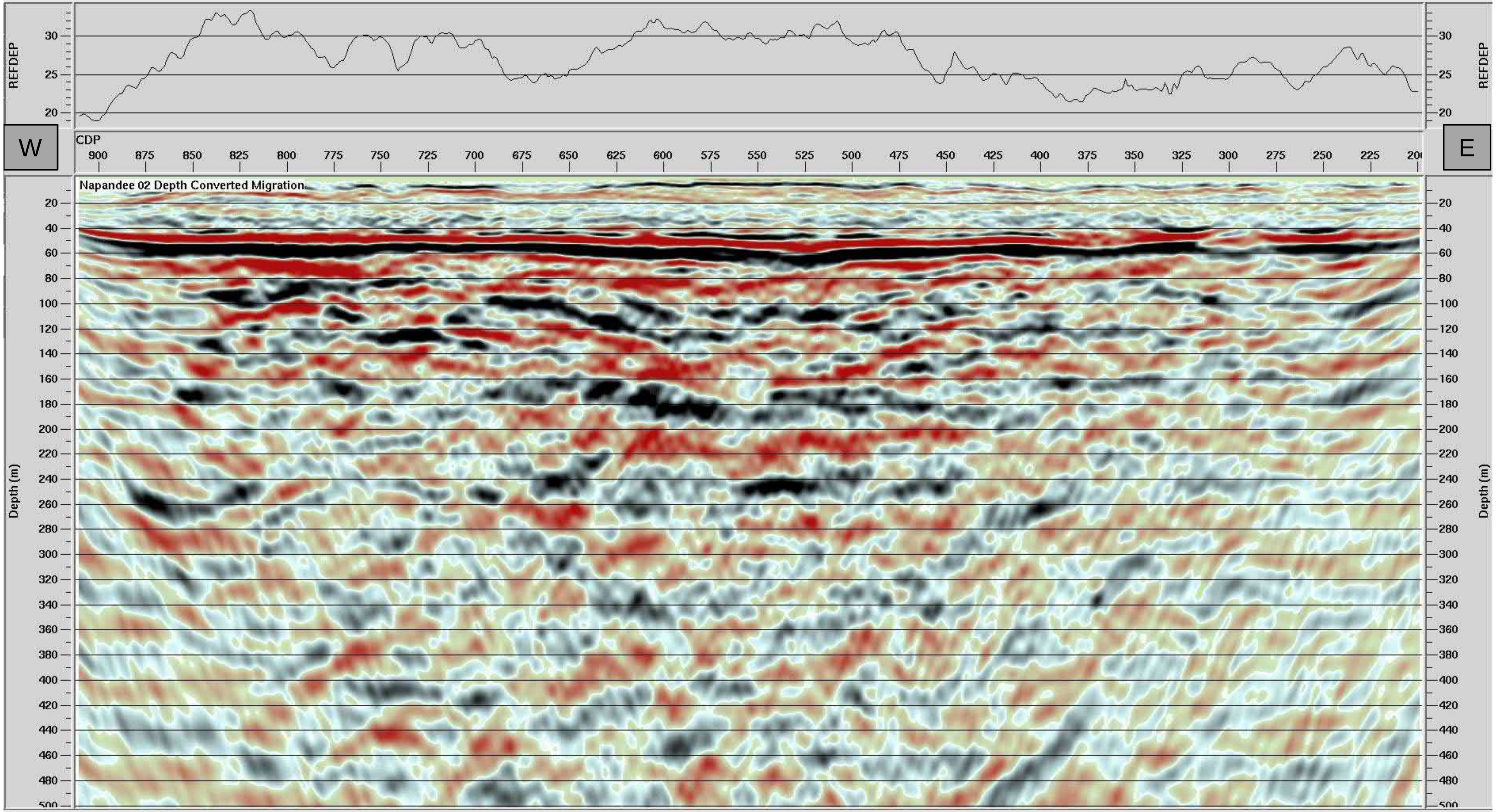
14 March, 2018
Velseis Processing

AECOM
2018 2D Seismic Program

Napandee 01 Depth Converted Migrated Stack
Interpreted Section at near surface



Napandee 02 Depth Converted Migrated Stack



Velseis

14 March, 2018
Velseis Processing

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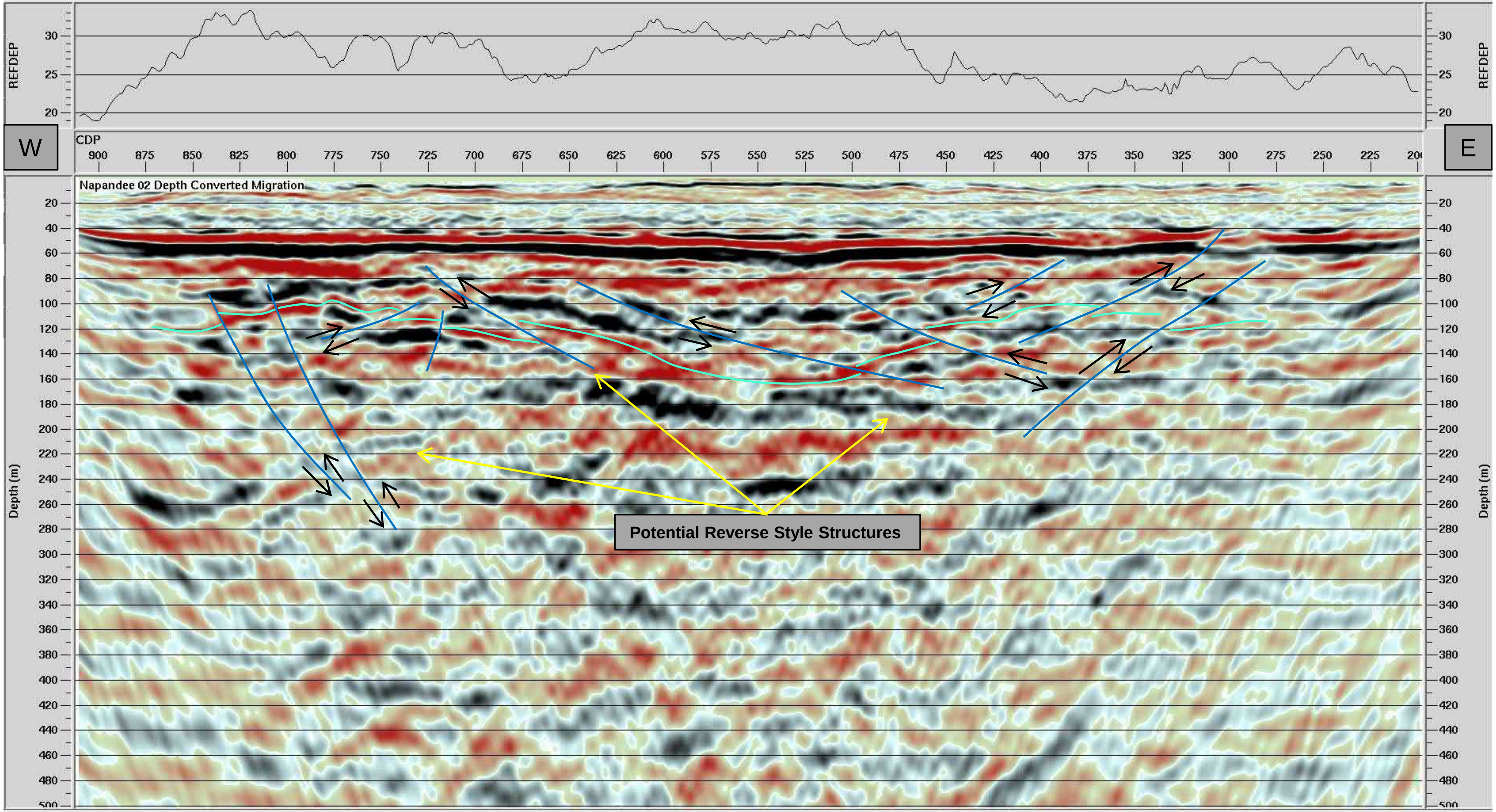
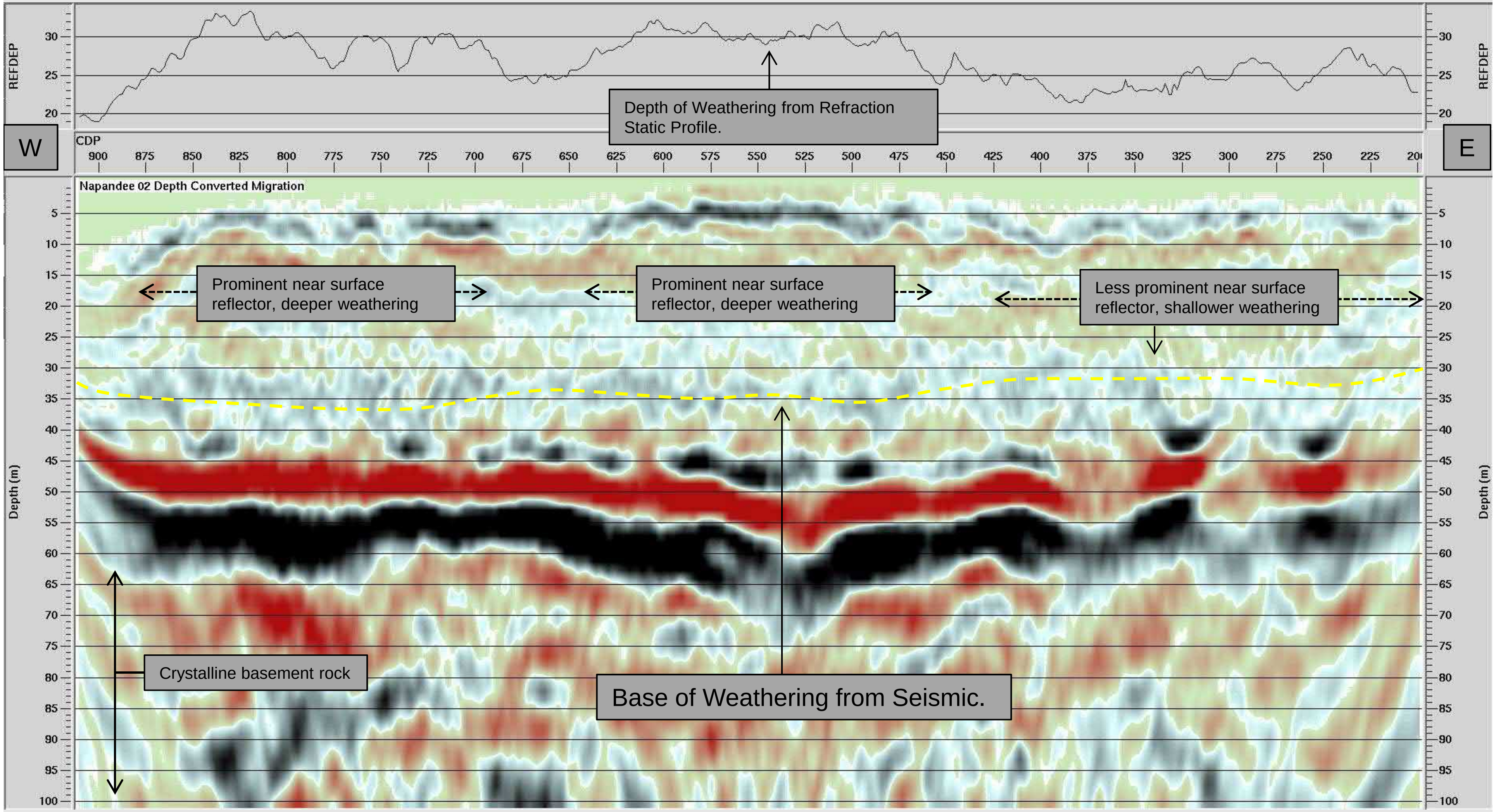
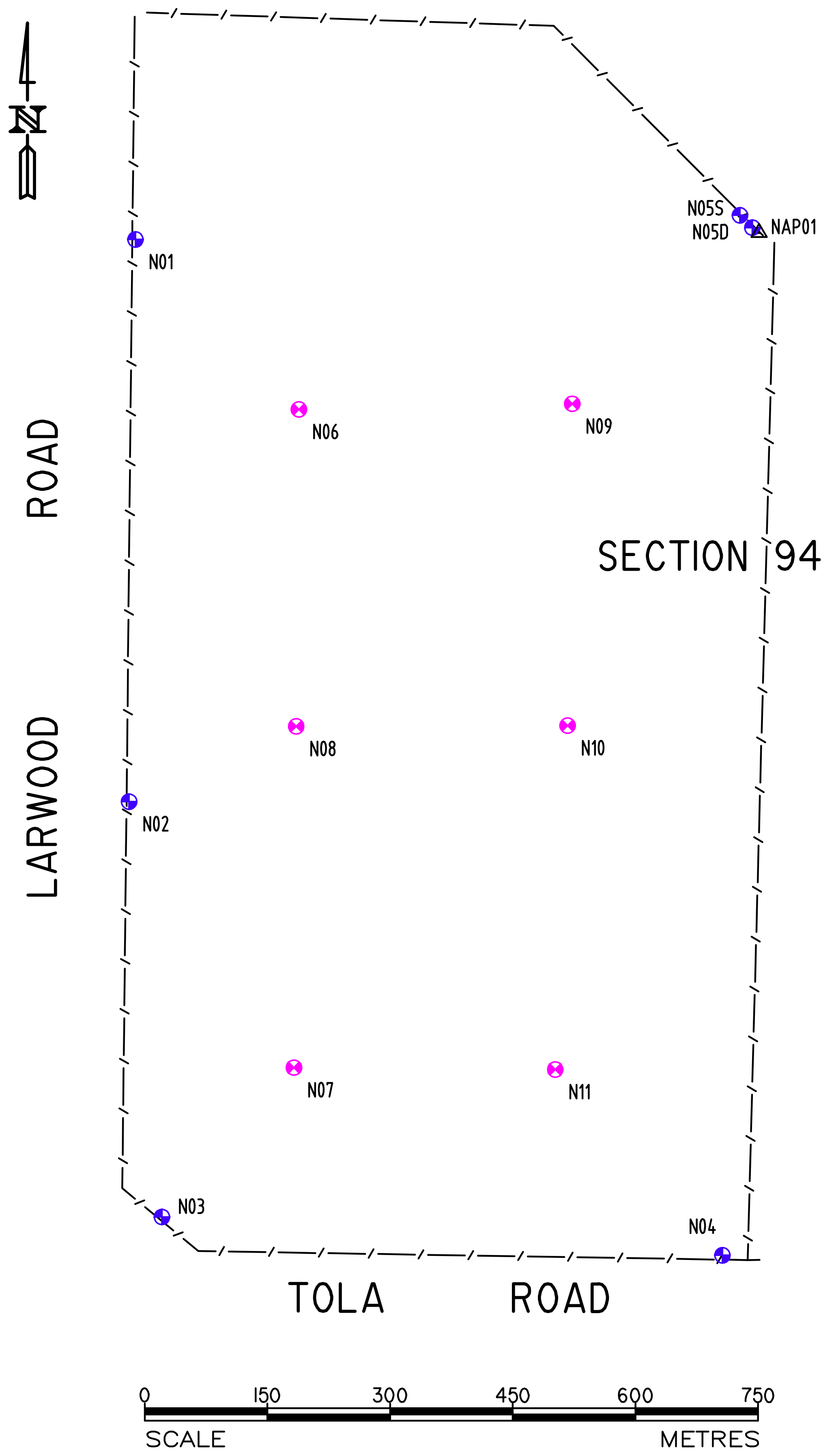
2018 2D Seismic Program

Napandee 02 Depth Converted Migrated Stack
Interpreted Structure



Napandee 02 Depth Converted Migrated Stack
Interpreted Section at near surface





Point ID	East	North	PVC Pipe RL	Lid RL	Ground RL	RL	Description
EXISTING BORE	610285.38	6335116.64			200.954	201.116	EXISTING BORE (Brass fitting)
N01	609162.92	6335603.15	184.745	184.828	183.967		50 mm PVC BORE TOP
N02	609155.12	6334916.24	185.532	185.627	184.989		50 mm PVC BORE TOP
N03	609195.29	6334408.71	184.595	184.731	183.827		50 mm PVC BORE TOP
N04	609880.58	6334361.97	194.010	194.094	193.560		50 mm PVC BORE TOP
N05D (deep)	609917.14	6335617.58	199.080	199.219	198.604		50 mm PVC BORE TOP
N05S (shallow)	609901.94	6335632.68	198.810	198.884	198.235		50 mm PVC BORE TOP
N06	609362.75	6335395.50			192.345		Testhole Surface RL
N07	609356.65	6334591.23			192.046		Testhole Surface RL
N08	609359.42	6335008.19			188.582		Testhole Surface RL
N09	609696.95	6335402.32			195.471		Testhole Surface RL
N10	609691.26	6335009.12			199.799		Testhole Surface RL
N11	609676.16	6334588.89			196.718		Testhole Surface RL
NAP01	609925.49	6335611.54				198.996	DROPPER-SURVEY BASE

EXISTING BORE

LEGEND

TEST HOLE
BORE HOLE
FENCE

EXAMPLE BORE

DEVELOP WITH CONFIDENCE ™

veris

Ground Floor, 22 Chancery Lane
Adelaide SA 5000
08 8100 5700
adelaide@veris.com.au
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_D1_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_D1 REV 0 SHEET No: 1 OF 1

AECOM AUSTRALIA PTY LTD
BORE HOLE LOCATIONS

NAPANDEE
23km WEST OF KIMBA

AECOM

Engineering Summary Log

BOREHOLE No. **N01**

Client: Department of Industry, Innovation and Science
Project: NRWMF - Site Characterisation
Location: Napandee (Kimba)
Drilling Water: Potable water sourced from Kimba (measured EC <1000 µS/cm)

Project No: 60565376
Logged by: TS
Checked by: HS

Start Date: 24/04/2018
End Date: 25/04/2018
Location Meth.: dGPS0.1

Driller: SWD
Drill Rig: Sonic (Geoprobe)

Hole Diameter: 169 mm
Inclination: -90°
Bearing: N/A

Easting: 609162.9 m
Northing: 6335603.2 m
Hor. Proj/Dat: MGA94/GDA94-54J

RL: 184.0 m
Ver. Datum: AHD
Surface:

Field Data | **Material Description** | **Rock Condition** | **Piezometer Details** | **Downhole Wireline** | **Laboratory Testing** | **Geology**

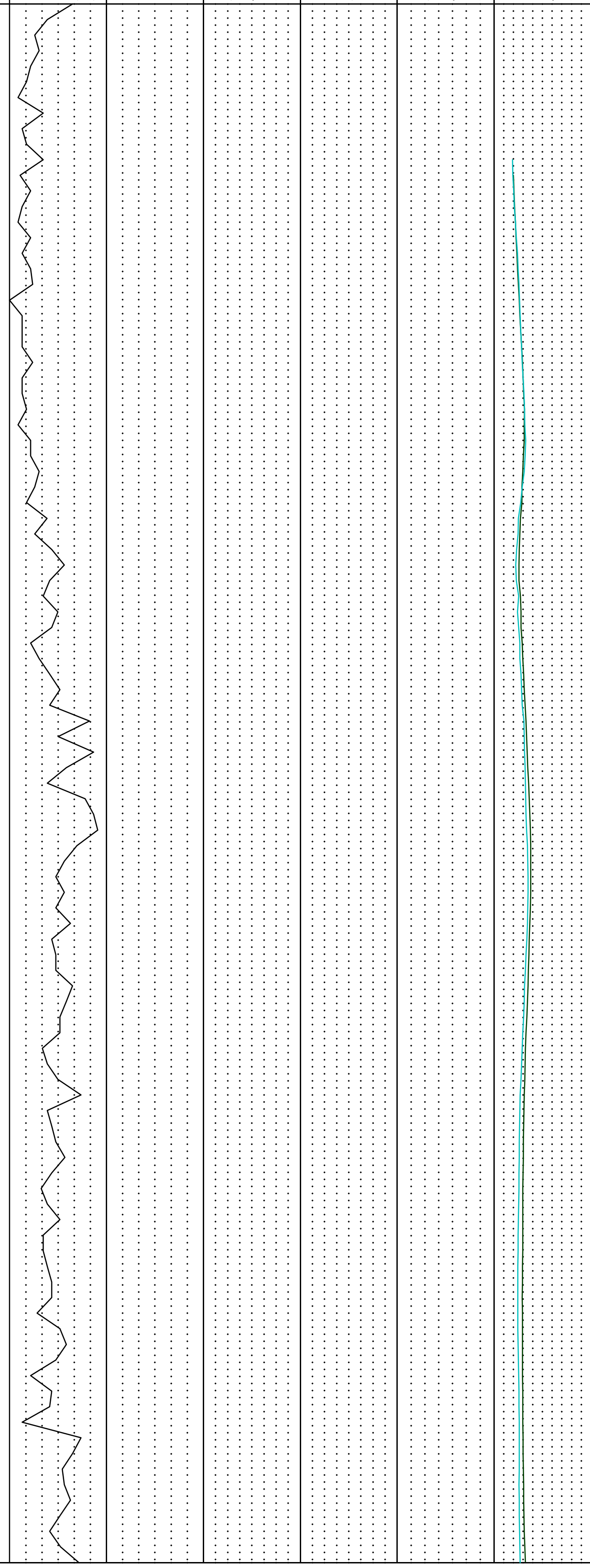
Columns: Reduced Level (m) Depth (m); Water; Field Tests; Samples; Graphic Log; Classification Symbol; Description; Weathering/ Consistency; TCR (SCR) [RQD] (%); Core Photo; Optical and Accoustic Televiewer (N E S W); Piezometer Details; Natural Gamma (API); Borehole Diameter (mm); Neutron Porosity (%); Density (g/cm3) (Short Density, Long Density); Neutron Log (CPS) (Short Neutron, Long Neutron); Induction (mS/m) (Short, Deep); Misc Laboratory Testing; Geochemical Testing; Geological Unit *(Geotech. Unit)*

Casing Top RL: 184.75 m AHD
Response Zone Top RL: -
Response Zone Base RL: -
Length of Response Zone: 6.00 m
Development Date: 26/04/2018

0.6 above ground to 0.0 m: Steel Monument

Depth (m)	Field Tests	Samples	Class. Symbol	Description
0.0			SM	silty SAND: fine grained; orange-brown; angular to sub-angular, siliceous, with silt, trace clay
0.3		N01_0.3-0.4		
0.7				becoming light red-brown; increasing clay content
1.5	SPT:10,12,16 N=28		CI	sandy CLAY: medium plasticity; red-brown; sand is fine grained, sub-angular, siliceous
2.9		N01_2.9-3.0		
3.0	SPT:15,17,15 N=32		GC	gravelly CLAY: low plasticity; brown,cream; with fine to coarse, angular to rounded gravel, trace fine to coarse grained sand
3.3				SILCRETE: fine grained; white-pink; very low to low strength, re-lithified bedrock insitu
4.0	SPT:10/0 N=R			
4.6				KAOLIN: fine grained; pink-grey; very low strength, residual soil, weathered bedrock insitu
5.0		N01_5.0-5.1		
5.9				from 5.90 m: white; very low to high strength quartz veins
6.6				from 6.60 m to 7.70 m: high strength bands, well cemented
7.7				from 7.70 m to 8.20 m: brown-yellow
8.2				at 8.20 m: white; very low strength, residual soil to extremely weathered insitu weathered bedrock

Depth scale: 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
Reduced Level: 183, 182, 181, 180, 179, 178, 177, 176, 175, 174



AECOM

Engineering Summary Log

Client: Department of Industry, Innovation and Science	**Project No:** 60565376	**Start Date:** 24/04/2018	**Driller:** SWD	**Hole Diameter:** 169 mm	**Easting:** 609162.9 m	**RL:** 184.0 m
Project: NRWMF - Site Characterisation	**Logged by:** TS	**End Date:** 25/04/2018	**Drill Rig:** Sonic (Geoprobe)	**Inclination:** -90°	**Northing:** 6335603.2 m	**Ver. Datum:** AHD
Location: Napandee (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**

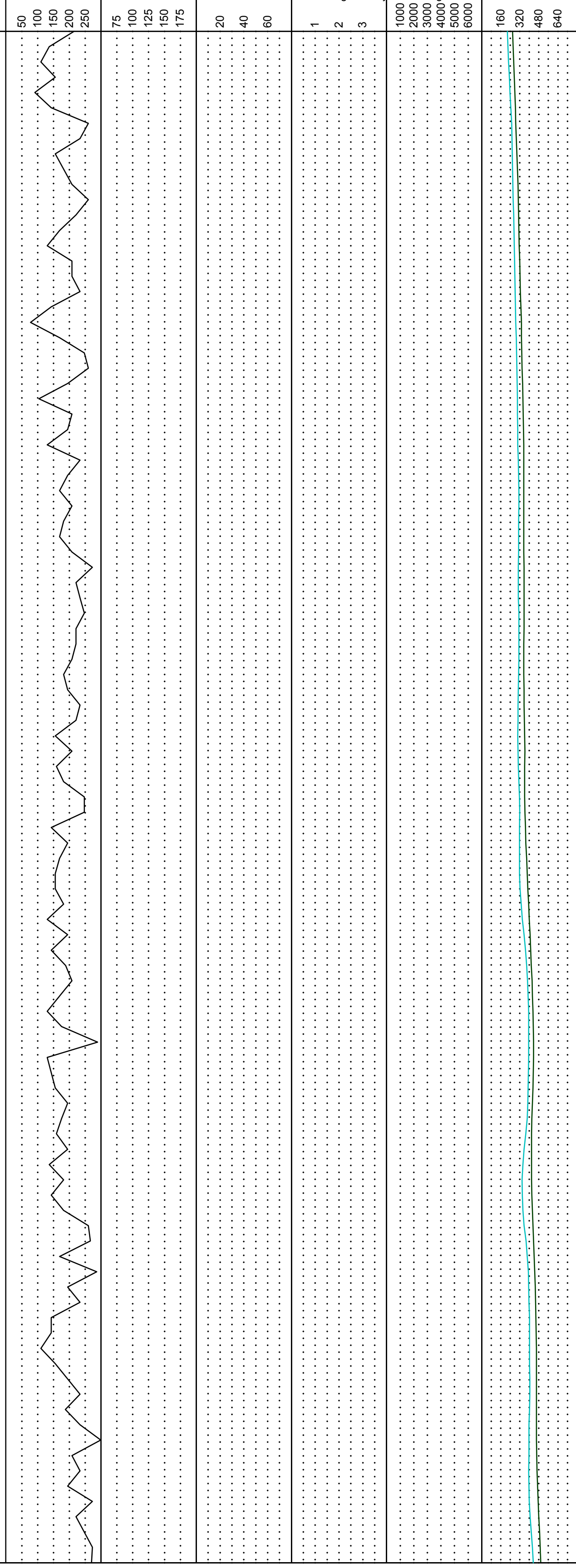
Columns: Reduced Level (m) / Depth (m); Water; Field Tests; Samples; Graphic Log; Classification Symbol; Description; Weathering/Consistency; TCR (SCR) [RQD] (%); Core Photo; Optical and Accoustic Televiewer (N E S W); Piezometer; Natural Gamma (API); Borehole Diameter (mm); Neutron Porosity (%); Density (g/cm3) — Short Density, Long Density; Neutron Log (CPS) — Short Neutron, Long Neutron; Induction (mS/m) — Short, Deep; Misc Laboratory Testing; Geochemical Testing; Geological Unit (Geotech. Unit)

Casing Top RL: 184.75 m AHD
Response Zone Top RL: -
Response Zone Base RL: -
Length of Response Zone: 6.00 m
Development Date: 26/04/2018

Depth (m)	Samples	Description
10.0–11.8		KAOLIN: fine grained; white; residual soil - extremely weathered, very low strength, very friable (insitu weathered bedrock)
11.8–13.3	N01_13.0-13.1	METAMORPHIC GNEISS: fine to medium grained; light grey; extremely low strength - highly weathered, very low strength from 12.20 m: red-brown; highly weathered, very low strength
13.3–20.0	N01_15.3-15.4	KAOLIN: fine to medium grained; white; extremely weathered, very low strength, with fine to medium grained quartz gravel from 15.00 m: light grey-pink; highly weathered, very low strength from 15.20 m: quartz crystals throughout from 15.40 m: white, pink and red; highly weathered from 16.00 m: iron staining occuring around quartz crystals and bands

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: 173, 172, 171, 170, 169, 168, 167, 166, 165, 164

Piezometer:
0.0 to 24.0 m: CEMENT/ BENTONITE GROUT
0.0 to 28.0 m: Solid Pipe



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Engineering Summary Log

BOREHOLE No. N01

Client: Department of Industry, Innovation and Science	**Project No:** 60565376	**Start Date:** 24/04/2018	**Driller:** SWD	**Hole Diameter:** 169 mm	**Easting:** 609162.9 m	**RL:** 184.0 m
Project: NRWMF - Site Characterisation	**Logged by:** TS	**End Date:** 25/04/2018	**Drill Rig:** Sonic (Geoprobe)	**Inclination:** -90°	**Northing:** 6335603.2 m	**Ver. Datum:** AHD
Location: Napandee (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**

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) | 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: 184.75 m AHD
Response Zone Top RL: -
Response Zone Base RL: -
Length of Response Zone: 6.00 m
Development Date: 26/04/2018

Depth (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): 163, 162, 161, 160, 159, 158, 157, 156, 155, 154

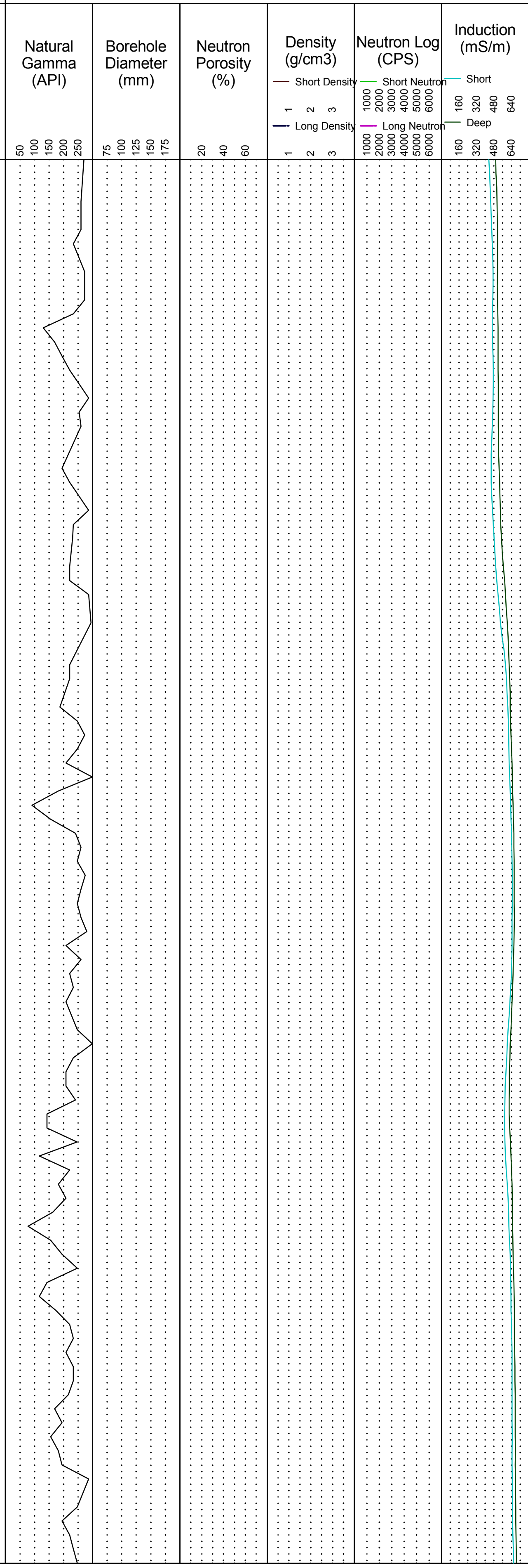
KAOLIN: fine to medium grained; light grey; extremely weathered, very low strength, very friable, most minerals weathered to clays

weathered pink/red mineral throughout matrix

from 25.00 m: trace iron staining, highly weathered, very low strength

METAMORPHIC GNEISS: fine to medium grained; light grey; extremely weathered - highly weathered, very low strength

24.0 to 27.0 m: BENTONITE SEAL (PELLETS)



AECOM

Engineering Summary Log

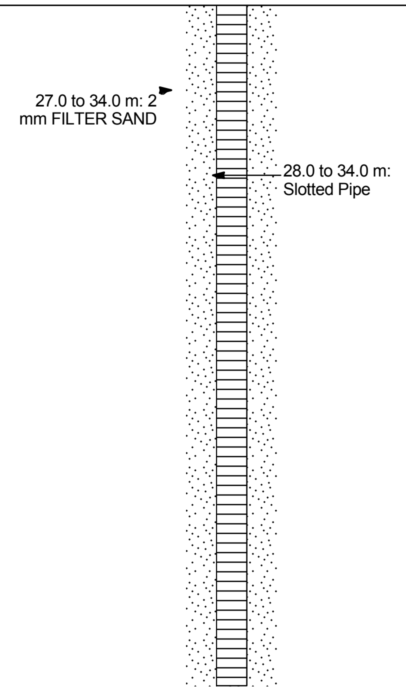
Client: Department of Industry, Innovation and Science	**Project No:** 60565376	**Start Date:** 24/04/2018	**Driller:** SWD	**Hole Diameter:** 169 mm	**Easting:** 609162.9 m
Project: NRWMF - Site Characterisation	**Logged by:** TS	**End Date:** 25/04/2018	**Drill Rig:** Sonic (Geoprobe)	**Inclination:** -90°	**Northing:** 6335603.2 m
Location: Napandee (Kimba)	**Checked by:** HS	**Location Meth.:** dGPS0.1		**Bearing:** N/A	**Hor. Proj/Dat:** MGA94/GDA94-54J

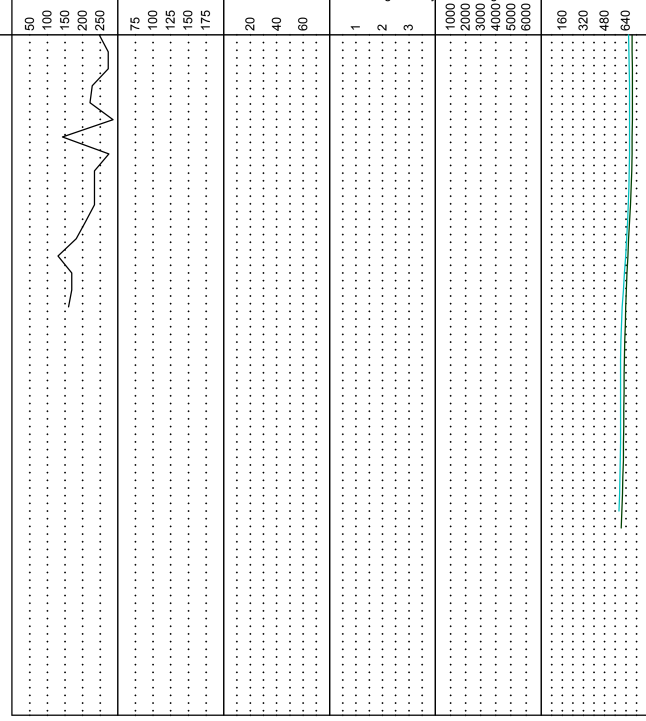
RL: 184.0 m **Ver. Datum:** AHD **Surface:**

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
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)	Casing Top RL: 184.75 m AHD; Response Zone Top RL: -; Response Zone Base RL: -; Length of Response Zone: 6.00 m; Development Date: 26/04/2018	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	Misc Laboratory Testing	Geochemical Testing	Geological Unit *(Geotech. Unit)*
30.0–34.0			N01_32.0-32.1 (32.0 m)			METAMORPHIC GNEISS: fine to medium grained; light grey; extremely weathered - highly weathered, very low strength *(continued)* from 30.00 m: friable, dark bands completed weathered to clays from 32.00 m to 32.30 m: weathered lense, weathered as sandy clay with quartz crystals up to 40 mm. NOTE: Water Strike not observed, formation very low yielding									
34.0–40.0						*Borehole N01 log continued as cored log from m.*									

Depth scale (m): 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
Reduced level scale (m): 153, 152, 151, 150, 149, 148, 147, 146, 145, 144





Client: Department of Industry, Innovation and Science	**Project No:** 60565376	**Start Date:** 25/04/2018	**Driller:** SWD	**Hole Diameter:** 169 mm	**Easting:** 609155.1 m	**RL:** 185.0 m
Project: NRWMF - Site Characterisation	**Logged by:** TS	**End Date:** 26/04/2018	**Drill Rig:** Sonic (Geoprobe)	**Inclination:** -90°	**Northing:** 6334916.2 m	**Ver. Datum:** AHD
Location: Napandee (Kimba)	**Checked by:** HS	**Location Meth.:** dGPS0.1		**Bearing:** N/A	**Hor. Proj/Dat:** MGA94/GDA94-54H	**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

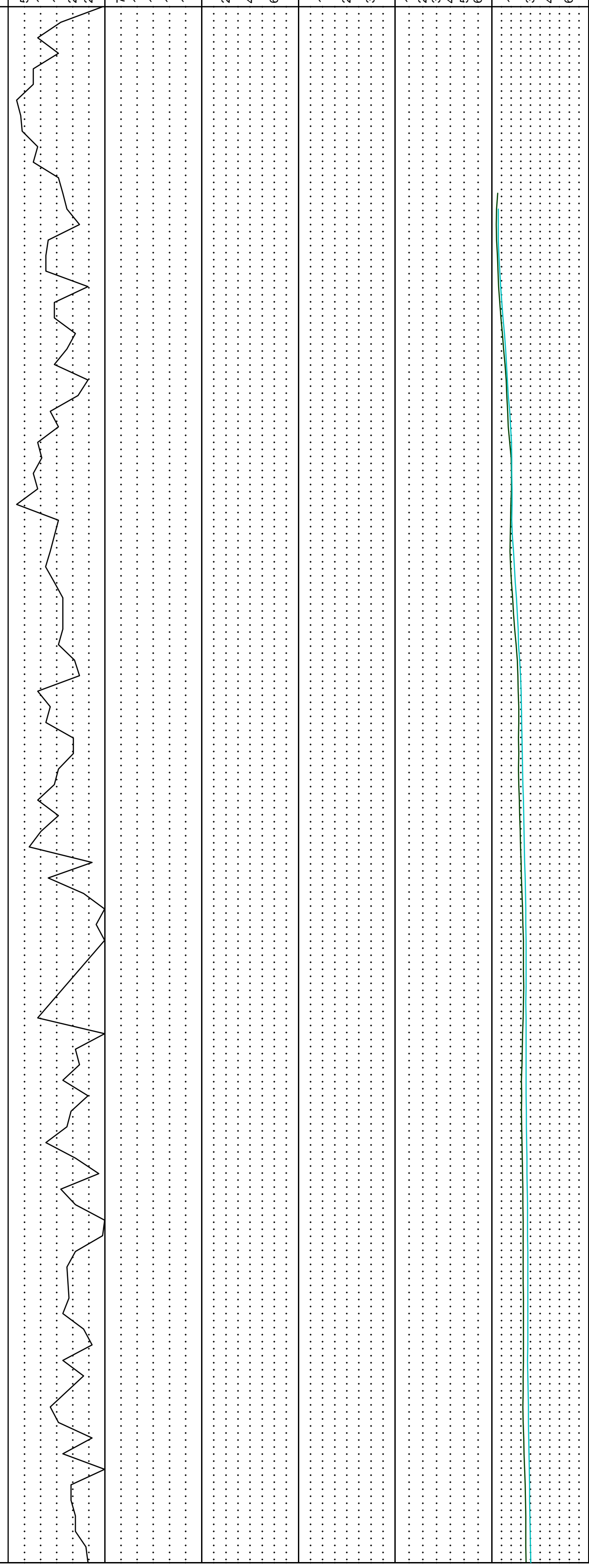
Casing Top RL: 185.53 m AHD
Response Zone Top RL: -
Response Zone Base RL: -
Length of Response Zone: 6.00 m
Development Date: 2/05/2018

0.6 above ground to 0.0 m: Steel Monument

Depth (m)	Reduced Level (m)	Water	Field Tests	Samples	Classification Symbol	Description	Weathering/ Consistency	TCR (SCR) [RQD] (%)	Core Photo	Optical and Accoustic Televiewer	Misc Laboratory Testing	Geochemical Testing	Geological Unit (Geotech. Unit)
0.0	185			N02_0-0.1, QC03, QC04	SM	silty SAND: fine grained; red-brown; sub-angular to sub-rounded siliceous, with silt							
0.7					SM	silty clayey SAND: fine to coarse grained; light brown-red; sub-angular to sub-rounded, siliceous, with silt and calcareous clays							
1.3						SILCRETE: fine grained; cream; moderate strength, poorly cemented							
1.5			SPT:/0 N=R			from 1.50 m: very high strength, strongly cemented							
2.8				N02_2.8-3		from 2.80 m: low strength, poorly cemented							
2.9					CH-CI	CLAY: medium to high plasticity; brown; trace sand (cherty?) and gravel (cherty)							
3.1			SPT:10,5,3 N=8			SILCRETE: fine grained; cream-pink; very high strength, strongly cemented							
4.2						KAOLIN: fine grained; white; residual - extremely weathered, very low to low strength, trace micas							
4.5			SPT:17,30,/0 N=R										
5.7						at 5.70 m: white-grey							
6.0			SPT:19,>40 N=R			at 6.00 m: residual, very low strength, clayey							
8.0						at 8.00 m: extremely weathered, very low strength, trace iron staining							
10.0	175												

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 2000 3000 4000 5000 6000
Induction (mS/m): — Short — Deep; 160 320 480 640



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Engineering Summary Log

BOREHOLE No. N02

Client:	Department of Industry, Innovation and Science	**Project No:**	60565376	**Start Date:**	25/04/2018	**Driller:**	SWD	**Hole Diameter:**	169 mm
Project:	NRWMF - Site Characterisation	**Logged by:**	TS	**End Date:**	26/04/2018	**Drill Rig:**	Sonic (Geoprobe)	**Inclination:**	-90°
Location:	Napandee (Kimba)	**Checked by:**	HS	**Location Meth.:**	dGPS0.1			**Bearing:**	N/A

Easting:	609155.1 m	**RL:**	185.0 m
Northing:	6334916.2 m	**Ver. Datum:**	AHD
Hor. Proj/Dat:	MGA94/GDA94-54H	**Surface:**	

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

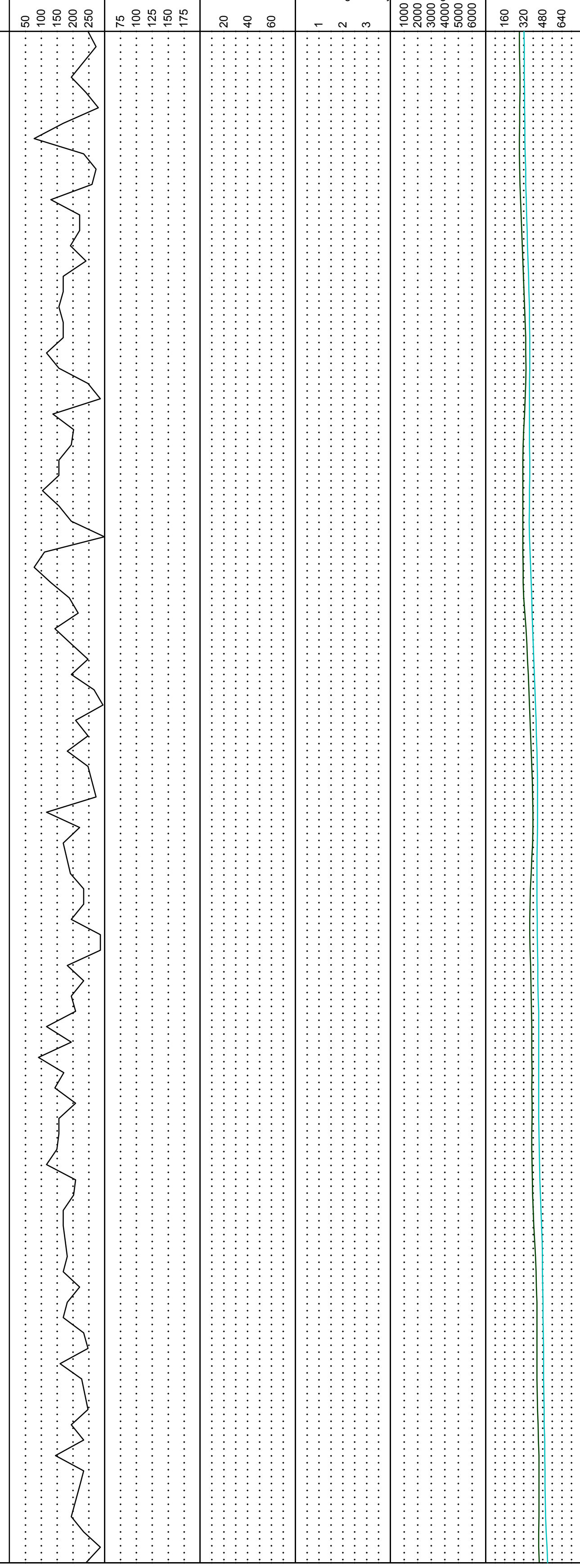
Casing Top RL: 185.53 m AHD
Response Zone Top RL: -
Response Zone Base RL: -
Length of Response Zone: 6.00 m
Development Date: 2/05/2018

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)*

Depth (m)	RL (m)	Samples	Description	Piezometer Details
10.0–10.5			KAOLIN: fine to medium grained; light grey; extremely weathered, very low strength, faint banding / foliation visible in rock, mostly clays and quartz remain	0.0 to 21.0 m: CEMENT/ BENTONITE GROUT
11.0	174			
11.5				
12.0	173	N02_12-12.1		
12.5				0.0 to 25.0 m: Solid Pipe
13.0	172			
13.5				
14.0	171			
14.5			from 14.70 m: grey-pink; clayey core returns	
15.0	170			
15.5			from 15.50 m: residual - extremely weathered	
16.0	169		at 16.00 m: pale grey	
16.5				
17.0	168			
17.5				
18.0	167		from 18.20 m: brown staining	
18.5				
19.0	166			
19.5				
20.0	165			



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Engineering Summary Log

BOREHOLE No. N02

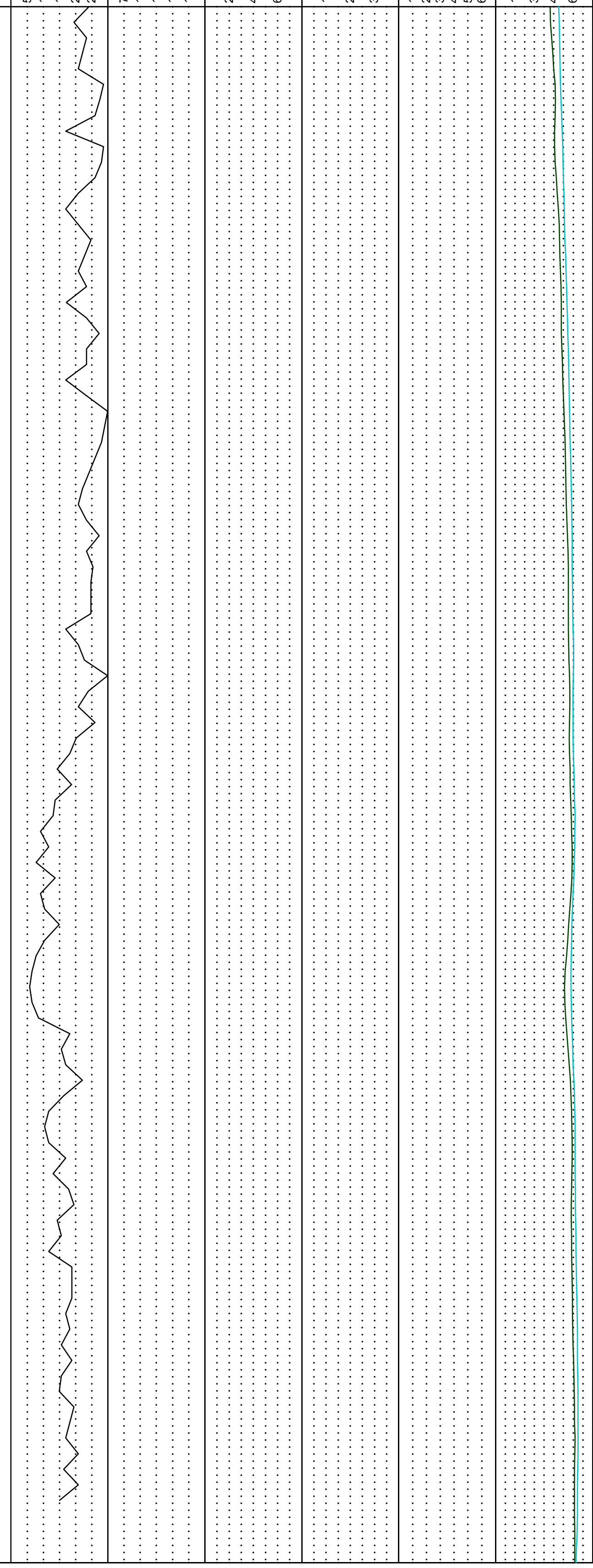
Client:	Department of Industry, Innovation and Science	**Project No:** 60565376	**Start Date:** 25/04/2018	**Driller:** SWD	**Hole Diameter:** 169 mm	**Easting:** 609155.1 m	**RL:** 185.0 m
Project:	NRWMF - Site Characterisation	**Logged by:** TS	**End Date:** 26/04/2018	**Drill Rig:** Sonic (Geoprobe)	**Inclination:** -90°	**Northing:** 6334916.2 m	**Ver. Datum:** AHD
Location:	Napandee (Kimba)	**Checked by:** HS	**Location Meth.:** dGPS0.1		**Bearing:** N/A	**Hor. Proj/Dat:** MGA94/GDA94-54H	**Surface:**

Drilling Water: Potable water sourced from Kimba (measured EC <1000 µS/cm)

Piezometer Details

Casing Top RL: 185.53 m AHD
Response Zone Top RL: -
Response Zone Base RL: -
Length of Response Zone: 6.00 m
Development Date: 2/05/2018

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)
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)*



Depth (m)	RL (m)	Water	Samples	Description	Piezometer Details	Misc Laboratory Testing
20.5				KAOLIN: fine to medium grained; light grey; extremely weathered, very low strength, faint banding / foliation visible in rock, mostly clays and quartz remain *(continued)* at 20.30 m: extremely weathered		
21.0	164					
21.5						
22.0	163					
22.5					21.0 to 24.0 m: BENTONITE SEAL (PELLETS)	
23.0	162					
23.5		∇				
24.0	161			METAMORPHIC GNEISS: fine to medium grained; white-grey; residual, very low strength, mostly clay, laminated-banded		
24.5						
25.0	160		N02_25-25.1	from 25.00 m: grey; very clayey		N02_25.0-25.1: XRD: Kandite group/ serpentinite 84%; Muscovite 8%; Quartz 8%; Halite <1%
25.5						
26.0	159			from 25.80 m: residual, gravelly clay lens from 26.20 m: residual, mostly clay		
26.5						
27.0	158		N02_27-27.1	from 27.00 m: residual, Sand, fine to medium grained, grey-red from 27.20 m: dark grey-pink; residual - extremely weathered, parent rock structure visible		
27.5						
28.0	157				25.0 to 31.0 m: Slotted Pipe	
28.5					24.0 to 33.0 m: 2 mm FILTER SAND	
29.0	156					
29.5						
30.0	155			from 29.70 m: dark grey; extremely weathered		

Client:	Department of Industry, Innovation and Science	**Project No:**	60565376	**Start Date:**	25/04/2018	**Driller:**	SWD	**Hole Diameter:**	169 mm
Project:	NRWMF - Site Characterisation	**Logged by:**	TS	**End Date:**	26/04/2018	**Drill Rig:**	Sonic (Geoprobe)	**Inclination:**	-90°
Location:	Napandee (Kimba)	**Checked by:**	HS	**Location Meth.:**	dGPS0.1			**Bearing:**	N/A

Easting:	609155.1 m	**RL:**	185.0 m
Northing:	6334916.2 m	**Ver. Datum:**	AHD
Hor. Proj/Dat:	MGA94/GDA94-54H	**Surface:**	

Drilling Water: Potable water sourced from Kimba (measured EC <1000 µS/cm)

Piezometer Details
- **Casing Top RL:** 185.53 m AHD
- **Response Zone Top RL:** -
- **Response Zone Base RL:** -
- **Length of Response Zone:** 6.00 m
- **Development Date:** 2/05/2018

Reduced Level (m)	Depth (m)	Description
	30.5	METAMORPHIC GNEISS: fine to medium grained; dark grey; extremely weathered, very low strength, faint banding / foliation visible
154	31.0	
	31.5	
153	32.0	from 31.80 m: extremely - highly weathered, iron staining, NOTE: Water strike not observed, formation very low yielding
	32.5	
152	33.0	*Borehole N02 log continued as cored log from m.*
	33.5	
151	34.0	
	34.5	
150	35.0	
	35.5	
149	36.0	
	36.5	
148	37.0	
	37.5	
147	38.0	
	38.5	
146	39.0	
	39.5	
145	40.0	

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 2000 3000 4000 5000 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

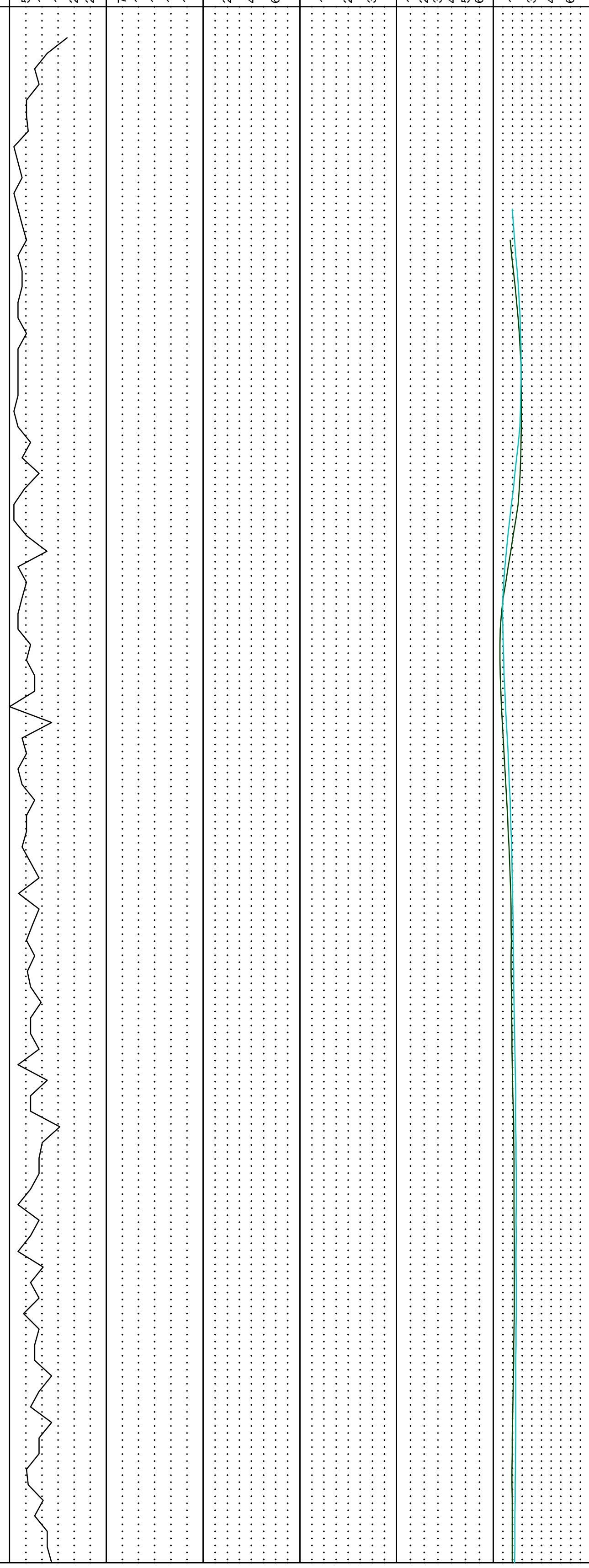
BOREHOLE No. N03
Sheet: 1 of 4

Client: Department of Industry, Innovation and Science	**Project No:** 60565376	**Start Date:** 01/05/2018	**Driller:** SWD	**Hole Diameter:** 169 mm	**Easting:** 609195.3 m	**RL:** 183.8 m
Project: NRWMF - Site Characterisation	**Logged by:** TS	**End Date:** 02/05/2018	**Drill Rig:** Sonic (Geoprobe)	**Inclination:** -90°	**Northing:** 6334408.7 m	**Ver. Datum:** AHD
Location: Napandee (Kimba)	**Checked by:** HS	**Location Meth.:** dGPS0.1		**Bearing:** N/A	**Hor. Proj/Dat:** MGA94/GDA94-54M	**Surface:**

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
Piezometer Details: Casing Top RL: 184.60 m AHD; Response Zone Top RL: -; Response Zone Base RL: -; Length of Response Zone: 6.00 m; Development Date: 7/05/2018; 0.6 above ground to 0.0 m: Steel Monument
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*)

RL (m)	Depth (m)	Field Tests	Classification Symbol	Description
	0.0		SP-SM	SAND: fine grained; brown; angular to sub-angular, quartz, trace silt
	0.5		SM	silty SAND: fine grained; red-brown; sub-angular to sub-rounded, quartz, with silt / clay (calcareous), trace gravel / calcrete
183	1.0			CALCRETE: fine grained; red-white; very low strength, poorly cemented with fine grained sand in matrix at 1.40 m: high strength
	1.5	SPT:16,16,16 N=32		SILCRETE: fine grained; red, white; very low strength, poorly cemented, with fine grained sands
182	2.0		CI-CL	sandy CLAY: low to medium plasticity; red-brown; sand is fine grained, angular
181	3.0	SPT:15/ N=R		SILCRETE: red, white; low strength, moderately cemented at 3.20 m: very low strength at 3.35 m: white, high strength at 3.37 m: cream, very low strength
	4.5	SPT:10/ N=R		KAOLIN: fine grained; white - cream; very low strength, trace quartz crystals from 6.10 m: medium to high strength, recemented, siliceous from 6.60 m: pale grey; very low strength, faint remnant foliation
174	10.0			



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Engineering Summary Log

Client: Department of Industry, Innovation and Science	**Project No:** 60565376	**Start Date:** 01/05/2018	**Driller:** SWD	**Hole Diameter:** 169 mm	**Easting:** 609195.3 m
Project: NRWMF - Site Characterisation	**Logged by:** TS	**End Date:** 02/05/2018	**Drill Rig:** Sonic (Geoprobe)	**Inclination:** -90°	**Northing:** 6334408.7 m
Location: Napandee (Kimba)	**Checked by:** HS	**Location Meth.:** dGPS0.1		**Bearing:** N/A	**Hor. Proj/Dat:** MGA94/GDA94-54M

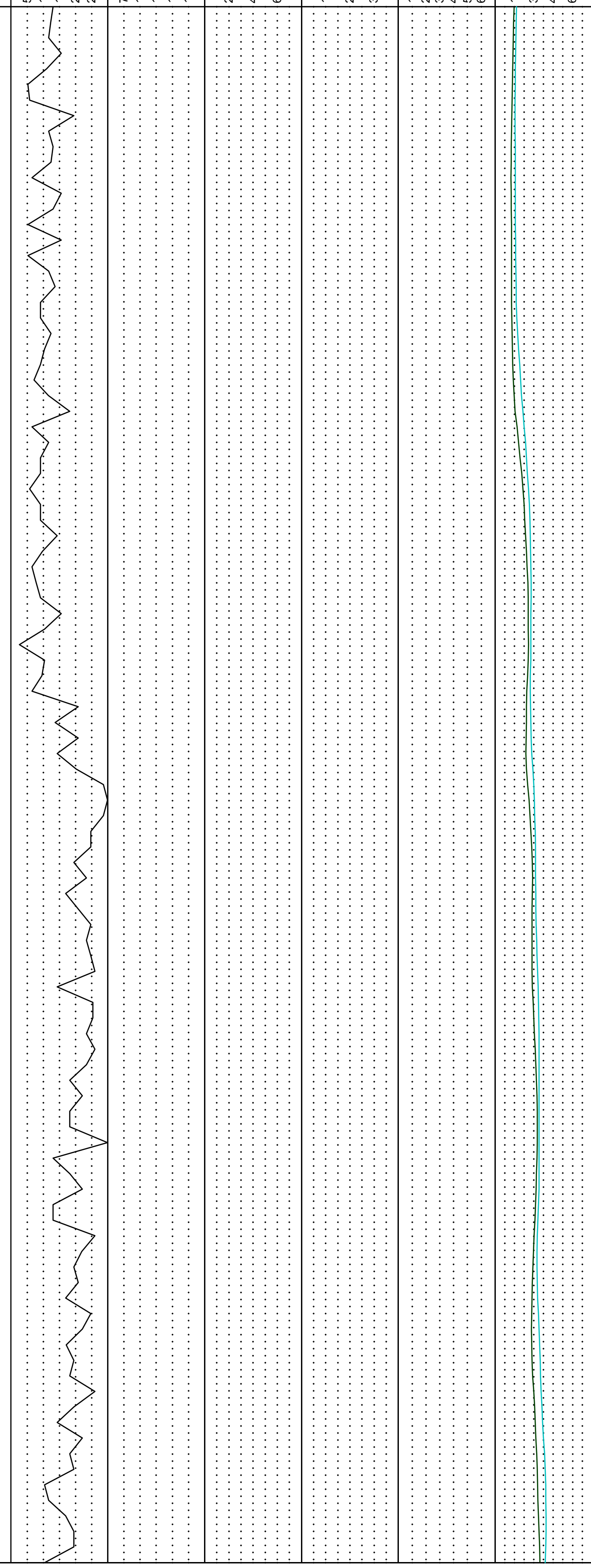
RL: 183.8 m **Ver. Datum:** AHD **Surface:**

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: 184.60 m AHD; Response Zone Top RL: -; Response Zone Base RL: -; Length of Response Zone: 6.00 m; Development Date: 7/05/2018
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)*

RL (m)	Depth (m)	Description
	10.5	KAOLIN: fine grained; white - cream; very low strength, trace quartz crystals *(continued)* becoming extremely weathered - highly weathered, trace oxidation, some feldspar observed
173	11.0	
	11.5	
172	12.0	from 11.90 m: white; residual, absence of parent rock structure
	12.5	
171	13.0	
	13.5	
170	14.0	
	14.5	
169	15.0	
	15.5	
168	16.0	
	16.5	
167	17.0	
	17.5	from 17.30 m: cream; extremely weathered - highly weathered, light bands have remnant crystalline structure, dark bands completely weathered to clays
166	18.0	METAMORPHIC GNEISS: cream, red bands; foliated - banded; extremely weathered - highly weathered, very low strength, micas and quartz crystals observed
	18.5	
165	19.0	
	19.5	
164	20.0	

Piezometer: 0.0 to 24.0 m: CEMENT/ BENTONITE GROUT; 0.0 to 28.0 m: Solid Pipe



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Engineering Summary Log

BOREHOLE No. N03

Client:	Department of Industry, Innovation and Science	**Project No:**	60565376	**Start Date:**	01/05/2018	**Driller:**	SWD	**Hole Diameter:**	169 mm	**Easting:**	609195.3 m
Project:	NRWMF - Site Characterisation	**Logged by:**	TS	**End Date:**	02/05/2018	**Drill Rig:**	Sonic (Geoprobe)	**Inclination:**	-90°	**Northing:**	6334408.7 m
Location:	Napandee (Kimba)	**Checked by:**	HS	**Location Meth.:**	dGPS0.1			**Bearing:**	N/A	**Hor. Proj/Dat:**	MGA94/GDA94-54M

RL: 183.8 m **Ver. Datum:** AHD **Surface:**

Drilling Water: Potable water sourced from Kimba (measured EC <1000 µS/cm)

Piezometer Details

Casing Top RL: 184.60 m AHD
Response Zone Top RL: -
Response Zone Base RL: -
Length of Response Zone: 6.00 m
Development Date: 7/05/2018

Reduced Level (m)	Depth (m)	Water	Field Tests	Samples	Description	Piezometer Details	Misc Laboratory Testing	Geochemical Testing	Geological Unit (Geotech. Unit)
	20.0				METAMORPHIC GNEISS: cream, red bands; foliated - banded; extremely weathered - highly weathered, very low strength, micas and quartz crystals observed *(continued)* from 20.00 m: fine to medium grained; cream, red-grey; highly weathered				
163	21.0								
	21.5				from 21.50 m: red-grey; moderate level of oxidation throughout rock structure, quartz content decreased				
162	22.0								
161	23.0	▽							
160	24.0				KAOLIN: fine grained; pale grey; residual (weathered Gneiss), very low strength, trace quartz grains / veins and micas (muscovite?)	24.0 to 27.0 m: BENTONITE SEAL (PELLETS)			
157	27.0				from 27.00 m: iron oxidisation on quartz veins		N03_27.0-27.4m: Permeability (U63): 1.0 x10^{-8} m/sec XRD: Kaolinite 81%; Muscovite - illite 5%; Talc <1%; Qtz 13%; Halite 1%.		
154	30.0								

Downhole Wireline

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Engineering Summary Log

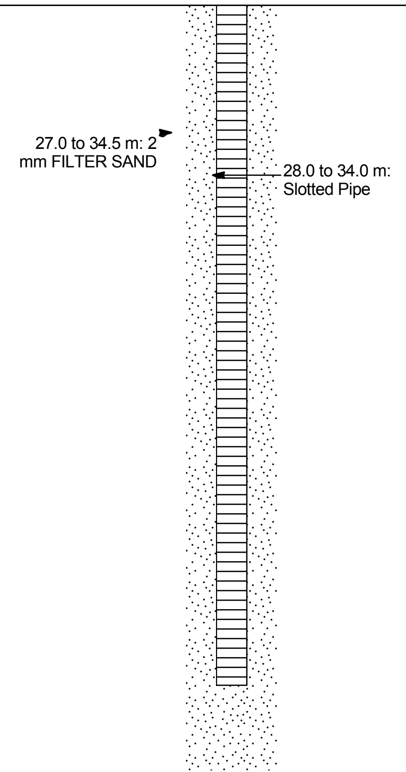
Client: Department of Industry, Innovation and Science | **Project No:** 60565376 | **Start Date:** 01/05/2018 | **Driller:** SWD | **Hole Diameter:** 169 mm | **Easting:** 609195.3 m | **RL:** 183.8 m

Project: NRWMF - Site Characterisation | **Logged by:** TS | **End Date:** 02/05/2018 | **Drill Rig:** Sonic (Geoprobe) | **Inclination:** -90° | **Northing:** 6334408.7 m | **Ver. Datum:** AHD

Location: Napandee (Kimba) | **Checked by:** HS | **Location Meth.:** dGPS0.1 | **Bearing:** N/A | **Hor. Proj/Dat:** MGA94/GDA94-54M | **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
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)	Casing Top RL: 184.60 m AHD Response Zone Top RL: - Response Zone Base RL: - Length of Response Zone: 6.00 m Development Date: 7/05/2018	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) 1000–6000 — Short Neutron — Long Neutron	Induction (mS/m) 160 320 480 640 — Short — Deep	Misc Laboratory Testing	Geochemical Testing	Geological Unit *(Geotech. Unit)*
30.5						METAMORPHIC GNEISS: grey, brown; laminated to banded; highly weathered, very low strength, oxidised throughout														
153 31.0																				
31.5																				
152 32.0						from 32.00 m to 32.10 m: fracture, closed, reduced to clayey quartz gravel														
32.5						becoming green-grey; laminated; abundant with micas														
151 33.0																				
33.5																				
150 34.0																				
34.5						*Borehole N03 log continued as cored log from m.*														
149 35.0																				
35.5																				
148 36.0																				
36.5																				
147 37.0																				
37.5																				
146 38.0																				
38.5																				
145 39.0																				
39.5																				
144 40.0																				



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Engineering Summary Log

BOREHOLE No. N04

Client:	Department of Industry, Innovation and Science	**Project No:**	60565376	**Start Date:**	02/05/2018	**Driller:**	SWD	**Hole Diameter:**	169 mm	**Easting:**	609880.6 m
Project:	NRWMF - Site Characterisation	**Logged by:**	TS	**End Date:**	03/05/2018	**Drill Rig:**	Sonic (Geoprobe)	**Inclination:**	-90°	**Northing:**	6334362.0 m
Location:	Napandee (Kimba)	**Checked by:**	HS	**Location Meth.:**	dGPS0.1			**Bearing:**	N/A	**Hor. Proj/Dat:**	MGA94/GDA94-54M

RL: 193.6 m **Ver. Datum:** AHD **Surface:**

Drilling Water: Potable water sourced from Kimba (measured EC <1000 µS/cm)

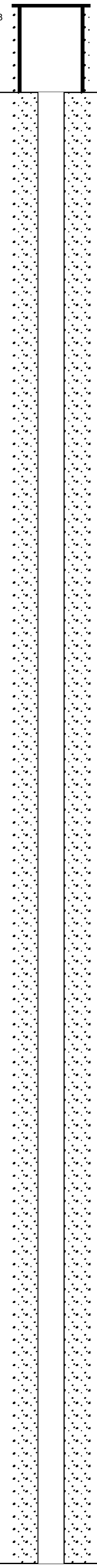
Field Data | **Material Description** | **Rock Condition** | **Piezometer Details** | **Downhole Wireline** | **Laboratory Testing** | **Geology**

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) — Short Density, — Long Density; Neutron Log (CPS) — Short Neutron, — Long Neutron; Induction (mS/m) — Short, — Deep; Misc Laboratory Testing; Geochemical Testing; Geological Unit *(Geotech. Unit)*

Piezometer Details

Casing Top RL: 194.01 m AHD
Response Zone Top RL: -
Response Zone Base RL: -
Length of Response Zone: 6.00 m
Development Date: 23/05/2018

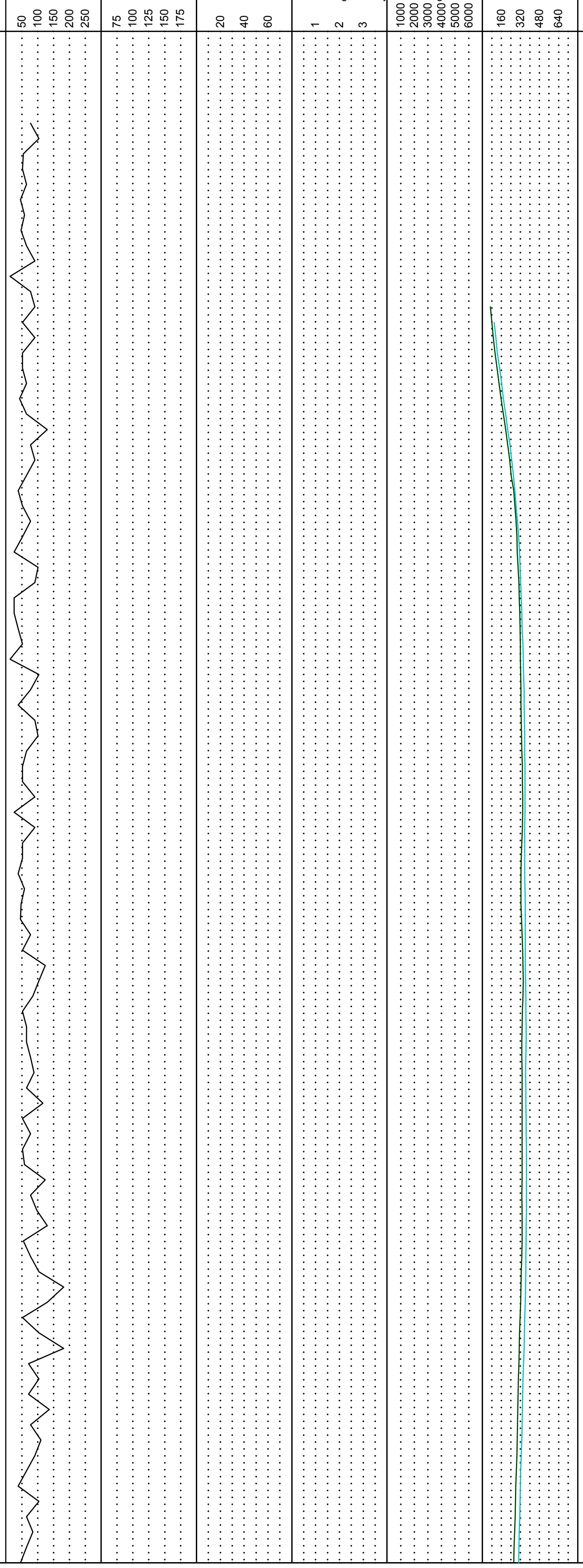
0.6 above ground to 0.0 m: Steel Monument



Depth (m)	Field Tests	Samples	Classification Symbol	Description
0.0		DS	SP-SM	SAND: fine grained; brown; angular to sub-angular, siliceous, trace silt/clay
~0.2			SC	clayey SAND: fine to coarse grained; brown-red; siliceous and calcrete, with clay and fine to coarse, angular to sub-angular, calcrete gravel becoming red-brown; increasing clay content
~1.1		DS		
~1.3				SILCRETE: fine grained; red, white; extremely weathered, very low strength, very poorly cemented, resembling gravelly clay becoming white-yellow from 1.45 m to 1.50 m: medium to high strength
~1.5	SPT:30/70mm N=R			
1.50				NO CORE: 1.50 m to 2.8 m, due to shearing of core barrel
2.8				KAOLIN: fine grained; white and pink; extremely weathered to residual soil, very low strength, matrix abundant with quartz crystals
~3.0	SPT:30/30mm N=R			
~4.5	SPT:8,14,20 N=34			
~5.1				becoming white/cream
5.50				at 5.50 m: trace iron staining, weathered feldspar and mica observed in rock fabric
~6.0	SPT:7,18,30 N=48			

Depth scale (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

Reduced Level (m): 193, 192, 191, 190, 189, 188, 187, 186, 185, 184



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Engineering Summary Log

BOREHOLE No. **N04**

Sheet: 2 of 4

Client: Department of Industry, Innovation and Science	**Project No:** 60565376	**Start Date:** 02/05/2018	**Driller:** SWD	**Hole Diameter:** 169 mm	**Easting:** 609880.6 m	**RL:** 193.6 m
Project: NRWMF - Site Characterisation	**Logged by:** TS	**End Date:** 03/05/2018	**Drill Rig:** Sonic (Geoprobe)	**Inclination:** -90°	**Northing:** 6334362.0 m	**Ver. Datum:** AHD
Location: Napandee (Kimba)	**Checked by:** HS	**Location Meth.:** dGPS0.1		**Bearing:** N/A	**Hor. Proj/Dat:** MGA94/GDA94-54M	**Surface:**

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: 194.01 m AHD
Response Zone Top RL: -
Response Zone Base RL: -
Length of Response Zone: 6.00 m
Development Date: 23/05/2018

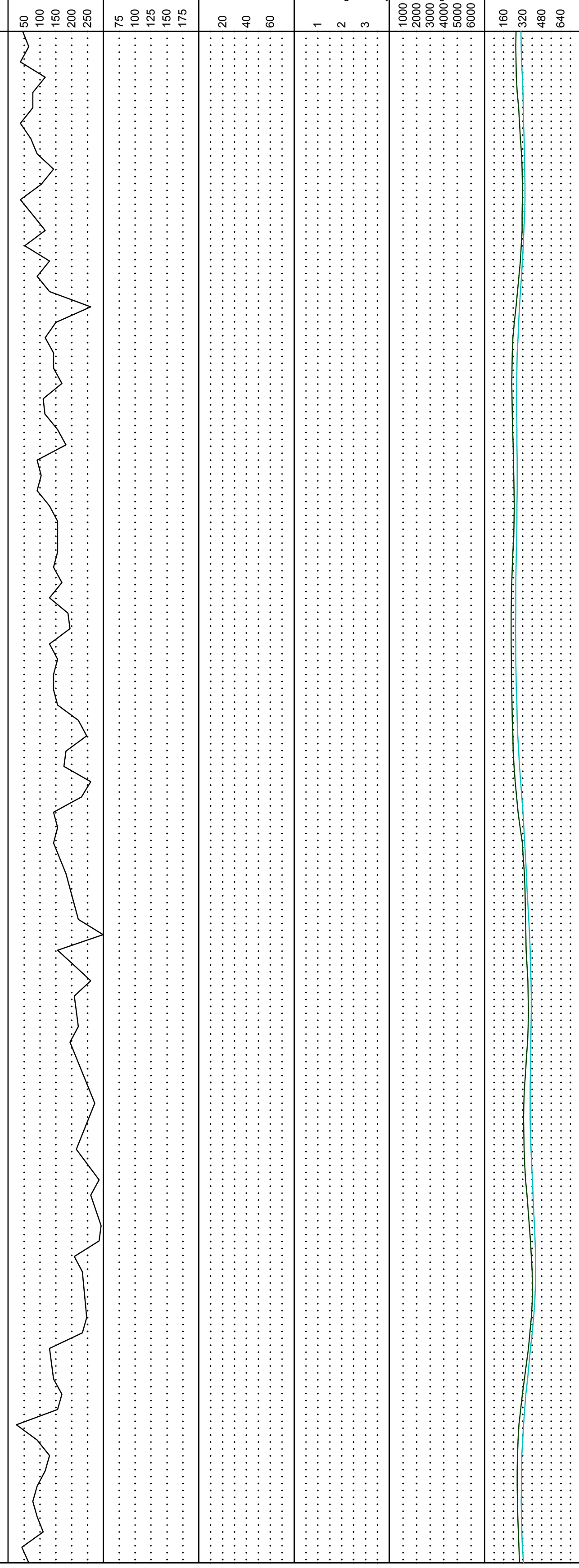
Downhole Wireline: Natural Gamma (API); Borehole Diameter (mm); Neutron Porosity (%); Density (g/cm3) — Short Density, Long Density; Neutron Log (CPS) — Short Neutron, Long Neutron; Induction (mS/m) — Short, Deep

Laboratory Testing: Misc Laboratory Testing; Geochemical Testing

Geology: Geological Unit *(Geotech. Unit)*

Depth (m)	RL (m)	Description
10.5	183	KAOLIN: fine grained; white and pink; extremely weathered to residual soil, very low strength, matrix abundant with quartz crystals *(continued)*
11.0		
11.5	182	
12.0		
12.5	181	GNEISS: fine to medium grained; cream; extremely weathered, very low strength, faint light and dark banding, bleached
13.0		
13.5	180	
14.0		
14.5	179	
15.0		
15.5	178	
16.0		
16.5	177	from 16.20 m to 18.00 m: pale grey/green, extremely weathered, absence of quartz crystals in core, very clayey
17.0		
17.5	176	
18.0		from 18.00 m: cream/grey, extremely to highly weathered, very low strength, light bands are low to medium strength
18.5	175	
19.0		
19.5	174	
20.0		

Piezometer: 0.0 to 22.0 m: CEMENT/ BENTONITE GROUT; 0.0 to 26.0 m: Solid Pipe



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Engineering Summary Log

BOREHOLE No. **N04**
Sheet: 3 of 4

Client: Department of Industry, Innovation and Science	**Project No:** 60565376	**Start Date:** 02/05/2018	**Driller:** SWD	**Hole Diameter:** 169 mm	**Easting:** 609880.6 m	**RL:** 193.6 m
Project: NRWMF - Site Characterisation	**Logged by:** TS	**End Date:** 03/05/2018	**Drill Rig:** Sonic (Geoprobe)	**Inclination:** -90°	**Northing:** 6334362.0 m	**Ver. Datum:** AHD
Location: Napandee (Kimba)	**Checked by:** HS	**Location Meth.:** dGPS0.1		**Bearing:** N/A	**Hor. Proj/Dat:** MGA94/GDA94-54M	**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
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)	Casing Top RL: 194.01 m AHD Response Zone Top RL: - Response Zone Base RL: - Length of Response Zone: 6.00 m Development Date: 23/05/2018	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	Misc Laboratory Testing	Geochemical Testing	Geological Unit *(Geotech. Unit)*

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 m

Reduced level scale: 173, 172, 171, 170, 169, 168, 167, 166, 165, 164 m

Water: ∇ at approx. 24.7 m

Description:

GNEISS: fine to medium grained; cream; extremely weathered, very low strength, faint light and dark banding, bleached *(continued)*

from 20.80 m: grey; significant reduction in lighter bands, predominantly fine grained

from 22.50 m: fine grained; grey/green; highly weathered, very low strength

from 23.50 m to 23.70 m: strongly banded, green/grey and cream

from 23.80 m: iron oxide on lighter bands, becoming laminated

from 28.40 m: significant reduction of iron oxide throughout matrix, fine to medium grained quartz in lighter bands

from 29.40 m: light brown; highly weathered, very low strength

from 29.80 m: grey/cream

Piezometer Details:

22.0 to 25.0 m: BENTONITE SEAL (PELLETS)

23.0 to 25.0 m: CAVE-IN

25.0 to 32.0 m: 2 mm FILTER SAND

26.0 to 32.0 m: Slotted Pipe

Downhole Wireline:

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Engineering Summary Log

Client:	Department of Industry, Innovation and Science	**Project No:**	60565376	**Start Date:**	02/05/2018	**Driller:**	SWD	**Hole Diameter:**	169 mm
Project:	NRWMF - Site Characterisation	**Logged by:**	TS	**End Date:**	03/05/2018	**Drill Rig:**	Sonic (Geoprobe)	**Inclination:**	-90°
Location:	Napandee (Kimba)	**Checked by:**	HS	**Location Meth.:**	dGPS0.1			**Bearing:**	N/A

Easting:	609880.6 m	**RL:**	193.6 m
Northing:	6334362.0 m	**Ver. Datum:**	AHD
Hor. Proj/Dat:	MGA94/GDA94-54M	**Surface:**	

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: 194.01 m AHD
Response Zone Top RL: -
Response Zone Base RL: -
Length of Response Zone: 6.00 m
Development Date: 23/05/2018

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) — Short Density — Long Density 1 2 3; Neutron Log (CPS) — Short Neutron — Long Neutron 1000 2000 3000 4000 5000 6000; Induction (mS/m) — Short — Deep 160 320 480 640

Laboratory Testing: Misc Laboratory Testing; Geochemical Testing

Geology: Geological Unit *(Geotech. Unit)*

Reduced Level (m)	Depth (m)	Description
		GNEISS: fine to medium grained; cream; extremely weathered, very low strength, faint light and dark banding, bleached *(continued)* from 30.30 m: moderately weathered, medium strength, fractured and jointed (closed)
163	30.5	
	31.0	
162	31.5	
	32.0	from 32.00 m: black/cream, extremely weathered, very low strength, highly mafic
161	32.5	
	33.0	*Borehole N04 log continued as cored log from m.*
160	33.5	
	34.0	
159	34.5	
	35.0	
158	35.5	
	36.0	
157	36.5	
	37.0	
156	37.5	
	38.0	
155	38.5	
	39.0	
154	39.5	
	40.0	

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Engineering Summary Log

BOREHOLE No. **N05S**

Client:	Department of Industry, Innovation and Science	**Project No:** 60565376	**Start Date:** 21/04/2018	**Driller:** SWD	**Hole Diameter:**	169 mm	**Easting:** 609901.9 m	**RL:**	198.2 m
Project:	NRWMF - Site Characterisation	**Logged by:** TS	**End Date:** 23/04/2018	**Drill Rig:** Sonic Geoprobe	**Inclination:**	-90°	**Northing:** 6335632.7 m	**Ver. Datum:**	AHD
Location:	Napandee (Kimba)	**Checked by:** HS	**Location Meth.:** dGPS0.1		**Bearing:**	N/A	**Hor. Proj/Dat:** MGA94/GDA94-54J	**Surface:**	Sand

Drilling Water: Potable water sourced from Kimba (measured EC <1000 μS/cm)

Piezometer Details

- **Casing Top RL:** 198.81 m AHD
- **Response Zone Top RL:** -
- **Response Zone Base RL:** -
- **Length of Response Zone:** -
- **Development Date:** 7/05/2018

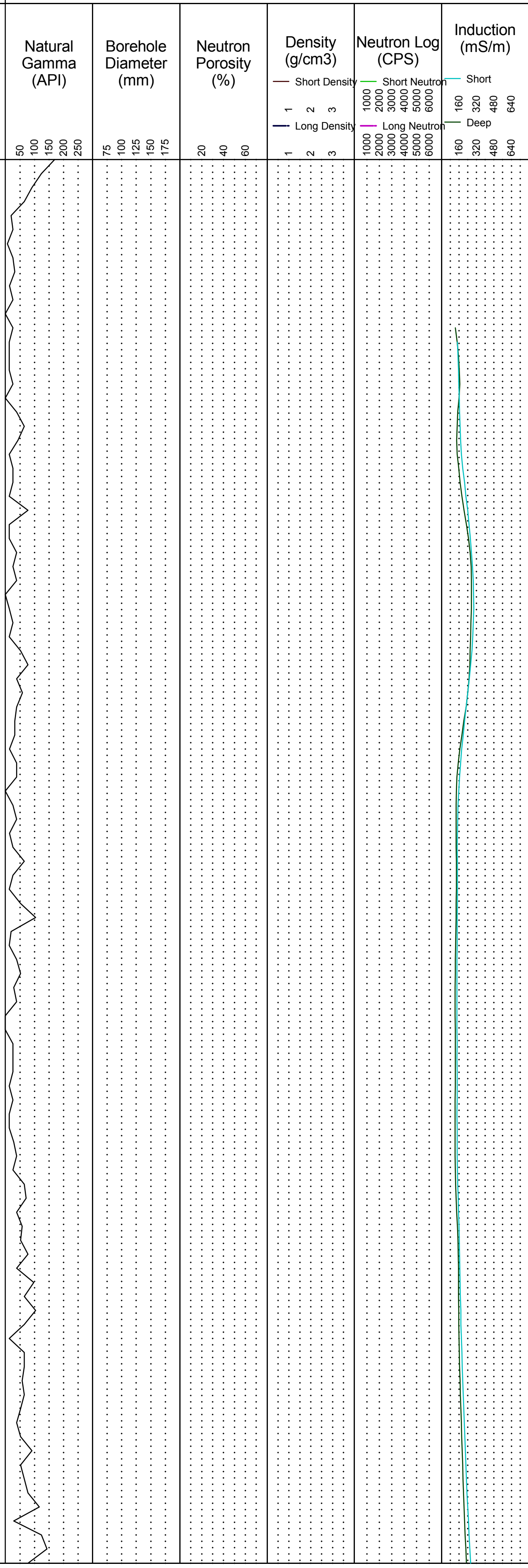
0.6 above ground to 0.0 m: Steel Monument

Depth (m)	Reduced Level (m)	Water	Field Tests	Samples	Classification Symbol	Description	Weathering/Consistency	TCR (SCR) [RQD] (%)	Core Photo	Optical and Accoustic Televiewer	Misc Laboratory Testing	Geochemical Testing	Geological Unit (Geotech. Unit)
0.0					SP-SM	SAND: fine grained; angular to sub-angular; pale pink-brown; trace silt and organics							
0.8					SP-SC	SAND: fine grained; red-brown; with silt, trace calcareous clay							
1.5			SPT:7,7,7 N=14										
2.1					CI-CL	sandy CLAY: low to medium plasticity; red-brown; with fine grained, angular to sub-angular sand, siliceous clay is calcareous							
3.0			SPT:7,11,15 N=26										
3.8						SILCRETE: fine grained; white; with quartz crystals (<1mm-25mm), trace iron oxide, VL							
4.5			SPT:>10 N=R										
6.5			SPT:>10 N=R			from 6.50 m: cream, H-VH							
8.0			SPT:>10 N=R			L-M							
9.0						from 9.00 m: cream to grey, L							
9.5			SPT:>10 N=R										

Reduced Level (m): 198, 197, 196, 195, 194, 193, 192, 191, 190, 189

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

Downhole Wireline



Laboratory Testing

Geology

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Engineering Summary Log

BOREHOLE No. **N05S**
Sheet: 2 of 5

Client: Department of Industry, Innovation and Science	**Project No:** 60565376	**Start Date:** 21/04/2018	**Driller:** SWD	**Hole Diameter:** 169 mm	**Easting:** 609901.9 m	**RL:** 198.2 m
Project: NRWMF - Site Characterisation	**Logged by:** TS	**End Date:** 23/04/2018	**Drill Rig:** Sonic Geoprobe	**Inclination:** -90°	**Northing:** 6335632.7 m	**Ver. Datum:** AHD
Location: Napandee (Kimba)	**Checked by:** HS	**Location Meth.:** dGPS0.1		**Bearing:** N/A	**Hor. Proj/Dat:** MGA94/GDA94-54J	**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**

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)

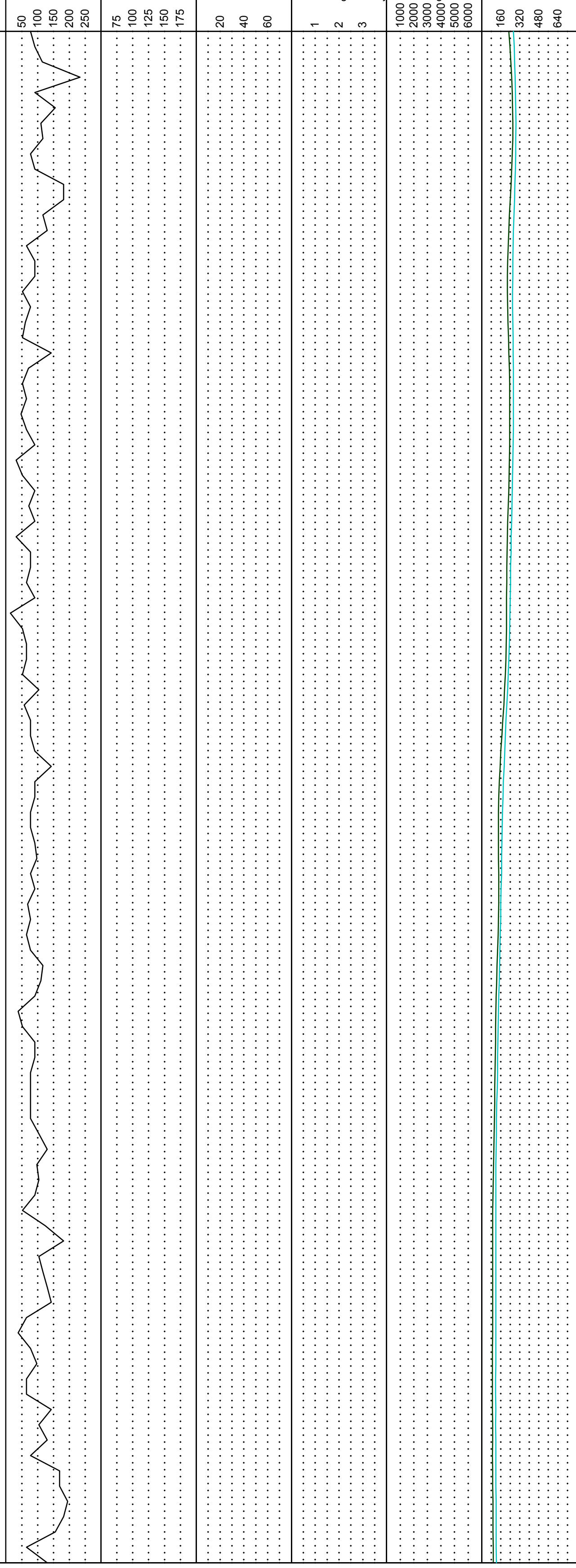
Casing Top RL: 198.81 m AHD
Response Zone Top RL: -
Response Zone Base RL: -
Length of Response Zone: -
Development Date: 7/05/2018

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 | Misc Laboratory Testing | Geochemical Testing | Geological Unit *(Geotech. Unit)*

Depth (m)	RL (m)	Field Tests	Description	Weathering/ Consistency
10.0–11.0	188		SILCRETE: fine grained; white; with quartz crystals (<1mm-25mm), trace iron oxide, VL *(continued)* from 10.00 m: quartz veins throughout, crystals <25mm	
11.0	187	SPT:>10 N=R	GNEISS: fine to medium grained; white; crystalline structure still intact, most minerals weathered, bleached white clays easily moulded into clay (Kaolin), XW, VL	XW
12.5	186	SPT:15,25,32 N=57		
15.0	183	SPT:14,18,32 N=50		
15.5			VL-L	
18.0			VL	

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: 188, 187, 186, 185, 184, 183, 182, 181, 180, 179

Piezometer: 0.0 to 29.0 m: CEMENT/ BENTONITE GROUT; 0.0 to 30.0 m: Solid Pipe



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Engineering Summary Log

BOREHOLE No. **N05S**

Client:	Department of Industry, Innovation and Science	**Project No:**	60565376	**Start Date:**	21/04/2018	**Driller:**	SWD	**Hole Diameter:**	169 mm
Project:	NRWMF - Site Characterisation	**Logged by:**	TS	**End Date:**	23/04/2018	**Drill Rig:**	Sonic Geoprobe	**Inclination:**	-90°
Location:	Napandee (Kimba)	**Checked by:**	HS	**Location Meth.:**	dGPS0.1			**Bearing:**	N/A

Easting:	609901.9 m	**RL:**	198.2 m
Northing:	6335632.7 m	**Ver. Datum:**	AHD
Hor. Proj/Dat:	MGA94/GDA94-54J	**Surface:**	Sand

Drilling Water: Potable water sourced from Kimba (measured EC <1000 µS/cm)

Piezometer Details

Casing Top RL: 198.81 m AHD
Response Zone Top RL: -
Response Zone Base RL: -
Length of Response Zone: -
Development Date: 7/05/2018

Reduced Level (m)	Depth (m)	Description	Weathering/ Consistency	Piezometer Details
		GNEISS: fine to medium grained; white; crystalline structure still intact, most minerals weathered, bleached white clays easily moulded into clay (Kaolin), XW, VL *(continued)* VL-L VL	XW	
178	20.5			
	21.0			
177	21.5	at 21.30 m: dark grey discolouration on outer core		
	22.0			
176	22.5			
	23.0			
175	23.5			
	24.0			
174	24.5			
	25.0	at 25.00 m: grey and light brown, banding apparent, iron oxide in lighter bands, heavily fractured, HW- MW	HW-MW	
173	25.5			
	26.0			
172	26.5	from 26.50 m: light grey to grey, XW- HW	XW-HW	
	27.0			
171	27.5	from 27.50 m: light pink		26.0 to 29.0 m: BENTONITE SEAL (PELLETS)
	28.0			
170	28.5			
	29.0			
169	29.5			
	30.0			

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 2000 3000 4000 5000 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. **N05S**

Client: Department of Industry, Innovation and Science | **Project No:** 60565376 | **Start Date:** 21/04/2018 | **Driller:** SWD | **Hole Diameter:** 169 mm | **Easting:** 609901.9 m | **RL:** 198.2 m

Project: NRWMF - Site Characterisation | **Logged by:** TS | **End Date:** 23/04/2018 | **Drill Rig:** Sonic Geoprobe | **Inclination:** -90° | **Northing:** 6335632.7 m | **Ver. Datum:** AHD

Location: Napandee (Kimba) | **Checked by:** HS | **Location Meth.:** dGPS0.1 | **Bearing:** N/A | **Hor. Proj/Dat:** MGA94/GDA94-54J | **Surface:** Sand

Drilling Water: Potable water sourced from Kimba (measured EC <1000 µS/cm)

Piezometer Details: Casing Top RL: 198.81 m AHD; Response Zone Top RL: -; Response Zone Base RL: -; Length of Response Zone: -; Development Date: 7/05/2018

Columns: 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); 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))

Depth (m)	RL (m)	Samples	Description	Weathering/Consistency
29.90	168		from 29.90 m: red-pink and light grey GNEISS: fine to medium grained; white; crystalline structure still intact, most minerals weathered, bleached white clays easily moulded into clay (Kaolin), XW, VL *(continued)*	XW-HW
32.90	165		from 32.90 m: pink to grey, HW, VL-L	HW
34.0			XW, VL	XW
35.10	163	DS (35.5)	from 35.10 m: grey, very clayey. NOTE: Water Strike not observed, formation very low yielding., HW, VL-L	HW
36.0–36.5	162	U_{63}		
36.5			*Borehole N05S log continued as cored log from 3.80 m.*	

Piezometer: 29.0 to 36.5 m: 2 mm FILTER SAND; 30.0 to 36.0 m: Slotted Pipe

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; RL: 168, 167, 166, 165, 164, 163, 162, 161, 160, 159

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Engineering Summary Log

BOREHOLE No. N05D

Sheet: 1 of 8

Client: Department of Industry, Innovation and Science
Project: NRWMF - Site Characterisation
Location: Napandee (Kimba)
Drilling Water: Potable water sourced from Kimba (measured EC <1000 µS/cm)

Project No: 60565376
Logged by: TS
Checked by: HS

Start Date: 17/04/2018
End Date: 21/04/2018
Location Meth.: dGPS0.1

Driller: SWD
Drill Rig: Sonic Geoprobe

Hole Diameter: 155 mm
Inclination: -90°
Bearing: N/A

Easting: 609917.1 m
Northing: 6335617.6 m
Hor. Proj/Dat: MGA94/GDA94-54J

RL: 198.6 m
Ver. Datum: AHD
Surface: Sand

Piezometer Details

Casing Top RL: 199.08 m AHD
Response Zone Top RL: -
Response Zone Base RL: -
Length of Response Zone: 6.00 m
Development Date: 23/04/2018

0.6 above ground to 0.0 m: Steel Monument

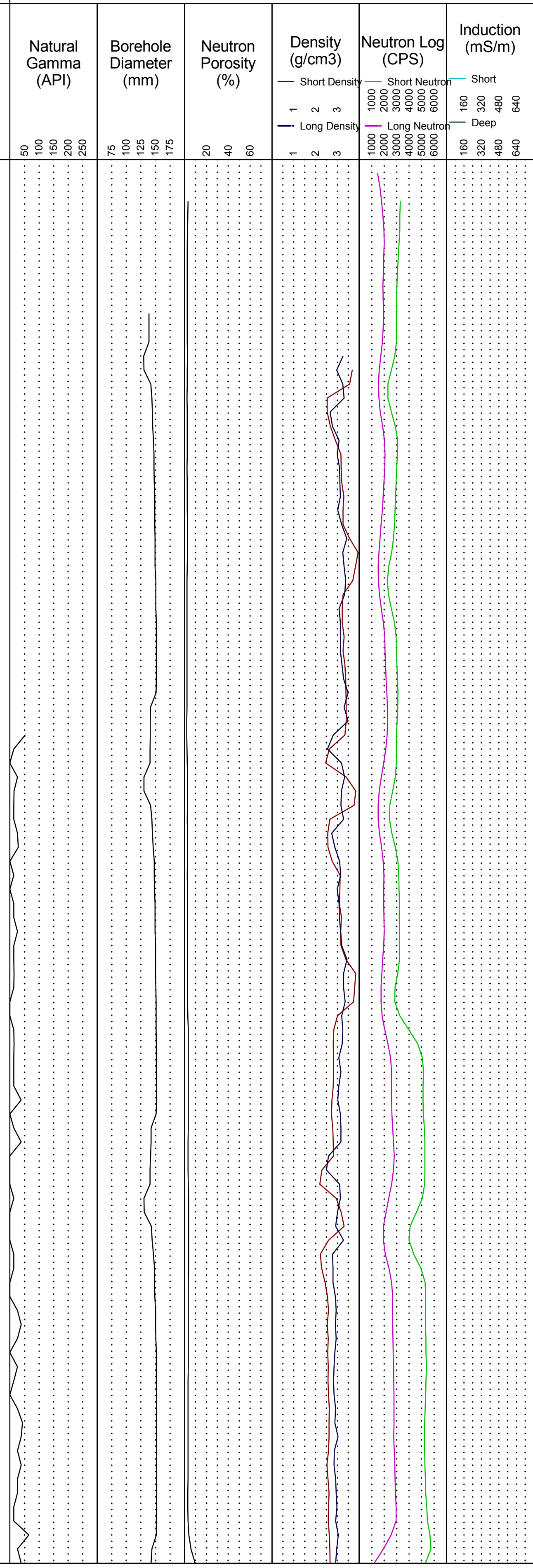
Log

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). Laboratory Testing: Misc Laboratory Testing, Geochemical Testing. Geology: Geological Unit (*Geotech. Unit*).

Depth (m)	Samples	Classification Symbol	Description	Misc Laboratory Testing
0.0	BAG JAR	SW	SAND: fine grained; sub-rounded to sub-angular; pale yellow; siliceous	
0.6	BAG JAR (c. 1.1)	SM	silty SAND: fine grained; angular to sub-angular; trace cementation (calcrete) at 1.20 m: pale yellow, with silt and clay	
2.2	BAG JAR (c. 2.9); U63 (c. 3.3–3.6)	CI	sandy CLAY: medium plasticity; red-orange; calcareous, sand is fine grained, angular to sub-angular, siliceous (tertiary calcrete) at 3.00 m: red	N05D_3.2-3.6m: **XRD:** Clay mineral 11%; Kandite 7%; K - Feldspar 1%; Qtz 82% **Permeability (U63):** 3.0×10^{-9} m/sec
3.8		GW	GRAVEL: fine to coarse grained; red-brown; angular to rounded, with fine grained sand and trace calcareous clay (weathered calcrete)	
4.2			KAOLIN: extremely weathered, very low strength, very soft, friable with fine sand in matrix at 4.30 m: white at 4.90 m: yellow; low strength at 5.20 m: white; very low strength at 5.50 m: white-pink	
6.1	BAG JAR (c. 6.6)	CL	KAOLIN: low plasticity; white-pink; with quartz crystals, fine to coarse grained, angular to sub-rounded (highly weathered granite)	
7.1			KAOLIN: white; very low strength, with fine to coarse grained, subangular quartz crystals, trace quartz veins at 7.10 m: low strength	
9.6			NO CORE: from 9.60 to 12.30m	

Depth scale: 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. Reduced level scale: 198, 197, 196, 195, 194, 193, 192, 191, 190, 189.

Downhole Wireline



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Engineering Summary Log

BOREHOLE No. **N05D**

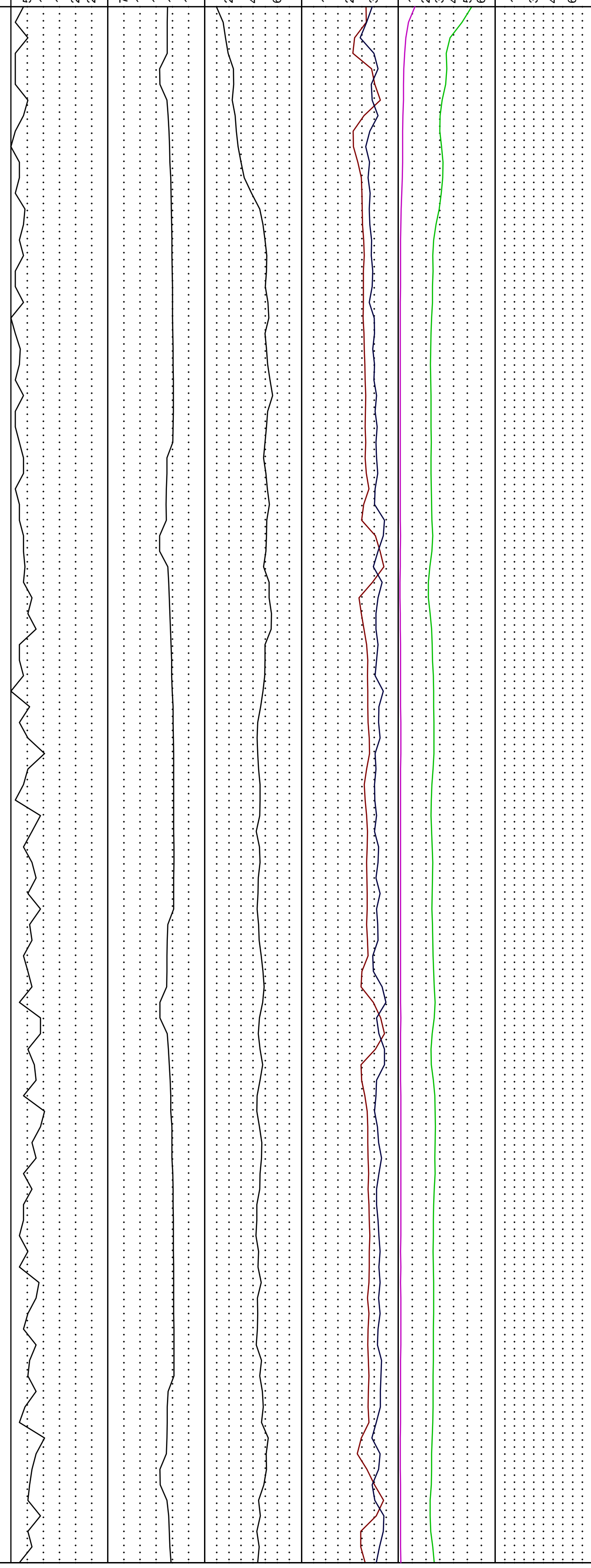
Client: Department of Industry, Innovation and Science	**Project No:** 60565376	**Start Date:** 17/04/2018	**Driller:** SWD	**Hole Diameter:** 155 mm	**Easting:** 609917.1 m	**RL:** 198.6 m
Project: NRWMF - Site Characterisation	**Logged by:** TS	**End Date:** 21/04/2018	**Drill Rig:** Sonic Geoprobe	**Inclination:** -90°	**Northing:** 6335617.6 m	**Ver. Datum:** AHD
Location: Napandee (Kimba)	**Checked by:** HS	**Location Meth.:** dGPS0.1		**Bearing:** N/A	**Hor. Proj/Dat:** MGA94/GDA94-54J	**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: 199.08 m AHD; Response Zone Top RL: -; Response Zone Base RL: -; Length of Response Zone: 6.00 m; Development Date: 23/04/2018
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)*

Depth (m)	RL (m)	Samples	Description
9.60–12.30			NO CORE: from 9.60 to 12.30m *(continued)*
12.30–20.0			KAOLIN: white and light grey; highly weathered to kaolin, rock fabric faintly visible, trace quartz crystals (weathered granite)
16.80			at 16.80 m: consistent mechanical breaks 10-20mm
18.5		BAG JAR	

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: 188, 187, 186, 185, 184, 183, 182, 181, 180, 179



AECOM

Engineering Summary Log

BOREHOLE No. **N05D**

Client: Department of Industry, Innovation and Science	**Project No:** 60565376	**Start Date:** 17/04/2018	**Driller:** SWD	**Hole Diameter:** 155 mm	**Easting:** 609917.1 m	**RL:** 198.6 m
Project: NRWMF - Site Characterisation	**Logged by:** TS	**End Date:** 21/04/2018	**Drill Rig:** Sonic Geoprobe	**Inclination:** -90°	**Northing:** 6335617.6 m	**Ver. Datum:** AHD
Location: Napandee (Kimba)	**Checked by:** HS	**Location Meth.:** dGPS0.1		**Bearing:** N/A	**Hor. Proj/Dat:** MGA94/GDA94-54J	**Surface:** Sand

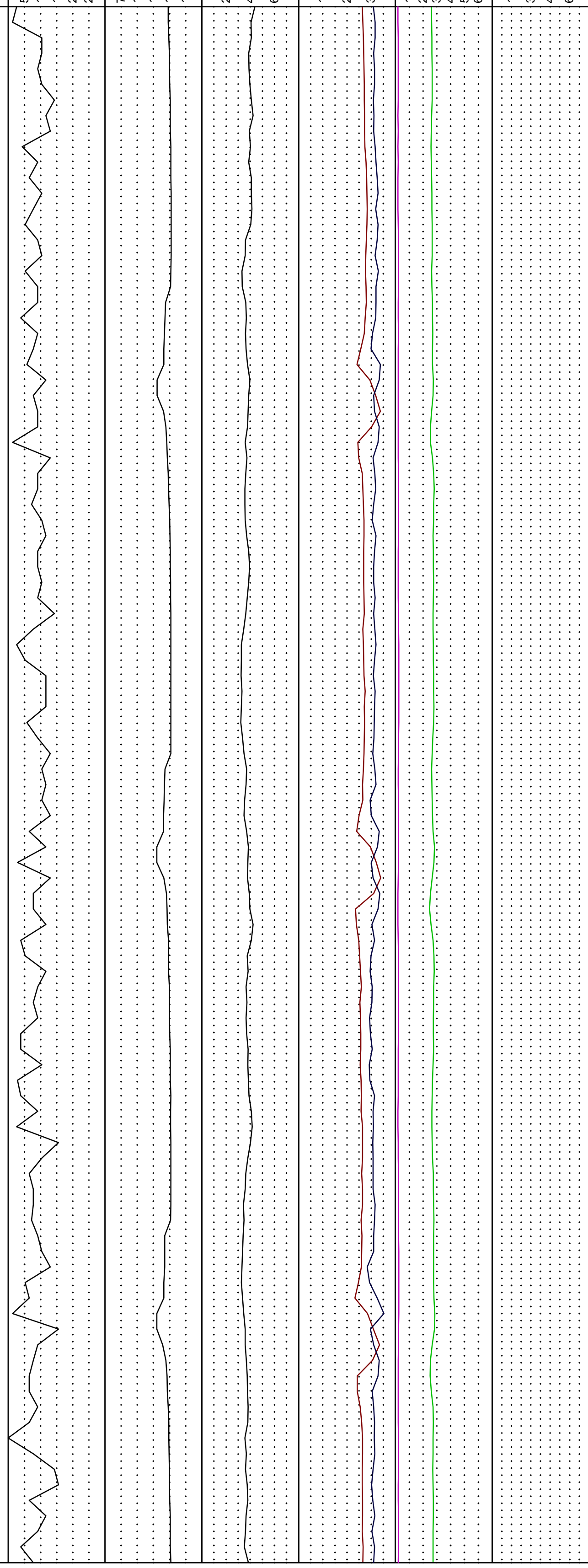
Drilling Water: Potable water sourced from Kimba (measured EC <1000 µS/cm)

Piezometer Details: Casing Top RL: 199.08 m AHD; Response Zone Top RL: -; Response Zone Base RL: -; Length of Response Zone: 6.00 m; Development Date: 23/04/2018

Depth (m)	Reduced Level (m)	Samples	Description
20.5			KAOLIN: white and light grey; highly weathered to kaolin, rock fabric faintly visible, trace quartz crystals (weathered granite) *(continued)*
21.0	178		
21.5	177		GNEISS: pale grey; highly weathered to kaolin, very low strength, fine to medium grained, trace micas, friable, faint remnants of foliation
22.0			
22.5	176		
23.0			
23.5	175		
24.0			at 24.00 m: low strength
24.5	174		at 24.30 m: grey, white and yellow; fine to medium grained, very low strength
25.0		BAG JAR	
25.5	173		
26.0			
26.5	172		
27.0			from 27.20 m to 27.30 m: very low strength
27.5	171		
28.0			
28.5	170		
29.0			
29.5	169		
30.0			

Piezometer: 0.0 to 54.0 m: CEMENT/ BENTONITE GROUT; 0.0 to 58.0 m: Solid Pipe

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)*

AECOM

Engineering Summary Log

BOREHOLE No. N05D
Sheet: 4 of 8

Client:	Department of Industry, Innovation and Science	**Project No:**	60565376	**Start Date:**	17/04/2018	**Driller:**	SWD	**Hole Diameter:**	155 mm	**Easting:**	609917.1 m
Project:	NRWMF - Site Characterisation	**Logged by:**	TS	**End Date:**	21/04/2018	**Drill Rig:**	Sonic Geoprobe	**Inclination:**	-90°	**Northing:**	6335617.6 m
Location:	Napandee (Kimba)	**Checked by:**	HS	**Location Meth.:**	dGPS0.1			**Bearing:**	N/A	**Hor. Proj/Dat:**	MGA94/GDA94-54J

RL: 198.6 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: 199.08 m AHD; Response Zone Top RL: -; Response Zone Base RL: -; Length of Response Zone: 6.00 m; Development Date: 23/04/2018
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) — Short Density, — Long Density 1 2 3; Neutron Log (CPS) — Short Neutron, — Long Neutron 1000 2000 3000 4000 5000 6000; Induction (mS/m) — Short, — Deep 160 320 480 640
Laboratory Testing: Misc Laboratory Testing; Geochemical Testing
Geology: Geological Unit *(Geotech. Unit)*

Depth (m)	RL (m)	Water	Samples	Description	Misc Laboratory Testing
30.5	168			GNEISS: pale grey; highly weathered to kaolin, very low strength, fine to medium grained, trace micas, friable, faint remnants of foliation *(continued)* from 30.00 m: grey to dark grey, significant weathering of mafic minerals to clay bands	
31.0					
31.5	167				
32.0					
32.5	166				
33.0					
33.5	165				
34.0		∇			
34.5	164				
35.0				at 34.90 m: becoming grey and pink GNEISS: fine to medium grained; grey and dark grey; extremely weathered to highly weathered, very low strength, faint biotite bands(metasediments)	
35.5	163				
36.0			BAG JAR		N05D_36.0-36: XRD: Clay mineral 10%; Kandite 5%; Mica 7%; Andausite 1%; Plagioclase 33%; K - Feldspar 19%; Qtz 25%
36.5	162			from 36.50 m: increased percentage of mafic minerals	
37.0					
37.5	161				
38.0					
38.5	160				
39.0					
39.5	159			at 39.30 m: dark grey; clayey	
40.0					

Client: Department of Industry, Innovation and Science	**Project No:** 60565376	**Start Date:** 17/04/2018	**Driller:** SWD	**Hole Diameter:** 155 mm	**Easting:** 609917.1 m
Project: NRWMF - Site Characterisation	**Logged by:** TS	**End Date:** 21/04/2018	**Drill Rig:** Sonic Geoprobe	**Inclination:** -90°	**Northing:** 6335617.6 m
Location: Napandee (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: 198.6 m | **Ver. Datum:** AHD | **Surface:** Sand

Piezometer Details: Casing Top RL: 199.08 m AHD; Response Zone Top RL: -; Response Zone Base RL: -; Length of Response Zone: 6.00 m; Development Date: 23/04/2018

Reduced Level (m)	Depth (m)	Water	Field Tests	Samples	Classification Symbol	Description
	40.5					GNEISS: fine to medium grained; grey and dark grey; extremely weathered to highly weathered, very low strength, faint biotite bands(metasediments) *(continued)*
158						
	41.0					at 41.00 m: light grey
	41.5					
157						
	42.0					at 42.20 m: yellow-brown bands, possible oxidation
	42.5					
156						
	43.0					
	43.5					
155						at 43.70 m: dark grey; residual soil to sandy clay
	44.0					
	44.5					at 44.30 m: extremely weathered, very low strength
154						at 44.70 m: yellow-brown, extremely weathered, signification oxidation in lighter zones
	45.0					
	45.5					sandy gravelly CLAY: yellow-brown
153					SW	SAND: fine to coarse grained; light brown; with clay, potential water bearing zone.
	46.0			BAG JAR		
	46.5					
152						
	47.0				SW	gravelly SAND: fine and coarse grained; sub-rounded to sub-angular; light brown; trace rounded siliceous cobbles
	47.5					
151						
	48.0					
	48.5					
150					GW	GRAVEL: fine and coarse grained; sub-angular; light brown; with clay
	49.0					
	49.5					
149						
	50.0					

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)*

Client: Department of Industry, Innovation and Science	**Project No:** 60565376	**Start Date:** 17/04/2018	**Driller:** SWD	**Hole Diameter:** 155 mm	**Easting:** 609917.1 m	**RL:** 198.6 m
Project: NRWMF - Site Characterisation	**Logged by:** TS	**End Date:** 21/04/2018	**Drill Rig:** Sonic Geoprobe	**Inclination:** -90°	**Northing:** 6335617.6 m	**Ver. Datum:** AHD
Location: Napandee (Kimba)	**Checked by:** HS	**Location Meth.:** dGPS0.1		**Bearing:** N/A	**Hor. Proj/Dat:** MGA94/GDA94-54J	**Surface:** Sand

Drilling Water: Potable water sourced from Kimba (measured EC <1000 µS/cm)

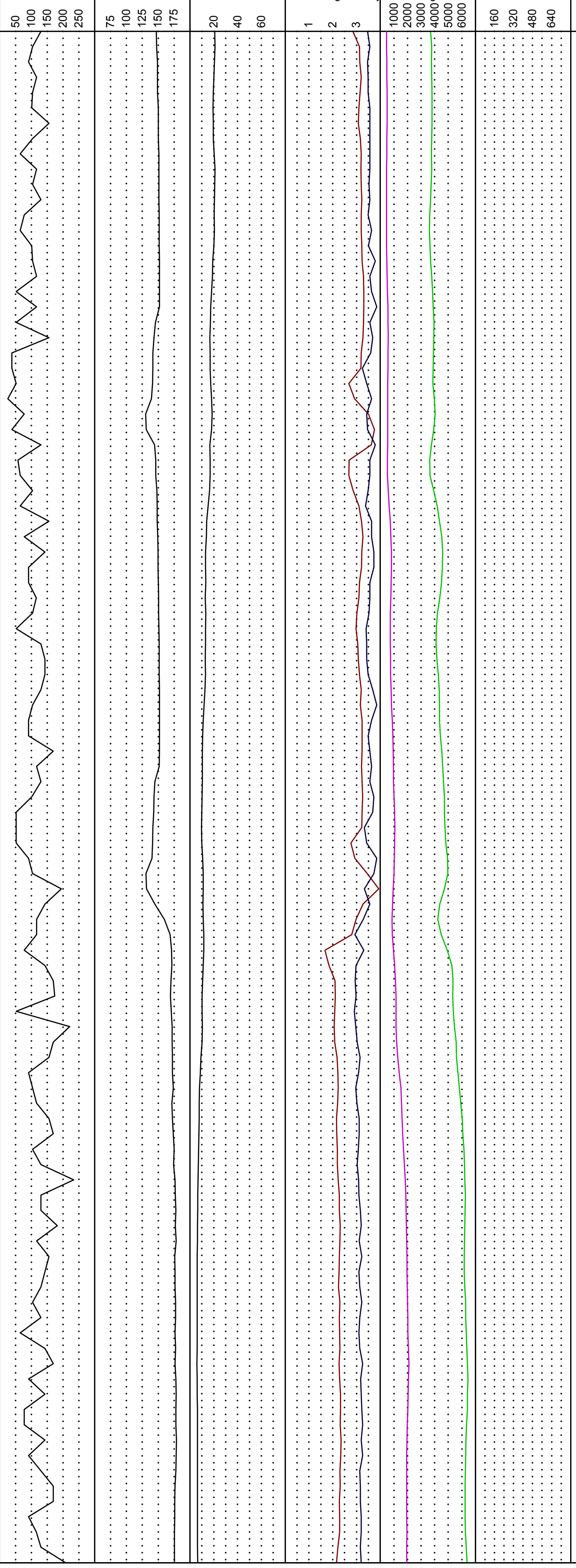
Field Data | **Material Description** | **Rock Condition** | **Piezometer Details** | **Downhole Wireline** | **Laboratory Testing** | **Geology**

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); 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; Misc Laboratory Testing; Geochemical Testing; Geological Unit (Geotech. Unit)

Casing Top RL: 199.08 m AHD
Response Zone Top RL: -
Response Zone Base RL: -
Length of Response Zone: 6.00 m
Development Date: 23/04/2018

Depth (m)	RL (m)	Classification Symbol	Description	Weathering/ Consistency
50.5	148	GC	clayey GRAVEL: fine and coarse grained; grey; with clays and find to coarse grained sand, weathered gneiss and quartz	
			GNEISS: fine to medium grained; orange-brown and grey; highly weathered, low strength, complete discolouration of rock fragments	
51.0				
51.5	147		from 51.50 m: residual to extremely weathered, resembles clayey SAND	XW
52.0			GNEISS: fine to medium grained; orange-brown; laminated light and dark bands, XW, VL	
			HW, L	HW
52.5	146			
53.0			at 53.00 m: black and white bands/laminae, MW, M	MW
53.5	145			
54.0			GNEISS: black and white; foliated, SW- FR, VH	SW-FR
54.5	144		FR, EH	FR
55.0				
55.5	143			
56.0				
56.5	142			
57.0				
57.5	141			
58.0				
58.5	140			
59.0			at 59.20 m: becoming fine to coarse grained	
59.5	139		at 59.40 m: trace iron staining throughout rock matrix. NOTE: Water Strike not observed, formation very low yielding	
60.0				

Piezometer: 54.0 to 57.0 m: BENTONITE SEAL (PELLETS)



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Engineering Summary Log

BOREHOLE No. **N05D**

Client: Department of Industry, Innovation and Science	**Project No:** 60565376	**Start Date:** 17/04/2018	**Driller:** SWD	**Hole Diameter:** 155 mm	**Easting:** 609917.1 m	**RL:** 198.6 m
Project: NRWMF - Site Characterisation	**Logged by:** TS	**End Date:** 21/04/2018	**Drill Rig:** Sonic Geoprobe	**Inclination:** -90°	**Northing:** 6335617.6 m	**Ver. Datum:** AHD
Location: Napandee (Kimba)	**Checked by:** HS	**Location Meth.:** dGPS0.1		**Bearing:** N/A	**Hor. Proj/Dat:** MGA94/GDA94-54J	**Surface:** Sand

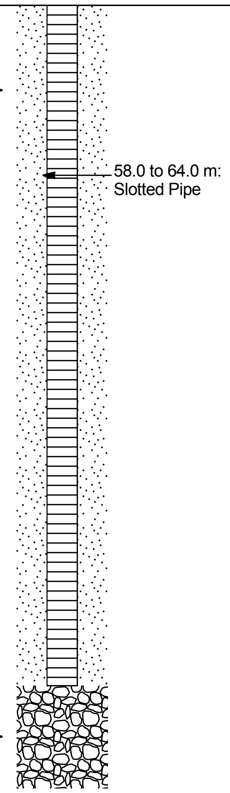
Drilling Water: Potable water sourced from Kimba (measured EC <1000 µS/cm)

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)
60.5 – 64.5 (RL 138 – 134)						GNEISS: black and white; foliated, SW- FR, VH *(continued)*	FR			
						SW- FR, VH	SW-FR			
64.6 – 70.0 (RL 134 – 129)						*Borehole N05D log continued as cored log from 51.60 m.*				

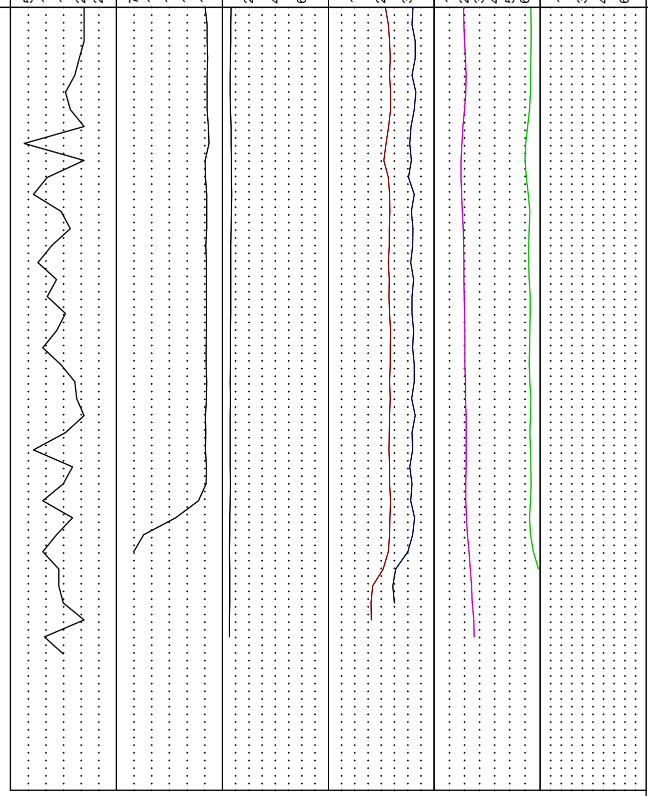
Depth markers: 60.5, 61.0, 61.5, 62.0, 62.5, 63.0, 63.5, 64.0, 64.5, 65.0, 65.5, 66.0, 66.5, 67.0, 67.5, 68.0, 68.5, 69.0, 69.5, 70.0. RL markers: 138, 137, 136, 135, 134, 133, 132, 131, 130, 129.

Piezometer Details

Casing Top RL: 199.08 m AHD
Response Zone Top RL: -
Response Zone Base RL: -
Length of Response Zone: 6.00 m
Development Date: 23/04/2018



Downhole Wireline



Laboratory Testing: Misc Laboratory Testing	Geochemical Testing	Geology: Geological Unit *(Geotech. Unit)*

AECOM

TEST PIT N06

Client:	Department of Industry, Innovation and Science	**Project No:**	60565376	**Start Date:**	25/04/2018
Project:	NRWMF - Site Characterisation	**Logged by:**	JT	**End Date:**	25/04/2018
Location:	Napandee (Kimba)	**Checked by:**	KS	**Location Meth.:**	dGPS0.1
Contractor:	JMAC Hire	**Easting:**	609362.8 m	**Surface level:**	192.3 mRL
Pit Length	4	**Northing:**	6335395.5 m	**Ver. Datum:**	AHD
Pit Width:	1.2	**Hor. Proj/Dat:**	MGA94/GDA94-54J	**Surface:**	Topsoil
Equipment:	JCB JS290LC (30 tonne)	**Orientation:**			
Pit Depth:	3				

Groundwater Data and Comments	Depth (m)	Classification	LITHOLOGICAL DESCRIPTION	Moisture	Consistency/ Relative Density	Sample Interval	PID (ppm)	Sample ID
	0	SM	Topsoil: Silty SAND: fine to medium grained, brown/light brown, with roots	D				JAR
		SC	Silty/Clayey SAND: fine to medium grained, brown/light brown			B		BAG
	1	CL	low plasticity; CLAY: medium plasticity, orange-brown/brown, with sand, fine to medium grained	w<PL				JAR
	2							JAR
						B		BAG
	3		*N06 terminated at 3.00 m.* *Target depth*					

Remarks: 0.00 m: ES & QC: Environmental sample & quality control sample
1.00 m: BS: Bulk sample for geotechnical analysis

AECOM

TEST PIT N07

Client:	Department of Industry, Innovation and Science	**Project No:**	60565376	**Start Date:**	25/04/2018
Project:	NRWMF - Site Characterisation	**Logged by:**	JT	**End Date:**	25/04/2018
Location:	Napandee (Kimba)	**Checked by:**	KS	**Location Meth.:**	dGPS0.1
Contractor:	JMAC Hire	**Easting:**	609356.7 m	**Surface level:**	192.0 mRL
Pit Length	4	**Northing:**	6334591.2 m	**Ver. Datum:**	AHD
Pit Width:	1.2	**Hor. Proj/Dat:**	MGA94/GDA94-54J	**Surface:**	Topsoil
Equipment:	JCB JS290LC (30 tonne)	**Orientation:**			
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, brown/light brown, with roots	D				JAR
			SC	Silty/Clayey SAND: fine to medium grained, brown/light brown			B		BAG
	1								
									JAR
	2		CL	low plasticity; CLAY: medium plasticity, orange-brown/brown, with sand, fine to medium grained	w<PL				
									JAR
	3			*N07 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

AECOM

TEST PIT N08

Sheet: 1 of 1

Client:	Department of Industry, Innovation and Science	**Project No:**	60565376	**Start Date:**	25/04/2018
Project:	NRWMF - Site Characterisation	**Logged by:**	JT	**End Date:**	25/04/2018
Location:	Napandee (Kimba)	**Checked by:**	KS	**Location Meth.:**	dGPS0.1
Contractor:	JMAC Hire	**Easting:**	609359.4 m	**Surface level:**	188.6 mRL
Pit Length	4	**Northing:**	6335008.2 m	**Ver. Datum:**	AHD
Pit Width:	1.2	**Hor. Proj/Dat:**	MGA94/GDA94-54J	**Surface:**	Topsoil
Equipment:	JCB JS290LC (30 tonne)	**Orientation:**			
Pit Depth:	2.1				

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, brown/light brown, with roots	D				JAR
			SC	Silty/Clayey SAND: fine to medium grained, brown/light brown			B		BAG
	1								
				CALCRETE: CALCRETE: low strength, extremely weathered, grey mottled yellow-brown					
	2								JAR
				N08 terminated at 2.10 m. *Target depth*					
	3								
	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 PIT N09

Client:	Department of Industry, Innovation and Science	**Project No:**	60565376	**Start Date:**	25/04/2018
Project:	NRWMF - Site Characterisation	**Logged by:**	JT	**End Date:**	25/04/2018
Location:	Napandee (Kimba)	**Checked by:**	KS	**Location Meth.:**	dGPS0.1
Contractor:	JMAC Hire	**Easting:**	609697.0 m	**Surface level:**	195.5 mRL
		Northing:	6335402.3 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, brown/light brown, with roots	D				JAR
			SC	Silty/Clayey SAND: fine to medium grained, brown/light brown					
	1								JAR
	2		CL	low plasticity; CLAY: medium plasticity, orange-brown/brown	w<PL		B		BAG
									JAR
	3			*N09 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

AECOM

TEST PIT N10

Client:	Department of Industry, Innovation and Science			**Project No:**	60565376	**Start Date:**	25/04/2018
Project:	NRWMF - Site Characterisation			**Logged by:**	JT	**End Date:**	25/04/2018
Location:	Napandee (Kimba)			**Checked by:**	KS	**Location Meth.:**	dGPS0.1
Contractor:	JMAC Hire	**Pit Length**	4	**Easting:**	609691.3 m	**Surface level:**	199.8 mRL
		Pit Width:	1.2	**Northing:**	6335009.1 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, brown/light brown, with roots	D				JAR
			SP	SAND: fine to medium grained, yellow-brown, trace of clay					BAG
	1								JAR
	2								JAR
			CL	low plasticity; CLAY: medium plasticity, orange-brown/brown	w<PL				
	3			*N10 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 N11

Sheet: 1 of 1

Client:	Department of Industry, Innovation and Science	**Project No:**	60565376	**Start Date:**	25/04/2018
Project:	NRWMF - Site Characterisation	**Logged by:**	JT	**End Date:**	25/04/2018
Location:	Napandee (Kimba)	**Checked by:**	KS	**Location Meth.:**	dGPS0.1
Contractor:	JMAC Hire	**Easting:**	609676.2 m	**Surface level:**	196.7 mRL
		Northing:	6334588.9 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, brown/light brown, with roots	D				JAR
			SC	Silty/Clayey SAND: fine to medium grained, brown/light brown from 0.50 m: with cobbles and gravels, gravels fine to coarse sized and both subangular to subrounded					
	1								JAR
			CL	low plasticity; CLAY: medium plasticity, orange-brown/brown	w<PL		B		BAG
	2								JAR
	3								
				N11 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 - Napandee

N06

N07

N08

N09

N10

N11

Field Chemistry - Napandee

Field Chemistry Parameters - Napandee

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
N01	25/04/18-17/05/2018	23/05/2018	4.24	4.54	44600	49601.7	32241	8.19	255.9	17.18	Grab sample obtained with dedicated disposable bailer, clear, very low turbidity, colourless, during sample collection with bailer (5L removed).
N02	01/05/18-17/05/18	23/05/2018	4.48	6.98	49100	52378	34046	9.91	206.2	16.51	Grab sample obtained with dedicated disposable bailer, clear, colourless, very low turbidity during sample collection with bailer (5L removed).
N03	04/05/18-17/05/18	23/05/2018	4.71	5.94	52500	59265	38522	8	177.3	16.23	Grab sample obtained with dedicated disposable bailer, clear, colourless, very low turbidity during sample collection with bailer (5L removed).
N04	04/05/18-17/05/18	23/05/2018	5.25	6.63	21000	11250	7313	9.66	142.2	16.21	Grab sample obtained with dedicated disposable bailer, first bailer volume was clear, colourless but became highly turbid (brown/gold shimmer) during sample collection with bailer (5L removed).
N05S	25/04/18-17/05/18	23/05/2018	5	4.41	41200	42684	27745	8.16	198.3	15.65	Grab sample obtained with dedicated disposable bailer, clear, colourless, very low turbidity during sample collection with bailer (5L removed).
N05D	23/04/18-07/05/18	23/05/2018	4.84	7.52	48200	54133.6	35187	7.94	179.3	15.7	Grab sample obtained with dedicated disposable bailer, clear, colourless, vey low turbidity during sample collection with bailer (5L removed).

Notes:
Total Dissolved Solids (TDS) estimated from EC (uS/cm) x 0.65
EC = Electrical Conductivity
DO = Dissolved Oxygen
Redox = Redox potential (uncorrected field measurement)
NA = Not Applicable
Laboratory reported pH and EC (batch EM1808769)
Field measured pH may be unreliable due to faulty connection on meter

ANZ

AECOM

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:	N01
Client:	OIIS	Project Location:	NAPANDEE	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	Bore Radius (mm):	0.0845
Depth to GW (m-pvc):	28.23 26.57	Screen Interval (m):	28-34
Bore Depth (m-pvc):	34.30	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):	46L	Includes/excludes bore annulus (circle)	

Parameter Info.

Chem Kit Serial No.: 8
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

\# 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
23 26/4/18	3:35pm	120	25.1	–	–	49843	4.16	305	20.88	white and turbid
17/5/18	3:11pm		26.07		5.82	47706.7	6.07	131.9	21.53	Clear
23/5/18	2:00	5	26.57	–	8.19	49601.7	4.24	255.9	17.18	clear, very low turbidity, colourless
					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: diss DOC metals
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	1 L p	1	500mL p	1	125mL p

QA/QC Information

–

Field Comments

Bore volume calculation, bore condition, fate of tubing, redox correction etc.

BV (34.30-26.57) x 6 ≈ 46L ✓ MM

* Potentially erroneous pH due to poor connection (JT) - check against lab pH to assess reliability.

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

Project Name:	NEWMF	Project Number:	60565376	PM Name:	James Rush	Bore ID:	N02
Client:	DIIS	Project Location:	NAPANDEE	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): 24.391
- Bore Depth (m-pvc): 32.00
- Depth to Product (m-pvc):
- Product Thickness (m):
- Bore Radius (mm): 0.0845
- Screen Interval (m): 25-31
- Casing Radius (mm): 0.025
- Cover Type (gatic/stick up):
- Bore Locked (YES/NO):
- Key Type (if applicable):
- Calculated bore volume (L): 46 L
- Includes/excludes bore annulus (circle)

Parameter Info.

- Chem Kit Serial No.: 8
- 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

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
1- 2/5/18	1:55pm	110	24.2	–	6.75	48451	7.51	118	21.73	light brown turbid, very clayey
17/5/18	3:30pm		24.5		5.80	50150.2	5.82	151.8	20.9	Clear
23/5/18	3:00pm	5	24.391		9.91	52378	4.48	206.2	16.51	clear, colourless/light br/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:	Unfiltered:
DOC diss metals	see COC

Bottles Collected

	x 40 mL Vial (HCl)	3	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	1 Lp.	1	125mLp	1	500mLp

QA/QC Information

–

Field Comments

Bore volume calculation, bore condition, fate of tubing, redox correction etc.

BV (32-24.391) x6
= 46L

* check lab pH against field pH.

Approval and Distribution

[signature]	23/5/18	M. Mom [signature]	30/5/18
Fieldwork Staff Signature	Date	Checker Name and Signature	Date
[signature] for JR	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

Project Name:	NEWMF	Project Number:	60565376	PM Name:	James Rusk	Bore ID:	N03
Client:	Oils	Project Location:	NAPANDEE	Fieldwork Staff:	Tim Smith / Joe Tan	Sample Date:	
						Well Development or Well Sampling Event? (circle	

General Bore Information

- Date of GW Level: See below
- Depth to GW (m-pvc): 23.952
- Bore Depth (m-pvc): 35.00
- Depth to Product (m-pvc): –
- Product Thickness (m): –
- Bore Radius (mm): 0.0845
- Screen Interval (m): 28-34
- Casing Radius (mm): 0.025
- Cover Type (gatic/stick up): stick up
- Bore Locked (YES/NO):
- Key Type (if applicable):
- Calculated bore volume (L): [illegible]
- Includes/excludes bore annulus (circle)

Parameter Info.

- Chem Kit Serial No.: 8
- Chem Kit Model: SMARTROLL
- Corrected Redox: Y / N (Y)
- (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
4-7/5/18	4:00pm	180	23.0	–	6.24	54458	5.09	183	20.29	bailed (white grey turbid w sediment 4/5/18)
17/5/18	3:51pm		24.0		6.04	60273	5.72	168.3	21.91	Clear
23/5/18	1:00	5	23.952	–	8.00	59265	4.71	177.3	16.23	clear, low turb, colourless
				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, diss metals

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	1 Lp	1	500mLp	1	125mLp

QA/QC Information

–

Field Comments

Bore volume calculation, bore condition, fate of tubing, redox correction etc.

BV = (35 - ~~23.952~~ 28) x 6L/m for screened sect
For water column above ≈ 36 L
∴ in screen 2/L
(28 - 23.952) 4 x 2 = 8L
∴ total BV ≈ 44L

* check field pH against lab pH.

Approval and Distribution

[signature] Fieldwork Staff Signature	23/5/18 Date	M. Mam [signature] Checker Name and Signature	30/5/18 Date
For JR [signature] Project Manager Signature	30/5/18 Date	Distribution: Project Central File	

ANZ

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:	N04
Client:	OIIS	Project Location:	NAPANDEE	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	Bore Radius (mm):	0.0845
Depth to GW (m-pvc):	28.048	Screen Interval (m):	26-32
Bore Depth (m-pvc):	32.62	Casing Radius (mm):	0.025
Depth to Product (m-pvc):		Cover Type (gatic/stick up):	stick up
Product Thickness (m):		Bore Locked (YES/NO):	
		Key Type (if applicable):	
Calculated bore volume (L):	27L	Includes/ excludes bore annulus (circle)	

Parameter Info.

Chem Kit Serial No.: 8

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)

\# 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
4 — 8/5/18	10:20am	100	24.68	-	3.84	18048	5.64	107	19.9	bailed dry
17/5/18	4:01pm		28.2		4.56	20645	5.48	93.2	23.28	Turbid (muddy)
23/5/18	4:00	5	28.048	—	9.66	11250	5.25	142.2	16.21	first bailer clear, colourless very low turb became brown/gold with shimmer and mod-high turb. let settle and decanted sample.
				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 diss metals

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	1 Lp.	1	500mL p	1	125mL p

QA/QC Information

—

Field Comments

Bore volume calculation, bore condition, rate of tubing, redox correction etc.

BV = (32.62 − 28.048) × 6L/m

≈ 27L

✓ [initials]

Approval and Distribution

[signature]	23/5/18	M. Mon [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:	NO55
Client:	DIIS	Project Location:	NAPANDEE	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):	31.607
Bore Depth (m-pvc):	37.00
Depth to Product (m-pvc):	–
Product Thickness (m):	–
Calculated bore volume (L):	32
Bore Radius (mm):	0.0845
Screen Interval (m):	30-36
Casing Radius (mm):	0.025
Cover Type (gatic/stick up):	stick up
Bore Locked (YES/NO):	
Key Type (if applicable):	
Includes/ excludes bore annulus (circle)	

Parameter Info.

Chem Kit Serial No.:	8
Chem Kit Model:	SMARTROLL
Corrected Redox:	Y / N (Y)
(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:

☑ Bailer ☐ Hydrasleeve ☐ Peristaltic Pump ☐ Waterra ☐ Other (specify)

Total purged volume (L): –

Hydrasleeve info.

		Monitoring sequence followed (number in order):
Hydrasleeve Size:	–	Gauging
Hydrasleeve Type:	–	Hydrasleeve in
Sampling Depth (m-pvc):	–	Hydrasleeve out
Hydrasleeve Install time:	–	Parameters
Sampling Start Time:	–	

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
25/4-7/5/18	9:50	250	~~30.8~~	–	6.86	45004	4.18	218	18.69	low yielding well, clayey
17/5/18	4:12pm		31.65		6.47	29573	4.57	198.5	19.34	Clear.
23/5/18	1:00pm	5	31.607	–	8.16	42684	5.00	198.3	15.65	clear, very low turb, colourless
					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: diss 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	500ml p	1	125ml p

QA/QC Information

–

Field Comments

Bore volume calculation, bore condition, fate of tubing, redox correction etc.

BV = (37 - 31.6) × 6 L/m

= 32L

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

Q4AN(EV)-405-FM1

WELL DEVELOPMENT AND SAMPLING RECORD

Project Name:	NEWMF	Project Number:	60565376	PM Name:	James Rusk	Bore ID:	N05D
Client:	DIIS	Project Location:	NAPANDEE	Fieldwork Staff:	Tim Smith / Joe Tan	Sample Date:	23/5/18

Well Development or Well Sampling Event? (circle): Sampling

General Bore Information

- Date of GW Level: See below
- Depth to GW (m-pvc): 32.655
- Bore Depth (m-pvc): 64.12
- Depth to Product (m-pvc):
- Product Thickness (m):
- Bore Radius (mm): 0.0845
- Screen Interval (m): 58-64
- Casing Radius (mm): 0.025
- Cover Type (gatic/stick up): stick up
- Bore Locked (YES/NO):
- Key Type (if applicable):
- Calculated bore volume (L): 87
- Includes/excludes bore annulus (circle)

Parameter Info.

- Chem Kit Serial No.: 8
- 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:
- ☑ 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
2										
23/4/18	5:32pm	300	34.7	–	–	55461	7.18	-89	20.19	Clear, very low turbidity, colourless
17/5/18	4:33pm		32.6	–	–	–	–	–	–	Could not get bailer to reach wt.
23/5/18	1:30pm	5	32.655	–	~~9.839~~ 7.94	54133.6	4.84	179.3	15.70	clear, very low turb, colourless
				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
- 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~~ 60 mL Plastic
1	1L p	1	500mL p	1	125mL p

QA/QC Information

–

Field Comments

Bore volume calculation, bore condition, fate of tubing, redox correction etc.

BV = (64.12 - 32.655) × 6L for screened section ≈ 87L
6 × 6 = 36L
for rest of water column above screen 2L/m
(58 - 32.655) × 2 ≈ 51 L
Total BV ≈ 87L

Approval and Distribution

Fieldwork Staff Signature: [signature]	Date: 23/5/18	Checker Name and Signature: McMahon [signature]	Date: 30/5/18
Project Manager Signature: For JR [signature]	Date: 30/5/18	Distribution: Project Central File	

Groundwater Analytical Results Table - Napandee

Reporting Group	Analyte	Unit	LOR	Location_Code	N01	N02	N03	N04	N05S	N05D	QC05
				Field_ID	N01_23/05/18	N02_23/05/18	N03_23/05/18	N04_22/05/18	N05S_23/05/18	N05D_23/05/18	QC01_23/05/18
				Sample_Type	Normal	Normal	Normal	Normal	Normal	Normal	Rinse blank
				Sampled_Date	23/05/018	23/05/2018	23/05/2018	22/05/2018	23/05/2018	23/05/2018	22/05/2018
				Lab_Report	EM1808769	EM1808769	EM1808769	EM1808769	EM1808769	EM1808769	EM1808769
Gross	pH	pH unit	0.01		**4.54**	**6.98**	**5.94**	**6.63**	**4.41**	**7.52**	**6.46**
	Electrical Conductivity (EC)	µS/cm	1		**44600**	**49100**	**52500**	**21000**	**41200**	**48200**	-
Radionuclides	Gross alpha	Bq/L	-		**4.4**	**7.78**	**24.2**	**1.84**	**3.6**	-	-
	Gross beta activity - 40 K	Bq/L	-		**19.2**	**34.8**	**95.3**	**3.31**	**9.72**	-	-
Dissolved Metals (15 NEPM)	Arsenic	mg/L	0.001		**0.003**	<0.002	<0.002	<0.001	**0.003**	<0.001	<0.001
	Boron	mg/L	0.05		**2.48**	**2.54**	**3.42**	**1.95**	**2.89**	**3.9**	<0.05
	Barium	mg/L	0.001		**0.184**	**0.297**	**0.243**	**0.194**	**0.107**	**0.283**	<0.001
	Beryllium	mg/L	0.001		**0.004**	<0.002	**0.002**	<0.001	**0.004**	<0.001	<0.001
	Cadmium	mg/L	0.0001		**0.0044**	**0.0008**	**0.0036**	**0.0005**	**0.0038**	**0.0007**	<0.0001
	Cobalt	mg/L	0.001		**0.073**	**0.009**	**0.04**	**0.041**	**0.439**	**0.004**	<0.001
	Chromium	mg/L	0.001		**0.004**	<0.002	<0.002	<0.001	**0.007**	<0.001	<0.001
	Copper	mg/L	0.001		**0.066**	**0.002**	**0.1**	<0.001	**0.016**	<0.001	<0.001
	Manganese	mg/L	0.001		**2.03**	**1.36**	**1.51**	**1.9**	**1.17**	**0.624**	**0.002**
	Nickel	mg/L	0.001		**0.217**	**0.042**	**0.095**	**0.072**	**0.128**	**0.011**	<0.001
	Lead	mg/L	0.001		**0.006**	<0.002	**0.005**	<0.001	**0.009**	<0.001	<0.001
	Selenium	mg/L	0.01		<0.01	<0.02	<0.02	<0.01	<0.01	<0.01	<0.001
	Vanadium	mg/L	0.01		<0.01	<0.02	<0.02	<0.01	<0.01	<0.01	<0.01
	Zinc	mg/L	0.005		**0.494**	**0.035**	**0.199**	**0.052**	**0.274**	**0.032**	<0.01
	Lithium	mg/L	0.001		**0.094**	**0.05**	**0.114**	**0.068**	**0.167**	**0.296**	<0.005
	Strontium	mg/L	0.001		**5.77**	**6.61**	**6.41**	**3.05**	**5.04**	**4.93**	<0.001
	Thorium	mg/L	0.001		<0.001	<0.002	<0.002	<0.001	<0.001	**0.004**	<0.001
	Uranium	mg/L	0.001		**0.003**	**0.003**	**0.004**	<0.001	**0.012**	**0.007**	<0.001
	Bromine	mg/L	0.1		**52.6**	**59.4**	**62.6**	**29.5**	**51.5**	**52.8**	<0.1
	Iodine	mg/L	0.1		**0.3**	**0.7**	**0.6**	**0.5**	**0.4**	**0.8**	<0.1
	Mercury	mg/L	0.0001		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Total Metals	Manganese	mg/L	0.001		**2.09**	**1.4**	**1.57**	**2.02**	**1.19**	-	-
	Iron	mg/L	0.05		**16.8**	**0.72**	**0.97**	**12**	**6.86**	-	-
Nutrients	Nitrite as N	mg/L	0.01		<0.01	**0.03**	**0.02**	**0.01**	<0.01	-	-
	Nitrate as N	mg/L	0.01		-	-	-	-	-	-	-
	Ammonia as N	mg/L	0.01		-	-	-	-	-	-	-
	Fluoride	mg/L	0.1		**0.4**	**0.3**	**0.8**	**1.2**	**0.5**	**1.7**	-
	Silicon	mg/L	0.05		**17.7**	**10.7**	**18.9**	**13.3**	**26**	**10**	<0.05
	Dissolved Sulphide as S2-	-	mg/L		<0.1	<0.1	<0.1	<0.1	<0.1	-	-
Alkalinity	Hydroxide Alkalinity as CaCO3	mg/L	1		<1	<1	<1	<1	<1	<1	<1
	Carbonate Alkalinity as CaCO3	mg/L	1		<1	<1	<1	<1	<1	<1	<1
	Bicarbonate Alkalinity as CaCO3	mg/L	1		<1	**155**	**25**	**78**	<1	**169**	**1**
	Total Alkalinity as CaCO3	mg/L	1		<1	**155**	**25**	**78**	<1	**169**	**1**
	Dissolved Organic Carbon (DOC)	-	mg/L		**6**	**6**	**4**	**5**	**5**	-	-
Major Ions	Calcium	mg/L	1		**618**	**823**	**700**	**349**	**613**	**491**	<1
	Magnesium	mg/L	1		**942**	**896**	**1180**	**387**	**1110**	**788**	<1
	Sodium	mg/L	1		**6690**	**9750**	**12300**	**5500**	**11800**	**10200**	<1
	Potassium	mg/L	1		**248**	**219**	**255**	**136**	**288**	**216**	<1
	Sulphate (as SO4-)	mg/L	1		**2100**	**2240**	**2590**	**1090**	**2190**	**2610**	<1
	Chloride	mg/L	1		**15600**	**16400**	**19800**	**7500**	-	**17800**	**1**
	Total Anions	meq/L	0.01		**484**	**512**	**613**	**236**	**452**	**560**	**0.05**
	Total Cations	meq/L	0.01		**548**	**544**	**674**	**206**	**458**	**538**	<0.01
	Ionic Balance	%	0.01		**6.22**	**3.04**	**4.71**	**6.86**	**0.7**	**1.94**	-

Notes:
Legend:
Not analysed/ Not calculated
LOR: Limit of Reporting
Bq/L = Becquerals per litre
mg/L: milligrams per Litre
µg/L: micrograms per litre
Pending: Preliminary report EM1808546 issued 01/06/18 for available data

CERTIFICATE OF ANALYSIS

Work Order	: **EM1808769**	Page	: 1 of 6
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	: 01-Jun-2018
C-O-C number	: ----	Issue Date	: 13-Jun-2018 16:54
Sampler	: SYLVIA BRETHERTON		
Site	: NRWMF Site Characterisation		
Quote number	: EN/004/16		
No. of samples received	: 8		
No. of samples analysed	: 7		

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: EM1808769-007 dissolved manganese result has been confirmed by re-preparation and re-analysis
- EG020F: EM1808769-002 & 003 required dilution prior to dissolved metals analysis due to sample matrix interference. LOR values have been raised accordingly.
- 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).
- Ionic balances were calculated using: major anions - chloride, alkalinity and sulfate; and major cations - calcium, magnesium, potassium and sodium.
- 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)

				N01_23/5/18	N02_23/5/18	N03_23/5/18	N04_23/5/18	N05S_23/5/18
				23-May-2018 00:00	23-May-2018 00:00	23-May-2018 00:00	23-May-2018 00:00	23-May-2018 00:00
				EM1808769-001	EM1808769-002	EM1808769-003	EM1808769-004	EM1808769-005
				Result	Result	Result	Result	Result
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	**4.54**	**6.98**	**5.94**	**6.63**	**4.41**
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	**44600**	**49100**	**52500**	**21000**	**41200**
EA250: Gross Alpha and Beta Activity								
Gross alpha	----	0.05	Bq/L	**4.40**	**7.78**	**24.2**	**1.84**	**3.60**
Gross beta activity - 40K	----	0.10	Bq/L	**19.2**	**34.8**	**95.3**	**3.31**	**9.72**
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	<1	**155**	**25**	**78**	<1
Total Alkalinity as CaCO3	----	1	mg/L	<1	**155**	**25**	**78**	<1
ED040F: Dissolved Major Anions								
Silicon	7440-21-3	0.05	mg/L	**17.7**	**10.7**	**18.9**	**13.3**	**26**
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	**2100**	**2240**	**2590**	**1090**	**2190**
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	**15600**	**16400**	**19800**	**7500**	**14400**
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	**618**	**823**	**700**	**349**	**613**
Magnesium	7439-95-4	1	mg/L	**942**	**896**	**1180**	**387**	**1110**
Sodium	7440-23-5	1	mg/L	**9960**	**9750**	**12300**	**5500**	**11800**
Potassium	7440-09-7	1	mg/L	**248**	**219**	**255**	**136**	**288**
EG020F: Dissolved Metals by ICP-MS								
Arsenic	7440-38-2	0.001	mg/L	**0.003**	<0.002	<0.002	<0.001	**0.003**
Boron	7440-42-8	0.05	mg/L	**2.48**	**2.54**	**3.42**	**1.95**	**2.89**
Barium	7440-39-3	0.001	mg/L	**0.184**	**0.297**	**0.243**	**0.194**	**0.107**
Beryllium	7440-41-7	0.001	mg/L	**0.004**	<0.002	**0.002**	<0.001	**0.004**
Cadmium	7440-43-9	0.0001	mg/L	**0.0044**	**0.0008**	**0.0036**	**0.0005**	**0.0038**
Cobalt	7440-48-4	0.001	mg/L	**0.073**	**0.009**	**0.040**	**0.041**	**0.439**
Chromium	7440-47-3	0.001	mg/L	**0.004**	<0.002	<0.002	<0.001	**0.007**
Copper	7440-50-8	0.001	mg/L	**0.066**	**0.002**	**0.010**	<0.001	**0.016**
Manganese	7439-96-5	0.001	mg/L	**2.03**	**1.36**	**1.51**	**1.90**	**1.17**
Nickel	7440-02-0	0.001	mg/L	**0.217**	**0.042**	**0.095**	**0.072**	**0.128**
Lead	7439-92-1	0.001	mg/L	**0.006**	<0.002	**0.005**	<0.001	**0.009**

Analytical Results

Sub-Matrix: WATER
(Matrix: WATER)

				N01_23/5/18	N02_23/5/18	N03_23/5/18	N04_23/5/18	N05S_23/5/18
				23-May-2018 00:00	23-May-2018 00:00	23-May-2018 00:00	23-May-2018 00:00	23-May-2018 00:00
				EM1808769-001	**EM1808769-002**	**EM1808769-003**	**EM1808769-004**	**EM1808769-005**
				Result	Result	Result	Result	Result
EG020F: Dissolved Metals by ICP-MS - Continued								
Selenium	7782-49-2	0.01	mg/L	<0.01	<0.02	<0.02	<0.01	<0.01
Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.02	<0.02	<0.01	<0.01
Zinc	7440-66-6	0.005	mg/L	**0.494**	**0.035**	**0.199**	**0.052**	**0.274**
Lithium	7439-93-2	0.001	mg/L	**0.094**	**0.050**	**0.114**	**0.068**	**0.167**
Strontium	7440-24-6	0.001	mg/L	**5.77**	**6.61**	**6.41**	**3.05**	**5.04**
Thorium	7440-29-1	0.001	mg/L	<0.001	<0.002	<0.002	<0.001	<0.001
Uranium	7440-61-1	0.001	mg/L	**0.003**	**0.003**	**0.004**	<0.001	**0.012**
Bromine	7726-95-6	0.1	mg/L	**52.6**	**59.4**	**62.6**	**29.5**	**51.5**
Iodine	7553-56-2	0.1	mg/L	**0.3**	**0.7**	**0.6**	**0.5**	**0.4**
EG020T: Total Metals by ICP-MS								
Manganese	7439-96-5	0.001	mg/L	**2.09**	**1.40**	**1.57**	**2.02**	**1.19**
Iron	7439-89-6	0.05	mg/L	**16.8**	**0.72**	**0.97**	**12.0**	**6.86**
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**	**0.3**	**0.8**	**1.2**	**0.5**
EK057G: Nitrite as N by Discrete Analyser								
Nitrite as N	14797-65-0	0.01	mg/L	<0.01	**0.03**	**0.02**	**0.01**	<0.01
EK058G: Nitrate as N by Discrete Analyser								
Nitrate as N	14797-55-8	0.01	mg/L	**0.11**	**0.12**	**0.04**	**0.07**	**0.06**
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								
Nitrite + Nitrate as N	----	0.01	mg/L	**0.11**	**0.15**	**0.06**	**0.08**	**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	<0.1
EN055: Ionic Balance								
Total Anions	----	0.01	meq/L	**484**	**512**	**613**	**236**	**452**
Total Cations	----	0.01	meq/L	**548**	**544**	**674**	**206**	**458**
Ionic Balance	----	0.01	%	**6.22**	**3.04**	**4.71**	**6.86**	**0.70**
EP002: Dissolved Organic Carbon (DOC)								
Dissolved Organic Carbon	----	1	mg/L	**6**	**6**	**4**	**5**	**5**

Analytical Results

Sub-Matrix: **WATER** (Matrix: **WATER**)				**N05D_23/5/18**	**QC05_23/5/18**	**----**	**----**	**----**
				23-May-2018 00:00	23-May-2018 00:00	----	----	----
				EM1808769-006	**EM1808769-007**	**--------**	**--------**	**--------**
				Result	Result	----	----	----
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	**7.52**	**6.46**	----	----	----
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	**48200**	**2**	----	----	----
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	----	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	----	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	**169**	**1**	----	----	----
Total Alkalinity as CaCO3	----	1	mg/L	**169**	**1**	----	----	----
ED040F: Dissolved Major Anions								
Silicon	7440-21-3	0.05	mg/L	**10**	<0.05	----	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	**2610**	<1	----	----	----
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	**17800**	**1**	----	----	----
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	**491**	<1	----	----	----
Magnesium	7439-95-4	1	mg/L	**788**	<1	----	----	----
Sodium	7440-23-5	1	mg/L	**10200**	<1	----	----	----
Potassium	7440-09-7	1	mg/L	**216**	<1	----	----	----
EG020F: Dissolved Metals by ICP-MS								
Arsenic	7440-38-2	0.001	mg/L	<0.001	<0.001	----	----	----
Boron	7440-42-8	0.05	mg/L	**3.90**	<0.05	----	----	----
Barium	7440-39-3	0.001	mg/L	**0.283**	<0.001	----	----	----
Beryllium	7440-41-7	0.001	mg/L	<0.001	<0.001	----	----	----
Cadmium	7440-43-9	0.0001	mg/L	**0.0007**	<0.0001	----	----	----
Cobalt	7440-48-4	0.001	mg/L	**0.004**	<0.001	----	----	----
Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	----	----	----
Copper	7440-50-8	0.001	mg/L	<0.001	<0.001	----	----	----
Manganese	7439-96-5	0.001	mg/L	**0.624**	**0.002**	----	----	----
Nickel	7440-02-0	0.001	mg/L	**0.011**	<0.001	----	----	----
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	----	----	----
Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	----	----	----
Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	----	----	----
Zinc	7440-66-6	0.005	mg/L	**0.032**	<0.005	----	----	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				N05D_23/5/18	QC05_23/5/18	----	----	----
				23-May-2018 00:00	23-May-2018 00:00	----	----	----
				EM1808769-006	EM1808769-007	--------	--------	--------
				Result	Result	----	----	----
EG020F: Dissolved Metals by ICP-MS - Continued								
Lithium	7439-93-2	0.001	mg/L	**0.296**	<0.001	----	----	----
Strontium	7440-24-6	0.001	mg/L	**4.93**	<0.001	----	----	----
Thorium	7440-29-1	0.001	mg/L	**0.004**	<0.001	----	----	----
Uranium	7440-61-1	0.001	mg/L	**0.007**	<0.001	----	----	----
Bromine	7726-95-6	0.1	mg/L	**52.8**	<0.1	----	----	----
Iodine	7553-56-2	0.1	mg/L	**0.8**	<0.1	----	----	----
EG035F: Dissolved Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	----	----	----
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	**1.7**	<0.1	----	----	----
EN055: Ionic Balance								
Total Anions	----	0.01	meq/L	**560**	**0.05**	----	----	----
Total Cations	----	0.01	meq/L	**538**	<0.01	----	----	----
Ionic Balance	----	0.01	%	**1.94**	----	----	----	----

ALS Environmental

QUALITY CONTROL REPORT

Work Order	: **EM1808769**	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	: 25-May-2018
Order number	: 60565376.4.0	Date Analysis Commenced	: 01-Jun-2018
C-O-C number	: ----	Issue Date	: 13-Jun-2018
Sampler	: SYLVIA BRETHERTON		
Site	: NRWMF Site Characterisation		
Quote number	: EN/004/16		
No. of samples received	: 8		
No. of samples analysed	: 7		

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 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: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
EP002: Dissolved Organic Carbon (DOC) (QC Lot: 1698358)									
ES1815872-001	Anonymous	EP002: Dissolved Organic Carbon	----	1	mg/L	108	127	16.2	0% - 20%
ES1815918-005	Anonymous	EP002: Dissolved Organic Carbon	----	1	mg/L	113	114	1.23	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: **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
EA250: Gross Alpha and Beta Activity (QCLot: 1724343)								
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
EP002: Dissolved Organic Carbon (DOC) (QCLot: 1698358)								
EP002: Dissolved Organic Carbon	----	1	mg/L	<1	10 mg/L	96.7	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**

				Matrix Spike (MS) Report			
				Spike	SpikeRecovery(%)	Recovery Limits (%)	
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Concentration	MS	Low	High
EP002: Dissolved Organic Carbon (DOC) (QCLot: 1698358)							
EM1808769-002	N02_23/5/18	EP002: Dissolved Organic Carbon	----	100 mg/L	82.0	70	130

ALS Environmental

QA/QC Compliance Assessment to assist with Quality Review

Work Order	: **EM1808769**	Page	: 1 of 8
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	: 13-Jun-2018
Sampler	: SYLVIA BRETHERTON	No. of samples received	: 8
Order number	: 60565376.4.0	No. of samples analysed	: 7

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

- **Quality Control Sample Frequency Outliers exist - please see following pages for full details.**

Outliers : Analysis Holding Time Compliance

Matrix: **WATER**

Method / Container / Client Sample ID(s)		Extraction / Preparation: Date extracted	Due for extraction	Days overdue	Analysis: Date analysed	Due for analysis	Days overdue
EA005P: pH by PC Titrator							
Clear Plastic Bottle - Natural							
N01_23/5/18, N03_23/5/18, N05S_23/5/18, QC05_23/5/18	N02_23/5/18, N04_23/5/18, N05D_23/5/18,	----	----	----	04-Jun-2018	24-May-2018	**11**
EK057G: Nitrite as N by Discrete Analyser							
Clear Plastic Bottle - Natural							
N01_23/5/18, N03_23/5/18, N05S_23/5/18	N02_23/5/18, N04_23/5/18,	----	----	----	01-Jun-2018	25-May-2018	**7**
EK085F: Dissolved Sulfide as S2-							
Clear Plastic Bottle - Zn Acetate/NaOH-FLOCCULATED							
N01_23/5/18, N03_23/5/18, N05S_23/5/18	N02_23/5/18, N04_23/5/18,	----	----	----	01-Jun-2018	30-May-2018	**2**

Outliers : Frequency of Quality Control Samples

Matrix: **WATER**

Quality Control Sample Type / Method	Count: QC	Count: Regular	Rate (%): Actual	Rate (%): Expected	Quality Control Specification
Laboratory Duplicates (DUP)					
Gross Alpha and Beta Activity	0	5	0.00	10.00	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 / Container / Client Sample ID(s)	Sample Date	Extraction / Preparation: Date extracted	Due for extraction	Evaluation	Analysis: 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: Date extracted	Extraction / Preparation: Due for extraction	Extraction / Preparation: Evaluation	Analysis: Date analysed	Analysis: Due for analysis	Analysis: Evaluation
EA005P: pH by PC Titrator							
Clear Plastic Bottle - Natural (EA005-P) N01_23/5/18, N02_23/5/18, N03_23/5/18, N04_23/5/18, N05S_23/5/18, N05D_23/5/18, QC05_23/5/18	**23-May-2018**	**----**	----	----	**04-Jun-2018**	24-May-2018	×
EA010P: Conductivity by PC Titrator							
Clear Plastic Bottle - Natural (EA010-P) N01_23/5/18, N02_23/5/18, N03_23/5/18, N04_23/5/18, N05S_23/5/18, N05D_23/5/18, QC05_23/5/18	**23-May-2018**	**----**	----	----	**04-Jun-2018**	20-Jun-2018	✓
EA250: Gross Alpha and Beta Activity							
Clear Plastic Bottle - Natural (EA250-LSC) N01_23/5/18, N02_23/5/18, N03_23/5/18, N04_23/5/18, N05S_23/5/18	**23-May-2018**	**----**	----	----	**13-Jun-2018**	19-Nov-2018	✓
ED037P: Alkalinity by PC Titrator							
Clear Plastic Bottle - Natural (ED037-P) N01_23/5/18, N02_23/5/18, N03_23/5/18, N04_23/5/18, N05S_23/5/18, N05D_23/5/18, QC05_23/5/18	**23-May-2018**	**----**	----	----	**04-Jun-2018**	06-Jun-2018	✓
ED040F: Dissolved Major Anions							
Clear Plastic Bottle - Natural (ED040F) N01_23/5/18, N02_23/5/18, N03_23/5/18, N04_23/5/18, N05S_23/5/18, N05D_23/5/18, QC05_23/5/18	**23-May-2018**	**----**	----	----	**01-Jun-2018**	20-Jun-2018	✓
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA							
Clear Plastic Bottle - Natural (ED041G) N01_23/5/18, N02_23/5/18, N03_23/5/18, N04_23/5/18, N05S_23/5/18, N05D_23/5/18, QC05_23/5/18	**23-May-2018**	**----**	----	----	**01-Jun-2018**	20-Jun-2018	✓
ED045G: Chloride by Discrete Analyser							
Clear Plastic Bottle - Natural (ED045G) N01_23/5/18, N02_23/5/18, N03_23/5/18, N04_23/5/18, N05S_23/5/18, N05D_23/5/18, QC05_23/5/18	**23-May-2018**	**----**	----	----	**01-Jun-2018**	20-Jun-2018	✓

Matrix: **WATER**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method / Container / Client Sample ID(s)		Sample Date	Extraction / Preparation: Date extracted	Due for extraction	Evaluation	Analysis: Date analysed	Due for analysis	Evaluation
ED093F: Dissolved Major Cations								
Clear Plastic Bottle - Filtered; Lab-acidified (ED093F)								
N01_23/5/18,	N02_23/5/18,	**23-May-2018**	**----**	----	----	**01-Jun-2018**	20-Jun-2018	✓
N03_23/5/18,	N04_23/5/18,							
N05S_23/5/18,	N05D_23/5/18,							
QC05_23/5/18								
EG020F: Dissolved Metals by ICP-MS								
Clear Plastic Bottle - Filtered; Lab-acidified (EG020B-F)								
N01_23/5/18,	N02_23/5/18,	**23-May-2018**	**----**	----	----	**04-Jun-2018**	19-Nov-2018	✓
N03_23/5/18,	N04_23/5/18,							
N05S_23/5/18,	N05D_23/5/18,							
QC05_23/5/18								
EG020T: Total Metals by ICP-MS								
Clear Plastic Bottle - Unfiltered; Lab-acidified (EG020A-T)								
N01_23/5/18,	N02_23/5/18,	**23-May-2018**	**01-Jun-2018**	19-Nov-2018	✓	**04-Jun-2018**	19-Nov-2018	✓
N03_23/5/18,	N04_23/5/18,							
N05S_23/5/18								
EG035F: Dissolved Mercury by FIMS								
Clear Plastic Bottle - Filtered; Lab-acidified (EG035F)								
N01_23/5/18,	N02_23/5/18,	**23-May-2018**	**----**	----	----	**04-Jun-2018**	20-Jun-2018	✓
N03_23/5/18,	N04_23/5/18,							
N05S_23/5/18,	N05D_23/5/18,							
QC05_23/5/18								
EK040P: Fluoride by PC Titrator								
Clear Plastic Bottle - Natural (EK040P)								
N01_23/5/18,	N02_23/5/18,	**23-May-2018**	**----**	----	----	**04-Jun-2018**	20-Jun-2018	✓
N03_23/5/18,	N04_23/5/18,							
N05S_23/5/18,	N05D_23/5/18,							
QC05_23/5/18								
EK057G: Nitrite as N by Discrete Analyser								
Clear Plastic Bottle - Natural (EK057G)								
N01_23/5/18,	N02_23/5/18,	**23-May-2018**	**----**	----	----	**01-Jun-2018**	25-May-2018	×
N03_23/5/18,	N04_23/5/18,							
N05S_23/5/18								
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								
Clear Plastic Bottle - Sulfuric Acid (EK059G)								
N01_23/5/18,	N02_23/5/18,	**23-May-2018**	**----**	----	----	**06-Jun-2018**	20-Jun-2018	✓
N03_23/5/18,	N04_23/5/18,							
N05S_23/5/18								

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
EK085F: Dissolved Sulfide as S2-							
Clear Plastic Bottle - Zn Acetate/NaOH-FLOCCULATED (EK085F) N01_23/5/18, N02_23/5/18, N03_23/5/18, N04_23/5/18, N05S_23/5/18	**23-May-2018**	**----**	----	----	**01-Jun-2018**	30-May-2018	×
EP002: Dissolved Organic Carbon (DOC)							
Amber DOC Filtered- Sulfuric Preserved (EP002) N01_23/5/18, N02_23/5/18, N03_23/5/18, N04_23/5/18, N05S_23/5/18	**23-May-2018**	**----**	----	----	**04-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)							
Dissolved Organic Carbon	EP002	2	15	**13.33**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Gross Alpha and Beta Activity	EA250-LSC	0	5	**0.00**	**10.00**	×	NEPM 2013 B3 & ALS QC Standard
Laboratory Control Samples (LCS)							
Dissolved Organic Carbon	EP002	1	15	**6.67**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Gross Alpha and Beta Activity	EA250-LSC	2	5	**40.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Method Blanks (MB)							
Dissolved Organic Carbon	EP002	1	15	**6.67**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Gross Alpha and Beta Activity	EA250-LSC	1	5	**20.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Matrix Spikes (MS)							
Dissolved Organic Carbon	EP002	1	15	**6.67**	**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)

ALS Environmental

SAMPLE RECEIPT NOTIFICATION (SRN)

Work Order	: **EM1808769**		
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 3
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	: 01-Jun-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	: 8 / 7

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)
EM1808769-001	23-May-2018 00:00	N01_23/5/18	✓	✓	✓	✓	✓	✓	✓
EM1808769-002	23-May-2018 00:00	N02_23/5/18	✓	✓	✓	✓	✓	✓	✓
EM1808769-003	23-May-2018 00:00	N03_23/5/18	✓	✓	✓	✓	✓	✓	✓
EM1808769-004	23-May-2018 00:00	N04_23/5/18	✓	✓	✓	✓	✓	✓	✓
EM1808769-005	23-May-2018 00:00	N05S_23/5/18	✓	✓	✓	✓	✓	✓	✓
EM1808769-006	23-May-2018 00:00	N05D_23/5/18	✓		✓			✓	✓
EM1808769-007	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
EM1808769-001	23-May-2018 00:00	N01_23/5/18		✓	✓	✓	✓
EM1808769-002	23-May-2018 00:00	N02_23/5/18		✓	✓	✓	✓
EM1808769-003	23-May-2018 00:00	N03_23/5/18		✓	✓	✓	✓
EM1808769-004	23-May-2018 00:00	N04_23/5/18		✓	✓	✓	✓
EM1808769-005	23-May-2018 00:00	N05S_23/5/18		✓	✓	✓	✓
EM1808769-006	23-May-2018 00:00	N05D_23/5/18		✓		✓	
EM1808769-007	23-May-2018 00:00	QC05_23/5/18		✓		✓	
EM1808769-008	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 Date	Samples Received Evaluation	Instructions Received Date	Instructions Received Evaluation
EA005-P: pH by PC Titrator							
N01_23/5/18	Clear Plastic Bottle - Natural	----	24-May-2018	25-May-2018		----	----
N02_23/5/18	Clear Plastic Bottle - Natural	----	24-May-2018	25-May-2018		----	----

N03_23/5/18	Clear Plastic Bottle - Natural	----	24-May-2018	25-May-2018		----	----
N04_23/5/18	Clear Plastic Bottle - Natural	----	24-May-2018	25-May-2018		----	----
N05D_23/5/18	Clear Plastic Bottle - Natural	----	24-May-2018	25-May-2018		----	----
N05S_23/5/18	Clear Plastic Bottle - Natural	----	24-May-2018	25-May-2018		----	----
QC05_23/5/18	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

2 of 2
(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.
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
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: [signature]
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	NAPANDEE	KIMBA	W	PRIMARY	N01	[redacted] 23/5/18	23/5/18	P,VS,C,S	2	10	✓	✓	✓	✓	✓	✓	✓	HOLD
2					N02	23/5/18					✓	✓	✓	✓	✓	✓	✓	HOLD
3					N03	23/5/18					✓	✓	✓	✓	✓	✓	✓	HOLD
4					N04	23/5/18					✓	✓	✓	✓	✓	✓	✓	HOLD
5					N05S	23/5/18					✓	✓	✓	✓	✓	✓	✓	HOLD
6					N05D	23/5/18					✓	✓	HOLD					HOLD
7				QAQC	QC05	23/5/18			N		✓	✓	HOLD					HOLD
8				QAQC	QC06	23/5/18			N		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. CHECKED:
DATE: 24/5/18 TIME:
RECEIVED BY: CHECKED:
DATE: TIME:

...DES
...C = Sodium Hydroxide Preserved; J = Solvent Washed Acid Rinsed Jar
... VC = Hydrochloric Acid Preserved Vial; VS Sulphuric Acid Preserved Glass Bottle;
...Preserved Bottle; ST = Sterile Bottle; O = Other

Environmental Division
Melbourne
Work Order Reference
EM1808769
Telephone : +61-3-8549 9600

Recieved by ~~Nicole~~ [ACS] 11.15
25/5/18

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		

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.

[illegible]

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.

[illegible]	[illegible]	[illegible]
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**	----	----	----

Soil Chemistry - Napandee

Soil Analytical Chemistry - Napandee

		Sample ID	N07_0.2-0.4m	QC104-25042018	N07_1.5-1.6m	N07_2.5-2.6m	N09_0.0-0.2m	N09_1.4-1.5m	N09_2.5-2.6m	N11_0.0-0.2m	N11_1.0-1.1m	N11_2.0-2.1m
		Sample Date	25/04/2018	-	25/04/2018	25/04/2018	25/04/2018	25/04/2018	25/04/2018	25/04/2018	25/04/2018	25/04/2018
		Description	Silty SAND topsoil	Field duplicate for N07_0.0-0.2m	Silty/Clayey SAND	CLAY	Silty SAND topsoil	Silty/Clayey SAND	CLAY	Silty SAND topsoil	Silty/Clayey SAND	CLAY
		Lab Batch	EM1807107	EM1807107	EM1807107	EM1807107	EM1807107	EM1807107	EM1807107	EM1807107	EM1807107	EM1807107
Laboratory Analyte	**LOR**	**Unit**										
pH	0.1	pH unit	6	8.2	8.3	8.1	6.2	8.1	5.2	6.7	8.4	6.1
Electrical Conductivity	1	µS/cm	105	404	1060	1150	157	1360	1620	333	1370	1630
Electrical Conductivity (Saturated Paste)	1	µS/cm	405	764	3330	3760	515	1000	5870	853	3700	5620
Exchangeable Cations on Alkaline Soils												
Exchangeable Calcium	0.2	meq/100g	-	4.7	1.7	1.2	-	1.3	-	2.4	1.7	-
Exchangeable Magnesium	0.2	meq/100g	-	2.6	3.1	3.5	-	3.7	-	1.3	4.1	-
Exchangeable Potassium	0.2	meq/100g	-	0.6	1.3	1.7	-	1.3	-	0.8	1.5	-
Exchangeable Sodium	0.2	meq/100g	-	2.2	4.4	5.8	-	4.1	-	0.3	5.5	-
Cation Exchange Capacity (CEC)	0.2	meq/100g	-	10.1	10.6	12.2	-	10.4	-	4.7	12.8	-
Exchangeable Sodium Percent (ESP)	0.2	%	-	21.3	41.4	47.1	-	39.3	-	5.7	43.1	-
Exchangeable Cations												
Exchangeable Calcium	0.2	meq/100g	2.1	-	-	-	1.8	-	0.5	-	-	1.1
Exchangeable Magnesium	0.2	meq/100g	0.8	-	-	-	0.9	-	3.8	-	-	4.1
Exchangeable Potassium	0.2	meq/100g	0.5	-	-	-	0.4	-	0.9	-	-	0.9
Exchangeable Sodium	0.2	meq/100g	0.2	-	-	-	0.4	-	2.5	-	-	2.7
Cation Exchange Capacity (CEC)	0.2	meq/100g	3.5	-	-	-	3.6	-	32.7	-	-	30.5
Exchangeable Sodium Percent (ESP)	0.2	%	5.4	-	-	-	12.2	-	7.7	-	-	8.7

Physical Properties - Selected Samples

Physical Properties - Selected Soil Samples

Laboratory Analyte	LOR	Unit	N06_2.8-2.9	N05D*_36.0-36.1	N02_25.0-25.1
		Sample Date	17/04/2018	17/04/2018	26/04/2018
		Description	CLAY	Weathered Gneiss	Weathered Gneiss
		Lab batch	EM1806934	EM1806934	EM1807110
Moisture Content (dried @105-110^{0}C)		%	16.2	11.9	25.5
Particle sizing					
+75µm	1	%	64	70	39
+150µm	1	%	47	52	24
+300µm	1	%	13	35	12
+425µm	1	%	4	25	6
+600µm	1	%	2	17	3
+1180µm	1	%	<1	7	1
+2.36mm	1	%	<1	1	<1
+4.75mm	1	%	<1	<1	<1
+9.5mm	1	%	<1	<1	<1
+19.0mm	1	%	<1	<1	<1
+37.5mm	1	%	<1	<1	<1
+75.0mm	1	%	<1	<1	<1
Soil Classification based on Particle Size	1	%	27	7	8
Silt (2-60 µm)	1	%	8	20	48
Sand (0.06-2.00 mm)	1	%	65	70	43
Gravel (>2mm)	1	%	<1	3	1
Cobbles (>6cm)	1	%	<1	<1	<1
Particle Density (Clay/Silt/Sand)	0.01	g/cm3	2.68	2.66	2.57
Exchangeable Cations on Alkaline Soils (ø Exchangeable Calcium)	0.2	meq/100g	2.1	----	0.6
ø Exchangeable Magnesium	0.2	meq/100g	7.2	----	1
ø Exchangeable Potassium	0.2	meq/100g	2.1	----	0.2
ø Exchangeable Sodium	0.2	meq/100g	5.6	----	0.1
ø Cation Exchange Capacity	0.2	meq/100g	17	----	6
ø Exchangeable Sodium Percent	0.2	%	32.9	----	1.9
Exchangeable Cations (Exchangeable Calcium)	0.1	meq/100g	----	0.4	----
Exchangeable Magnesium	0.1	meq/100g	----	0.8	----
Exchangeable Potassium	0.1	meq/100g	----	0.3	----
Exchangeable Sodium	0.1	meq/100g	----	0.5	----
Exchangeable Sodium Percent (ESP)	0.1	%	----		----
Cation Exchange Capacity (CEC)	0.1	meq/100g	----	2	----
Alkalinity (Total Alkalinity as CaCO3)	1	mg/kg	76	1	<1
Bicarbonate Alkalinity as CaCO3	1	mg/kg	70	1	<1
Carbonate Alkalinity as CaCO3	1	mg/kg	6	<1	<1
Total Metals					
Arsenic	5	mg/kg	<5	<5	<5
Barium	10	mg/kg	60	30	<10
Beryllium	1	mg/kg	<1	<1	<1
Boron	50	mg/kg	70	<50	<50
Cadmium	1	mg/kg	<1	<1	<1
Chromium	2	mg/kg	18	38	3
Cobalt	2	mg/kg	6	6	<2
Copper	5	mg/kg	10	<5	<5
Iron	50	mg/kg	14200	18200	160
Lead	5	mg/kg	5	7	<5
Manganese	5	mg/kg	72	56	<5
Nickel	2	mg/kg	7	12	<2
Selenium	5	mg/kg	<5	<5	<5
Vanadium	5	mg/kg	30	26	6
Zinc	5	mg/kg	8	32	<5
Total Recoverable Mercury	0.1	mg/kg	<0.1	<0.1	<0.1
Organic Matter					
Organic Matter	0.5	%	<0.5	<0.5	<0.5
Total Organic Carbon	0.5	%	<0.5	<0.5	<0.5
Radionuclides / Activity	500	Bq/kg DW			
Gross alpha	500	Bq/kg DW	----	2200	1260
Gross beta	500	Bq/kg DW	----	1740	<500

Note:
*Originally identified as N06 but renamed N05D once converted to a well.

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **EM1806934**	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	: 27-Apr-2018 10:00
Order number	: 60565376.4.0	Date Analysis Commenced	: 01-May-2018
C-O-C number	: ----	Issue Date	: 18-Jun-2018 13:51
Sampler	: TIMOTHY SMITH		
Site	: Napandee		
Quote number	: EN/004/16		
No. of samples received	: 10		
No. of samples analysed	: 2		

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.

[illegible]

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.

[illegible]	[illegible]	[illegible]
Dilani Fernando	Senior Inorganic Chemist	Melbourne Inorganics, Springvale, VIC
Kim McCabe	Senior Inorganic Chemist	Brisbane External Subcontracting, Stafford, QLD
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.

- ED037 (Alkalinity): NATA accreditation does not cover the performance of this service.
- EG035T: EM1807577 #16 Poor matrix spike recovery for total mercury due to sample matrix.
- 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)

				N06_2.8-2.9	N06_36.0-36.1	----	----	----
				17-Apr-2018 00:00	18-Apr-2018 00:00	----	----	----
				EM1806934-003	EM1806934-008	--------	--------	--------
				Result	Result	----	----	----
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	1.0	%	**16.2**	**11.9**	----	----	----
EA150: Particle Sizing								
+75µm	----	1	%	**64**	**70**	----	----	----
+150µm	----	1	%	**47**	**52**	----	----	----
+300µm	----	1	%	**13**	**35**	----	----	----
+425µm	----	1	%	**4**	**25**	----	----	----
+600µm	----	1	%	**2**	**17**	----	----	----
+1180µm	----	1	%	<1	**7**	----	----	----
+2.36mm	----	1	%	<1	**1**	----	----	----
+4.75mm	----	1	%	<1	<1	----	----	----
+9.5mm	----	1	%	<1	<1	----	----	----
+19.0mm	----	1	%	<1	<1	----	----	----
+37.5mm	----	1	%	<1	<1	----	----	----
+75.0mm	----	1	%	<1	<1	----	----	----
EA150: Soil Classification based on Particle Size								
Clay (<2 µm)	----	1	%	**27**	**7**	----	----	----
Silt (2-60 µm)	----	1	%	**8**	**20**	----	----	----
Sand (0.06-2.00 mm)	----	1	%	**65**	**70**	----	----	----
Gravel (>2mm)	----	1	%	<1	**3**	----	----	----
Cobbles (>6cm)	----	1	%	<1	<1	----	----	----
EA152: Soil Particle Density								
ø Soil Particle Density (Clay/Silt/Sand)	----	0.01	g/cm3	**2.68**	**2.66**	----	----	----
ED006: Exchangeable Cations on Alkaline Soils								
ø Exchangeable Calcium	----	0.2	meq/100g	**2.1**	----	----	----	----
ø Exchangeable Magnesium	----	0.2	meq/100g	**7.2**	----	----	----	----
ø Exchangeable Potassium	----	0.2	meq/100g	**2.1**	----	----	----	----
ø Exchangeable Sodium	----	0.2	meq/100g	**5.6**	----	----	----	----
ø Cation Exchange Capacity	----	0.2	meq/100g	**17.0**	----	----	----	----
ø Exchangeable Sodium Percent	----	0.2	%	**32.9**	----	----	----	----
ED008: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	----	**0.4**	----	----	----
Exchangeable Magnesium	----	0.1	meq/100g	----	**0.8**	----	----	----
Exchangeable Potassium	----	0.1	meq/100g	----	**0.3**	----	----	----
Exchangeable Sodium	----	0.1	meq/100g	----	**0.5**	----	----	----

Analytical Results

Sub-Matrix: **SOIL** (Matrix: **SOIL**)				**N06_2.8-2.9**	**N06_36.0-36.1**	**----**	**----**	**----**
				17-Apr-2018 00:00	18-Apr-2018 00:00	----	----	----
				EM1806934-003	**EM1806934-008**	--------	--------	--------
				Result	Result	----	----	----
ED008: Exchangeable Cations - Continued								
Exchangeable Sodium Percent	----	0.1	%	**----**	**24.0**	----	----	----
Cation Exchange Capacity	----	0.1	meq/100g	**----**	**2.0**	----	----	----
ED037: Alkalinity								
Total Alkalinity as CaCO3	----	1	mg/kg	**76**	**1**	----	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/kg	**70**	**1**	----	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/kg	**6**	<1	----	----	----
EG005T: Total Metals by ICP-AES								
Arsenic	7440-38-2	5	mg/kg	<5	<5	----	----	----
Barium	7440-39-3	10	mg/kg	**60**	**30**	----	----	----
Beryllium	7440-41-7	1	mg/kg	<1	<1	----	----	----
Boron	7440-42-8	50	mg/kg	**70**	<50	----	----	----
Cadmium	7440-43-9	1	mg/kg	<1	<1	----	----	----
Chromium	7440-47-3	2	mg/kg	**18**	**38**	----	----	----
Cobalt	7440-48-4	2	mg/kg	**6**	**6**	----	----	----
Copper	7440-50-8	5	mg/kg	**10**	<5	----	----	----
Iron	7439-89-6	50	mg/kg	**14200**	**18200**	----	----	----
Lead	7439-92-1	5	mg/kg	**5**	**7**	----	----	----
Manganese	7439-96-5	5	mg/kg	**72**	**56**	----	----	----
Nickel	7440-02-0	2	mg/kg	**7**	**12**	----	----	----
Selenium	7782-49-2	5	mg/kg	<5	<5	----	----	----
Vanadium	7440-62-2	5	mg/kg	**30**	**26**	----	----	----
Zinc	7440-66-6	5	mg/kg	**8**	**32**	----	----	----
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.1	mg/kg	<0.1	<0.1	----	----	----
EP004: Organic Matter								
Organic Matter	----	0.5	%	<0.5	<0.5	----	----	----
Total Organic Carbon	----	0.5	%	<0.5	<0.5	----	----	----
Radionuclides / Activity								
Gross alpha	----	500	Bq/kg DW	**----**	**2200**	----	----	----
Gross beta	----	500	Bq/kg DW	**----**	**1740**	----	----	----

ALS Environmental

QUALITY CONTROL REPORT

Work Order	: **EM1806934**	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	: 27-Apr-2018
Order number	: 60565376.4.0	Date Analysis Commenced	: 01-May-2018
C-O-C number	: ----	Issue Date	: 18-Jun-2018
Sampler	: TIMOTHY SMITH		
Site	: Napandee		
Quote number	: EN/004/16		
No. of samples received	: 10		
No. of samples analysed	: 2		

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

[illegible]

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.

[illegible]	[illegible]	[illegible]
Dilani Fernando	Senior Inorganic Chemist	Melbourne Inorganics, Springvale, VIC
Kim McCabe	Senior Inorganic Chemist	Brisbane External Subcontracting, Stafford, QLD
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%.

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: 1608219)									
EM1806934-003	N06_2.8-2.9	EA055: Moisture Content	----	0.1	%	16.2	17.0	4.84	0% - 50%
ED006: Exchangeable Cations on Alkaline Soils (QC Lot: 1614046)									
EM1806934-003	N06_2.8-2.9	ED006: Exchangeable Sodium Percent	----	0.2	%	32.9	32.2	2.04	0% - 20%
		ED006: Exchangeable Calcium	----	0.2	meq/100g	2.1	2.3	8.38	0% - 50%
		ED006: Exchangeable Magnesium	----	0.2	meq/100g	7.2	7.0	2.75	0% - 20%
		ED006: Exchangeable Potassium	----	0.2	meq/100g	2.1	2.0	5.57	0% - 50%
		ED006: Exchangeable Sodium	----	0.2	meq/100g	5.6	5.4	4.12	0% - 20%
		ED006: Cation Exchange Capacity	----	0.2	meq/100g	17.0	16.6	2.08	0% - 20%
ED008: Exchangeable Cations (QC Lot: 1608177)									
EM1806934-008	N06_36.0-36.1	ED008: Exchangeable Sodium Percent	----	0.1	%	24.0	23.4	2.90	0% - 20%
		ED008: Exchangeable Calcium	----	0.1	meq/100g	0.4	0.4	0.00	No Limit
		ED008: Exchangeable Magnesium	----	0.1	meq/100g	0.8	0.8	0.00	No Limit
		ED008: Exchangeable Potassium	----	0.1	meq/100g	0.3	0.3	0.00	No Limit
		ED008: Exchangeable Sodium	----	0.1	meq/100g	0.5	0.5	0.00	No Limit
		ED008: Cation Exchange Capacity	----	0.1	meq/100g	2.0	2.0	0.00	0% - 20%
ED037: Alkalinity (QC Lot: 1617063)									
EM1806934-003	N06_2.8-2.9	ED037: Total Alkalinity as CaCO3	----	1	mg/kg	76	80	5.74	0% - 20%
EG005T: Total Metals by ICP-AES (QC Lot: 1629241)									
EM1807577-002	Anonymous	EG005T: Copper	7440-50-8	5	mg/kg	93	92	0.00	0% - 50%
		EG005T: Zinc	7440-66-6	5	mg/kg	1260	1300	3.05	0% - 20%
EM1806934-003	N06_2.8-2.9	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	60	60	0.00	No Limit
		EG005T: Chromium	7440-47-3	2	mg/kg	18	16	8.90	No Limit

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: 1629241) - continued									
EM1806934-003	N06_2.8-2.9	EG005T: Cobalt	7440-48-4	2	mg/kg	6	6	0.00	No Limit
		EG005T: Nickel	7440-02-0	2	mg/kg	7	7	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	72	73	1.98	0% - 50%
		EG005T: Selenium	7782-49-2	5	mg/kg	<5	<5	0.00	No Limit
		EG005T: Vanadium	7440-62-2	5	mg/kg	30	28	8.52	No Limit
		EG005T: Zinc	7440-66-6	5	mg/kg	8	7	0.00	No Limit
		EG005T: Boron	7440-42-8	50	mg/kg	70	70	0.00	No Limit
		EG005T: Iron	7439-89-6	50	mg/kg	14200	13100	7.97	0% - 20%
EM1807577-002	Anonymous	EG005T: Beryllium	7440-41-7	1	mg/kg	<1	<1	0.00	No Limit
		EG005T: Cadmium	7440-43-9	1	mg/kg	6	2	83.9	No Limit
		EG005T: Barium	7440-39-3	10	mg/kg	300	340	14.3	0% - 20%
		EG005T: Chromium	7440-47-3	2	mg/kg	91	110	18.9	0% - 20%
		EG005T: Cobalt	7440-48-4	2	mg/kg	3	<2	54.4	No Limit
		EG005T: Nickel	7440-02-0	2	mg/kg	82	92	11.2	0% - 20%
		EG005T: Arsenic	7440-38-2	5	mg/kg	<5	<5	0.00	No Limit
		EG005T: Lead	7439-92-1	5	mg/kg	78	59	27.5	0% - 50%
		EG005T: Manganese	7439-96-5	5	mg/kg	76	92	19.1	0% - 50%
		EG005T: Selenium	7782-49-2	5	mg/kg	<5	<5	0.00	No Limit
		EG005T: Vanadium	7440-62-2	5	mg/kg	6	<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	3050	3280	7.47	0% - 20%
EG035T: Total Recoverable Mercury by FIMS (QC Lot: 1629242)									
EM1806934-003	N06_2.8-2.9	EG035T: Mercury	7439-97-6	0.1	mg/kg	<0.1	<0.1	0.00	No Limit
EM1807577-002	Anonymous	EG035T: Mercury	7439-97-6	0.1	mg/kg	<0.1	<0.1	0.00	No Limit
EP004: Organic Matter (QC Lot: 1610788)									
EM1806934-003	N06_2.8-2.9	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
ED006: Exchangeable Cations on Alkaline Soils (QCLot: 1614046)								
ED006: Exchangeable Calcium	----	0.2	meq/100g	<0.2	33 meq/100g	86.3	80	120
ED006: Exchangeable Magnesium	----	0.2	meq/100g	<0.2	32 meq/100g	101	80	120
ED006: Exchangeable Potassium	----	0.2	meq/100g	<0.2	2.2 meq/100g	97.7	80	120
ED006: Exchangeable Sodium	----	0.2	meq/100g	<0.2	5.6 meq/100g	82.0	80	120
ED006: Cation Exchange Capacity	----	0.2	meq/100g	<0.2	----	----	----	----
ED006: Exchangeable Sodium Percent	----	0.2	%	<0.2	----	----	----	----
ED008: Exchangeable Cations (QCLot: 1608177)								
ED008: Exchangeable Calcium	----	0.1	meq/100g	<0.1	3.45 meq/100g	96.1	80	120
ED008: Exchangeable Magnesium	----	0.1	meq/100g	<0.1	1.09 meq/100g	93.8	80	120
ED008: Exchangeable Potassium	----	0.1	meq/100g	<0.1	0.609 meq/100g	110	80	120
ED008: Exchangeable Sodium	----	0.1	meq/100g	<0.1	0.347 meq/100g	95.2	80	120
ED008: Cation Exchange Capacity	----	0.1	meq/100g	<0.1	----	----	----	----
ED037: Alkalinity (QCLot: 1617063)								
ED037: Total Alkalinity as CaCO3	----	----	mg/kg	----	200 mg/kg	101	92	107
EG005T: Total Metals by ICP-AES (QCLot: 1629241)								
EG005T: Arsenic	7440-38-2	5	mg/kg	<5	21.7 mg/kg	96.0	79	113
EG005T: Barium	7440-39-3	10	mg/kg	<10	143 mg/kg	102	79	110
EG005T: Beryllium	7440-41-7	1	mg/kg	<1	5.63 mg/kg	102	85	120
EG005T: Boron	7440-42-8	50	mg/kg	<50	33.2 mg/kg	112	82	126
EG005T: Cadmium	7440-43-9	1	mg/kg	<1	4.64 mg/kg	92.1	85	109
EG005T: Chromium	7440-47-3	2	mg/kg	<2	43.9 mg/kg	99.8	83	109
EG005T: Cobalt	7440-48-4	2	mg/kg	<2	16 mg/kg	95.7	78	112
EG005T: Copper	7440-50-8	5	mg/kg	<5	32 mg/kg	97.5	78	108
EG005T: Iron	7439-89-6	50	mg/kg	<50	8400 mg/kg	103	90	110
EG005T: Lead	7439-92-1	5	mg/kg	<5	40 mg/kg	90.1	78	106
EG005T: Manganese	7439-96-5	5	mg/kg	<5	130 mg/kg	99.9	82	107
EG005T: Nickel	7440-02-0	2	mg/kg	<2	55 mg/kg	100	82	111
EG005T: Selenium	7782-49-2	5	mg/kg	<5	5.37 mg/kg	102	93	109
EG005T: Vanadium	7440-62-2	5	mg/kg	<5	29.6 mg/kg	97.1	80	109
EG005T: Zinc	7440-66-6	5	mg/kg	<5	60.8 mg/kg	96.9	82	111
EG035T: Total Recoverable Mercury by FIMS (QCLot: 1629242)								
EG035T: Mercury	7439-97-6	0.1	mg/kg	<0.1	2.57 mg/kg	83.6	77	104
EP004: Organic Matter (QCLot: 1610788)								
EP004: Organic Matter	----	0.5	%	<0.5	77 %	91.5	81	112

Sub-Matrix: **SOIL**

Method: Compound	CAS Number	LOR	Unit	Method Blank (MB) Report Result	Laboratory Control Spike (LCS) Report Spike Concentration	Spike Recovery (%) LCS	Recovery Limits (%) Low	High
EP004: Organic Matter (QCLot: 1610788) - continued								
EP004: Total Organic Carbon	----	0.5	%	<0.5	43.5 %	94.0	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**

Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Matrix Spike (MS) Report Spike Concentration	SpikeRecovery(%) MS	Recovery Limits (%) Low	High
EG005T: Total Metals by ICP-AES (QCLot: 1629241)							
EM1806934-008	N06_36.0-36.1	EG005T: Arsenic	7440-38-2	50 mg/kg	95.8	78	124
		EG005T: Barium	7440-39-3	50 mg/kg	91.2	71	135
		EG005T: Beryllium	7440-41-7	50 mg/kg	101	85	125
		EG005T: Cadmium	7440-43-9	50 mg/kg	93.2	84	116
		EG005T: Chromium	7440-47-3	50 mg/kg	97.0	79	121
		EG005T: Copper	7440-50-8	50 mg/kg	92.6	82	124
		EG005T: Lead	7439-92-1	50 mg/kg	99.7	76	124
		EG005T: Manganese	7439-96-5	50 mg/kg	91.0	68	136
		EG005T: Nickel	7440-02-0	50 mg/kg	86.4	78	120
		EG005T: Selenium	7782-49-2	50 mg/kg	89.5	71	125
		EG005T: Vanadium	7440-62-2	50 mg/kg	99.1	76	124
		EG005T: Zinc	7440-66-6	50 mg/kg	77.0	74	128
EG035T: Total Recoverable Mercury by FIMS (QCLot: 1629242)							
EM1806934-008	N06_36.0-36.1	EG035T: Mercury	7439-97-6	5 mg/kg	89.3	76	116
EP004: Organic Matter (QCLot: 1610788)							
EM1806934-008	N06_36.0-36.1	EP004: Organic Matter	----	0.77 %	76.8	70	120
		EP004: Total Organic Carbon	----	0.45 %	76.2	70	120

Environmental

QA/QC Compliance Assessment to assist with Quality Review

Work Order	: **EM1806934**	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	: 27-Apr-2018
Site	: Napandee	Issue Date	: 18-Jun-2018
Sampler	: TIMOTHY SMITH	No. of samples received	: 10
Order number	: 60565376.4.0	No. of samples analysed	: 2

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*
EA055: Moisture Content (Dried @ 105-110°C)							
Soil Glass Jar - Unpreserved (EA055) N06_2.8-2.9	**17-Apr-2018**	**----**	----	----	**01-May-2018**	01-May-2018	✓
Soil Glass Jar - Unpreserved (EA055) N06_36.0-36.1	**18-Apr-2018**	**----**	----	----	**01-May-2018**	02-May-2018	✓
EA150: Particle Sizing							
Snap Lock Bag (EA150H) N06_2.8-2.9	**17-Apr-2018**	**----**	----	----	**09-May-2018**	14-Oct-2018	✓
Snap Lock Bag (EA150H) N06_36.0-36.1	**18-Apr-2018**	**----**	----	----	**09-May-2018**	15-Oct-2018	✓
EA150: Soil Classification based on Particle Size							
Snap Lock Bag (EA150H) N06_2.8-2.9	**17-Apr-2018**	**----**	----	----	**09-May-2018**	14-Oct-2018	✓
Snap Lock Bag (EA150H) N06_36.0-36.1	**18-Apr-2018**	**----**	----	----	**09-May-2018**	15-Oct-2018	✓
EA152: Soil Particle Density							
Snap Lock Bag (EA152) N06_2.8-2.9	**17-Apr-2018**	**----**	----	----	**09-May-2018**	14-Oct-2018	✓
Snap Lock Bag (EA152) N06_36.0-36.1	**18-Apr-2018**	**----**	----	----	**09-May-2018**	15-Oct-2018	✓
ED006: Exchangeable Cations on Alkaline Soils							
Soil Glass Jar - Unpreserved (ED006) N06_2.8-2.9	**17-Apr-2018**	**03-May-2018**	15-May-2018	✓	**03-May-2018**	15-May-2018	✓
ED007: Exchangeable Cations							
Soil Glass Jar - Unpreserved (ED007) N06_36.0-36.1	**18-Apr-2018**	**01-May-2018**	16-May-2018	✓	**03-May-2018**	16-May-2018	✓
ED008: Exchangeable Cations							
Soil Glass Jar - Unpreserved (ED008) N06_36.0-36.1	**18-Apr-2018**	**01-May-2018**	16-May-2018	✓	**03-May-2018**	16-May-2018	✓

Matrix: **SOIL**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method / Container / Client Sample ID(s)	Sample Date	Extraction / Preparation: Date extracted	Due for extraction	Evaluation	Analysis: Date analysed	Due for analysis	Evaluation
ED037: Alkalinity							
Soil Glass Jar - Unpreserved (ED037) N06_2.8-2.9	**17-Apr-2018**	**04-May-2018**	14-Oct-2018	✓	**07-May-2018**	14-Oct-2018	✓
Soil Glass Jar - Unpreserved (ED037) N06_36.0-36.1	**18-Apr-2018**	**04-May-2018**	15-Oct-2018	✓	**07-May-2018**	15-Oct-2018	✓
EG005T: Total Metals by ICP-AES							
Soil Glass Jar - Unpreserved (EG005T) N06_2.8-2.9	**17-Apr-2018**	**10-May-2018**	14-Oct-2018	✓	**10-May-2018**	14-Oct-2018	✓
Soil Glass Jar - Unpreserved (EG005T) N06_36.0-36.1	**18-Apr-2018**	**10-May-2018**	15-Oct-2018	✓	**10-May-2018**	15-Oct-2018	✓
EG035T: Total Recoverable Mercury by FIMS							
Soil Glass Jar - Unpreserved (EG035T) N06_2.8-2.9	**17-Apr-2018**	**10-May-2018**	15-May-2018	✓	**11-May-2018**	15-May-2018	✓
Soil Glass Jar - Unpreserved (EG035T) N06_36.0-36.1	**18-Apr-2018**	**10-May-2018**	16-May-2018	✓	**11-May-2018**	16-May-2018	✓
EP004: Organic Matter							
Soil Glass Jar - Unpreserved (EP004) N06_2.8-2.9	**17-Apr-2018**	**03-May-2018**	15-May-2018	✓	**03-May-2018**	15-May-2018	✓
Soil Glass Jar - Unpreserved (EP004) N06_36.0-36.1	**18-Apr-2018**	**03-May-2018**	16-May-2018	✓	**03-May-2018**	16-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)							
Alkalinity in Soil	ED037	1	3	**33.33**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Exchangeable Cations on Alkaline Soils	ED006	1	3	**33.33**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Exchangeable Cations with pre-treatment	ED008	1	2	**50.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Moisture Content	EA055	1	2	**50.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Organic Matter	EP004	1	7	**14.29**	**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	3	**33.33**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Exchangeable Cations on Alkaline Soils	ED006	1	3	**33.33**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Exchangeable Cations with pre-treatment	ED008	1	2	**50.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Organic Matter	EP004	1	7	**14.29**	**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 on Alkaline Soils	ED006	1	3	**33.33**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Exchangeable Cations with pre-treatment	ED008	1	2	**50.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Organic Matter	EP004	1	7	**14.29**	**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	7	**14.29**	**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 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)
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 (Alkaline Soils)	ED006PR	SOIL	In house: Referenced to Rayment and Lyons 2011 method 15C1.

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.
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)

ALS Environmental

QA/QC Compliance Assessment to assist with Quality Review

Work Order	: **EM1806934**	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	: 27-Apr-2018
Site	: Napandee	Issue Date	: 18-Jun-2018
Sampler	: TIMOTHY SMITH	No. of samples received	: 10
Order number	: 60565376.4.0	No. of samples analysed	: 2

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*
EA055: Moisture Content (Dried @ 105-110°C)							
Soil Glass Jar - Unpreserved (EA055) N06_2.8-2.9	**17-Apr-2018**	**----**	----	----	**01-May-2018**	01-May-2018	✓
Soil Glass Jar - Unpreserved (EA055) N06_36.0-36.1	**18-Apr-2018**	**----**	----	----	**01-May-2018**	02-May-2018	✓
EA150: Particle Sizing							
Snap Lock Bag (EA150H) N06_2.8-2.9	**17-Apr-2018**	**----**	----	----	**09-May-2018**	14-Oct-2018	✓
Snap Lock Bag (EA150H) N06_36.0-36.1	**18-Apr-2018**	**----**	----	----	**09-May-2018**	15-Oct-2018	✓
EA150: Soil Classification based on Particle Size							
Snap Lock Bag (EA150H) N06_2.8-2.9	**17-Apr-2018**	**----**	----	----	**09-May-2018**	14-Oct-2018	✓
Snap Lock Bag (EA150H) N06_36.0-36.1	**18-Apr-2018**	**----**	----	----	**09-May-2018**	15-Oct-2018	✓
EA152: Soil Particle Density							
Snap Lock Bag (EA152) N06_2.8-2.9	**17-Apr-2018**	**----**	----	----	**09-May-2018**	14-Oct-2018	✓
Snap Lock Bag (EA152) N06_36.0-36.1	**18-Apr-2018**	**----**	----	----	**09-May-2018**	15-Oct-2018	✓
ED006: Exchangeable Cations on Alkaline Soils							
Soil Glass Jar - Unpreserved (ED006) N06_2.8-2.9	**17-Apr-2018**	**03-May-2018**	15-May-2018	✓	**03-May-2018**	15-May-2018	✓
ED007: Exchangeable Cations							
Soil Glass Jar - Unpreserved (ED007) N06_36.0-36.1	**18-Apr-2018**	**01-May-2018**	16-May-2018	✓	**03-May-2018**	16-May-2018	✓
ED008: Exchangeable Cations							
Soil Glass Jar - Unpreserved (ED008) N06_36.0-36.1	**18-Apr-2018**	**01-May-2018**	16-May-2018	✓	**03-May-2018**	16-May-2018	✓

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
ED037: Alkalinity							
Soil Glass Jar - Unpreserved (ED037) N06_2.8-2.9	**17-Apr-2018**	**04-May-2018**	14-Oct-2018	✓	**07-May-2018**	14-Oct-2018	✓
Soil Glass Jar - Unpreserved (ED037) N06_36.0-36.1	**18-Apr-2018**	**04-May-2018**	15-Oct-2018	✓	**07-May-2018**	15-Oct-2018	✓
EG005T: Total Metals by ICP-AES							
Soil Glass Jar - Unpreserved (EG005T) N06_2.8-2.9	**17-Apr-2018**	**10-May-2018**	14-Oct-2018	✓	**10-May-2018**	14-Oct-2018	✓
Soil Glass Jar - Unpreserved (EG005T) N06_36.0-36.1	**18-Apr-2018**	**10-May-2018**	15-Oct-2018	✓	**10-May-2018**	15-Oct-2018	✓
EG035T: Total Recoverable Mercury by FIMS							
Soil Glass Jar - Unpreserved (EG035T) N06_2.8-2.9	**17-Apr-2018**	**10-May-2018**	15-May-2018	✓	**11-May-2018**	15-May-2018	✓
Soil Glass Jar - Unpreserved (EG035T) N06_36.0-36.1	**18-Apr-2018**	**10-May-2018**	16-May-2018	✓	**11-May-2018**	16-May-2018	✓
EP004: Organic Matter							
Soil Glass Jar - Unpreserved (EP004) N06_2.8-2.9	**17-Apr-2018**	**03-May-2018**	15-May-2018	✓	**03-May-2018**	15-May-2018	✓
Soil Glass Jar - Unpreserved (EP004) N06_36.0-36.1	**18-Apr-2018**	**03-May-2018**	16-May-2018	✓	**03-May-2018**	16-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)							
Alkalinity in Soil	ED037	1	3	**33.33**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Exchangeable Cations on Alkaline Soils	ED006	1	3	**33.33**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Exchangeable Cations with pre-treatment	ED008	1	2	**50.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Moisture Content	EA055	1	2	**50.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Organic Matter	EP004	1	7	**14.29**	**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	3	**33.33**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Exchangeable Cations on Alkaline Soils	ED006	1	3	**33.33**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Exchangeable Cations with pre-treatment	ED008	1	2	**50.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Organic Matter	EP004	1	7	**14.29**	**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 on Alkaline Soils	ED006	1	3	**33.33**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Exchangeable Cations with pre-treatment	ED008	1	2	**50.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Organic Matter	EP004	1	7	**14.29**	**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	7	**14.29**	**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 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)
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 (Alkaline Soils)	ED006PR	SOIL	In house: Referenced to Rayment and Lyons 2011 method 15C1.

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.
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)

Environmental

SAMPLE RECEIPT NOTIFICATION (SRN)

Work Order	: **EM1806934**		
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 3
Order number	: 60565376.4.0	Quote number	: EM2017URSSA0002 (EN/004/16)
C-O-C number	: ----	QC Level	: NEPM 2013 B3 & ALS QC Standard
Site	: Napandee		
Sampler	: TIMOTHY SMITH		

Dates

Date Samples Received	: 27-Apr-2018 10:00	Issue Date	: 17-May-2018
Client Requested Due Date	: 15-Jun-2018	Scheduled Reporting Date	: **15-Jun-2018**

Delivery Details

Mode of Delivery	: Carrier	Security Seal	: Intact.
No. of coolers/boxes	: 1	Temperature	: 8.9°C - Ice present
Receipt Detail	:	No. of samples received / analysed	: 10 / 2

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 scheduled reporting date has been extended due to analytical testing conducted by ALS interstate and international laboratories. Please refer to your quotation for further information.**
- **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 Minerals Balcatta, ALS Newcastle & ALS Prague.**
- **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 - EA055-103 Moisture Content	SOIL - ED006 Exchangeable Cations on Alkaline Soils - All	SOIL - ED037 Alkalinity in Soil	SOIL - EP004 (Carbon) Organic Matter & Total Organic Carbon (Calc.)	SOIL - MIS-SOL (Subcontracted) Miscellaneous Subcontracted Analysis (Solid)	SOIL - S-03 15 Metals (NEPM 2013 Suite - incl. Digestion)
EM1806934-001	17-Apr-2018 00:00	N06_0.0-0.1	▯						
EM1806934-002	17-Apr-2018 00:00	N06_1.0-1.1	▯						
EM1806934-003	17-Apr-2018 00:00	N06_2.8-2.9		▯	▯	▯	▯	▯	▯
EM1806934-004	17-Apr-2018 00:00	N06_3.8-3.9	▯						
EM1806934-005	17-Apr-2018 00:00	N06_6.5-6.6	▯						
EM1806934-006	18-Apr-2018 00:00	N06_18.1-18.2	▯						
EM1806934-007	18-Apr-2018 00:00	N06_25.1-25.2	▯						
EM1806934-008	18-Apr-2018 00:00	N06_36.0-36.1		▯		▯	▯	▯	▯
EM1806934-009	19-Apr-2018 00:00	N06_41.0-41.1	▯						
EM1806934-010	19-Apr-2018 00:00	N06_47.0-47.1	▯						

Matrix: **SOIL**

Laboratory sample ID	*Client sampling date / time*	*Client sample ID*	SOIL - EA150H/EA152 Particle Sizing with Hydrometer + Soil Particle	SOIL - EA250 (Subcontracted) Gross beta/alpha activity in Soils	SOIL - ED007/ED008 - Melb CEC / Exchangeable Cations (ED007/ED008) -	SOIL - EG005T (solids) Total Metals by ICP-AES
EM1806934-003	17-Apr-2018 00:00	N06_2.8-2.9	▯			▯
EM1806934-008	18-Apr-2018 00:00	N06_36.0-36.1	▯	▯	▯	▯

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

ATT: KIEREN BURNS

SOIL

FREIGHT

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			
PROJECT NO:	60565376.4.0	SAMPLERS:	Timothy Smith	SIGNED:	

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)
NAPANDEE	N06	SOIL	PRIMARY	N06_0.0	0.1	17/4	JAR/BAG	NA	3	X	X	X	X	X	X	X	X	X	X
↓	↓	↓	↓	N06_1.0	1.1	"	↓	↓	2	X	X	X	X	X	X	X		X	X
↓	↓	↓	↓	N06_2.8	2.9	"	↓	↓	2	X	X	X	X	X	X	X		X	X
↓	↓	↓	↓	N06_3.8	3.9	"	↓	↓	2	X	X	X	X	X	X	X		X	X
↓	↓	↓	↓	N06_6.5	6.6	"	↓	↓	2	X	X	X	X	X	X	X		X	X
↓	↓	ROCK	↓	N06_18.1	18.2	18/4	↓	↓	2	X	X	X	X	X	X	X			X
↓	↓	↓	↓	N06_25.1	25.2	"	↓	↓	2	X	X	X	X	X	X	X			X
↓	↓	↓	↓	N06_36.0	36.1	"	↓	↓	2	X	X	X	X	X	X	X			X
↓	↓	↓	↓	N06_41.0	41.1	19/4	↓	↓	2	X	X	X	X	X	X	X			X
↓	↓	SOIL	↓	N06_47.0	47.1	"	↓	↓	2	X	X	X	X	X	X	X		X	X

RELINQUISHED BY: TIM SMITH		CHECKED:	
DATE: 22/4		TIME:	Am
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

Environmental Division
Melbourne
Work Order Reference
EM1806934

Telephone : + 61-3-8549 9600

KANU (ALS)
27/4, 10:30

Samples Melbourne

From:	Kieren Burns
Sent:	Friday, 27 April 2018 5:05 PM
To:	Samples Melbourne
Subject:	RE: CoC for ALS Workorder : EM1806934
Follow Up Flag:	Follow up
Flag Status:	Completed

Put it all on hold for now

Regards

Kieren Burns
Business Development Manager - SA
Environmental

T +61 8 8162 5130
F +61 8 8349 0199 M +61 448 527 608
kieren.burns@alsglobal.com
Unit 3/1 Burma Road
Pooraka SA 5095
Australia

From: Samples Melbourne
Sent: Friday, 27 April 2018 4:12 PM
To: Kieren Burns <Kieren.Burns@alsglobal.com>
Subject: RE: CoC for ALS Workorder : EM1806934

Hi Kieren,

Getting a bit confusing.
For this new COC, all samples look like they're on hold except for one.

Is that one for analysis or on hold too?

Ryan O'Donnell
Committal Officer – Springvale
Environmental

From: Kieren Burns
Sent: Friday, 27 April 2018 4:00 PM

Analysis received at 16.40 30/4

ATT: KIEREN BURNS

SOIL

FREIGHT

U63 Permeability to SMS Geo

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:	[illegible]	
		SAMPLERS:	Timothy Smith	SIGNED:
PROJECT NO:	60565376.4.0			

COMMENTS: SPECIAL HANDLING/STORAGE

Please forward U63 samples to SMSGeo for permeability

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	N06	SOIL	PRIMARY	1	N06_0.0	0.1	17/4	JAR/BAG	NA	3											X
				2	N06_1.0	1.1	"			2											X
				3	N06_2.8	2.9	"			2	X	X				X			X	X	X
				4	N06_3.8	3.9	"			2											X
				5	N06_6.5	6.6	"			2											X
		ROCK		6	N06_18.1	18.2	18/4			2											X
				7	N06_25.1	25.2	"			2											X
				8	N06_36.0	36.1	"			2	X	X				X		X	X	X	X
				9	N06_41.0	41.1	19/4			2											X
		SOIL		10	N06_47.0	47.1	"			2											X
			U63		3.2	3.6															X
			U63		36.0	36.5															X

RELINQUISHED BY: TIM SMITH	CHECKED:		CONTAINER TYPE AND PRESERVATIVE CODES
DATE: 22/4	TIME: Am		P = Natural Plastic; N = Nitric Acid Preserved; C = Sodium Hydroxide Preserved; J = Solvent Washed Acid Rinsed Jar
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

KANN (ALS)
27/4 10:30

ATT: KIEREN BURNS

SOIL

FREIGHT

AECOM PROJECT - CHAIN OF CUSTODY

CLIENT:	AECOM Services	LABORATORY:	ALS	All results to be provided in ESDAT format. email address: adelaide@urscorp.com	[redacted]
ADDRESS:	Level 28, 91 King William St Adelaide SA 5000	ADDRESS:	2-4 Westall Rd Springvale Vic, 3171	Quote Number:	
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:	Timothy Smith	SIGNED:	

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)
[redacted]	NAPANDEE	N06	SOIL	PRIMARY	N06_0.0	[redacted]	0.1	17/4	JAR/BAG	NA	3	X	X	X	X	X	X	X	X	X	X
	↓	↓	↓	↓	N06_1.0		1.1	"	↓	↓	2	X	X	X	X	X	X	X		X	X
					N06_2.8		2.9	"			2	X	X	X	X	X	X	X		X	X
					N06_3.8		3.9	"			2	X	X	X	X	X	X	X		X	X
					N06_6.5		6.6	"			2	X	X	X	X	X	X	X		X	X
			ROCK		N06_18.1		18.2	18/4			2	X	X	X	X	X	X	X			X
			↓		N06_25.1		25.2	"			2	X	X	X	X	X	X	X			X
					N06_36.0		36.1	"			2	X	X	X	X	X	X	X			X
					N06_41.0		41.1	19/4			2	X	X	X	X	X	X	X			X
			SOIL		N06_47.0		47.1	"			2	X	X	X	X	X	X	X		X	X

RELINQUISHED BY: TIM SMITH	CHECKED:		CONTAINER TYPE AND PRESERVATIVE CODES
DATE: 22/4	TIME: Am		P = Natural Plastic; N = Nitric Acid Preserved; C = Sodium Hydroxide Preserved; J = Solvent Washed Acid Rinsed Jar
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

KANU (ALS)
27/4. 10:30

Environmental Division
Melbourne
Work Order Reference
EM1806934

Telephone : + 61-3-8549 9600

Ryan ODonnell

From:	Kieren Burns
Sent:	Friday, 27 April 2018 12:34 PM
To:	Samples Melbourne; Andrew Matheson
Subject:	FW: W02D sent 24 April
Attachments:	Tim Napandee COC No.1.jpg
Follow Up Flag:	Follow up
Flag Status:	Completed

Hi Guys

Can you please have these Aecom samples on hold until they let me know what is to be tested.

Regards

Kieren Burns
Business Development Manager - SA
Environmental

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F +61 8 8349 0199 M +61 448 527 608
kieren.burns@alsglobal.com
Unit 3/1 Burma Road
Pooraka SA 5095
Australia

From: Morris, Melinda [mailto:melinda.morris@aecom.com]
Sent: Friday, 27 April 2018 12:01 PM
To: Kieren Burns <Kieren.Burns@alsglobal.com>
Cc: Seear, Hayden <hayden.seear@aecom.com>; Smith, Timothy (Melbourne) <Timothy.Smith@aecom.com>
Subject: RE: 2nd batch samples - W02D sent 26 April

OK thanks Kieren. Can you please get them to pop everything on hold until we finalise the COC this afternoon?

Melinda Morris
Associate Director – Hydrogeologist
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melinda.morris@aecom.com

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aecom.com

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From: Kieren Burns [mailto:Kieren.Burns@alsglobal.com]
Sent: Friday, 27 April 2018 11:59 AM
To: Morris, Melinda
Cc: Seear, Hayden; Smith, Timothy (Melbourne)
Subject: RE: 2nd batch samples - W02D sent 26 April

Hi Melinda

Yes I got Tim's samples yesterday and sent them to Melbourne.

I have not seen anything today yet.

Regards

Kieren Burns
Business Development Manager - SA
Environmental

ALS

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F +61 8 8349 0199 M +61 448 527 608
kieren.burns@alsglobal.com
Unit 3/1 Burma Road
Pooraka SA 5095
Australia

From: Morris, Melinda [mailto:melinda.morris@aecom.com]
Sent: Friday, 27 April 2018 11:58 AM
To: Kieren Burns <Kieren.Burns@alsglobal.com>
Cc: Seear, Hayden <hayden.seear@aecom.com>; Smith, Timothy (Melbourne) <Timothy.Smith@aecom.com>
Subject: RE: 2nd batch samples - W02D sent 26 April

Hi Kieren,

Did you receive samples from Tim Smith from Kimba yesterday? Apparently Kimba Transport dropped them off.

Tim is coming back from site this afternoon. We'll clarify the sample analytes for his site and send through an updated COC today but it would be good to know whether they've been received OK.

Cheers,

M.

Melinda Morris
Associate Director – Hydrogeologist
D +61 8 7223 5543 M +61 408 387 495

melinda.morris@aecom.com

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Level 28, 91 King William Street, Adelaide, SA 5000
T +61 8 7223 5400 F +61 8 7223 5499
aecom.com

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From: Morris, Melinda
Sent: Friday, 27 April 2018 11:28 AM
To: 'Kieren Burns'; Radford, Joshua
Cc: Seear, Hayden
Subject: RE: 2nd batch samples - W02D sent 26 April

Hi Kieren,

Is there anyone on duty at ALS Melb to log them in on Saturday? If not then hang onto them.

Cheers,

M.

Melinda Morris
Associate Director – Hydrogeologist
D +61 8 7223 5543 M +61 408 387 495
melinda.morris@aecom.com

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Level 28, 91 King William Street, Adelaide, SA 5000
T +61 8 7223 5400 F +61 8 7223 5499
aecom.com

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LinkedIn Twitter Facebook Instagram

From: Kieren Burns [mailto:Kieren.Burns@alsglobal.com]
Sent: Friday, 27 April 2018 9:38 AM
To: Radford, Joshua
Cc: Morris, Melinda; Seear, Hayden
Subject: RE: 2nd batch samples - W02D sent 26 April

Hi Joshua/Melinda

Is this ok to hold on to over the weekend or does this need to be dispatched to Melbourne tonight?

Regards

Kieren Burns
Business Development Manager - SA
Environmental

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F +61 8 8349 0199 M +61 448 527 608
kieren.burns@alsglobal.com
Unit 3/1 Burma Road

Pooraka SA 5095
Australia

We are keen for your feedback! Please click here for your 1 question survey

EnviroMail™ 114 - Asbestos Fibre Identification by SEM/EDS
EnviroMail™ 113 - Amoeba Confirmation PCR
EnviroMail™ 00 - Summary of all EnviroMails™ by Category

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From: Radford, Joshua [mailto:josh.radford@aecom.com]
Sent: Friday, 27 April 2018 6:04 AM
To: Kieren Burns <Kieren.Burns@alsglobal.com>
Cc: Morris, Melinda <melinda.morris@aecom.com>; Seear, Hayden <hayden.seear@aecom.com>
Subject: 2nd batch samples - W02D sent 26 April

Kieran,

A second batch of samples in one eskie were dispatched late yesterday.COC also attached Can you please repack with ice and forward to ALS Melbourne once received?

Thanks

Josh

Josh Radford
Environmental Geologist
D +61 2 8934 0589
josh.radford@aecom.com

AECOM
Level 21, 420 George Street, Sydney, NSW 2000
PO Box Q410, QVB PO, Sydney, NSW, 1230
T +61 2 8934 0000 F +61 2 8934 0001
aecom.com

Imagine it. Delivered.

LinkedIn Twitter Facebook Instagram

From: Kieren Burns [mailto:Kieren.Burns@alsglobal.com]
Sent: Thursday, 26 April 2018 12:14 PM
To: Radford, Joshua; Seear, Hayden
Cc: Morris, Melinda
Subject: RE: W02D_COC_24 April 18

Hi Joshua

All eskies received and will be forwarded tonight.

Regards

Kieren Burns
Business Development Manager - SA
Environmental

T +61 8 8162 5130
F +61 8 8349 0199 M +61 448 527 608
kieren.burns@alsglobal.com
Unit 3/1 Burma Road
Pooraka SA 5095
Australia

From: Radford, Joshua [mailto:josh.radford@aecom.com]
Sent: Wednesday, 25 April 2018 6:20 AM
To: Seear, Hayden <hayden.seear@aecom.com>
Cc: Morris, Melinda <melinda.morris@aecom.com>; Kieren Burns <Kieren.Burns@alsglobal.com>
Subject: FW: W02D_COC_24 April 18

Hayden, COC attached for W02D samples sent to ALS Adelaide yesterday from TNT Port Augusta.
Hayden can you please check the scheduling?

Kieran – 3 eskies will require repacking with ice and forwarding on to ALS Melbourne asap,.
QC02 will need to be forwarded to ALS Sydney

Cheers

Josh

Josh Radford
Environmental Geologist
D +61 2 8934 0589
josh.radford@aecom.com

AECOM
Level 21, 420 George Street, Sydney, NSW 2000
PO Box Q410, QVB PO, Sydney, NSW, 1230
T +61 2 8934 0000 F +61 2 8934 0001
aecom.com

From: Radford, Joshua
Sent: Wednesday, 25 April 2018 6:28 AM
To: Radford, Joshua
Subject: W02D_COC_24 April 18

ATT: KIEREN BURNS

SOIL

FREIGHT

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:	neiladamorris@aecom.com 0408 297 490		
		SAMPLERS:	Timothy Smith	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/Phenol 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)
NAPANDEE	N06	SOIL	PRIMARY	N06_0.0	0.1	17/4	JAR/BAG	NA	3	X	X	X	X	X	X	X	X	X	X
				N06_1.0	1.1	"			2	X	X	X	X	X	X	X		X	X
				N06_2.8	2.9	"			2	X	X	X	X	X	X	X		X	X
				N06_3.8	3.9	"			2	X	X	X	X	X	X	X		X	X
				N06_6.5	6.6	"			2	X	X	X	X	X	X	X		X	X
		ROCK		N06_18.1	18.2	18/4			2	X	X	X	X	X	X	X			X
				N06_25.1	25.2	"			2	X	X	X	X	X	X	X			X
				N06_36.0	36.1	"			2	X	X	X	X	X	X	X			X
				N06_41.0	41.1	19/4			2	X	X	X	X	X	X	X			X
		SOIL		N06_47.0	47.1	"			2	X	X	X	X	X	X	X		X	X

RELINQUISHED BY: TIM SMITH	CHECKED:		
DATE: 22/4	TIME: Am		
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

KARN (AM)
27/4. 10:30

Environmental Division
Melbourne
Work Order Reference
EM1806934

Telephone : + 61-3-8549 9600

Att:	
Due Date:	6/06/2018
Purchase Order #:	503451
ALS Batch #:	EM1807266

PLEASE RETURN ESKY TO ALS BRISBANE

CHAIN OF CUSTODY

From: Australian Laboratory Services Pty Ltd (ABN 84 009 936 029)
2 Byth st
Stafford QLD 4053
PH: 07 3243 7222
FAX: 07 3352 3662

To: ALS Ceska Lipa, Czech Republic
Bendlova 1687/7
CESKA LIPA, CZECH REPUPLIC 47006
PH: 487 828 511

Please email SRN, est. due date and results to: subresults.bri@alsglobal.com

ALS

ALS sample	SAMPLE IDENTIFICATION: SAMPLE ID.	CONTAINER DATA #: DATE	TYPE	NO.	Water_EA250: Radon 222 by Gamma Spectrometry - W	Water_EA255 SL: Standard Level Tritium Volume Activi	COMMENTS
1	BH76	01/05/18	W	1L	x	x	
2	BH77	01/05/18	W	1L	x	x	

NOTES: 1. Please ensure that a signed copy is emailed back immediately to subresults.bri@alsenviro.com acknowledging receipt.

RELINQUISHED BY (SIGN / PRINT):	DATE:	RECEIVED BY (SIGN / PRINT):	DATE:
OF: ALS	TIME:	OF: (ARRIVAL TEMP: deg. C)	TIME:
RELINQUISHED BY (SIGN / PRINT):	DATE:	RECEIVED BY (SIGN / PRINT):	DATE:
OF:	TIME:	OF: (ARRIVAL TEMP: deg. C)	TIME:

ATT: KIEREN BURNS

SOIL

FREIGHT

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 397 490			
		SAMPLERS:	Timothy Smith	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)
NAPANDEE	NO6	SOIL	PRIMARY	NO6_0.0	0.1	17/4	JAR/BAG	NA	3	X	X	X	X	X	X	X	X	X	X
				NO6_1.0	1.1	"			2	X	X	X	X	X	X	X		X	X
				NO6_2.8	2.9	"			2	X	X	X	X	X	X	X		X	X
				NO6_3.8	3.9	"			2	X	X	X	X	X	X	X		X	X
				NO6_6.5	6.6	"			2	X	X	X	X	X	X	X		X	X
		ROCK		NO6_18.1	18.2	18/4			2	X	X	X	X	X	X	X		X	X
				NO6_25.1	25.2	"			2	X	X	X	X	X	X	X			X
				NO6_36.0	36.1	"			2	X	X	X	X	X	X	X			X
				NO6_41.0	41.1	19/4			2	X	X	X	X	X	X	X			X
		SOIL		NO6_47.0	47.1	"			2	X	X	X	X	X	X	X		X	X

RELINQUISHED BY: TIM SMITH	CHECKED:		
DATE: 27/4	TIME: AM		
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

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Z = Zinc acetate Preserved Bottle; E = EDTA Preserved Bottle; ST = Sterile Bottle; O = Other

KANN (ALS)
27/4, 10:30

Environmental Division
Melbourne
Work Order Reference
EM1806934

Telephone : +61-3-8549 9600

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **EM1807107**	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 09:45
Order number	: 60565376.4.0	Date Analysis Commenced	: 11-May-2018
C-O-C number	: ----	Issue Date	: 16-May-2018 14:57
Sampler	: ----		
Site	: NRWMF Site Characterisation		
Quote number	: EN/004/16		
No. of samples received	: 29		
No. of samples analysed	: 10		

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)

				N07_0-0.2	N07_1.5-1.6	N07_2.5-2.6	N11_ 0-0.2	N11_1.0-1.1
				25-Apr-2018 00:00	25-Apr-2018 00:00	25-Apr-2018 00:00	25-Apr-2018 00:00	25-Apr-2018 00:00
				EM1807107-006	EM1807107-007	EM1807107-008	EM1807107-009	EM1807107-010
				Result	Result	Result	Result	Result
EA001: pH in soil using 0.01M CaCl extract								
pH (CaCl2)	----	0.1	pH Unit	**6.0**	**8.3**	**8.1**	**6.7**	**8.4**
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	**105**	**1060**	**1150**	**333**	**1370**
EA032: Electrical Conductivity (saturated paste)								
Electrical Conductivity (Saturated Paste)	----	1	µS/cm	**405**	**3330**	**3760**	**853**	**3700**
ED006: Exchangeable Cations on Alkaline Soils								
ø **Exchangeable Calcium**	----	0.2	meq/100g	----	**1.7**	**1.2**	**2.4**	**1.7**
ø **Exchangeable Magnesium**	----	0.2	meq/100g	----	**3.1**	**3.5**	**1.3**	**4.1**
ø **Exchangeable Potassium**	----	0.2	meq/100g	----	**1.3**	**1.7**	**0.8**	**1.5**
ø **Exchangeable Sodium**	----	0.2	meq/100g	----	**4.4**	**5.8**	**0.3**	**5.5**
ø **Cation Exchange Capacity**	----	0.2	meq/100g	----	**10.6**	**12.2**	**4.7**	**12.8**
ø **Exchangeable Sodium Percent**	----	0.2	%	----	**41.4**	**47.1**	**5.7**	**43.1**
ED007: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	**2.1**	----	----	----	----
Exchangeable Magnesium	----	0.1	meq/100g	**0.8**	----	----	----	----
Exchangeable Potassium	----	0.1	meq/100g	**0.5**	----	----	----	----
Exchangeable Sodium	----	0.1	meq/100g	**0.2**	----	----	----	----
Cation Exchange Capacity	----	0.1	meq/100g	**3.5**	----	----	----	----
Exchangeable Sodium Percent	----	0.1	%	**5.4**	----	----	----	----

Analytical Results

Sub-Matrix: SOIL
(Matrix: SOIL)

				N11_2.0-2.1	N09_0-0.2	N09_1.4-1.5	N09_2.5-2.6	QC104_250418
				25-Apr-2018 00:00	25-Apr-2018 00:00	25-Apr-2018 00:00	25-Apr-2018 00:00	25-Apr-2018 00:00
				EM1807107-011	EM1807107-015	EM1807107-016	EM1807107-017	EM1807107-022
				Result	Result	Result	Result	Result
EA001: pH in soil using 0.01M CaCl extract								
pH (CaCl2)	----	0.1	pH Unit	6.1	6.2	8.1	5.2	6.1
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	1630	157	1360	1620	170
EA032: Electrical Conductivity (saturated paste)								
Electrical Conductivity (Saturated Paste)	----	1	µS/cm	5620	515	1000	5870	454
ED006: Exchangeable Cations on Alkaline Soils								
ø Exchangeable Calcium	----	0.2	meq/100g	----	----	1.3	----	----
ø Exchangeable Magnesium	----	0.2	meq/100g	----	----	3.7	----	----
ø Exchangeable Potassium	----	0.2	meq/100g	----	----	1.3	----	----
ø Exchangeable Sodium	----	0.2	meq/100g	----	----	4.1	----	----
ø Cation Exchange Capacity	----	0.2	meq/100g	----	----	10.4	----	----
ø Exchangeable Sodium Percent	----	0.2	%	----	----	39.3	----	----
ED007: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	----	1.8	----	----	----
Exchangeable Magnesium	----	0.1	meq/100g	----	0.9	----	----	----
Exchangeable Potassium	----	0.1	meq/100g	----	0.4	----	----	----
Exchangeable Sodium	----	0.1	meq/100g	----	0.4	----	----	----
Cation Exchange Capacity	----	0.1	meq/100g	----	3.6	----	----	----
Exchangeable Sodium Percent	----	0.1	%	----	12.2	----	----	----
ED008: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	1.1	----	----	0.5	----
Exchangeable Magnesium	----	0.1	meq/100g	4.1	----	----	3.8	----
Exchangeable Potassium	----	0.1	meq/100g	0.9	----	----	0.9	----
Exchangeable Sodium	----	0.1	meq/100g	2.7	----	----	2.5	----
Exchangeable Sodium Percent	----	0.1	%	30.5	----	----	32.7	----
Cation Exchange Capacity	----	0.1	meq/100g	8.7	----	----	7.7	----

ALS Environmental

QUALITY CONTROL REPORT

Work Order	: **EM1807107**	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	: 29		
No. of samples analysed	: 10		

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: 1633667)									
EM1807107-006	N07_0-0.2	EA001: pH (CaCl2)	----	0.1	pH Unit	6.0	5.8	3.39	0% - 20%
EM1807107-022	QC104_250418	EA001: pH (CaCl2)	----	0.1	pH Unit	6.1	6.1	0.00	0% - 20%
EA010: Conductivity (QC Lot: 1633668)									
EM1807107-006	N07_0-0.2	EA010: Electrical Conductivity @ 25°C	----	1	µS/cm	105	116	10.3	0% - 20%
EM1807107-022	QC104_250418	EA010: Electrical Conductivity @ 25°C	----	1	µS/cm	170	150	12.3	0% - 20%
EA032: Electrical Conductivity (saturated paste) (QC Lot: 1637862)									
EM1807107-006	N07_0-0.2	EA032: Electrical Conductivity (Saturated Paste)	----	1	µS/cm	405	407	0.493	0% - 20%
EM1807107-022	QC104_250418	EA032: Electrical Conductivity (Saturated Paste)	----	1	µS/cm	454	470	3.46	0% - 20%
ED006: Exchangeable Cations on Alkaline Soils (QC Lot: 1644175)									
EM1807107-007	N07_1.5-1.6	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%
ED007: Exchangeable Cations (QC Lot: 1637854)									
EM1807107-006	N07_0-0.2	ED007: Exchangeable Sodium Percent	----	0.1	%	5.4	5.5	0.00	0% - 20%
		ED007: Exchangeable Calcium	----	0.1	meq/100g	2.1	2.0	0.00	0% - 20%

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 (%)
ED007: Exchangeable Cations (QC Lot: 1637854) - continued									
EM1807107-006	N07_0-0.2	ED007: Exchangeable Magnesium	----	0.1	meq/100g	0.8	0.8	0.00	No Limit
		ED007: Exchangeable Potassium	----	0.1	meq/100g	0.5	0.5	0.00	No Limit
		ED007: Exchangeable Sodium	----	0.1	meq/100g	0.2	0.2	0.00	No Limit
		ED007: Cation Exchange Capacity	----	0.1	meq/100g	3.5	3.4	0.00	0% - 20%
ED008: Exchangeable Cations (QC Lot: 1637853)									
EM1807107-011	N11_2.0-2.1	ED008: Exchangeable Sodium Percent	----	0.1	%	30.5	30.5	0.00	0% - 20%
		ED008: Exchangeable Calcium	----	0.1	meq/100g	1.1	1.1	0.00	0% - 50%
		ED008: Exchangeable Magnesium	----	0.1	meq/100g	4.1	4.1	0.00	0% - 20%
		ED008: Exchangeable Potassium	----	0.1	meq/100g	0.9	0.9	0.00	No Limit
		ED008: Exchangeable Sodium	----	0.1	meq/100g	2.7	2.6	0.00	0% - 20%
		ED008: Cation Exchange Capacity	----	0.1	meq/100g	8.7	8.7	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: 1633668)								
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
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	----	----	----	----
ED007: Exchangeable Cations (QCLot: 1637854)								
ED007: Exchangeable Calcium	----	0.1	meq/100g	<0.1	3.45 meq/100g	108	80	120
ED007: Exchangeable Magnesium	----	0.1	meq/100g	<0.1	1.09 meq/100g	95.6	80	120
ED007: Exchangeable Potassium	----	0.1	meq/100g	<0.1	0.609 meq/100g	114	80	120
ED007: Exchangeable Sodium	----	0.1	meq/100g	<0.1	0.347 meq/100g	100	80	120
ED007: Cation Exchange Capacity	----	0.1	meq/100g	<0.1	----	----	----	----
ED008: Exchangeable Cations (QCLot: 1637853)								
ED008: Exchangeable Calcium	----	0.1	meq/100g	<0.1	3.45 meq/100g	101	80	120
ED008: Exchangeable Magnesium	----	0.1	meq/100g	<0.1	1.09 meq/100g	91.5	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	95.8	80	120
ED008: 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	: **EM1807107**	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	: 29
Order number	: 60565376.4.0	No. of samples analysed	: 10

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 / Container / Client Sample ID(s)		Extraction / Preparation: Date extracted	Due for extraction	Days overdue	Analysis: Date analysed	Due for analysis	Days overdue
EA001: pH in soil using 0.01M CaCl extract							
Soil Glass Jar - Unpreserved							
N07_0-0.2,	N07_1.5-1.6,	11-May-2018	02-May-2018	**9**	----	----	----
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,	QC104_250418						
EA010: Conductivity							
Soil Glass Jar - Unpreserved							
N07_0-0.2,	N07_1.5-1.6,	11-May-2018	02-May-2018	**9**	----	----	----
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,	QC104_250418						

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 / Container / Client Sample ID(s)		Sample Date	Extraction / Preparation: Date extracted	Due for extraction	Evaluation	Analysis: Date analysed	Due for analysis	Evaluation
EA001: pH in soil using 0.01M CaCl extract								
Soil Glass Jar - Unpreserved (EA001)								
N07_0-0.2,	N07_1.5-1.6,	**25-Apr-2018**	**11-May-2018**	02-May-2018	✘	**11-May-2018**	11-May-2018	✓
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,	QC104_250418							

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)								
N07_0-0.2, N07_2.5-2.6, N11_1.0-1.1, N09_0-0.2, N09_2.5-2.6,	N07_1.5-1.6, N11_ 0-0.2, N11_2.0-2.1, N09_1.4-1.5, QC104_250418	**25-Apr-2018**	**11-May-2018**	02-May-2018	×	**11-May-2018**	08-Jun-2018	✓
EA032: Electrical Conductivity (saturated paste)								
Soil Glass Jar - Unpreserved (EA032)								
N07_0-0.2, N07_2.5-2.6, N11_1.0-1.1, N09_0-0.2, N09_2.5-2.6,	N07_1.5-1.6, N11_ 0-0.2, N11_2.0-2.1, N09_1.4-1.5, QC104_250418	**25-Apr-2018**	**----**	----	----	**14-May-2018**	22-Oct-2018	✓
ED006: Exchangeable Cations on Alkaline Soils								
Soil Glass Jar - Unpreserved (ED006)								
N07_1.5-1.6, N11_ 0-0.2, N09_1.4-1.5	N07_2.5-2.6, N11_1.0-1.1,	**25-Apr-2018**	**16-May-2018**	23-May-2018	✓	**16-May-2018**	23-May-2018	✓
ED007: Exchangeable Cations								
Soil Glass Jar - Unpreserved (ED007)								
N07_0-0.2, N09_0-0.2, QC104_250418	N11_2.0-2.1, N09_2.5-2.6,	**25-Apr-2018**	**14-May-2018**	23-May-2018	✓	**16-May-2018**	23-May-2018	✓
ED008: Exchangeable Cations								
Soil Glass Jar - Unpreserved (ED008)								
N07_0-0.2, N09_0-0.2, QC104_250418	N11_2.0-2.1, N09_2.5-2.6,	**25-Apr-2018**	**14-May-2018**	23-May-2018	✓	**16-May-2018**	23-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 / *Analytical Methods*	*Method*	*Count QC*	*Count Regular*	***Rate (%) Actual***	***Rate (%) Expected***	*Evaluation*	*Quality Control Specification*
Laboratory Duplicates (DUP)							
Electrical Conductivity (1:5)	EA010	2	10	**20.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Electrical Conductivity (Saturated Paste)	EA032	2	20	**10.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Exchangeable Cations	ED007	1	3	**33.33**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Exchangeable Cations on Alkaline Soils	ED006	2	20	**10.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Exchangeable Cations with pre-treatment	ED008	1	2	**50.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
pH in soil using a 0.01M CaCl2 extract	EA001	2	10	**20.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Laboratory Control Samples (LCS)							
Electrical Conductivity (1:5)	EA010	1	10	**10.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Electrical Conductivity (Saturated Paste)	EA032	1	20	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Exchangeable Cations	ED007	1	3	**33.33**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Exchangeable Cations on Alkaline Soils	ED006	1	20	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Exchangeable Cations with pre-treatment	ED008	1	2	**50.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Method Blanks (MB)							
Electrical Conductivity (1:5)	EA010	1	10	**10.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Electrical Conductivity (Saturated Paste)	EA032	1	20	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Exchangeable Cations	ED007	1	3	**33.33**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Exchangeable Cations on Alkaline Soils	ED006	1	20	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Exchangeable Cations with pre-treatment	ED008	1	2	**50.00**	**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*
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.

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 367 495			
		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	H06	0-0.2	25/04/2018	1 Jar, 1 Bag	NA	2	1										
	NRWMF SCP	Napandee	Soil	Primary	[redacted]		[redacted]	1 Jar, 1 Bag	NA	2	1										
	NRWMF SCP	Napandee	Soil	Primary	H06	1.0 -1.1	25/04/2018	1 Jar, 1 Bag	NA	2	1										
	NRWMF SCP	Napandee	Soil	Primary	H06	2.0-2.1	25/04/2018	1 Jar, 1 Bag	NA	2	1										
	NRWMF SCP	Napandee	Soil	Primary	[redacted]	[redacted]	[redacted]	1 Jar, 1 Bag	NA	2	1										
	NRWMF SCP	Napandee	Soil	Primary	H08	0-0.2	25/04/2018	1 Jar, 1 Bag	NA	2	1										
	NRWMF SCP	Napandee	Soil	Primary	[redacted]	[redacted]	[redacted]	1 Jar, 1 Bag	NA	2	1										
	NRWMF SCP	Napandee	Soil	Primary	H08	1.9-2.0	25/04/2018	1 Jar, 1 Bag	NA	2	1										
	NRWMF SCP	Napandee	Soil	Primary	H07	0-0.2	25/04/2018	1 Jar, 1 Bag	NA	2	1										
	NRWMF SCP	Napandee	Soil	Primary	H07	1.5-1[redacted]	25/04/2018	[redacted] 1JAR/1BAG													
	NRWMF SCP	Napandee	Soil	Primary	H07	2.5-2.6	25/04/2018	1 Jar, 1 Bag	NA	2	1										
	NRWMF SCP	Napandee	Soil	Primary	H11	0-0.2	25/04/2018	1 Jar, 1 Bag	NA	2	1										
	NRWMF SCP	Napandee	Soil	Primary	H11	1.0-1.1	25/04/2018	1 Jar, 1 Bag	NA	2	1										
	NRWMF SCP	Napandee	Soil	Primary	H11	2.0-2.1	25/04/2018	1 Jar, 1 Bag	NA	2	1										
	NRWMF SCP	Napandee	Soil	Primary	H10	0-0.2	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: 30/4/18	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 a	Z = Zinc acetate Preserved Bottle; E = EDTA Preserved Bottle; ST = Sterile Bottle; O = Other

Environmental Division
Melbourne
Work Order Reference
EM1807107

Telephone : + 61-3-8549 9600

AECOM PROJECT - CHAIN OF CUSTODY

CLIENT: AECOM Services
ADDRESS: Level 28, 91 King William St, Adelaide, SA 5000
PHONE NO: 08 7100 6400
FAX NO: 08 7223 5499
PROJECT NAME: NRWMF Site Characterisation
PROJECT NO: 60565376.4.0

LABORATORY: ALS
ADDRESS: 2-4 Westall Rd, Springvale, Vic, 3171
PHONE NO: 03 8549 9600
FAX NO:
PROJECT MANAGER: melinda.morris@aecom.com 0408 387 495
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	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										
	NRWMF SCP	Lyndhurst	Soil	Primary	L11	0-0.2	26/04/2018	1 Jar, 1 Bag	NA	2	1										
	NRWMF SCP	Lyndhurst	Soil	Primary	L11	1.1-1.2	26/04/2018	1 Jar, 1 Bag	NA	2	1										
	NRWMF SCP	Lyndhurst	Soil	Primary	L11	2.0-2.1	26/04/2018	1 Jar, 1 Bag	NA	2	1										
	NRWMF SCP	Lyndhurst	Soil	Primary	L09	0-0.2	26/04/2018	1 Jar, 1 Bag	NA	2	1										
	NRWMF SCP	Lyndhurst	Soil	Primary	L09	1.0-1.1	26/04/2018	1 Jar, 1 Bag	NA	2	1										
	NRWMF SCP	Lyndhurst	Soil	Primary	L09	2.1-2.2	26/04/2018	1 Jar, 1 Bag	NA	2	1										
	NRWMF SCP	Lyndhurst	Soil	Primary	L10	0-0.2	26/04/2018	1 Jar, 1 Bag	NA	2	1										
	NRWMF SCP	Lyndhurst	Soil	Primary	L10	1.0-1.1	26/04/2018	1 Jar, 1 Bag	NA	2	1										
	NRWMF SCP	Lyndhurst	Soil	Primary	L10	2.0-2.1	26/04/2018	1 Jar, 1 Bag	NA	2	1										
	NRWMF SCP	Lyndhurst	Soil	Primary	L07	0-0.2	26/04/2018	1 Jar, 1 Bag	NA	2	1										
										TOTAL											

Custody Seal? Y N NA
Samples Cold? Y N NA
Comments:

RELINQUISHED BY: DATE:
CHECKED: TIME:
RECEIVED BY: Bharathi (ALS) DATE:
CHECKED: 01/5/18 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

AECOM PROJECT - CHAIN OF CUSTODY

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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 367 495			
		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	Lyndhurst	Soil	Primary	L07	0.5-0.6	26/04/2018	1 Jar, 1 Bag	NA	2	1										
	NRWMF SCP	Lyndhurst	Soil	Primary	L07	1.6-1.7	26/04/2018	[illegible]	NA	2	1	1 Bag		1 Jar							
	NRWMF SCP	Lyndhurst	Soil	Primary	L07	2.1-2.2	26/04/2018	[illegible]	NA	2	1										
	NRWMF SCP	Lyndhurst	Soil	Primary	L06	0-0.2	26/04/2018	1 Jar, 1 Bag	NA	2	1										
	NRWMF SCP	Lyndhurst	Soil	Primary	L06	1.0-1.1	26/04/2018	1 Jar, 1 Bag	NA	2	1										
	NRWMF SCP	Lyndhurst	Soil	Primary	L06	2.0-2.1	26/04/2018	1 Jar, 1 Bag	NA	2	1										
	NRWMF SCP	Lyndhurst	Soil	Primary	L08	0-0.2	26/04/2018	1 Jar, 1 Bag	NA	2	1										
	NRWMF SCP	Lyndhurst	Soil	Primary	L08	0.3-0.5	26/04/2018	1 Jar, 1 Bag	NA	2	1										
	NRWMF SCP	Lyndhurst	Soil	Primary	L08	1.0-1.1	26/04/2018	1 Jar, 1 Bag	NA	2	1										
	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:	
Samples Cold ?	Y N NA	DATE:		TIME:	
Comments:		RECEIVED BY:	Bharathi (ACS)	CHECKED:	
		DATE:		TIME:	01/5/18 10.15 am

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)
	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										
	NRWMF SCP	Lyndhurst	Soil	QA\QC	QC209 260418	26/04/2018	1 Jar, 1 Bag	NA	2	1										
	NRWMF SCP	Lyndhurst	Soil	QA\QC	QC210 260418	26/04/2018	1 Jar, 1 Bag	NA	2	1										
	NRWMF SCP	Lyndhurst	Soil	QA\QC	QC207 260418	26/04/2018	1 Jar, 1 Bag	NA	2	1										
	NRWMF SCP	Lyndhurst	Soil	QA\QC	QC208 260418	26/04/2018	1 Jar, 1 Bag	NA	2	1										
	NRWMF SCP	Lyndhurst	Soil	QA\QC	QC205 260418	26/04/2018	1 Jar, 1 Bag	NA	2	1										
	NRWMF SCP	Lyndhurst	Soil	QA\QC	QC206 260418	26/04/2018	1 Jar, 1 Bag	NA	2	1										
	NRWMF SCP	Lyndhurst	Soil	QA\QC	QC203 260418	26/04/2018	1 Jar, 1 Bag	NA	2	1										
	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:		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:	01/5/16	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

AECOM PROJECT - CHAIN OF CUSTODY

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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 387 496		
		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)
	NRWMF SCP	Lyndhurst	Soil	QA\QC	QC201 260418	26/04/2018	1 Jar, 1 Bag	NA	2	1										
	NRWMF SCP	Lyndhurst	Soil	QA\QC	QC202 260418	26/04/2018	2 Jar, 1 Bag	NA	3	1										
	NRWMF SCP	Lyndhurst	Soil	QA\QC	QC211 260418	26/04/2018	3 Jar, 1 Bag	NA	4	1										
	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

r...GHT

AECOM PROJECT - CHAIN OF CUSTODY

CLIENT:	AECOM Services	LABORATORY:	ALS	All results to be provided in ESDAT format. email address: adelaide@urscorp.com	FOR LABORATORY USE ONLY
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PHONE NO:	08 7100 6400	PHONE NO:	03 8549 9600	Quote Number:	
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PROJECT NAME:	NRWMF Site Characterisation	PROJECT MANAGER: melinda.morris@aecom.com 0408 387 495			
		SAMPLERS:		SIGNED:	
PROJECT NO:	60565376.4.0				

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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)
1	NRWMF SCP	Napandee	Soil	Primary	H06	0-0.2	25/04/2018	1 Jar, 1 Bag	NA	2	1										
1	NRWMF SCP	Napandee	Soil	Primary	[redacted]		[redacted]	1 Jar, 1 Bag	NA	2	1										
2	NRWMF SCP	Napandee	Soil	Primary	H06	1.0-1.1	25/04/2018	1 Jar, 1 Bag	NA	2	1										
3	NRWMF SCP	Napandee	Soil	Primary	H06	2.0-2.1	25/04/2018	1 Jar, 1 Bag	NA	2	1										
	NRWMF SCP	Napandee	Soil	Primary	[redacted]	[redacted]	[redacted]	1 Jar, 1 Bag	NA	2	1										
4	NRWMF SCP	Napandee	Soil	Primary	H08	0-0.2	25/04/2018	1 Jar, 1 Bag	NA	2	1										
	NRWMF SCP	Napandee	Soil	Primary	[redacted]	[redacted]	[redacted]	1 Jar, 1 Bag	NA	2	1										
5	NRWMF SCP	Napandee	Soil	Primary	H08	1.9-2.0	25/04/2018	1 Jar, 1 Bag	NA	2	1										
6	NRWMF SCP	Napandee	Soil	Primary	H07	0-0.2	25/04/2018	1 Jar, 1 Bag	NA	2	1										
7	NRWMF SCP	Napandee	Soil	Primary	H07	1.5-1.[redacted]	25/04/2018	[redacted]	NA 1JAR/1BAG	2	1										
8	NRWMF SCP	Napandee	Soil	Primary	H07	2.5-2.6	25/04/2018	1 Jar, 1 Bag	NA	2	1										
9	NRWMF SCP	Napandee	Soil	Primary	H11	0-0.2	25/04/2018	1 Jar, 1 Bag	NA	2	1										
10	NRWMF SCP	Napandee	Soil	Primary	H11	1.0-1.1	25/04/2018	1 Jar, 1 Bag	NA	2	1										
11	NRWMF SCP	Napandee	Soil	Primary	H11	2.0-2.1	25/04/2018	1 Jar, 1 Bag	NA	2	1										
12	NRWMF SCP	Napandee	Soil	Primary	H10	0-0.2	25/04/2018	1 Jar, 1 Bag	NA	2	1										
										TOTAL											

Custody Seal ?	Y N NA	RELINQUISHED BY:	CHECKED:	30/4/18	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:		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	Z = Zinc acetate Preserved Bottle; E = EDTA Preserved Bottle; ST = Sterile Bottle; O = Other

Environmental Division
Melbourne
Work Order Reference
EM1807107

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)
13	NRWMF SCP	Napandee	Soil	Primary	H10	1.0-1.1	25/04/2018	1 Jar, 1 Bag	NA	2	1										
14	NRWMF SCP	Napandee	Soil	Primary	H10	2.0-2.1	25/04/2018	1 Jar, 1 Bag	NA	2	1										
15	NRWMF SCP	Napandee	Soil	Primary	H09	0-0.2	25/04/2018	1 Jar, 1 Bag	NA	2	1										
16	NRWMF SCP	Napandee	Soil	Primary	H09	1.4-1.5	25/04/2018	1 Jar, 1 Bag	NA	2	1										
17	NRWMF SCP	Napandee	Soil	Primary	H09	2.5-2.6	25/04/2018	1 Jar, 1 Bag	NA	2	1										
	NRWMF SCP	Lyndhurst	Soil	Primary	L11	0-0.2	26/04/2018	1 Jar, 1 Bag	NA	2	1										
	NRWMF SCP	Lyndhurst	Soil	Primary	L11	1.1-1.2	26/04/2018	1 Jar, 1 Bag	NA	2	1										
	NRWMF SCP	Lyndhurst	Soil	Primary	L11	2.0-2.1	26/04/2018	1 Jar, 1 Bag	NA	2	1										
	NRWMF SCP	Lyndhurst	Soil	Primary	L09	0-0.2	26/04/2018	1 Jar, 1 Bag	NA	2	1										
	NRWMF SCP	Lyndhurst	Soil	Primary	L09	1.0-1.1	26/04/2018	1 Jar, 1 Bag	NA	2	1										
	NRWMF SCP	Lyndhurst	Soil	Primary	L09	2.1-2.2	26/04/2018	1 Jar, 1 Bag	NA	2	1										
	NRWMF SCP	Lyndhurst	Soil	Primary	L10	0-0.2	26/04/2018	1 Jar, 1 Bag	NA	2	1										
	NRWMF SCP	Lyndhurst	Soil	Primary	L10	1.0-1.1	26/04/2018	1 Jar, 1 Bag	NA	2	1										
	NRWMF SCP	Lyndhurst	Soil	Primary	L10	2.0-2.1	26/04/2018	1 Jar, 1 Bag	NA	2	1										
	NRWMF SCP	Lyndhurst	Soil	Primary	L07	0-0.2	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:	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

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	Lyndhurst	Soil	Primary	L07	0.5-0.6	26/04/2018	1 Jar, 1 Bag	NA	2	1										
	NRWMF SCP	Lyndhurst	Soil	Primary	L07	1.6-1.7	26/04/2018	[redacted]	NA	2	1	1 bag	1	1 jar							
	NRWMF SCP	Lyndhurst	Soil	Primary	L07	2.1-2.2	26/04/2018	[redacted]	NA	2	1										
	NRWMF SCP	Lyndhurst	Soil	Primary	L06	0-0.2	26/04/2018	1 Jar, 1 Bag	NA	2	1										
	NRWMF SCP	Lyndhurst	Soil	Primary	L06	1.0-1.1	26/04/2018	1 Jar, 1 Bag	NA	2	1										
	NRWMF SCP	Lyndhurst	Soil	Primary	L06	2.0-2.1	26/04/2018	1 Jar, 1 Bag	NA	2	1										
	NRWMF SCP	Lyndhurst	Soil	Primary	L08	0-0.2	26/04/2018	1 Jar, 1 Bag	NA	2	1										
	NRWMF SCP	Lyndhurst	Soil	Primary	L08	0.3-0.5	26/04/2018	1 Jar, 1 Bag	NA	2	1										
	NRWMF SCP	Lyndhurst	Soil	Primary	L08	1.0-1.1	26/04/2018	1 Jar, 1 Bag	NA	2	1										
	NRWMF SCP	Lyndhurst	Soil	Primary	L08	2.2-2.3	26/04/2018	1 Jar, 1 Bag	NA	2	1										
13 18	NRWMF SCP	Napandee	Soil	QA\QC	QC100	250418	25/04/2018	1 Jar, 1 Bag	NA	2	1										
14 19	NRWMF SCP	Napandee	Soil	QA\QC	QC101	250418	25/04/2018	1 Jar, 1 Bag	NA	2	1										
15 20	NRWMF SCP	Napandee	Soil	QA\QC	QC102	250418	25/04/2018	1 Jar, 1 Bag	NA	2	1										
16 21	NRWMF SCP	Napandee	Soil	QA\QC	QC103	250418	25/04/2018	1 Jar, 1 Bag	NA	2	1										
17 22	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)
23 18	NRWMF SCP	Napandee	Soil	QA\QC	QC105	250418	25/04/2018	1 Jar, 1 Bag	NA	2	1										
24 19	NRWMF SCP	Napandee	Soil	QA\QC	QC106	250418	25/04/2018	1 Jar, 1 Bag	NA	2	1										
25 20	NRWMF SCP	Napandee	Soil	QA\QC	QC107	250418	25/04/2018	1 Jar, 1 Bag	NA	2	1										
26 21	NRWMF SCP	Napandee	Soil	QA\QC	QC108	250418	25/04/2018	1 Jar, 1 Bag	NA	2	1										
27 22	NRWMF SCP	Napandee	Soil	QA\QC	QC109	250418	25/04/2018	1 Jar, 1 Bag	NA	2	1										
28 23	NRWMF SCP	Napandee	Soil	QA\QC	QC110	250418	25/04/2018	1 Jar, 1 Bag	NA	2	1										
29 24	NRWMF SCP	Napandee	Soil	QA\QC	QC111	250418	25/04/2018	1 Jar, 1 Bag	NA	2	1										
30	NRWMF SCP	Lyndhurst	Soil	QA\QC	QC209	260418	26/04/2018	1 Jar, 1 Bag	NA	2	1										
	NRWMF SCP	Lyndhurst	Soil	QA\QC	QC210	260418	26/04/2018	1 Jar, 1 Bag	NA	2	1										
	NRWMF SCP	Lyndhurst	Soil	QA\QC	QC207	260418	26/04/2018	1 Jar, 1 Bag	NA	2	1										
	NRWMF SCP	Lyndhurst	Soil	QA\QC	QC208	260418	26/04/2018	1 Jar, 1 Bag	NA	2	1										
	NRWMF SCP	Lyndhurst	Soil	QA\QC	QC205	260418	26/04/2018	1 Jar, 1 Bag	NA	2	1										
	NRWMF SCP	Lyndhurst	Soil	QA\QC	QC206	260418	26/04/2018	1 Jar, 1 Bag	NA	2	1										
	NRWMF SCP	Lyndhurst	Soil	QA\QC	QC203	260418	26/04/2018	1 Jar, 1 Bag	NA	2	1										
	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:		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: Bharati (ALS)	CHECKED:	01/5/16	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 6	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)
		22	QC104_250418			
		7	N07_1.5-1.6			
		8	N07_2.5-2.6			
		9	N11_0-0.2			
		10	N11_1.0-1.1			
		11	N11_2.0-2.1			
		15	N09_0-0.2			
		16	N09_1.4-1.5			
		17	N09_2.5-2.6			
EM1807107	Not assigned	Lyndhurst	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)
			L07_0.5-0.6			
			L07_1.5-1.6			
			L07_2.1-2.2			
			QC203_260418			
			L08_0-0.2			
			L08_1.0-1.1			
			L08_2.2-2.3			
			L10_0-0.2			
			L10_1.0-1.1			
			L10_2.0-2.2			

^ 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	: **EM1807110**	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 12:15
Order number	: 60565376.4.0	Date Analysis Commenced	: 01-May-2018
C-O-C number	: ----	Issue Date	: 18-Jun-2018 13:51
Sampler	: TIMOTHY SMITH		
Site	: Napandee		
Quote number	: EN/004/16		
No. of samples received	: 15		
No. of samples analysed	: 1		

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.

Dilani Fernando	Senior Inorganic Chemist	Melbourne Inorganics, Springvale, VIC
Kim McCabe	Senior Inorganic Chemist	Brisbane External Subcontracting, Stafford, QLD
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.

- ED037 (Alkalinity): NATA accreditation does not cover the performance of this service.
- EG035T: EM1807577 #16 Poor matrix spike recovery for total mercury due to sample matrix.
- 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)

				N02_25.0-25.1	----	----	----	----
				26-Apr-2018 00:00	----	----	----	----
				EM1807110-012	--------	--------	--------	--------
				Result	----	----	----	----
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	1.0	%	**25.5**	----	----	----	----
EA150: Particle Sizing								
+75µm	----	1	%	**39**	----	----	----	----
+150µm	----	1	%	**24**	----	----	----	----
+300µm	----	1	%	**12**	----	----	----	----
+425µm	----	1	%	**6**	----	----	----	----
+600µm	----	1	%	**3**	----	----	----	----
+1180µm	----	1	%	**1**	----	----	----	----
+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	%	**8**	----	----	----	----
Silt (2-60 µm)	----	1	%	**48**	----	----	----	----
Sand (0.06-2.00 mm)	----	1	%	**43**	----	----	----	----
Gravel (>2mm)	----	1	%	**1**	----	----	----	----
Cobbles (>6cm)	----	1	%	<1	----	----	----	----
EA152: Soil Particle Density								
ø **Soil Particle Density (Clay/Silt/Sand)**	----	0.01	g/cm3	**2.57**	----	----	----	----
ED008: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	**0.6**	----	----	----	----
Exchangeable Magnesium	----	0.1	meq/100g	**1.0**	----	----	----	----
Exchangeable Potassium	----	0.1	meq/100g	**0.2**	----	----	----	----
Exchangeable Sodium	----	0.1	meq/100g	**0.1**	----	----	----	----
Exchangeable Sodium Percent	----	0.1	%	**6.0**	----	----	----	----
Cation Exchange Capacity	----	0.1	meq/100g	**1.9**	----	----	----	----
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)				N02_25.0-25.1	----	----	----	----
				26-Apr-2018 00:00	----	----	----	----
				EM1807110-012	--------	--------	--------	--------
				Result	----	----	----	----
EG005T: Total Metals by ICP-AES - Continued								
Arsenic	7440-38-2	5	mg/kg	<5	----	----	----	----
Barium	7440-39-3	10	mg/kg	<10	----	----	----	----
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	**3**	----	----	----	----
Cobalt	7440-48-4	2	mg/kg	<2	----	----	----	----
Copper	7440-50-8	5	mg/kg	<5	----	----	----	----
Iron	7439-89-6	50	mg/kg	**160**	----	----	----	----
Lead	7439-92-1	5	mg/kg	<5	----	----	----	----
Manganese	7439-96-5	5	mg/kg	<5	----	----	----	----
Nickel	7440-02-0	2	mg/kg	<2	----	----	----	----
Selenium	7782-49-2	5	mg/kg	<5	----	----	----	----
Vanadium	7440-62-2	5	mg/kg	**6**	----	----	----	----
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	**1260**	----	----	----	----
Gross beta	----	500	Bq/kg DW	<500	----	----	----	----

ALS Environmental

QUALITY CONTROL REPORT

Work Order	: **EM1807110**	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
Order number	: 60565376.4.0	Date Analysis Commenced	: 01-May-2018
C-O-C number	: ----	Issue Date	: 18-Jun-2018
Sampler	: TIMOTHY SMITH		
Site	: Napandee		
Quote number	: EN/004/16		
No. of samples received	: 15		
No. of samples analysed	: 1		

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Accredited for compliance with
ISO/IEC 17025 - Testing

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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.

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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: 1610364)									
EM1806156-009	Anonymous	EA055: Moisture Content	----	0.1	%	9.5	8.0	18.0	No Limit
EM1807081-003	Anonymous	EA055: Moisture Content	----	0.1	%	5.8	6.2	5.51	No Limit
ED008: Exchangeable Cations (QC Lot: 1608177)									
EM1806934-008	Anonymous	ED008: Exchangeable Sodium Percent	----	0.1	%	24.0	23.4	2.90	0% - 20%
		ED008: Exchangeable Calcium	----	0.1	meq/100g	0.4	0.4	0.00	No Limit
		ED008: Exchangeable Magnesium	----	0.1	meq/100g	0.8	0.8	0.00	No Limit
		ED008: Exchangeable Potassium	----	0.1	meq/100g	0.3	0.3	0.00	No Limit
		ED008: Exchangeable Sodium	----	0.1	meq/100g	0.5	0.5	0.00	No Limit
		ED008: Cation Exchange Capacity	----	0.1	meq/100g	2.0	2.0	0.00	0% - 20%
ED037: Alkalinity (QC Lot: 1617063)									
EM1806934-003	Anonymous	ED037: Total Alkalinity as CaCO3	----	1	mg/kg	76	80	5.74	0% - 20%
EG005T: Total Metals by ICP-AES (QC Lot: 1629241)									
EM1807577-002	Anonymous	EG005T: Copper	7440-50-8	5	mg/kg	93	92	0.00	0% - 50%
		EG005T: Zinc	7440-66-6	5	mg/kg	1260	1300	3.05	0% - 20%
EM1806934-003	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	60	60	0.00	No Limit
		EG005T: Chromium	7440-47-3	2	mg/kg	18	16	8.90	No Limit
		EG005T: Cobalt	7440-48-4	2	mg/kg	6	6	0.00	No Limit
		EG005T: Nickel	7440-02-0	2	mg/kg	7	7	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	72	73	1.98	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: 1629241) - continued									
EM1806934-003	Anonymous	EG005T: Selenium	7782-49-2	5	mg/kg	<5	<5	0.00	No Limit
		EG005T: Vanadium	7440-62-2	5	mg/kg	30	28	8.52	No Limit
		EG005T: Zinc	7440-66-6	5	mg/kg	8	7	0.00	No Limit
		EG005T: Boron	7440-42-8	50	mg/kg	70	70	0.00	No Limit
		EG005T: Iron	7439-89-6	50	mg/kg	14200	13100	7.97	0% - 20%
EM1807577-002	Anonymous	EG005T: Beryllium	7440-41-7	1	mg/kg	<1	<1	0.00	No Limit
		EG005T: Cadmium	7440-43-9	1	mg/kg	6	2	83.9	No Limit
		EG005T: Barium	7440-39-3	10	mg/kg	300	340	14.3	0% - 20%
		EG005T: Chromium	7440-47-3	2	mg/kg	91	110	18.9	0% - 20%
		EG005T: Cobalt	7440-48-4	2	mg/kg	3	<2	54.4	No Limit
		EG005T: Nickel	7440-02-0	2	mg/kg	82	92	11.2	0% - 20%
		EG005T: Arsenic	7440-38-2	5	mg/kg	<5	<5	0.00	No Limit
		EG005T: Lead	7439-92-1	5	mg/kg	78	59	27.5	0% - 50%
		EG005T: Manganese	7439-96-5	5	mg/kg	76	92	19.1	0% - 50%
		EG005T: Selenium	7782-49-2	5	mg/kg	<5	<5	0.00	No Limit
		EG005T: Vanadium	7440-62-2	5	mg/kg	6	<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	3050	3280	7.47	0% - 20%
EG035T: Total Recoverable Mercury by FIMS (QC Lot: 1629242)									
EM1806934-003	Anonymous	EG035T: Mercury	7439-97-6	0.1	mg/kg	<0.1	<0.1	0.00	No Limit
EM1807577-002	Anonymous	EG035T: Mercury	7439-97-6	0.1	mg/kg	<0.1	<0.1	0.00	No Limit
EP004: Organic Matter (QC Lot: 1610788)									
EM1806934-003	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: 1608177)								
ED008: Exchangeable Calcium	----	0.1	meq/100g	<0.1	3.45 meq/100g	96.1	80	120
ED008: Exchangeable Magnesium	----	0.1	meq/100g	<0.1	1.09 meq/100g	93.8	80	120
ED008: Exchangeable Potassium	----	0.1	meq/100g	<0.1	0.609 meq/100g	110	80	120
ED008: Exchangeable Sodium	----	0.1	meq/100g	<0.1	0.347 meq/100g	95.2	80	120
ED008: Cation Exchange Capacity	----	0.1	meq/100g	<0.1	----	----	----	----
ED037: Alkalinity (QCLot: 1617063)								
ED037: Total Alkalinity as CaCO3	----	----	mg/kg	----	200 mg/kg	101	92	107
EG005T: Total Metals by ICP-AES (QCLot: 1629241)								
EG005T: Arsenic	7440-38-2	5	mg/kg	<5	21.7 mg/kg	96.0	79	113
EG005T: Barium	7440-39-3	10	mg/kg	<10	143 mg/kg	102	79	110
EG005T: Beryllium	7440-41-7	1	mg/kg	<1	5.63 mg/kg	102	85	120
EG005T: Boron	7440-42-8	50	mg/kg	<50	33.2 mg/kg	112	82	126
EG005T: Cadmium	7440-43-9	1	mg/kg	<1	4.64 mg/kg	92.1	85	109
EG005T: Chromium	7440-47-3	2	mg/kg	<2	43.9 mg/kg	99.8	83	109
EG005T: Cobalt	7440-48-4	2	mg/kg	<2	16 mg/kg	95.7	78	112
EG005T: Copper	7440-50-8	5	mg/kg	<5	32 mg/kg	97.5	78	108
EG005T: Iron	7439-89-6	50	mg/kg	<50	8400 mg/kg	103	90	110
EG005T: Lead	7439-92-1	5	mg/kg	<5	40 mg/kg	90.1	78	106
EG005T: Manganese	7439-96-5	5	mg/kg	<5	130 mg/kg	99.9	82	107
EG005T: Nickel	7440-02-0	2	mg/kg	<2	55 mg/kg	100	82	111
EG005T: Selenium	7782-49-2	5	mg/kg	<5	5.37 mg/kg	102	93	109
EG005T: Vanadium	7440-62-2	5	mg/kg	<5	29.6 mg/kg	97.1	80	109
EG005T: Zinc	7440-66-6	5	mg/kg	<5	60.8 mg/kg	96.9	82	111
EG035T: Total Recoverable Mercury by FIMS (QCLot: 1629242)								
EG035T: Mercury	7439-97-6	0.1	mg/kg	<0.1	2.57 mg/kg	83.6	77	104
EP004: Organic Matter (QCLot: 1610788)								
EP004: Organic Matter	----	0.5	%	<0.5	77 %	91.5	81	112
EP004: Total Organic Carbon	----	0.5	%	<0.5	43.5 %	94.0	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**

Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Matrix Spike (MS) Report			
				Spike	SpikeRecovery(%)	Recovery Limits (%)	
				Concentration	MS	Low	High
EG005T: Total Metals by ICP-AES (QCLot: 1629241)							
EM1806934-008	Anonymous	EG005T: Arsenic	7440-38-2	50 mg/kg	95.8	78	124
		EG005T: Barium	7440-39-3	50 mg/kg	91.2	71	135
		EG005T: Beryllium	7440-41-7	50 mg/kg	101	85	125
		EG005T: Cadmium	7440-43-9	50 mg/kg	93.2	84	116
		EG005T: Chromium	7440-47-3	50 mg/kg	97.0	79	121
		EG005T: Copper	7440-50-8	50 mg/kg	92.6	82	124
		EG005T: Lead	7439-92-1	50 mg/kg	99.7	76	124
		EG005T: Manganese	7439-96-5	50 mg/kg	91.0	68	136
		EG005T: Nickel	7440-02-0	50 mg/kg	86.4	78	120
		EG005T: Selenium	7782-49-2	50 mg/kg	89.5	71	125
		EG005T: Vanadium	7440-62-2	50 mg/kg	99.1	76	124
		EG005T: Zinc	7440-66-6	50 mg/kg	77.0	74	128
EG035T: Total Recoverable Mercury by FIMS (QCLot: 1629242)							
EM1806934-008	Anonymous	EG035T: Mercury	7439-97-6	5 mg/kg	89.3	76	116
EP004: Organic Matter (QCLot: 1610788)							
EM1806934-008	Anonymous	EP004: Organic Matter	----	0.77 %	76.8	70	120
		EP004: Total Organic Carbon	----	0.45 %	76.2	70	120

QA/QC Compliance Assessment to assist with Quality Review

Work Order	: **EM1807110**	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	: Napandee	Issue Date	: 18-Jun-2018
Sampler	: TIMOTHY SMITH	No. of samples received	: 15
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 Container / Client Sample ID(s)	Sample Date	Extraction / Preparation			Analysis		
		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EA055: Moisture Content (Dried @ 105-110°C)							
Soil Glass Jar - Unpreserved (EA055) N02_25.0-25.1	**26-Apr-2018**	**----**	----	----	**02-May-2018**	10-May-2018	✓
EA150: Particle Sizing							
Snap Lock Bag (EA150H) N02_25.0-25.1	**26-Apr-2018**	**----**	----	----	**09-May-2018**	23-Oct-2018	✓
EA150: Soil Classification based on Particle Size							
Snap Lock Bag (EA150H) N02_25.0-25.1	**26-Apr-2018**	**----**	----	----	**09-May-2018**	23-Oct-2018	✓
EA152: Soil Particle Density							
Snap Lock Bag (EA152) N02_25.0-25.1	**26-Apr-2018**	**----**	----	----	**09-May-2018**	23-Oct-2018	✓
ED007: Exchangeable Cations							
Soil Glass Jar - Unpreserved (ED007) N02_25.0-25.1	**26-Apr-2018**	**01-May-2018**	24-May-2018	✓	**03-May-2018**	24-May-2018	✓
ED008: Exchangeable Cations							
Soil Glass Jar - Unpreserved (ED008) N02_25.0-25.1	**26-Apr-2018**	**01-May-2018**	24-May-2018	✓	**03-May-2018**	24-May-2018	✓
ED037: Alkalinity							
Soil Glass Jar - Unpreserved (ED037) N02_25.0-25.1	**26-Apr-2018**	**04-May-2018**	23-Oct-2018	✓	**07-May-2018**	23-Oct-2018	✓
EG005T: Total Metals by ICP-AES							
Soil Glass Jar - Unpreserved (EG005T) N02_25.0-25.1	**26-Apr-2018**	**10-May-2018**	23-Oct-2018	✓	**10-May-2018**	23-Oct-2018	✓
EG035T: Total Recoverable Mercury by FIMS							
Soil Glass Jar - Unpreserved (EG035T) N02_25.0-25.1	**26-Apr-2018**	**10-May-2018**	24-May-2018	✓	**11-May-2018**	24-May-2018	✓
EP004: Organic Matter							
Soil Glass Jar - Unpreserved (EP004) N02_25.0-25.1	**26-Apr-2018**	**03-May-2018**	24-May-2018	✓	**03-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)							
Alkalinity in Soil	ED037	1	3	**33.33**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Exchangeable Cations with pre-treatment	ED008	1	2	**50.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Moisture Content	EA055	2	14	**14.29**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Organic Matter	EP004	1	7	**14.29**	**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	3	**33.33**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Exchangeable Cations with pre-treatment	ED008	1	2	**50.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Organic Matter	EP004	1	7	**14.29**	**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	2	**50.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Organic Matter	EP004	1	7	**14.29**	**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	7	**14.29**	**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	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)
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)

Certificate of Analysis

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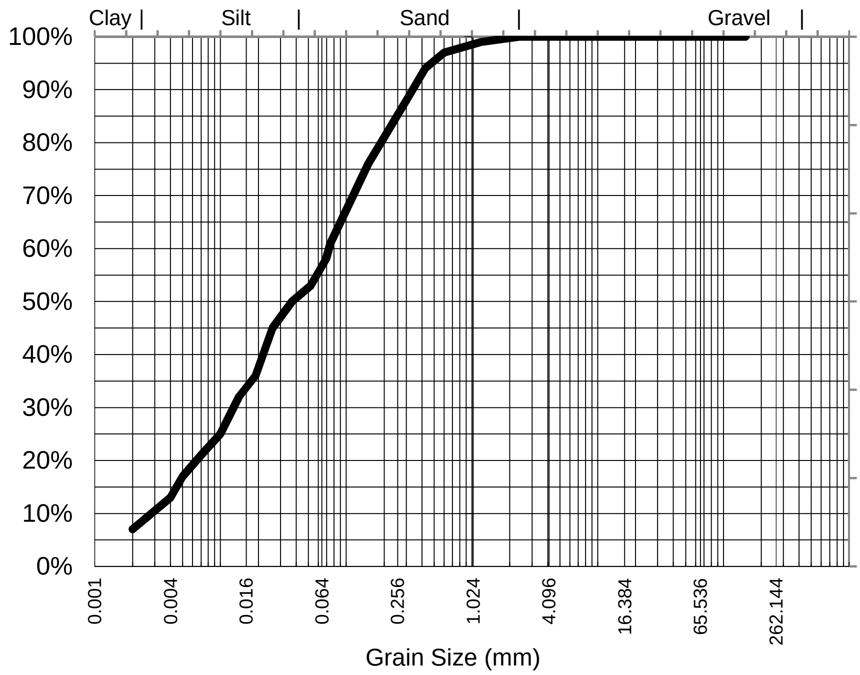
ALS Environmental

Newcastle, NSW

CLIENT:	Melinda Morris	**DATE REPORTED:**	21-May-2018
COMPANY:	AECOM Services Pty Ltd	**DATE RECEIVED:**	1-May-2018
ADDRESS:	Level 28, 91 King William Street, Adelaide SA, Australia 5000	**REPORT NO:**	EM1807110-012 / PSD
PROJECT:	60565376	**SAMPLE ID:**	N02_25.0-25.1

Particle Size Distribution



Particle Size (mm)	Percent Passing
2.36	100%
1.18	99%
0.600	97%
0.425	94%
0.300	88%
0.150	76%
0.075	61%
Particle Size (microns)	
69	58%
52	53%
37	50%
19	36%
10	25%
5	17%
2	7%

Samples analysed as received.

Median Particle Size (mm)*	0.037

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

Sample Comments:

Analysed: 7-May-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) 2.57 g/cm3

NATA Accreditation: 825 Site: Newcastle
This document is issued in accordance with NATA's accreditation requirements.
Accredited for compliance with ISO/IEC 17025. This document shall not be reproduced, except in full.

Nathan Webb
Laboratory Coordinator
Authorised Signatory

Environmental Division
Melbourne
Work Order Reference
EM1807110

Telephone : + 61-3-8549 9600

FREIGHT

AECOM PROJECT - CHAIN OF CUSTODY

CLIENT:	AECOM Services
ADDRESS:	Level 28, 91 King William St Adelaide SA 5000
PHONE NO:	08 7100 6400
FAX NO:	08 7223 5499
PROJECT NAME:	NRWMF Site Charactersation
PROJECT NO:	60565376.4.0
LABORATORY:	ALS
ADDRESS:	2-4 Westall Rd Springvale Vic, 3171
PHONE NO:	03 8549 9600
FAX NO:	
PROJECT MANAGER:	melinda.morris@aecom.com 0408 387 485
SAMPLERS:	Timothy Smith
SIGNED:	[signature]

All results to be provided in ESDAT format.
email address: adelaide@urscorp.com
Quote Number:

[redacted]

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)	HOLD
NAPANDEE	N01	SOIL	PRIMARY	N01 —	[redacted]	0.3-0.4	24/4/18	1 JAR 1 BAG	NA	2											
	〃			N01 —	[redacted]	2.9-3.0				〃											X
	〃			N01 —	[redacted]	5.0-5.1				〃											X
	〃			N01 —	[redacted]	13.0-13.1				〃											X
	〃			N01 — 15.3	[redacted]	15.4				〃											X
	〃			N01 — 32.0	[redacted]	33.1				〃											X
	〃		DUPLICATE	QC01	[redacted]		24-4			〃											X
	〃		TRIPLICATE	QC02	[redacted]		24-4			〃											X
	N02		PRIMARY	N02_0.0	[redacted]	0.1	26-4			〃											X
				N02_2.8	[redacted]	3.0				〃											X
				N02_12.0	[redacted]	12.1				〃											X
				N02_25.0	[redacted]	25.1				〃											X
				N02_27.0	[redacted]	27.1				〃											X
			DUPLICATE	QC03	[redacted]					〃											X
			TRIPLICATE	QC04	[redacted]					〃											X

RELINQUISHED BY: Tim Smith
DATE: 27/4/18
CHECKED:
TIME:
RECEIVED BY: Bharathi (ALS)
DATE:
CHECKED: 1/5/18
TIME: 12:15

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

Tim Smith MOBILE 0401 911 967

Environmental Division
Melbourne
Work Order Reference
EM1807110

Telephone : + 61-3-8549 9600

FREIGHT

AECOM PROJECT - CHAIN OF CUSTODY

CLIENT:	AECOM Services
ADDRESS:	Level 28, 91 King William St Adelaide SA 5000
PHONE NO:	08 7100 6400
FAX NO:	08 7223 5499
PROJECT NAME:	NRWMF Site Charactersation
PROJECT NO:	60565376.4.0
LABORATORY:	ALS
ADDRESS:	2-4 Westall Rd Springvale Vic, 3171
PHONE NO:	03 8549 9600
FAX NO:	
PROJECT MANAGER:	melinda.morris@aecom.com 0466 387 490
SAMPLERS:	Timothy Smith
SIGNED:	

All results to be provided in ESDAT format.
email address: adelaide@urscorp.com
Quote Number:

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/Phenole 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 (subsampled from 500 g bag)	HOLD
NAPANDEE	NO1	SOIL	PRIMARY	NO1 –	0.3-0.4	24/4/18	1 JAR 1 BAG	NA	2											X
	"			NO1 –	2.9-3.0				"											X
	"			NO1 –	5.0-5.1				"											X
	"			NO1 –	13.0-13.1				"											X
	"			NO1 – 15.3	15.4				"											X
	"			NO1 – 32.0	33.1				"											X
	"		DUPLICATE	QC01		24-4			"											X
	"		TRIPLICATE	QC02		24-4			"											X
	NO2		PRIMARY	NO2_0.0	0.1	26-4			"											X
				NO2 – 2.8	3.0				"											X
				NO2 12.0	12.1				"											X
				NO2 – 25.0	25.1				"											X
				NO2 – 27.0	27.1				"											X
			DUPLICATE	QC03					"											X
			TRIPLICATE	QC04					"											X
									"											X

RELINQUISHED BY:		CHECKED:	
DATE:	27/4/18	TIME:	
RECEIVED BY:	Bharathi (ALS)	CHECKED:	1/5/18
DATE:		TIME:	12:15

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

Tim Smith MOBILE 0401 911 967

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **EM1808008**	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	: Napandee		
Quote number	: EN/004/16		
No. of samples received	: 4		
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**)

				N03_27-27.4	----	----	----	----
				02-May-2018 00:00	----	----	----	----
				EM1808008-002	--------	--------	--------	--------
				Result	----	----	----	----
EA150: Particle Sizing								
+75µm	----	1	%	**28**	----	----	----	----
+150µm	----	1	%	**20**	----	----	----	----
+300µm	----	1	%	**17**	----	----	----	----
+425µm	----	1	%	**15**	----	----	----	----
+600µm	----	1	%	**13**	----	----	----	----
+1180µm	----	1	%	**11**	----	----	----	----
+2.36mm	----	1	%	**7**	----	----	----	----
+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	%	**21**	----	----	----	----
Silt (2-60 µm)	----	1	%	**50**	----	----	----	----
Sand (0.06-2.00 mm)	----	1	%	**21**	----	----	----	----
Gravel (>2mm)	----	1	%	**8**	----	----	----	----
Cobbles (>6cm)	----	1	%	<1	----	----	----	----
EA152: Soil Particle Density								
ø **Soil Particle Density (Clay/Silt/Sand)**	----	0.01	g/cm3	**2.50**	----	----	----	----

ALS Environmental

QUALITY CONTROL REPORT

Work Order	: **EM1808008**	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	: Napandee		
Quote number	: EN/004/16		
No. of samples received	: 4		
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

[illegible]

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.

[illegible]	[illegible]	[illegible]
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.**

ALS Environmental

QA/QC Compliance Assessment to assist with Quality Review

Work Order	: **EM1808008**	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	: Napandee	Issue Date	: 13-Jul-2018
Sampler	: TIM SMITH	No. of samples received	: 4
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 / *Container / Client Sample ID(s)*	*Sample Date*	*Extraction / Preparation*			*Analysis*		
		Date extracted	*Due for extraction*	*Evaluation*	*Date analysed*	*Due for analysis*	*Evaluation*
EA150: Particle Sizing							
Snap Lock Bag (EA150H) N03_27-27.4	**02-May-2018**	**----**	----	----	**04-Jun-2018**	29-Oct-2018	✓
EA150: Soil Classification based on Particle Size							
Snap Lock Bag (EA150H) N03_27-27.4	**02-May-2018**	**----**	----	----	**04-Jun-2018**	29-Oct-2018	✓
EA152: Soil Particle Density							
Snap Lock Bag (EA152) N03_27-27.4	**02-May-2018**	**----**	----	----	**04-Jun-2018**	29-Oct-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.

Certificate of Analysis

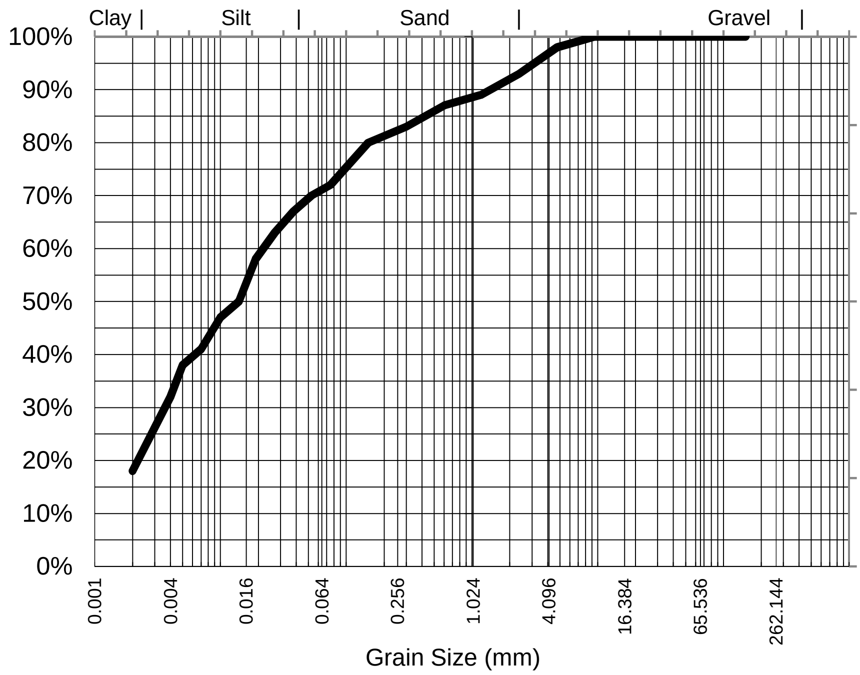
ALS Laboratory Group Pty Ltd
5/585 Maitland Road
Mayfield West, NSW 2304
pH 02 4014 2500
fax 02 4968 0349
samples.newcastle@alsenviro.com

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:**	EM1808008-002 / PSD
PROJECT:	60565376	**SAMPLE ID:**	N03_27-27.4

Particle Size Distribution



Particle Size (mm)	Percent Passing
9.50	100%
4.75	98%
2.36	93%
1.18	89%
0.600	87%
0.425	85%
0.300	83%
0.150	80%
0.075	72%
Particle Size (microns)	
75	72%
53	70%
38	67%
19	58%
10	47%
5	38%
2	18%

Median Particle Size (mm)*	0.014

Samples analysed as received.

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) 2.5 g/cm3

NATA
WORLD RECOGNISED ACCREDITATION

Nathan Webb
Laboratory Coordinator
Authorised Signatory

ALS Environmental

SAMPLE RECEIPT NOTIFICATION (SRN)

Work Order : **EM1808008**

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	: Napandee		
Sampler	: TIM SMITH		

Dates

Date Samples Received	: 15-May-2018 14:15	Issue Date	: 17-May-2018
Client Requested Due Date	: 15-Jun-2018	Scheduled Reporting Date	: **15-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	: 4 / 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 & 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)
EM1808008-001	01-May-2018 00:00	N03_0.0-0.1	▯		
EM1808008-002	02-May-2018 00:00	N03_27-27.4		▯	▯
EM1808008-003	02-May-2018 00:00	N04_0.0-0.1	▯		
EM1808008-004	02-May-2018 00:00	N04_1.0-1.1	▯		

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.	
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			
PROJECT NO:	60565376.4.0	SAMPLERS:	Tim Smith	SIGNED:	JR

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	15, 2B	–	3											X
"	"	"	"	N03	27-27.4	2-5-18	15, 1B	–	2									X	X	
"	"	"	"	N04	0.0-0.1	2-5-18	15, 2B	–	3											X
"	"	"	"	N04	1.0-1.1	2-5-18	15, 1B	–	2											X
LYNDHURST	"	"	"	L05D	0.0-0.1	5-5-18	15, 2B	–	3											X
"	"	"	"	L05D	4.0-4.1	5-5-18	15, 1B	–	2											X
"	"	"	"	L05D	11.8-11.9	5-5-18	15, 1B	–	2											X
"	"	"	"	L05D	24.0-24.1	5-5-18	15, 1B	–	2											X
"	"	"	"	L05D	35.0-35.1	5-5-18	15, 1B	–	2											X
"	"	"	"	L05D	50-50.1	5-5-18	15/1B	–	2											X
"	"	"	"	L05D	72-72.1	5/5	15, 1B	–	2											X
"	"	"	"	L01	21.0-21.4	9/5	15, 1B	–	2									X	X	

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, 14:40

J = JAR
B = BAG LARGE & SMALL

Environmental Division
Melbourne
Work Order Reference
EM1808008

Telephone : + 61-3-8549 9600

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: SYD1801232
Issue No: 1
This report replaces all previous issues of report no 'SYD1801232'.

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	SYD18-0241-03
Date Sampled	07/05/2018
Sampled By	Supplied by Client
Location	SMS.G18135
BH / TP No.	NO3
Depth (m)	27.0 - 27.4
Soil Description	SILT / CLAY: off white

Test Results

Description	Method	Result	Limits
Coef of Permeability (m/sec)	AS 1289.6.7.3	1 e -08	
Mean Stress Level (kPa)		30	
Permeant Used		tap water	
Length (mm)		78.7	
Diameter (mm)		65.0	
Length/Diameter Ratio		1.21	
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 (%)		35.3	
Date Tested		15/06/2018	

Comments

Moisture and Density Ratio's not applicable. Undisturbed sample.
Initial moisture content = 26.2% , initial dry density = 1.494 t/m³

Ground Science
A C N 105 704 078
13 Brock Street Thomastown VIC, P 03 9464 4617 F 03 9464 4618

PERMEABILITY - CONSTANT HEAD (Triaxial method) AS1289 6.7.3

client :	SMS GEOTECHNICAL (PARA HILLS WEST,SA)	job No.	GS4242/1
project:	GEOTECHNICAL TESTING	report No.	CO
location:	SUBMITTED SAMPLES	test date:	15/6/2018
		page:	1

Sample identification		**#57 (181004)**
Borehole / test pit		**NO6 3.2 - 3.6 tube**
Depth, m		**-**
sample diameter	mm	62.98
sample height	mm	64.40
specimen wet density	t/m3	2.213
specimen dry density	t/m3	1.99
moisture content	%	11.3
cell pressure	kPa	550
inlet pressure	kPa	510
outlet pressure	kPa	490
mean effective stress	kPa	50
hydraulic head	kPa	20
saturation	%	100
PERMEABILITY	**m/sec**	**3.E-09**
water type		de-aired - filtered
specimen description		sandy CLAY, high plasticity, red brown, fine to coarse sand
Notes:		undisturbed sample

Comments sample provided by client, tested "as received"

NATA ACCREDITED FOR TECHNICAL COMPETENCE

NATA Accredited Laboratory No. 15055
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

Date of issue
19/06/2018

Jaquinde

Jean Aquinde
Approved Signatory

A19004 (MIN3323)
ALS Environmental

SAMPLES RECEIVED

One sample was submitted to ALS Metallurgy for semi-quantitative XRD analysis.

Sample 1	N02_25.0-25.1

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

18 June 2018

A19036 (MIN3343)
ALS Environmental

SAMPLES RECEIVED

One sample was submitted to ALS Metallurgy for semi-quantitative XRD analysis.

Sample 1	N03_27-27.4

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

RESULTS

The quantitative results shown in the table below have been normalised to 100 %, and the values shown represent the relative proportion of the crystalline material in the sample. Totals greater or smaller than 100 % are due to rounding errors.

Results in the table preceded by an asterisk indicate normally a larger than usual uncertainty in regard to the quantity of the phase reported; for some of the minor and trace phases it might also indicate an uncertainty in regard of the phase itself, or both.

Mineral or mineral group	Sample 1
	N03_27-27.4
	Mass %
Clay mineral	< 1
Kaolinite	81
Muscovite - illite	5
Talc	< 1
Alpha quartz	13
Halite	1

COMMENTS

'Clay mineral' appears to be mainly smectite.

Some amorphous material is most likely present.

A19006 (MIN3324)
ALS Environmental

SAMPLES RECEIVED

Two samples were submitted to ALS Metallurgy for semi-quantitative XRD analysis.

Sample 1	N06-2.8-2.9
Sample 2	N06-36.0-36.1

SAMPLE PREPARATION

Each 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 each sample and a combination of matrix flushing and reference intensity ratio (RIR) derived constants was used in the quantification of the minerals identified in each 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

18 June 2018

RESULTS

The quantitative results shown in the table below have been normalised to 100 %, and the values shown represent the relative proportion of the crystalline material in the sample. Totals greater or smaller than 100 % are due to rounding errors.

Results in the table preceded by an asterisk indicate normally a larger than usual uncertainty in regard to the quantity of the phase reported; for some of the minor and trace phases it might also indicate an uncertainty in regard of the phase itself, or both.

Mineral or mineral group	Sample 1	Sample 2
	N06-2.8-2.9	N06-36.0-36.1
	Mass %	
Clay mineral	11	10
Kandite group	7	5
Mica	0	7
Andalusite	0	1
Sodic and calcic plagioclase	0	33
K-feldspar	1	19
Alpha quartz	82	25

SUMMARY

'Clay mineral' seems to be mainly illite.

'Kandite group' refers to kaolinite, nacrite and/or dickite.

Some amorphous material is most likely present.

DATA VALIDATION REPORT

Project number:	60565376	**Validation by:**	Sylvia Bretherton	**Date:**	17/07/2018
Client:	Department of Industry, Innovation and Science				
Site:	Napandee	**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:	EM1808769				

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 extracted and analysed outside recommended holding times for pH (11 days), nitrite as N (7 days) and dissolved sulphide as S2- (2 days). 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.
- 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 as per the assessment for the broader Kimba sampling program.

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 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	Rinsate blank samples were analysed at a frequency of one per day per piece of equipment. One rinsate sample, collected from the interface probe, was analysed for the day of sampling. Manganese (2 ug/L), electrical conductivity (2 µS/cm), bicarbonate alkalinity as CaCO3 (1 mg/L), total alkalinity as CaCO3 (1 mg/L), chloride (1 mg/L) and total anions (0.05 meq/L) were reported in the rinsate blank sample. Bicarbonate alkalinity as CaCO3 and total alkalinity as CaCO3 concentrations were reported below the LOR in two primary samples indicating potential cross contamination from the interface probe is unlikely. Concentrations of other analytes which were reported in the rinsate blank sample are approximately two to four orders of magnitude below concentrations reported for primary samples, and are therefore not considered to materially 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	Inter- and intra-laboratory duplicate samples are collected at a rate of one per twenty primary samples in the Kimba groundwater sampling program (Lyndhurst and Napandee). No duplicates were collected in this batch. The precision of the data can be assessed based on the inter- and intra-laboratory duplicate RPDs analysed as part of the broader sampling program (discussed within the Lyndhurst Data Validation Report) and the laboratory duplicate RPDs which were at the required frequency and within control limits.
Handling and Preservation	Groundwater samples were received preserved and chilled at the laboratory. Sample receipt temperature (9.3°C) was outside of the recommended range (≤6°C) in primary batch EM1808769. 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). All samples were received at the laboratory in appropriate sample containers.
Laboratory QA/QC	
Tests Requested/Reported	Samples were analysed and reported as requested on the COC. Results of the broader Kimba sampling program were initially reported as one laboratory batch, however were subsequently reported as two separate batches.
Holding Time Compliance	Samples were analysed outside recommended holding times for pH (11 days), nitrite as N (7 days) and dissolved sulphide as S2- (2 days). 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. The triplicate sample was analysed at Eurofins-MGT (Melbourne). All three laboratories are accredited by the National Association of Testing Authorities Australia (NATA) for the analyses undertaken.
Frequency of Laboratory QC	The laboratory did not report a sufficient frequency of quality control samples in laboratory batch EM1808769. However, based on results of the broader Kimba sampling program (comprising 12 samples in total) a sufficient frequency of quality control samples were reported, with the following exceptions: 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 LCS (where reported), 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 in EM1808769 and within the broader Kimba sampling program.
Laboratory Duplicate RPDs	Laboratory duplicate relative percentage differences (RPDs) were within control limits in EM1808769 and the broader Kimba sampling program. The laboratory duplicate RPDs are presented in the laboratory Quality Control Reports (EM1808769 & EM1808546).
Laboratory Control Spike Recovery	Laboratory control spike recoveries were within control limits in EM1808769 and within the broader Kimba sampling program.
Matrix Spike Recovery	Matrix spike (MS) recoveries (where reported) were within control limits in EM1808769 and within the broader Kimba sampling program. The following recoveries in laboratory batch EM1808546 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 (N02 reported a laboratory pH of 4.5 and a field pH of 7, and N05D reported a laboratory pH of 4.8 and a field pH of 7.5). 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	NA – based on results of the broader Kimba sampling program elevated RPDs for filtered thorium and ionic balance should be taken into consideration when using the data quantitatively.

Field Triplicate RPDs	NA - based on results of the broader Kimba sampling program elevated RPDs for gross alpha, nitrate as N, filtered cadmium, filtered cobalt, filtered zinc, filtered thorium, filtered potassium and filtered bromine should 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**: QC05 dissolved manganese result has been confirmed by re-preparation and re-analysis - **EG020F**: N02 and N03 required dilution prior to dissolved metals analysis due to sample matrix interference. LOR values have been raised accordingly. - **EA010-P**: Electrical Conductivity @ 25°C was analysed by manual method (EA010). - Ionic balances were calculated using: major anions - chloride, alkalinity and sulfate; and major cations - calcium, magnesium, potassium and sodium. - 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.

Napandee Groundwater Rinsate Blank Sample Analysis

Lab Report	EM1808769
Field ID	QC05_23/5/18
Sample Date	23/05/2018
Sample Type	Rinsate blank

Reporting Group	Analyte	Units	LOR	
Physio-Chemical Parameters	pH (Lab)	pH Units	0.01	**6.46**
	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	**2**
	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	**0.05**
	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

Napandee Groundwater Frequency Table

Site Name	NRWMF
Project No.	60565376
Project Manager	Melinda Morris
Matrix	WATER
Laboratory	ALS and Eurofins|MGT
Batch File Number	EM1808769

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)	7	7	6	×	✓	1	0	1	1	1	0	1	0	1	0	1	0	0	0	1	0	-	-
EA010P: Conductivity by PC Titrator	Electrical conductivity (lab)	7	7	6	✓	✓	1	0	1	1	1	0	1	0	1	0	1	0	0	0	1	0	-	-
EA250: Gross Alpha and Beta Activity	Gross alpha	5	5	5	✓	✓	1	0	1	0	1	1	1	0	1	0	1	0	0	0	1	1	-	-
	Gross beta	5	5	5	✓	✓	1	0	1	0	1	1	1	0	1	0	1	0		0	1	1	-	-
ED041G: Sulfate (Turbidimetric) as SO4 2- by D	Sulfate (as SO4-)	7	7	6	✓	✓	1	0	1	1	1	0	1	0	1	0	1	0	1	0	1	0	-	-
EG020F: Dissolved Metals by ICP-MS	Arsenic	7	7	6	✓	✓	1	0	1	1	1	0	1	0	1	0	1	0	1	0	1	0	-	-
	Boron	7	7	6	✓	✓	1	0	1	1	1	0	1	0	1	0	1	0		0	1	0	-	-
	Barium	7	7	6	✓	✓	1	0	1	1	1	0	1	0	1	0	1	0		0	1	0	-	-
	Beryllium	7	7	6	✓	✓	1	0	1	1	1	0	1	0	1	0	1	0		0	1	0	-	-
	Cadmium	7	7	6	✓	✓	1	0	1	1	1	0	1	0	1	0	1	0		0	1	0	-	-
	Cobalt	7	7	6	✓	✓	1	0	1	1	1	0	1	0	1	0	1	0		0	1	0	-	-
	Chromium	7	7	6	✓	✓	1	0	1	1	1	0	1	0	1	0	1	0		0	1	0	-	-
	Copper	7	7	6	✓	✓	1	0	1	1	1	0	1	0	1	0	1	0		0	1	0	-	-
	Manganese	7	7	6	✓	✓	1	0	1	1	1	0	1	0	1	0	1	0		0	1	0	-	-
	Nickel	7	7	6	✓	✓	1	0	1	1	1	0	1	0	1	0	1	0		0	1	0	-	-
	Lead	7	7	6	✓	✓	1	0	1	1	1	0	1	0	1	0	1	0		0	1	0	-	-
	Selenium	7	7	6	✓	✓	1	0	1	1	1	0	1	0	1	0	1	0		0	1	0	-	-
	Vanadium	7	7	6	✓	✓	1	0	1	1	1	0	1	0	1	0	1	0		0	1	0	-	-
	Zinc	7	7	6	✓	✓	1	0	1	1	1	0	1	0	1	0	1	0		0	1	0	-	-
	Lithium	7	7	6	✓	✓	1	0	1	1	1	0	1	0	1	0	1	0		0	1	0	-	-
	Strontium	7	7	6	✓	✓	1	0	1	1	1	0	1	0	1	0	1	0		0	1	0	-	-
	Thorium	7	7	6	✓	✓	1	0	1	1	1	0	1	0	1	0	1	0		0	1	0	-	-
	Uranium	7	7	6	✓	✓	1	0	1	1	1	0	1	0	1	0	1	0		0	1	0	-	-
	Iodine	7	7	6	✓	✓	1	0	1	1	1	0	1	0	1	0	1	0		0	1	0	-	-
	Bromine	7	7	6	✓	✓	1	0	1	1	1	0	1	0	1	0	1	0		0	1	0	-	-
EG035F: Dissolved Mercury by FIMS	Mercury	7	7	6	✓	✓	1	0	1	1	1	0	1	0	1	0	1	0	1	0	1	0	-	-
EG020T: Total Metals by ICP-MS	Manganese	5	5	5	✓	✓	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	-	-
	Iron	5	5	5	✓	✓	1	0	1	0	1	0	1	0	1	0	1	0		0	1	0	-	-
EK057G: Nitrite as N by Discrete Analyser	Nitrite (as N)	5	5	5	×	✓	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	-	-
EK058G: Nitrate as N by Discrete Analyser	Nitrate (as N)	5	5	5	✓	✓	1	0	1	0	1	0	1	0	1	0	1	0	0	0	1	0	-	-
EK040P: Fluoride by PC Titrator	Fluoride	7	7	6	✓	✓	1	0	1	1	1	0	1	0	1	0	1	0	1	0	1	0	-	-
ED040F: Dissolved Major Anions	Silicon	7	7	6	✓	✓	1	0	1	1	1	0	1	0	1	0	1	0	1	0	1	0	-	-
EK085F: Dissolved Sulfide as S2-	Sulphide (as S2-)	5	5	5	×	✓	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	-	-
ED037P: Alkalinity by PC Titrator	Bicarbonate Alkalinity as CaCO3	7	7	6	✓	✓	1	0	1	1	1	0	1	0	1	0	1	0	0	0	1	0	-	-
	Total Alkalinity as CaCO3	7	7	6	✓	✓	1	0	1	1	1	0	1	0	1	0	1	0		0	1	0	-	-
	Carbonate Alkalinity as CaCO3	7	7	6	✓	✓	1	0	1	1	1	0	1	0	1	0	1	0		0	1	0	-	-
	Hydroxide Alkalinity as CaCO3	7	7	6	✓	✓	1	0	1	1	1	0	1	0	1	0	1	0		0	1	0	-	-
EP002: Dissolved Organic Carbon (DOC)	Dissolved Organic Carbon	5	5	5	✓	✓	1	0	1	0	1	1	1	0	1	0	1	2	1	1	1	1	-	-
ED093F: Dissolved Major Cations	Potassium	7	7	6	✓	✓	1	0	1	1	1	0	1	0	1	0	1	0	0	0	1	0	-	-
	Sodium	7	7	6	✓	✓	1	0	1	1	1	0	1	0	1	0	1	0		0	1	0	-	-
	Calcium	7	7	6	✓	✓	1	0	1	1	1	0	1	0	1	0	1	0		0	1	0	-	-
	Magnesium	7	7	6	✓	✓	1	0	1	1	1	0	1	0	1	0	1	0		0	1	0	-	-
ED045G: Chloride by Discrete Analyser	Chloride	7	7	6	✓	✓	1	0	1	1	1	0	1	0	1	0	1	0	1	0	1	0	-	-
EN055: Ionic Balance	Ionic Balance	6	6	6	✓	✓	1	0	1	0	1	0	1	0	1	0	1	0	0	0	1	0	-	-
	Total Anions	7	7	6	✓	✓	1	0	1	1	1	0	1	0	1	0	1	0		0	1	0	-	-
	Total Cations	7	7	6	✓	✓	1	0	1	1	1	0	1	0	1	0	1	0		0	1	0	-	-

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coffey
A TETRA TECH COMPANY

Material Test Report

Report No: ADEL18S-02168-1
Issue No: 2
This report replaces all previous issues of report no 'ADEL18S-02168-1'.

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: 4/06/2018

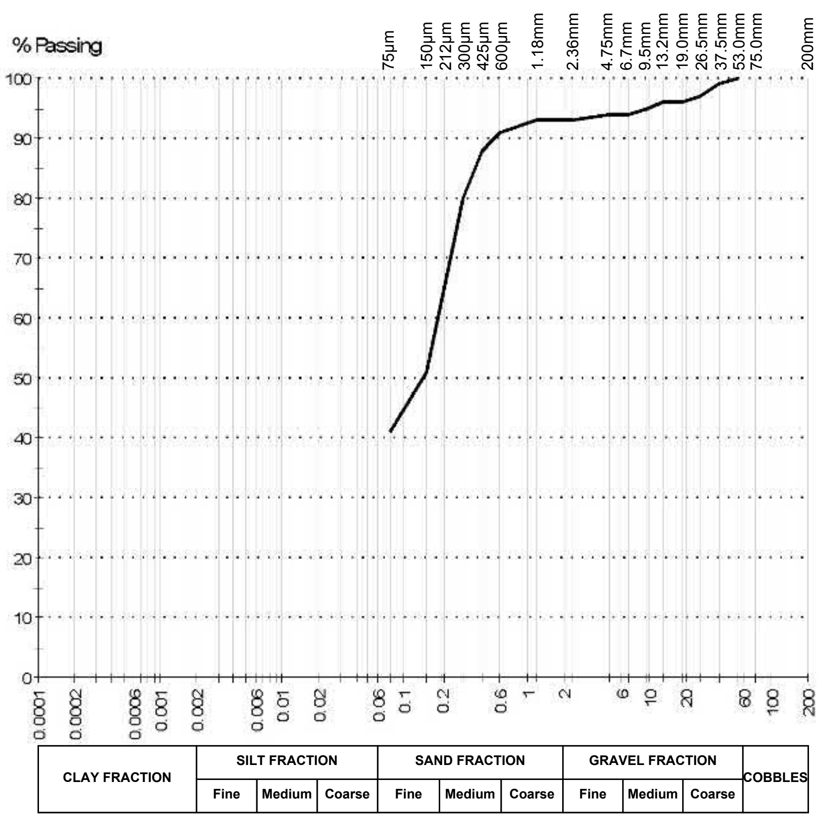
Sample Details

Sample ID:	ADEL18S-02168
Client Sample:	
Date Sampled:	
Source:	
Material:	
Specification:	No Specification
Sampling Method:	Submitted by client
Project Location:	South Australia
Sample Location:	N06, 2.80-3.00m

Other Test Results

Description	Method	Result	Limits
Moisture Content (%)	AS 1289.2.1.1	12.2	
Sample History	AS 1289.1.1	Oven-dried	
Preparation	AS 1289.1.1	Dry Sieved	
Linear Shrinkage (%)	AS 1289.3.4.1	11.0	
Mould Length (mm)		250	
Cracking		Yes	
Liquid Limit (%)	AS 1289.3.1.1	41	
Method		Four Point	
Plastic Limit (%)	AS 1289.3.2.1	16	
Plasticity Index (%)	AS 1289.3.3.1	25	
Date Tested		31/05/2018	

Particle Size Distribution



Particle Size (mm)

Method: AS 1289.3.6.1
Drying by: Oven
Date Tested: 29/05/2018

Note: Sample Washed

Sieve Size	% Passing	Limits
53.0mm	100	
37.5mm	99	
26.5mm	97	
19.0mm	96	
13.2mm	96	
9.5mm	95	
6.7mm	94	
4.75mm	94	
2.36mm	93	
1.18mm	93	
600µm	91	
425µm	88	
300µm	80	
150µm	51	
75µm	41	

Comments

N/A

Adelaide Laboratory

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coffey
A TETRA TECH COMPANY

Material Test Report

Report No: ADEL18S-02169-1
Issue No: 2
This report replaces all previous issues of report no 'ADEL18S-02169-1'.

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-02169
Client Sample:	
Date Sampled:	
Source:	
Material:	
Specification:	No Specification
Sampling Method:	Submitted by client
Project Location:	South Australia
Sample Location:	N07, 0.30-0.50m

Other Test Results

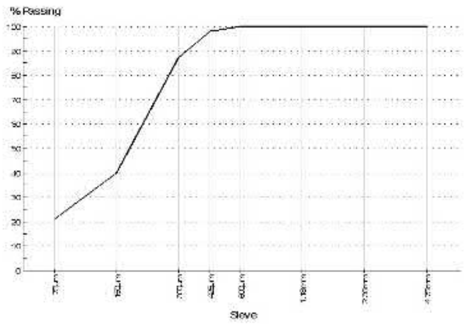
Description	Method	Result	Limits
Moisture Content (%)	AS 1289.2.1.1	8.1	
Sample History	AS 1289.1.1	Oven-dried	
Preparation	AS 1289.1.1	Dry Sieved	
Linear Shrinkage (%)	AS 1289.3.4.1	6.0	
Mould Length (mm)		254	
Liquid Limit (%)	AS 1289.3.1.1	29	
Method		Four Point	
Plastic Limit (%)	AS 1289.3.2.1	16	
Plasticity Index (%)	AS 1289.3.3.1	13	
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:	29/06/2018
Note:	Sample Washed

Sieve Size	% Passing	Limits
4.75mm	100	
2.36mm	100	
1.18mm	100	
600µm	100	
425µm	98	
300µm	87	
150µm	40	
75µm	21	

Chart



Comments

N/A

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A TETRA TECH COMPANY

California Bearing Ratio Test Report

Report No: CBR:ADEL18S-02169
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:**

WORLD RECOGNISED ACCREDITATION

Accredited for compliance with ISO/IEC 17025 - Testing.

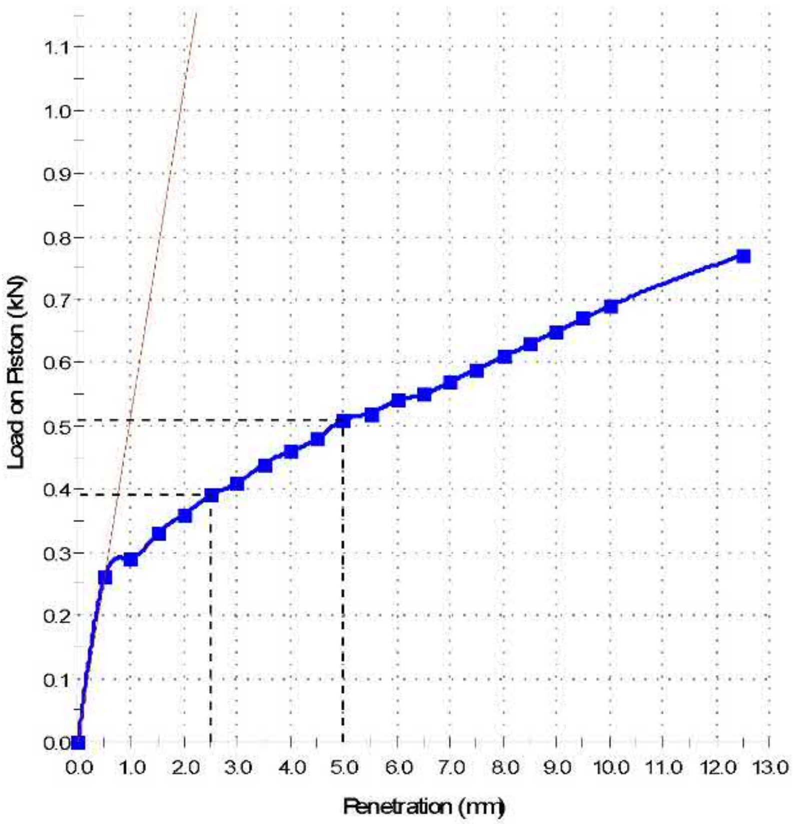
The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards.

Approved Signatory: Marie Edwards (Geotechnician)
NATA Accredited Laboratory Number:431
Date of Issue: 5/06/2018

Sample Details

Sample ID:	ADEL18S-02169	**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:	N07, 0.30-0.50m		

Load vs Penetration



Test Results

AS 1289.6.1.1

CBR At 2.5mm (%):	**3.0**
Maximum Dry Density (t/m³):	1.77
Optimum Moisture Content (%):	10.5
Dry Density before Soaking (t/m³):	1.74
Density Ratio before Soaking (%):	98
Moisture Content before Soaking (%):	10.2
Moisture Ratio before Soaking (%):	97
Dry Density after Soaking (t/m³):	1.73
Density Ratio after Soaking (%):	98
Swell (%):	0.5
Moisture Content of Top 30mm (%):	20.8
Moisture Content of Remaining Depth (%):	14.6
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 (%):	8.1
Curing Time (Hrs):	1.0
Plasticity Level Method:	Linear shrinkage

Comments

AECOM

AECOM Contact: Kylie Schmidt & Joseph Tan
Tel: 08 7223 5538 **Fax:** 08 7223 5499 email: kylie.schmidt@aecom.com joseph.tan@aecom.com
Level 28, 91 King William Street
Adelaide, SA 5000

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																				
N06	0.50	1.00		Bag																												
N06	2.80	3.00		Bag		1	1	1																								
N08	0.50	0.70		Bag																												
N07	0.30	0.50		Bag		1	1	1		1	1	1																				
N11	1.30	1.50		Bag																												
N10	0.60	0.80		Bag																												
N09	2.00	2.30		Bag																												
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: N06

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	**7**	2100	**10**
200	**5**	1200	**9**	2200	**8**
300	**6**	1300	**8**	2300	**10**
400	**4**	1400	**9**	2400	**12**
500	**5**	1500	**8**	2500	**12**
600	**6**	1600	**12**	2600	**8**
700	**7**	1700	**7**	2700	**7**
800	**4**	1800	**6**	2800	**11**
900	**8**	1900	**7**	2900	**9**
1000	**8**	2000	**8**	3000	**9**
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: N07

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	**3**	1100	**6**	2100	**3**
200	**5**	1200	**7**	2200	**3**
300	**5**	1300	**12**	2300	**3**
400	**5**	1400	**15**	2400	**4**
500	**5**	1500	**7**	2500	**5**
600	**3**	1600	**4**	2600	**5**
700	**3**	1700	**5**	2700	**6**
800	**3**	1800	**3**	2800	**8**
900	**5**	1900	**3**	2900	**8**
1000	**4**	2000	**4**	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: N08

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	**4**	1100	**12**	2100	
200	**13**	1200	**11**	2200	
300	**4**	1300	**9**	2300	
400	**6**	1400	**8**	2400	
500	**9**	1500	**10**	2500	
600	**10**	1600	**20**	2600	
700	**9**	1700	**32**	2700	
800	**15**	1800	**R**	2800	
900	**11**	1900		2900	
1000	**11**	2000		3000	

Test Procedure: AS 1289.6.3.2

Comments:

DCP refusal (bouncing and eight consecutive blows gave less than 20mm penetration) at depth 1.8m.

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: N09

Date: 22/04/2018

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	**4**	1100	**10**	2100	**8**
200	**9**	1200	**11**	2200	**11**
300	**6**	1300	**9**	2300	**11**
400	**6**	1400	**10**	2400	**12**
500	**8**	1500	**9**	2500	**12**
600	**8**	1600	**9**	2600	**12**
700	**10**	1700	**9**	2700	**17**
800	**10**	1800	**10**	2800	**12**
900	**15**	1900	**10**	2900	**12**
1000	**10**	2000	**8**	3000	**12**
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: N10

Date: 22/04/2018

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	**5**
200	**14**	1200	**2**	2200	**6**
300	**12**	1300	**5**	2300	**7**
400	**9**	1400	**8**	2400	**7**
500	**6**	1500	**8**	2500	**8**
600	**3**	1600	**9**	2600	**8**
700	**2**	1700	**5**	2700	**8**
800	**2**	1800	**3**	2800	**8**
900	**2**	1900	**5**	2900	**7**
1000	**3**	2000	**4**	3000	**8**
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

Project: NRWMF

Project Number: 60565376

Client: DIIS

Tested By: JT

Location: N11

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	**8**	1100	**22**	2100	**12**
200	**17**	1200	**10**	2200	**12**
300	**8**	1300	**9**	2300	**14**
400	**8**	1400	**11**	2400	**12**
500	**13**	1500	**9**	2500	**11**
600	**24**	1600	**12**	2600	**8**
700	**19**	1700	**10**	2700	**9**
800	**22**	1800	**8**	2800	**9**
900	**15**	1900	**9**	2900	**8**
1000	**22**	2000	**10**	3000	**10**
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:**	17/07/2018
Client:	Department of Industry, Innovation and Science				
Site:	Napandee	**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:	EM1808769				

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 extracted and analysed outside recommended holding times for pH (11 days), nitrite as N (7 days) and dissolved sulphide as S2- (2 days). 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.
- 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 as per the assessment for the broader Kimba sampling program.

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 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	Rinsate blank samples were analysed at a frequency of one per day per piece of equipment. One rinsate sample, collected from the interface probe, was analysed for the day of sampling. Manganese (2 ug/L), electrical conductivity (2 µS/cm), bicarbonate alkalinity as CaCO3 (1 mg/L), total alkalinity as CaCO3 (1 mg/L), chloride (1 mg/L) and total anions (0.05 meq/L) were reported in the rinsate blank sample. Bicarbonate alkalinity as CaCO3 and total alkalinity as CaCO3 concentrations were reported below the LOR in two primary samples indicating potential cross contamination from the interface probe is unlikely. Concentrations of other analytes which were reported in the rinsate blank sample are approximately two to four orders of magnitude below concentrations reported for primary samples, and are therefore not considered to materially 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	Inter- and intra-laboratory duplicate samples are collected at a rate of one per twenty primary samples in the Kimba groundwater sampling program (Lyndhurst and Napandee). No duplicates were collected in this batch. The precision of the data can be assessed based on the inter- and intra-laboratory duplicate RPDs analysed as part of the broader sampling program (discussed within the Lyndhurst Data Validation Report) and the laboratory duplicate RPDs which were at the required frequency and within control limits.
Handling and Preservation	Groundwater samples were received preserved and chilled at the laboratory. Sample receipt temperature (9.3°C) was outside of the recommended range (≤6°C) in primary batch EM1808769. 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). All samples were received at the laboratory in appropriate sample containers.
Laboratory QA/QC	
Tests Requested/Reported	Samples were analysed and reported as requested on the COC. Results of the broader Kimba sampling program were initially reported as one laboratory batch, however were subsequently reported as two separate batches.
Holding Time Compliance	Samples were analysed outside recommended holding times for pH (11 days), nitrite as N (7 days) and dissolved sulphide as S2- (2 days). 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. The triplicate sample was analysed at Eurofins-MGT (Melbourne). All three laboratories are accredited by the National Association of Testing Authorities Australia (NATA) for the analyses undertaken.
Frequency of Laboratory QC	The laboratory did not report a sufficient frequency of quality control samples in laboratory batch EM1808769. However, based on results of the broader Kimba sampling program (comprising 12 samples in total) a sufficient frequency of quality control samples were reported, with the following exceptions: 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 LCS (where reported), 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 in EM1808769 and within the broader Kimba sampling program.
Laboratory Duplicate RPDs	Laboratory duplicate relative percentage differences (RPDs) were within control limits in EM1808769 and the broader Kimba sampling program. The laboratory duplicate RPDs are presented in the laboratory Quality Control Reports (EM1808769 & EM1808546).
Laboratory Control Spike Recovery	Laboratory control spike recoveries were within control limits in EM1808769 and within the broader Kimba sampling program.
Matrix Spike Recovery	Matrix spike (MS) recoveries (where reported) were within control limits in EM1808769 and within the broader Kimba sampling program. The following recoveries in laboratory batch EM1808546 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 (N02 reported a laboratory pH of 4.5 and a field pH of 7, and N05D reported a laboratory pH of 4.8 and a field pH of 7.5). 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	NA – based on results of the broader Kimba sampling program elevated RPDs for filtered thorium and ionic balance should be taken into consideration when using the data quantitatively.

Field Triplicate RPDs	NA - based on results of the broader Kimba sampling program elevated RPDs for gross alpha, nitrate as N, filtered cadmium, filtered cobalt, filtered zinc, filtered thorium, filtered potassium and filtered bromine should be taken into consideration when using the data quantitatively.
Other	
Ionic Balance	Acceptable
Sum Totals	Total alkalinity as $CaCO_3$, ionic balance, total anions and total cations were laboratory reported.
General Comments	ALS laboratory noted the following comments: - **EG020F**: QC05 dissolved manganese result has been confirmed by re-preparation and re-analysis - **EG020F**: N02 and N03 required dilution prior to dissolved metals analysis due to sample matrix interference. LOR values have been raised accordingly. - **EA010-P**: Electrical Conductivity @ 25°C was analysed by manual method (EA010). - Ionic balances were calculated using: major anions - chloride, alkalinity and sulfate; and major cations - calcium, magnesium, potassium and sodium. - 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.

Napandee Groundwater Rinsate Blank Sample Analysis

Lab Report	EM1808769
Field ID	QC05_23/5/18
Sample Date	23/05/2018
Sample Type	Rinsate blank

Reporting Group	**Analyte**	**Units**	**LOR**	
Physio-Chemical Parameters	pH (Lab)	pH Units	0.01	**6.46**
	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	**2**
	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	**0.05**
	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

Napandee Groundwater Frequency Table

Site Name	NRWMF
Project No.	60565376
Project Manager	Melinda Morris
Matrix	WATER
Laboratory	ALS and Eurofins|MGT
Batch File Number	EM1808769

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)	7	7	6	×	✓	1	0	1	1	1	0	1	0	1	0	1	0	0	0	1	0	-	-
EA010P: Conductivity by PC Titrator	Electrical conductivity (lab)	7	7	6	✓	✓	1	0	1	1	1	0	1	0	1	0	1	0	0	0	1	0	-	-
EA250: Gross Alpha and Beta Activity	Gross alpha	5	5	5	✓	✓	1	0	1	0	1	1	1	0	1	0	1	0	0	0	1	1	-	-
	Gross beta	5	5	5	✓	✓	1	0	1	0	1	1	1	0	1	0	1	0		0	1	1	-	-
ED041G: Sulfate (Turbidimetric) as SO4 2- by D	Sulfate (as SO4-)	7	7	6	✓	✓	1	0	1	1	1	0	1	0	1	0	1	0	1	0	1	0	-	-
EG020F: Dissolved Metals by ICP-MS	Arsenic	7	7	6	✓	✓	1	0	1	1	1	0	1	0	1	0	1	0	1	0	1	0	-	-
	Boron	7	7	6	✓	✓	1	0	1	1	1	0	1	0	1	0	1	0		0	1	0	-	-
	Barium	7	7	6	✓	✓	1	0	1	1	1	0	1	0	1	0	1	0		0	1	0	-	-
	Beryllium	7	7	6	✓	✓	1	0	1	1	1	0	1	0	1	0	1	0		0	1	0	-	-
	Cadmium	7	7	6	✓	✓	1	0	1	1	1	0	1	0	1	0	1	0		0	1	0	-	-
	Cobalt	7	7	6	✓	✓	1	0	1	1	1	0	1	0	1	0	1	0		0	1	0	-	-
	Chromium	7	7	6	✓	✓	1	0	1	1	1	0	1	0	1	0	1	0		0	1	0	-	-
	Copper	7	7	6	✓	✓	1	0	1	1	1	0	1	0	1	0	1	0		0	1	0	-	-
	Manganese	7	7	6	✓	✓	1	0	1	1	1	0	1	0	1	0	1	0		0	1	0	-	-
	Nickel	7	7	6	✓	✓	1	0	1	1	1	0	1	0	1	0	1	0		0	1	0	-	-
	Lead	7	7	6	✓	✓	1	0	1	1	1	0	1	0	1	0	1	0		0	1	0	-	-
	Selenium	7	7	6	✓	✓	1	0	1	1	1	0	1	0	1	0	1	0		0	1	0	-	-
	Vanadium	7	7	6	✓	✓	1	0	1	1	1	0	1	0	1	0	1	0		0	1	0	-	-
	Zinc	7	7	6	✓	✓	1	0	1	1	1	0	1	0	1	0	1	0		0	1	0	-	-
	Lithium	7	7	6	✓	✓	1	0	1	1	1	0	1	0	1	0	1	0		0	1	0	-	-
	Strontium	7	7	6	✓	✓	1	0	1	1	1	0	1	0	1	0	1	0		0	1	0	-	-
	Thorium	7	7	6	✓	✓	1	0	1	1	1	0	1	0	1	0	1	0		0	1	0	-	-
	Uranium	7	7	6	✓	✓	1	0	1	1	1	0	1	0	1	0	1	0		0	1	0	-	-
	Iodine	7	7	6	✓	✓	1	0	1	1	1	0	1	0	1	0	1	0		0	1	0	-	-
	Bromine	7	7	6	✓	✓	1	0	1	1	1	0	1	0	1	0	1	0		0	1	0	-	-
EG035F: Dissolved Mercury by FIMS	Mercury	7	7	6	✓	✓	1	0	1	1	1	0	1	0	1	0	1	0	1	0	1	0	-	-
EG020T: Total Metals by ICP-MS	Manganese	5	5	5	✓	✓	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	-	-
	Iron	5	5	5	✓	✓	1	0	1	0	1	0	1	0	1	0	1	0		0	1	0	-	-
EK057G: Nitrite as N by Discrete Analyser	Nitrite (as N)	5	5	5	×	✓	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	-	-
EK058G: Nitrate as N by Discrete Analyser	Nitrate (as N)	5	5	5	✓	✓	1	0	1	0	1	0	1	0	1	0	1	0	0	0	1	0	-	-
EK040P: Fluoride by PC Titrator	Fluoride	7	7	6	✓	✓	1	0	1	1	1	0	1	0	1	0	1	0	1	0	1	0	-	-
ED040F: Dissolved Major Anions	Silicon	7	7	6	✓	✓	1	0	1	1	1	0	1	0	1	0	1	0	1	0	1	0	-	-
EK085F: Dissolved Sulfide as S2-	Sulphide (as S2-)	5	5	5	×	✓	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	-	-
ED037P: Alkalinity by PC Titrator	Bicarbonate Alkalinity as CaCO3	7	7	6	✓	✓	1	0	1	1	1	0	1	0	1	0	1	0	0	0	1	0	-	-
	Total Alkalinity as CaCO3	7	7	6	✓	✓	1	0	1	1	1	0	1	0	1	0	1	0		0	1	0	-	-
	Carbonate Alkalinity as CaCO3	7	7	6	✓	✓	1	0	1	1	1	0	1	0	1	0	1	0		0	1	0	-	-
	Hydroxide Alkalinity as CaCO3	7	7	6	✓	✓	1	0	1	1	1	0	1	0	1	0	1	0		0	1	0	-	-
EP002: Dissolved Organic Carbon (DOC)	Dissolved Organic Carbon	5	5	5	✓	✓	1	0	1	0	1	1	1	0	1	0	1	2	1	1	1	1	-	-
ED093F: Dissolved Major Cations	Potassium	7	7	6	✓	✓	1	0	1	1	1	0	1	0	1	0	1	0	0	0	1	0	-	-
	Sodium	7	7	6	✓	✓	1	0	1	1	1	0	1	0	1	0	1	0		0	1	0	-	-
	Calcium	7	7	6	✓	✓	1	0	1	1	1	0	1	0	1	0	1	0		0	1	0	-	-
	Magnesium	7	7	6	✓	✓	1	0	1	1	1	0	1	0	1	0	1	0		0	1	0	-	-
ED045G: Chloride by Discrete Analyser	Chloride	7	7	6	✓	✓	1	0	1	1	1	0	1	0	1	0	1	0	1	0	1	0	-	-
EN055: Ionic Balance	Ionic Balance	6	6	6	✓	✓	1	0	1	0	1	0	1	0	1	0	1	0	0	0	1	0	-	-
	Total Anions	7	7	6	✓	✓	1	0	1	1	1	0	1	0	1	0	1	0		0	1	0	-	-
	Total Cations	7	7	6	✓	✓	1	0	1	1	1	0	1	0	1	0	1	0		0	1	0	-	-

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