Appendix L

Soil Resource Assessment

Balranald Mineral Sands Project

Soil Resources Assessment

Prepared for Iluka Resources Limited
May 2015

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EMM
EMGA Mitchell McLennan

Balranald Mineral Sands Project

Soil Resource Assessment

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Prepared for Iluka Resources Ltd| 1 May 2015

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Balranald Mineral Sands Project

Final

Report J12011RP1 | Prepared for Iluka Resources Ltd | 1 May 2015

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Executive Summary

EMGA Mitchell McLennan Pty Ltd (EMM) was commissioned by Iluka Resources Limited (Iluka) to undertake a Soil Resource Assessment of the area covered by the Balranald Mineral Sands Project (the project) in south-western New South Wales (NSW). This report presents the following:

- an assessment and mapping of soil types within the project area;
- provides an assessment of land and soil capability (LSC) and Biophysical Strategic Agricultural Land (BSAL)within the project area;
- identifies potential impacts on soil resources that may result from the project; and
- provides measures for managing soil resources and mitigating potential impacts.

A qualitative soil survey was undertaken by GSS Environmental in 2013 (GSSE 2013). An additional detailed field survey of approximately 4,000 ha of the West Balranald and Nepean mine areas was undertaken by Sunraysia Environmental on behalf of EMM in June and July 2014. Soil sampling and subsequent mapping was undertaken at a scale of 1:25000 in accordance with the NCST (2008).

The soil survey identified six main soil types (or orders) at West Balranald corresponding with 12 soil colour variations (sub-orders). This is consistent with the significant transition in landscape and vegetation from south to north within the project area. The soil types identified comprise:

- Calcarosols (Hypo- and Hypercalcic);
- Chromosols (Red);
- Dermosols (Red);
- Kandosols (Red and Brown);
- Sodosols (Red, Brown and Grey); and
- Vertosols (Brown and Grey).

The Nepean mine area was found to be more homogenous than West Balranald with only three soil types and three variants identified comprising Calcarosols (Hypercalcic), Dermosols (Brown) and Kandosols (Red).

Hypercalcic Calcarosols are the dominant soil type at both the West Balranald and Nepean mine areas. Red Kandosol is the second most extensive soil type in the Nepean mine area, with Brown Sodosol being the second most common in the West Balranald mine area. Red Dermosol and Grey Vertosol are the least extensive soil types found across the mine areas.

Characteristics of the predominant soils in the project areas include:

- very shallow topsoils with very low organic matter levels;
- significant levels of carbonates, notably in the Calcarosols;

- moderately to strongly alkaline at depth;
- sodicity and salinity levels are high to extreme in most of the clayey soils (eg Sodosols and Dermosols) but lower in the sandy/loamy soils (eg Kandosols); and
- poorly drained and highly infertile.

The assessment of the LSC for the project and each soil type was done and found that both project areas have been identified (based on the OEH assessment process) as predominantly land suitability class 6 ie *Low capability land: Land has very high limitations for high-impact land uses. Land use restricted to low-impact land uses such as grazing, forestry and nature conservation. Careful management of limitations is required to prevent severe land and environmental degradation*. Assessed land suitability outcomes generally reflect the current and historical uses of the land, being primarily used for low productivity grazing on mainly chenopod (saltbush and bluebush) pasture or uncleared. There is no cropping undertaken on the land.

In terms of BSAL, an assessment has been done in accordance with the OEH (2012) guidelines and it has been found that:

- the project area does not lie within the 350mm and above rainfall isohyet for 9 out of 10 years;
- the project does not overlie a groundwater resource declared by the NSW Office of Water as highly productive groundwater;
- the project does not lie within the area mapped by the NSW Office of Water as being within 150m of a highly reliable surface water supply; and
- the BSAL assessment of site conditions determined that no BSAL occurs in the mine area. All soils sampled failed the criteria for fertility and most failed additional BSAL criteria such as salinity and chloride levels.

An assessment of the suitability of topsoil and subsoil resources for mine rehabilitation has found that most soils would not be suitable for stripping for reuse (based on standard criteria) due to the predominantly unsuitable soil structure combined with the very shallow topsoil and salinity and sodicity limitations noted above. However, it is considered that most soils can be successfully stripped to predetermined depths and reinstated on the final landforms for subsequent establishment of vegetative cover given appropriate stripping, handling and re-establishment techniques. Such techniques are described within this report.

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1 Introduction

1.1 Overview

Iluka Resources Limited (Iluka) proposes to develop a mineral sands mine in south-western New South Wales (NSW), known as the Balranald Mineral Sands Project (the Balranald Project). The Balranald Project includes construction, mining and rehabilitation of two linear mineral sand deposits, known as West Balranald and Nepean. These mineral sands deposits are located approximately 12 kilometres (km) and 66 km north-west of the town of Balranald, respectively (Figure 1.1).

Iluka is seeking development consent under Part 4, Division 4.1 of the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act) for the Balranald Project, broadly comprising:

- open cut mining of the West Balranald and Nepean deposits, referred to as the West Balranald and Nepean mines, including progressive rehabilitation;
- processing of extracted ore to produce heavy mineral concentrate (HMC) and ilmenite;
- road transport of HMC and ilmenite to Victoria;
- backfilling of the mine voids with overburden and tailings, including transport of by-products from the processing of HMC in Victoria for backfilling in the mine voids;
- return of hypersaline groundwater extracted prior to mining to its original aquifer by a network of injection borefields;
- an accommodation facility for the construction and operational workforce;
- gravel extraction from local sources for construction requirements; and
- a water supply pipeline from the Murrumbidgee River to provide fresh water during construction and operation.

Separate approvals, are being sought for:

- the construction of a transmission line to supply power to the Balranald Project; and
- project components located within Victoria.

1.2 Approval process

In NSW, the Balranald Project requires development consent under Part 4, Division 4.1 of the EP&A Act. Part 4 of the EP&A Act relates to development assessment. Division 4.1 specifically relates to the assessment of development deemed to be State significant development (SSD). The Balranald Project is a mineral sands mining development which meets the requirements for SSD.

An application for SSD must be accompanied by an environmental impact statement (EIS), prepared in accordance with the NSW *Environmental Planning and Assessment Regulation 2000* (EP&A Regulation).

An approval under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) is required for the Balranald Project (with the exception of the transmission line which will be subject to a separate EPBC Act referral process). A separate EIS will be prepared to support an application in accordance with the requirements of Part 8 of the EPBC Act.

1.3 Secretary's environmental assessment requirements

This EIS has been prepared to address specific requirements provided in the Secretary's environmental assessment requirements (SEARs) for the SSD application, issued on 2 December 2014.

This Soil Resource Assessment has been prepared to address specific requirements for land resources in the SEARs (Table 1.1).

Table 1.1 Relevant SEARs for this assessment

Requirement	Section addressed
An assessment of the likely impacts of the development on the soils, land capability, and landforms (topography) of the site	Section 6
An assessment of the compatibility of the development with other land uses in the vicinity of the development in accordance with the requirements in Clause 12 of State Environmental Planning Policy (Mining Petroleum Production and Extractive Industries) 2007	Section 4 and Section 5

This report assesses likely impacts of the project on soils, Land and Soil Capability (LSC) and Biophysical Strategic Agricultural Land (BSAL). Assessment of landforms, topography and agricultural impact assessment more broadly (including reference to the Agricultural Impact Assessment guidelines and Agricultural Land Classification guidelines) is not within the scope of this report and will be addressed in the project AIS.

In 2013 the *State Environmental Planning Policy (Mining, Petroleum Production and Extractive Industries) 2007* (NSW DP&E 2014a) was amended to include a process for assessing State Significant Development located wholly or partially on BSAL (the Gateway process). The Gateway process is an independent, scientific and upfront assessment of how a proposal will impact the agricultural values of the land on which it is proposed to be located.

1.4 Purpose of this report

EMGA Mitchell McLennan Pty Ltd (EMM) was commissioned by Iluka Resources Limited to undertake a Soil Resource Assessment of the Balranald Project. The objectives of the Soil Resource Assessment (the report) are to address the SEARs and inform the Balranald Project Agricultural Impact Statement (AIS) (SLR 2015) and Environmental Impact Statement (EIS) as to the nature of the soils occurring in the project area and potential impacts on those soils that may result from the Balranald Project. To this end the report:

- classifies and maps soil types within the project area;
- describes and maps land and soil capability (LSC) within the project area;
- verifies the absence of BSAL;
- identifies potential impacts on soil resources that may result from the project; and
- provides measures for managing soil resources and mitigating potential impacts.

To achieve these objectives, this report includes the following elements:

- a brief description of the regulatory framework governing the Soil Resource Assessment;
- a description of the soil survey methodology considering the standards in the *Guidelines for Surveying Soil and Land Resources* (NCST 2008) at the West Balranald and Nepean mine areas within the project area (Figure 1.2 and Figure 1.3);
- a description of soil profiles investigated to a depth of 750 mm below ground level. Soils are described according to the *Australian Soil and Land Survey Field Handbook* (NCST 2009), grouped according to Great Soil Group and Land System and classified according to The Australian Soil Classification System (Isbell 2002);
- a map of the location of LSC and BSAL and an interpretation of the attributes of land resources in terms of suitability for the major agricultural land uses of the area;
- a description of physical and chemical properties of the soils that will influence the severity of potential impacts and inform management measures; and
- a description of recommended soil stripping depths for rehabilitation and best management of stripped topsoil and subsoil.

This report was prepared in consideration of the following guidelines:

- *Guidelines for Surveying Soil and Land Resources* (NCST 2008);
- *Australian Soil and Land Survey Field Handbook* (NCST 2009);
- *The Australian Soil Classification System* (Isbell 2002);
- *Soil data entry handbook* (DLWC 2001);
- *Agricultural Impact Assessment Guidelines 2012* (DP&I) and *Agfact AC25: Agricultural Land Classification* (NSW Agriculture);
- *Interim protocol for site verification and mapping of Biophysical Strategic Agricultural Land* (NSW Government 2013) (BSAL interim protocol); and
- *The land and soil capability assessment scheme: second approximation* (NSW OEH 2012) (LSC assessment scheme).

Soil and Land Information System (SALIS) data cards prepared during the field survey (conducted as part of this assessment) are required to be submitted to the NSW Office of Environment and Heritage (NSW OEH) under the *Interim protocol for site verification and mapping of Biophysical Strategic Agricultural Land* (NSW Government 2013). The SALIS data cards must be processed by OEH prior to the assessment agency determining the adequacy of the baseline soil survey, BSAL verification and LSC assessment as presented in the AIS and EIS. Data cards were submitted to the OEH immediately following the soil surveys in accordance with the guidelines.

1.5 Project overview

1.5.1 Project schedule

The Balranald Project will have a life of approximately 15 years, including construction, mining, backfilling of all overburden material, rehabilitation and decommissioning.

Construction of the Balranald Project will commence at the West Balranald mine, and is expected to take about 2.5 years. Operations will commence at the West Balranald mine in Year 1 of the operational phase, which will overlap with approximately the last six months of the construction. The operational phase would include mining and associated ore extraction, processing and transport activities, and would be approximately nine years in duration. This would include completion of backfilling overburden into the pits at both the West Balranald and Nepean mines. Construction of infrastructure at the Nepean mine will commence in approximately Year 5 of the operational phase, with mining of ore starting in Year 6, and being complete by approximately Year 8.

Rehabilitation and decommissioning is expected to take a further two to five years following Year 9 of the operational phase.

1.5.2 Project area

All development for the Balranald Project that is the subject of the SSD application is within the project area (Figure 1.1, Figure 1.2 and Figure 1.3). The project area is approximately 9,964 ha, and includes the following key project elements, described in subsequent sections:

- West Balranald and Nepean mines (Figure 1.4 and Figure 1.5);
- West Balranald access road;
- Nepean access road;
- injection borefields;
- gravel extraction;
- water supply pipeline (from the Murrumbidgee River); and
- accommodation facility.

Within the project area, the land directly disturbed for the Balranald Project is referred to as the disturbance area. For some project elements in the project area, a larger area has been surveyed than would actually be disturbed. This enables some flexibility to account for changes that may occur during detailed design and operation. The project area and disturbance area for each project element are in Table 1.2.

Table 1.2 Balranald Project project area and disturbance area

Project element	Project area (ha)	Disturbance area (ha)
West Balranald mine	3,059	3,059
Nepean mine	805	805
West Balranald access road	128	52 [1]
Nepean access road	173	156 [2]
Injection borefields	5,721	1,214 [3]
Gravel extraction	42	42
Water supply pipeline	29	11 [4]
Accommodation facility	7	7
Total	**9,964**	**5,346**

Notes: 1. 60 m wide corridor within project area.
2. 40-50 m wide corridor within project area.
3. 100 m wide corridors within project area.
4. 15 m wide corridor within project area.

i West Balranald and Nepean mines

The West Balranald and Nepean mines include:

- open cut mining areas (ie pit/mine void) that would be developed using conventional dry mining methods to extract the ore;
- soil and overburden stockpiles;
- ore stockpiles and mining unit plant (MUP) locations;
- a processing area (at the West Balranald mine), including a mineral processing plant, tailings storage facility (TSF), maintenance areas and workshops, product stockpiles, truck load-out area, administration offices and amenities;
- groundwater management infrastructure, including dewatering, injection and monitoring bores and associated pumps and pipelines;
- surface water management infrastructure;
- service infrastructure (eg power);
- haul roads for heavy machinery and service roads for light vehicles; and
- other ancillary equipment and infrastructure.

The location of infrastructure at the West Balranald and Nepean mines would vary over the life of the Balranald Project according to the stage of mining.

ii Injection borefields

The Balranald Project requires a network of injection borefields in the project area for the return of hypersaline groundwater to the Loxton Parilla Sands aquifer. Within each borefield, infrastructure is generally located in two 50 m wide corridors (approximately 350 m apart) and typically comprises:

- a network of pipelines with a graded windrow on either side;
- access roads for vehicle access during construction and operation;
- rows of injection wells, with wells spaced at approximately 100 m intervals; and
- a series of water storage dams to store water during well development.

iii Access roads

There are two primary access roads within the project area to provide access to the Balranald Project:

- West Balranald access road – a private access road to be constructed from the Balranald Ivanhoe Road to the West Balranald mine.
- Nepean access road – a route comprising private access roads and existing public roads. A private access road would be constructed from the southern end of the West Balranald mine to the Burke and Wills Road. The middle section of the route would be two public roads, Burke and Wills Road and Arumpo Road. A private access road would be constructed from Arumpo Road to the Nepean mine.

The West Balranald access road would be the primary access point to the project area, and would be used by heavy vehicles transporting HMC and ilmenite. The Nepean access road would primarily be used by heavy vehicles transporting ore mined at the Nepean mine to the processing area at the West Balranald mine.

During the initial construction phase, existing access tracks through the project area from the local road network may also be used temporarily until the West Balranald and Nepean access roads and internal access roads within the project are established.

iv Accommodation facility

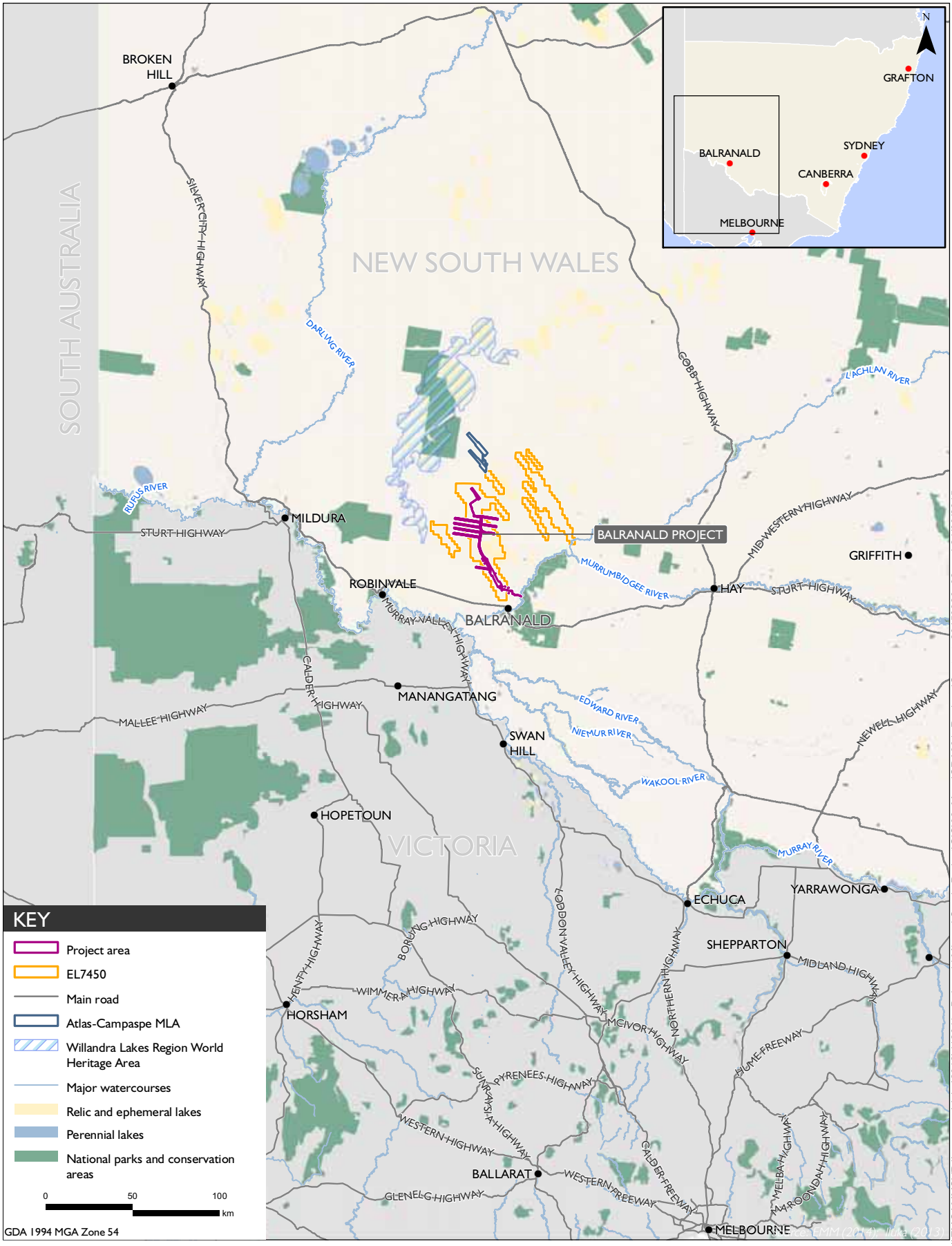
An accommodation facility would be constructed for the Balranald Project workforce. It would operate throughout the construction and operation phases of the project. It would be located adjacent to the West Balranald mine near the intersection of the West Balranald access road with the Balranald Ivanhoe Road.

v Water supply pipeline

A water supply pipeline would be constructed to supply water from the Murrumbidgee River for operation of the Balranald Project.

vi Gravel extraction

Gravel would be required during the construction and operational phases of the Balranald Project. Local sources of gravel (borrow pits) have been included in the project area to provide gravel during the construction phase. During the construction phase, gravel would be required for the construction of the West Balranald access road, internal haul roads and service roads, and hardstand areas for infrastructure. Processing operations, such as crushing and screening activities (if required) would also be undertaken at the borrow pits. Gravel for the operational phase would be obtained from external sources.



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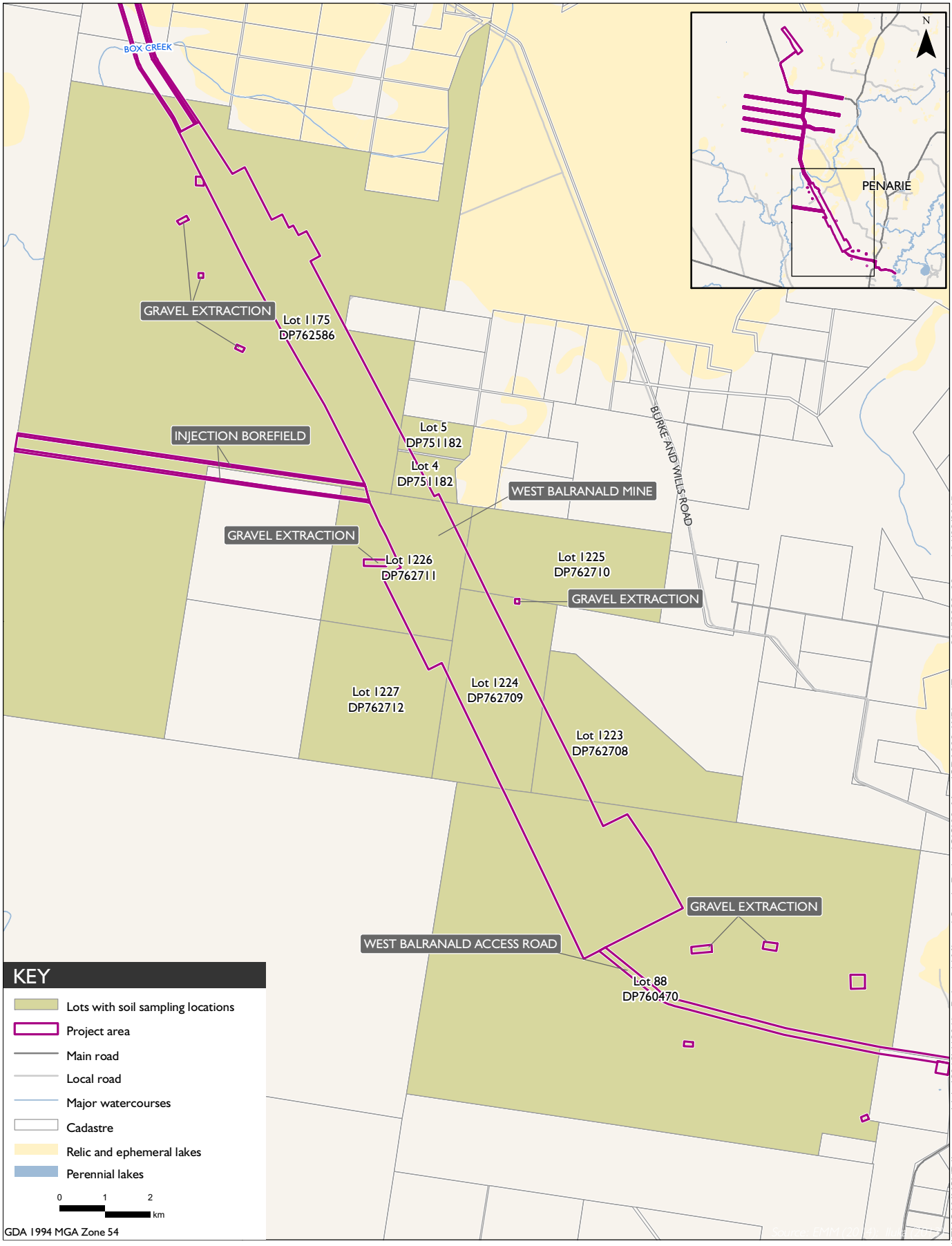
Regional context

Balranald Mineral Sands Project

Soil Resource Assessment

Figure 1.1



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West Balranald project area and tenure

Balranald Mineral Sands Project

Soil Resource Assessment

Figure 1.2

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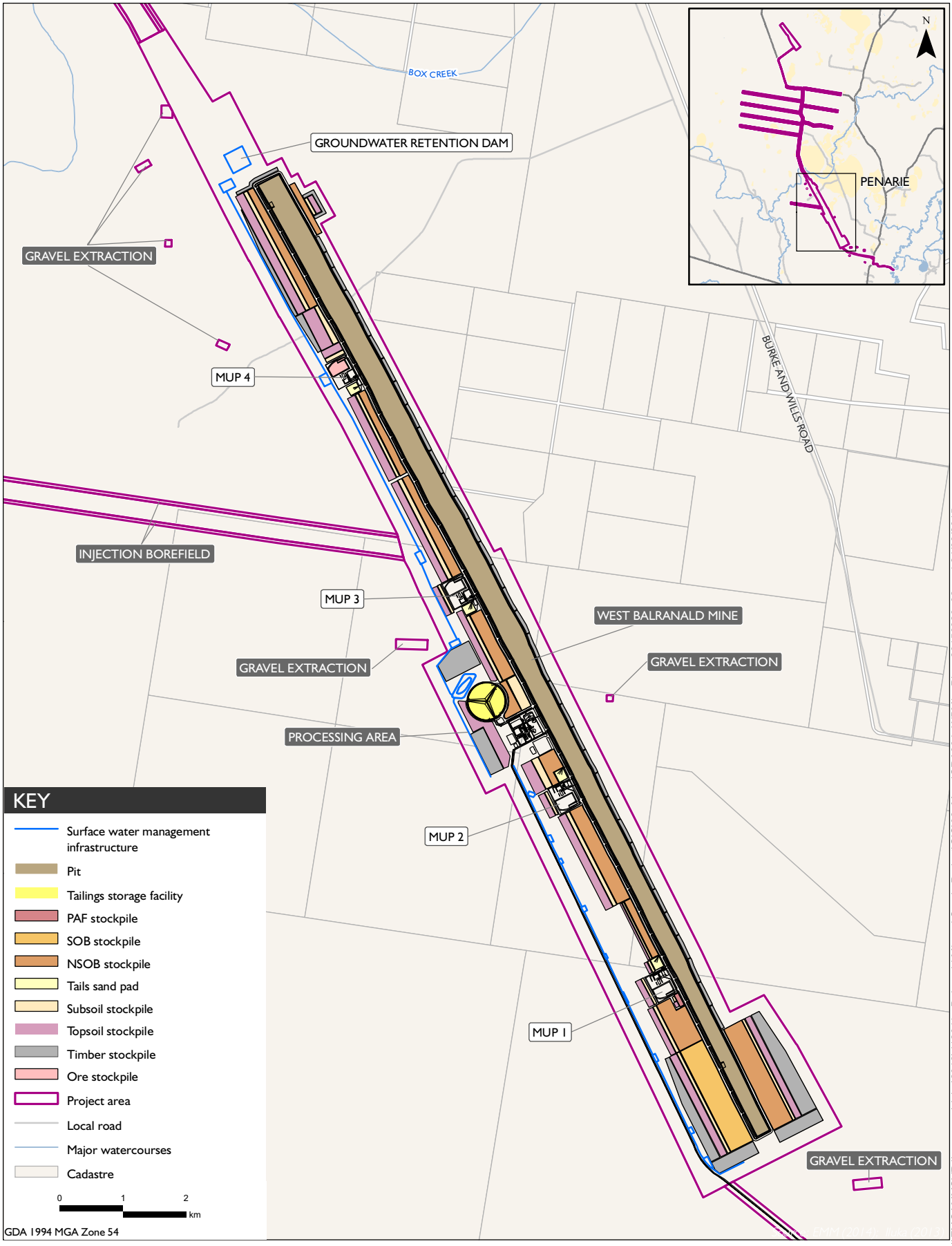
Nepean project area and tenure

Balranald Mineral Sands Project
Soil Resource Assessment
Figure 1.3

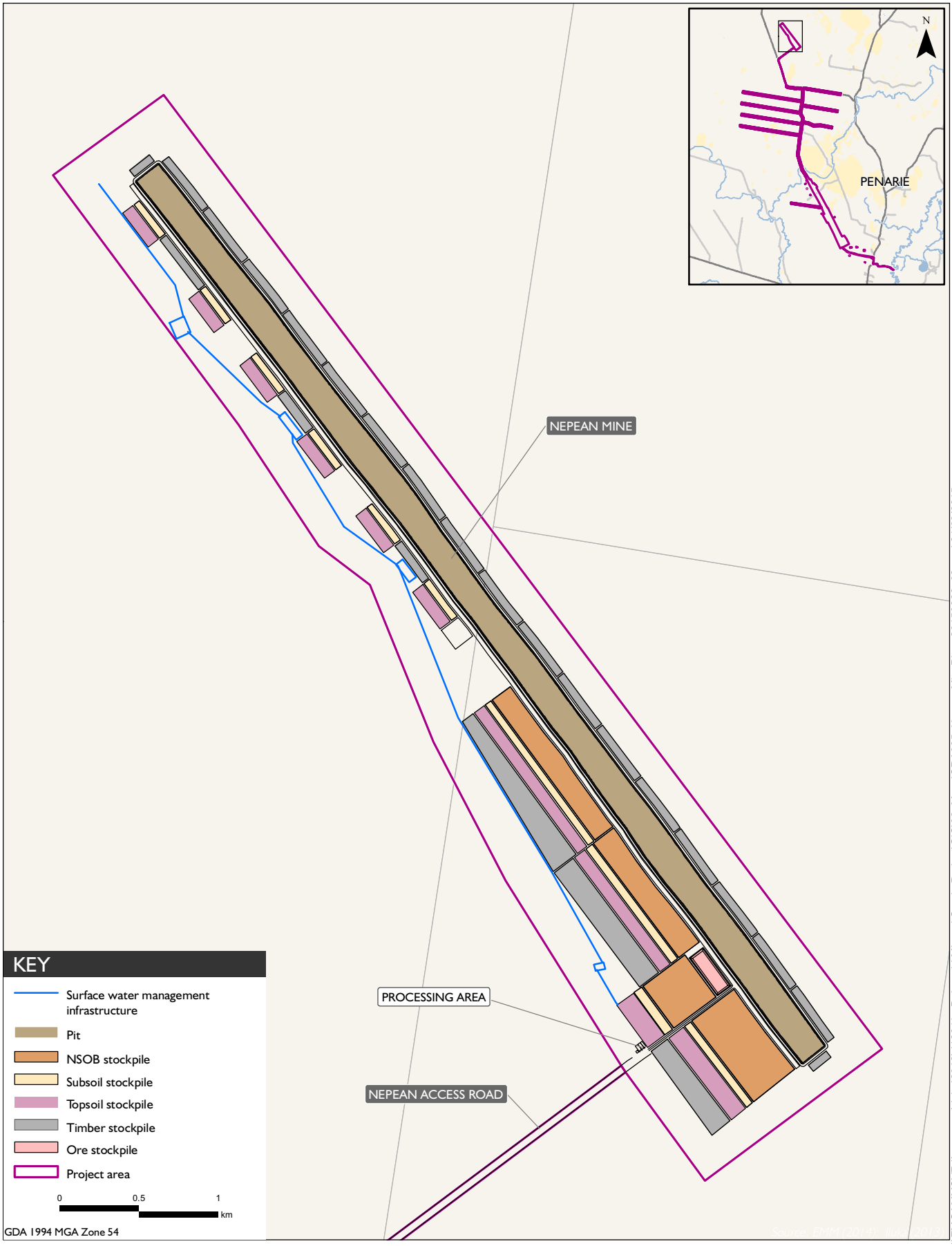


West Balranald indicative mine layout

Balranald Mineral Sands Project

Soil Resource Assessment

Figure 1.4



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Nepean indicative mine layout

Balranald Mineral Sands Project
Rehabilitiation and Closure Strategy
Figure 1.5

2 Existing environment

2.1 Climate

The project area is characterised by hot dry summers and cold winters. Climatic data from the Bureau of Meteorology's weather station at Balranald town indicates that monthly mean minimum temperature ranges from 3.5°C to 16.4°C and the monthly mean maximum temperature ranges from 15.7°C to 33°C.

The median annual rainfall is 324.8 mm (marginally less than the 350 mm average used in the BSAL interim protocol assessment criteria). Rainfall generally occurs throughout the year with the highest median rainfall over spring and the lowest median rainfall over summer.

2.2 Topography and geomorphology

The West Balranald mine is generally flat with elevations ranging from 62 to 70 m Australian Height Datum (AHD) while the terrain of the Nepean mine is slightly more undulating with elevations ranging from 64 to 100 m AHD (Figure 2.1 and Figure 2.2).

The project area lies in a region principally defined as part of the Murray Basin, an extensive intra-cratonic sedimentary basin of Cainozoic age (60 million years before present) covering part of NSW, Victoria and South Australia. Its stratigraphic sequences are dominated by consolidated sand, silt, clay and lime-rich sediments formed by marine, deltaic, fluvial and aeolian depositional environments. It is a closed groundwater system ie ground waters are trapped by the basin's shape with the water table usually occurring at the basin's surface. Landforms in the project area may have formed in either the Pleistocene period (approximately 2.5 million to 12,000 before present) or the Holocene period (approximately 12,000 years to the present).

Geomorphically, the ore deposits within the project area lie beneath a layer of lacustrine, fluvial and aeolian sediments. Parts of the project area contain three dry clay pans which include Tin Tin, Pitarpunga and Muckee lakes. The lakes have been dry for at least the last few hundreds to thousands of years. These lakes functioned as overflow lakes being fed through a tributary of the Lachlan River called Box Creek.

Much of the project area at the West Balranald mine forms part of a meander back plain which contain swamps and marshes containing black box open woodland and chenopod. Small networks of channels cut across these swamp features and contain deep organic grey to black clays. In the southern section of the West Balranald mine are longitudinal dune formations, approximately 2 to 6 m above the swales. In some places these cover parts of old lake beds. Some of these dunes have also been extensively eroded and now form a series of sand sheets. Sand that has been cemented by calcium carbonate (ie calcrete) can also be found in the dunes.

Although geomorphically stable, parts of the project area have been subject to erosion caused by pastoral activity resulting in eroded pans and scalds where vegetation has been removed and the aeolian sands have deflated. Other areas of exposure and erosion are a result of mechanical disturbance from rural infrastructure such as ground tanks, tracks and cut lines for fences. Significant erosion caused by European farming practices has led to soils on lunette features to be dispersed upon wetting and move downslope. On the back plain landforms, sheet erosion has led to the topsoil being stripped resulting in the formation of hard surfaced scalds. Some of these scalds also contain patchy vegetation mounds around their margins. These mounds may preserve an original soil profile beneath a cap of windblown sediment.

2.3 Geology

The West Balranald and Nepean mines share the same two stratigraphical units namely the Loxton Parilla Sands (LPS) and the Sheppard Formation, but with differing local features (Figure 2.1 and Figure 2.2).

2.3.1 West Balranald mine

At the West Balranald mine, the Shepparton Formation consists of a thick grouping of unconsolidated to poorly consolidated clays and silty clays with inter-bedded sand lenses deposited in a fluvio-lacustrine environment. The strata unit is highly variable across the West Balranald deposit. Two dense clay layers are present and moderately to strongly indurated iron cemented rock layers are present within the sand-dominant lenses between the clay layers. The thickness of the unit varies from approximately 19 m at the northern end to more than 36 m through central and southern areas of the deposit.

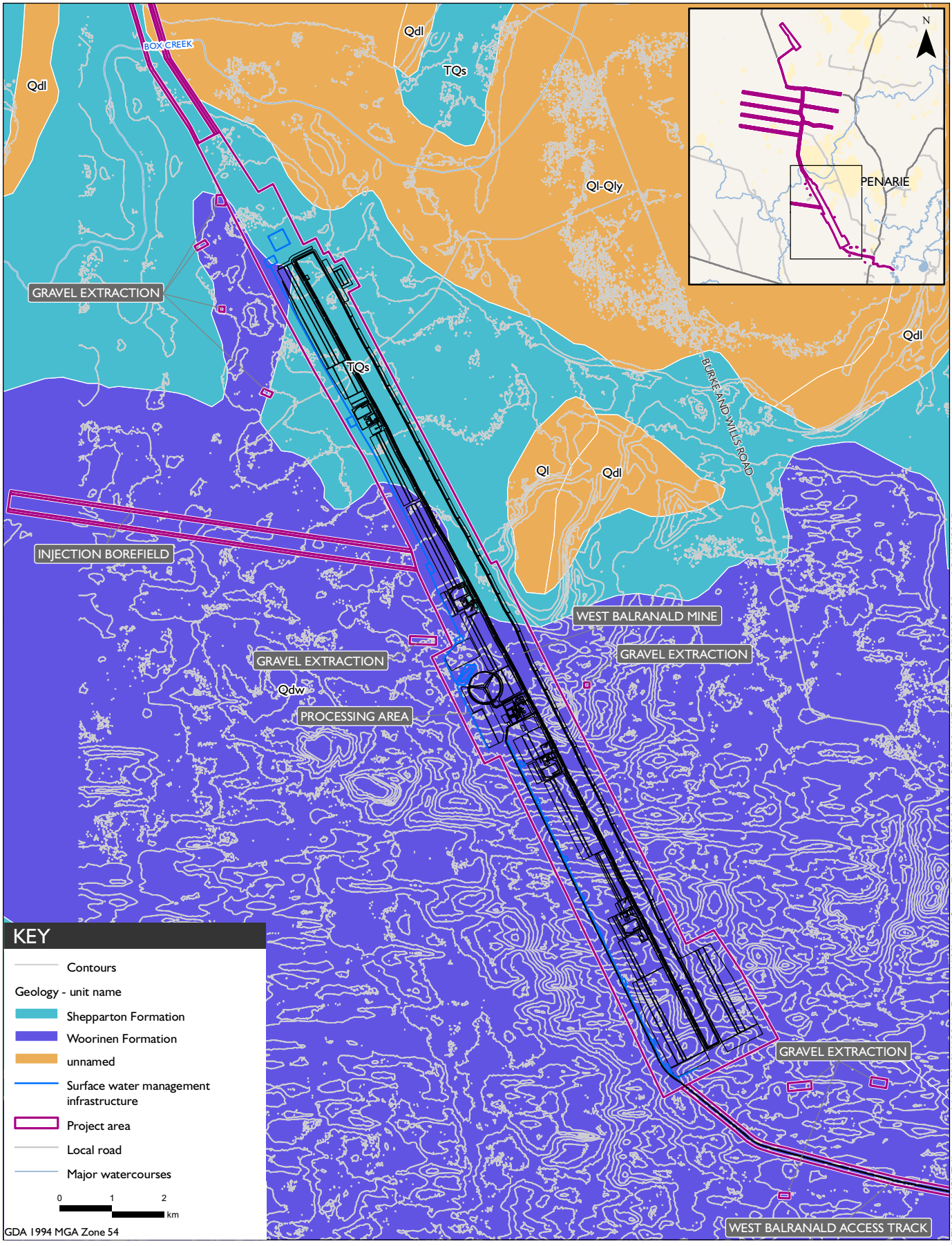
The LPS forms a thick sequence of marine sands which were deposited during two marine regressions. The upper marine sequence (LPS1) varies in thickness along the strike of the deposit from 16 to 20 m in the north to more than 60 m at the southern end. The sequence typically consists of three upper beach facies: foreshore, surf zone and lower shore. A marine transgression marks the boundary between the LPS1 and the lower (older) marine sequence (LPS2). At the southern end of the deposit, there is a lagoonal deposit consisting of black carbonaceous clays and sands.

The LPS2 is host to the mineral sand deposit proposed to be mined and also consists of three facies (foreshore, surf zone and lower shore), with the mineral sands deposit lying within the foreshore facies of LPS2. These sands comprise well to very well-sorted medium grained sands. The base of LPS2 is situated on the Geera Clay unit.

2.3.2 Nepean mine

The Shepparton Formation found across the extent of the Nepean mine consists of an upper package which contains the consistently high clay contents of the typical Shepparton Formation. Underlying this at the northern and southern ends of the deposit are additional fluvio-lacustrine sediments of the Shepparton Formation, these with more highly variable clay contents than typically seen in the region. These sediments are derived from material eroded from the uplifted Iona Ridge and a broad paleo-channel immediately adjacent to the southern edge of the Iona Ridge. In the south this unit is 80 m thick including up to 60 m of the highly variable sediment package beneath the typical Shepparton Formation sediments.

Within the LPS unit, unlike the West Balranald mine, the contact between the LPS2 and the overlying LPS1 regressive sequence is impossible to delineate as the LPS1 sequence is incomplete with LPS1 foreshore facies sediments sitting uncomformably above the LPS2 foreshore sediments. Similar to West Balranald, the LPS2 is host to the Nepean deposit, also located within the foreshore facies, often immediately above the poorly sorted coarser surf zone sands. The foreshore sands comprise well to very well sorted medium grained sands. The base of LPS2 at Nepean is also situated on the Geera Clay unit.

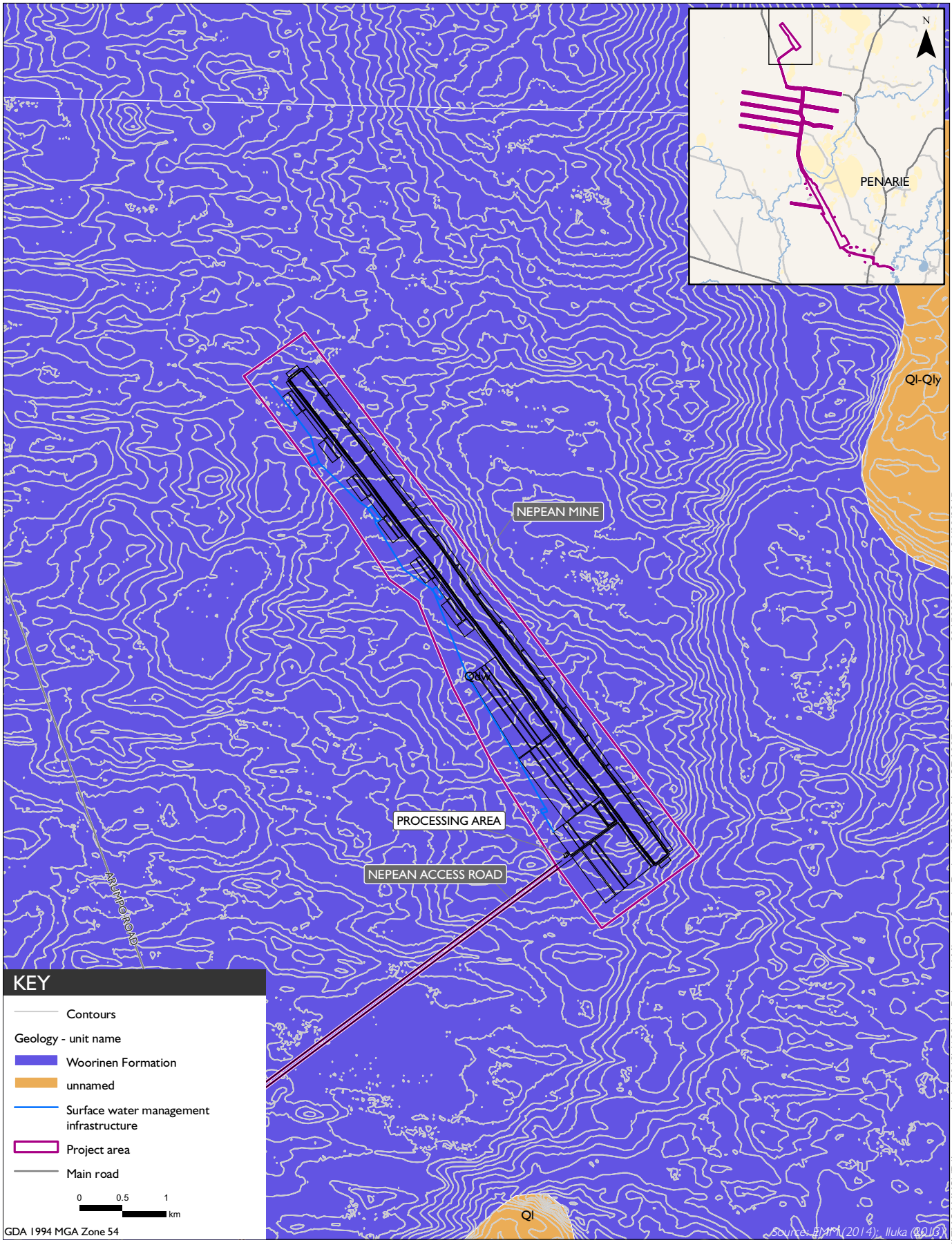


Geology and topography of the West Balranald project area

Balranald Mineral Sands Project

Soil Resource Assessment

Figure 2.1



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Geology and topography of the Nepean project area

Balranald Mineral Sands Project
Rehabilitiation and Closure Strategy
Figure 2.2

2.4 Surface water

The Lachlan, Murrumbidgee and Murray rivers are the major permanent surface water features in the vicinity of the project area. The main surface water feature within the project area is Box Creek, an ephemeral watercourse which flows to the north of the West Balranald mine. The Nepean mine is also within the catchment of Box Creek. Box Creek flows into the Lachlan River to the north-west and the Murrumbidgee River floodplains to the south. Dry relic lake beds (Pitarpunga Lake and Tin Tin Lake) occur in the northern half of the West Balranald mine and are subject to agricultural activities including cropping and grazing. Due to the dry climate, flat landscape, and large areas of permeable soils, there is little locally derived runoff in the project area. Extreme rainfall events are capable of filling local topographic depressions including dry relic beds and creating temporary flow in drainage features, such as Box Creek.

2.5 Groundwater

Shallow aquifers (Shepparton Formation, LPS and Upper/Middle Remark Group) and deeper aquifers (Lower Renmark Group) occur in and around the project area. Groundwater aquifers overly and surround the ore body in both mine areas necessitating pit dewatering to dry-mine the resource. De-watered groundwater will be injected into the LPS aquifer.

Groundwater is recharged predominantly to the east of the project area at the edge of the Murray Basin, near Griffith/Narrandera and continuously across the Basin in the wetter zones of the foothills of the Great Dividing Range to drive the regional groundwater flow from east to west. Local rainfall recharge to unconfined aquifers is extremely low due to the low annual rainfall and high evaporation rates. Groundwater in the region is generally at least 10 m below ground level with the exception of major water channels. Groundwater in the project area is located approximately 20 m below ground level. The deep water table means that groundwater does not discharge to the surface or to the atmosphere via evapotranspiration in the project area. Discharge occurs to the Balranald-Hatfield discharge zone, identified as the western half of the Balranald Trough, to the north of the project area.

Groundwater salinity levels are generally higher at shallow depths and increase along the flow path from east to west across the region. The salinity levels across the project area vary greatly in all aquifers. The more saline areas tend to be further away from river channels at shallower depths. The groundwater salinity and pH of hydrogeological units in the project area are:

- Shepparton Formation: 350 to 5,300 mg/L salinity with pH between 6.7 and 8.6;
- LPS: 14,000 to 100,000 mg/L salinity with a pH between 4.2 and 9.5; and
- Renmark group: 1,500 to 14,000 mg/L salinity with pH between 7.2 and 8.0.

2.6 Vegetation and land use

Nine natural vegetation communities occur across the project area as follows:

- Spinifex Dune Mallee Woodland;
- Chenopod Sandplain/Swale Mallee Woodland;
- Black Bluebush Low Open Shrubland;
- Pearl Bluebush Low Open Shrubland;

- Bladder Saltbush Low Open Shrubland;
- Old Man Saltbush Shrubland;
- Belah Pearl Bluebush Woodland;
- Belah Woodland; and
- Black Box Grassy Open Woodland.

Table 3.3 identifies which vegetation types are associated with soil types across the project area. Much of the project area, including the southern mallee conservation areas, is grazed by feral animals, particularly goats. Grazing has resulted in degradation of the shrub and ground vegetation layers within mallee vegetation across the project area and surrounds.

Land uses within and in proximity to the project area are primarily agricultural and include sheep grazing and minor areas of intermittent broadacre grain cropping. Agricultural land is interspersed with areas of native vegetation, primarily mallee scrub. Small charcoal farming and gypsum mining operations are also undertaken to the east of the project area.

3 Soil assessment

3.1 Review of existing information

Existing information on soils and soil environments for the project area was sourced from:

- the guidelines listed in Section 1.3.3;
- background soils information in the *Balranald Project Pre-feasibility Study (PFS) Soils and Land Capability Assessment* (GSS Environmental 2013);
- Soil Landscapes of the Balranald Field Sheet 1:250,000 (Eldridge 1985) cited in GSS Environmental (2013);
- Land System Mapping of the Western Division of NSW (1:250,000) (Walker 1991);
- Great Soil Group (GSG) Soil Type Mapping of NSW (NSW OEH 2014a);
- NSW Government inherent soil fertility mapping;
- NSW Government land and soil capability classes mapping; and
- Soil Profile Attribute Data Environment (SPADE) online database (NSW OEH 2014b).

The Soil Resource Assessment primarily relates to the West Balranald and Nepean mine areas within the project area. These areas are where the greatest level of disturbance will occur as a result of mining.

3.1.1 Soil landscapes

Three soil landscapes (mapped to a scale of 1:250,000 by Eldridge 1985) are identified as occurring in the Balranald area. These comprise: plains of calcareous earths; dunefields of calcareous and brownish sands; and plains of grey cracking clays. Calcareous earths/sands and duplex soils are common features of these three soil landscapes. The plains also exhibit various clays (Table 3.1).

Table 3.1 Soil landscapes of the Balranald Area[1] and associated land systems in the project area

Soil landscape	Description	Associated land systems in the project area
Plains of calcareous earths	Extensive areas of grey-brown loamy calcareous earths, often with exposed cemented carbonate at the surface, to the north of Balranald and between Balranald and Euston; isolated sandy dunes of low relief are associated with flats of various duplex soils; calcareous earths, transitional hard red and yellow duplex soils and areas of grey cracking clays to the east of Balranald.	Arumpo, Condoulpe, Hatfield, Marma
Dunefields of calcareous and brownish sands	Linear dunes of deep brownish sands in association with calcareous sands to the west and northwest of the Balranald, supporting Mallee vegetation; plains and swales of brown calcareous earths and assorted duplex soils associated with the dunes.	Arumpo, Bulgamurra, Condoulpe, Hatfield
Plains of grey cracking clays	Self-mulching grey and yellow-grey cracking clays associated with the rivers and floodplains; mosaic of grey cracking clays and hard duplex soils (red-brown earths) east of Balranald; the remains of prior streams have typically scalded margins and levees, and beds of shallow, calcareous sands south-east of Balranald. Bordering dunes are composed of deep, calcareous and siliceous sands; lunettes and rises consist of yellow duplex soils and granulated clays.	Marma, Rata, Youhl

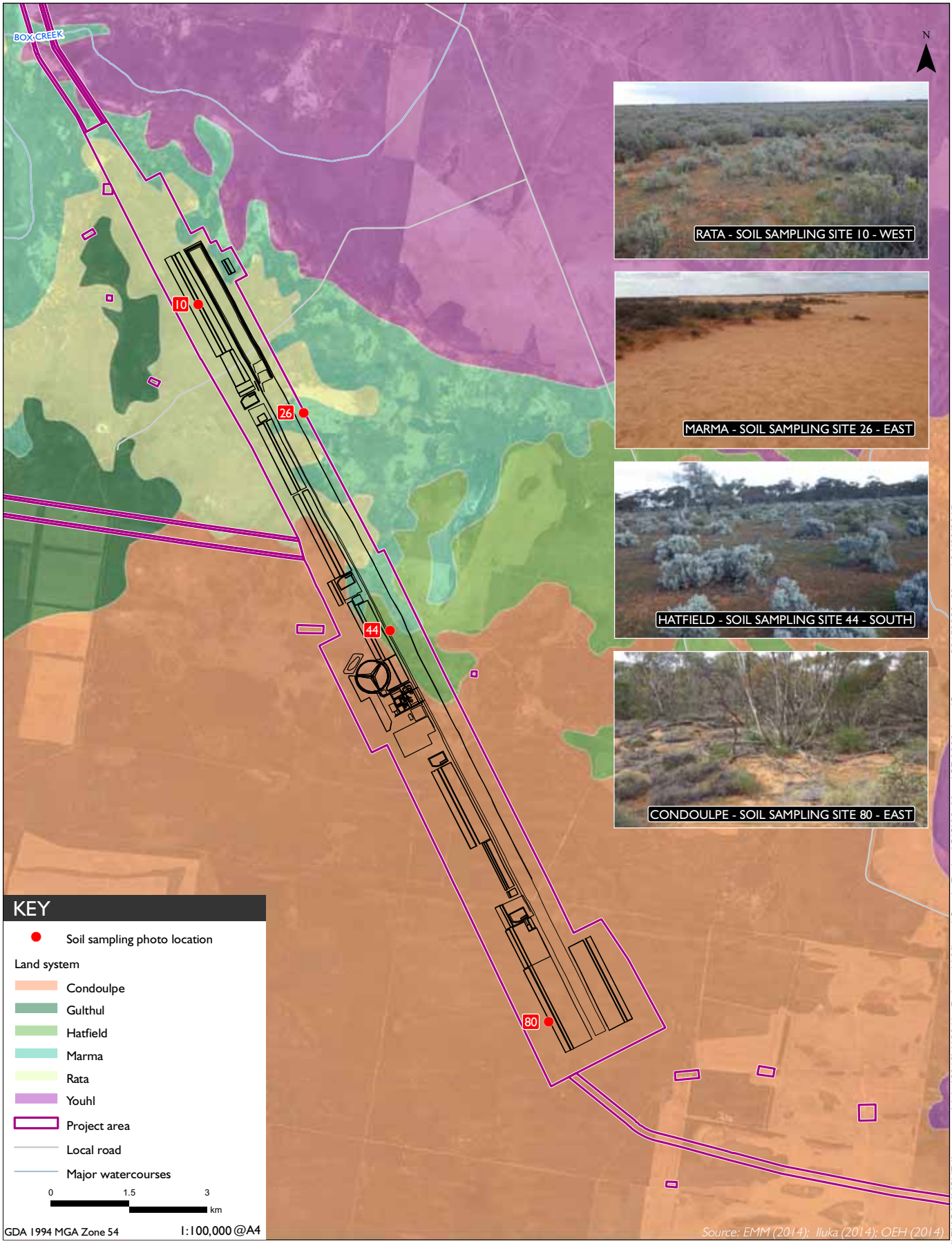
Notes: 1.From Eldridge (1985).

3.1.2 Land systems

Five land systems corresponding with the above soil landscapes occur in the vicinity of the West Balranald mine and three occur in the area of the Nepean mine (Walker 1991). The most extensive land system at the West Balranald mine is the Rata land system (28.0% or approximately 2,561 ha). Arumpo is the most extensive land system at the Nepean mine (9.09% or approximately 773.2 ha) (Table 3.2, Figure 3.1 and Figure 3.2). These land systems are described in Table 3.3 and associated soil types are discussed in Section 3.3.

Table 3.2 Land systems and extent in the project area

Land system	Approx. area (ha)	Percentage of total (%)
Arumpo	773.2	7.8
Bulgamurra	2.0	0.0
Condoulpe	2058.4	20.6
Gulthul	1967.7	19.7
Hatfield	975.8	9.8
Marma	1263.4	12.7
Riverland	17.8	0.2
Rata	2561.1	25.7
Wilkurra	75.3	0.8
Youhl	274.2	2.8
Total	9969.01	



EMM

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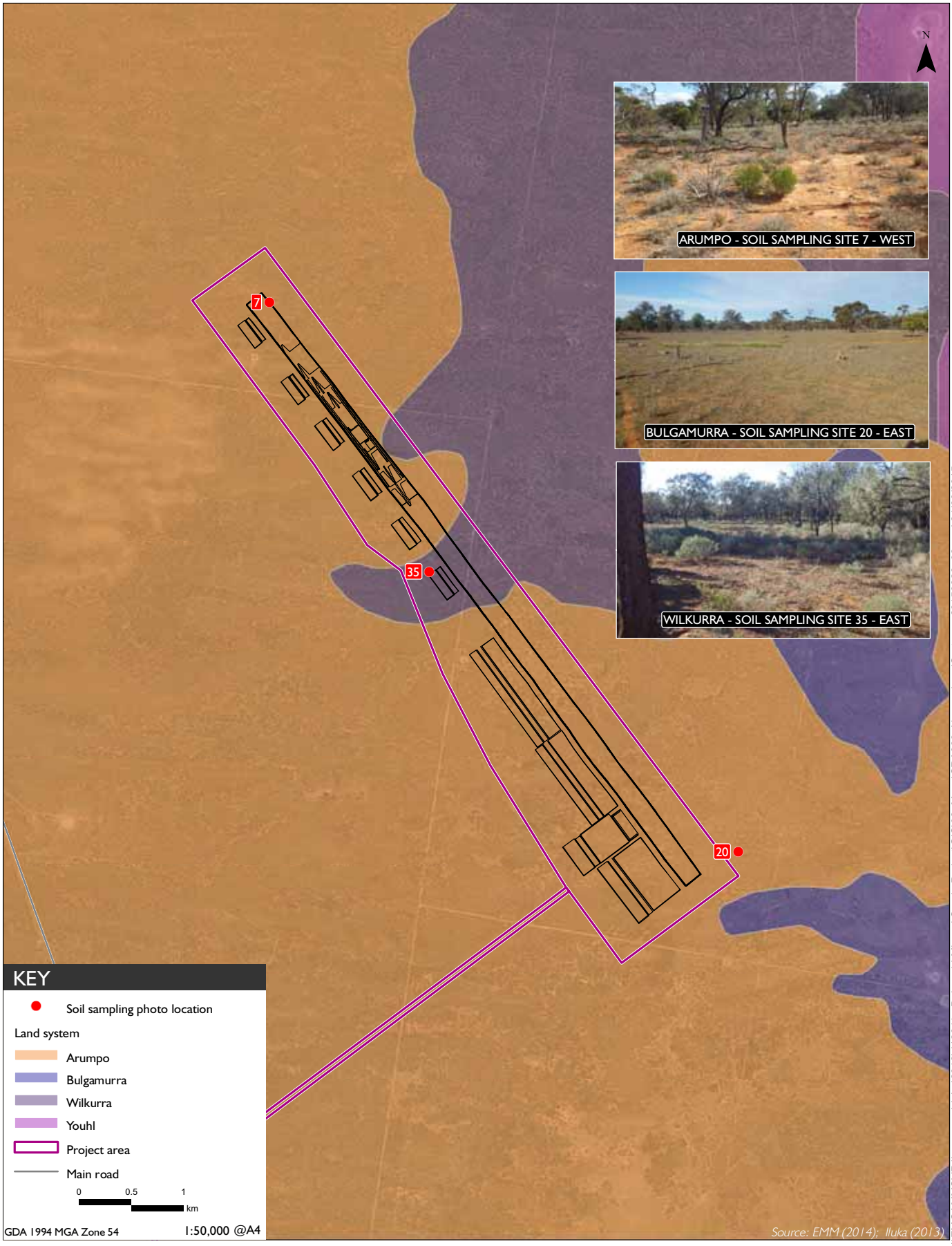
West Balranald land systems

Balranald Mineral Sands Project

Soil Resource Assessment

Figure 3.1



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Nepean land systems

Balranald Mineral Sands Project

Soil Resource Assessment

Figure 3.2

3.1.3 Great soil groups

GSGs identified from NSW Government mapping (OEH 2014a) and with reference to Isbell (2002) for the West Balranald mine comprise: Solonized Brown Soils; Grey, Brown and Red Clays; and Red Brown Earths. Great soils groups present in the Nepean mine area comprise Solonized Brown Soils and Calcareous Sands.

The following describes the general characteristics of each of these Great Soil Groups:

- **Solonized Brown Soils:** Soils characterised by large amounts of calcareous material in the profile, both in the fine earth fraction and as soft and hard segregations, consisting of calcium and magnesium carbonates, but usually the calcium is predominant.

- **Grey, Brown and Red Clays:** A broad group of soils whose common properties are determined by their high clay contents. Typically, they are moderately deep to very deep soils with uniform colour and texture profiles, weak horizonation mostly related to structure differentiation and some carbonates and/or gypsum in their subsoils. They crack deeply on drying.

- **Red Brown Earths:** The characteristic features of these soils are grey-brown to red-brown loamy A horizons, weakly structured to massive, an abrupt to clear boundary between A and B horizons, and brighter brown to red clay B horizons with well-developed medium prismatic to blocky structure.

- **Calcareous Sands:** Sands with significant calcareous material that show no profile development beyond some accumulation of organic matter in the surface horizon.

3.1.4 SPADE soil profiles

The SPADE soil profile database search identifies information on a number of soils profiles in the greater Balranald area. None of the soil profiles occur either within the project area, within 5 km of the West Balranald mine, or within 7.5 km of the Nepean mine (NSW OEH 2014b). As such, SPADE soil profiles were not examined further.

3.1.5 Inherent soil fertility

The Inherent Fertility of Soils in NSW mapping (based on GSG Classification) (NSW OEH 2013a) identifies soils at the West Balranald mine as having Moderate (3) to Moderately Low (2) fertility. To the west/north-west, soil fertility declines further to Moderately Low (2) to Low (1).

Soil fertility at the Nepean mine is defined as Moderately Low (2) to Low (1).

These fertility rankings are defined by the NSW OEH (2013a) as follows:

- **Moderate (3):** Soils have low to moderate fertilities and usually require fertiliser and/or have some physical restriction for arable use.

- **Moderately Low (2):** Includes soils with low fertilities, such that, generally, only plants suited to grazing can be supported. Large inputs of fertiliser are required to make the soil useable for arable purposes.

- **Low (1):** Includes soils which, due to their poor physical and/or chemical status only support plant growth. The maximum agricultural use of these soils is low intensity grazing.

3.1.6 Biophysical strategic agricultural land

BSAL is land with high quality soil and water resources capable of sustaining high levels of productivity. As of January 2014, there is no BSAL formally recognised by the NSW Government as occurring in the Balranald LGA or surrounding LGAs (NSW DP&E 2014b). A BSAL assessment has been undertaken for the project area and the results are summarised in Section 4 and presented in full in Appendix A.

3.1.7 Land and soil capability classes

The West Balranald mine is mapped in the Land and Soil Capability Mapping of NSW (NSW OEH 2013b) as predominantly LSC Class 5 - Severe limitations with some Class 6 - Very severe limitations. The Nepean mine has predominantly Class 7 - Extremely severe limitations with small areas of Class 5 – Severe limitations and Class 3 – Moderate limitations (NSW OEH, 2013b). LSC class definitions and assessment for the project area is summarised in Section 5 and presented in full in Appendix B.

3.1.8 Hydrologic soil group

The hydrologic soils groups present at the West Balranald mine comprise predominantly D - Very slow infiltration with some C - Slow infiltration. The hydrologic soil groups present in the Nepean mine area are predominantly C -slow infiltration with some D - Very slow infiltration characteristics. NSW OEH (2014c) defines these groups as:

- **C:** soils having slow infiltration rates when thoroughly wetted and consisting chiefly of soils with a layer that impedes downward movement of water, or soils with moderately fine to fine texture. These soils have a slow rate of water transmission.

- **D:** soils having very slow infiltration rates when thoroughly wetted and consisting chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with a claypan or clay layer at or near the surface, and shallow soils over nearly impervious material. These soils have a very slow rate of water transmission.

Table 3.3 Description of Land Systems in the West Balranald and Nepean mine areas[1]

Land System								
Description	**Arumpo**	**Bulgamurra**	**Condoulpe**	**Hatfield**	**Marma**	**Rata**	**Wilkurra**	**Youhl**
General	Parallel dunes and sandplain with narrow calcareous swales.	Extensive undulating sandplain with dunes and open flats.	Sandplain between dunefields and the Riverine Plain near Balranald.	Extensive undulating plains with bluebush.	Ill-defined scalded drainage tracts associated with the Riverine Plain.	Extensive saltbush plain with small subcircular depressions.	Level sandplains with belah.	Relict lakes adjacent to the Riverine Plain.
Geomorphology	Long linear, east-west trending dunes of reworked Quaternary aeolian material with narrow swales and flats merging to level sandplains; dune relief to 7 m.	Slightly undulating sandplain of Quaternary Aeolian material and areas of east-west trending dunes and rises; relief to 6 m; open calcareous flats and scattered swamps and depressions to 500 m diameter.	Sandplain of Quaternary aeolian material with large areas of east-west trending dunes; relief to 5 m; open flats, terminal drainage basins, locally depressed to 2 m.	Undulating sandplain of Quaternary aeolian material, east-west trending dunes, relief to 5 m; depressions of fine-textured alluvium to 500 m wide and depressed to 5 m.	Severely scalded levees, with associated swamps, pans and lunettes; relief to 5 m; associated floodplain of fine-textured Quaternary alluvium and aeolian sandplains.	Relict floodplain of grey, fine-textured Quaternary alluvium with small, shallow sub-circular depressions to 500 m wide; relief to 2 m; isolated low rises of coarse-textured aeolian material.	Sandplain of Quaternary aeolian material with isolated dunes and rises trending east-west, relief to 5 m; small level swales and flats.	Reniform to sub-circular depressions of fine textured Quaternary alluvium to 10 km in diameter; remnant lunettes on eastern margins; relief to 5 m; associated sandy rises.

Table 3.3 Description of Land Systems in the West Balranald and Nepean mine areas[1]

Land System								
Description	**Arumpo**	**Bulgamurra**	**Condoulpe**	**Hatfield**	**Marma**	**Rata**	**Wilkurra**	**Youhl**
Soils and vegetation	Dunes of deep brownish sands and calcareous sands; swales of highly calcareous solonized brown soils and texture-contrast soils; sandplains of solonized brown soils and calcareous red earths; dunes with dense mallee and variable porcupine grass; swales with belah, rosewood and inedible shrubs; variable speargrass, cannon-ball and forbs.	Sandplain of solonized brown soils with clumps of belah, rosewood, scattered wilga and nelia; dunes of deep brownish sands with white cypress pine or mallee and porcupine grass; areas of edible and inedible shrubs, variable speargrass, copperburrs and forbs; depressions of grey cracking clays with fringing black box.	Plain and flats of predominantly solonized brown soils and areas of red earths; dunes of deep brownish sands; drainage basins of grey cracking clays; generally dense to scattered belah and mallee; areas of dense edible chenopods; drainage basins of dense black box, nitre goosefoot and dillon bush; variable speargrass, annual saltbushes and forbs.	Plains of solonized brown soils, red and brown texture-contrast soils and red earths with scattered clumps of rosewood and belah; moderately dense bluebushes and bladder saltbush; dunes of deep brownish sands with clumped white cypress pine, prickly wattle and bluebushes; depressions of grey clays with nitre goosefoot, dillon bush and canegrass.	Levees of red and yellow texture-contrast soils and grey cracking clays; sandplains and lunettes of solonized brown soils and red texture-contrast soils; floodplains of grey cracking clays; scattered to dense bluebushes, bladder saltbush and old man saltbush; canegrass in swamps; abundant forbs, copperburrs and annual saltbushes.	Plains of grey cracking clays and compact clays with dense stands of bladder saltbush; canegrass and nitre goosefoot in depressions; black bluebush, scattered belah and rosewood on sandy rises; abundant annual saltbushes, copperburrs, annual forbs and grasses.	Plains and flats with highly calcareous solonized brown soils; dunes with deep brownish sands; uniformly dense stands of belah and rosewood, scattered mulga, wilga and inedible shrubs; white cypress pine on sandy rises; variable speargrass, copperburrs and forbs.	Lakebeds of grey cracking clays and red texture-contrast soils; lunettes of saline or compact clays, or calcareous red earths; sandy rises of earthy sands and red earths; lakebeds treeless with dense bladder saltbush and bluebushes, scattered Dillon bush, nitre goosefoot and old man saltbush; lunettes of scattered bluebush; perennial grasses, copperburrs and annual saltbushes.
Erosion	Minor to moderate windsheeting.	Minor to moderate windsheeting and drift.	Minor to moderate windsheeting and scalding.	Moderate scalding on plain; slight drift on sandy rises.	Severe scalding and watersheeting.	Minor scalding on plains; minor windsheeting on rises.	Minor windsheeting and drift.	Moderate to severe scalding on lakebeds; gullying and rilling of lunettes.

Notes: 1.From Walker (1991).

3.2 Soil survey methodology

3.2.1 Background

Soil surveys of the project area were previously undertaken for the *Balranald Project Prefeasibility Study Soils and Land Capability Assessment* (GSS Environmental 2013). Since the survey was undertaken, the OEH's guideline *Land and soil capability assessment scheme – second approximation* (NSW OEH 2012), was introduced. The requirements of these guidelines were subsequently addressed in the field survey undertaken by EMM as described below.

3.2.2 Field survey

A field survey of approximately 4,000 ha of the project area, predominantly at the West Balranald and Nepean mines was undertaken by Sunraysia Environmental on behalf of EMM between 24 June and 30 July 2014.

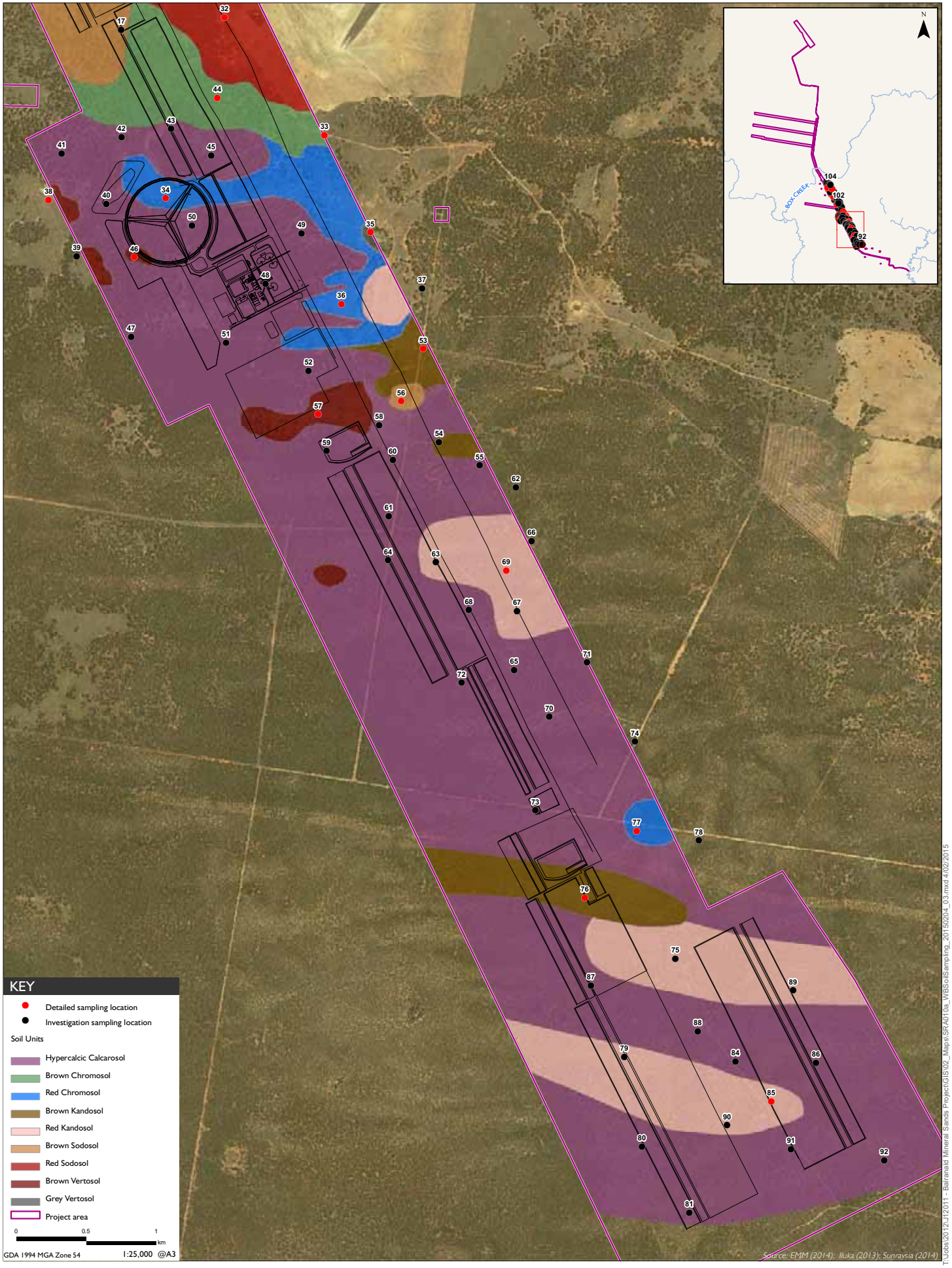
For a soil survey at 1:25,000, NCST (2008) recommends one soil description per 5 to 25 ha. The soil survey was conducted at one soil description per 25 ha, equivalent to 129 soil descriptions across the two mine areas (95 locations at the West Balranald mine, 34 locations at the Nepean mine). Of the 129 locations, 38 (25%) were described in full and 97 locations (75%) were described to a lesser level of detail (termed investigation sites). For the 38 locations described in full:

- Up to eight sub-samples were collected down hole at each of 38 locations (≤256 subsamples in total) to a depth of 750mm. Half of the sub-samples were submitted for laboratory analysis (≤128 subsamples from 16 locations).
- Soils were sampled to a maximum depth of 750 mm for investigation sites. Check sites had a lower level of description than the full sites. No sub-sampling was undertaken for investigation sites.
- Soils were classified to type (order) and variant (sub-order) level using the Australian soil classification system (Isbell 2002).

Figure 3.3 and Figure 3.4 show the sample locations for the West Balranald mine and the Nepean mine respectively.

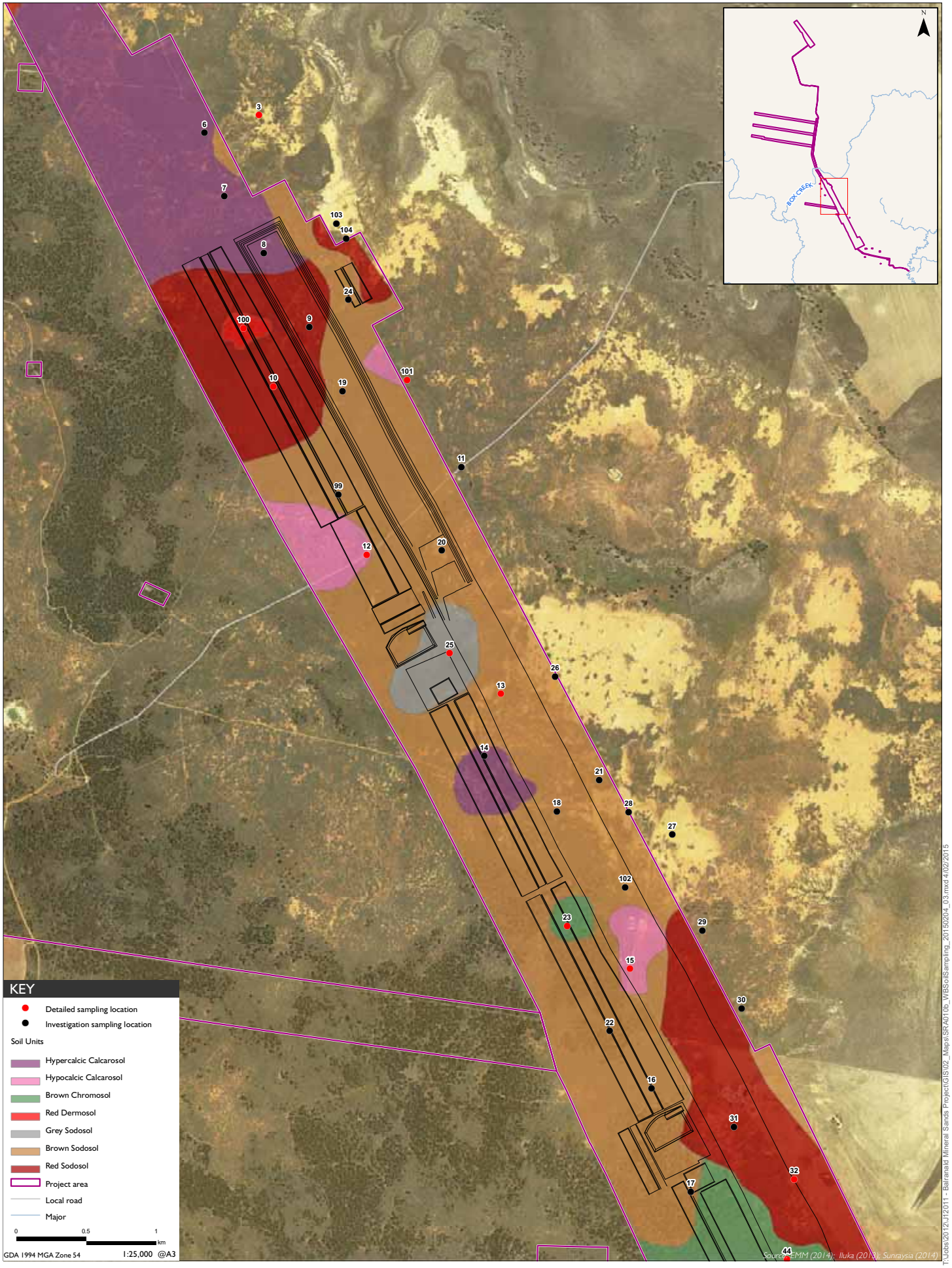
Soil sampling was carried out primarily using a 4WD-mounted push tube machine. This method created a typical disturbance area of approximately 300 x 300 mm to a depth of 750 mm, with an additional surface area disturbed to a lesser extent by the vehicle footprint. Sampling was undertaken using a hand auger in 17 locations to minimise disturbance, with sample depth to 750 mm. Soil core holes were backfilled immediately upon completion of field assessment. A 'free' survey method was used.

Field observations were recorded (including GPS locations) and SALIS data completed and submitted to OEH. Soils are described with photographs in Section 3.3. Soil profiles were assessed in accordance with the *Australian Soil and Land Survey Handbook* (NCST 2009).



West Balranald soil sampling locations and soil types

Balranald Mineral Sands Project
Soil Resource Assessment
Figure 3.3a

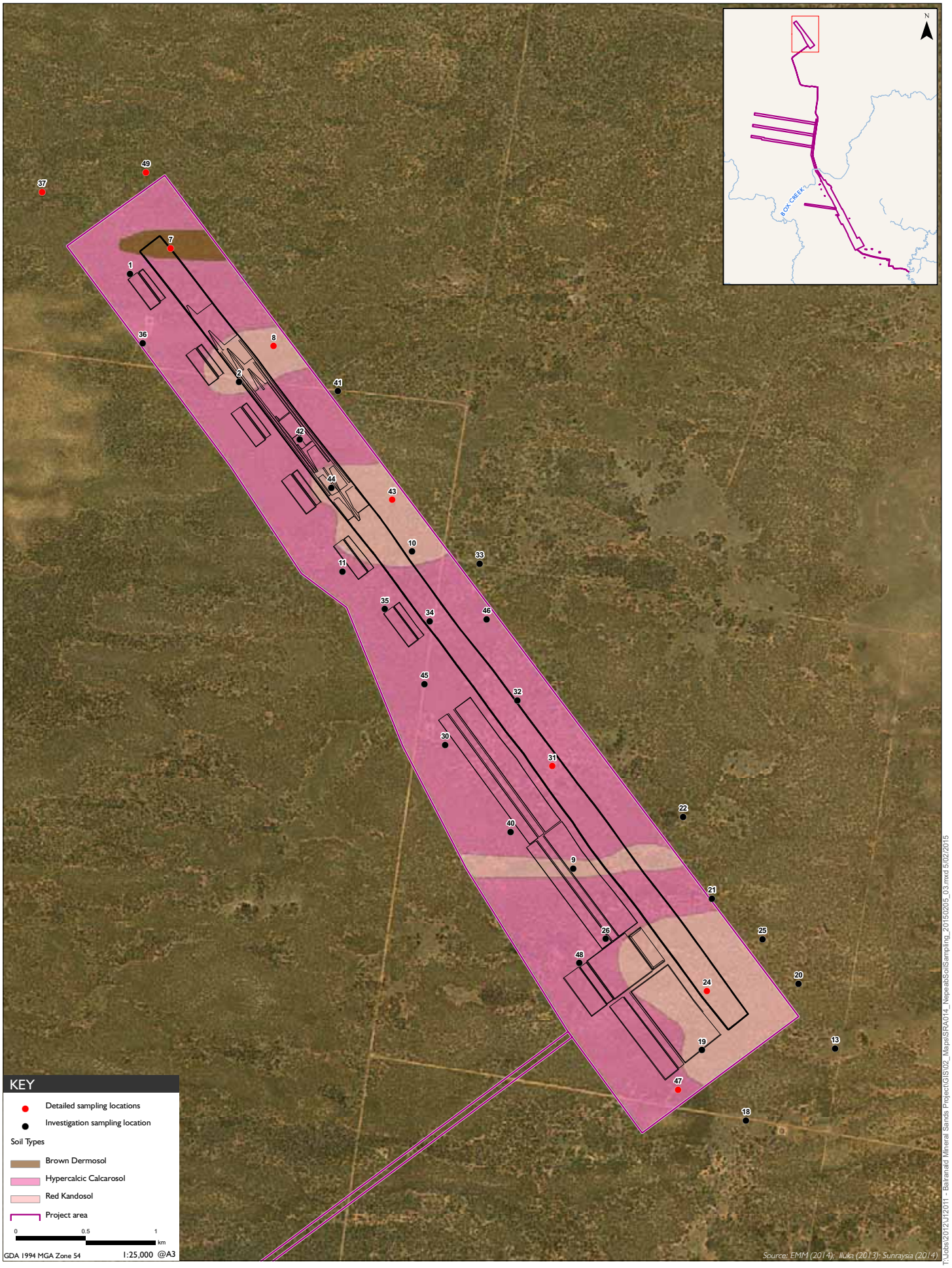


West Balranald soil sampling locations and soil types

Balranald Mineral Sands Project

Soil Resource Assessment

Figure 3.3b



Nepean soil sampling locations and soil types

Balranald Mineral Sands Project

Soil Resource Assessment

Figure 3.4

3.2.3 Laboratory soil testing

Soil samples collected during the field survey were analysed between 22 August and 23 September 2014 at ALS Environmental, Springvale, Victoria (a NATA laboratory) for the following parameters:

- pH (1:5)($CaCl_2$);
- electrical conductivity (EC) at 25^oC;
- moisture content (%, dried at 103^oC);
- exchangeable cations (calcium, magnesium, sodium and potassium) (Ca, Mg, Na, K) and cation exchange capacity (CEC) (%);
- exchangeable sodium percentage (ESP) (%);
- sulfate as SO_4^{2-};
- chloride (Cl); and
- organic carbon (OC) and organic matter (%).

These results were used in conjunction with field observations to calculate:

- calcium:magnesium ratio (Ca:Mg);
- plant available water content (PAWC); and
- EC saturation extract (EC_{SE}).

3.3 Survey results

The soil survey identified six soil types (or orders) at West Balranald corresponding with 12 soil colour variations (sub-orders) (Figure 3.3). This is consistent with the significant transition in landscape and vegetation from south to north within the project area. The soil types identified comprise:

- Calcarosols (Hypocalcic and Hypercalcic);
- Chromosols (Red);
- Dermosols (Red);
- Kandosols (Red and Brown);
- Sodosols (Red, Brown and Grey); and
- Vertosols (Brown and Grey).

The Nepean mine was found to be more homogenous than West Balranald with only three soil types and three variants identified (Figure 3.4). The soil types comprised Calcarosols (Hypercalcic), Dermosols (Brown) and Kandosols (Red).

Hypercalcic Calcarosols are the dominant soil type at both the West Balranald (48.9%) and Nepean mines (75.4%). Red Kandosol is the second most extensive soil type in the Nepean mine area (22.8%), with Brown Sodosol being the second most common in the West Balranald mine area (21.4%). Red Dermosol (0.2%) and Grey Vertosol (0.04%) are the least extensive soil types found across the mine areas (Table 3.4).

The West Balranald mine area is characterised by dense Whipstick Mallee in the south (associated with Calcarasols), interspersed with ridges of Spinifex Mallee (Kandosols). This trends to Calcarosol rises (Mallee) and Vertosol swales with gilgai (bluebush) on the western side of the mid section of the mine area. Gentler slopes with belah and bluebush characterise the east of the mid section (Chromosols) of the West Balranald mine area, trending to the Sodosols of the bluebush plains interspersed with small patches of timber.

The Calcarosols in the Nepean mine area and in the southern part of West Balranald (ie Pine Lodge and southern part of Hughdale) have a greater depth above the calcareous horizon than those in the mid and northern section of the West Balranald mine area.

Table 3.4 Great soil groups, land systems, soil types and areas

Great Soil Groups associated with ASC order[1]	Land systems[2]	ASC order (Soil type)	ASC sub-order (Variant)	Total area mapped within project boundary[3]	
				(ha)	(%)
West Balranald mine area					
Solonised brown soils, grey-brown and red calcareous soils	Rata	Calcarosol	Hypocalcic	51.35	1.72
	Condoulpe, Hatfield, Rata		Hypercalcic	1,463.73	48.96
Non-calcic brown soils, some red-brown earths and a range of podzolic soils	Condoulpe, Hatfield	Chromosol	Red	87.17	2.92
			Brown	85.99	2.88
Prairie soils, chocolate soils, some red and yellow podzolic soils	Rata	Dermosol	Red	6.11	0.20
Red, yellow and grey earths, calcareous red earths	Condoulpe, Hatfield	Kandosol	Red	236.79	7.92
	Condoulpe		Brown	76.03	2.54
Solodized solonetz and solodic soils, some soloths and red-brown earths, desert loams	Rata	Sodosol	Red	273.21	9.14
	Condoulpe, Marma		Brown	641.00	21.44
	Rata		Grey	34.02	1.14
Black earths, grey, brown and red clays	Condoulpe	Vertosol	Brown	32.68	1.09
	Hatfield		Grey	1.30	0.04
Total				**2,989.37**	

Table 3.4 Great soil groups, land systems, soil types and areas

Great Soil Groups associated with ASC order[1]	Land systems[2]	ASC order (Soil type)	ASC sub-order (Variant)	Total area mapped within project boundary[3]	
				(ha)	(%)
Nepean mine area					
Solonised brown soils, grey-brown and red calcareous soils	Wilkurra	Calcarosol	Hypercalcic	607.62	75.48
Prairie soils, chocolate soils, some red and yellow podzolic soils	Arumpo	Dermosol	Brown	13.24	1.64
Red, yellow and grey earths, calcareous red earths	Arumpo, Bulgamurra, Wilkurra	Kandosol	Red	184.15	22.88
Total				**805.01**	

Notes: 1. From Isbell (2002), Appendix 5.

2. No soil was sampled from the Youhl land system.

3. Not all of each mine area was mapped for soil type, hence totals are less than that presented in Section 3.1.2.

Tables identifying exceedance of soil sufficiency criteria for ESP, CEC, EC_{SE}, pH, sulfate, chloride and organic matter are presented in Section 4 and Appendix B (as sourced from the BSAL interim protocol and the LSC assessment scheme). Soil chemistry for each identified soil type is summarised below and laboratory data for soil samples are attached as Appendix C.

3.3.1 Calcarosols

Calcarosols are defined as soils that are either calcareous throughout the solum (or at least directly below the A1 horizon or at a depth of 0.2 m, whichever is shallower) and do not have clear or abrupt textural B horizons. The calcium carbonate can either be in the form of carbonate segregations or fine earth. The carbonate must have resulted from soil forming processes.

The two Suborders present are defined for differentiation purposes as follows:

- **Hypocalcic Calcarosols :** calcarosols in which the carbonate is evident only as a slight to moderate effervescence to 1M HCl, and or contains less than 2% soft finely divided carbonate and have less than 20% hard carbonate nodules or concretions (Isbell 2002).

- **Hypercalcic Calcarosols :** calcarosols with a calcareous horizon containing more than 20% of mainly soft, finely divided carbonate, and 0-20% of hard calcrete fragments and/or carbonate nodules or concretions and/or carbonate coated gravel (Isbell 2002).

In the West Balranald mine area, Calcarosols are present in all but the lowest topographical sites and are associated with the chenopod Mallee, the fringes of the swales and flats and with belah, Mallee and Rosewood vegetation.

In the Nepean mine area, Calcarosols are present in all topographical locations and associated with all vegetation types except the Spinifex Mallee.

Characteristic of the Woorinen formation and the most common soils in the Mallee, Calcarosols lack strong texture contrast between surface (A) and subsoil (B) horizons. Formed on calcareous, aeolian sediments of variable texture, these soils can be calcareous throughout and often have accumulations of calcium carbonate (lime) in the soil profile. These soils generally have a small, gradual increase in clay content with depth. Lime is abundant in the subsoils either in soft form, in nodules or as blocks and it may extend to the surface of medium to heavy textured soils.

The pH tends to be highly alkaline; however the upper horizons in sands may only be weakly alkaline. Sodicity and salinity levels are usually high in the heavier subsoils. The Calcarosols in the Mallee region vary quite considerably in terms of soil texture. The two Suborders found in the project area are described below.

i Hypocalcic Calcarosols

Hypocalcic Calcarosols are present in the West Balranald mine area (Photograph 3.1). In the West Balranald mine area these soils are moderately alkaline with generally non-restrictive levels of chloride in the B2 horizon. All horizons are strongly sodic and have a low to very low CEC. Low to very low levels of organic matter occur in the A1 horizon declining with depth (Photograph 3.2).

A soil profile description for a typical Hypocalcic Calcarosol is provided in Table 3.5. It is noted that the laboratory pH values presented in Table 3.5 are a median value.

Soil chemistry results for the Hypocalcic Calcarosols is presented as Table 3.6. The results presented are the median value for each horizon from full description sites where samples for laboratory analysis were taken. Table 3.6

also shows the lowest and highest recorded values in brackets. Appendix C presents individual soil chemistry results for each full description site where samples for laboratory analysis were taken. The soil chemistry constituent values highlighted in the 'soil sufficiency' column in Table 3.6 are agricultural industry benchmarks (Baker and Eldershaw 1993, DERM 2011 and Previll, Sparrow and Reuter 1999) and have been referenced in interpreting the laboratory results. The outcomes are presented in the comments column of Table 3.7. The comments are in reference to the median values with increasing depth.

Photograph 3.1 **West Balranald Hypocalcic Calcarosol (site 12 facing east)**

Photograph 3.2 **West Balranald Hypocalcic Calcarosol (site 12 profile)**

Table 3.5 **Hypocalcic Calcarosol typical physical characteristics summary**

Horizon name and depth (average) (m)	Colour, mottles and bleach	Moisture, laboratory pH (median) and drainage	Texture and structure	Coarse fragments, segregations and roots
A1 0.0-0.16	Dark brown and no mottles.	Dry, pH 7.8 and well drained.	Sandy loam and granular.	No surface rock, few coarse fragments, no segregations and few roots.
A2 0.16-0.30	Brown and no mottles.	Dry, pH 8.1 and well drained.	Sandy loam and granular.	Common coarse fragments, no segregations and few roots.
B1 0.30-0.36	Brown and no mottles.	Dry, pH 8.3 and well drained.	Sandy clay loam and granular.	Common coarse fragments, few calcareous segregations and few roots.
B2 0.36-0.64	Brown and no mottles.	Dry, pH 8.3 and moderately well drained.	Clay loam and sub-angular blocky.	Common coarse fragments, few calcareous segregations and no roots.

Table 3.6 Hypocalcic Calcarosol typical soil chemical profile summary

Constituents	Unit	Soil sufficiency[1]	A1 0.0-0.16	A2 0.16-0.30	B1 0.30-0.36	B2 0.36-0.64	Comments on medians (in increasing depth)
pH	pH units	6.0-7.5	7.80 (7.70-8.00)	8.10 (8.10-8.10)	8.30 (8.00-8.50)	8.30 (8.30-8.60)	Moderately alkaline
EC_{se}	dS/m	<1.9	1.43 (1.41-1.55)	0.98 (0.98-0.98)	2.16 (1.68-7.10)	8.19 (8.19-8.19)	Medium (A horizon) to very high soil salinity (B horizon).
Cl^-	mg/kg	<800	40 (<10-120)	<10 (<10)	90 (50-910)	360 (360-950)	Not restrictive.
PAWC	mm	>80	8.0 (SL-SL)	7.0 (SL-ZL)	3.6 (L-CLS)	22.4 (SCL-LC)	Low (total of 41.0).
CEC	meq/ 100g	12-25	9.40 (1.60-17.20)	<0.1 (<0.1)	2.50 (1.10-11.20)	4.80 (4.80-6.70)	Low to very low
Ca	meq/ 100g	>5	28.80 (11.30-30.30)	28.50 (28.50)	27.10 (26.20-29.00)	26.30 (26.30-26.40)	Very high
Mg	meq/ 100g	>1	4.30 (1.80-12.60)	3.00 (3.00)	7.20 (5.10-8.60)	0.30 (7.30-11.00)	High (A horizon andB1 horizon) to low.
Na	meq/ 100g	<0.7	0.30 (<0.1-9.20)	<0.1 (<0.1)	1.00 (0.40-4.40)	1.70 (1.70-2.70)	Low (A horizon) to high.
K	meq/ 100g	>0.3	1.10 (0.90-1.40)	0.70 (0.70)	1.20 (0.40-1.20)	0.30 (0.30-0.70)	High (A horizon andB1 horizon) to low.
ESP	%	<6	31.60 (17.30-53.20)	32.20 (32.20)	39.00 (33.00-39.00)	35.80 (35.80-40.70)	Very strongly sodic (all horizons).
Ca:Mg ratio		>2	2.63 (2.40-16.00)	9.50 (9.50)	3.64 (3.37-5.31)	2.39 (2.39-3.62)	Unfavourable for dispersion (refer comment in Table 3.7).
OC	%	>1.2	0.60 (0.50-1.00)	0.70 (0.70)	<0.50 (<0.50)	<0.50 (<0.50)	Very low

Notes: *1. Plant sufficiency sources: Baker and Eldershaw 1993, DERM 2011 and Previll, Sparrow and Reuter, 1999.*

2. Values in brackets are the ranges measured.

*3. *these values are an approximation based on calculations using the lowest measurable level.*

Table 3.7 Hypocalcic Calcarosol soil chemistry summary

Elements	Comments
pH	Moderately alkaline throughout the profile. Would not restrict cropping (some amelioration required).
EC	Low salinity levels in the upper profile that increase through medium to very high in the lower profile. Soil salinity in the lower profile is well outside of the desirable range for plant growth. Would severely restrict cropping.
Chloride	Acceptable chloride levels that would not restrict cropping.
PAWC	At the lower limit of a low PAWC, this would severely restrict dryland cropping.
Fertility	
CEC	Low to very low CEC that would present some fertility issues and affect fertiliser application rates.
Fertility Ranking	**Relative Fertility of ASC Classes (NSW Government 2013):** Low to Moderately low (1 or 2) **EMM applied Relative Fertility of ASC Classes (Lab and field data applied to Murphy et al 2007):** Low to Moderately low **Explanation:** Low fertilities that generally only support plants suited to grazing. Generally likely to be deficient in nitrogen, phosphorus and many other elements with poor physical properties. Large inputs of fertiliser would be required.
ESP	Very strongly sodic soil, which would cause severe restriction to cropping.
Ca:Mg ratio	A stable Ca:Mg ratio throughout the profile normally suggests strong soil stability. Calcareous segregations are present in the soil in insoluble form. This will skew the Ca:Mg ratio. This result is therefore inconclusive but it is likely that the dispersibility is high given the highly elevated level of sodicity.
OC	Indicative of poor structural condition.
Major limitations to agriculture	EC PAWC ESP OC

ii Hypercalcic Calcarosols

Hypercalcic Calcarosols are present in both the West Balranald (Photograph 3.3) and Nepean mine areas (Photograph 3.4). These soils are neutral to alkaline and are very sodic throughout the soil profile. They have a moderate to high CEC ranking due to the presence of calcium. Chloride concentrations are restrictive in the B2 horizon. Hypercalcic Calcarosols in the West Balranald mine area have low organic matter in the A horizon declining with depth (Photograph 3.5). These soils in the Nepean mine area also have low organic matter in the A horizon also declining further with depth (Photograph 3.6).

A soil profile description for a typical Hypercalcic Calcarosol is provided in Table 3.8. It is noted that the laboratory pH values presented in Table 3.8 are a median value.

Soil chemistry results for the Hypercalcic Calcarosols is presented as Table 3.9. The results presented are the median value for each horizon from full description sites where samples for laboratory analysis were taken. Table 3.9 also shows the lowest and highest recorded values in brackets. Appendix C presents individual soil chemistry results for each full description site where samples for laboratory analysis were taken. The soil chemistry constituent values highlighted in the 'soil sufficiency' column in Table 3.9 are agricultural industry benchmarks (Baker and Eldershaw 1993, DERM 2011 and Previll, Sparrow and Reuter 1999) and have been referenced in interpreting the laboratory results. The outcomes are presented in the comments column of Table 3.10. The comments are in reference to the median values with increasing depth.

Photograph 3.3 **West Balranald Hypercalcic Calcarosol (site 6 facing east)**

Photograph 3.4 **Nepean Hypercalcic Calcarosol (site 31 facing west)**

Photograph 3.5 **West Balranald Hypercalcic Calcarosol (site 6 profile to 750 mm)**

Photograph 3.6 **Nepean Hypercalcic Calcarosol (site 31 profile to 750 mm)**

Table 3.8 **Hypercalcic Calcarosol typical physical characteristics summary**

Horizon name and depth (average) (m)	Colour, mottles and bleach	Moisture, laboratory pH (median) and drainage	Texture and structure	Coarse fragments, segregations and roots
A1 0.0-0.14	Dark brown and no mottles.	Dry, pH 7.8 and well drained.	Sandy loam and granular.	No surface rock, few coarse fragments, no segregations and few roots.
A2 0.14-0.30	Brown and no mottles.	Dry, pH 8.1 and well drained.	Sandy loam and granular.	Minor coarse fragments, no segregations and few roots.
B1 0.30-0.45	Brown and no mottles.	Dry, pH 8.3 and well drained.	Sandy clay loam and sub-angular blocky.	Common coarse fragments, very few calcareous segregations and few roots.
B2 0.45-0.75	Light brown and no mottles.	Dry, pH 8.5 and well drained.	Sandy clay loam and sub-angular blocky.	Common coarse fragments, very few calcareous segregations and no roots.

Table 3.9 Hypercalcic Calcarosol typical soil chemical profile summary

Constituents	Unit	Soil sufficiency[1]	A1 0.0-0.14	A2 0.14-0.30	B1 0.30-0.45	B2 0.45-0.75	Comments on medians (in increasing depth)
pH	pH units	6.0-7.5	7.90 (6.50-8.00)	8.05 (7.90-8.30)	8.30 (7.80-8.50)	8.50 (8.10-8.60)	Moderately alkaline
EC_{se}	dS/m	<1.9	1.07 (0.24-1.44)	2.20 (0.82-5.43)	4.20 (1.08-9.20)	13.35 (1.22-13.35)	Medium (A horizon) to extreme soil salinity (B horizon).
Cl^-	mg/kg	<800	20 (10-20)	100 (30-290)	380 (30-1070)	580 (10-2510)	Not restrictive near surface; may be restrictive at depth.
PAWC	mm	>80	7.0 (SL-SCL)	8.0 (SL-SCL)	9.0 (SL-LC)	18.0 (SCL-LMC)	Low (total of 42.0).
CEC	meq/ 100g	12-25	0.10 (<0.10-10.80)	0.95 (<0.10-4.90)	3.40 (1.00-9.90)	9.10 (4.90-10.00)	Very low to low (lower B horizon).
Ca	meq/ 100g	>5	29.05 (3.70-32.60)	28.80 (12.40-31.80)	28.10 (4.70-30.00)	24.70 (23.30-25.30)	Very high
Mg	meq/ 100g	>1	2.60 (1.20-12.30)	2.95 (2.60-8.80)	5.75 (4.70-8.80)	10.70 (7.50-11.50)	High (A horizon and B1 horizon) to very high.
Na	meq/ 100g	<0.7	<0.1 (<0.1-5.10)	0.35 (<0.10-0.80)	1.15 (0.4-1.70)	3.40 (1.70-4.20)	Very low (upper A horizon) to very high.
K	meq/ 100g	>0.3	0.8 (0.50-1.00)	0.65 (0.20-1.10)	0.55 (0.20-1.30)	0.40 (0.30-1.20)	Moderate
ESP	%	<6	33.15 (5.40-47.50)	33.05 (17.20-34.80)	34.95 (13.00-40.80)	37.80 (34.80-41.50)	Very strongly sodic (all horizons).
Ca:Mg ratio		>2	9.38 (2.39-20.50)	9.68 (3.88-11.78)	4.87 (0.81-5.98)	2.18 (2.15-3.37)	Unfavourable for dispersion (refer comment in Table 3.10).
OC	%	>1.2	0.75 (<0.50-1.40)	0.85 (<0.50-1.40)	<0.50 (<0.50-0.60)	<0.50 (<0.50-<0.50)	Low (A horizon) to very low (B horizon).

Notes: *1. Plant sufficiency sources: Baker and Eldershaw 1993, DERM 2011 and Previll, Sparrow and Reuter, 1999.*

2. Values in brackets are the ranges measured.

*3. *these values are an approximation based on calculations using the lowest measurable level.*

Table 3.10 Hypercalcic Calcarosol soil chemistry summary

Elements	Comments
pH	Moderately alkaline throughout the profile. Would not restrict cropping (some amelioration required).
EC	Low to medium salinity levels in the upper profile that increase to extreme levels in the lower profile. Soil salinity in the lower profile is outside of the desirable range for plant growth. Would severely restrict cropping.
Chloride	Acceptable chloride levels that would not restrict cropping however may be restrictive at depth).
PAWC	At the lower limit of a low PAWC, this would severely restrict dryland cropping.
Fertility	
CEC	Very low to low CEC that may present some fertility issues and affect fertiliser application rates.
Fertility Ranking	**Relative Fertility of ASC Classes (NSW Government 2013):** Low to Moderately low (1 or 2) **EMM applied Relative Fertility of ASC Classes (Lab and field data applied to Murphy et al 2007):** Low to Moderately low **Explanation** Low fertilities that generally only support plants suited to grazing. Generally likely to be deficient in nitrogen, phosphorus and many other elements with poor physical properties. Large inputs of fertiliser would be required.
ESP	Very strongly sodic soil, which would cause severe restriction to cropping.
Ca:Mg ratio	A stable Ca:Mg ratio throughout the profile normally suggests strong soil stability. Calcareous segregations are present in the soil in insoluble form. This will skew the Ca:Mg ratio. This result is therefore inconclusive but it is likely that the dispersibility is high given the highly elevated level of sodicity.
OC	Indicative of poor structural condition.
Major limitations to agriculture	EC PAWC ESP OC

3.3.2 Chromosol

Chromosols are texture contrast soils with a sandy or loamy surface horizon overlying a clay-textured B horizon. The subsoil (B) horizon is not strongly acid (pH greater than 5.5) and it is non-sodic throughout the profile. The structure of the subsoil ranges from massive to strongly structured and the B horizon is often brightly coloured. The variants (Suborders) of Chromosols are defined by the dominant colour class in the major part of the upper 200 mm of the B2 horizon (or the major part of the entire B2 horizon if it is less than 200 mm thick) (Isbell 2002). These soils generally have good soil physical properties but can become hard-setting after long periods of cropping. Some Chromosols have bleached subsurface (A2) horizons indicating poor internal drainage and seasonal waterlogging. Chromosol variants usually allow for better root and water movement compared to dispersive Sodosols.

Chromosols are a minor soil type in the West Balranald mine area (Photograph 3.7). The variant of Chromosol present in the West Balranald mine area is Red. Chromosols are not present in the Nepean mine area.

The Chromosol A1 and B horizons in the West Balranald mine area are neutral to moderately alkaline and non-sodic. The B horizons rank highly for CEC and chloride is not restrictive at depth. The soil has low levels of organic matter in the A1 horizon declining further with depth (Photograph 3.8).

A soil profile description for a typical Chromosols is provided in Table 3.11. It is noted that the laboratory pH values presented in Table 3.11 are a median value.

Soil chemistry results for Chromosols are presented as Table 3.12. The results presented are the median value for each horizon from full description sites where samples for laboratory analysis were taken. Table 3.12 also shows the lowest and highest recorded values in brackets. Appendix C presents individual soil chemistry results for each full description site where samples for laboratory analysis were taken. The soil chemistry constituent values highlighted in the 'soil sufficiency' column in Table 3.12 are agricultural industry benchmarks (Baker and Eldershaw 1993, DERM 2011 and Previll, Sparrow and Reuter 1999) and have been referenced in interpreting the laboratory results. The outcomes are presented in the comments column of Table 3.13. The comments are in reference to the median values with increasing depth.

Photograph 3.7 **West Balranald Chromosol (site 77 facing east)**

Photograph 3.8 **West Balranald Chromosol (site 77 profile to 700 mm)**

Table 3.11 Chromosol typical physical characteristics summary

Horizon name and depth (average) (m)	Colour, mottles and bleach	Moisture, laboratory pH (median) and drainage	Texture and structure	Coarse fragments, segregations and roots
A1 0.0-0.10	Dark brown and no mottles.	Dry, pH 7.4 and imperfectly drained.	Sandy loam and granular	No surface rock, few coarse fragments, no segregations and common roots.
B1 0.10-0.35	Dark reddish brown and no mottles.	Dry, pH 7.6 and imperfectly drained.	Sandy clay loam and sub-angular blocky	Few coarse fragments, no segregations and few roots.
B2 0.35 -0.70	Brown and no mottles.	Dry, pH 7.9 and imperfectly drained.	Light clay and angular blocky	Few coarse fragments, no segregations and no roots.

Table 3.12 Chromosol typical soil profile summary

Constituents	Unit	Soil sufficiency[1]	A1 0.0-0.10	B1 0.10-0.35	B2 0.35-0.70	Comments on medians (in increasing depth)
pH	pH units	6.0-7.5	7.4	7.6	7.9	Mildly alkaline
EC_{se}	dS/m	<1.9	1.05	0.89	1.35	Low soil salinity
Cl^-	mg/kg	<800	<10	20	20	Not restrictive
PAWC	mm	>80	5.0 (SL)	15.0 (SCL)	35.0 (LC)	Low (total of 55.0)
CEC	meq/ 100g	12-25	20.1	16.0	21.7	Moderate capacity
Ca	meq/ 100g	>5	15.4	12.0	18.6	High
Mg	meq/ 100g	>1	3.6	3.0	2.6	High (A horizon andB1 horizon) to moderate.
Na	meq/ 100g	<0.7	<0.1	0.1	<0.1	Very low
K	meq/ 100g	>0.3	1.1	1.0	0.4	High (A1 horizon andB1 horizon) to moderate.
ESP	%	<6	0.2	0.8	0.2	Non-sodic
Ca:Mg ratio		>2	4.28	4.00	7.15	Unfavourable for dispersion
OC	%	>1.2	1.6	1.2	<0.5	Moderate (A1 horizon andB1 horizon) to very low.

Notes: *1. Plant sufficiency sources: Baker and Eldershaw 1993, DERM 2011 and Previll, Sparrow and Reuter, 1999.*

2. Values in brackets are the ranges measured.

*3. *these values are an approximation based on calculations using the lowest measurable level.*

Table 3.13 Chromosol soil chemistry summary

Elements	Comments
pH	Mildly alkaline. Would not restrict cropping (some amelioration required).
EC	Low salinity levels throughout the profile, with a band of very low salinity in the B1 horizon. Soil salinity in the lower profile is inside of the desirable range for plant growth. Would not restrict cropping.
Chloride	Acceptable chloride levels. Would not restrict cropping.
PAWC	A low PAWC, which would restrict cropping.
Fertility	
CEC	Acceptable CEC.
Fertility Ranking	**Relative Fertility of ASC Classes (NSW Government 2013):** Moderately low (2) **EMM applied Relative Fertility of ASC Classes (Lab and field data applied to Murphy et al 2007):** Moderately low **Explanation:** Low fertilities that generally only support plants suited to grazing. Generally deficient in nitrogen, phosphorus and many other elements with generally poor physical properties.
ESP	Non- Sodic soils
Ca:Mg ratio	A stable Ca:Mg ratio throughout the profile normally suggests strong soil stability.
OC	Indicative of average structural condition.
Major limitations to agriculture	PAWC

3.3.3 Dermosol

Dermosols are present in both the West Balranald (Photograph 3.9) and Nepean mine areas (Photograph 3.10). Dermosols are soils that have B2 horizons with a structure more developed than weak throughout the major part of the horizon and do not have clear or abrupt textural B horizons (Photograph 3.9 and Photograph 3.10). Commonly found in the wetter areas in the arid zone, these clayey soils are relatively high in salt and tend to have strong, fine blocky structure.

Dermosols in the West Balranald mine area are a minor soil type (Photograph 3.11) and can be associated with chenopod shrub land. This soil type is located within the Nepean mine area in woodland with shrub understorey (Photograph 3.12). Variants are defined by the dominant colour class in the major part of the upper 500 mm of the B2 horizon (or the major part of the entire B2 horizon if it is less than 500 mm thick) (Isbell 2002). Red Dermosol was identified at West Balranald and a Brown variant at Nepean.

Brown Dermosol in the Nepean mine area has a slightly alkaline A horizon and a moderately alkaline B horizon. The soil is very sodic and has a high ranking for EC. Chloride is highly variable from not restrictive to highly restrictive and organic matter is very low.

A soil profile description for a typical Dermosol is provided in Table 3.14. It is noted that the laboratory pH values presented in Table 3.14 are a median value.

Soil chemistry results for Dermosol are presented as Table 3.15. The results presented are the median value for each horizon from full description sites where samples for laboratory analysis were taken. Table 3.15 also shows the lowest and highest recorded values in brackets. Appendix C presents individual soil chemistry results for each full description site where samples for laboratory analysis were taken. The soil chemistry constituent values highlighted in the 'soil sufficiency' column in Table 3.15 are agricultural industry benchmarks (Baker and Eldershaw 1993, DERM 2011 and Previll, Sparrow and Reuter 1999) and have been referenced in interpreting the laboratory results. The outcomes are presented in the comments column of Table 3.16. The comments are in reference to the median values with increasing depth.

Photograph 3.9 West Balranald Dermosol (site 100 profile to 750 mm)

Photograph 3.10 Nepean Dermosol (site 7 profile to 750 mm)

Photograph 3.11 West Balranald Dermosol (site 100 facing north)

Photograph 3.12 Nepean Dermosol (site 7 facing east)

Table 3.14 Dermosol typical physical characteristics summary

Horizon name and depth (average) (m)	Colour, mottles and bleach	Moisture, laboratory pH (median) and drainage	Texture and structure	Coarse fragments, segregations and roots
A1 0.0-0.13	Dark brown and no mottles.	Dry, pH 7.1 and moderately well drained.	Sandy clay loam and granular.	No surface rock, few coarse fragments, no segregations and few roots.
B1 0.13-0.46	Strong brown and no mottles.	Dry, pH 8.5 and moderately well drained.	Clay loam sandy and sub-angular blocky.	Few coarse fragments, no segregations and few roots.
B2 0.46-0.75	Strong brown and no mottles.	Dry, pH 8.3 and moderately well drained.	Light clay and sub-angular blocky.	Few coarse fragments, no segregations and no roots.

Table 3.15 Dermosol typical soil profile summary

Constituents	Unit	Soil sufficiency[1]	A1 0.0-0.13	B1 0.13-0.46	B2 0.46-0.75	Comments on medians (in increasing depth)
pH	pH units	6.0-7.5	7.10 (6.00-8.20)	8.45 (7.90-9.00)	8.30	Neutral (A horizon) to moderately alkaline (B horizon).
EC_{se}	dS/m	<1.9	1.01 (0.76-1.25)	10.68 (3.36-18.00)	4.80	Low (A horizon) to very high (B2 horizon) to high soil salinity (B2 horizon).
Cl^-	mg/kg	<800	65 (30-100)	1985 (<50-3920)	440	Acceptable (A + lower B horizons) to Restrictive (upper B horizon).
PAWC	mm	>80	7.8 (LS-SCL)	26.4 (SL-CLS)	29.0 (LC-LC)	Low (total of 63.2).
CEC	meq/ 100g	12-25	9.90 (7.70-12.10)	29.35 (5.10-53.60)	9.90	Low
Ca	meq/ 100g	>5	17.80 (3.60-32.00)	34.10 (32.80-35.40)	28.00	High (A1 horizon) to very high.
Mg	meq/ 100g	>1	6.25 (2.60-9.90)	12.40 (10.40-14.40)	10.80	High (A horizon) to very high.
Na	meq/ 100g	<0.7	3.30 (0.70-5.90)	4.10 (2.50-5.70)	4.30	Very high
K	meq/ 100g	>0.3	0.85 (0.70-1.00)	0.70 (0.70-0.70)	0.50	High (A1 horizon) to moderate.
ESP	%	<6	28.75 (8.60-48.90)	29.85 (10.60-49.10)	43.60	Very strongly sodic
Ca:Mg ratio		>2	2.31 (1.38-3.23)	2.84 (2.28-3.40)	2.59	Unfavourable for dispersion (refer comment in Table 3.16).
OC	%	>1.2	0.75 (<0.50-1.00)	0.75 (<0.50-1.00)	0.5	Low (A1 horizon) to very low.

Notes: *1. Plant sufficiency sources: Baker and Eldershaw 1993, DERM 2011 and Previll, Sparrow and Reuter, 1999.*

2. Values in brackets are the ranges measured.

*3. *these values are an approximation based on calculations using the lowest measurable level.*

Table 3.16 Dermosol soil chemistry summary

Elements	Comments
pH	Mildly to moderately alkaline. Would not restrict cropping.
EC	Low salinity levels in the upper profile that increases to very high to high in the lower profile. Soil salinity in the lower profile is well outside of the desirable range for plant growth. Would restrict cropping.
Chloride	Acceptable chloride levels in the upper and lower profile with restrictive levels in the mid profile. Would restrict cropping.
PAWC	A low PAWC, which would severely restrict dryland cropping.
Fertility	
CEC	Low CEC that would present some fertility issues and affect fertiliser application rates.
Fertility Ranking	**Relative Fertility of ASC Classes (NSWG 2013):** Moderately low (2) **EMM applied Relative Fertility of ASC Classes (Lab and field data applied to Murphy et al. 2007):** Moderately low **Explanation:** Low fertilities that generally only support plants suited to grazing. Generally likely to be deficient in nitrogen, phosphorus and many other elements and with poor physical properties.
ESP	Very strongly sodic soil, which would cause severe restriction to cropping.
Ca:Mg ratio	A stable Ca:Mg ratio throughout the profile normally suggests strong soil stability. Calcareous segregations are present in the soil in insoluble form. This will skew the Ca:Mg ratio. This result is therefore inconclusive but it is likely that the dispersibility is high given the highly elevated level of Sodicity.
OC	Indicative of poor structural condition.
Major limitations to agriculture	EC Chloride PAWC ESP OC

3.3.4 Kandosol

Kandosols do not have a strong texture contrast between the A and B horizons; they have massive or only weakly structured horizons and are not calcareous. They are found in well-drained sites (Brown and Red Kandosols) with rainfall between 250 mm and 1,400 mm. Generally, Kandosols have low to moderate agricultural potential with moderate chemical fertility and water-holding capacity.

Kandosols are common in the southern part of the West Balranald mine area, generally mid slope to higher in the landscape and often associated with Spinifex Mallee (Photograph 3.13). Within the Nepean mine area, Kandosols are associated with the sandy ridges and Spinifex Mallee, also mid slope to higher in the landscape (Photograph 3.14).

Variants are defined by the dominant colour class in the major part of the upper 500 mm of the B2 horizon (Isbell 2002). In the West Balranald mine area, the two variants present are Brown and Red, with Red more common (Photograph 3.15). Red Kandosols are also present in the Nepean mine area (Photograph 3.16).

Kandosols in the West Balranald mine area have neutral A1 horizons and moderately alkaline B1 and B2 horizons. Chloride is moderately restrictive in B1 horizons but acceptable in the B2 horizons.

As with the West Balranald Kandosols, these soils in the Nepean mine area have mildly to moderately alkaline B2 horizons (some strongly alkaline) and are generally strongly sodic.

Soils at both mine areas have very low organic matter.

A soil profile description for a typical Kandosol is provided in Table 3.17. It is noted that the laboratory pH values presented in Table 3.17 are a median value.

Soil chemistry results for Kandosol are presented as Table 3.18. The results presented are the median value for each horizon from full description sites where samples for laboratory analysis were taken. Table 3.18 also shows the lowest and highest recorded values in brackets. Appendix C presents individual soil chemistry results for each full description site where samples for laboratory analysis were taken. The soil chemistry constituent values highlighted in the 'soil sufficiency' column in Table 3.18 are agricultural industry benchmarks (Baker and Eldershaw 1993, DERM 2011 and Previll, Sparrow and Reuter 1999) and have been referenced in interpreting the laboratory results. The outcomes are presented in the comments column of Table 3.19. The comments are in reference to the median values with increasing depth.

Photograph 3.13 West Balranald Kandosol (site 85 facing north)

Photograph 3.14 **Nepean Kandosol (site 8 facing east)**

Photograph 3.15 **West Balranald Kandosol (site 85 profile to 750 mm)**

Photograph 3.16 **Nepean Kandosol (site 8 profile to 750 mm)**

Table 3.17 Kandosol typical physical characteristics summary

Horizon name and depth (average) (m)	Colour, mottles and bleach	Moisture, laboratory pH (median) and drainage	Texture and structure	Coarse fragments, segregations and roots
A1 0.0-0.19	Reddish brown and no mottles.	Dry, pH 7.1 and well drained.	Loamy sand and granular.	No surface rock, few coarse fragments, no segregations and few roots.
A2 0.19-0.33	Dark reddish brown and no mottles.	Dry, pH 8.0 and well drained.	Sandy loam and granular.	Few coarse fragments, no segregations and few roots.
B2 0.33-0.56	Strong brown and no mottles.	Dry, pH 8.4and well drained.	Sandy loam and crumb.	Few coarse fragments, no segregations and few to no roots.
B3 0.56-0.75	Strong brown and no mottles.	Dry, pH 8.4 and well drained.	Sandy clay loam and sub-angular.	Few coarse fragments, very few calcareous segregations and few to no roots.

Table 3.18 Kandosol typical soil profile summary

Constituents	Unit	Soil sufficiency[1]	A1 0.0-0.19	A2 0.19-0.33	B1 0.33-0.56	B2 0.56-0.75	Comments on medians (in increasing depth)
pH	pH units	6.0-7.5	7.10 (5.70-8.60)	8.00 (8.00-8.40)	8.35 (7.70-9.20)	8.40 (8.10-9.70)	Neutral (A horizon) to moderately or strongly alkaline (B horizon).
EC_{se}	dS/m	<1.9	1.07 (0.24-7.22)	1.95 (1.70-9.23)	3.55 (0.88-14.42)	6.99 (1.72-12.88)	Medium to high (A horizon) to high to very high soil salinity (B horizon).
Cl^-	mg/kg	<800	40 (20-50)	10 (10-470)	270 (20-1210)	490 (10-490)	Not restrictive (some marginal).
PAWC	mm	>80	7.6 (S-SL)	7 (LS-L)	11.5 (SL-ZCL)	11.4 (LMC-LMC)	Very low (total of 37.5).
CEC	meq/100g	12-25	6.30 (<0.10-33.30)	5.30 (0.30-29.60)	7.00 (<0.10-38.20)	5.20 (0.80-35.00)	Low
Ca	meq/100g	>5	28.55 (6.70-31.50)	21.50 (21.50-27.80)	29.30 (18.10-32.90)	29.00 (15.80-36.40)	Very high
Mg	meq/100g	>1	2.50 (1.20-12.10)	3.60 (1.40-4.50)	4.20 (2.80-10.90)	6.80 (1.60-11.70)	High (A horizon) to very high.
Na	meq/100g	<0.7	0.20 (<0.10-6.30)	<0.10 (<0.10-1.40)	0.90 (<0.10-3.70)	2.20 (0.40-2.30)	Low (A horizon) to very high.

Table 3.18 Kandosol typical soil profile summary

Constituents	Unit	Soil sufficiency[1]	A1 0.0-0.19	A2 0.19-0.33	B1 0.33-0.56	B2 0.56-0.75	Comments on medians (in increasing depth)
K	meq/ 100g	>0.3	0.65 (0.30-1.00)	0.60 (0.40-2.00)	0.55 (0.30-1.00)	0.90 (0.30-1.80)	Moderate to high (B2 horizon).
ESP	%	<6	35.20 (0.10-47.60)	27.65 (27.10-28.20)	31.30 (0.30-43.40)	39.80 (1.40-51.90)	Very strongly sodic
Ca:Mg ratio		>2	3.50 (2.36-20.25)	5.97 (4.78-19.86)	7.15 (2.18-11.50)	4.58 (2.74-9.88)	Unfavourable for dispersion (refer comment in Table 3.19).
OC	%	>1.2	<0.5 (<0.50-1.00)	<0.5 (<0.50-0.80)	<0.5 (<0.50-0.90)	<0.5 (<0.50-0.70)	Very low

Notes: *1. Plant sufficiency sources: Baker and Eldershaw 1993, DERM 2011 and Previll, Sparrow and Reuter, 1999.*

2. Values in brackets are the ranges measured.

*3. *these values are an approximation based on calculations using the lowest measurable level.*

Table 3.19 Kandosol soil chemistry summary

Elements	Comments
pH	Neutral to moderately alkaline with some strongly alkaline levels in subsoil. Would not restrict cropping but amelioration may be required.
EC	Medium to high salinity levels in the upper profile that increases through medium to high and very high levels in the lower profile. Soil salinity in the lower profile is well outside of the desirable range for plant growth. Would cause severe restriction to cropping.
Chloride	Acceptable chloride levels that would not restrict cropping.
PAWC	Low PAWC which would severely restrict cropping.
Fertility	
CEC	Low CEC that may present some fertility issues and affect fertiliser application rates.
Fertility Ranking	**Relative Fertility of ASC Classes (NSW Government 2013):** Moderately low (2) **EMM applied Relative Fertility of ASC Classes (Lab and field data applied to Murphy et al 2007):** Moderately low **Explanation:** Low fertilities that generally only support plants suited to grazing. Likely to be generally deficient in nitrogen, phosphorus and many other elements and with poor physical properties.
ESP	Very strongly sodic soil, which would cause severe restriction to cropping.
Ca:Mg ratio	A stable Ca:Mg ratio throughout the profile normally suggests strong soil stability. Calcareous segregations are present in the soil in insoluble form. This will skew the Ca:Mg ratio. This result is therefore inconclusive but it is likely that the dispersibility is high given the highly elevated level of Sodicity.
OC	Indicative of very poor structural condition.
Major limitations to agriculture	EC PAWC ESP OC

3.3.5 Sodosol

Sodosols are soils that display strong texture contrast between the surface (A horizons) and the subsoil (B horizons). Their surface texture ranges from sandy loam to clay loam over medium to heavy clay B horizon. Sodosols generally have subsoils which are moderately acidic to alkaline but are very sodic. Sodosols are separated into suborders on the basis of the dominant colour of the upper 200 mm of the subsoil (or the major part of the entire B2 horizon if it is less than 200 mm thick) and divided into Red, Brown, Yellow, Grey and Black groups (Isbell 2002).

Variants present at West Balranald are Brown, Grey and Red with Red most common (Photograph 3.17 and Photograph 3.18). Sodosols were not identified in the Nepean mine area.

In the West Balranald mine area, they are neutral to moderately or strongly alkaline and moderately sodic to strongly sodic in the A1 and B1 horizons respectively. Very strong sodicity is found in the B2 horizon. Chloride is restrictive in B horizons. Organic matter levels are very low.

A soil profile description for a typical Sodosol is provided in Table 3.20. It is noted that the laboratory pH values presented in Table 3.20 are a median value.

Soil chemistry results for Sodosol are presented as Table 3.21. The results presented are the median value for each horizon from full description sites where samples for laboratory analysis were taken. Table 3.21 also shows the lowest and highest recorded values in brackets. Appendix C presents individual soil chemistry results for each full description site where samples for laboratory analysis were taken. The soil chemistry constituent values highlighted in the 'soil sufficiency' column in Table 3.21 are agricultural industry benchmarks (Baker and Eldershaw 1993, DERM 2011 and Previll, Sparrow and Reuter 1999) and have been referenced in interpreting the laboratory results. The outcomes are presented in the comments column of Table 3.22. The comments are in reference to the median values with increasing depth.

Photograph 3.17 West Balranald Sodosol soil (site 25 facing east).

Photograph 3.18 West Balranald Sodosol (site 25 profile to 750 mm)

Table 3.20 Sodosol typical physical characteristics summary

Horizon name and depth (average) (m)	Colour, mottles and bleach	Moisture, laboratory pH (median) and drainage	Texture and structure	Coarse fragments, segregations and roots
A1 0.0-0.11	Dark brown and no mottles.	Dry, pH 8.0 and imperfectly drained.	Sandy clay loam and granular.	No surface rock, few coarse fragments, no segregations and few roots.
B1 0.11-0.44	Reddish brown and no mottles.	Dry, pH 8.6 and imperfectly drained.	Light clay and sub-angular blocky.	Few coarse fragments, no segregations and no roots.
B2 0.44-0.75	Strong brown and no mottles.	Dry, pH 8.4 and imperfectly drained.	Light clay and sub-angular blocky.	Few coarse fragments, very few calcareous segregations and no roots.

Table 3.21 Sodosol typical soil profile chemistry summary

Constituents	Unit	Soil sufficiency[1]	A1 0.0-0.11	B1 0.11-0.44	B2 0.44-0.75	Comments on medians (in increasing depth)
pH	pH units	6.0-7.5	8.00 (5.60-8.90)	8.60 (6.10-9.30)	8.40 (7.90-8.90)	Moderately alkaline with strongly alkaline band (B1 horizon).
EC_{se}	dS/m	<1.9	2.83 (0.39-6.80)	10.44 (0.20-23.70)	20.68 (0.99-60.46)	Medium (A horizon) to very high (B1 horizon) to extreme soil salinity (B horizon).
Cl^-	mg/kg	<800	70 (0.80-420)	1100 (0.60-3520)	3820 (30-9910)	Acceptable (A horizon) to highly restrictive (B horizon).

Table 3.21 Sodosol typical soil profile chemistry summary

Constituents	Unit	Soil sufficiency[1]	A1 0.0-0.11	B1 0.11-0.44	B2 0.44-0.75	Comments on medians (in increasing depth)
PAWC	mm	>80	6.6 (SL-CL)	33.0 (CL-LMC)	31.0 (CL-LMC)	Low (total of 70.6)
CEC	meq/ 100g	12-25	4.90 (0.10-45.70)	12.60 (0.20-50.50)	8.80 (1.00-51.70)	Very low (A1 horizon) to moderate (B1 horizon) to low (B2 horizon).
Ca	meq/ 100g	>5	22.10 (3.80-34.80)	28.00 (3.00-32.50)	28.40 (13.10-34.40)	Very high
Mg	meq/ 100g	>1	5.80 (1.00-12.30)	9.70 (2.10-13.10)	10.40 (5.90-13.80)	High (A1 horizon) to very high.
Na	meq/ 100g	<0.7	1.00 (<0.10-4.60)	4.60 (<0.10-9.70)	2.40 (0.40-4.80)	High (A1 horizon) to very high.
K	meq/ 100g	>0.3	1.10 (0.40-1.90)	0.70 (0.20-1.30)	0.60 (0.20-0.80)	High (A1 andB1 horizon) to moderate (B2).
ESP	%	<6	25.40 (0.90-50.30)	34.20 (3.30-52.00)	41.80 (4.60-46.50)	Very strongly sodic
Ca:Mg ratio		>2	3.46 (0.79-15.84)	2.48 (1.03-11.22)	2.73 (0.98-4.98)	Unfavourable for dispersion (refer comment in Table 3.22).
OC	%	>1.2	0.85 (<0.50-2.80)	<0.5 (<0.5-0.90)	<0.5 (<0.5-0.80)	Low (A1 horizon) to very low.

Notes: *1. Plant sufficiency sources: Baker and Eldershaw 1993, DERM 2011 and Previll, Sparrow and Reuter, 1999.*

2. Values in brackets are the ranges measured.

*3. *these values are an approximation based on calculations using the lowest measurable level.*

Table 3.22 Sodosol soil chemistry summary

Elements	Comments
pH	Moderately alkaline in the A and lower B horizon with strong alkalinity in the upper B horizon. Outside of the desirable range for cropping in the B horizon. Would restrict cropping and amelioration would be required.
EC	Medium salinity levels in the upper profile that increase through very high to extreme levels in the lower profile. Soil salinity throughout B horizon is well outside of the desirable range for plant growth. Would cause severe restrictions to cropping.
Chloride	Acceptable chloride levels in the upper profile with restrictive levels in the lower profile. Would cause restriction to cropping.
PAWC	Low PAWC, which would restrict cropping.
Fertility	
CEC	Low to moderate CEC that may present some fertility issues and affect fertiliser application rates.
Fertility Ranking	**Relative Fertility of ASC Classes (NSW Government 2013):** Moderately low (2) **EMM applied Relative Fertility of ASC Classes (Lab and field data applied to Murphy et al 2007):** Moderately low **Explanation:** Low fertilities that generally only support plants suited to grazing. Likely to be generally deficient in nitrogen, phosphorus and many other elements and has poor physical properties.
ESP	Very strongly sodic soil, which would severely restrict cropping.
Ca:Mg ratio	A stable Ca:Mg ratio throughout the profile normally suggests strong soil stability. Calcareous segregations are present in the soil in insoluble form. This will skew the Ca:Mg ratio. This result is therefore inconclusive but it is likely that the dispersibility is high given the highly elevated level of Sodicity.
OC	Indicative of poor structural condition.
Major limitations to agriculture	pH EC Chloride PAWC ESP OC

3.3.6 Brown Vertosol

Vertosols are cracking clays that occur on alluvium and associated lake bed deposits as well as on broad low-lying plains in the northern Mallee. Vertosols display significant shrinking and swelling during wetting and drying cycles. They exhibit strong cracking when dry and at depth have slickensides and/or lenticular peds. The various colour suborders are defined by the dominant colour class in the upper 500 mm of the solum (or the major part of the solum if it is less than 500 mm thick) (Isbell 2002).

These soils are found in minor areas in the West Balranald mine area in the lower swales and flats associated with chenopod shrubland (Photograph 3.19). These soils are thought to have formed from ancient lake deposits fed by the River Murray system. Profiles are typically gilgaied, coarsely structured, sodic, gypseous and somewhat saline. Vertosols were not identified in the Nepean mine area.

The suborders present in the West Balranald mine area are Brown and Grey. These soils were found to have a sodic to strongly sodic, neutral to moderately alkaline A1 horizon increasing to moderately to strongly alkaline and very strongly sodic B2 horizons. Chloride is not restrictive in A1 and B1 horizons and restrictive in the B2 horizons. The soil has a low to moderate CEC ranking and low organic matter in the A1 horizon declining to very low with depth (Photograph 3.20).

Table 3.23, Table 3.24 and Table 3.25 provide physical and chemical summaries of this soil type.

A soil profile description for a typical Vertosol is provided in Table 3.23. It is noted that the laboratory pH values presented in Table 3.23 are a median value.

Soil chemistry results for Vertosol are presented as Table 3.24. The results presented are the median value for each horizon from full description sites where samples for laboratory analysis were taken. Table 3.24 also shows the lowest and highest recorded values in brackets. Appendix C presents individual soil chemistry results for each full description site where samples for laboratory analysis were taken. The soil chemistry constituent values highlighted in the 'soil sufficiency' column in Table 3.24 are agricultural industry benchmarks (Baker and Eldershaw 1993, DERM 2011 and Previll, Sparrow and Reuter 1999) and have been referenced in interpreting the laboratory results. The outcomes are presented in the comments column of Table 3.25. The comments are in reference to the median values with increasing depth.

Photograph 3.19 West Balranald Vertosol (site 38 facing west)

Photograph 3.20 West Balranald Vertosol (site 38 profile to 750 mm)

Table 3.23 Vertosol typical physical characteristics summary

Horizon name and depth (average) (m)	Colour, mottles and bleach	Moisture, laboratory pH (median) and drainage	Texture and structure	Coarse fragments, segregations and roots
A1 0.0-0.09	Dark brown and no mottles.	Dry, pH 7.8 and imperfectly drained.	Sandy clay loam and granular.	No surface rock, few coarse fragments, no segregations and few roots.
B1 0.09-0.42	Strong brown and no mottles.	Dry; pH 8.4 and imperfectly drained.	Light clay and sub-angular blocky.	Few coarse fragments, few calcareous segregations and few roots.
B2 0.42-0.75	Brown and no mottles.	Dry, pH 8.6 and imperfectly.	Light medium clay and angular blocky.	Few coarse fragments, no segregations and no roots.

Table 3.24 Brown Vertosol typical soil profile chemistry summary

Constituents	Unit	Soil sufficiency[1]	A1 0.0-0.09	B1 0.09-0.42	B2 0.42-0.75	Comments on medians (in increasing depth)
pH	pH units	6.0-7.5	7.8 (6.8-8.0)	8.4 (8.3-8.4)	8.6 (8.5-8.6)	Moderate (A and upper B horizon) to strong alkalinity (lower B horizon).
EC_{se}	dS/m	<1.9	1.00 (0.53-1.29)	3.66 (3.48-3.94)	10.41 (8.20-11.91)	Low (A horizon) to very high soil salinity (B horizon).
Cl^-	mg/kg	<800	10 (10-30)	240 (240-270)	1670 (1050-1780)	Acceptable (A and upper B horizon) to Restrictive (lower B horizon).
PAWC	mm	>80	5.4 (SCL-SCL)	33 (SCL-LC)	33 (LMC-MC)	Low (total of 71.4).
CEC	meq/ 100g	12-25	3.10 (1.20-8.70)	12.80 (1.50-18.90)	9.70 (2.50-10.60)	Low (A1 andB2 horizon) with a moderate band (B1 horizon).
Ca	meq/ 100g	>5	24.70 (22.70-28.20)	13.00 (11.80-30.40)	30.40 (27.90-30.80)	Very high (A1 andB2 horizon) with a high band (B1 horizon).

Table 3.24 Brown Vertosol typical soil profile chemistry summary

Constituents	Unit	Soil sufficiency[1]	A1 0.0-0.09	B1 0.09-0.42	B2 0.42-0.75	Comments on medians (in increasing depth)
Mg	meq/ 100g	>1	6.30 (6.10-11.00)	9.20 (4.30-12.50)	9.50 (8.90-13.80)	Very High
Na	meq/ 100g	<0.7	1.0 (0.40-3.40)	6.00 (0.30-6.30)	4.60 (1.00-4.80)	High (A1 horizon) to very high.
K	meq/ 100g	>0.3	0.4 (0.30-1.10)	1.40 (1.00-1.40)	0.90 (0.60-1.20)	Moderate (A1 andB2 horizon) with a high band (B1 horizon).
ESP	%	<6	35.00 (31.10-39.50)	33.20 (17.80-46.70)	45.70 (41.50-47.20)	Very strongly sodic.
Ca:Mg ratio		>2	3.6 (2.25-4.62)	2.74 (1.04-3.30)	3.24 (2.02-3.42)	Unfavourable for dispersion (refer comment in Table 3.25).
OC	%	>1.2	0.90 (0.60-1.00)	<0.5 (<0.5-0.8)	0.6 (<0.5-0.6)	Low (A1 horizon) to very low.

Notes: *1. Plant sufficiency sources: Baker and Eldershaw 1993, DERM 2011 and Previll, Sparrow and Reuter, 1999.*

2. Values in brackets are the ranges measured.

*3. *these values are an approximation based on calculations using the lowest measurable level.*

Table 3.25 Brown Vertosol soil chemistry summary

Elements	Comments
pH	Moderate alkalinity at the surface, progressing to strong alkalinity with depth. Outside of the desirable range for cropping in the lower profile. Would restrict cropping and amelioration would be required.
EC	Medium salinity levels in the upper profile that increase to very high to extreme levels in the lower profile. Soil salinity in the lower profile is well outside of the desirable range for plant growth. Would cause severe restrictions to cropping.
Chloride	Acceptable chloride levels in the upper profile with restrictive levels in the lower profile. Would restrict cropping.
PAWC	At the upper limit of a low PAWC, which would restrict cropping.
Fertility	
CEC	Low to moderate CEC that may present some fertility issues and increase fertiliser application rates.
Fertility Ranking	**Relative Fertility of ASC Classes (NSW Government 2013):** Moderately low to moderate (2 or 3) **EMM applied Relative Fertility of ASC Classes (Lab and field data applied to Murphy et al 2007):** Moderately low **Explanation:** Low fertilities that generally only support plants suited to grazing. Likely to be generally deficient in nitrogen and many other elements and has poor physical properties.

Table 3.25 Brown Vertosol soil chemistry summary

Elements	Comments
ESP	Very strongly sodic soil, which would cause severe restrictions to cropping.
Ca:Mg ratio	A stable Ca:Mg ratio throughout the profile normally suggests strong soil stability. Calcareous segregations are present in the soil in insoluble form. This will skew the Ca:Mg ratio. This result is therefore inconclusive but it is likely that the dispersibility is high given the highly elevated level of Sodicity.
OC	Indicative of poor structural condition.
Major limitations to agriculture	EC Chloride PAWC ESP OC

3.4 Injection borefields

As noted in Section 1.2, the project includes the development of a groundwater injection borefield to the north-west of the project areas. A detailed soils investigation has not been undertaken for the purposes of this report due to the relatively small areas of disturbance that is likely to be associated with the borefields. This area is also not likely to be BSAL.

Based on existing published mapping, the bulk of the western portion of the borefield would be located on the Gulthul Land System as part of the Lachlan Sand Plains Landscape (as derived from Walker 1991 and Mitchell 2002). That is:

> Extensive slightly undulating Quaternary aeolian sands with isolated sandy hummocks and depressions, relief 4 to 8 m. Loamy to clay loam calcareous earths with limestone nodules frequently exposed, solonized brown soils and sandy red and brown texture-contrast soils ,deep red sands on hummocks and dunes and grey clays in depressions.

The eastern portion of the injection borefield is located mainly on the Rata and Mama Land Systems described in Table 3.3, that is, mainly red brown and grey Sodosols.

The LSC for the injection borefields has been classified in the OEH (2013b) mapping as either Class 5 or 6.

3.5 Access roads

The project includes the West Balranald access road and the Nepean Access road. The West Balranald access road is located within the Condoulpe Land System. The Condoulpe Land System is diversely composed of Calcarosol, Chromosol, Dermosol, Kandosol, Sodosol and Vertosol soils. These soils fall under LSC classes 5 and 6, except for Chromosol which is LSC class 4.

Similarly, the Nepean access road has a variety of soil classes within its domain. Specifically it passes through land systems Marma, Youhl, Rata, Hatfield, Gulthul, Arumpo and Bulgamurra which yield soil classes 5 and 6, except for Chromosol which is LSC class 4. No soil was sampled from the Youhl land system however its properties are almost identical to Rata (Table 3.1). Gulthul has been described previously in section 3.4.

Because of the linear nature of the access road infrastructure it is expected that there will be at most a 60 m wide easement, meaning there will be minimal spatial impact on these soils. Furthermore, the LSC classes of the aforementioned soils indicate moderate to very severe limitations of the area supporting many land use practises. A detailed soils assessment of the access roads domain was not undertaken because of the pre-existing land systems classifications and the relatively small impact area.

3.6 Gravel extraction pits

The gravel extraction pits are divided into three areas: gravel extraction area A, gravel extraction area B and gravel extraction area C. A detailed soils assessment has not been undertaken within the gravel extraction pits domain.

Gravel extraction area A and gravel extraction area B both intersect the Condoulpe Land System which consists of Calcarosol, Chromosol, Dermosol, Kandosol, Sodosol and Vertosol soils. These soils fall under LSC classes 5 and 6, except for some Chromosol which is LSC class 4, all of which are unlikely to be BSAL.

Gravel extraction area C intersects the Gulthul and Rata Land Systems. Gulthul and Rata land systems carry similar soil characteristics. The Rata Land System consists of soils Calcarosol, Dermosol and Sodosol. These three soils fall predominately within LSC class 6.

Classes 5 and 6 have severe to very severe limitations of supporting many land use practices making the area suitable for gravel extraction pits.

3.7 Water supply pipelines

The water supply pipelines domain intersects the Condoulpe Land System. This domain has not has not undergone a detailed soils assessment due to the minimal area of disturbance. Water pipelines by design do not disturb large areas of surface.

The Condoulpe Land System contains Calcarosol, Chromosol, Dermosol, Kandosol, Sodosol and Vertosol soils. These soils fall under LSC classes 5 and 6, except for Chromosol which is LSC class 4. Due to these soil qualities, the domain has moderate to very severe limitations in supporting land use practices.

4 Biophysical strategic agricultural land assessment

4.1 Background

BSAL is land with a rare combination of natural resources highly suitable for agriculture. These lands intrinsically have the best quality landforms, soil and water resources which are naturally capable of sustaining high levels of productivity and require minimal management practices to maintain this high quality (NSW Government 2013). BSAL is able to be used sustainably for intensive purposes, is inherently fertile and generally lacks significant biophysical constraints (NSW Government 2013).

The NSW Government's regional maps of BSAL meet the following criteria (NSW Government 2013):

- *properties with access to a reliable water supply, defined by:*
  - *rainfall of 350 mm or more per annum (9 out of 10 years); or*
  - *a regulated river (maps show those within 150 m); or*
  - *a 5th order or higher unregulated river (maps show those within 150 m); or*
  - *an unregulated river which flows at least 95% of the time (maps show those within 150 m); or*
  - *highly productive groundwater sources, as declared by the NSW Office of Water. These are characterised by bores having yield rates greater than 5L/s and total dissolved solids of less than 1,500 mg/L and exclude miscellaneous alluvial aquifers, also known as small storage aquifers.*

AND

- *land that falls under soil fertility classes 'high' or 'moderately high' under the Draft Inherent General Fertility of NSW [Inherent Fertility of Soils in NSW mapping, OEH 2013a], where it is also present with land capability classes I, II or III under the Land and Soil Capability Mapping of NSW.*

OR

- *land that falls under soil fertility classes 'moderate' under the Draft Inherent General Fertility of NSW [Inherent Fertility of Soils in NSW mapping, OEH 2013a], where it is also present with land capability classes I or II under the Land and Soil Capability Mapping of NSW.*

No Government-mapped BSAL occurs in the project area or more broadly in the Balranald LGA or surrounding regions. The BSAL interim protocol outlines the process for seeking verification of whether or not land mapped as BSAL meets the BSAL criteria. As such a BSAL assessment was undertaken in accordance with the protocol.

4.2 Verification process

As described above, BSAL is classified as land with: a reliable water supply of suitable quality; and with a soil fertility of 'high' or 'moderately high' (Inherent General Fertility of NSW) and Class I, II or III LSC; or a soil fertility of 'moderate' and Class I or II LSC. The BSAL verification process comprises four major components:

- identifying the assessment area;
- determining access to reliable water supply (Figure 4.1);
- soils and landscape verification (Figure 4.2); and
- a minimum area requirement of 20 ha.

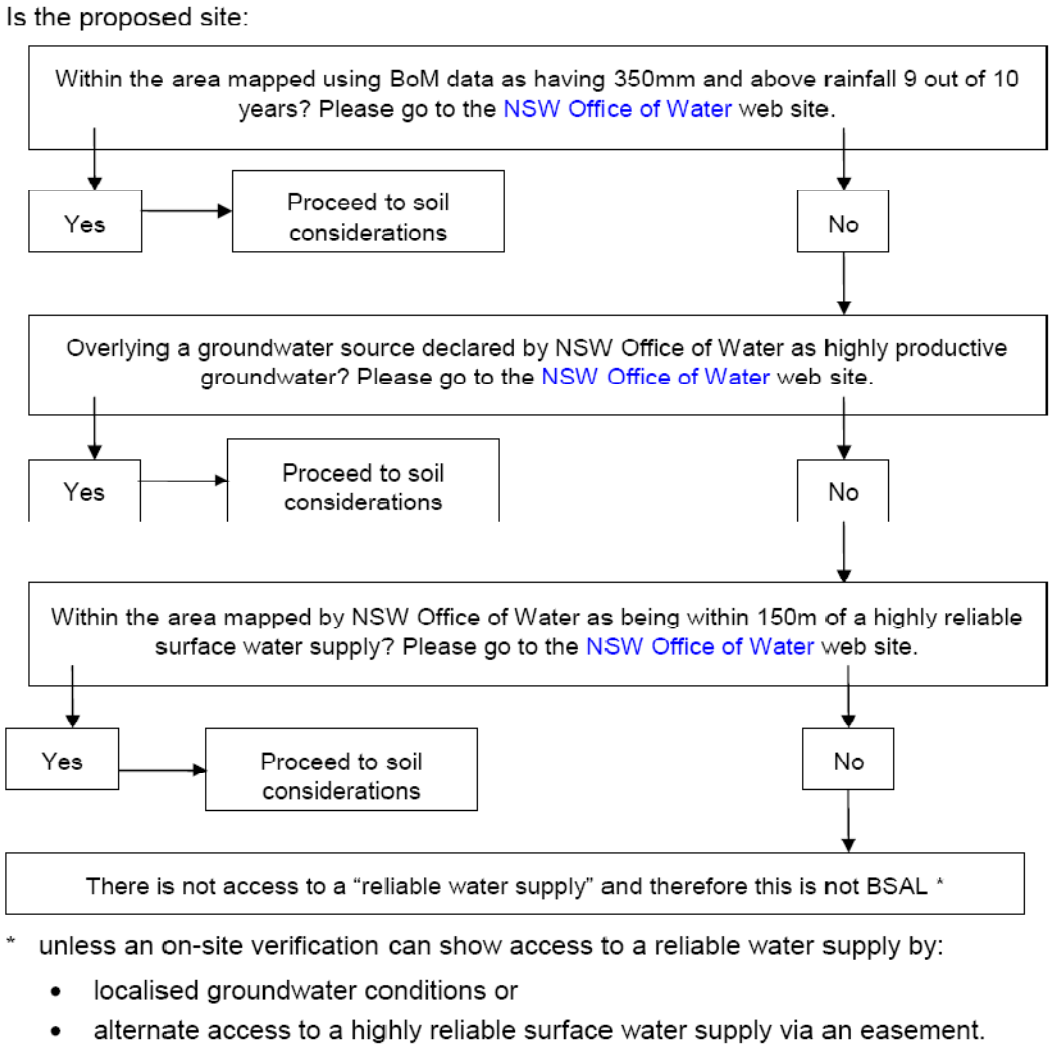


Figure 4.1 Reliable water supply assessment flow chart

The BSAL assessment was undertaken for the West Balranald and Nepean mines within the project area as described in Section 1.2.

By assessing these sites in relation to the above steps and the associated NSW Office of Water on-line information, it concluded that:

- the mine areas do not lie within the 350 mm and above rainfall isohyet for 9 out of 10 years;
- the mine areas do not overlie a groundwater resource declared by the NSW Office of Water as highly productive groundwater; and
- the mine areas do not lie within the area mapped by the NSW Office of Water as being within 150 m of a highly reliable surface water supply.

Local rainfall recharge of regional groundwater systems is extremely low due to the low annual rainfall and high evaporation rates. Depth to groundwater is generally greater than 10 m, except along the major river channels. Directly beneath the West Balranald and Nepean deposits the depth to groundwater is approximately 20 m below ground level. Regionally, groundwater salinities increase along the flow path (from east to west) and are higher at shallower depths, ranging from 1,500 mg/L at depth to over 35,000 mg/L towards the surface (Earth Systems Pty Ltd 2015). Furthermore, there is no alternate access to a highly reliable surface water supply via an easement.

Despite the outcomes of the above water supply assessment, for areas within the project area that would be subject to mining a BSAL site verification process has been conducted. The process that was followed is presented in Figure 4.2.

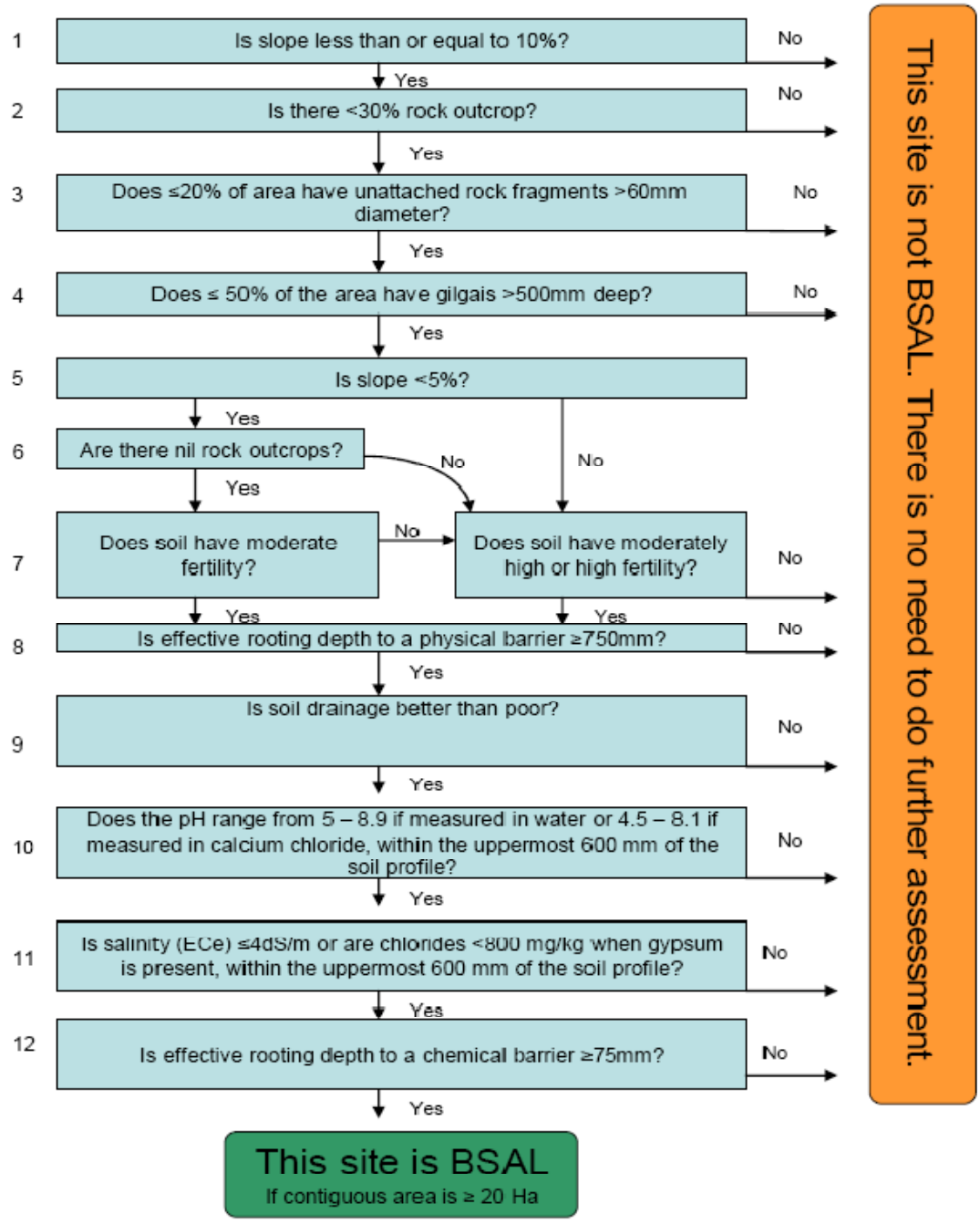


Figure 4.2 BSAL site verification flow chart

The verification assessment undertaken is detailed in full in Appendices A. Soil chemistry results were assessed against the chemistry-related criteria in the soil and landscape verification process (NSW Government 2013). These results were then transferred into the assessment tables (Appendix A).

4.3 BSAL assessment results

Soils in the West Balranald and Nepean mine areas were assessed against the BSAL criteria as presented in Table A.1 in Appendix A. These results are presented in Table 4.1 for each full description site where samples were taken for laboratory analysis. A summary of the BSAL assessment for each soil type is presented as Table A.2 in Appendix A.

The BSAL assessment determined that no BSAL occurs at either the West Balranald or Nepean mine. All soils sampled failed the criteria for various assessment parameters with all failing on fertility criteria (ie not moderately high or high) and almost all failing on having an effective rooting depth to a chemical barrier being less than 750 mm (due to the elevated sodicity and salinity levels in subsoils).

Table 4.1 Summary of BSAL verification assessment

Site No.	ASC soil type (to Great Group)	BSAL verification criteria															Is the site BSAL
		Water	1	2	3	4	5	6	7a[1]	7b	8	9	10	11	12	Area	
		Access to reliable water supply?	Slope ≤ 10%?	< 30% rock outcrop?	≤ 20% of area have unattached rock fragments > 60 mm diameter?	≤ 50% of the area has gilgais > 500 mm deep	Slope < 5 %	Nil rock outcrops	Does soil have moderate fertility	Does soil have moderately high or high fertility	Effective rooting depth to physical barrier is ≥ 750 mm	Soil drainage is better than poor	pH ranges from 5-8.9 if measured in water or 4.5-8.1 if measured in calcium chloride,	Salinity is ≤ 4 dS/m or chlorides < 800 mg/kg when gypsum is present, within the	Effective rooting depth to a chemical barrier is ≥ 750 mm	Is the contiguous area ≥20 Ha	
Calcarosols																	
Hypercalcic Calcarosol																Y	No
West Balranald 6	Epihypersodic Regolithic Hypercalcic Calcarosol	N	Y	Y	Y	Y	Y	Y	N	N	Y	Y	Y	Y	N	-	No
West Balranald 14	Epihypersodic Regolithic Hypercalcic Calcarosol	N	Y	Y	Y	Y	Y	Y	N	N	Y	Y	Y	N	N	-	No
West Balranald 70	Epihypersodic Regolithic Hypercalcic Calcarosol	N	Y	Y	Y	Y	Y	Y	N	N	Y	Y	Y	Y	N	-	No
Nepean 31	Epihypersodic Regolithic Hypercalcic Calcarosol	N	Y	Y	Y	Y	Y	Y	N	N	Y	Y	Y	Y	N	-	No
Nepean 49	Epihypersodic Regolithic Hypercalcic Calcarosol	N	Y	Y	Y	Y	Y	Y	N	N	Y	Y	Y	N	N	-	No
Nepean 47	Epihypersodic Regolithic Hypercalcic Calcarosol	N	Y	Y	Y	Y	Y	Y	N	N	Y	Y	Y	N	N	-	No

Table 4.1 Summary of BSAL verification assessment

Site No.	ASC soil type (to Great Group)	BSAL verification criteria															Is the site BSAL
		Water	1	2	3	4	5	6	7a[1]	7b	8	9	10	11	12	Area	
Hypocalcic Calcarosol																-Y	No
West Balranald 12	Hypersodic Regolithic Hypocalcic Calcarosol	N	Y	Y	Y	Y	Y	Y	N	N	Y	Y	Y	N	N	-	No
West Balranald 15	Hypersodic Regolithic Hypocalcic Calcarosol	N	Y	Y	Y	Y	Y	Y	N	N	Y	Y	Y	Y	N	-	No
West Balranald 101	Hypersodic Regolithic Hypocalcic Calcarosol	N	Y	Y	Y	Y	Y	Y	N	N	Y	Y	Y	N	N	-	No
Chromosols																-No	No
West Balranald 77	Haplic Eutrophic Red Chromosol	N	Y	Y	Y	Y	Y	Y	N	N	Y	Y	Y	N	N		No
Dermosols																-N	No
West Balranald 100	Sodic Hypocalcic Red Dermosol	N	Y	Y	Y	Y	Y	Y	N	N	Y	Y	N	N	N	-	No
West Balranald 100	Sodic Mesotrophic Brown Dermosol	N	Y	Y	Y	Y	Y	Y	N	N	Y	Y	Y	N	N	-	No
Kandosols																Y	No
West Balranald 53	Haplic Eutrophic Brown Kandosol	N	Y	Y	Y	Y	N	Y	Y	N	Y	Y	Y	N	Y	-	No
West Balranald 76	Haplic Eutrophic Brown Kandosol	N	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	-	No
West Balranald 37	Sodic Dystrophic Red Kandosol	N	Y	Y	Y	Y	Y	Y	N	N	Y	Y	Y	Y	N	-	No
West Balranald 69	Sodic Dystrophic Red Kandosol	N	Y	Y	Y	Y	N	Y	N	N	Y	Y	Y	N	N	-	No
West Balranald 85	Sodic Mesotrophic Red Kandosol	N	Y	Y	Y	Y	N	Y	N	N	Y	Y	Y	N	N	-	No
Nepean 8	Sodic Mesotrophic Red Kandosol	N	Y	Y	Y	Y	Y	Y	N	N	Y	Y	Y	N	N	-	No
Nepean 24	Sodic Dystrophic Red Kandosol	N	Y	Y	Y	Y	N	Y	N	N	Y	Y	Y	Y	N	-	No
Nepean 43	Sodic Mesotrophic Red Kandosol	N	Y	Y	Y	Y	Y	Y	N	N	Y	Y	Y	N	N	-	No

Table 4.1 Summary of BSAL verification assessment

Site No.	ASC soil type (to Great Group)	BSAL verification criteria															Is the site BSAL
		Water	1	2	3	4	5	6	7a[1]	7b	8	9	10	11	12	Area	
Sodosols																-Y	No
West Balranald 910	Hypocalcic Subnatric Brown Sodosol	N	Y	Y	Y	Y	Y	Y	N	N	Y	N	N	N	Y	-	No
West Balranald 3	Hypocalcic Hypernatric Red Sodosol	N	Y	Y	Y	Y	Y	Y	N	N	Y	Y	Y	N	N	-	No
West Balranald 10	Hypocalcic Hypernatric Red Sodosol	N	Y	Y	Y	Y	Y	Y	N	N	Y	Y	Y	Y	N	-	No
West Balranald 13	Mesotrophic Hypernatric Brown Sodosol	N	Y	Y	Y	Y	Y	Y	N	N	Y	Y	Y	N	N		No
West Balranald 24	Mesotrophic Hypernatric Brown Sodosol	N	Y	Y	Y	Y	Y	Y	N	N	Y	Y	Y	N	N		No
West Balranald 32	Mesotrophic Hypernatric Brown Sodosol	N	Y	Y	Y	Y	Y	Y	N	N	Y	N	Y	N	N		No
West Balranald 56	Dystrophic Hypernatric Brown Sodosol	N	Y	Y	Y	Y	Y	Y	N	N	Y	Y	Y	N	N		No
West Balranald 25	Mesotrophic Hypernatric Grey Sodosol	N	Y	Y	Y	Y	Y	Y	N	N	Y	Y	Y	N	N		No
West Balranald 34	Hypocalcic Subnatric Red Sodosol	N	Y	Y	Y	Y	N	Y	N	Y	Y	Y	Y	N	N		No
West Balranald 36	Hypercalcic Hypernatric Brown Sodosol	N	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y		No
West Balranald 23	Mesotrophic Hypernatric Brown Sodosol	N	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	N	N		No
West Balranald 33	Mesotrophic Hypernatric Grey Sodosol	N	Y	Y	Y	Y	Y	Y	N	Y	Y	N	Y	N	N		No
West Balranald 44	Dystrophic Hypernatric Brown Sodosol	N	Y	Y	Y	Y	Y	Y	N	N	Y	Y	Y	N	N		No

Table 4.1 Summary of BSAL verification assessment

Site No.	ASC soil type (to Great Group)	BSAL verification criteria														Is the site BSAL
		Water	1	2	3	4	5	6	7a[1]	7b	8	9	10	11	12	Area	
Vertosols																N	No
West Balranald 38	Episodic-Epicalcareous Crusty Brown Vertosol	N	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	N	N		No
West Balranald 46	Episodic-Epicalcareous Crusty Brown Vertosol	N	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	N	N		No
West Balranald 57	Episodic-Epicalcareous Crusty Brown Vertosol	N	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	N	N		No

Notes: 1. Assessment of fertility is based on NSW Government 2013 and Murphy et al 2007.

5 Land and soil capability class assessment

5.1 Background

LSC describes the inherent physical capacity of the land and soil to sustain a range of land uses and management practices in the long term without degradation to soil, land, air and water resources. It is based on biophysical features of the land (eg terrain, soil and climatic attributes) (NSW OEH 2012).

As discussed in Section 3.1.7, Government mapping identifies predominantly LSC Class 5 - Severe limitations as occurring in the West Balranald mine area, with some Class 6 - Very severe limitations also present. Government mapping indicates that the Nepean mine area is predominantly Class 7 - Extremely severe limitations with small areas of Class 5 – Severe limitations and Class 3 – Moderate limitations (NSW OEH, 2013b). LSC classes and their definitions as presented in LSC assessment scheme (OEH 2012b) and NSW Government mapping (NSW OEH 2013b) are shown in Table 5.1.

Table 5.1 Land and soil capability classes

LSC class	General definition[1]	Limitations[2]
Land capable of a wide variety of land uses (cropping, grazing, horticulture, forestry, nature conservation)		
1	**Extremely high capability land**: Land has no limitations. No special land management practices required. Land capable of all rural land uses and land management practices.	**Very slight to negligible limitations.** Land capable of sustaining high impact land uses (eg cultivation) and no special land management practices required.
2	**Very high capability land**: Land has slight limitations. These can be managed by readily available, easily implemented management practices. Land is capable of most land uses and land management practices, including intensive cropping with cultivation.	**Slight but significant limitations.** Land capable of sustaining high impact land uses which can be managed by readily available, and easily implemented management practices.
3	**High capability land**: Land has moderate limitations and is capable of sustaining high-impact land uses, such as cropping with cultivation, using more intensive, readily available and widely accepted management practices. However, careful management of limitations is required for cropping and intensive grazing to avoid land and environmental degradation.	**Moderate limitations.** Land capable of sustaining high impact land uses using more intensive, readily available and accepted management practices.
Land capable of a variety of land uses (cropping with restricted cultivation, pasture cropping, grazing, some horticulture, forestry, nature conservation)		
4	**Moderate capability land**: Land has moderate to high limitations for high-impact land uses. Will restrict land management options for regular high-impact land uses such as cropping, high-intensity grazing and horticulture. These limitations can only be managed by specialised management practices with a high level of knowledge, expertise, inputs, investment and technology.	**Moderate to severe limitations.** Land generally not capable of sustaining high impact land uses unless using specialised management practices with high level of knowledge, expertise, inputs, investment and technology. Limitations are more easily managed for lower impact land uses (eg grazing).
5	**Moderate–low capability land**: Land has high limitations for high-impact land uses. Will largely restrict land use to grazing, some horticulture (orchards), forestry and nature conservation. The limitations need to be carefully managed to prevent long-term degradation.	**Severe limitations.** Land not capable of sustaining high impact land uses except where resources allow for highly specialised land management practices to overcome limitations (eg high value crops). Lower impact land uses (eg grazing) can be managed by readily available practices.

Table 5.1 Land and soil capability classes

LSC class	General definition[1]	Limitations[2]
Land capable for a limited set of land uses (grazing, forestry and nature conservation		
6	**Low capability land**: Land has very high limitations for high-impact land uses. Land use restricted to low-impact land uses such as grazing, forestry and nature conservation. Careful management of limitations is required to prevent severe land and environmental degradation.	**Very severe limitations.** Land incapable of sustaining many land use practices (eg cultivation, moderate to high intensity grazing and horticulture). Highly specialised practices can overcome some limitations for some high value products. Land often used for low intensity land uses (low intensity grazing).
Land generally incapable of agricultural land use (selective forestry and nature conservation)		
7	**Very low capability land**: Land has severe limitations that restrict most land uses and generally cannot be overcome. On-site and off-site impacts of land management practices can be extremely severe if limitations not managed. There should be minimal disturbance of native vegetation.	**Extremely severe limitations.** Land incapable of sustaining most land uses. Limitations cannot be overcome.
8	**Extremely low capability land**: Limitations are so severe that the land is incapable of sustaining any land use apart from nature conservation. There should be no disturbance of native vegetation.	**Extreme limitations.** Land incapable of sustaining any land use and best left undisturbed and managed for conservation.

Note: 1 From OEH 2012.

2 From OEH 2013b.

5.2 Methodology

LSC assessment and mapping was undertaken in accordance with the LSC assessment scheme and with reference to the NSW Government mapping (NSW OEH 2013b). LSC classes are determined at a local scale using the information collected during the field soil survey and supplemented with information gathered during the desktop assessment. The assessment process involves determination of soils and landscape characteristics against eight decision tables. The decision tables use landscape, soils and climate data on the various hazards or limitations to allocate a tract of land to an LSC class for each hazard or limitation (NSW OEH 2012).

Each hazard is assigned one of eight LSC classes where Class 1 represents the least hazard and Class 8 represents the greatest hazard. Each hazard is assessed individually and in this way a profile of hazards is developed for the parcel of land being assessed. The final hazard assessment for a parcel of land is based on the highest hazard in that parcel of land (NSW OEH 2012). Data for the assessment was sourced from field survey observations, desktop analysis and soil laboratory analysis. Appendix B presents the detailed LSC assessment.

5.3 Extent of land and soil capability classes

The results of the assessment are shown in Table 5.2.

Table 5.2 Pre-mining LSC classes identified across the West Balranald and Nepean mine areas

Soil type and site number	Water erosion	Wind erosion	Soil structural decline	Soil acidification	Salinity	Water logging	Shallow soils and rockiness	Mass movement	LSC class
Calcarosols									
Hypercalcic Calcarosol									
West Balranald 6	2	3	6	3	4	2	1	1	**6**
West Balranald 14	1	3	6	1	4	3	1	1	**6**
West Balranald 70	5	5	6	3	4	1	1	1	**6**
Nepean 31	3	4	4	2	4	1	1	1	**4**
Nepean 49	1	5	6	1	4	1	1	1	**6**
Nepean 47	5	4	6	1	4	1	1	1	**6**
Hypocalcic Calcarosol									
West Balranald 12	1	5	6	1	4	2	1	1	**6**
West Balranald 15	1	5	4	1	4	3	1	1	**5**
West Balranald 101	1	5	6	1	4	1	1	1	**6**
Chromosols									
West Balranald 77	2	4	4	3	4	3	1	1	**4**
Dermosols									
West Balranald 100	1	3	6	1	4	3	1	1	**6**
West Balranald 100	2	6	3	4	4	1	1	1	**6**
Kandosols									
West Balranald 53	4	5	3	3	4	1	1	1	**5**
West Balranald 76	1	5	3	3	4	1	1	1	**5**
West Balranald 37	2	5	6	3	4	1	1	1	**6**
West Balranald 69	6	6	1	3	4	1	1	1	**6**
West Balranald 85	5	5	3	3	4	1	1	1	**5**
Nepean 8	2	5	3	4	4	1	1	1	**5**

Table 5.2 Pre-mining LSC classes identified across the West Balranald and Nepean mine areas

Soil type and site number	Water erosion	Wind erosion	Soil structural decline	Soil acidification	Salinity	Water logging	Shallow soils and rockiness	Mass movement	LSC class
Nepean 24	5	6	3	3	4	1	1	1	**6**
Nepean 43	5	4	6	3	4	1	1	1	**6**
Sodosols									
West Balranald 910	1	3	6	1	4	6	1	1	**6**
West Balranald 3	1	3	6	1	4	3	1	1	**6**
West Balranald 10	1	5	6	3	4	3	1	1	**6**
West Balranald 13	1	5	6	3	4	3	1	1	**6**
West Balranald 24	1	3	6	3	4	3	1	1	**6**
West Balranald 32	2	3	6	1	4	6	1	1	**6**
West Balranald 56	2	3	6	1	4	3	1	1	**6**
West Balranald 25	2	2	6	1	4	3	1	1	**6**
West Balranald 34	1	2	6	1	4	3	1	1	**6**
West Balranald 36	5	4	4	3	4	2	1	1	**5**
West Balranald 23	1	3	6	2	4	3	1	1	**6**
West Balranald 33	2	3	6	2	4	3	1	1	**6**
West Balranald 35	2	2	6	2	4	8	1	1	**6**
West Balranald 44	2	3	6	3	4	1	1	1	**6**
Vertosols									
West Balranald 38	1	3	6	2	4	3	1	1	**6**
West Balranald 46	2	2	6	2	4	3	1	1	**6**
West Balranald 57	2	3	6	2	4	3	1	1	**6**

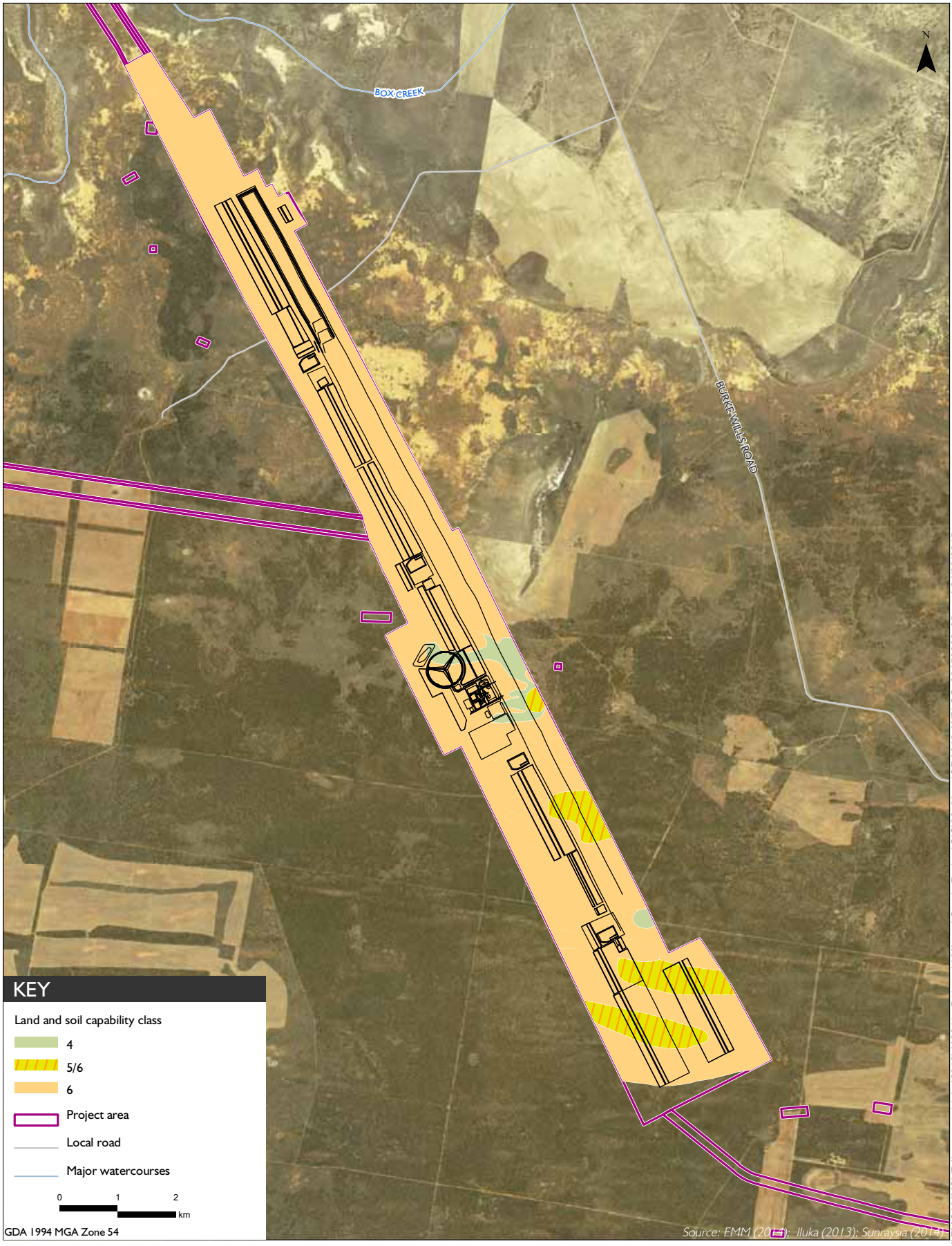
5.4 Land and soil capability assessment conclusions

The land and soil classes for each soil type are summarised in Table 5.3. The results of the pre-mining LSC assessment range from class 5 to (predominantly) class 6 land that has severe to very severe limitations to agriculture. These results suggest that land use is best suited to grazing, some horticulture, forestry and nature conservation. It is also recommended by OEH 2012, that land is carefully managed to prevent long term degradation.

Table 5.3 Summary land and soil capability classes per soil type

Soil type	Land and soil capability class
Calcarosols	
Hypercalcic Calcarosol	6
Hypocalcic Calcarosol	6
Chromosols	4
Dermosols	6
Kandosols	5/6 (see comment below)
Sodosols	6
Vertosols	6

As is noted in Appendix B, given the limitations of the physical and chemical properties of the subsoils in all soil types, it is considered that the LSC for both the West Balranald and Nepean mines would be Class 6 and minor areas of Class 5 in the Red Kandosol soil type with the exception of the Chromosol soil type which would be Class 4. The spatial distribution of pre-mining LSC classes for the West Balranald mine area and the Nepean mine area are shown in Figure 5.1 and Figure 5.2 respectively.



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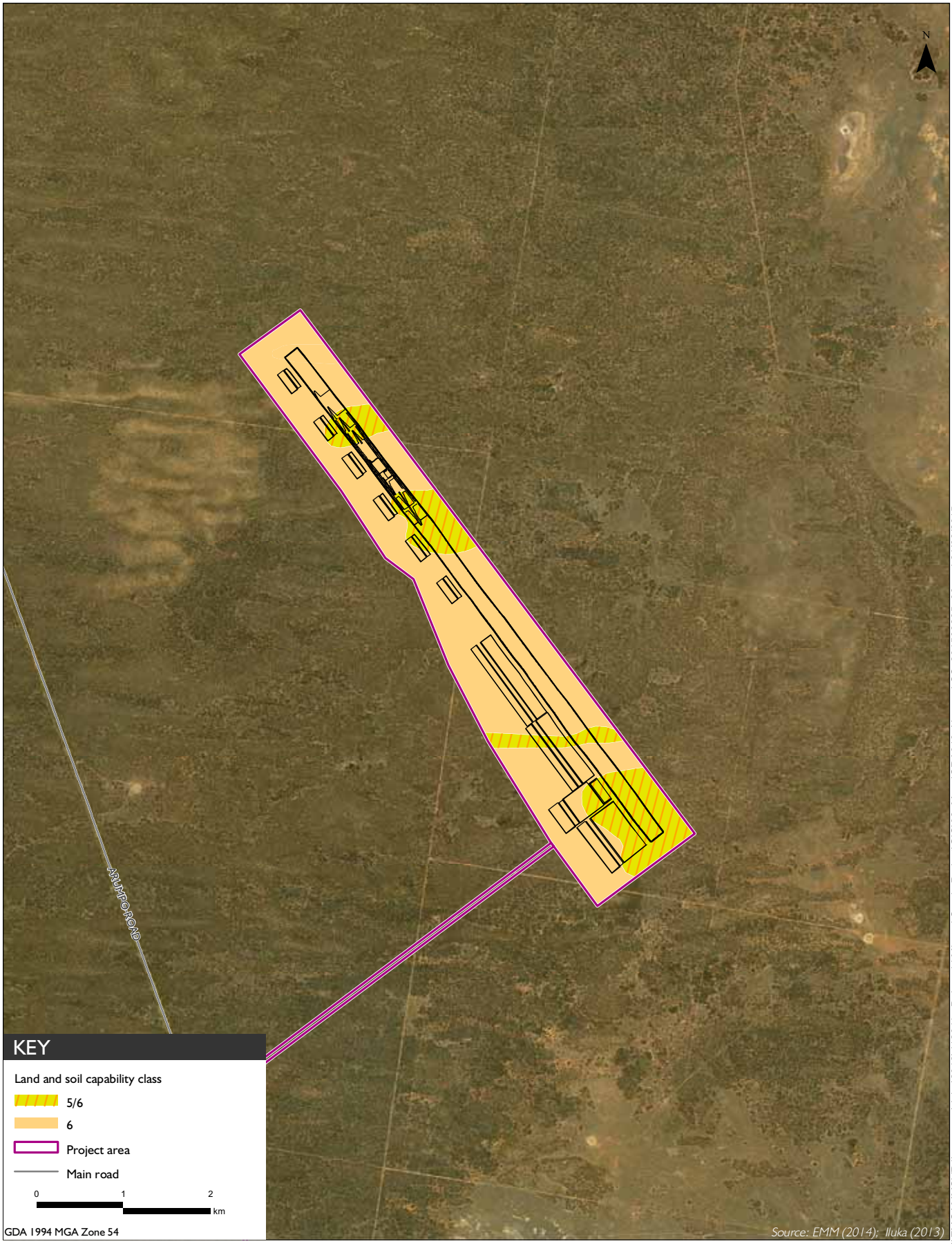
Pre-mining land and soil capability in the West Balranald project area

Balranald Mineral Sands Project

Soil Resource Assessment

Figure 5.1



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Pre-mining land and soil capability in the Nepean project area

Balranald Mineral Sands Project

Soil Resource Assessment

Figure 5.2

6 Potential impacts on soil resources

Potential impacts of the Balranald Project on soil resources are associated with temporary loss of land due to construction and operation of mine infrastructure (eg surface facilities) and permanent loss of land due to open cut mining. Activities may impact on soil physical and chemical properties and post-mining land use including through the following:

- excavation of soil to access the resource;
- temporary storage of overburden adjacent to the pit during mining;
- long-term storage of soil in stockpiles;
- compaction of soil by machinery and infrastructure placement;
- contamination of soil resulting from storage of fuel and chemicals, refuelling activities, windblown mineral concentrates resulting in elevated gamma radiation etc;
- sterilisation when areas of land able to support agricultural uses are cut off from other suitable areas, or reduced in size to be no longer viable for those land uses; and
- loss of soil through wind and water erosion.

These activities can reduce the capability of land and soils and also reduce its quality as agricultural land.

6.1 Erosion potential

Chemistry results (Appendix C) and classification (Section 3.3 and Table 5.2) indicates that a number of soils in the mine areas have high erosion potential. The potential for soils to erode determines the applicability of management measures and whether the soils are appropriate for use in rehabilitation activities. The erosion potential of soils (also taking account of their landscape position) in the mine areas are as summarised in Table 6.1.

Table 6.1 Summary erosion potential

Soil type	Water erosion	Wind erosion
Calcarosols		
Hypercalcic Calcarosol	Variable (mainly low to moderate)	Moderate to high
Hypocalcic Calcarosol	Low	High
Chromosols	Low to moderate	Moderate to high
Dermosols	Low	Moderate to high
Kandosols	Variable (mainly moderate to high)	High
Sodosols	Low	Moderate to high
Vertosols	Low	Low

6.2 Post-mining biophysical strategic agricultural land

Section 4.3 has indicated that no BSAL is present within the project area. Accordingly, there is no requirement to address the need for reinstatement of BSAL post-mining.

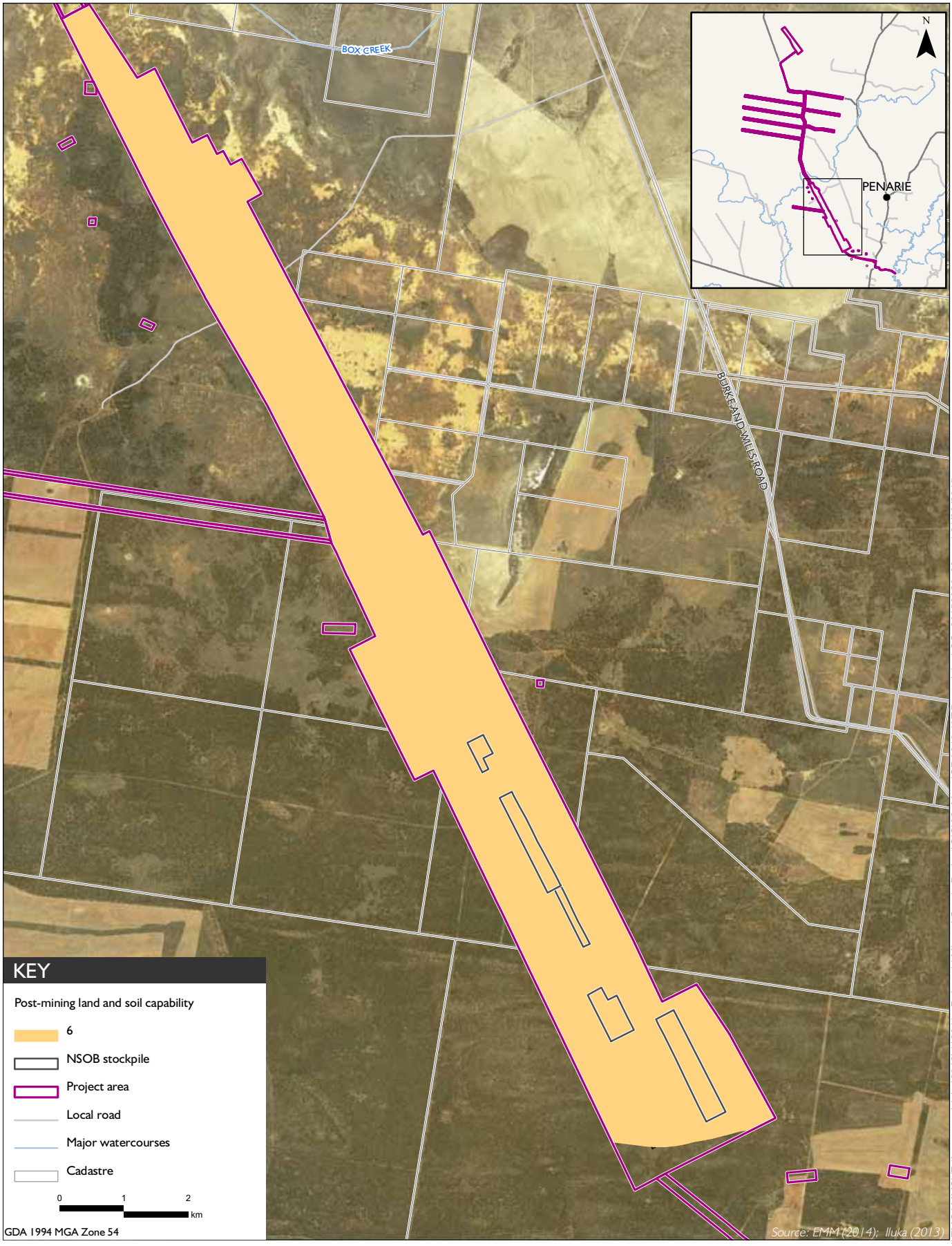
6.3 Post-mining land and soil capability

Table 6.2 presents the potential changes to land and soil capability at the project area following mining and rehabilitation. Figure 6.1 and Figure 6.2 show the project area land capability following mining for the West Balranald and Nepean mine areas respectively.

Table 6.2 Changes to land and soil capability

Area	Pre-mining	ha	Post-mining-mine infrastructure [1]	ha	Change	Comment
Calcarosols-hypercalcic	6	1463.73	6	1463.73	No change	
Calcarosols-hypocalcic	6	51.35	6	51.35	No change	
Chromosols	4	173.15	6	173.15	reduction	Very small area changes with negligible consequences
Dermosols	6	6.11	6	6.11	No change for most of area	
Kandosols	5/6	312.82	6	312.82	No change for most of area	
Sodosols	6	948.23	6	948.23	No change	
Vertosols	6	33.98	6	33.98	No change	
Dermosols	6	13.24	6	13.24	No change	
Calcarosols-hypercalcic	6	607.62	6	607.62	No change	
Kandosols	5/6	184.15	6	184.15	No change	

[1] Some post-mining land capability will be class 7 based on final landform; native woody vegetation is to be established for conservation purposes and is not intended to be subject to long term grazing (refer Figure 6.1 and Figure 6.2).



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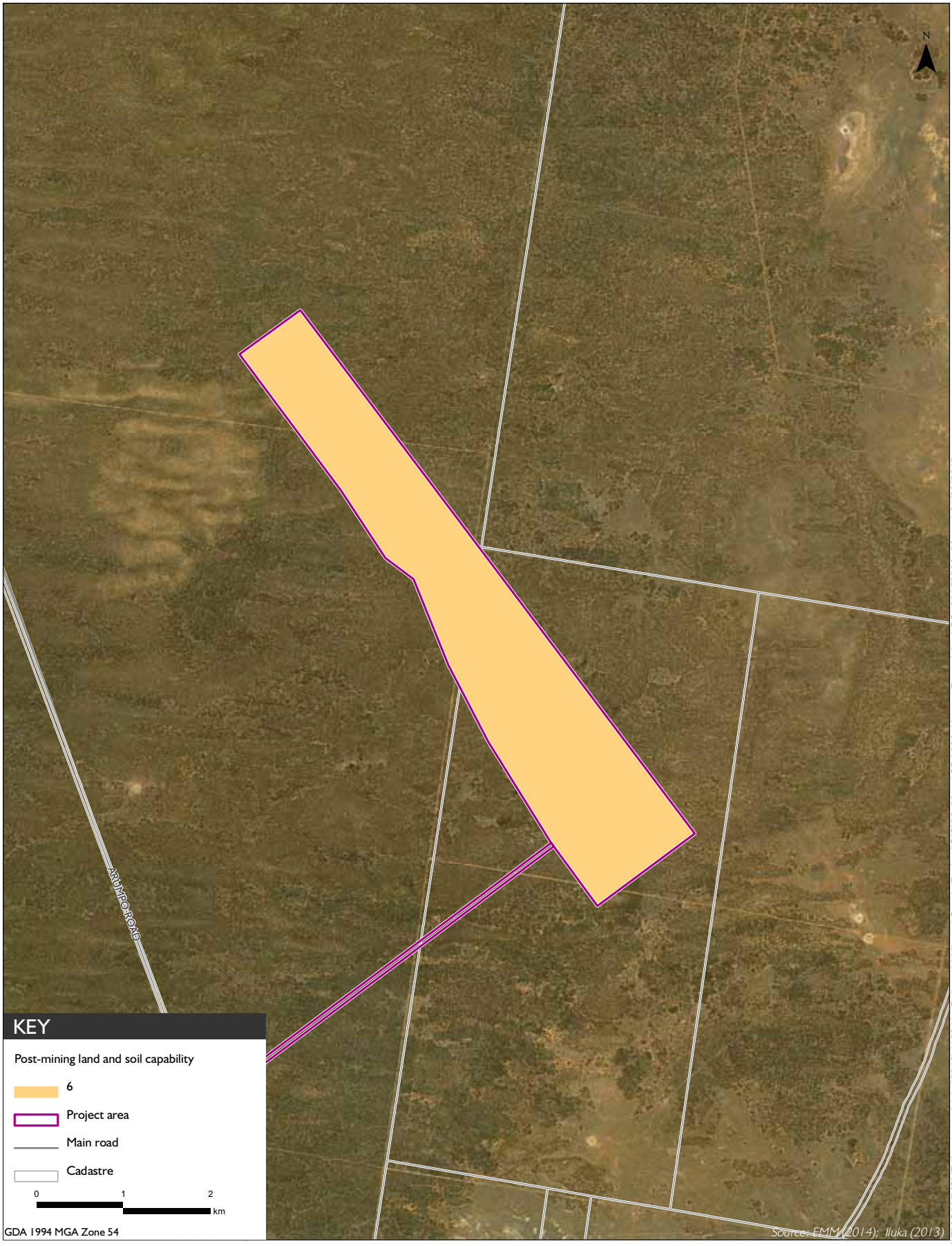
Post mining land and soil capability for West Balranald

Balranald Mineral Sands Project

Soil Resource Assessment

Figure 6.1



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Post-mining land and soil capability at Nepean

Balranald Mineral Sands Project

Soil Resource Assessment

Figure 6.2

7 Management and mitigation measures

7.1 General

Soil resources in the project area that will be impacted by the Balranald Project will generally be managed through:

- installing appropriate erosion and sediment control measures (ESC) prior to undertaking any disturbance on site;
- identifying and quantifying the soil requirements for rehabilitation works over the project life based on mine progression information and the nature of project activities;
- identifying and mapping soil resources (including topsoil and soil with specific management requirements) and locations of stockpiles across the site and managing this information via appropriate systems and databases;
- optimising the recovery of topsoil and useable subsoil during stripping operations;
- stockpiling soil appropriately and managing stockpiled soil to minimise resource degradation (including installation of ESCs and application of amelioration measures where required); and
- carrying out rehabilitation works in appropriate conditions to minimise deterioration of the soil resource and to maximise rehabilitation success.

The following sections provide greater detail on the above general soil resource management practices.

7.2 Erosion and sediment control

ESC measures will be defined in an Erosion and Sediment Control Plan to be implemented throughout the life of the project. ESC measures will be area-specific within the project area to maximise effectiveness (Table 7.1) and will be consistent with the practices described in *Managing Urban Stormwater: Soils and Construction – Volume 2E Mines and Quarries* (NSW Department of Environment and Climate Change 2008). Reference may also be had as appropriate to *Selection of Top Dressing Material for Rehabilitation of Disturbed Areas in the Hunter Valley* (Elliott and Veness 1981) and *Technical Guidelines for Environmental Management for Exploration and Mining in Queensland* (DME 1995).

Prior to any vegetation clearing:

- ESCs will be installed with priority given to sloped areas and areas adjacent to drainage lines.
- The limits of the area to be disturbed can be delineated using pegs and flagging tape.
- All construction and operational activities should be planned and carried out to ensure that there is no damage to soil and vegetation outside the area designated for clearing.
- Where practicable, consideration will be given to the timing of disturbance and vegetation clearing ahead of project activities to ensure disturbed areas are exposed for the shortest possible time.
- Disturbed areas should be stabilised and progressively rehabilitated as quickly as possible.

The design parameters for the construction of ESCs will be in accordance with sound engineering and soil conservation earthworks principles. A number of variables will be considered such as time of concentration, rainfall intensity, soil erosivity, gradient, scour velocities and flow estimations.

Training will be provided for all staff with responsibility for ESC, topsoil and subsoil stripping, stockpile and management and rehabilitation activities.

Table 7.1 Erosion and sedimentation control measures by area

Area	Erosion and sediment control measures
Areas cleared of vegetation	• divert run-off from undisturbed areas away from the works; • windrow vegetation debris along the contour; • minimise length of time soil is exposed; and • direct run-off from cleared areas to sediment basins.
Exposed subsoils	• minimise length of time subsoil is exposed; and • direct run-off from exposed areas to sediment basins.
Overburden stockpiles (prior to backfilling)	• direct all run-off from dumps to sediment dams; • avoid placement of sodic waste material on external batters; • control surface drainage to minimise the formation of active gullies; • use soil and rock mulching to armour long slopes; and • direct run-off from rehabilitated areas to sediment basins.
Topsoil stockpiles	• locate stockpiles away from drainage lines or windy areas in order to minimise the risk of soil and wind erosion; • install ESC measures; • if stockpile to be retained for a period greater than 6 months deep rip and revegetate the stockpile and apply an appropriate fertiliser; • topsoil stockpiles to have an embankment grade of approximately 1v:4h and maximum height of 2 m to limit the potential for erosion of the outer face and to maintain viability; • construct stockpiles with a 'rough' surface condition to reduce erosion hazard, improve drainage and promote revegetation; and • construct of stockpiles using equipment that minimises structural degradation of the soil.
Subsoil stockpiles	• only subsoils identified as suitable for rehabilitation should be stockpiled as subsoil stockpiles; • locate stockpiles away from drainage lines or windy areas in order to minimise the risk of soil and wind erosion; • subsoil stockpiles can have a maximum height of up to 10 m; • install ESC measures; • if stockpile to be retained for a period greater than 6 months a topsoil cap may be required to revegetate the stockpile; • construct stockpiles with a 'rough' surface condition to reduce erosion hazard, improve drainage and promote revegetation; and • construct of stockpiles using equipment that minimises structural degradation of the soil.
Residual void	• progressively backfill in-pit areas during operations; • grade voids to ensure stability and minimise erosion; • apply rock mulch to control erosion; and • apply seed and fertiliser as necessary to ensure rapid re-establishment of vegetation.

Table 7.1 Erosion and sedimentation control measures by area

Area	Erosion and sediment control measures
Dams, banks and creek crossings	• retain water storages where agreed to by the landholder (in support of post-mining land use); • construct creek crossing on angles appropriate for crossing points and install ESCs; and • rehabilitate any dam not required post-mining by: regrading embankments; capping any residual saline material; replacing topsoil; rip on the contour; and seed.
Infrastructure	• provide protection in drains (eg rip rap, revegetate) where water velocity may cause scouring; • confine traffic to maintained tracks and roads; • install sediment traps, silt fences, hay bales and other ESCs; and • rehabilitate disturbed areas around construction sites promptly.
Access roads	• optimise surface drainage and stabilise drainage lines; • implement cross-fall drainage structures and mitre drainage for the entire length of roads; • crowning may be necessary on steeper sections of roads; • construct outfall drainage where roads traverse small fill batter areas and construct in-fall drainage where roads traverse larger fill batter areas; • intercept road runoff at regular intervals to reduce runoff velocity in each mitre drain; and • construct mitre drains so that water from internal haul roads is directed to the in-pit sediment control structures or the out-of-pit sediment basins.

7.3 Topsoil and subsoil assessment, stripping, management and application

7.3.1 Assessment of soil stripping

Elliott and Reynolds (2007) provide the approach for determining soil handling procedures in the NSW coal mining industry and many of the recommendations made are applicable to other mining activities across NSW. The approach involves assessing a range of soil physical and chemical parameters. Table 7.2 lists the key parameters and corresponding desirable selection criteria.

Table 7.2 Desirable soil stripping criteria (from Elliot and Reynolds 2007)

Parameter	Desirable criteria
Structure grade	>30% peds
Coherence	Coherent (wet and dry)
Mottling	Absent
Macrostructure	>10cm
Force to disrupt peds	≤ 3 (moderately weak force and above)
Texture	Finer than a Fine Sandy Loam
Gravel and sand content	<60%
pH	4.5 to 8.4
Salt content	<1.5 dS/m

The soil sampling program included assessments of texture, gravel and sand content, pH and salt content (EC) and, in virtually all cases, the 'topsoil' (A horizon) had suboptimal to poor characteristics for a number of parameters.

Table 7.3 presents the key parameters for the A horizon for each of the site soil types.

Table 7.3 Summary of key parameters for stripping- A horizon

Soil type	Depth of A horizon (cm)	EC (d/cm)	ESP (%Na)	OC %	pH
Calcarosols					
Hypocalcic Calcarosol	0.30	1.43	32.2	0.7	8.1
Hypercalcic Calcarosol	0.30	2.20	33.15	0.85	8.05
Chromosols	0.10	1.05	0.2	1.6	7.4
Dermosols	0.13	1.24	25.4	1.0	7.7
Kandosols	0.33	1.95	35.2	<0.5	8.0
Sodosols	0.11	2.83	25.4	0.85	8.0
Vertosols	0.09	1.00	35.0	0.9	7.8

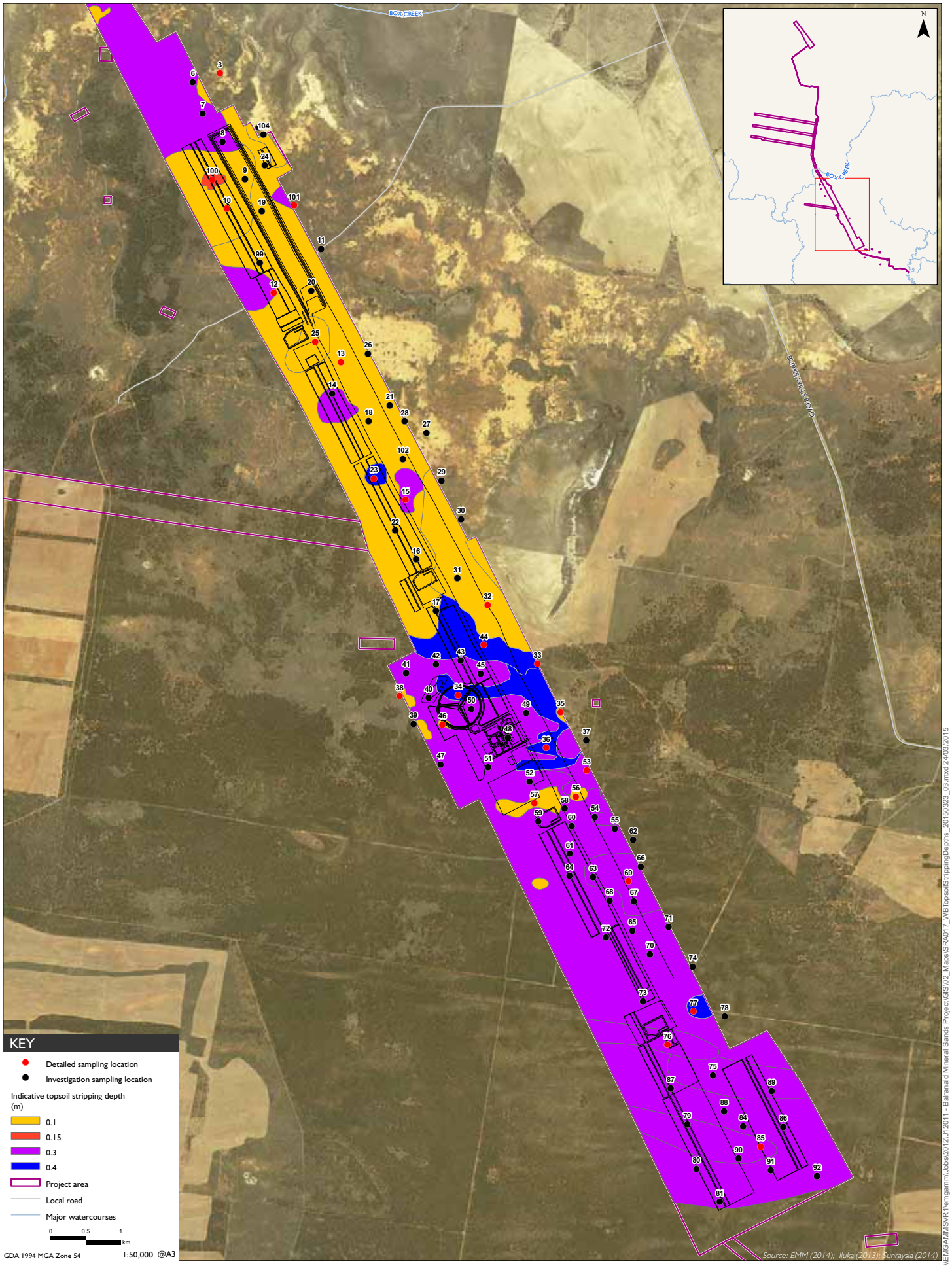
In all soils, the ESP levels are high to very high while the salinity (EC) levels are also elevated. Organic carbon levels are very low while pH levels are generally acceptable. The depths of the A horizon are highly variable but very shallow in the Sodosols and Chromosols in particular.

The implications of the above are that the 'topsoils' have (by assessment against Elliott and Reynolds 2007) undesirable characteristics for stripping in most cases. Subsoils have adverse characteristics in all cases. The soils nevertheless demonstrably provide a suitable growth medium for the predominant chenopod (saltbush and bluebush) and mallee vegetation. Table 7.4 presents the recommended topsoil stripping depths for each of the soil types based on the assessment (presented in Table 7.3) and soil structure (refer to Section 3.3).

Table 7.4 Top soil stripping recommendations

Soil type	Topsoil stripping depth recommendations (m)
Calcarosol- hypercalcic and hypocalcic	Typical: 0.3 Maximum depth: 0.4
Chromosol	Typical:0.4 Maximum depth: 0.7
Dermosol	Typical:0.15 Maximum depth: : 0.45
Kandosol	Typical:0.3 Maximum depth : 0.75
Sodosol	Typical: 0.1 Maximum depth: 0.1
Vertosol	Typical:0.1 Maximum depth: 0.4

West Balranald mine area includes 5.2 M m^3 reserves of topsoil that may be used in rehabilitation programs. The Nepean mine area has 1.1 M m^3 topsoil reserves. Specific recommendations for soil stripping and management are summarised in Section 7.3.2 and Section 7.3.3. Recommended topsoil stripping depths across the mine areas are presented as Figure 7.1 and Figure 7.2.



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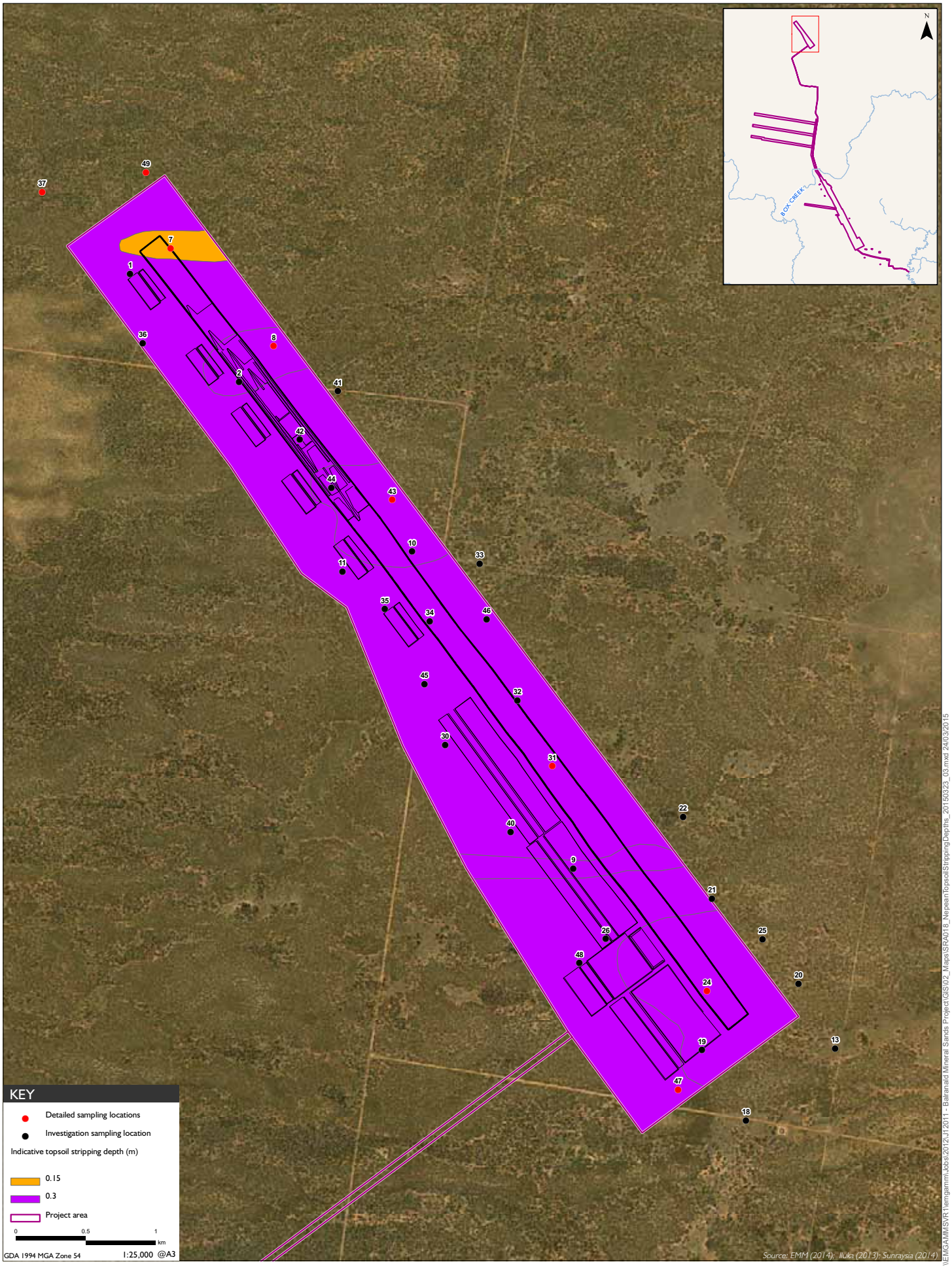
West Balranald topsoil stripping depths

Balranald Mineral Sands Project

Soil Resource Assessment

Figure 7.1



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Nepean topsoil stripping depths

Balranald Mineral Sands Project

Soil Resource Assessment

Figure 7.2

7.3.2 General soil stripping procedures

All areas which may be disturbed will require stripping of surface soil for reuse in rehabilitation programs. The basic principle in determining useable depths of soil for rehabilitation is its quality in comparison to the spoil requiring rehabilitation and as such the quality of surface soil should exceed that of the spoil. Where constraining factors occur, suitable subsoil can sometimes be appropriate for amelioration and direct rehabilitation without the need for topsoil. Soil will be stripped in consideration of the following:

- The volume of soil retained and subsequently required for rehabilitation is determined by availability (ie area available to be stripped and depth of stripping). Ideally, all topsoil used in rehabilitation should be applied to a thickness of at least 250 mm. This provides sufficient depth for ripping, should follow-up maintenance work be required. Soils placed to 150 mm or less can be contaminated by poorer quality material from deeper subsoils when a single pass of deep ripping occurs.

- Prior to commencement of stripping activities, appropriate approvals will be obtained from relevant mine site personnel.

- Earthmoving plant operators will be trained and supervised to ensure that stripping operations are conducted in accordance with stripping plans and in situ soil conditions. Where practicable, surface soil should be stripped in a slightly moist condition and appropriate machinery must be used to minimise structural degradation. It should not be trafficked or deep ripped prior to stripping.

- Remove surface soil using elevating scrapers or suitable alternatives if the area is clear of stumps or other obstructions, otherwise blading with bulldozers into piles and removal by front endloaders and dump trucks will be required. The use of wheeled machinery or narrow tracked equipment of high ground pressure which cause greater soil compaction should be avoided wherever possible.

- Following the removal of topsoil deep ripping with knife rippers, followed by dozing or scraping should then be used to remove the remainder of the soil with care taken not to mix surface soil layers with subsoil.

- During the stripping process there may be some unexpected changes in the depth and the nature of the soil. This will be evident through visual observation of horizon boundaries. Where practical the inclusion of obviously poorer quality material will be avoided such as material dominated with stones.

- All machinery used in the stripping operation should be clean of weeds.

- Where practicable, consideration will be given to the timing of disturbance and vegetation clearing ahead of project activities to ensure disturbed areas are exposed for the shortest possible time so as to reduce erosion and sediment generation, to reduce the extent of stockpiles and to utilise stripped soil as soon as possible for rehabilitation.

- Rehabilitation of disturbed areas (ie roads, embankments and batters) will be undertaken as soon as practicable after these structures are completed or as areas are no longer required.

Subsoil associated with most soils may be appropriate for use in rehabilitation. These subsoils will be stripped and stored separately from, but in the same manner as, topsoil with depths determined by results of soil testing (principally salinity and sodicity levels). The placement of subsoil during rehabilitation activities needs to be assessed with reference to the landscape position it was stripped from.

7.3.3 Soil stockpile management

Stockpiling of stripped soil will be necessary initially as areas will only become available for rehabilitation once project activities in those areas have concluded. As project activities progress, areas may become available for direct placement of soil following stripping. Once stripped, topsoil and subsoil (where appropriate for use in rehabilitation) will be stockpiled as follows:

- Soil types with significantly different properties will be stockpiled separately.
- Stockpiles will be located so that they will not be further disturbed by project activities and positioned to avoid surface water flow.
- ESCs will be installed around stockpile areas and regularly maintained.
- Locations of stockpiles will be recorded using GPS and an inventory of data relating to the soil type, volumes and use in rehabilitation maintained by appropriate mine site personnel.
- Topsoil stockpiles should be retained at a height of no more than 2 m, with slopes no greater than a grade of approximately 1V:3H and a slightly roughened surface to minimise erosion. Subsoil stockpiles can be managed at greater heights with appropriate erosion protections.
- Where ameliorants such as lime, gypsum or native suitable fertilisers are needed to improve the condition of stripped soil, it should either be applied to the stockpiles in-between the application of separate layers from the scrapers, or be spread on the soil prior to scraping.
- Where soil is to be stockpiled for greater than six months, stockpiles should be ripped and revegetated. This may involve seeding with a sterile cover crop to rapidly provide cover and reducing potential for erosion.
- Vehicle access on soil stockpiles should be prohibited except when necessary for soil quality monitoring.
- Weed management should be applied to stockpiles to minimise the accumulation of weed seed in the soil.

7.3.4 Soil application

Topsoil and subsoil will be applied to landforms once they are recontoured and drainage works are complete. Contour or diversion banks with stable discharge points should be constructed to limit slope lengths and control runoff. Collection drains and sedimentation basins will be installed to collect runoff and remove suspended sediment.

Areas identified for topsoil application must no longer be required for project activities and must have an identified post-mining land capability and land use to inform rehabilitation activities. Consideration should be had to the following:

- The volume of growth media material available will be reconciled with the estimated volume needed for successful rehabilitation.
- Scrapers are preferred for the placement procedures with care taken not to unduly compact the growth media.

- Topsoil and subsoil placement is to be undertaken from the top of slopes or top of sub drainage catchment to minimise erosion damage created by storm run-off from bare upslope areas. More erodible soils will be placed on flatter rehabilitation areas to minimise erosion potential.

- Topsoil and subsoil placement is to be conducted along the general run of the contour to minimise the incidence of erosion. It is not to be placed in the invert of drainage lines or drainage works.

- Prior to seeding, topsoil may be cross ripped to encourage rainfall infiltration and minimise runoff.

- Seeding of vegetation (with species determined by the landform and post-mining land use) will be undertaken soon after soil respreading to establish cover and minimise erosion potential.

- Ongoing inspection of rehabilitated areas for declared weeds will be undertaken and weeds controlled via chemical spraying, fire management, grazing management and hygiene management as appropriate.

- Ongoing inspection, monitoring and maintenance of rehabilitation areas in accordance with the project Rehabilitation Plan to ensure sediment and erosion control and revegetation success.

i Soil compaction and remediation

Upon decommissioning of infrastructure and hardstand areas at mine closure, compacted soil will be ripped under dry conditions to break up hard layers and provide a favourable root zone. These areas will be seeded with species appropriate to the identified post-mining land use.

In areas where project activities may have potentially caused soil contamination (eg fuel storage areas), testing will be undertaken to determine the extent of any contamination and soil remediated or disposed of in accordance with project approval conditions and appropriate regulations.

8 Conclusion

The field survey and subsequent assessment of the survey results in conjunction with a desktop review of existing published information applicable to the project area has indicated that six main soil types (or orders) are found at West Balranald corresponding with 12 soil colour variations (sub-orders). The soil types identified comprise:

- Calcarosols (Hypo and Hypercalcic);
- Chromosols (Red);
- Dermosols (Red);
- Kandosols (Red and Brown);
- Sodosols (Red, Brown and Grey); and
- Vertosols (Brown and Grey).

The Nepean mine area was found to be more homogenous than West Balranald with only three soil types and three variants identified comprising Calcarosols (Hypercalcic), Dermosols (Brown) and Kandosols (Red).

Hypercalcic Calcarosols are the dominant soil type at both the West Balranald and Nepean mine areas. Red Kandosol is the second most extensive soil type in the Nepean mine area, with Brown Sodosol being the second most common in the West Balranald mine area. Red Dermosol and Grey Vertosol. are the least extensive soil types found across the mine areas.

Characteristics of the dominant soils in the project areas include:

- very shallow topsoils with very low organic matter levels;
- significant levels of carbonates, notably in the Calcarosols;
- moderately to strongly alkaline at depth;
- sodicity and salinity levels are high to extreme in most of the clayey soils (eg Sodosols and Dermosols) but lower in the sandy/loamy soils (eg Kandosols); and
- most soils are poorly drained and highly infertile.

The assessment of the LSC for the project and each soil unit was conducted and found that both project areas have been identified (based on the OEH assessment process) as predominantly land suitability class 6, that is:

> Low capability land: Land has very high limitations for high-impact land uses. Land use restricted to low-impact land uses such as grazing, forestry and nature conservation. Careful management of limitations is required to prevent severe land and environmental degradation.

Assessed land suitability outcomes generally reflect the current and historical uses of the land, being primarily used for low productivity grazing on mainly chenopod (saltbush and bluebush) pasture or uncleared.

In terms of BSAL, an assessment has been conducted in accordance with the OEH (2012) guidelines and it has been found that:

- the project area does not lie within the 350mm and above rainfall isohyet for 9 out of 10 years;
- the project does not overlie a groundwater resource declared by the NSW Office of Water as highly productive groundwater;
- the project does not lie within the area mapped by the NSW Office of Water as being within 150 m of a highly reliable surface water supply; and
- the BSAL assessment of site conditions determined that no BSAL occurs in the mine area. All soils sampled failed the criteria for fertility (based on existing published data) and most failed additional BSAL criteria such as salinity and chloride levels.

An assessment of the suitability of topsoil and subsoil resources for mine rehabilitation has found that most soils would not be suitable for stripping for reuse (based on standard criteria) due to the predominantly unsuitable soil structure combined with the very shallow topsoil and salinity and sodicity limitations noted above. However, it is considered that most soils can be successfully stripped to predetermined depths and reinstated on the final landforms for subsequent establishment of vegetative cover given appropriate stripping, handling and re-establishment techniques.

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Abbreviations

%	percentage
<	less than
>	greater than
≤	less than or equal to
≥	greater than or equal to
^{o}	degrees
^{o}C	degrees Celsius
4WD	four wheel drive
AIS	Agricultural Impact Statement
BSAL	Biophysical Strategic Agricultural Land
BSAL interim protocol	Interim protocol for site verification and mapping of Biophysical Strategic Agricultural Land (NSW Government 2013)
Ca	calcium
$CaCl_2$	calcium chloride
CEC	cation exchange capacity
dS/m	deci Siemens per metre
E	easting
EC	electrical conductivity
EC_{SE}	electrical conductivity saturation extract
eg	for example
EIS	Environmental Impact Statement
EMM	EMGA Mitchell McLennan Pty Ltd
ESC	erosion and sediment control measures
ESP	exchangeable sodium percentage
GSG	Great soil group
ha	hectare
ie	that is
K	potassium
km	kilometre
LGA	Local Government Area
LPS	Loxton Parilla Sands
LSC	land and soil capability
LSC assessment scheme	The land and soil capability assessment scheme: second approximation (OEH 2012
m	metre

meq/100g	milliequivalent of hydrogen per 100 g of dry soil
Mg	magnesium
mg/kg	milligram per kilogram
mg/L	milligram per litre
mm	millimetre
N	northing
Na	sodium
NCST	National Committee on Soil and Terrain
NSW	New South Wales
OEH	NSW Office of Environment and Heritage
PAWC	plant available water content
PFS	Pre-feasibility study
pH	percentage hydrogen (measure of acidity)
SALIS	Soil and Land Information System
SEARs	Secretary's Environmental Assessment Requirements
SO_4^{2-}	sulfate
SPADE	Soil Profile Attribute Data Environment
The project	Balranald Mineral Sands Project
The report	Balranald Mineral Sands Project Soil Resource Assessment
V:H	vertical to horizontal
x	times

Appendix A

Biophysical Strategic Agricultural Land assessment

ASC	Epihypersodic Regolithic Hypercalcic Calcarosol		Epihypersodic Regolithic Hypercalcic Calcarosol		Epihypersodic Regolithic Hypercalcic Calcarosol	
Site number	West Balranald 6		West Balranald 14		West Balranald 70	
Assessment Item	Value	Decision	Value	Decision	Value	Decision
Reliable water source						
Access to "reliable water supply"	No	No	No	No	No	No
Soils and landscape verification - All YES's required						
Is the slope ≤ 10%	2%	Yes	0%	Yes	5%	Yes
Is there <30% rock outcrop?	0%	Yes	0%	Yes	0%	Yes
Does ≤ 20%of area have unattached rock fragments >60mm diameter?	0%	Yes	0%	Yes	0%	Yes
Does ≤ 50%of area have gilgais >500mm deep?	0%	Yes	0%	Yes	0%	Yes
Only 1 YES required						
Is slope >5%? And does soil have moderately high or high fertility?	2% Slope + Low	No	0% Slope + Low	No	5% Slope + Low	No
Is slope <5%? And Are there SOME rock outcrops? And does soil have moderately high or high fertility?	2% Slope + 0% Outcrops + Low	No	0% Slope + 0% Outcrops + Low	No	5% Slope + 0% Outcrops + Low	No
Is slope <5%? And Are there NIL rock outcrops? And does soil have moderately fertility?	2% Slope + 0% Outcrops + Low	No	0% Slope + 0% Outcrops + Low	No	5% Slope + 0% Outcrops + Low	No
All YES's required						
Is effective rooting depth to a physical barrier ≥ 750mm?	No barrier	Yes	No barrier	Yes	No barrier	Yes
Is soil drainage better than poor?	Moderately Well	Yes	Imperfectly	Yes	Well drained	Yes
IS pH within the upper 600mm pH_{water} 5-8.9 or ph_{CaCl} 4.5-8.1?	7.8-8.1	Yes	8.0-8.6	Yes	6.7-8.1	Yes
Is salinity within the upper 600mm (ECe) ≤4dS/m or chloride <800mg/kg when gypsum is present?	0.82-1.08 Ece + Cl <10	Yes	1.38-13.35 ECe + Cl 20-2510	No	0.34-1.33 ECe + Cl <10-30	Yes
Is effective rooting depth to a chemical barrier ≥ 750mm?	Barrier at 0mm ESP 34.7%	No	Barrier at 0mm ESP 31.6%	No	Barrier at 0mm ESP 47.5%	No
Is the soil BSAL?						
Comments on pass/failure criteria	Failed fertiliy and chemical barrier	No	Failed fertiliy, salinity and chemical barrier	No	Failed fertiliy and chemical barrier	No

ASC	Epihypersodic Regolithic Hypercalcic Calcarosol		Epihypersodic Regolithic Hypercalcic Calcarosol		Epihypersodic Regolithic Hypercalcic Calcarosol	
Site number	Nepean 31		Nepean 49		Nepean 47	
Assessment Item	Value	Decision	Value	Decision	Value	Decision
Reliable water source - Only 1 YES required						
Access to "reliable water supply"	No	No	No	No	No	No
Soils and landscape verification - All YES's required						
Is the slope ≤ 10%	3%	Yes	0%	Yes	4%	Yes
Is there <30% rock outcrop?	0%	Yes	0%	Yes	0%	Yes
Does ≤ 20%of area have unattached rock fragments >60mm diameter?	0%	Yes	0%	Yes	0%	Yes
Does ≤ 50%of area have gilgais >500mm deep?	0%	Yes	0%	Yes	0%	Yes
Only 1 YES required						
Is slope >5%? And does soil have moderately high or high fertility?	3% Slope + Low	No	0% Slope + Low	No	4% Slope + Low	No
Is slope <5%? And Are there SOME rock outcrops? And does soil have moderately high or high fertility?	3% Slope + 0% Outcrops + Low	No	0% Slope + 0% Outcrops + Low	No	4% Slope + 0% Outcrops + Low	No
Is slope <5%? And Are there NIL rock outcrops? And does soil have moderately fertility?	3% Slope + 0% Outcrops + Low	No	0% Slope + 0% Outcrops + Low	No	4% Slope + 0% Outcrops + Low	No
All YES's required						
Is effective rooting depth to a physical barrier ≥ 750mm?	No barrier	Yes	No barrier	Yes	No barrier (<2% surface)	Yes
Is soil drainage better than poor?	Well drained	Yes	Well drained	Yes	Well drained	Yes
IS pH within the upper 600mm pH_{water} 5-8.9 or ph_{CaCl} 4.5-8.1?	6.5-8.5	Yes	8.0-8.5	Yes	8.0-8.5	Yes
Is salinity within the upper 600mm (ECe) ≤4dS/m or chloride <800mg/kg when gypsum is present?	0.24-3.05 ECe + Cl 20-380	Yes	1.44-14.00 ECe + Cl <10-580	No	1.15-9.20 ECe + Cl 10-1070	No
Is effective rooting depth to a chemical barrier ≥ 750mm?	Barrier at 150mm ESP 17.2%	No	Barrier at 0mm ESP 37.6%	No	Barrier at 0mm ESP 31.0%	No
Is the soil BSAL?						
Comments on pass/failure criteria	Failed fertiliy and chemical barrier	No	Failed fertiliy, salinity and chemical barrier	No	Failed fertiliy, salinity and chemical barrier	No

ASC	Hypersodic Regolithic Hypocalcic Calcarosol		Hypersodic Regolithic Hypocalcic Calcarosol		Hypersodic Regolithic Hypocalcic Calcarosol	
Site number	West Balranald 12		West Balranald 15		West Balranald 101	
Assessment Item	Value	Decision	Value	Decision	Value	Decision
Reliable water source - Only 1 YES required						
Access to "reliable water supply"	No	No	No	No	No	No
Soils and landscape verification - All YES's required						
Is the slope ≤ 10%	0%	Yes	0%	Yes	0%	Yes
Is there <30% rock outcrop?	0%	Yes	0%	Yes	0%	Yes
Does ≤ 20%of area have unattached rock fragments >60mm diameter?	0%	Yes	0%	Yes	0%	Yes
Does ≤ 50%of area have gilgais >500mm deep?	0%	Yes	0%	Yes	0%	Yes
Only 1 YES required						
Is slope >5%? And does soil have moderately high or high fertility?	0% Slope + Low	No	0% Slope + Low	No	0% Slope + Low	No
Is slope <5%? And Are there SOME rock outcrops? And does soil have moderately high or high fertility?	0% Slope + 0% Outcrops + Low	No	0% Slope + 0% Outcrops + Low	No	0% Slope + 0% Outcrops + Low	No
Is slope <5%? And Are there NIL rock outcrops? And does soil have moderately fertility?	0% Slope + 0% Outcrops + Low	No	0% Slope + 0% Outcrops + Low	No	0% Slope + 0% Outcrops + Low	No
All YES's required						
Is effective rooting depth to a physical barrier ≥ 750mm?	No barrier	Yes	No barrier	Yes	No barrier	Yes
Is soil drainage better than poor?	Moderately Well	Yes	Imperfectly	Yes	Well drained	Yes
IS pH within the upper 600mm pH_{water} 5-8.9 or ph_{CaCl} 4.5-8.1?	8.0-8.6	Yes	7.8-8.3	Yes	7.7-8.5	Yes
Is salinity within the upper 600mm (ECe) ≤4dS/m or chloride <800mg/kg when gypsum is present?	0.98-8.19 Ece + Cl <10-950	No	1.55-1.68 ECe + Cl 40-360	Yes	1.43-7.10 ECe + Cl 120-910	No
Is effective rooting depth to a chemical barrier ≥ 750mm?	Barrier at 0mm ESP 31.6%	No	Barrier at 0mm ESP 17.3%	No	Barrier at 0mm ESP 53.2%	No
Is the soil BSAL?						
Comments on pass/failure criteria	Failed fertiliy, salinity and chemical barrier	No	Failed fertiliy and chemical barrier	No	Failed fertiliy, salinity and chemical barrier	No

ASC	Haplic Eutrophic Red Chromosol	
Site number	West Balranald 77	
Assessment Item	Value	Decision
Reliable water source - Only 1 YES required		
Access to "reliable water supply"	No	No
Soils and landscape verification - All YES's required		
Is the slope ≤ 10%	1%	Yes
Is there <30% rock outcrop?	0%	Yes
Does ≤ 20%of area have unattached rock fragments >60mm diameter?	0%	Yes
Does ≤ 50%of area have gilgais >500mm deep?	0%	Yes
Only 1 YES required		
Is slope >5%? And does soil have moderately high or high fertility?	1% Slope + Mod High	No
Is slope <5%? And Are there SOME rock outcrops? And does soil have moderately high or high fertility?	1% Slope + 0% Outcrops + Mod High	Yes
Is slope <5%? And Are there NIL rock outcrops? And does soil have moderately fertility?	1% Slope + 0% Outcrops + Mod High	Yes
All YES's required		
Is effective rooting depth to a physical barrier ≥ 750mm?	No barrier	Yes
Is soil drainage better than poor?	Imperfectly	Yes
IS pH within the upper 600mm pH_{water} 5-8.9 or ph_{CaCl} 4.5-8.1?	7.4-7.9	Yes
Is salinity within the upper 600mm (ECe) ≤4dS/m or chloride <800mg/kg when gypsum is present?	0.89-1.35 ECe + Cl <10-20	Yes
Is effective rooting depth to a chemical barrier ≥ 750mm?	No barrier	Yes
Is the soil BSAL?		
Comments on pass/failure criteria	Yes	Yes

ASC	Sodic Hypocalcic Red Dermosol		Sodic Mesotrophic Brown Dermosol	
Site number	West Balranald 100		Nepean 7	
Assessment Item	Value	Decision	Value	Decision
Reliable water source - Only 1 YES required				
Access to "reliable water supply"	No	No	No	No
Soils and landscape verification - All YES's required				
Is the slope ≤ 10%	0%	Yes	1%	Yes
Is there <30% rock outcrop?	0%	Yes	0%	Yes
Does ≤ 20%of area have unattached rock fragments >60mm diameter?	0%	Yes	0%	Yes
Does ≤ 50%of area have gilgais >500mm deep?	0%	Yes	0%	Yes
Only 1 YES required				
Is slope >5%? And does soil have moderately high or high fertility?	0% Slope + Mod High	No	1% Slope + Mod High	No
Is slope <5%? And Are there SOME rock outcrops? And does soil have moderately high or high fertility?	0% Slope + 0% Outcrops + Mod High	Yes	1% Slope + 0% Outcrops + Mod High	Yes
Is slope <5%? And Are there NIL rock outcrops? And does soil have moderately fertility?	0% Slope + 0% Outcrops + Mod High	Yes	1% Slope + 0% Outcrops + Mod High	Yes
All YES's required				
Is effective rooting depth to a physical barrier ≥ 750mm?	No barrier	Yes	No barrier	Yes
Is soil drainage better than poor?	Imperfectly	Yes	Well drained	Yes
IS pH within the upper 600mm pH_{water} 5-8.9 or ph_{CaCl} 4.5-8.1?	8.2-9.0	No	6.0-8.3	Yes
Is salinity within the upper 600mm (ECe) ≤4dS/m or chloride <800mg/kg when gypsum is present?	1.25-18.00 Ece + Cl 100-3920	No	0.76-4.80 ECe + Cl 30-440	No
Is effective rooting depth to a chemical barrier ≥ 750mm?	Barrier at 5mm ESP 20.0%	No	Barrier at 0mm ESP 48.9%	No
Is the soil BSAL?				
Comments on pass/failure criteria	Failed pH, salinity and chemical barrier	No	Failed salinity and chemical barrier	No

ASC	Haplic Eutrophic Brown Kandosol		Haplic Eutrophic Brown Kandosol		Sodic Dystrophic Red Kandosol	
Site number	West Balranald 53		West Balranald 76		West Balranald 37	
Assessment Item	Value	Decision	Value	Decision	Value	Decision
Reliable water source - Only 1 YES required						
Access to "reliable water supply"	No	No	No	No	No	No
Soils and landscape verification - All YES's required						
Is the slope ≤ 10%	5%	Yes	4%	Yes	2%	Yes
Is there <30% rock outcrop?	0%	Yes	0%	Yes	0%	Yes
Does ≤ 20%of area have unattached rock fragments >60mm diameter?	0%	Yes	0%	Yes	0%	Yes
Does ≤ 50%of area have gilgais >500mm deep?	0%	Yes	0%	Yes	0%	Yes
Only 1 YES required						
Is slope >5%? And does soil have moderately high or high fertility?	5% Slope + Mod	No	4% Slope + Mod	No	2% Slope + Mod Low	No
Is slope <5%? And Are there SOME rock outcrops? And does soil have moderately high or high fertility?	5% Slope + 0% Outcrops + Mod	No	4% Slope + 0% Outcrops + Mod	No	2% Slope + 0% Outcrops + Mod Low	No
Is slope <5%? And Are there NIL rock outcrops? And does soil have moderately fertility?	5% Slope + 0% Outcrops + Mod	Yes	4% Slope + 0% Outcrops + Mod	Yes	2% Slope + 0% Outcrops + Mod Low	No
All YES's required						
Is effective rooting depth to a physical barrier ≥ 750mm?	No barrier	Yes	No barrier	Yes	No barrier	Yes
Is soil drainage better than poor?	Well drained	Yes	Rapidly	Yes	Well drained	Yes
IS pH within the upper 600mm pH_{water} 5-8.9 or ph_{CaCl} 4.5-8.1?	8.4-9.7	Yes	8.6-8.8	Yes	7.0-8.0	Yes
Is salinity within the upper 600mm (ECe) ≤4dS/m or chloride <800mg/kg when gypsum is present?	1.95-7.22 Ece + Cl <10-120	No	2.16-2.94 ECe + Cl 40-270	Yes	0.66-0.88 ECe + Cl 20-40	Yes
Is effective rooting depth to a chemical barrier ≥ 750mm?	No Barrier	Yes	No Barrier	Yes	Barrier at 0mm ESP 35.2%	No
Is the soil BSAL?						
Comments on pass/failure criteria	Failed salinity	No		No	Failed fertiliy and chemical barrier	No

ASC	Sodic Dystrophic Red Kandosol		Sodic Mesotrophic Red Kandosol		Sodic Mesotrophic Red Kandosol	
Site number	West Balranald 69		West Balranald 85		Nepean 8	
Assessment Item	Value	Decision	Value	Decision	Value	Decision
Reliable water source - Only 1 YES required						
Access to "reliable water supply"	No	No	No	No	No	No
Soils and landscape verification - All YES's required						
Is the slope ≤ 10%	7%	Yes	5%	Yes	2%	Yes
Is there <30% rock outcrop?	0%	Yes	0%	Yes	0%	Yes
Does ≤ 20%of area have unattached rock fragments >60mm diameter?	0%	Yes	0%	Yes	0%	Yes
Does ≤ 50%of area have gilgais >500mm deep?	0%	Yes	0%	Yes	0%	Yes
Only 1 YES required						
Is slope >5%? And does soil have moderately high or high fertility?	7% Slope + Mod Low	No	5% Slope + Mod Low	No	2% Slope + Mod Low	No
Is slope <5%? And Are there SOME rock outcrops? And does soil have moderately high or high fertility?	7% Slope + 0% Outcrops + Mod Low	No	5% Slope + 0% Outcrops + Mod Low	No	2% Slope + 0% Outcrops + Mod Low	No
Is slope <5%? And Are there NIL rock outcrops? And does soil have moderately fertility?	7% Slope + 0% Outcrops + Mod Low	No	5% Slope + 0% Outcrops + Mod Low	No	2% Slope + 0% Outcrops + Mod Low	No
All YES's required						
Is effective rooting depth to a physical barrier ≥ 750mm?	No barrier	Yes	No barrier	Yes	No barrier	Yes
Is soil drainage better than poor?	Rapidly	Yes	Well drained	Yes	Well drained	Yes
IS pH within the upper 600mm pH_{water} 5-8.9 or ph_{CaCl} 4.5-8.1?	6.5-8.2	Yes	7.3-8.4	Yes	5.7-8.4	Yes
Is salinity within the upper 600mm (ECe) ≤4dS/m or chloride <800mg/kg when gypsum is present?	0.37-12.88 ECe + Cl <10-510	No	0.80-14.42 ECe + Cl 20-1280	No	0.24-5.95 ECe + Cl <10-470	No
Is effective rooting depth to a chemical barrier ≥ 750mm?	Barrier at 200mm ESP 43.2%	No	Barrier at 0mm ESP 47.6%	No	Barrier at 10mm ESP 28.9%	No
Is the soil BSAL?						
Comments on pass/failure criteria	Failed fertiliy, salinity and chemical barrier	No	Failed fertiliy, salinity and chemical barrier	No	Failed fertiliy, salinity and chemical barrier	No

ASC	Sodic Dystrophic Red Kandosol		Sodic Mesotrophic Red Kandosol	
Site number	Nepean 24		Nepean 43	
Assessment Item	Value	Decision	Value	Decision
Reliable water source - Only 1 YES required				
Access to "reliable water supply"	No	No	No	No
Soils and landscape verification - All YES's required				
Is the slope ≤ 10%	5%	Yes	3%	Yes
Is there <30% rock outcrop?	0%	Yes	0%	Yes
Does ≤ 20%of area have unattached rock fragments >60mm diameter?	0%	Yes	0%	Yes
Does ≤ 50%of area have gilgais >500mm deep?	0%	Yes	0%	Yes
Only 1 YES required				
Is slope >5%? And does soil have moderately high or high fertility?	5% Slope + Mod Low	No	3% Slope + Mod Low	No
Is slope <5%? And Are there SOME rock outcrops? And does soil have moderately high or high fertility?	5% Slope + 0% Outcrops + Mod Low	No	3% Slope + 0% Outcrops + Mod Low	No
Is slope <5%? And Are there NIL rock outcrops? And does soil have moderately fertility?	5% Slope + 0% Outcrops + Mod Low	No	3% Slope + 0% Outcrops + Mod Low	No
All YES's required				
Is effective rooting depth to a physical barrier ≥ 750mm?	No barrier	Yes	No barrier	Yes
Is soil drainage better than poor?	Rapidly drained	Yes	Well drained	Yes
IS pH within the upper 600mm pH_{water} 5-8.9 or ph_{CaCl} 4.5-8.1?	6.9-8.1	Yes	7.2-8.4	Yes
Is salinity within the upper 600mm (ECe) ≤4dS/m or chloride <800mg/kg when gypsum is present?	1.34-1.72 ECe + Cl <10-10	Yes	2.17-11.63 ECe + Cl 50-850	No
Is effective rooting depth to a chemical barrier ≥ 750mm?	Barrier at 0mm ESP 44.2%	No	Barrier at 0mm ESP 27.1%	No
Is the soil BSAL?				
Comments on pass/failure criteria	Failed fertiliy and chemical barrier	No	Failed fertiliy, physical boundary, pH, salinity and chemical barrier	No

ASC	Hypocalcic Subnatric Brown Sodosol		Hypocalcic Hypernatric Red Sodosol		Hypocalcic Hypernatric Red Sodosol	
Site number	West Balranald 910		West Balranald 3		West Balranald 10	
Assessment Item	Value	Decision	Value	Decision	Value	Decision
Reliable water source - Only 1 YES required						
Access to "reliable water supply"	No	No	No	No	No	No
Soils and landscape verification - All YES's required						
Is the slope ≤ 10%	0%	Yes	0%	Yes	0%	Yes
Is there <30% rock outcrop?	0%	Yes	0%	Yes	0%	Yes
Does ≤ 20%of area have unattached rock fragments >60mm diameter?	0%	Yes	0%	Yes	0%	Yes
Does ≤ 50%of area have gilgais >500mm deep?	0%	Yes	0%	Yes	0%	Yes
Only 1 YES required						
Is slope >5%? And does soil have moderately high or high fertility?	0% Slope + Mod Low	No	0% Slope + Mod Low	No	0% Slope + Mod Low	No
Is slope <5%? And Are there SOME rock outcrops? And does soil have moderately high or high fertility?	0% Slope + 0% Outcrops + Mod Low	No	0% Slope + 0% Outcrops + Mod Low	No	0% Slope + 0% Outcrops + Mod Low	No
Is slope <5%? And Are there NIL rock outcrops? And does soil have moderately fertility?	0% Slope + 0% Outcrops + Mod Low	No	0% Slope + 0% Outcrops + Mod Low	No	0% Slope + 0% Outcrops + Mod Low	No
All YES's required						
Is effective rooting depth to a physical barrier ≥ 750mm?	No barrier	Yes	No barrier	Yes	No barrier	Yes
Is soil drainage better than poor?	Poorly drained	No	Imperfectly	Yes	Imperfect	Yes
IS pH within the upper 600mm pH_{water} 5-8.9 or ph_{CaCl} 4.5-8.1?	8.9-9.3	No	8.2-8.4	Yes	6.8-8.4	Yes
Is salinity within the upper 600mm (ECe) ≤4dS/m or chloride <800mg/kg when gypsum is present?	6.8-10.44 Ece + Cl <10	No	49.58-60.64 ECe + Cl 8950-10200	No	0.81-24.00 ECe + Cl 60-4690	Yes
Is effective rooting depth to a chemical barrier ≥ 750mm?	No barrier	Yes	Barrier at 0mm ESP 30.6%	No	Barrier at 0mm ESP 18.3%	No
Is the soil BSAL?						
Comments on pass/failure criteria	Failed fertiliy and chemical barrier	No	Failed fertiliy, salinity and chemical barrier	No	Failed fertiliy and chemical barrier	No

ASC	Mesotrophic Hypernatric Brown Sodosol		Mesotrophic Hypernatric Brown Sodosol		Mesotrophic Hypernatric Brown Sodosol	
Site number	West Balranald 13		West Balranald 24		West Balranald 32	
Assessment Item	Value	Decision	Value	Decision	Value	Decision
Reliable water source - Only 1 YES required						
Access to "reliable water supply"	No	No	No	No	No	No
Soils and landscape verification - All YES's required						
Is the slope ≤ 10%	0%	Yes	0%	Yes	1%	Yes
Is there <30% rock outcrop?	0%	Yes	0%	Yes	0%	Yes
Does ≤ 20%of area have unattached rock fragments >60mm diameter?	0%	Yes	0%	Yes	0%	Yes
Does ≤ 50%of area have gilgais >500mm deep?	0%	Yes	0%	Yes	0%	Yes
Only 1 YES required						
Is slope >5%? And does soil have moderately high or high fertility?	0% Slope + Mod Low	No	0% Slope + Mod Low	No	1% Slope + Mod Low	No
Is slope <5%? And Are there SOME rock outcrops? And does soil have moderately high or high fertility?	0% Slope + 0% Outcrops + Mod Low	No	0% Slope + 0% Outcrops + Mod Low	No	1% Slope + 0% Outcrops + Mod Low	No
Is slope <5%? And Are there NIL rock outcrops? And does soil have moderately fertility?	0% Slope + 0% Outcrops + Mod Low	No	0% Slope + 0% Outcrops + Mod Low	No	1% Slope + 0% Outcrops + Mod Low	No
All YES's required						
Is effective rooting depth to a physical barrier ≥ 750mm?	No barrier	Yes	No barrier	Yes	No barrier	Yes
Is soil drainage better than poor?	Imperfect	Yes	Imperfect	Yes	Poorly drained	No
IS pH within the upper 600mm pH_{water} 5-8.9 or ph_{CaCl} 4.5-8.1?	8.0-8.5	Yes	5.6-8.6	Yes	5.6-8.6	Yes
Is salinity within the upper 600mm (ECe) ≤4dS/m or chloride <800mg/kg when gypsum is present?	2.83-20.68 ECe + Cl 80-3820	No	0.59-23.18 ECe + Cl 110-4550	No	0.59-23.18 ECe + Cl 110-4550	No
Is effective rooting depth to a chemical barrier ≥ 750mm?	Barrier at 0mm ESP 30.4%	No	Barrier at 5mm ESP 39.%	No	Barrier at 5mm ESP 39.7%	No
Is the soil BSAL?						
Comments on pass/failure criteria	Failed fertiliy, salinity and chemical barrier	No	Failed fertiliy, salinity and chemical barrier	No	Failed fertiliy, salinity and chemical barrier	No

ASC	Mesotrophic Hypernatric Grey Sodosol		Hypocalcic Subnatric Red Sodosol		Hypercalcic Hypernatric Brown Sodosol	
Site number	West Balranald 25		West Balranald 34		West Balranald 36	
Assessment Item	Value	Decision	Value	Decision	Value	Decision
Reliable water source - Only 1 YES required						
Access to "reliable water supply"	No	No	No	No	No	No
Soils and landscape verification - All YES's required						
Is the slope ≤ 10%	1%	Yes	0%	Yes	5%	Yes
Is there <30% rock outcrop?	0%	Yes	0%	Yes	0%	Yes
Does ≤ 20%of area have unattached rock fragments >60mm diameter?	0%	Yes	0%	Yes	0%	Yes
Does ≤ 50%of area have gilgais >500mm deep?	0%	Yes	0%	Yes	0%	Yes
Only 1 YES required						
Is slope >5%? And does soil have moderately high or high fertility?	1% Slope + Mod Low	No	0% Slope + Mod High	No	5% Slope + Mod High	Yes
Is slope <5%? And Are there SOME rock outcrops? And does soil have moderately high or high fertility?	1% Slope + 0% Outcrops + Mod Low	No	0% Slope + 0% Outcrops + Mod High	Yes	5% Slope + 0% Outcrops + Mod High	Yes
Is slope <5%? And Are there NIL rock outcrops? And does soil have moderately fertility?	1% Slope + 0% Outcrops + Mod Low	No	0% Slope + 0% Outcrops + Mod High	Yes	5% Slope + 0% Outcrops + Mod High	Yes
All YES's required						
Is effective rooting depth to a physical barrier ≥ 750mm?	No barrier	Yes	No barrier	Yes	No barrier	Yes
Is soil drainage better than poor?	Imperfect	Yes	Imperfectly	Yes	Moderately well drained	Yes
IS pH within the upper 600mm pH_{water} 5-8.9 or ph_{CaCl} 4.5-8.1?	8.1-8.6	Yes	8.3-8.9	Yes	8.0-8.9	Yes
Is salinity within the upper 600mm (ECe) ≤4dS/m or chloride <800mg/kg when gypsum is present?	2.71-8.03 ECe + Cl 130-1100	No	4.25-26.85 Ece + Cl 340-4970	No	2.57-21.90 ECe + Cl 30-3410	No
Is effective rooting depth to a chemical barrier ≥ 750mm?	Barrier at 0mm ESP 50.3%	No	Barrier at 0mm 4.55 Ece	No	Barrier at 150mm ESP 39.2%	No
Is the soil BSAL?						
Comments on pass/failure criteria	Failed fertiliy, salinity and chemical barrier	No	Failed salinity and chemical barrier	No	Failed salinity and chemical barrier	No

ASC	Mesotrophic Hypernatric Brown Sodosol		Mesotrophic Hypernatric Grey Sodosol	
Site number	West Balranald 23		West Balranald 33	
Assessment Item	Value	Decision	Value	Decision
Reliable water source - Only 1 YES required				
Access to "reliable water supply"	No	No	No	No
Soils and landscape verification - All YES's required				
Is the slope ≤ 10%	0%	Yes	1%	Yes
Is there <30% rock outcrop?	0%	Yes	0%	Yes
Does ≤ 20%of area have unattached rock fragments >60mm diameter?	0%	Yes	0%	Yes
Does ≤ 50%of area have gilgais >500mm deep?	0%	Yes	0%	Yes
Only 1 YES required				
Is slope >5%? And does soil have moderately high or high fertility?	0% Slope + Mod High	No	1% Slope + Mod High	No
Is slope <5%? And Are there SOME rock outcrops? And does soil have moderately high or high fertility?	0% Slope + 0% Outcrops + Mod High	Yes	1% Slope + 0% Outcrops + Mod High	Yes
Is slope <5%? And Are there NIL rock outcrops? And does soil have moderately fertility?	0% Slope + 0% Outcrops + Mod High	Yes	1% Slope + 0% Outcrops + Mod High	Yes
All YES's required				
Is effective rooting depth to a physical barrier ≥ 750mm?	No barrier	Yes	No barrier	Yes
Is soil drainage better than poor?	Imperfectly	Yes	Imperfectly	Yes
IS pH within the upper 600mm pH_{water} 5-8.9 or ph_{CaCl} 4.5-8.1?	7.8-8.4	Yes	6.9-8.4	Yes
Is salinity within the upper 600mm (ECe) ≤4dS/m or chloride <800mg/kg when gypsum is present?	0.12-12.48 ECe + Cl 20-2480	No	1.28-8.78 ECe + Cl <10-1400	No
Is effective rooting depth to a chemical barrier ≥ 750mm?	Barrier at 0mm ESP 42.6%	No	Barrier at 5mm ESP 27.0%	No
Is the soil BSAL?				
Comments on pass/failure criteria	Failed salinity and chemical barrier	No	Failed salinity and chemical barrier	No

ASC	Mesotrophic Hypernatric Grey Sodosol		Dystrophic Hypernatric Brown Sodosol	
Site number	West Balranald 35		West Balranald 44	
Assessment Item	Value	Decision	Value	Decision
Reliable water source - Only 1 YES required				
Access to "reliable water supply"	No	No	No	No
Soils and landscape verification - All YES's required				
Is the slope ≤ 10%	2%	Yes	1%	Yes
Is there <30% rock outcrop?	0%	Yes	0%	Yes
Does ≤ 20%of area have unattached rock fragments >60mm diameter?	0%	Yes	0%	Yes
Does ≤ 50%of area have gilgais >500mm deep?	0%	Yes	0%	Yes
Only 1 YES required				
Is slope >5%? And does soil have moderately high or high fertility?	2% Slope + Mod High	No	1% Slope + Mod Low	No
Is slope <5%? And Are there SOME rock outcrops? And does soil have moderately high or high fertility?	2% Slope + 0% Outcrops + Mod High	Yes	1% Slope + 0% Outcrops + Mod Low	No
Is slope <5%? And Are there NIL rock outcrops? And does soil have moderately fertility?	2% Slope + 0% Outcrops + Mod High	Yes	1% Slope + 0% Outcrops + Mod Low	No
All YES's required				
Is effective rooting depth to a physical barrier ≥ 750mm?	No barrier	Yes	No barrier	Yes
Is soil drainage better than poor?	Very poorly drained	No	Well drained	Yes
IS pH within the upper 600mm pH_{water} 5-8.9 or ph_{CaCl} 4.5-8.1?	8.0-8.5	Yes	6.6-8.5	Yes
Is salinity within the upper 600mm (ECe) ≤4dS/m or chloride <800mg/kg when gypsum is present?	0.99-1.24 ECe + Cl 20-30	Yes	0.39-14.26 ECe + Cl 40-2490	No
Is effective rooting depth to a chemical barrier ≥ 750mm?	Barrier at 0mm ESP 24.4%	No	Barrier at 0mm ESP 33.0%	No
Is the soil BSAL?				
Comments on pass/failure criteria	Failed drainage and chemical barrier	No	Failed fertility, salinity and chemical barrier	No

ASC	Episodic-Epicalcareous Crusty Brown Vertosol		Episodic-Epicalcareous Crusty Brown Vertosol		Episodic-Epicalcareous Crusty Brown Vertosol	
Site number	West Balranald 38		West Balranald 46		West Balranald 57	
Assessment Item	Value	Decision	Value	Decision	Value	Decision
Reliable water source - Only 1 YES required						
Access to "reliable water supply"	No	No	No	No	No	No
Soils and landscape verification - All YES's required						
Is the slope ≤ 10%	0%	Yes	1%	Yes	1%	Yes
Is there <30% rock outcrop?	0%	Yes	0%	Yes	0%	Yes
Does ≤ 20%of area have unattached rock fragments >60mm diameter?	0%	Yes	0%	Yes	0%	Yes
Does ≤ 50%of area have gilgais >500mm deep?	0%	Yes	0%	Yes	0%	Yes
Only 1 YES required						
Is slope >5%? And does soil have moderately high or high fertility?	0% Slope + Mod	Yes	1% Slope + Mod	Yes	1% Slope + Mod	Yes
Is slope <5%? And Are there SOME rock outcrops? And does soil have moderately high or high fertility?	0% Slope + 0% Outcrops + Mod	No	1% Slope + 0% Outcrops + Mod	No	1% Slope + 0% Outcrops + Mod	No
Is slope <5%? And Are there NIL rock outcrops? And does soil have moderately fertility?	0% Slope + 0% Outcrops + Mod	No	1% Slope + 0% Outcrops + Mod	No	1% Slope + 0% Outcrops + Mod	No
All YES's required						
Is effective rooting depth to a physical barrier ≥ 750mm?	No barrier	Yes	No barrier	Yes	No barrier	Yes
Is soil drainage better than poor?	Imperfectly	Yes	Imperfectly	Yes	Imperfectly	Yes
IS pH within the upper 600mm pH_{water} 5-8.9 or ph_{CaCl} 4.5-8.1?	6.8-8.5	Yes	7.8-8.6	Yes	8.0-8.6	Yes
Is salinity within the upper 600mm (ECe) ≤4dS/m or chloride <800mg/kg when gypsum is present?	0.53-8.20 Ece + Cl 30-1050	No	1.00-11.91 ECe + Cl 1780	No	1.29-10.41 ECe + Cl 10-1670	No
Is effective rooting depth to a chemical barrier ≥ 750mm?	Barrier at 0mm ESP 35.0%	No	Barrier at 0mm ESP 31.1%	No	Barrier at 0mm ESP 39.5%	No
Is the soil BSAL?						
Comments on pass/failure criteria	Failed salinity and chemical barrier	No	Failed salinity and chemical barrier	No	Failed fertiliy and chemical barrier	No

Appendix B

Land and Soil Capability assessment

Land and Soil Capability Assessment Report

Decision Tables | Balranald Mineral Sands

Prepared for Iluka Resources | 20 February 2015

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Land and Soil Capability Assessment Report

Draft Report

Report J12011RP1 | Prepared for Iluka Resources | 20 February 2015

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Signature		Signature	
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Document Control

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1 Introduction

This report addresses the requirements of *The land and soil capability assessment scheme* (OEH 2012). *The land and soil capability assessment scheme* (OEH 2012) outlines the process to assess the limitations of land use based on the biophysical characteristics of the land. It should be noted that the tables enclosed within this report are either directly replicated or adapted from OEH 2012.

The land and soil capability (LSC) classes are presented for each soil type. This is done using information collected during field (soil) survey and supplemented with information gathered during desktop assessment. Table 1.1 shows the information required to make an assessment of LSC classes (OEH 2012). Table 1.2 presents definitions of the LSC classes.

Table 1.1 Data requirements for determining LSC classes (OEH 2012)

	Water erosion	Wind erosion	Soil structure decline	Soil acidification	Salinity	Water-logging	Shallow soils and rock	Mass movement
NSW Division	✓							
Sand dune or mobile sand body	✓							
Slope %	✓							✓
Scree or talus slope								✓
Footslope or drainage plain receiving high run-on	✓							
Gully erosion or sodic dispersible subsoils	✓							
Annual rainfall		✓		✓				✓
Wind erosive power		✓						
Exposure to wind		✓						
Surface soil texture		✓	✓	✓				
Surface soil texture modifier			✓					
Great Soil Group				✓				
pH of surface soil				✓				
Surface soil modifier				✓				
Parent material				✓				
Recharge potential of landscape					✓			
Discharge potential of landscape					✓			
Salt store of landscape					✓			
Waterlogging duration						✓		
Return period of waterlogging						✓		
Rocky outcrop							✓	
Soil depth							✓	
Presence of existing mass movement								✓

Table 1.2 LSC classes - general definitions (OEH 2012)

LSC class	General definition
Land capable of a wide variety of land uses (cropping, grazing, horticulture, forestry, nature conservation)	
1	**Extremely high capability land**: Land has no limitations. No special land management practices required. Land capable of all rural land uses and land management practices.
2	**Very high capability land**: Land has slight limitations. These can be managed by readily available, easily implemented management practices. Land is capable of most land uses and land management practices, including intensive cropping with cultivation.
3	**High capability land**: Land has moderate limitations and is capable of sustaining high-impact land uses, such as cropping with cultivation, using more intensive, readily available and widely accepted management practices. However, careful management of limitations is required for cropping and intensive grazing to avoid land and environmental degradation.
Land capable of a variety of land uses (cropping with restricted cultivation, pasture cropping, grazing, some horticulture, forestry, nature conservation)	
4	**Moderate capability land**: Land has moderate to high limitations for high-impact land uses. Will restrict land management options for regular high-impact land uses such as cropping, high-intensity grazing and horticulture. These limitations can only be managed by specialised management practices with a high level of knowledge, expertise, inputs, investment and technology. **,**
5	**Moderate–low capability land**: Land has high limitations for high-impact land uses. Will largely restrict land use to grazing, some horticulture (orchards), forestry and nature conservation. The limitations need to be carefully managed to prevent long-term degradation.
Land capable for a limited set of land uses (grazing, forestry and nature conservation	
6	**Low capability land**: Land has very high limitations for high-impact land uses. Land use restricted to low-impact land uses such as grazing, forestry and nature conservation. Careful management of limitations is required to prevent severe land and environmental degradation
Land generally incapable of agricultural land use (selective forestry and nature conservation)	
7	**Very low capability land**: Land has severe limitations that restrict most land uses and generally cannot be overcome. On-site and off-site impacts of land management practices can be extremely severe if limitations not managed. There should be minimal disturbance of native vegetation.
8	**Extremely low capability land**: Limitations are so severe that the land is incapable of sustaining any land use apart from nature conservation. There should be no disturbance of native vegetation.

2 New South Wales land divisions

The land and soil capability assessment scheme (OEH 2012) applies different criteria to properties depending on their location in NSW. Under the *Crown Lands Act 1884 (NSWG 1884),* NSW was divided into the three land division zones of Western, Central and Eastern. The first step in the assessment process is to determine which zone the property exists in. This can be determined by locating the property on the map in Figure 2.1.

Figure 2.1 **Map of NSW land divisions**
(Source: http://www.nla.gov.au/apps/cdview/?pi=nla.map-rm2795-sd)

The property zone can be accurately determined through examination of the 1907 Map of New South Wales (DOL 1907). The Balranald Project is located in the Western Land Division.

3 Assessment of water erosion LSC classes

Table 3.1 shows the assessment table for determining water erosion LSC classes. Assessment has been based on the criteria applicable to the Western Land Division.

Table 3.1 Water erosion LSC class assessment table (OEH 2012)

NSW division	Slope class (%) for each LSC class							
	Class 1	Class 2	Class 3	Class 4	Class 5	Class 6	Class 7	Class 8
Western division[1]	<1	1 to <3 or <1 for hardsetting red soils	1 to 3	3 to 5	3 to 5	5 to 33	33 to 50	>50

Notes: 1. Western catchment management authority (CMA) provided advice on slope classes.

Table 3.2 presents water erosion LSC class results for each of the detailed sites in both the West Balranald and Nepean project areas.

Table 3.2 Water erosion LSC classes for each soil type

Soil type	Slope class (%)[1]	Water Erosion LSC class
Calcarosols		
Hypercalcic Calcarosol		
West Balranald 6	2	2
West Balranald 14	0	1
West Balranald 70	5	5
Nepean 31	3	3
Nepean 49	0	1
Nepean 47	4	5
Hypocalcic Calcarosol		
West Balranald 12	0	1
West Balranald 15	0	1
West Balranald 101	0	1
Chromosols		
West Balranald 77	1	2
Dermosols		
West Balranald 100	0	1
Nepean 7	1	2
Kandosols		
West Balranald 53	5	4
West Balranald 76	4	4
West Balranald 37	2	2
West Balranald 69	7	6
West Balranald 85	5	5
Nepean 8	2	2

Table 3.2 Water erosion LSC classes for each soil type

Soil type	Slope class (%)[1]	Water Erosion LSC class
Nepean 24	5	5
Nepean 43	3	5
Sodosols		
West Balranald 910	0	1
West Balranald 3	0	1
West Balranald 10	0	1
West Balranald 13	0	1
West Balranald 24	0	1
West Balranald 32	1	2
West Balranald 56	1	2
West Balranald 25	1	2
West Balranald 34	0	1
West Balranald 36	5	5
West Balranald 23	0	1
West Balranald 33	1	2
West Balranald 35	2	2
West Balranald 44	1	2
Vertosols		
West Balranald 38	0	1
West Balranald 46	1	2
West Balranald 57	1	2

4 Assessment of wind erosion LSC classes

The wind erosion LSC class requires the assessment of four hazards:

1. wind erodibility class of surface soil;
2. wind erosion power;
3. exposure to wind; and
4. average yearly rainfall.

4.1 Wind erodibility hazard

Table 4.1 shows the assessment wind erodibility hazard using surface soil texture.

Table 4.1 Wind erodibility hazard of surface soils (OEH 2012)

Wind erodibility class of surface soil	Surface soil texture
Low	Loams, clay loams or clays (all with >13% clay)
Moderate	Fine sandy loams or sandy loams (all with 6–13% clay); also includes organic peats
High	Loamy sands or loose sands (all with <6% clay).

4.2 Exposure to wind

Table 4.2 shows the assessment exposure to wind from surface soil erodibility class determined from Table 4.1.

Table 4.2 Exposure to wind (OEH 2012)

Wind erodibility class of surface soil	Site exposure to prevailing winds
Low	Sheltered locations in valleys or in the lee of hills
Moderate	Intermediate situations – not low or high exposure locations
High	Hilltops, cols or saddles, open plains or exposed coastal locations

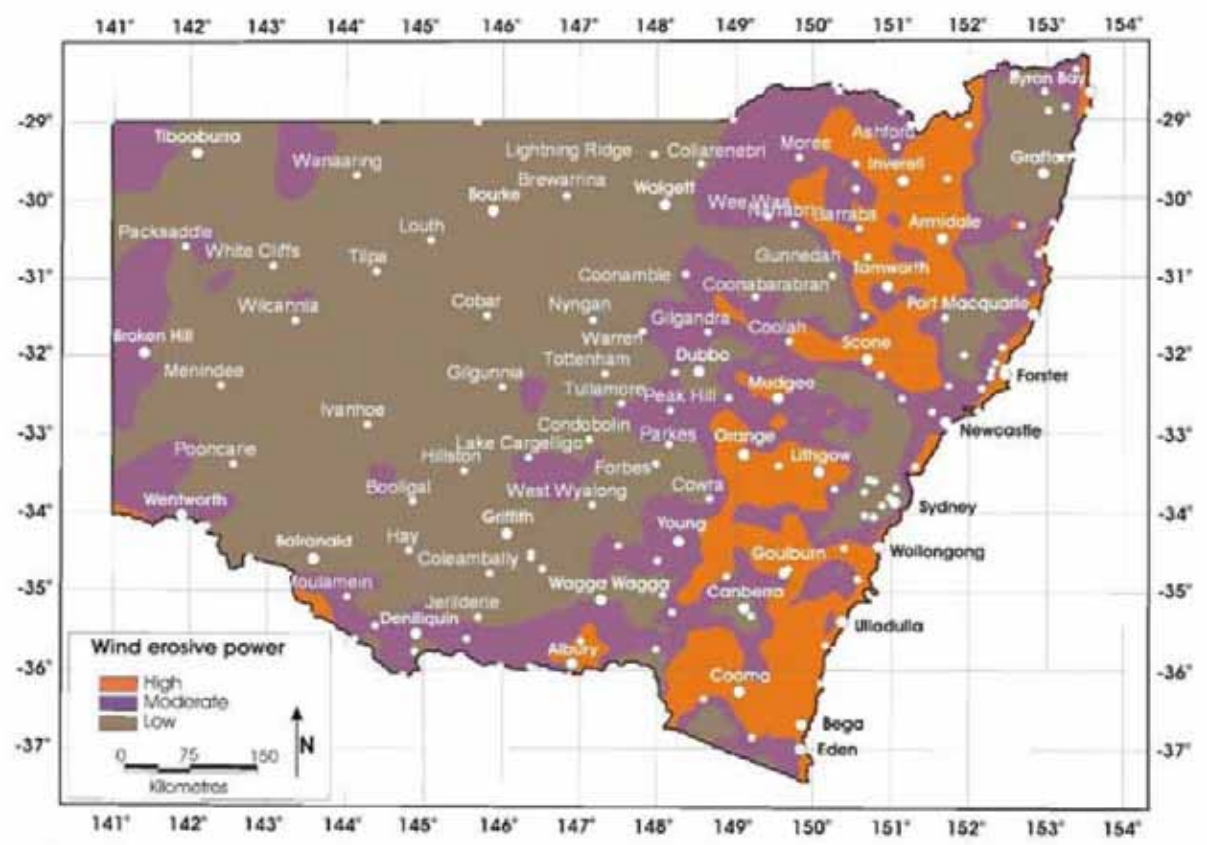
4.3 Average yearly rainfall

This can be found on the Australian Bureau of Meteorology's website at http://www.bom.gov.au/climate/data/

4.4 Wind erosion power

Figure 4.1 shows the assessment figure for determining wind erosion power.

Figure 4.1 Wind erosive power (NSW Department of Trade and Investment in OEH 2012)



Source: NSW Department of Trade and Investment (undated).

4.5 Wind erosion LSC classes

Table 4.3 shows the assessment table for determining wind erosion LSC classes.

Table 4.3 Wind erosion LSC class assessment table (OEH 2012)

Wind erodibility class of surface soil	Wind erosive power	Exposure to wind	Average annual rainfall (mm)			
			>500	300–500	200 to <300	<200
Low	Low	Low	1	2	3	6
		Moderate	1	2	3	6
		High	2	3	4	7
	Moderate	Low	1	2	3	6
		Moderate	2	3	4	6
		High	3	4	5	7
	High	Low	2	3	4	6
		Moderate	3	4	5	7
		High	4	5	6	7
Moderate	Low	Low	2	3	4	7
		Moderate	3	4	5	7
		High	4	5	6	8
	Moderate	Low	2	3	4	6
		Moderate	3	4	5	7
		High	4	5	6	8
	High	Low	3	4	5	7
		Moderate	4	5	6	8
		High	5	6	7	8
High	Low	Low	3	4	5	7
		Moderate	4	5	6	8
		High	5	6	7	8
	Moderate	Low	4	5	6	8
		Moderate	5	6	7	8
		High	6	7	8	8
	High	Low	5	6	7	8
		Moderate	6	7	8	8
		High	7 (8*)	8	8	8

*Notes: * Mobile sand bodies such as coastal beaches, foredunes and blowouts are Class 8.*

Table 4.4 presents the results table for water erosion LSC classes.

Table 4.4 Wind erosion LSC classes for each soil type

Soil type	Surface soils texture	Wind erodibility class	Wind erosive power class	Site exposure	Exposure to wind class	Average annual rainfall[1]	Wind Erosion LSC class
Calcarosols							
Hypercalcic Calcarosol							
West Balranald 6	SCL	Low	Low	Plain	High	324.0	3
West Balranald 14	SCL	Low	Low	Plain	High	324.0	3
West Balranald 70	LS	High	Low	Mid-slope, duneslope	Moderate	324.0	5
Nepean 31	SL	Moderate	Low	Lower-slope, duneslope	Moderate	324.0	4
Nepean 49	SL	Moderate	Low	Plain	High	324.0	5
Nepean 47	SL	Moderate	Low	Mid-slope, duneslope	Moderate	324.0	4
Hypocalcic Calcarosol							
West Balranald 12	SL	Moderate	Low	Plain	High	324.0	5
West Balranald 15	SL	Moderate	Low	Plain	High	324.0	5
West Balranald 101	SL	Moderate	Low	Plain	High	324.0	5
Chromosols							
West Balranald 77	SL	Moderate	Low	Closed depression, swale	Moderate	324.0	4
Dermosols							
West Balranald 100	SCL	Low	Low	Plain	High	324.0	3
Nepean 7	LS	High	Low	Duneslope	High	324.0	6
Kandosols							
West Balranald 53	LS	High	Low	Mid-slope, duneslope	Moderate	324.0	5
West Balranald 76	LS	High	Low	Mid-slope, duneslope	Moderate	324.0	5
West Balranald 37	SL	Moderate	Low	Hillock Dunecrest	High	324.0	5
West Balranald 69	S	High	Low	Upper-slope, duneslope	High	324.0	6
West Balranald 85	LS	High	Low	Mid-slope, duneslope	Moderate	324.0	5
Nepean 8	LS	High	Low	Simple-slope, duneslope	Moderate	324.0	5
Nepean 24	LS	High	Low	Upper-slope Dunecrest	High	324.0	6
Nepean 43	SL	Moderate	Low	Simple-slope, duneslope	Moderate	324.0	4
Sodosols							
West Balranald 910	CL	Low	Low	Plain	High	324.0	3
West Balranald 3	SCL	Low	Low	Scald	High	324.0	3

Table 4.4 Wind erosion LSC classes for each soil type

Soil type	Surface soils texture	Wind erodibility class	Wind erosive power class	Site exposure	Exposure to wind class	Average annual rainfall[1]	Wind Erosion LSC class
West Balranald 10	SL	Moderate	Low	Plain	High	324.0	5
West Balranald 13	SL	Moderate	Low	Plain	High	324.0	5
West Balranald 24	SCL	Low	Low	Plain	High	324.0	3
West Balranald 32	CL	Low	Low	Plain	High	324.0	3
West Balranald 56	SCL	Low	Low	Flat swale	High	324.0	3
West Balranald 25	CLS	Low	Low	Closed depression, plain	Moderate	324.0	2
West Balranald 34	SCL	Low	Low	Plain	High	324.0	3
West Balranald 36	SL	Moderate	Low	Mid-slope, duneslope	Moderate	324.0	4
West Balranald 23	CLS	Low	Low	Plain	High	324.0	3
West Balranald 33	SCL	Low	Low	Plain	High	324.0	3
West Balranald 35	ZCL	Low	Low	Closed depression, drainage depression	Moderate	324.0	2
West Balranald 44	SCL	Low	Low	Plain	High	324.0	3
Vertosols							
West Balranald 38	SCL	Low	Low	Plain	High	324.0	3
West Balranald 46	SCL	Low	Low	Open depression, swamp	Moderate	324.0	2
West Balranald 57	SCL	Low	Low	Flat swale	High	324.0	3

Notes: 1.Climate data from nearest the site, Balranald (RSL) Bureau of Meteorology weather station, site number 049002

5 Assessment of soil structural decline LSC classes

Table 5.1 shows the assessment table for determining soil structural decline LSC classes. Table 5.2 provides further information on the surface soil properties of clays to be used in collaboration with Table 5.1.

Table 5.1 Soil structural decline LSC class assessment table (OEH 2012)

Field texture (surface soils)	Modifier	Outcome - surface soil type	LCS class
Loose sand	Nil	Loose sand	1
Sandy loam	Nil	Fragile light textured surface soil	3
Fine sandy loam	Normal	Fragile light textured soil	3
	High levels of silt and very fine sand (>60%)	Fragile light textured soil – very hardsetting	4
Loam	Normal	Fragile medium textured soil	3
	Friable/ferric[1]	Friable medium textured soils – includes dark, friable loam soils	1
	High levels of silt and very fine sand	Fragile medium textured soil – very hardsetting	4
	Mildly sodic	Mildly sodic loam surface soil	4
	Moderately sodic	Moderately sodic loam surface soil	6
Clay loam	Normal	Fragile medium textured soil	3
	Friable/ferric[1]	Friable clay loam surface soil – includes dark, friable clay loam soils	1
	High levels of silt and very fine sand (>60%)	Fragile medium textured soil – very hardsetting	4
	Mildly sodic	Mildly sodic clay loam surface soil	4
	Moderately sodic	Moderately sodic clay loam surface soil	6
Clay	Friable/ferric[1]	Friable clay surface soil	2
	Strongly self-mulching	Strongly self-mulching surface soil	1
	Weakly self-mulching	Weakly self-mulching surface soil	3
	Mildly sodic	Mildly sodic/coarsely structured clay surface soil	4
	Moderately sodic	Moderately sodic/coarsely structured clay surface soil	6
	Strongly sodic	Strongly sodic surface soil	7
Highly organic soils	Mineral soils with high organic matter[2]	Mineral soils with high organic matter	-[2]
	Organosol/peat soils[3]	Organic/peat soils	7

Notes:

[1] The occurrence of friable or ferric surface soils is associated with (a) basaltic or basic parent materials and soils of the Ferrosols groups in the Australian Soil Classification or the Krasnozems and Euchrozem Great Soil Groups, and (b) the dark loam surface soils of the Chernozems and Prairie Soils on alluvial flats.

[2] Loosely defined here as soils with over 8% organic carbon. These soils revert to the LSC class determined by the mineral component of the soils.

[3] Organosols have organic material layers over 0.4 m thick with minimum organic carbon of 12% if sands or 18% if clays (Isbell 2002).

Table 5.2 Guidelines for evaluating some surface soil properties of clays

Sodicity/size of soil structural units	Character of surface soil
Very low exchangeable sodium (<3%), high exchangeable calcium, strongly swelling clays (smectitic) as in Vertosols (GSG Black Earths) Peds/aggregates 2–5 mm in an air dry condition	Strongly self-mulching surface soil
Low exchangeable sodium (3–5%), moderate exchangeable calcium, moderately swelling clays (illitic, interstratified, kaolinitic) as in many Dermosols and fertile Chromosols (GSG, Krasnozems, Euchrozems and others) Peds/aggregates 5–10 mm in an air dry condition	Weakly self-mulching surface soil
Moderate levels of exchangeable sodium (5–8%), often moderately low exchangeable calcium relative to exchangeable magnesium (ratio <2:1) Peds/aggregates 10–20 mm in an air dry condition	Mildly sodic surface soils
High levels of exchangeable sodium (8–15%), often low exchangeable calcium relative to exchangeable magnesium (ratio <1:1) Peds/aggregates 20–50 mm in an air dry condition	Moderately sodic surface soils
Very high levels of exchangeable sodium (>15%), often very low exchangeable calcium relative to exchangeable magnesium (ratio <0.5:1) Peds/aggregates >50 mm in an air dry condition	Strongly sodic surface soils

Table 5.3 presents the results for soil structural decline LSC classes in the project area.

Table 5.3 Soil structural decline LSC classes for each soil type

Soil type	Field texture (surface soils)	Modifier	Outcome - surface soil type	Soil structural decline LSC class
Calcarosols				
Hypercalcic Calcarosol				
West Balranald 6	SCL	Moderately sodic	Moderately sodic clay loam surface soil	6
West Balranald 14	SCL	Moderately sodic	Moderately sodic clay loam surface soil	6
West Balranald 70	LS	Moderately sodic	Moderately sodic clay loam surface soil	6
Nepean 31	SL	Mildly sodic	Mildly sodic loam surface soil	4
Nepean 49	SL	Moderately sodic	Moderately sodic clay loam surface soil	6
Nepean 47	SL	Moderately sodic	Moderately sodic clay loam surface soil	6
Hypocalcic Calcarosol				
West Balranald 12	SL	Moderately sodic	Moderately sodic loam surface soil	6
West Balranald 15	SL	Mildly sodic	Mildly sodic loam surface soil	4
West Balranald 101	SL	Moderately sodic	Moderately sodic loam surface soil	6
Chromosols				
West Balranald 77	SL	Mildly sodic	Mildly sodic loam surface soil	4
Dermosols				
West Balranald 100	SCL	Moderately sodic	Moderately sodic clay loam surface soil	6
Nepean 7	LS	Nil	Fragile light textured surface soil	3
Kandosols				
West Balranald 53	LS	Nil	Fragile light textured surface soil	3
West Balranald 76	LS	Nil	Fragile light textured surface soil	3
West Balranald 37	SL	Moderately sodic	Moderately sodic loam surface soil	6
West Balranald 69	S	Nil	Loose sand	1
West Balranald 85	LS	Nil	Fragile light textured surface soil	3
Nepean 8	LS	Nil	Fragile light textured surface soil	3

Table 5.3 Soil structural decline LSC classes for each soil type

Soil type	Field texture (surface soils)	Modifier	Outcome - surface soil type	Soil structural decline LSC class
Nepean 24	LS	Nil	Fragile light textured surface soil	3
Nepean 43	SL	Moderately sodic	Moderately sodic loam surface soil	6
Sodosols				
West Balranald 910	CL	Moderately sodic	Moderately sodic clay loam surface soil	6
West Balranald 3	SCL	Moderately sodic	Moderately sodic clay loam surface soil	6
West Balranald 10	SL	Moderately sodic	Moderately sodic loam surface soil	6
West Balranald 13	SL	Moderately sodic	Moderately sodic loam surface soil	6
West Balranald 24	SCL	Moderately sodic	Moderately sodic clay loam surface soil	6
West Balranald 32	CL	Moderately sodic	Moderately sodic clay loam surface soil	6
West Balranald 56	SCL	Moderately sodic	Moderately sodic clay loam surface soil	6
West Balranald 25	CLS	Moderately sodic	Moderately sodic clay loam surface soil	6
West Balranald 34	SCL	Moderately sodic	Moderately sodic clay loam surface soil	6
West Balranald 36	SL	Mildly sodic	Mildly sodic loam surface soil	4
West Balranald 23	CLS	Moderately sodic	Moderately sodic clay loam surface soil	6
West Balranald 33	SCL	Moderately sodic	Moderately sodic clay loam surface soil	6
West Balranald 35	ZCL	Moderately sodic	Moderately sodic clay loam surface soil	6
West Balranald 44	SCL	Moderately sodic	Moderately sodic clay loam surface soil	6
Vertosols				
West Balranald 38	SCL	Moderately sodic	Moderately sodic clay loam surface soil	6
West Balranald 46	SCL	Moderately sodic	Moderately sodic clay loam surface soil	6
West Balranald 57	SCL	Moderately sodic	Moderately sodic clay loam surface soil	6

6 Assessment of soil acidification LSC classes

Soil acidification is determined through a combination of buffering capacity of the soil surface, mean annual rainfall and pH of the natural soil surface. Buffering capacity of the soil surface can be determined through three different processes. Using either the Great Soil Group (Table 6.1), the soil surface texture (Table 6.2) or the geology of the area (Table 6.3). Table 6.4 is the assessment table that uses the buffering capacity information to determine the LSC class.

Table 6.1 Estimating buffering capacity of the soil surface by Great Soil Group (OEH 2012)

Great Soil Group	Buffering capacity of surface soil	Great Soil Group	Buffering capacity of surface soil
Acid Peats	VL	Non-calcic Brown soils	M
Alluvial Soils – Light sandy textured (Sands to Sandy Loams)	L	Peaty Podzols	L
Alluvial Soils – Medium textured (Loams clay loams)	M	Podzols	VL
Alpine Humus soils	M	Prairie Soils	H
Black Earths	VH	Red and Brown Hardpan Soils	H
Brown Earths	M	Red-brown Earths	M
Brown Podzolic Soils	M	Red Earths – less fertile (granites and metasediments)	L
Calcareous Red Earths	H	Red Earths – more fertile (volcanics, granodiorites) or highly structured	M
Calcareous Sands	M	Red Podzolic Soils – less fertile (granites and metasediments)	L
Chernozems	H	Red Podzolic Soils – more fertile (volcanics, granodiorites) or highly structured	M
Chocolate soils	M	Rendzinas	H
Desert Loams	M	Siliceous Sands	VL
Earthy Sands	VL	Solodic soils	L
Euchrozems	H	Solonchaks	H
Gleyed Podzolic Soils	L	Solonetz	M
Grey-brown and Red Calcareous Soils	H	Solonized Brown Soils	M
Grey-brown Podzolic soils	L	Solonized Solonetz	L
Grey, Brown and Red Clays	VH	Soloths	L
Humic Gleys	L	Terra Rossa Soils	M
Humus Podzols	L	Wiesenboden	H
Krasnozems	M	Xanthozems	M
Lateritic Podzolic Soils	L	Yellow Earths	L
Lithosols	VL	Yellow Podzolic Soils – less fertile (granites and metasediments)	L
Neutral to Alkaline Peats	M	Yellow Podzolic Soils – more fertile (volcanics, granodiorites) or highly structured	M

Table 6.2 Estimating buffering capacity of the soil surface by surface soil texture (OEH 2012)

Surface soil texture	Buffering capacity of surface soil
Sands and sandy loams – no calcium carbonate	VL
Sands and sandy loams – with calcium carbonate	M
Fine sandy loams – no calcium carbonate	L
Fine sandy loams – with calcium carbonate	M
Loams and clay loams – no calcium carbonate	M
Loams and clay loams – with calcium carbonate	H
Dark loams and clay loams (e.g. topsoils in Chernozems and Prairie Soils)	H
Clays – no calcium carbonate	H
Clays – with calcium carbonate	VH
Clays – with high shrink–swell	VH

Table 6.3 Estimating buffering capacity of the soil surface by geology (OEH 2012)

Nature of parent material	Buffering capacity of surface soil
Highly weathered shales and metamorphic rocks, quartzose sandstones – highly siliceous	VL
Siliceous granites, sandstones	VL to L
Intermediate parent materials – granodiorites, less weathered shales and metamorphic rocks, andesites	M
Intermediate to basic rocks and parent materials – basalts, some andesites, gabbros, dolerites	H
Basic to ultrabasic rocks and parent materials – highly mafic or carbonates present, e.g. limestones	VH
Alluvium with high levels of carbonates and clays	H
Alluvium – sandy light textured	L
Alluvium – medium textured	M

Table 6.4 Soil acidification LSC class assessment table (OEH 2012)

Texture/ buffering capacity	pH of the natural surface soil				
	<4.0 (CaCl2) <4.7 (water)	4.0–4.7 (CaCl2) 4.7–5.5 (water)	4.7–6.0 (CaCl2) 5.5–6.7 (water)	6.0–7.5 (CaCl2) 6.7–8.0 (water)	>7.5 (CaCl2) >8.0 (water)
Mean annual rainfall <550 mm					
Very low	6*	5	4	3	n/a
Low	5	5	3	3	n/a
Moderate	5	4	3	2	1
High	4	3	2	1	1
Very high	n/a	n/a	1	1	1
Mean annual rainfall 550–700 mm					
Very low	6*	5	5	4	n/a
Low	5	5	4	3	n/a
Moderate	5	4	3	3	1
High	n/a	n/a	2	2	1
Very high	n/a	n/a	1	1	1
Mean annual rainfall 700–900 mm					
Very low	6*	5	5	4	n/a
Low	6*	5	4	4	n/a
Moderate	5	4	3	3	2
High	n/a	n/a	2	2	1
Very high	n/a	n/a	2	1	1
Mean annual rainfall >900 mm or irrigation					
Very low	6*	5	5*	4	n/a
Low	6*	4	4	3*	n/a
Moderate	5	4	3	3	2
High	5	3	2	2	1
Very high	5	3	2	1	1

Notes:

Based on natural pH status, buffering capacity and climate

** These lands usually have very low fertility.*

Table 6.5 presents the results for soil acidification LSC classes for the project area.

Table 6.5 Soil acidification LSC classes for each soil type

Soil type	Great Soil Group	Surface soil texture	Geology	Buffering capacity of surface soil	Mean annual rainfall[1]	pH of the natural surface soil	Soil acidification LSC class
Calcarosols							
Hypercalcic Calcarosol							
West Balranald 6		SCL		H	324.0	7.8	3
West Balranald 14		SCL		H	324.0	8.0	1
West Balranald 70		LS		M	324.0	6.7	3
Nepean 31		SL		H	324.0	6.5	2
Nepean 49		SL		H	324.0	8.0	1
Wintong 47		SL		H	324.0	8.0	1
Hypocalcic Calcarosol							
West Balranald 12		SL		H	324.0	8.0	1
West Balranald 15		SL		H	324.0	7.8	1
West Balranald 101		SL		H	324.0	7.7	1
Chromosols							
West Balranald 77		SL		VL	324.0	7.4	3
Dermosols							
West Balranald 100		SCL		M	324.0	8.2	1
Nepean 7		LS		VL	324.0	6.0	4
Kandosols							
West Balranald 53		LS		VL	324.0	8.6	3
West Balranald 76		LS		VL	324.0	8.6	3
West Balranald 37		SL		VL	324.0	7.0	3
West Balranald 69		S		L	324.0	6.5	3
West Balranald 85		LS		VL	324.0	7.3	3
Nepean 8		LS		VL	324.0	5.7	4
Nepean 24		LS		VL	324.0	6.9	3
Nepean 43		SL		L	324.0	7.2	3
Sodosols							
West Balranald 910		CL		M	324.0	8.9	1
West Balranald 3		SCL		M	324.0	8.2	1
West Balranald 10		SL		L	324.0	6.8	3
West Balranald 13		SL		L	324.0	8.0	3
West Balranald 24		SCL		M	324.0	5.6	3
West Balranald 32		CL		M	324.0	8.4	1
West Balranald 56		SCL		M	324.0	8.3	1
West Balranald 25		CLS		M	324.0	8.1	1
West Balranald 34		SCL		M	324.0	8.3	1
West Balranald 36		SL		VL	324.0	8.0	3
West Balranald 23		CLS		M	324.0	7.8	2
West Balranald 33		SCL		M	324.0	6.9	2

Table 6.5 Soil acidification LSC classes for each soil type

Soil type	Great Soil Group	Surface soil texture	Geology	Buffering capacity of surface soil	Mean annual rainfall[1]	pH of the natural surface soil	Soil acidification LSC class
West Balranald 35		ZCL		M	324.0	7.7	2
West Balranald 44		SCL		M	324.0	6.6	3
Vertosols							
West Balranald 38		SCL		M	324.0	6.8	2
West Balranald 46		SCL		M	324.0	7.8	2
West Balranald 57		SCL		M	324.0	8.0	2

Notes: 1.Climate data from nearest the site, Balranald (RSL) Bureau of Meteorology weather station, site number 049002

7 Assessment of salinity LSC classes

Salinity hazard is determined as a result of recharge potential, discharge potential and salt store. Table 7.1 and Figure 7.1 summarise the decision making method. Table 7.2 is the assessment table for salinity LSC classes.

Table 7.1 A summary of salinity LSC notes from OEH 2012

Factor	Notes	Example	Information Source
Recharge potential	Recharge potential is the potential for water from rainfall, irrigation or streams to infiltrate past the plant root zone into the underlying groundwater system. This can occur over a whole landscape, or a component of the landscape, where water readily infiltrates soil, sediment or rock. Typically recharge areas have permeable, shallow and/or stony soils and fractured and/or weathered rock.	Recharge potential is highest where there is high rainfall relative to evaporation, low leaf area and plant water use, low water-holding capacity, and high permeability of the soils, regolith and rocks. Under natural conditions it relates to the climate, land use and hydrological characteristics of the catchment. It is exacerbated by land-use practices that disturb the vegetation cover or soil surface.	The value assigned for recharge potential is a qualitative assessment based on aerial photography, field observation and/or available literature, in particular soil landscape maps and reports.
Discharge potential	Discharge potential is the potential for groundwater to flow from the saturated zone to the land surface. It is a function of position in the landscape, depth to water table, groundwater pressure, soil type, substrate permeability and evapotranspiration. Discharge may occur as leakage to streams, evaporation from shallow water tables, or as springs and wet areas where water tables intersect the land surface or where narrow breaks occur in low permeability layers above confined aquifers.	Discharge potential is highest when recharge rates are greater than the amount of water that leaves the groundwater system through base flow and evapotranspiration. Typical discharge areas are low in the landscape and have high water tables, or higher in the landscape if sub-surface barriers impede groundwater flow.	The value assigned for discharge potential is a qualitative assessment based on aerial photography, field observation and/or available literature, in particular soil landscape maps and reports.
Salt store	**Salt stores** are high for many soils, regolith materials and rock types. This will depend on weathering characteristics, geological structures, rock and soil type, depth of the various materials and salt flux.	It is possible to have areas of low salt store and still have a salinity hazard due to evaporative concentration of salts at the soil surface. Conversely, areas of high salt store can have a lower hazard due to low rainfall. For example, in areas of low rainfall and low slope, salinity hazard can be low.	Figure 7.1 provides a broad indication of salt stores throughout NSW. This map is generalised and local information should be used where available.

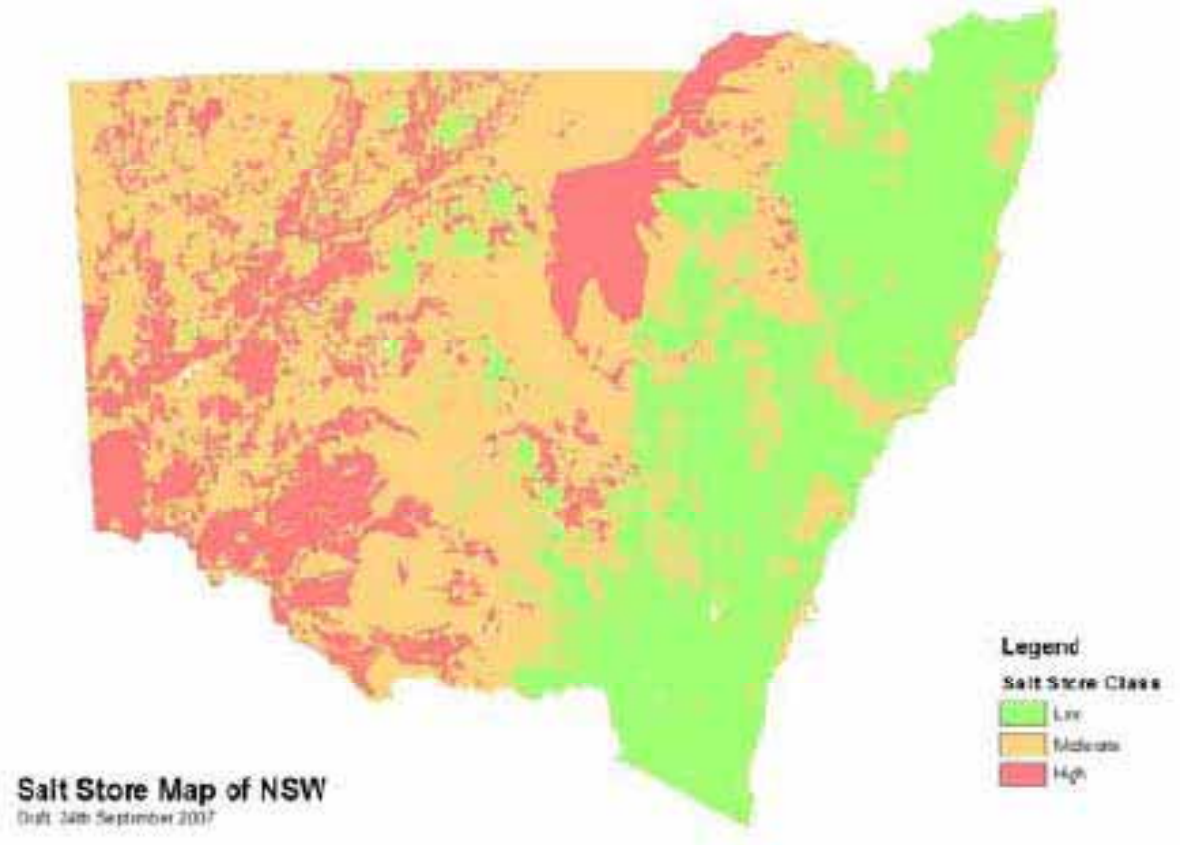


Figure 7.1 Salt store map of NSW (OEH 2012)

Table 7.2 Salinity LSC class assessment table (OEH 2012)

Recharge potential	Discharge potential	Salt store	LSC class
Low	Low	Low	1
		Moderate	3
		High	4
	Moderate	Low	1
		Moderate	4
		High	4
	High	Low	1
		Moderate	4
		High	5
Moderate	Low	Low	1
		Moderate	3
		High	4
	Moderate	Low	2
		Moderate	5
		High	6
	High	Low	1 (3) *
		Moderate	6
		High	6
High	Low	Low	1
		Moderate	4
		High	5
	Moderate	Low	3 (2) *
		Moderate	4
		High	7
	High	Low	2 (3) *
		Moderate	6
		High	7

Notes: ** The values in brackets are more accurate and should be used in preference to the original*

Table 7.3 presents the results table for salinity LSC classes for the project area.

Table 7.3 Salinity LSC classes for each soil type

Soil type	Recharge Potential	Discharge Potential	Salt store	Information sources	Salinity LSC class
Calcarosols					
Hypercalcic Calcarosol					
West Balranald 6	Low	Low	High	Salis data cards, lab data, BOM	4
West Balranald 14	Low	Low	High	Salis data cards, lab data, BOM	4
West Balranald 70	Low	Low	High	Salis data cards, lab data, BOM	4
Nepean 31	Low	Low	High	Salis data cards, lab data, BOM	4
Nepean 49	Low	Low	High	Salis data cards, lab data, BOM	4
Wintong 47	Low	Low	High	Salis data cards, lab data, BOM	4
Hypocalcic Calcarosol					
West Balranald 12	Low	Low	High	Salis data cards, lab data, BOM	4
West Balranald 15	Low	Low	High	Salis data cards, lab data, BOM	4
West Balranald 101	Low	Low	High	Salis data cards, lab data, BOM	4
Chromosols					
West Balranald 77	Low	Low	High	Salis data cards, lab data, BOM	4
Dermosols					
West Balranald 100	Low	Low	High	Salis data cards, lab data, BOM	4
Nepean 7	Low	Low	High	Salis data cards, lab data, BOM	4
Kandosols					
West Balranald 53	Low	Low	High	Salis data cards, lab data, BOM	4
West Balranald 76	Low	Low	High	Salis data cards, lab data, BOM	4
West Balranald 37	Low	Low	High	Salis data cards, lab data, BOM	4
West Balranald 69	Low	Low	High	Salis data cards, lab data, BOM	4
West Balranald 85	Low	Low	High	Salis data cards, lab data, BOM	4
Nepean 8	Low	Low	High	Salis data cards, lab data, BOM	4
Nepean 24	Low	Low	High	Salis data cards, lab data, BOM	4
Nepean 43	Low	Low	High	Salis data cards, lab data, BOM	4
Sodosols					
West Balranald 910	Low	Low	High	Salis data cards, lab data, BOM	4
West Balranald 3	Low	Low	High	Salis data cards, lab data, BOM	4
West Balranald 10	Low	Low	High	Salis data cards, lab data, BOM	4
West Balranald 13	Low	Low	High	Salis data cards, lab data, BOM	4
West Balranald 24	Low	Low	High	Salis data cards, lab data, BOM	4
West Balranald 32	Low	Low	High	Salis data cards, lab data, BOM	4
West Balranald 56	Low	Low	High	Salis data cards, lab data, BOM	4
West Balranald 25	Low	Low	High	Salis data cards, lab data, BOM	4
West Balranald 34	Low	Low	High	Salis data cards, lab data, BOM	4
West Balranald 36	Low	Low	High	Salis data cards, lab data, BOM	4
West Balranald 23	Low	Low	High	Salis data cards, lab data, BOM	4
West Balranald 33	Low	Low	High	Salis data cards, lab data, BOM	4
West Balranald 35	Low	Low	High	Salis data cards, lab data, BOM	4

Table 7.3 Salinity LSC classes for each soil type

Soil type	Recharge Potential	Discharge Potential	Salt store	Information sources	Salinity LSC class
West Balranald 44	Low	Low	High	Salis data cards, lab data, BOM	4
Vertosols					
West Balranald 38	Low	Low	High	Salis data cards, lab data, BOM	4
West Balranald 46	Low	Low	High	Salis data cards, lab data, BOM	4
West Balranald 57	Low	Low	High	Salis data cards, lab data, BOM	4

8 Assessment of waterlogging LSC classes

Table 8.1 shows the assessment table for determining waterlogging LSC classes and Table 8.2 presents the results for the project area.

Table 8.1 Waterlogging LSC class assessment table (OEH 2012)

Typical waterlogging duration (months)	Return period	Typical soil drainage*	LSC class**
0	every year	rapidly drained and well drained	1
0–0.25	every year	moderately well drained	2
0.25–2	every year	imperfectly drained	3
2–3	every 2 to 3 years	imperfectly drained	4
2–3	every year	imperfectly drained	5
>3	every year	poorly drained	6
Almost permanently	every year	very poorly drained	8

Notes:

** NCST (2009, p.202–4)*

*** Based on slope position, climate and length of time soils are wet.*

Table 8.2 Waterlogging LSC classes for each soil type in the project area

Soil type	Typical waterlogging duration (months)	Return period	Typical soil drainage	Waterlogging LSC class
Calcarosols				
Hypercalcic Calcarosol				
West Balranald 6	0–0.25	every year	Moderately Well	2
West Balranald 14	0.25–2	every year	imperfectly drained	3
West Balranald 70	0	every year	Well drained	1
Nepean 31	0	every year	Well drained	1
Nepean 49	0	every year	Well drained	1
Nepean 47	0	every year	Well drained	1
Hypocalcic Calcarosol				
West Balranald 12	0–0.25	every year	Moderately Well	2
West Balranald 15	0.25–2	every year	imperfectly drained	3
West Balranald 101	0	every year	Well drained	1
Chromosols				
West Balranald 77	0.25–2	every year	imperfectly drained	3
Dermosols				
West Balranald 100	0.25–2	every year	imperfectly drained	3
Nepean 7	0	every year	Well drained	1
Kandosols				
West Balranald 53	0	every year	Well drained	1

Table 8.2 Waterlogging LSC classes for each soil type in the project area

Soil type	Typical waterlogging duration (months)	Return period	Typical soil drainage	Waterlogging LSC class
West Balranald 76	0	every year	rapidly drained	1
West Balranald 37	0	every year	Well drained	1
West Balranald 69	0	every year	rapidly drained	1
West Balranald 85	0	every year	Well drained	1
Nepean 8	0	every year	Well drained	1
Nepean 24	0	every year	rapidly drained	1
Nepean 43	0	every year	Well drained	1
Sodosols				
West Balranald 910	>3	every year	poorly drained	6
West Balranald 3	0.25–2	every year	imperfectly drained	3
West Balranald 10	0.25–2	every year	imperfectly drained	3
West Balranald 13	0.25–2	every year	imperfectly drained	3
West Balranald 24	0.25–2	every year	imperfectly drained	3
West Balranald 32	>3	every year	poorly drained	6
West Balranald 56	0.25–2	every year	imperfectly drained	3
West Balranald 25	0.25–2	every year	imperfectly drained	3
West Balranald 34	0.25–2	every year	imperfectly drained	3
West Balranald 36	0–0.25	every year	Moderately Well	2
West Balranald 23	0.25–2	every year	imperfectly drained	3
West Balranald 33	0.25–2	every year	imperfectly drained	3
West Balranald 35	Almost permanently	every year	very poorly drained	8
West Balranald 44	0	every year	Well drained	1
Vertosols				
West Balranald 38	0.25–2	every year	imperfectly drained	3
West Balranald 46	0.25–2	every year	imperfectly drained	3
West Balranald 57	0.25–2	every year	imperfectly drained	3

9 Assessment of shallow soils and rockiness LSC classes

Table 9.1 shows the assessment table for determining shallow soils and rockiness LSC classes and Table 9.2 presents results for each of the soil monitoring unit (SMU) the project area.

Table 9.1 Shallow soils and rockiness LSC class assessment table (OEH 2012)

Rocky outcrop (% coverage)*	Soil depth (cm)	LSC class**
Nil	>100	1
<30 (localised*)	>100	2
	75– <100	3
	50– <75	4
	25– <50	6
	0– <25	7
30–50 (widespread*)	>100	4
	75–100	5
	25–75	6
	<25	7
50–70 (widespread*)	>100	6
	50–100	6
	25– <50	7
	<25	7
>70	n/a	8

Notes:

** Rock outcrop limitation from soil landscape report.*

*** Based on rocky outcrop and soil depth*

Table 9.2 Shallow soils and rockiness LSC classes for each soil type

SMUs	Rocky outcrop (% coverage)	Soil depth (cm)	Shallow soils and rockiness LSC class
Calcarosols			
Hypercalcic Calcarosol			
West Balranald 6	0	>100	1
West Balranald 14	0	>100	1
West Balranald 70	0	>100	1
Nepean 31	0	>100	1
Nepean 49	0	>100	1
Wintong 47	0	>100	1
Hypocalcic Calcarosol			
West Balranald 12	0	>100	1
West Balranald 15	0	>100	1
West Balranald 101	0	>100	1

Table 9.2 Shallow soils and rockiness LSC classes for each soil type

SMUs	Rocky outcrop (% coverage)	Soil depth (cm)	Shallow soils and rockiness LSC class
Chromosols			
West Balranald 77	0	>100	1
Dermosols			
West Balranald 100	0	>100	1
Nepean 7	0	>100	1
Kandosols			
West Balranald 53	0	>100	1
West Balranald 76	0	>100	1
West Balranald 37	0	>100	1
West Balranald 69	0	>100	1
West Balranald 85	0	>100	1
Nepean 8	0	>100	1
Nepean 24	0	>100	1
Nepean 43	0	>100	1
Sodosols			
West Balranald 910	0	>100	1
West Balranald 3	0	>100	1
West Balranald 10	0	>100	1
West Balranald 13	0	>100	1
West Balranald 24	0	>100	1
West Balranald 32	0	>100	1
West Balranald 56	0	>100	1
West Balranald 25	0	>100	1
West Balranald 34	0	>100	1
West Balranald 36	0	>100	1
West Balranald 23	0	>100	1
West Balranald 33	0	>100	1
West Balranald 35	0	>100	1
West Balranald 44	0	>100	1
Vertosols			
West Balranald 38	0	>100	1
West Balranald 46	0	>100	1
West Balranald 57	0	>100	1

10 Assessment of mass movement LSC classes

Table 10.1 shows the assessment table for determining mass movement LSC classes and Table 10.2 presents the results.

Table 10.1 Mass movement LSC class assessment table (OEH 2012)

Mean annual rainfall (mm)	Mass movement present	Slope class (%)	LSC class
<500	No	n/a	1
	Yes	n/a	8
>500	No	n/a	1
	Yes	<20	6
		>20–50	7
		50 or any scree or talus slope	8

Notes: Note that scree or talus slopes go automatically into Class 8

Table 10.2 Mass movement LSC classes for the SMUs within the project area

SMU	Mean annual rainfall (mm)	Mass movement present	Slope class (%)	Mass movement LSC class
Calcarosols				
Hypercalcic Calcarosol				
West Balranald 6	<500	No	n/a	1
West Balranald 14	<500	No	n/a	1
West Balranald 70	<500	No	n/a	1
Nepean 31	<500	No	n/a	1
Nepean 49	<500	No	n/a	1
Wintong 47	<500	No	n/a	1
Hypocalcic Calcarosol				
West Balranald 12	<500	No	n/a	1
West Balranald 15	<500	No	n/a	1
West Balranald 101	<500	No	n/a	1
Chromosols				
West Balranald 77	<500	No	n/a	1
Dermosols				
West Balranald 100	<500	No	n/a	1
Nepean 7	<500	No	n/a	1
Kandosols				
West Balranald 53	<500	No	n/a	1
West Balranald 76	<500	No	n/a	1
West Balranald 37	<500	No	n/a	1
West Balranald 69	<500	No	n/a	1

Table 10.2 Mass movement LSC classes for the SMUs within the project area

SMU	Mean annual rainfall (mm)	Mass movement present	Slope class (%)	Mass movement LSC class
West Balranald 85	<500	No	n/a	1
Nepean 8	<500	No	n/a	1
Nepean 24	<500	No	n/a	1
Nepean 43	<500	No	n/a	1
Sodosols				
West Balranald 910	<500	No	n/a	1
West Balranald 3	<500	No	n/a	1
West Balranald 10	<500	No	n/a	1
West Balranald 13	<500	No	n/a	1
West Balranald 24	<500	No	n/a	1
West Balranald 32	<500	No	n/a	1
West Balranald 56	<500	No	n/a	1
West Balranald 25	<500	No	n/a	1
West Balranald 34	<500	No	n/a	1
West Balranald 36	<500	No	n/a	1
West Balranald 23	<500	No	n/a	1
West Balranald 33	<500	No	n/a	1
West Balranald 35	<500	No	n/a	1
West Balranald 44	<500	No	n/a	1
Vertosols				
West Balranald 38	<500	No	n/a	1
West Balranald 46	<500	No	n/a	1
West Balranald 57	<500	No	n/a	1

11 Assessment of LSC classes for each soil type

Table 11.1 is a summary of each soil type LSC class for each assessment element, and the overall LSC class determined by the most limiting element. Mapping of LSC classes across the project area in accordance with the spatial distribution of the SMUs has not been undertaken as, while there are minor areas of the project area that are classified as either Class 5 or Class 4, this has been based primarily on the soil surface layer characteristics. When the physical properties of the subsoil layers of the soils are taken into account, it is considered that all areas would have an LSC class of 6.

Table 11.1 Summary of LSC classes

Soil type	Water erosion	Wind erosion	Soil structural decline	Soil acidification	Salinity	Water logging	Shallow soils and rockiness	Mass movement	SMU LSC class
Calcarosols									
Hypercalcic Calcarosol									
West Balranald 6	2	3	6	3	4	2	1	1	6
West Balranald 14	1	3	6	1	4	3	1	1	6
West Balranald 70	5	5	6	3	4	1	1	1	6
Nepean 31	3	4	4	2	4	1	1	1	4
Nepean 49	1	5	6	1	4	1	1	1	6
Wintong 47	5	4	6	1	4	1	1	1	6
Hypocalcic Calcarosol									
West Balranald 12	1	5	6	1	4	2	1	1	6
West Balranald 15	1	5	4	1	4	3	1	1	5
West Balranald 101	1	5	6	1	4	1	1	1	6
Chromosols									
West Balranald 77	2	4	4	3	4	3	1	1	4
Dermosols									
West Balranald 100	1	3	6	1	4	3	1	1	6
Nepean 7	2	6	3	4	4	1	1	1	6
Kandosols									
West Balranald 53	4	5	3	3	4	1	1	1	5
West Balranald 76	4	5	3	3	4	1	1	1	5
West Balranald 37	2	5	6	3	4	1	1	1	6
West Balranald 69	6	6	1	3	4	1	1	1	6
West Balranald 85	5	5	3	3	4	1	1	1	5
Nepean 8	2	5	3	4	4	1	1	1	5
Nepean 24	5	6	3	3	4	1	1	1	6
Nepean 43	5	4	6	3	4	1	1	1	6
Sodosols									
West Balranald 910	1	3	6	1	4	6	1	1	6
West Balranald 3	1	3	6	1	4	3	1	1	6
West Balranald 10	1	5	6	3	4	3	1	1	6
West Balranald 13	1	5	6	3	4	3	1	1	6

Table 11.1 Summary of LSC classes

Soil type	Water erosion	Wind erosion	Soil structural decline	Soil acidification	Salinity	Water logging	Shallow soils and rockiness	Mass movement	SMU LSC class
West Balranald 24	1	3	6	3	4	3	1	1	6
West Balranald 32	2	3	6	1	4	6	1	1	6
West Balranald 56	2	3	6	1	4	3	1	1	6
West Balranald 25	2	2	6	1	4	3	1	1	6
West Balranald 34	1	3	6	1	4	3	1	1	6
West Balranald 36	5	4	4	3	4	2	1	1	5
West Balranald 23	1	3	6	2	4	3	1	1	6
West Balranald 33	2	3	6	2	4	3	1	1	6
West Balranald 35	2	2	6	2	4	8	1	1	6
West Balranald 44	2	3	6	3	4	1	1	1	6
Vertosols									
West Balranald 38	1	3	6	2	4	3	1	1	6
West Balranald 46	2	2	6	2	4	3	1	1	6
West Balranald 57	2	3	6	2	4	3	1	1	6

12 Conclusion

The assessment of the LSC classes for the project and each soil type was conducted in accordance with the requirements of *The land and soil capability assessment scheme* (OEH 2012). The assessment found that:

- The project area has been identified (based on the OEH assessment process) as predominantly land suitability class 6 – Low capability land: Land has very high limitations for high-impact land uses. Land use restricted to low-impact land uses such as grazing, forestry and nature conservation. Careful management of limitations is required to prevent severe land and environmental degradation).

- Minor areas of the Kandosols and Chromosols (as mapped) have been classified as having either:

  - Class 5 – Moderate to low capability land: Land has high limitations for high-impact land uses. Will largely restrict land use to grazing, some horticulture (orchards), forestry and nature conservation. The limitations need to be carefully managed to prevent long-term degradation; or

  - Class 4 – Moderate capability land: Land has moderate to high limitations for high-impact land uses. Will restrict land management options for regular high-impact land uses such as cropping, high-intensity grazing and horticulture. The limitations can only be managed by specialised management practices with a high level of knowledge, expertise, inputs, investment and technology.

- While the assessment has been undertaken in accordance with the OEH guidelines, it is considered that, through further consideration of the physical and chemical properties of the subsoils for each of the SMUs, none of the project area would have a land suitability class of better than 6.

13 References

Department of Lands, 1907, *Map of New South Wales: showing all divisions for the purposes of the Crown Lands acts 1907*, viewed 16 May 2013, http://www.nla.gov.au/apps/cdview/?pi=nla.map-rm2795-sd.

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Appendix C

Soil sampling laboratory result

CERTIFICATE OF ANALYSIS

Work Order	: **EB1442542**	Page	: 1 of 30
Client	: **EMGA MITCHELL MCLENNAN**	Laboratory	: Environmental Division Brisbane
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Project	: Balranald (J12011)	QC Level	: NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Order number	: ----	Date Samples Received	: 16-Sep-2014 09:05
C-O-C number	: ----	Date Analysis Commenced	: 22-Sep-2014
Sampler	: KYM LUITJES	Issue Date	: 07-Oct-2014 16:37
Site	: ----		
		No. of samples received	: 70
Quote number	: ----	No. of samples analysed	: 70

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

NATA Accredited Laboratory 825

Accredited for compliance with ISO/IEC 17025.

Signatories

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

Signatories	*Position*	*Accreditation Category*
Hamish Murray	Supervisor - Soils	Newcastle - Inorganics
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics

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.

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.

- **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) is a more suitable method for the determination of exchange acidity (H+ + Al3+).**

Analytical Results

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

Compound	CAS Number	LOR	Unit	Client sample ID	Met 10 Surface	Met 10 0-35cm	Met 10 35-85cm	Met 10 1.0-2.0	Met 10 2.0-3.0
				Client sampling date / time	[16-Sep-2014]	[16-Sep-2014]	[16-Sep-2014]	[16-Sep-2014]	[16-Sep-2014]
					EB1442542-001	EB1442542-002	EB1442542-003	EB1442542-004	EB1442542-005
					Result	Result	Result	Result	Result
EA002 : pH (Soils)									
pH Value	----	0.1	pH Unit		**7.6**	**8.9**	**9.3**	**8.1**	**8.5**
EA010: Conductivity									
Electrical Conductivity @ 25°C	----	1	µS/cm		**195**	**756**	**1160**	**2970**	**2350**
EA055: Moisture Content									
^ **Moisture Content (dried @ 103°C)**	----	1	%		**10.2**	**13.6**	**8.1**	**10.7**	**11.2**
EA150: Particle Sizing									
+75µm	----	1	%		**51**	**27**	**20**	**11**	**12**
+150µm	----	1	%		**33**	**17**	**12**	**3**	**2**
+300µm	----	1	%		**12**	**6**	**3**	**1**	<1
+425µm	----	1	%		**4**	**3**	**1**	<1	<1
+600µm	----	1	%		**1**	**2**	<1	<1	<1
+1180µm	----	1	%		<1	**2**	<1	<1	<1
+2.36mm	----	1	%		<1	**2**	<1	<1	<1
+4.75mm	----	1	%		<1	**1**	<1	<1	<1
+9.5mm	----	1	%		<1	<1	<1	<1	<1
+19.0mm	----	1	%		<1	<1	<1	<1	<1
+37.5mm	----	1	%		<1	<1	<1	<1	<1
+75.0mm	----	1	%		<1	<1	<1	<1	<1
EA150: Soil Classification based on Particle Size									
Clay (<2 µm)	----	1	%		**21**	**26**	**39**	**23**	**32**
Silt (2-60 µm)	----	1	%		**24**	**46**	**37**	**60**	**49**
Sand (0.06-2.00 mm)	----	1	%		**55**	**27**	**24**	**17**	**19**
Gravel (>2mm)	----	1	%		<1	**1**	<1	<1	<1
Cobbles (>6cm)	----	1	%		<1	<1	<1	<1	<1
EA152: Soil Particle Density									
ø **Soil Particle Density (Clay/Silt/Sand)**	----	0.01	g/cm3		**2.51**	**2.58**	**2.61**	**2.64**	**2.59**
ED008: Exchangeable Cations									
^ **Exchangeable Calcium**	----	0.1	meq/100g		**13.3**	**29.5**	**27.9**	**9.4**	**2.6**
^ **Exchangeable Magnesium**	----	0.1	meq/100g		**5.1**	**12.3**	**6.0**	**2.6**	**0.7**
^ **Exchangeable Potassium**	----	0.1	meq/100g		**1.3**	**0.6**	**0.2**	<0.1	<0.1
^ **Exchangeable Sodium**	----	0.1	meq/100g		<0.1	**3.2**	**1.2**	**0.3**	**0.2**
^ **Cation Exchange Capacity**	----	0.1	meq/100g		**19.8**	**45.7**	**35.3**	**12.3**	**3.5**
^ **Exchangeable Sodium Percent**	----	0.1	%		**0.3**	**6.9**	**3.3**	**2.3**	**5.8**
ED040S : Soluble Sulfate by ICPAES									

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	Met 10 Surface	Met 10 0-35cm	Met 10 35-85cm	Met 10 1.0-2.0	Met 10 2.0-3.0
				Client sampling date / time	[16-Sep-2014]	[16-Sep-2014]	[16-Sep-2014]	[16-Sep-2014]	[16-Sep-2014]
Compound	CAS Number	LOR	Unit		EB1442542-001	EB1442542-002	EB1442542-003	EB1442542-004	EB1442542-005
					Result	Result	Result	Result	Result
ED040S : Soluble Sulfate by ICPAES - Continued									
Sulfate as SO4 2-	14808-79-8	10	mg/kg		**10**	**220**	**230**	**5120**	**1580**
EP004: Organic Matter									
Organic Matter	----	0.5	%		**1.3**	**0.8**	**0.6**	**0.8**	**0.7**
Total Organic Carbon	----	0.5	%		**0.7**	<0.5	<0.5	<0.5	<0.5

Analytical Results

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

Compound	CAS Number	LOR	Unit	Client sample ID	Met 10 3.0-4.0	Met 10 4.0-5.0	Met 10 5.0-6.0	Met 10 6.0-7.0	Met 10 7.0-8.0
				Client sampling date / time	[16-Sep-2014]	[16-Sep-2014]	[16-Sep-2014]	[16-Sep-2014]	[16-Sep-2014]
					EB1442542-006	EB1442542-007	EB1442542-008	EB1442542-009	EB1442542-010
					Result	Result	Result	Result	Result
EA002 : pH (Soils)									
pH Value	----	0.1	pH Unit		**7.6**	**8.4**	**7.3**	**5.6**	**7.0**
EA010: Conductivity									
Electrical Conductivity @ 25°C	----	1	µS/cm		**1840**	**1730**	**968**	**2020**	**1760**
EA055: Moisture Content									
^ **Moisture Content (dried @ 103°C)**	----	1	%		**7.4**	**7.5**	**3.0**	**10.8**	**5.6**
EA150: Particle Sizing									
+75µm	----	1	%		**16**	**43**	**82**	**30**	**46**
+150µm	----	1	%		**5**	**32**	**58**	**13**	**22**
+300µm	----	1	%		**1**	**1**	**4**	**1**	<1
+425µm	----	1	%		<1	<1	<1	<1	<1
+600µm	----	1	%		<1	<1	<1	<1	<1
+1180µm	----	1	%		<1	<1	<1	<1	<1
+2.36mm	----	1	%		<1	<1	<1	<1	<1
+4.75mm	----	1	%		<1	<1	<1	<1	<1
+9.5mm	----	1	%		<1	<1	<1	<1	<1
+19.0mm	----	1	%		<1	<1	<1	<1	<1
+37.5mm	----	1	%		<1	<1	<1	<1	<1
+75.0mm	----	1	%		<1	<1	<1	<1	<1
EA150: Soil Classification based on Particle Size									
Clay (<2 µm)	----	1	%		**20**	**22**	**10**	**33**	**28**
Silt (2-60 µm)	----	1	%		**54**	**28**	**8**	**34**	**22**
Sand (0.06-2.00 mm)	----	1	%		**26**	**50**	**82**	**33**	**50**
Gravel (>2mm)	----	1	%		<1	<1	<1	<1	<1
Cobbles (>6cm)	----	1	%		<1	<1	<1	<1	<1
EA152: Soil Particle Density									
ø **Soil Particle Density (Clay/Silt/Sand)**	----	0.01	g/cm3		**2.63**	**2.64**	**2.65**	**2.58**	**2.65**
ED008: Exchangeable Cations									
^ **Exchangeable Calcium**	----	0.1	meq/100g		**0.3**	**0.3**	**0.4**	**0.2**	**0.7**
^ **Exchangeable Magnesium**	----	0.1	meq/100g		**1.1**	**1.1**	**0.9**	**1.1**	**0.8**
^ **Exchangeable Potassium**	----	0.1	meq/100g		<0.1	<0.1	<0.1	<0.1	<0.1
^ **Exchangeable Sodium**	----	0.1	meq/100g		**0.7**	**0.6**	**0.2**	**0.8**	**0.4**
^ **Cation Exchange Capacity**	----	0.1	meq/100g		**2.2**	**2.0**	**1.5**	**2.2**	**1.9**
^ **Exchangeable Sodium Percent**	----	0.1	%		**29.7**	**27.4**	**13.6**	**35.8**	**17.6**
ED040S : Soluble Sulfate by ICPAES									

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	Met 10 3.0-4.0	Met 10 4.0-5.0	Met 10 5.0-6.0	Met 10 6.0-7.0	Met 10 7.0-8.0
				Client sampling date / time	[16-Sep-2014]	[16-Sep-2014]	[16-Sep-2014]	[16-Sep-2014]	[16-Sep-2014]
Compound	CAS Number	LOR	Unit		EB1442542-006	EB1442542-007	EB1442542-008	EB1442542-009	EB1442542-010
					Result	Result	Result	Result	Result
ED040S : Soluble Sulfate by ICPAES - Continued									
Sulfate as SO4 2-	14808-79-8	10	mg/kg		**940**	**920**	**450**	**1090**	**1140**
EP004: Organic Matter									
Organic Matter	----	0.5	%		**0.7**	**0.8**	<0.5	**0.8**	<0.5
Total Organic Carbon	----	0.5	%		<0.5	<0.5	<0.5	<0.5	<0.5

Analytical Results

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

Compound	CAS Number	LOR	Unit	Client sample ID	Met 10 8.0-9.0	Met 10 9.0-10.0	Met 10 10.0-11.0	Met 10 11.0-12.0	Met 10 12.0-13.0
				Client sampling date / time	[16-Sep-2014]	[16-Sep-2014]	[16-Sep-2014]	[16-Sep-2014]	[16-Sep-2014]
					EB1442542-011	EB1442542-012	EB1442542-013	EB1442542-014	EB1442542-015
					Result	Result	Result	Result	Result
EA002 : pH (Soils)									
pH Value	----	0.1	pH Unit		**6.1**	**6.3**	**6.7**	**7.5**	**7.4**
EA010: Conductivity									
Electrical Conductivity @ 25°C	----	1	µS/cm		**2740**	**2180**	**2370**	**2240**	**2560**
EA055: Moisture Content									
^ **Moisture Content (dried @ 103°C)**	----	1	%		**20.7**	**12.5**	**16.6**	**13.1**	**14.1**
EA150: Particle Sizing									
+75µm	----	1	%		**4**	**22**	**20**	**36**	**38**
+150µm	----	1	%		**2**	**4**	**4**	**7**	**11**
+300µm	----	1	%		<1	**1**	**2**	**2**	<1
+425µm	----	1	%		<1	**1**	**1**	**1**	<1
+600µm	----	1	%		<1	<1	**1**	**1**	<1
+1180µm	----	1	%		<1	<1	<1	<1	<1
+2.36mm	----	1	%		<1	<1	<1	<1	<1
+4.75mm	----	1	%		<1	<1	<1	<1	<1
+9.5mm	----	1	%		<1	<1	<1	<1	<1
+19.0mm	----	1	%		<1	<1	<1	<1	<1
+37.5mm	----	1	%		<1	<1	<1	<1	<1
+75.0mm	----	1	%		<1	<1	<1	<1	<1
EA150: Soil Classification based on Particle Size									
Clay (<2 µm)	----	1	%		**47**	**24**	**21**	**15**	**17**
Silt (2-60 µm)	----	1	%		**47**	**44**	**51**	**40**	**38**
Sand (0.06-2.00 mm)	----	1	%		**6**	**32**	**28**	**45**	**45**
Gravel (>2mm)	----	1	%		<1	<1	<1	<1	<1
Cobbles (>6cm)	----	1	%		<1	<1	<1	<1	<1
EA152: Soil Particle Density									
ø **Soil Particle Density (Clay/Silt/Sand)**	----	0.01	g/cm3		**2.73**	**2.70**	**2.73**	**2.72**	**2.72**
ED008: Exchangeable Cations									
^ **Exchangeable Calcium**	----	0.1	meq/100g		<0.1	**0.4**	**0.4**	**0.5**	**0.4**
^ **Exchangeable Magnesium**	----	0.1	meq/100g		**0.3**	**1.2**	**1.3**	**1.5**	**1.2**
^ **Exchangeable Potassium**	----	0.1	meq/100g		<0.1	<0.1	<0.1	<0.1	<0.1
^ **Exchangeable Sodium**	----	0.1	meq/100g		**0.3**	**0.8**	**0.8**	**0.9**	**0.8**
^ **Cation Exchange Capacity**	----	0.1	meq/100g		**0.7**	**2.4**	**2.7**	**3.0**	**2.5**
^ **Exchangeable Sodium Percent**	----	0.1	%		**36.5**	**33.8**	**30.6**	**30.4**	**31.4**
ED040S : Soluble Sulfate by ICPAES									

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	Met 10 8.0-9.0	Met 10 9.0-10.0	Met 10 10.0-11.0	Met 10 11.0-12.0	Met 10 12.0-13.0
				Client sampling date / time	[16-Sep-2014]	[16-Sep-2014]	[16-Sep-2014]	[16-Sep-2014]	[16-Sep-2014]
Compound	CAS Number	LOR	Unit		EB1442542-011	EB1442542-012	EB1442542-013	EB1442542-014	EB1442542-015
					Result	Result	Result	Result	Result
ED040S : Soluble Sulfate by ICPAES - Continued									
Sulfate as SO4 2-	14808-79-8	10	mg/kg		**2020**	**1190**	**1270**	**1030**	**1170**
EP004: Organic Matter									
Organic Matter	----	0.5	%		**0.7**	**0.7**	**0.8**	**0.6**	**0.6**
Total Organic Carbon	----	0.5	%		<0.5	<0.5	<0.5	<0.5	<0.5

Analytical Results

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

Compound	CAS Number	LOR	Unit	Client sample ID	Met 10 13.0-14.0	Met 10 14.0-15.0	Met 10 15.0-16.0	Met 10 16.0-17.0	Met 10 17.0-18.0
				Client sampling date / time	[16-Sep-2014]	[16-Sep-2014]	[16-Sep-2014]	[16-Sep-2014]	[16-Sep-2014]
					EB1442542-016	EB1442542-017	EB1442542-018	EB1442542-019	EB1442542-020
					Result	Result	Result	Result	Result
EA002 : pH (Soils)									
pH Value	----	0.1	pH Unit		**6.9**	**7.7**	**7.3**	**7.8**	**7.7**
EA010: Conductivity									
Electrical Conductivity @ 25°C	----	1	µS/cm		**2670**	**2730**	**3190**	**2950**	**2770**
EA055: Moisture Content									
^ **Moisture Content (dried @ 103°C)**	----	1	%		**19.0**	**17.0**	**18.2**	**21.2**	**17.3**
EA150: Particle Sizing									
+75µm	----	1	%		**49**	**69**	**52**	**40**	**87**
+150µm	----	1	%		**11**	**27**	**45**	**33**	**80**
+300µm	----	1	%		<1	**2**	**2**	<1	**3**
+425µm	----	1	%		<1	**1**	<1	<1	<1
+600µm	----	1	%		<1	<1	<1	<1	<1
+1180µm	----	1	%		<1	<1	<1	<1	<1
+2.36mm	----	1	%		<1	<1	<1	<1	<1
+4.75mm	----	1	%		<1	<1	<1	<1	<1
+9.5mm	----	1	%		<1	<1	<1	<1	<1
+19.0mm	----	1	%		<1	<1	<1	<1	<1
+37.5mm	----	1	%		<1	<1	<1	<1	<1
+75.0mm	----	1	%		<1	<1	<1	<1	<1
EA150: Soil Classification based on Particle Size									
Clay (<2 µm)	----	1	%		**15**	**11**	**15**	**17**	**4**
Silt (2-60 µm)	----	1	%		**32**	**18**	**30**	**40**	**9**
Sand (0.06-2.00 mm)	----	1	%		**53**	**71**	**55**	**43**	**87**
Gravel (>2mm)	----	1	%		<1	<1	<1	<1	<1
Cobbles (>6cm)	----	1	%		<1	<1	<1	<1	<1
EA152: Soil Particle Density									
ø **Soil Particle Density (Clay/Silt/Sand)**	----	0.01	g/cm3		**2.72**	**2.73**	**2.72**	**2.72**	**2.67**
ED008: Exchangeable Cations									
^ **Exchangeable Calcium**	----	0.1	meq/100g		**0.4**	**0.5**	**0.5**	**0.4**	**0.4**
^ **Exchangeable Magnesium**	----	0.1	meq/100g		**1.3**	**1.4**	**1.1**	**1.0**	**0.4**
^ **Exchangeable Potassium**	----	0.1	meq/100g		<0.1	<0.1	<0.1	<0.1	<0.1
^ **Exchangeable Sodium**	----	0.1	meq/100g		**1.0**	**0.8**	<0.1	**0.5**	<0.1
^ **Cation Exchange Capacity**	----	0.1	meq/100g		**2.8**	**2.8**	**1.7**	**1.9**	**0.9**
^ **Exchangeable Sodium Percent**	----	0.1	%		**34.2**	**29.1**	**5.4**	**26.7**	**2.9**
ED040S : Soluble Sulfate by ICPAES									

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	Met 10 13.0-14.0	Met 10 14.0-15.0	Met 10 15.0-16.0	Met 10 16.0-17.0	Met 10 17.0-18.0
				Client sampling date / time	[16-Sep-2014]	[16-Sep-2014]	[16-Sep-2014]	[16-Sep-2014]	[16-Sep-2014]
Compound	CAS Number	LOR	Unit		EB1442542-016	EB1442542-017	EB1442542-018	EB1442542-019	EB1442542-020
					Result	Result	Result	Result	Result
ED040S : Soluble Sulfate by ICPAES - Continued									
Sulfate as SO4 2-	14808-79-8	10	mg/kg		**1210**	**1200**	**1470**	**1370**	**1100**
EP004: Organic Matter									
Organic Matter	----	0.5	%		**0.9**	<0.5	<0.5	**0.7**	**0.6**
Total Organic Carbon	----	0.5	%		**0.5**	<0.5	<0.5	<0.5	<0.5

Analytical Results

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

Compound	CAS Number	LOR	Unit	Client sample ID	Met 10 18.0-19.0	Met 10 19.0-19.5	Met 10 19.5-20.0	Geochem 2 Surface	Geochem 2 0-0.6m
				Client sampling date / time	[16-Sep-2014]	[16-Sep-2014]	[16-Sep-2014]	[16-Sep-2014]	[16-Sep-2014]
					EB1442542-021	EB1442542-022	EB1442542-023	EB1442542-024	EB1442542-025
					Result	Result	Result	Result	Result
EA002 : pH (Soils)									
pH Value	----	0.1	pH Unit		**7.4**	**7.7**	**7.4**	**7.7**	**7.8**
EA010: Conductivity									
Electrical Conductivity @ 25°C	----	1	µS/cm		**2700**	**2530**	**2180**	**298**	**2450**
EA055: Moisture Content									
^ **Moisture Content (dried @ 103°C)**	----	1	%		**15.0**	**14.5**	**17.6**	**1.9**	**12.6**
EA150: Particle Sizing									
+75µm	----	1	%		**87**	**87**	**32**	**66**	**47**
+150µm	----	1	%		**80**	**84**	**27**	**41**	**33**
+300µm	----	1	%		**14**	**41**	**7**	**11**	**10**
+425µm	----	1	%		<1	**6**	**2**	**3**	**3**
+600µm	----	1	%		<1	<1	<1	<1	<1
+1180µm	----	1	%		<1	<1	<1	<1	<1
+2.36mm	----	1	%		<1	<1	<1	<1	<1
+4.75mm	----	1	%		<1	<1	<1	<1	<1
+9.5mm	----	1	%		<1	<1	<1	<1	<1
+19.0mm	----	1	%		<1	<1	<1	<1	<1
+37.5mm	----	1	%		<1	<1	<1	<1	<1
+75.0mm	----	1	%		<1	<1	<1	<1	<1
EA150: Soil Classification based on Particle Size									
Clay (<2 µm)	----	1	%		**4**	**4**	**27**	**10**	**30**
Silt (2-60 µm)	----	1	%		**9**	**9**	**42**	**20**	**23**
Sand (0.06-2.00 mm)	----	1	%		**87**	**87**	**31**	**70**	**47**
Gravel (>2mm)	----	1	%		<1	<1	<1	<1	<1
Cobbles (>6cm)	----	1	%		<1	<1	<1	<1	<1
EA152: Soil Particle Density									
ø **Soil Particle Density (Clay/Silt/Sand)**	----	0.01	g/cm3		**2.66**	**2.64**	**2.72**	**2.61**	**2.68**
ED008: Exchangeable Cations									
^ **Exchangeable Calcium**	----	0.1	meq/100g		**0.4**	**0.2**	<0.1	**5.2**	**25.4**
^ **Exchangeable Magnesium**	----	0.1	meq/100g		**0.4**	**0.2**	**0.2**	**1.5**	**5.6**
^ **Exchangeable Potassium**	----	0.1	meq/100g		<0.1	<0.1	<0.1	**0.7**	**0.4**
^ **Exchangeable Sodium**	----	0.1	meq/100g		<0.1	<0.1	**0.2**	**0.1**	**1.8**
^ **Cation Exchange Capacity**	----	0.1	meq/100g		**0.8**	**0.5**	**0.4**	**7.6**	**33.2**
^ **Exchangeable Sodium Percent**	----	0.1	%		**2.6**	**2.7**	**40.3**	**1.4**	**5.6**
ED040S : Soluble Sulfate by ICPAES									

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	Met 10 18.0-19.0	Met 10 19.0-19.5	Met 10 19.5-20.0	Geochem 2 Surface	Geochem 2 0-0.6m
				Client sampling date / time	[16-Sep-2014]	[16-Sep-2014]	[16-Sep-2014]	[16-Sep-2014]	[16-Sep-2014]
Compound	CAS Number	LOR	Unit		EB1442542-021	EB1442542-022	EB1442542-023	EB1442542-024	EB1442542-025
					Result	Result	Result	Result	Result
ED040S : Soluble Sulfate by ICPAES - Continued									
Sulfate as SO4 2-	14808-79-8	10	mg/kg		**1060**	**960**	**1160**	**10**	**1950**
EP004: Organic Matter									
Organic Matter	----	0.5	%		<0.5	<0.5	<0.5	**1.4**	<0.5
Total Organic Carbon	----	0.5	%		<0.5	<0.5	<0.5	**0.8**	<0.5

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	Geochem 2 0.6-0.8m	Geochem 2 1.0m	Geochem 2 2.0m	Geochem 2 3.0m	Geochem 2 4.0m
			Client sampling date / time	[16-Sep-2014]	[16-Sep-2014]	[16-Sep-2014]	[16-Sep-2014]	[16-Sep-2014]
Compound	CAS Number	LOR	Unit	EB1442542-026	EB1442542-027	EB1442542-028	EB1442542-029	EB1442542-030
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	8.0	8.8	8.6	7.6	6.4
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	3400	2240	2090	1500	1100
EA055: Moisture Content								
^ Moisture Content (dried @ 103°C)	----	1	%	11.3	11.1	10.1	11.6	4.9
EA150: Particle Sizing								
+75µm	----	1	%	26	12	14	26	74
+150µm	----	1	%	15	3	3	9	44
+300µm	----	1	%	4	<1	<1	3	3
+425µm	----	1	%	1	<1	<1	<1	1
+600µm	----	1	%	<1	<1	<1	<1	<1
+1180µm	----	1	%	<1	<1	<1	<1	<1
+2.36mm	----	1	%	<1	<1	<1	<1	<1
+4.75mm	----	1	%	<1	<1	<1	<1	<1
+9.5mm	----	1	%	<1	<1	<1	<1	<1
+19.0mm	----	1	%	<1	<1	<1	<1	<1
+37.5mm	----	1	%	<1	<1	<1	<1	<1
+75.0mm	----	1	%	<1	<1	<1	<1	<1
EA150: Soil Classification based on Particle Size								
Clay (<2 µm)	----	1	%	37	33	33	25	13
Silt (2-60 µm)	----	1	%	37	51	48	45	10
Sand (0.06-2.00 mm)	----	1	%	26	16	19	30	77
Gravel (>2mm)	----	1	%	<1	<1	<1	<1	<1
Cobbles (>6cm)	----	1	%	<1	<1	<1	<1	<1
EA152: Soil Particle Density								
ø Soil Particle Density (Clay/Silt/Sand)	----	0.01	g/cm3	2.74	2.67	2.62	2.68	2.63
ED008: Exchangeable Cations								
^ Exchangeable Calcium	----	0.1	meq/100g	28.8	0.3	0.2	1.1	0.1
^ Exchangeable Magnesium	----	0.1	meq/100g	5.6	0.8	0.9	0.9	0.8
^ Exchangeable Potassium	----	0.1	meq/100g	0.3	<0.1	<0.1	<0.1	<0.1
^ Exchangeable Sodium	----	0.1	meq/100g	1.2	0.8	0.9	0.8	1.0
^ Cation Exchange Capacity	----	0.1	meq/100g	35.9	1.8	2.1	2.8	1.9
^ Exchangeable Sodium Percent	----	0.1	%	3.3	39.1	41.0	28.4	48.1
ED040S : Soluble Sulfate by ICPAES								

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	Geochem 2 0.6-0.8m	Geochem 2 1.0m	Geochem 2 2.0m	Geochem 2 3.0m	Geochem 2 4.0m
				Client sampling date / time	[16-Sep-2014]	[16-Sep-2014]	[16-Sep-2014]	[16-Sep-2014]	[16-Sep-2014]
Compound	CAS Number	LOR	Unit		EB1442542-026	EB1442542-027	EB1442542-028	EB1442542-029	EB1442542-030
					Result	Result	Result	Result	Result
ED040S : Soluble Sulfate by ICPAES - Continued									
Sulfate as SO4 2-	14808-79-8	10	mg/kg		**5070**	**1120**	**1010**	**460**	**320**
EP004: Organic Matter									
Organic Matter	----	0.5	%		<0.5	<0.5	<0.5	<0.5	<0.5
Total Organic Carbon	----	0.5	%		<0.5	<0.5	<0.5	<0.5	<0.5

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	Geochem 2 5.0m	Geochem 2 5.2-5.6m	Geochem 2 5.6-6.2m	Geochem 2 7.0m	Geochem 2 8.0m
			Client sampling date / time	[16-Sep-2014]	[16-Sep-2014]	[16-Sep-2014]	[16-Sep-2014]	[16-Sep-2014]
Compound	CAS Number	LOR	Unit	EB1442542-031	EB1442542-032	EB1442542-033	EB1442542-034	EB1442542-035
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	7.2	7.4	7.5	7.4	7.3
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	821	2100	2040	2090	2550
EA055: Moisture Content								
^ Moisture Content (dried @ 103°C)	----	1	%	3.8	23.8	25.1	22.5	20.6
EA150: Particle Sizing								
+75µm	----	1	%	85	6	6	8	8
+150µm	----	1	%	72	4	4	5	4
+300µm	----	1	%	19	1	1	2	1
+425µm	----	1	%	4	<1	<1	<1	<1
+600µm	----	1	%	<1	<1	<1	<1	<1
+1180µm	----	1	%	<1	<1	<1	<1	<1
+2.36mm	----	1	%	<1	<1	<1	<1	<1
+4.75mm	----	1	%	<1	<1	<1	<1	<1
+9.5mm	----	1	%	<1	<1	<1	<1	<1
+19.0mm	----	1	%	<1	<1	<1	<1	<1
+37.5mm	----	1	%	<1	<1	<1	<1	<1
+75.0mm	----	1	%	<1	<1	<1	<1	<1
EA150: Soil Classification based on Particle Size								
Clay (<2 µm)	----	1	%	8	55	52	55	29
Silt (2-60 µm)	----	1	%	6	38	40	36	63
Sand (0.06-2.00 mm)	----	1	%	86	7	8	9	8
Gravel (>2mm)	----	1	%	<1	<1	<1	<1	<1
Cobbles (>6cm)	----	1	%	<1	<1	<1	<1	<1
EA152: Soil Particle Density								
ø Soil Particle Density (Clay/Silt/Sand)	----	0.01	g/cm3	2.67	2.70	2.69	2.69	2.80
ED008: Exchangeable Cations								
^ Exchangeable Calcium	----	0.1	meq/100g	0.1	<0.1	<0.1	<0.1	<0.1
^ Exchangeable Magnesium	----	0.1	meq/100g	0.5	0.2	0.2	0.2	0.3
^ Exchangeable Potassium	----	0.1	meq/100g	<0.1	<0.1	<0.1	<0.1	<0.1
^ Exchangeable Sodium	----	0.1	meq/100g	0.6	0.3	0.3	0.2	0.5
^ Cation Exchange Capacity	----	0.1	meq/100g	1.3	0.6	0.6	0.4	0.9
^ Exchangeable Sodium Percent	----	0.1	%	48.4	47.7	46.8	45.7	48.0
ED040S : Soluble Sulfate by ICPAES								

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	Geochem 2 5.0m	Geochem 2 5.2-5.6m	Geochem 2 5.6-6.2m	Geochem 2 7.0m	Geochem 2 8.0m
				Client sampling date / time	[16-Sep-2014]	[16-Sep-2014]	[16-Sep-2014]	[16-Sep-2014]	[16-Sep-2014]
Compound	CAS Number	LOR	Unit		EB1442542-031	EB1442542-032	EB1442542-033	EB1442542-034	EB1442542-035
					Result	Result	Result	Result	Result
ED040S : Soluble Sulfate by ICPAES - Continued									
Sulfate as SO4 2-	14808-79-8	10	mg/kg		**350**	**1480**	**1460**	**1460**	**1890**
EP004: Organic Matter									
Organic Matter	----	0.5	%		<0.5	<0.5	<0.5	<0.5	**0.6**
Total Organic Carbon	----	0.5	%		<0.5	<0.5	<0.5	<0.5	<0.5

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	Geochem 2 9.0m	Geochem 2 10.0m	Geochem 2 11.0m	Geochem 2 12.0m	Geochem 2 13.0m
			Client sampling date / time	[16-Sep-2014]	[16-Sep-2014]	[16-Sep-2014]	[16-Sep-2014]	[16-Sep-2014]
Compound	CAS Number	LOR	Unit	EB1442542-036	EB1442542-037	EB1442542-038	EB1442542-039	EB1442542-040
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	7.3	7.6	8.0	8.2	7.9
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	1970	1270	1070	1600	1750
EA055: Moisture Content								
^ Moisture Content (dried @ 103°C)	----	1	%	11.7	6.8	6.6	15.5	13.1
EA150: Particle Sizing								
+75µm	----	1	%	22	46	69	72	69
+150µm	----	1	%	4	1	6	29	54
+300µm	----	1	%	2	<1	<1	<1	10
+425µm	----	1	%	2	<1	<1	<1	2
+600µm	----	1	%	1	<1	<1	<1	<1
+1180µm	----	1	%	<1	<1	<1	<1	<1
+2.36mm	----	1	%	<1	<1	<1	<1	<1
+4.75mm	----	1	%	<1	<1	<1	<1	<1
+9.5mm	----	1	%	<1	<1	<1	<1	<1
+19.0mm	----	1	%	<1	<1	<1	<1	<1
+37.5mm	----	1	%	<1	<1	<1	<1	<1
+75.0mm	----	1	%	<1	<1	<1	<1	<1
EA150: Soil Classification based on Particle Size								
Clay (<2 µm)	----	1	%	17	14	7	8	16
Silt (2-60 µm)	----	1	%	54	35	20	19	15
Sand (0.06-2.00 mm)	----	1	%	29	51	73	73	69
Gravel (>2mm)	----	1	%	<1	<1	<1	<1	<1
Cobbles (>6cm)	----	1	%	<1	<1	<1	<1	<1
EA152: Soil Particle Density								
ø Soil Particle Density (Clay/Silt/Sand)	----	0.01	g/cm3	2.79	2.72	2.74	2.71	2.70
ED008: Exchangeable Cations								
^ Exchangeable Calcium	----	0.1	meq/100g	0.3	0.2	0.3	0.2	0.1
^ Exchangeable Magnesium	----	0.1	meq/100g	1.6	1.0	1.2	1.1	0.5
^ Exchangeable Potassium	----	0.1	meq/100g	0.1	0.1	<0.1	<0.1	<0.1
^ Exchangeable Sodium	----	0.1	meq/100g	2.4	1.8	2.1	1.1	0.4
^ Cation Exchange Capacity	----	0.1	meq/100g	4.4	3.1	3.7	2.6	1.0
^ Exchangeable Sodium Percent	----	0.1	%	53.6	56.2	55.9	42.4	36.4
ED040S : Soluble Sulfate by ICPAES								

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	Geochem 2 9.0m	Geochem 2 10.0m	Geochem 2 11.0m	Geochem 2 12.0m	Geochem 2 13.0m
				Client sampling date / time	[16-Sep-2014]	[16-Sep-2014]	[16-Sep-2014]	[16-Sep-2014]	[16-Sep-2014]
Compound	CAS Number	LOR	Unit		EB1442542-036	EB1442542-037	EB1442542-038	EB1442542-039	EB1442542-040
					Result	Result	Result	Result	Result
ED040S : Soluble Sulfate by ICPAES - Continued									
Sulfate as SO4 2-	14808-79-8	10	mg/kg		**1220**	**580**	**470**	**890**	**1030**
EP004: Organic Matter									
Organic Matter	----	0.5	%		<0.5	**0.7**	<0.5	**0.7**	<0.5
Total Organic Carbon	----	0.5	%		<0.5	<0.5	<0.5	<0.5	<0.5

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	Geochem 2 14.0m	Geochem 2 14.0-14.7m	Geochem 2 14.7-15.2m	Geochem 2 16.0m	Geochem 2 17.0m
			Client sampling date / time	[16-Sep-2014]	[16-Sep-2014]	[16-Sep-2014]	[16-Sep-2014]	[16-Sep-2014]
Compound	CAS Number	LOR	Unit	EB1442542-041	EB1442542-042	EB1442542-043	EB1442542-044	EB1442542-045
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	8.1	7.9	8.0	7.8	7.8
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	1550	1560	1490	1880	1450
EA055: Moisture Content								
^ Moisture Content (dried @ 103°C)	----	1	%	10.6	10.7	10.3	11.0	14.4
EA150: Particle Sizing								
+75µm	----	1	%	68	69	72	77	78
+150µm	----	1	%	41	60	65	71	72
+300µm	----	1	%	5	11	11	20	12
+425µm	----	1	%	2	3	5	9	3
+600µm	----	1	%	<1	<1	2	3	<1
+1180µm	----	1	%	<1	<1	1	<1	<1
+2.36mm	----	1	%	<1	<1	<1	<1	<1
+4.75mm	----	1	%	<1	<1	<1	<1	<1
+9.5mm	----	1	%	<1	<1	<1	<1	<1
+19.0mm	----	1	%	<1	<1	<1	<1	<1
+37.5mm	----	1	%	<1	<1	<1	<1	<1
+75.0mm	----	1	%	<1	<1	<1	<1	<1
EA150: Soil Classification based on Particle Size								
Clay (<2 µm)	----	1	%	16	16	13	13	16
Silt (2-60 µm)	----	1	%	16	15	13	10	6
Sand (0.06-2.00 mm)	----	1	%	68	69	73	77	78
Gravel (>2mm)	----	1	%	<1	<1	1	<1	<1
Cobbles (>6cm)	----	1	%	<1	<1	<1	<1	<1
EA152: Soil Particle Density								
ø Soil Particle Density (Clay/Silt/Sand)	----	0.01	g/cm3	2.67	2.67	2.66	2.64	2.65
ED008: Exchangeable Cations								
^ Exchangeable Calcium	----	0.1	meq/100g	0.2	0.2	0.2	0.2	0.2
^ Exchangeable Magnesium	----	0.1	meq/100g	0.8	0.8	1.3	1.1	1.0
^ Exchangeable Potassium	----	0.1	meq/100g	<0.1	<0.1	<0.1	<0.1	<0.1
^ Exchangeable Sodium	----	0.1	meq/100g	0.7	0.7	1.1	0.4	0.4
^ Cation Exchange Capacity	----	0.1	meq/100g	1.7	1.8	2.7	1.8	1.8
^ Exchangeable Sodium Percent	----	0.1	%	38.5	40.0	39.4	22.3	24.6
ED040S : Soluble Sulfate by ICPAES								

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	Geochem 2 14.0m	Geochem 2 14.0-14.7m	Geochem 2 14.7-15.2m	Geochem 2 16.0m	Geochem 2 17.0m
				Client sampling date / time	[16-Sep-2014]	[16-Sep-2014]	[16-Sep-2014]	[16-Sep-2014]	[16-Sep-2014]
Compound	CAS Number	LOR	Unit		EB1442542-041	EB1442542-042	EB1442542-043	EB1442542-044	EB1442542-045
					Result	Result	Result	Result	Result
ED040S : Soluble Sulfate by ICPAES - Continued									
Sulfate as SO4 2-	14808-79-8	10	mg/kg		**870**	**980**	**840**	**1050**	**810**
EP004: Organic Matter									
Organic Matter	----	0.5	%		**0.5**	**0.5**	<0.5	<0.5	**0.5**
Total Organic Carbon	----	0.5	%		<0.5	<0.5	<0.5	<0.5	<0.5

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	Geochem 2 18.0m	Geochem 2 19.0m	Geochem 2 20.0m	Geochem 3 0-0.4m	Geochem 3 0.4-0.7m
			Client sampling date / time	[16-Sep-2014]	[16-Sep-2014]	[16-Sep-2014]	[16-Sep-2014]	[16-Sep-2014]
Compound	CAS Number	LOR	Unit	EB1442542-046	EB1442542-047	EB1442542-048	EB1442542-049	EB1442542-050
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	7.7	7.6	7.5	9.2	9.6
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	1600	1630	1730	537	1060
EA055: Moisture Content								
^ Moisture Content (dried @ 103°C)	----	1	%	10.1	10.0	10.9	13.6	10.1
EA150: Particle Sizing								
+75µm	----	1	%	76	77	78	53	47
+150µm	----	1	%	68	64	69	36	33
+300µm	----	1	%	11	1	6	12	13
+425µm	----	1	%	2	<1	2	4	6
+600µm	----	1	%	<1	<1	<1	1	2
+1180µm	----	1	%	<1	<1	<1	<1	<1
+2.36mm	----	1	%	<1	<1	<1	<1	<1
+4.75mm	----	1	%	<1	<1	<1	<1	<1
+9.5mm	----	1	%	<1	<1	<1	<1	<1
+19.0mm	----	1	%	<1	<1	<1	<1	<1
+37.5mm	----	1	%	<1	<1	<1	<1	<1
+75.0mm	----	1	%	<1	<1	<1	<1	<1
EA150: Soil Classification based on Particle Size								
Clay (<2 µm)	----	1	%	19	21	18	22	30
Silt (2-60 µm)	----	1	%	4	2	3	23	23
Sand (0.06-2.00 mm)	----	1	%	77	77	79	55	47
Gravel (>2mm)	----	1	%	<1	<1	<1	<1	<1
Cobbles (>6cm)	----	1	%	<1	<1	<1	<1	<1
EA152: Soil Particle Density								
ø Soil Particle Density (Clay/Silt/Sand)	----	0.01	g/cm3	2.66	2.64	2.63	2.63	2.64
ED008: Exchangeable Cations								
^ Exchangeable Calcium	----	0.1	meq/100g	0.1	<0.1	<0.1	29.9	25.3
^ Exchangeable Magnesium	----	0.1	meq/100g	0.5	0.1	0.1	7.8	5.4
^ Exchangeable Potassium	----	0.1	meq/100g	<0.1	<0.1	<0.1	0.4	0.2
^ Exchangeable Sodium	----	0.1	meq/100g	0.2	<0.1	<0.1	0.7	0.7
^ Cation Exchange Capacity	----	0.1	meq/100g	0.8	0.2	0.2	38.8	31.7
^ Exchangeable Sodium Percent	----	0.1	%	24.1	4.9	3.2	1.9	2.4
ED040S : Soluble Sulfate by ICPAES								

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	Geochem 2 18.0m	Geochem 2 19.0m	Geochem 2 20.0m	Geochem 3 0-0.4m	Geochem 3 0.4-0.7m
				Client sampling date / time	[16-Sep-2014]	[16-Sep-2014]	[16-Sep-2014]	[16-Sep-2014]	[16-Sep-2014]
Compound	CAS Number	LOR	Unit		EB1442542-046	EB1442542-047	EB1442542-048	EB1442542-049	EB1442542-050
					Result	Result	Result	Result	Result
ED040S : Soluble Sulfate by ICPAES - Continued									
Sulfate as SO4 2-	14808-79-8	10	mg/kg		**850**	**820**	**910**	**110**	**490**
EP004: Organic Matter									
Organic Matter	----	0.5	%		**0.8**	**0.7**	**0.7**	**1.7**	**1.0**
Total Organic Carbon	----	0.5	%		<0.5	<0.5	<0.5	**1.0**	**0.6**

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	Geochem 3 0.7-2.0m	Geochem 3 2.0-3.0m	Geochem 3 3.0-4.3m	Geochem 3 4.3-5.0m	Geochem 3 5.0-6.1m
			Client sampling date / time	[16-Sep-2014]	[16-Sep-2014]	[16-Sep-2014]	[16-Sep-2014]	[16-Sep-2014]
Compound	CAS Number	LOR	Unit	EB1442542-051	EB1442542-052	EB1442542-053	EB1442542-054	EB1442542-055
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	9.0	8.0	7.2	5.0	8.3
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	1490	1320	1200	1620	1610
EA055: Moisture Content								
^ Moisture Content (dried @ 103°C)	----	1	%	14.3	12.4	11.9	17.5	14.7
EA150: Particle Sizing								
+75µm	----	1	%	47	43	34	10	13
+150µm	----	1	%	32	29	23	6	10
+300µm	----	1	%	13	11	8	3	5
+425µm	----	1	%	5	4	3	1	2
+600µm	----	1	%	1	<1	<1	<1	1
+1180µm	----	1	%	<1	<1	<1	<1	<1
+2.36mm	----	1	%	<1	<1	<1	<1	<1
+4.75mm	----	1	%	<1	<1	<1	<1	<1
+9.5mm	----	1	%	<1	<1	<1	<1	<1
+19.0mm	----	1	%	<1	<1	<1	<1	<1
+37.5mm	----	1	%	<1	<1	<1	<1	<1
+75.0mm	----	1	%	<1	<1	<1	<1	<1
EA150: Soil Classification based on Particle Size								
Clay (<2 µm)	----	1	%	35	40	48	59	42
Silt (2-60 µm)	----	1	%	17	15	14	31	43
Sand (0.06-2.00 mm)	----	1	%	48	45	38	10	15
Gravel (>2mm)	----	1	%	<1	<1	<1	<1	<1
Cobbles (>6cm)	----	1	%	<1	<1	<1	<1	<1
EA152: Soil Particle Density								
ø Soil Particle Density (Clay/Silt/Sand)	----	0.01	g/cm3	2.65	2.65	2.64	2.68	2.65
ED008: Exchangeable Cations								
^ Exchangeable Calcium	----	0.1	meq/100g	2.6	1.8	0.3	0.5	1.5
^ Exchangeable Magnesium	----	0.1	meq/100g	1.6	0.8	0.6	2.0	2.1
^ Exchangeable Potassium	----	0.1	meq/100g	0.1	<0.1	<0.1	0.2	0.2
^ Exchangeable Sodium	----	0.1	meq/100g	0.5	0.3	0.4	1.6	1.1
^ Cation Exchange Capacity	----	0.1	meq/100g	4.9	2.9	1.3	4.2	4.9
^ Exchangeable Sodium Percent	----	0.1	%	11.0	8.9	28.4	37.0	22.0
ED040S : Soluble Sulfate by ICPAES								

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	Geochem 3 0.7-2.0m	Geochem 3 2.0-3.0m	Geochem 3 3.0-4.3m	Geochem 3 4.3-5.0m	Geochem 3 5.0-6.1m
				Client sampling date / time	[16-Sep-2014]	[16-Sep-2014]	[16-Sep-2014]	[16-Sep-2014]	[16-Sep-2014]
Compound	CAS Number	LOR	Unit		EB1442542-051	EB1442542-052	EB1442542-053	EB1442542-054	EB1442542-055
					Result	Result	Result	Result	Result
ED040S : Soluble Sulfate by ICPAES - Continued									
Sulfate as SO4 2-	14808-79-8	10	mg/kg		**700**	**650**	**600**	**800**	**720**
EP004: Organic Matter									
Organic Matter	----	0.5	%		**0.5**	**1.2**	**0.7**	**0.7**	<0.5
Total Organic Carbon	----	0.5	%		<0.5	**0.7**	<0.5	<0.5	<0.5

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	Geochem 3 6.1-7.0m	Geochem 3 7.0-8.0m	Geochem 3 8.0-9.0m	Geochem 3 9.0-10.25m	Geochem 3 10.25-10.5m
			Client sampling date / time	[16-Sep-2014]	[16-Sep-2014]	[16-Sep-2014]	[16-Sep-2014]	[16-Sep-2014]
Compound	CAS Number	LOR	Unit	EB1442542-056	EB1442542-057	EB1442542-058	EB1442542-059	EB1442542-060
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	4.9	5.4	4.8	5.2	5.1
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	1530	1250	1220	755	655
EA055: Moisture Content								
^ Moisture Content (dried @ 103°C)	----	1	%	16.7	12.5	11.3	8.2	5.4
EA150: Particle Sizing								
+75µm	----	1	%	20	40	34	51	62
+150µm	----	1	%	16	33	27	42	51
+300µm	----	1	%	6	12	10	18	24
+425µm	----	1	%	3	5	4	8	15
+600µm	----	1	%	1	1	1	3	10
+1180µm	----	1	%	<1	<1	<1	<1	7
+2.36mm	----	1	%	<1	<1	<1	<1	6
+4.75mm	----	1	%	<1	<1	<1	<1	2
+9.5mm	----	1	%	<1	<1	<1	<1	<1
+19.0mm	----	1	%	<1	<1	<1	<1	<1
+37.5mm	----	1	%	<1	<1	<1	<1	<1
+75.0mm	----	1	%	<1	<1	<1	<1	<1
EA150: Soil Classification based on Particle Size								
Clay (<2 µm)	----	1	%	44	34	32	27	18
Silt (2-60 µm)	----	1	%	31	24	30	18	16
Sand (0.06-2.00 mm)	----	1	%	25	42	38	55	60
Gravel (>2mm)	----	1	%	<1	<1	<1	<1	6
Cobbles (>6cm)	----	1	%	<1	<1	<1	<1	<1
EA152: Soil Particle Density								
ø Soil Particle Density (Clay/Silt/Sand)	----	0.01	g/cm3	2.73	2.69	2.69	2.69	2.66
ED008: Exchangeable Cations								
^ Exchangeable Calcium	----	0.1	meq/100g	<0.1	<0.1	<0.1	<0.1	0.1
^ Exchangeable Magnesium	----	0.1	meq/100g	4.7	3.7	3.9	2.7	1.7
^ Exchangeable Potassium	----	0.1	meq/100g	0.7	0.7	0.7	0.4	0.2
^ Exchangeable Sodium	----	0.1	meq/100g	3.8	2.6	2.8	2.0	1.4
^ Cation Exchange Capacity	----	0.1	meq/100g	9.2	7.1	7.5	5.2	3.4
^ Exchangeable Sodium Percent	----	0.1	%	36.0	32.8	33.8	31.7	35.5
ED040S : Soluble Sulfate by ICPAES								

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	Geochem 3 6.1-7.0m	Geochem 3 7.0-8.0m	Geochem 3 8.0-9.0m	Geochem 3 9.0-10.25m	Geochem 3 10.25-10.5m
				Client sampling date / time	[16-Sep-2014]	[16-Sep-2014]	[16-Sep-2014]	[16-Sep-2014]	[16-Sep-2014]
Compound	CAS Number	LOR	Unit		EB1442542-056	EB1442542-057	EB1442542-058	EB1442542-059	EB1442542-060
					Result	Result	Result	Result	Result
ED040S : Soluble Sulfate by ICPAES - Continued									
Sulfate as SO4 2-	14808-79-8	10	mg/kg		**810**	**520**	**560**	**400**	**300**
EP004: Organic Matter									
Organic Matter	----	0.5	%		**0.5**	**0.7**	**0.7**	**1.0**	**1.2**
Total Organic Carbon	----	0.5	%		<0.5	<0.5	<0.5	**0.6**	**0.7**

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	Geochem 3 10.5-11.8m	Geochem 3 11.8-12.7m	Geochem 3 12.7-14.0m	Geochem 3 14.0-14.1m	Geochem 3 14.1-15.0m
			Client sampling date / time	[16-Sep-2014]	[16-Sep-2014]	[16-Sep-2014]	[16-Sep-2014]	[16-Sep-2014]
Compound	CAS Number	LOR	Unit	EB1442542-061	EB1442542-062	EB1442542-063	EB1442542-064	EB1442542-065
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	5.0	5.2	5.2	6.0	5.3
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	590	453	553	80	843
EA055: Moisture Content								
^ Moisture Content (dried @ 103°C)	----	1	%	5.7	4.6	5.0	17.0	8.1
EA150: Particle Sizing								
+75µm	----	1	%	70	64	74	97	73
+150µm	----	1	%	58	49	60	85	62
+300µm	----	1	%	28	20	26	33	34
+425µm	----	1	%	16	10	15	18	26
+600µm	----	1	%	8	6	10	12	22
+1180µm	----	1	%	4	4	6	10	20
+2.36mm	----	1	%	2	3	5	10	18
+4.75mm	----	1	%	1	1	3	9	14
+9.5mm	----	1	%	<1	<1	<1	9	8
+19.0mm	----	1	%	<1	<1	<1	9	8
+37.5mm	----	1	%	<1	<1	<1	<1	<1
+75.0mm	----	1	%	<1	<1	<1	<1	<1
EA150: Soil Classification based on Particle Size								
Clay (<2 µm)	----	1	%	16	19	13	2	13
Silt (2-60 µm)	----	1	%	11	15	9	<1	11
Sand (0.06-2.00 mm)	----	1	%	71	63	73	88	58
Gravel (>2mm)	----	1	%	2	3	5	10	18
Cobbles (>6cm)	----	1	%	<1	<1	<1	<1	<1
EA152: Soil Particle Density								
ø Soil Particle Density (Clay/Silt/Sand)	----	0.01	g/cm3	2.68	2.64	2.63	2.64	2.63
ED008: Exchangeable Cations								
^ Exchangeable Calcium	----	0.1	meq/100g	<0.1	<0.1	<0.1	0.3	0.2
^ Exchangeable Magnesium	----	0.1	meq/100g	1.8	1.4	1.2	0.6	2.4
^ Exchangeable Potassium	----	0.1	meq/100g	0.2	0.4	0.2	0.2	0.5
^ Exchangeable Sodium	----	0.1	meq/100g	1.7	1.4	1.5	0.9	3.4
^ Cation Exchange Capacity	----	0.1	meq/100g	3.7	3.2	3.0	2.0	6.6
^ Exchangeable Sodium Percent	----	0.1	%	34.8	35.7	41.8	44.6	50.1
ED040S : Soluble Sulfate by ICPAES								

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	Geochem 3 10.5-11.8m	Geochem 3 11.8-12.7m	Geochem 3 12.7-14.0m	Geochem 3 14.0-14.1m	Geochem 3 14.1-15.0m
				Client sampling date / time	[16-Sep-2014]	[16-Sep-2014]	[16-Sep-2014]	[16-Sep-2014]	[16-Sep-2014]
Compound	CAS Number	LOR	Unit		EB1442542-061	EB1442542-062	EB1442542-063	EB1442542-064	EB1442542-065
					Result	Result	Result	Result	Result
ED040S : Soluble Sulfate by ICPAES - Continued									
Sulfate as SO4 2-	14808-79-8	10	mg/kg		**330**	**230**	**210**	**60**	**320**
EP004: Organic Matter									
Organic Matter	----	0.5	%		<0.5	<0.5	**0.5**	**0.7**	<0.5
Total Organic Carbon	----	0.5	%		<0.5	<0.5	<0.5	<0.5	<0.5

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	Geochem 3 15.0-16.0m	Geochem 3 16.0-17.0m	Geochem 3 17.0-18.0m	Geochem 3 18.0-19.0m	Geochem 3 19.0-20.0m
			Client sampling date / time	[16-Sep-2014]	[16-Sep-2014]	[16-Sep-2014]	[16-Sep-2014]	[16-Sep-2014]
Compound	CAS Number	LOR	Unit	EB1442542-066	EB1442542-067	EB1442542-068	EB1442542-069	EB1442542-070
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	5.2	5.0	5.2	5.2	5.8
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	944	1310	1370	1400	1380
EA055: Moisture Content								
^ Moisture Content (dried @ 103°C)	----	1	%	7.0	11.5	12.4	11.5	12.1
EA150: Particle Sizing								
+75µm	----	1	%	72	74	81	81	82
+150µm	----	1	%	61	64	67	69	70
+300µm	----	1	%	33	38	27	38	42
+425µm	----	1	%	24	30	16	31	34
+600µm	----	1	%	20	26	11	27	30
+1180µm	----	1	%	18	24	9	26	29
+2.36mm	----	1	%	17	21	9	25	28
+4.75mm	----	1	%	14	19	8	24	26
+9.5mm	----	1	%	10	17	3	21	25
+19.0mm	----	1	%	10	14	3	19	25
+37.5mm	----	1	%	<1	<1	<1	<1	<1
+75.0mm	----	1	%	<1	<1	<1	<1	<1
EA150: Soil Classification based on Particle Size								
Clay (<2 µm)	----	1	%	14	14	13	12	11
Silt (2-60 µm)	----	1	%	11	11	6	5	6
Sand (0.06-2.00 mm)	----	1	%	58	54	72	58	55
Gravel (>2mm)	----	1	%	17	21	9	25	28
Cobbles (>6cm)	----	1	%	<1	<1	<1	<1	<1
EA152: Soil Particle Density								
ø Soil Particle Density (Clay/Silt/Sand)	----	0.01	g/cm3	2.66	2.66	2.66	2.66	2.66
ED008: Exchangeable Cations								
^ Exchangeable Calcium	----	0.1	meq/100g	0.2	0.5	0.6	0.6	0.5
^ Exchangeable Magnesium	----	0.1	meq/100g	2.2	3.1	2.6	2.7	2.0
^ Exchangeable Potassium	----	0.1	meq/100g	0.3	0.4	0.3	0.3	0.2
^ Exchangeable Sodium	----	0.1	meq/100g	2.7	4.8	2.7	2.7	2.0
^ Cation Exchange Capacity	----	0.1	meq/100g	5.5	8.8	6.2	6.3	4.7
^ Exchangeable Sodium Percent	----	0.1	%	45.0	51.4	43.2	42.7	41.3
ED040S : Soluble Sulfate by ICPAES								

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	Geochem 3 15.0-16.0m	Geochem 3 16.0-17.0m	Geochem 3 17.0-18.0m	Geochem 3 18.0-19.0m	Geochem 3 19.0-20.0m
				Client sampling date / time	[16-Sep-2014]	[16-Sep-2014]	[16-Sep-2014]	[16-Sep-2014]	[16-Sep-2014]
Compound	CAS Number	LOR	Unit		EB1442542-066	EB1442542-067	EB1442542-068	EB1442542-069	EB1442542-070
					Result	Result	Result	Result	Result
ED040S : Soluble Sulfate by ICPAES - Continued									
Sulfate as SO4 2-	14808-79-8	10	mg/kg		**310**	**400**	**420**	**420**	**380**
EP004: Organic Matter									
Organic Matter	----	0.5	%		<0.5	<0.5	<0.5	<0.5	<0.5
Total Organic Carbon	----	0.5	%		<0.5	<0.5	<0.5	<0.5	<0.5

CERTIFICATE OF ANALYSIS

Work Order	: **EB1442554**	Page	: 1 of 10
Amendment	: **1**		
Client	: **EMGA MITCHELL MCLENNAN**	Laboratory	: Environmental Division Brisbane
Contact	: MR TIMOTHY ROHDE	Contact	: Customer Services EB
Address	: 1/4 87 WICKHAM TERRACE SPRING HILL QLD 4000	Address	: 2 Byth Street Stafford QLD Australia 4053
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Telephone	: 07 3839 1800	Telephone	: +61-7-3243 7222
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Project	: Balranald (J12011)	QC Level	: NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Order number	: ----		
C-O-C number	: ----	Date Samples Received	: 16-Sep-2014 09:05
Sampler	: KYM LUITJES	Issue Date	: 29-Sep-2014 11:32
Site	: ----		
		No. of samples received	: 19
Quote number	: ----	No. of samples analysed	: 19

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

NATA Accredited Laboratory 825

Accredited for compliance with ISO/IEC 17025.

Signatories

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

Signatories	*Position*	*Accreditation Category*
Andrew Epps	Senior Inorganic Chemist	Brisbane Inorganics
Hamish Murray	Supervisor - Soils	Newcastle - Inorganics

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.

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.

- **This report has been amended as a result of changes to the contacts for the distribution of the report. All analysis results are as per the previous report.**

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	Hughdale 34 0-5	Hughdale 34 5-35	Hughdale 34 35-75	Hughdale 36 0-20	Hughdale 36 20-35
			Client sampling date / time	[15-Sep-2014]	[15-Sep-2014]	[15-Sep-2014]	[15-Sep-2014]	[15-Sep-2014]
Compound	CAS Number	LOR	Unit	EB1442554-001	EB1442554-002	EB1442554-003	EB1442554-004	EB1442554-005
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	8.3	8.9	8.5	8.0	8.8
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	455	2220	3580	254	285
EA055: Moisture Content								
^ Moisture Content (dried @ 103°C)	----	1	%	5.0	10.9	11.2	2.1	4.7
EA150: Particle Sizing								
+75µm	----	1	%	----	----	----	78	74
+150µm	----	1	%	----	----	----	50	47
+300µm	----	1	%	----	----	----	18	17
+425µm	----	1	%	----	----	----	7	6
+600µm	----	1	%	----	----	----	2	1
+1180µm	----	1	%	----	----	----	<1	<1
+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	%	----	----	----	8	13
Silt (2-60 µm)	----	1	%	----	----	----	12	9
Sand (0.06-2.00 mm)	----	1	%	----	----	----	80	78
Gravel (>2mm)	----	1	%	----	----	----	<1	<1
Cobbles (>6cm)	----	1	%	----	----	----	<1	<1
EA152: Soil Particle Density								
ø Soil Particle Density (Clay/Silt/Sand)	----	0.01	g/cm3	----	----	----	2.64	2.63
ED008: Exchangeable Cations								
^ Exchangeable Calcium	----	0.1	meq/100g	9.2	32.5	35.4	3.8	3.0
^ Exchangeable Magnesium	----	0.1	meq/100g	4.4	12.2	13.2	1.0	2.1
^ Exchangeable Potassium	----	0.1	meq/100g	1.4	1.2	0.7	0.4	0.7
^ Exchangeable Sodium	----	0.1	meq/100g	2.2	4.6	2.4	<0.1	3.8
^ Cation Exchange Capacity	----	0.1	meq/100g	17.2	50.5	51.7	5.2	9.6
^ Exchangeable Sodium Percent	----	0.1	%	12.7	9.0	4.6	0.9	39.2
ED040S : Soluble Sulfate by ICPAES								

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	Hughdale 34 0-5	Hughdale 34 5-35	Hughdale 34 35-75	Hughdale 36 0-20	Hughdale 36 20-35
				Client sampling date / time	[15-Sep-2014]	[15-Sep-2014]	[15-Sep-2014]	[15-Sep-2014]	[15-Sep-2014]
Compound	CAS Number	LOR	Unit		EB1442554-001	EB1442554-002	EB1442554-003	EB1442554-004	EB1442554-005
					Result	Result	Result	Result	Result
ED040S : Soluble Sulfate by ICPAES - Continued									
Sulfate as SO4 2-	14808-79-8	10	mg/kg		20	1520	4970	20	70
ED045G: Chloride by Discrete Analyser									
Chloride	16887-00-6	10	mg/kg		340	3390	4290	30	210
EP004: Organic Matter									
Organic Matter	----	0.5	%		1.6	1.5	1.3	1.6	1.3
Total Organic Carbon	----	0.5	%		1.0	0.9	0.8	0.9	0.8

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	Hughdale 36 35-50	Hughdale 36 50-75	Hughdale 53 0-5	Hughdale 53 5-25	Hughdale 53 25-55
			Client sampling date / time	[15-Sep-2014]	[15-Sep-2014]	[15-Sep-2014]	[15-Sep-2014]	[15-Sep-2014]
Compound	CAS Number	LOR	Unit	EB1442554-006	EB1442554-007	EB1442554-008	EB1442554-009	EB1442554-010
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	8.9	8.4	8.6	8.4	9.2
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	1860	2920	361	139	167
EA055: Moisture Content								
^ Moisture Content (dried @ 103°C)	----	1	%	8.5	8.6	3.4	3.1	6.0
EA150: Particle Sizing								
+75µm	----	1	%	54	47	79	80	72
+150µm	----	1	%	34	30	52	54	48
+300µm	----	1	%	13	12	17	17	17
+425µm	----	1	%	5	5	6	5	6
+600µm	----	1	%	1	1	1	1	1
+1180µm	----	1	%	<1	<1	<1	<1	<1
+2.36mm	----	1	%	<1	<1	<1	<1	<1
+4.75mm	----	1	%	<1	<1	<1	<1	<1
+9.5mm	----	1	%	<1	<1	<1	<1	<1
+19.0mm	----	1	%	<1	<1	<1	<1	<1
+37.5mm	----	1	%	<1	<1	<1	<1	<1
+75.0mm	----	1	%	<1	<1	<1	<1	<1
EA150: Soil Classification based on Particle Size								
Clay (<2 µm)	----	1	%	27	28	12	12	16
Silt (2-60 µm)	----	1	%	18	24	7	7	8
Sand (0.06-2.00 mm)	----	1	%	55	48	81	81	76
Gravel (>2mm)	----	1	%	<1	<1	<1	<1	<1
Cobbles (>6cm)	----	1	%	<1	<1	<1	<1	<1
EA152: Soil Particle Density								
ø Soil Particle Density (Clay/Silt/Sand)	----	0.01	g/cm3	2.66	2.68	2.64	2.64	2.63
ED008: Exchangeable Cations								
^ Exchangeable Calcium	----	0.1	meq/100g	30.6	33.6	24.3	27.8	30.3
^ Exchangeable Magnesium	----	0.1	meq/100g	8.6	8.4	1.2	1.4	3.8
^ Exchangeable Potassium	----	0.1	meq/100g	0.6	0.5	0.3	0.4	0.4
^ Exchangeable Sodium	----	0.1	meq/100g	2.1	0.9	<0.1	<0.1	0.1
^ Cation Exchange Capacity	----	0.1	meq/100g	41.9	43.5	25.8	29.6	34.6
^ Exchangeable Sodium Percent	----	0.1	%	5.0	2.1	<0.1	<0.1	0.3
ED040S : Soluble Sulfate by ICPAES								

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	Hughdale 36 35-50	Hughdale 36 50-75	Hughdale 53 0-5	Hughdale 53 5-25	Hughdale 53 25-55
				Client sampling date / time	[15-Sep-2014]	[15-Sep-2014]	[15-Sep-2014]	[15-Sep-2014]	[15-Sep-2014]
Compound	CAS Number	LOR	Unit		EB1442554-006	EB1442554-007	EB1442554-008	EB1442554-009	EB1442554-010
					Result	Result	Result	Result	Result
ED040S : Soluble Sulfate by ICPAES - Continued									
Sulfate as SO4 2-	14808-79-8	10	mg/kg		**1820**	**3890**	**20**	<10	<10
ED045G: Chloride by Discrete Analyser									
Chloride	16887-00-6	10	mg/kg		**2360**	**3410**	**20**	**10**	<10
EP004: Organic Matter									
Organic Matter	----	0.5	%		**1.3**	**1.5**	**1.5**	**1.3**	**1.3**
Total Organic Carbon	----	0.5	%		**0.8**	**0.9**	**0.9**	**0.8**	**0.8**

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	Hughdale 53 55-75	Pine Lodge 76 0-20	Pine Lodge 76 20-75	Pine Lodge 77 0-10	Pine Lodge 77 10-35
			Client sampling date / time	[15-Sep-2014]	[15-Sep-2014]	[15-Sep-2014]	[15-Sep-2014]	[15-Sep-2014]
Compound	CAS Number	LOR	Unit	EB1442554-011	EB1442554-012	EB1442554-013	EB1442554-014	EB1442554-015
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	9.7	8.6	8.8	7.4	7.6
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	346	108	315	75	95
EA055: Moisture Content								
^ Moisture Content (dried @ 103°C)	----	1	%	4.7	4.3	6.2	7.1	7.9
EA150: Particle Sizing								
+75µm	----	1	%	77	----	----	----	----
+150µm	----	1	%	53	----	----	----	----
+300µm	----	1	%	18	----	----	----	----
+425µm	----	1	%	5	----	----	----	----
+600µm	----	1	%	1	----	----	----	----
+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	%	15	----	----	----	----
Silt (2-60 µm)	----	1	%	7	----	----	----	----
Sand (0.06-2.00 mm)	----	1	%	78	----	----	----	----
Gravel (>2mm)	----	1	%	<1	----	----	----	----
Cobbles (>6cm)	----	1	%	<1	----	----	----	----
EA152: Soil Particle Density								
ø Soil Particle Density (Clay/Silt/Sand)	----	0.01	g/cm3	2.66	----	----	----	----
ED008: Exchangeable Cations								
^ Exchangeable Calcium	----	0.1	meq/100g	27.9	30.9	32.9	15.4	12.0
^ Exchangeable Magnesium	----	0.1	meq/100g	5.6	1.8	4.2	3.6	3.0
^ Exchangeable Potassium	----	0.1	meq/100g	1.0	0.6	0.8	1.1	1.0
^ Exchangeable Sodium	----	0.1	meq/100g	0.5	<0.1	0.2	<0.1	0.1
^ Cation Exchange Capacity	----	0.1	meq/100g	35.0	33.3	38.2	20.1	16.0
^ Exchangeable Sodium Percent	----	0.1	%	1.4	0.1	0.4	0.2	0.8
ED040S : Soluble Sulfate by ICPAES								

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	Hughdale 53 55-75	Pine Lodge 76 0-20	Pine Lodge 76 20-75	Pine Lodge 77 0-10	Pine Lodge 77 10-35
				Client sampling date / time	[15-Sep-2014]	[15-Sep-2014]	[15-Sep-2014]	[15-Sep-2014]	[15-Sep-2014]
Compound	CAS Number	LOR	Unit		EB1442554-011	EB1442554-012	EB1442554-013	EB1442554-014	EB1442554-015
					Result	Result	Result	Result	Result
ED040S : Soluble Sulfate by ICPAES - Continued									
Sulfate as SO4 2-	14808-79-8	10	mg/kg		**50**	<10	**20**	<10	<10
ED045G: Chloride by Discrete Analyser									
Chloride	16887-00-6	10	mg/kg		**120**	**40**	**270**	<10	**20**
EP004: Organic Matter									
Organic Matter	----	0.5	%		**1.2**	**1.8**	**1.5**	**2.8**	**2.0**
Total Organic Carbon	----	0.5	%		**0.7**	**1.0**	**0.9**	**1.6**	**1.2**

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	Pine Lodge 77 35-70	Karra 100 0-5	Karra 100 5-30	Karra 100 30-75	----
			Client sampling date / time	[15-Sep-2014]	[15-Sep-2014]	[15-Sep-2014]	[15-Sep-2014]	----
Compound	CAS Number	LOR	Unit	EB1442554-016	EB1442554-017	EB1442554-018	EB1442554-019	--------
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	7.9	8.2	8.5	9.0	----
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	180	134	1180	2400	----
EA055: Moisture Content								
^ Moisture Content (dried @ 103°C)	----	1	%	10.4	2.6	12.3	12.1	----
EA150: Particle Sizing								
+75µm	----	1	%	----	61	29	20	----
+150µm	----	1	%	----	28	14	9	----
+300µm	----	1	%	----	9	4	3	----
+425µm	----	1	%	----	4	1	1	----
+600µm	----	1	%	----	2	<1	<1	----
+1180µm	----	1	%	----	<1	<1	<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	----
EA150: Soil Classification based on Particle Size								
Clay (<2 µm)	----	1	%	----	13	40	36	----
Silt (2-60 µm)	----	1	%	----	24	28	42	----
Sand (0.06-2.00 mm)	----	1	%	----	63	32	22	----
Gravel (>2mm)	----	1	%	----	<1	<1	<1	----
Cobbles (>6cm)	----	1	%	----	<1	<1	<1	----
EA152: Soil Particle Density								
ø Soil Particle Density (Clay/Silt/Sand)	----	0.01	g/cm3	----	2.63	2.65	2.71	----
ED008: Exchangeable Cations								
^ Exchangeable Calcium	----	0.1	meq/100g	18.6	3.6	11.0	32.8	----
^ Exchangeable Magnesium	----	0.1	meq/100g	2.6	2.6	12.1	14.4	----
^ Exchangeable Potassium	----	0.1	meq/100g	0.4	0.7	0.9	0.7	----
^ Exchangeable Sodium	----	0.1	meq/100g	<0.1	0.7	6.2	5.7	----
^ Cation Exchange Capacity	----	0.1	meq/100g	21.7	7.7	30.2	53.6	----
^ Exchangeable Sodium Percent	----	0.1	%	0.2	8.6	20.0	10.6	----
ED040S : Soluble Sulfate by ICPAES								

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	Pine Lodge 77 35-70	Karra 100 0-5	Karra 100 5-30	Karra 100 30-75	----
				Client sampling date / time	[15-Sep-2014]	[15-Sep-2014]	[15-Sep-2014]	[15-Sep-2014]	----
Compound	CAS Number	LOR	Unit		EB1442554-016	EB1442554-017	EB1442554-018	EB1442554-019	--------
					Result	Result	Result	Result	Result
ED040S : Soluble Sulfate by ICPAES - Continued									
Sulfate as SO4 2-	14808-79-8	10	mg/kg		20	<10	200	1290	----
ED045G: Chloride by Discrete Analyser									
Chloride	16887-00-6	10	mg/kg		20	100	2160	3920	----
EP004: Organic Matter									
Organic Matter	----	0.5	%		<0.5	1.6	1.5	1.6	----
Total Organic Carbon	----	0.5	%		<0.5	1.0	0.9	1.0	----

CERTIFICATE OF ANALYSIS

Work Order	: **EM1407357**	Page	: 1 of 29
Client	: **EMGA MITCHELL MCLENNAN**	Laboratory	: Environmental Division Melbourne
Contact	: MR TIMOTHY ROHDE	Contact	: Client Services
Address	: 1/4 87 WICKHAM TERRACE SPRING HILL QLD 4000	Address	: 4 Westall Rd Springvale VIC Australia 3171
E-mail	: trohde@emgamm.com	E-mail	: Melbourne.Enviro.Services@alsglobal.com
Telephone	: 07 3839 1800	Telephone	: +61-3-8549 9600
Facsimile	: 07 3839 1866	Facsimile	: +61-3-8549 9601
Project	: Iluka-Balranald-SE	QC Level	: NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Order number	: ----		
C-O-C number	: ----	Date Samples Received	: 25-JUL-2014
Sampler	: KL	Issue Date	: 01-AUG-2014
Site	: ----		
		No. of samples received	: 133
Quote number	: BNBQ/083/14	No. of samples analysed	: 133

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

NATA Accredited Laboratory 825

Accredited for compliance with ISO/IEC 17025.

Signatories

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

Signatories	*Position*	*Accreditation Category*
Christopher Lemaitre	Non-Metals Team Leader	Melbourne Inorganics

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

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	LF1_0-20	LF1_20-40	LF1_40-60	LF1_60-80	LF1_80-100
			Client sampling date / time	24-JUL-2014 15:00	24-JUL-2014 15:00	24-JUL-2014 15:00	24-JUL-2014 15:00	24-JUL-2014 15:00
Compound	CAS Number	LOR	Unit	EM1407357-001	EM1407357-002	EM1407357-003	EM1407357-004	EM1407357-005
EA001: pH in soil using 0.01M CaCl extract								
pH (CaCl2)	----	0.1	pH Unit	8.1	8.2	8.4	8.5	8.6
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	2550	537	534	679	915

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	LF1_100-120	LF1_120-140	WBIW 10_0-20	WBIW 10_20-40	WBIW 10_40-60
			Client sampling date / time	24-JUL-2014 15:00	24-JUL-2014 15:00	24-JUL-2014 15:00	24-JUL-2014 15:00	24-JUL-2014 15:00
Compound	CAS Number	LOR	Unit	EM1407357-006	EM1407357-007	EM1407357-008	EM1407357-009	EM1407357-010
EA001: pH in soil using 0.01M CaCl extract								
pH (CaCl2)	----	0.1	pH Unit	8.5	8.2	8.2	8.5	8.5
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	1050	1340	3450	2220	1960

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	WBIW 10_60-80	WBIW 10_80-100	WBIW 10_100-120	WBIW 10_120-140	WBIW11_0-20
			Client sampling date / time	24-JUL-2014 15:00	24-JUL-2014 15:00	24-JUL-2014 15:00	24-JUL-2014 15:00	24-JUL-2014 15:00
Compound	CAS Number	LOR	Unit	EM1407357-011	EM1407357-012	EM1407357-013	EM1407357-014	EM1407357-015
EA001: pH in soil using 0.01M CaCl extract								
pH (CaCl2)	----	0.1	pH Unit	8.5	8.4	8.4	8.3	8.2
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	2020	2350	2770	2660	1140

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	WBIW11_20-40	WBIW11_40-60	WBIW11_60-80	WBIW11_80-100	WBIW11_100-120
			Client sampling date / time	24-JUL-2014 15:00	24-JUL-2014 15:00	24-JUL-2014 15:00	24-JUL-2014 15:00	24-JUL-2014 15:00
Compound	CAS Number	LOR	Unit	EM1407357-016	EM1407357-017	EM1407357-018	EM1407357-019	EM1407357-020
EA001: pH in soil using 0.01M CaCl extract								
pH (CaCl2)	----	0.1	pH Unit	8.5	8.6	8.4	8.4	8.1
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	1820	2320	3510	3880	4180

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	WBIW11_120-140	WBMW 13 _0-20	WBMW 13 _20-40	WBMW 13 _40-60	WBMW 13 _60-80
			Client sampling date / time	24-JUL-2014 15:00	24-JUL-2014 15:00	24-JUL-2014 15:00	24-JUL-2014 15:00	24-JUL-2014 15:00
Compound	CAS Number	LOR	Unit	EM1407357-021	EM1407357-022	EM1407357-023	EM1407357-024	EM1407357-025
EA001: pH in soil using 0.01M CaCl extract								
pH (CaCl2)	----	0.1	pH Unit	8.1	8.4	8.5	8.5	8.5
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	4130	451	1510	2820	3070

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	WBMW 13 _80-100	WBMW 13 _100-120	WBMW 13 _120-140	WBMB 09_0-20	WBMB 09_20-40
				Client sampling date / time	24-JUL-2014 15:00	24-JUL-2014 15:00	24-JUL-2014 15:00	24-JUL-2014 15:00	24-JUL-2014 15:00
Compound	CAS Number	LOR	Unit		EM1407357-026	EM1407357-027	EM1407357-028	EM1407357-029	EM1407357-030
EA001: pH in soil using 0.01M CaCl extract									
pH (CaCl2)	----	0.1	pH Unit		8.4	8.4	8.4	8.2	8.6
EA010: Conductivity									
Electrical Conductivity @ 25°C	----	1	µS/cm		4520	3490	3580	236	1060

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	WBMB 09_40-60	WBMB 09_60-80	WBMB 09_80-100	WBMB 09_100-120	WBMB 09_120-140
			Client sampling date / time	24-JUL-2014 15:00	24-JUL-2014 15:00	24-JUL-2014 15:00	24-JUL-2014 15:00	24-JUL-2014 15:00
Compound	CAS Number	LOR	Unit	EM1407357-031	EM1407357-032	EM1407357-033	EM1407357-034	EM1407357-035
EA001: pH in soil using 0.01M CaCl extract								
pH (CaCl2)	----	0.1	pH Unit	**8.5**	**8.5**	**8.4**	**8.4**	**8.3**
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	**1660**	**2040**	**2190**	**2240**	**2340**

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	INJ 01_0-20	INJ 01_20-40	INJ 01_40-60	INJ 01_60-80	INJ 01_80-100
			Client sampling date / time	24-JUL-2014 15:00	24-JUL-2014 15:00	24-JUL-2014 15:00	24-JUL-2014 15:00	24-JUL-2014 15:00
Compound	CAS Number	LOR	Unit	EM1407357-036	EM1407357-037	EM1407357-038	EM1407357-039	EM1407357-040
EA001: pH in soil using 0.01M CaCl extract								
pH (CaCl2)	----	0.1	pH Unit	8.3	8.8	8.8	8.6	8.5
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	416	1300	1740	2160	2530

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	INJ 01_100-120	INJ 01_120-140	WBIW 07A_0-20	WBIW 07A_20-40	WBIW 07A_40-60
			Client sampling date / time	24-JUL-2014 15:00	24-JUL-2014 15:00	24-JUL-2014 15:00	24-JUL-2014 15:00	24-JUL-2014 15:00
Compound	CAS Number	LOR	Unit	EM1407357-041	EM1407357-042	EM1407357-043	EM1407357-044	EM1407357-045
EA001: pH in soil using 0.01M CaCl extract								
pH (CaCl2)	----	0.1	pH Unit	8.4	8.4	8.4	8.5	8.5
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	2670	2590	1050	1530	1980

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	WBIW 07A_60-80	WBIW 07A_80-100	WBIW 07A_100-120	WBIW 07A_120-140	WBIW 08_0-20
			Client sampling date / time	24-JUL-2014 15:00	24-JUL-2014 15:00	24-JUL-2014 15:00	24-JUL-2014 15:00	24-JUL-2014 15:00
Compound	CAS Number	LOR	Unit	EM1407357-046	EM1407357-047	EM1407357-048	EM1407357-049	EM1407357-050
EA001: pH in soil using 0.01M CaCl extract								
pH (CaCl2)	----	0.1	pH Unit	8.1	8.2	8.2	8.2	8.0
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	2310	3160	3010	2710	776

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	WBIW 08_20-40	WBIW 08_40-60	WBIW 08_60-80	WBIW 08_80-100	WBIW 08_100-120
			Client sampling date / time	24-JUL-2014 15:00	24-JUL-2014 15:00	24-JUL-2014 15:00	24-JUL-2014 15:00	24-JUL-2014 15:00
Compound	CAS Number	LOR	Unit	EM1407357-051	EM1407357-052	EM1407357-053	EM1407357-054	EM1407357-055
EA001: pH in soil using 0.01M CaCl extract								
pH (CaCl2)	----	0.1	pH Unit	**7.8**	**7.7**	**7.8**	**7.9**	**8.2**
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	**282**	**334**	**271**	**359**	**588**

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	WBIW 08_120-140	RBBL 3_0-20	RBBL 3_20-40	RBBL 3_40-60	RBBL 3_60-80
			Client sampling date / time	24-JUL-2014 15:00	24-JUL-2014 15:00	24-JUL-2014 15:00	24-JUL-2014 15:00	24-JUL-2014 15:00
Compound	CAS Number	LOR	Unit	EM1407357-056	EM1407357-057	EM1407357-058	EM1407357-059	EM1407357-060
EA001: pH in soil using 0.01M CaCl extract								
pH (CaCl2)	----	0.1	pH Unit	8.3	8.0	8.2	8.4	8.5
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	968	271	408	720	1230

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	RBBL 3_80-100	RBBL 3_100-120	RBBL 3_120-140	WBMB 08 _0-20	WBMB 08 _20-40
			Client sampling date / time	24-JUL-2014 15:00	24-JUL-2014 15:00	24-JUL-2014 15:00	24-JUL-2014 15:00	24-JUL-2014 15:00
Compound	CAS Number	LOR	Unit	EM1407357-061	EM1407357-062	EM1407357-063	EM1407357-064	EM1407357-065
EA001: pH in soil using 0.01M CaCl extract								
pH (CaCl2)	----	0.1	pH Unit	8.5	8.3	8.3	8.0	8.5
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	1550	1920	2310	315	1260

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	WBMB 08 _40-60	WBMB 08 _60-80	WBMB 08 _80-100	WBMB 08 _100-120	WBMB 08 _120-140
			Client sampling date / time	24-JUL-2014 15:00	24-JUL-2014 15:00	24-JUL-2014 15:00	24-JUL-2014 15:00	24-JUL-2014 15:00
Compound	CAS Number	LOR	Unit	EM1407357-066	EM1407357-067	EM1407357-068	EM1407357-069	EM1407357-070
EA001: pH in soil using 0.01M CaCl extract								
pH (CaCl2)	----	0.1	pH Unit	8.5	8.5	8.4	8.2	8.1
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	1660	1980	2250	2330	2330

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	RBBL 2_0-20	RBBL 2_20-40	RBBL 2_40-60	RBBL 2_60-80	RBBL 2_80-100
			Client sampling date / time	24-JUL-2014 15:00	24-JUL-2014 15:00	24-JUL-2014 15:00	24-JUL-2014 15:00	24-JUL-2014 15:00
Compound	CAS Number	LOR	Unit	EM1407357-071	EM1407357-072	EM1407357-073	EM1407357-074	EM1407357-075
EA001: pH in soil using 0.01M CaCl extract								
pH (CaCl2)	----	0.1	pH Unit	8.2	8.3	8.4	8.4	8.4
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	322	604	978	1260	1350

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	RBBL 2_100-120	RBBL 2_120-140	WBIW 05_0-20	WBIW 05_20-40	WBIW 05_40-60
			Client sampling date / time	24-JUL-2014 15:00	24-JUL-2014 15:00	24-JUL-2014 15:00	24-JUL-2014 15:00	24-JUL-2014 15:00
Compound	CAS Number	LOR	Unit	EM1407357-076	EM1407357-077	EM1407357-078	EM1407357-079	EM1407357-080
EA001: pH in soil using 0.01M CaCl extract								
pH (CaCl2)	----	0.1	pH Unit	8.4	8.3	8.3	8.5	8.5
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	1520	1640	526	1400	2220

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	WBIW 05_60-80	WBIW 05_80-100	WBIW 05_100-120	WBIW 05_120-140	WBIW 12_0-20
			Client sampling date / time	24-JUL-2014 15:00	24-JUL-2014 15:00	24-JUL-2014 15:00	24-JUL-2014 15:00	24-JUL-2014 15:00
Compound	CAS Number	LOR	Unit	EM1407357-081	EM1407357-082	EM1407357-083	EM1407357-084	EM1407357-085
EA001: pH in soil using 0.01M CaCl extract								
pH (CaCl2)	----	0.1	pH Unit	8.5	8.5	8.4	8.4	8.0
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	2050	2310	2490	2610	3760

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	WBIW 12_20-40	WBIW 12_40-60	WBIW 12_60-80	WBIW 12_80-100	WBIW 12_100-120
			Client sampling date / time	24-JUL-2014 15:00	24-JUL-2014 15:00	24-JUL-2014 15:00	24-JUL-2014 15:00	24-JUL-2014 15:00
Compound	CAS Number	LOR	Unit	EM1407357-086	EM1407357-087	EM1407357-088	EM1407357-089	EM1407357-090
EA001: pH in soil using 0.01M CaCl extract								
pH (CaCl2)	----	0.1	pH Unit	**8.4**	**8.4**	**8.3**	**8.3**	**8.3**
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	**2200**	**1810**	**1730**	**1780**	**1950**

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	WBIW 12_120-140	RBBL 1_0-20	RBBL 1_20-40	RBBL 1_40-60	RBBL 1_60-80
			Client sampling date / time	24-JUL-2014 15:00	24-JUL-2014 15:00	24-JUL-2014 15:00	24-JUL-2014 15:00	24-JUL-2014 15:00
Compound	CAS Number	LOR	Unit	EM1407357-091	EM1407357-092	EM1407357-093	EM1407357-094	EM1407357-095
EA001: pH in soil using 0.01M CaCl extract								
pH (CaCl2)	----	0.1	pH Unit	8.2	8.2	8.4	8.5	8.5
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	1920	223	456	687	944

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	RBBL 1_80-100	RBBL 1_100-120	RBBL 1_120-140	WBIW 02 _0-20	WBIW 02 _20-40
			Client sampling date / time	24-JUL-2014 15:00	24-JUL-2014 15:00	24-JUL-2014 15:00	24-JUL-2014 15:00	24-JUL-2014 15:00
Compound	CAS Number	LOR	Unit	EM1407357-096	EM1407357-097	EM1407357-098	EM1407357-099	EM1407357-100
EA001: pH in soil using 0.01M CaCl extract								
pH (CaCl2)	----	0.1	pH Unit	8.5	8.3	8.3	8.2	8.4
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	1020	1160	1220	340	1320

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	WBIW 02 _40-60	WBIW 02 _60-80	WBIW 02 _80-100	WBIW 02 _100-120	WBIW 02 _120-140
			Client sampling date / time	24-JUL-2014 15:00	24-JUL-2014 15:00	24-JUL-2014 15:00	24-JUL-2014 15:00	24-JUL-2014 15:00
Compound	CAS Number	LOR	Unit	EM1407357-101	EM1407357-102	EM1407357-103	EM1407357-104	EM1407357-105
EA001: pH in soil using 0.01M CaCl extract								
pH (CaCl2)	----	0.1	pH Unit	8.4	8.4	8.3	8.1	7.6
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	1810	2180	2550	2590	2310

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	WBIW 03 _0-20	WBIW 03 _20-40	WBIW 03 _40-60	WBIW 03 _60-80	WBIW 03 _80-100
				Client sampling date / time	24-JUL-2014 15:00	24-JUL-2014 15:00	24-JUL-2014 15:00	24-JUL-2014 15:00	24-JUL-2014 15:00
Compound	CAS Number	LOR	Unit		EM1407357-106	EM1407357-107	EM1407357-108	EM1407357-109	EM1407357-110
EA001: pH in soil using 0.01M CaCl extract									
pH (CaCl2)	----	0.1	pH Unit		8.0	8.4	8.5	8.4	8.4
EA010: Conductivity									
Electrical Conductivity @ 25°C	----	1	µS/cm		745	1030	1960	1910	1930

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	WBIW 03 _100-120	WBIW 03 _120-140	WBIW 04 _0-20	WBIW 04 _20-40	WBIW 04 _40-60
			Client sampling date / time	24-JUL-2014 15:00	24-JUL-2014 15:00	24-JUL-2014 15:00	24-JUL-2014 15:00	24-JUL-2014 15:00
Compound	CAS Number	LOR	Unit	EM1407357-111	EM1407357-112	EM1407357-113	EM1407357-114	EM1407357-115
EA001: pH in soil using 0.01M CaCl extract								
pH (CaCl2)	----	0.1	pH Unit	**8.3**	**8.4**	**8.1**	**8.1**	**8.5**
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	**2020**	**1950**	**935**	**809**	**970**

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	WBIW 04 _60-80	WBIW 04 _80-100	WBIW 04 _100-120	WBIW 04 _120-140	WBIW 06 _0-20
			Client sampling date / time	24-JUL-2014 15:00	24-JUL-2014 15:00	24-JUL-2014 15:00	24-JUL-2014 15:00	24-JUL-2014 15:00
Compound	CAS Number	LOR	Unit	EM1407357-116	EM1407357-117	EM1407357-118	EM1407357-119	EM1407357-120
EA001: pH in soil using 0.01M CaCl extract								
pH (CaCl2)	----	0.1	pH Unit	8.5	8.4	8.4	8.3	8.4
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	1420	1510	1810	1890	802

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	WBIW 06 _20-40	WBIW 06 _40-60	WBIW 06 _60-80	WBIW 06 _80-100	WBIW 06 _100-120
			Client sampling date / time	24-JUL-2014 15:00	24-JUL-2014 15:00	24-JUL-2014 15:00	24-JUL-2014 15:00	24-JUL-2014 15:00
Compound	CAS Number	LOR	Unit	EM1407357-121	EM1407357-122	EM1407357-123	EM1407357-124	EM1407357-125
EA001: pH in soil using 0.01M CaCl extract								
pH (CaCl2)	----	0.1	pH Unit	8.7	8.7	8.6	8.5	8.5
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	2520	2530	2680	2630	2550

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	WBIW 06 _120-140	WBIW 09 _0-20	WBIW 09 _20-40	WBIW 09 _40-60	WBIW 09 _60-80
			Client sampling date / time	24-JUL-2014 15:00	24-JUL-2014 15:00	24-JUL-2014 15:00	24-JUL-2014 15:00	24-JUL-2014 15:00
Compound	CAS Number	LOR	Unit	EM1407357-126	EM1407357-127	EM1407357-128	EM1407357-129	EM1407357-130
EA001: pH in soil using 0.01M CaCl extract								
pH (CaCl2)	----	0.1	pH Unit	**8.5**	**8.2**	**8.4**	**8.4**	**8.4**
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	**2530**	**1100**	**1570**	**1700**	**1970**

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	WBIW 09 _80-100	WBIW 09 _100-120	WBIW 09 _120-140	----	----
			Client sampling date / time	24-JUL-2014 15:00	24-JUL-2014 15:00	24-JUL-2014 15:00	----	----
Compound	CAS Number	LOR	Unit	EM1407357-131	EM1407357-132	EM1407357-133	----	----
EA001: pH in soil using 0.01M CaCl extract								
pH (CaCl2)	----	0.1	pH Unit	**8.2**	**8.3**	**8.3**	----	----
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	**2870**	**2760**	**3060**	----	----

CERTIFICATE OF ANALYSIS

Work Order	: **EM1408549**	Page	: 1 of 21
Client	: **EMGA MITCHELL MCLENNAN**	Laboratory	: Environmental Division Melbourne
Contact	: MR TIMOTHY ROHDE	Contact	: Client Services
Address	: 1/4 87 WICKHAM TERRACE SPRING HILL QLD 4000	Address	: 4 Westall Rd Springvale VIC Australia 3171
E-mail	: trohde@emgamm.com	E-mail	: Melbourne.Enviro.Services@alsglobal.com
Telephone	: 07 3839 1800	Telephone	: +61-3-8549 9600
Facsimile	: 07 3839 1866	Facsimile	: +61-3-8549 9601
Project	: Balranald (J12011)	QC Level	: NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Order number	: ----		
C-O-C number	: ----	Date Samples Received	: 22-AUG-2014
Sampler	: KL	Issue Date	: 02-SEP-2014
Site	: ----		
		No. of samples received	: 94
Quote number	: BNBQ/083/14	No. of samples analysed	: 94

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

NATA Accredited Laboratory 825

Accredited for compliance with ISO/IEC 17025.

Signatories

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

Signatories	*Position*	*Accreditation Category*
Dilani Fernando	Senior Inorganic Chemist	Melbourne Inorganics
Eric Chau	Metals Team Leader	Melbourne Inorganics
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics

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

- **CEC (ED008) conducted by ALS Brisbane, NATA accreditation no. 825, site no. 818.**
- **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) is a more suitable method for the determination of exchange acidity (H+ + Al3+).**
- **ED045G: The presence of thiocyanate can positively contribute to the chloride result, thereby may bias results higher than expected. Results should be scrutinised accordingly.**
- **ED045HG:EM1408549_074 has been diluted for Chloride due to sample matrix. LOR has been raised accordingly.**
- **This is a split batch with EM1408597 due to the longer turnaround required for PSD analysis.**

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	Karra 3 (20)	Karra 3 (35)	Karra 3 (75)	Karra 6 (15)	Karra 6 (30)
			Client sampling date / time	[21-AUG-2014]	[21-AUG-2014]	[21-AUG-2014]	[21-AUG-2014]	[21-AUG-2014]
Compound	CAS Number	LOR	Unit	EM1408549-001	EM1408549-002	EM1408549-003	EM1408549-004	EM1408549-005
EA001: pH in soil using 0.01M CaCl extract								
pH (CaCl2)	----	0.1	pH Unit	8.2	8.4	8.4	7.8	7.9
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	6480	6380	6610	107	88
EA055: Moisture Content								
Moisture Content (dried @ 103°C)	----	1.0	%	9.4	8.8	10.6	9.6	12.5
ED008: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	13.1	25.6	32.2	31.1	31.8
Exchangeable Magnesium	----	0.1	meq/100g	13.4	13.0	12.0	2.6	2.7
Exchangeable Potassium	----	0.1	meq/100g	0.6	0.5	0.4	0.9	0.2
Exchangeable Sodium	----	0.1	meq/100g	3.6	3.9	2.4	<0.1	<0.1
Cation Exchange Capacity	----	0.1	meq/100g	30.6	43.0	47.0	34.7	34.8
Exchangeable Sodium Percent	----	0.1	%	11.7	9.0	5.0	<0.1	<0.1
ED040N: Sulfate - Calcium Phosphate Soluble (NEPM)								
Sulfate as SO4 2-	14808-79-8	50	mg/kg	2100	1330	2890	<50	<50
ED045G: Chloride Discrete analyser								
Chloride	16887-00-6	10	mg/kg	9910	10200	8950	<10	<10
EP004: Organic Matter								
Organic Matter	----	0.5	%	<0.5	0.6	<0.5	1.6	2.4
Total Organic Carbon	----	0.5	%	<0.5	<0.5	<0.5	0.9	1.4

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	Karra 6 (75)	Karra 10 (5)	Karra 10 (25)	Karra 10 (75)	Karra 12 (15)
			Client sampling date / time	[21-AUG-2014]	[21-AUG-2014]	[21-AUG-2014]	[21-AUG-2014]	[21-AUG-2014]
Compound	CAS Number	LOR	Unit	EM1408549-006	EM1408549-007	EM1408549-008	EM1408549-009	EM1408549-010
EA001: pH in soil using 0.01M CaCl extract								
pH (CaCl2)	----	0.1	pH Unit	8.1	6.8	8.2	8.4	8.0
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	144	58	1640	3200	101
EA055: Moisture Content								
Moisture Content (dried @ 103°C)	----	1.0	%	10.2	9.6	12.7	14.4	8.9
ED008: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	28.1	6.5	12.6	27.4	28.8
Exchangeable Magnesium	----	0.1	meq/100g	6.0	7.1	12.2	13.8	1.8
Exchangeable Potassium	----	0.1	meq/100g	0.2	1.9	1.3	0.8	0.9
Exchangeable Sodium	----	0.1	meq/100g	0.4	2.7	6.0	4.5	<0.1
Cation Exchange Capacity	----	0.1	meq/100g	34.8	18.3	32.2	46.5	31.6
Exchangeable Sodium Percent	----	0.1	%	1.3	14.7	18.7	9.6	<0.1
ED040N: Sulfate - Calcium Phosphate Soluble (NEPM)								
Sulfate as SO4 2-	14808-79-8	50	mg/kg	<50	<50	440	1660	<50
ED045G: Chloride Discrete analyser								
Chloride	16887-00-6	10	mg/kg	<10	60	2530	4690	<10
EP004: Organic Matter								
Organic Matter	----	0.5	%	<0.5	0.7	0.5	<0.5	1.7
Total Organic Carbon	----	0.5	%	<0.5	<0.5	<0.5	<0.5	1.0

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	Karra 12 (30)	Karra 12 (50)	Karra 12 (75)	Karra 13 (5)	Karra 13 (20)
			Client sampling date / time	[21-AUG-2014]	[21-AUG-2014]	[21-AUG-2014]	[21-AUG-2014]	[21-AUG-2014]
Compound	CAS Number	LOR	Unit	EM1408549-011	EM1408549-012	EM1408549-013	EM1408549-014	EM1408549-015
EA001: pH in soil using 0.01M CaCl extract								
pH (CaCl2)	----	0.1	pH Unit	8.1	8.3	8.6	8.0	8.5
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	101	232	910	202	624
EA055: Moisture Content								
Moisture Content (dried @ 103°C)	----	1.0	%	8.8	8.4	8.8	8.6	13.5
ED008: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	28.5	27.1	26.4	22.1	29.7
Exchangeable Magnesium	----	0.1	meq/100g	3.0	5.1	7.3	6.2	9.0
Exchangeable Potassium	----	0.1	meq/100g	0.7	0.4	0.3	1.1	1.0
Exchangeable Sodium	----	0.1	meq/100g	<0.1	0.4	1.7	1.0	5.7
Cation Exchange Capacity	----	0.1	meq/100g	32.2	33.0	35.8	30.4	45.4
Exchangeable Sodium Percent	----	0.1	%	0.1	1.1	4.8	3.1	12.6
ED040N: Sulfate - Calcium Phosphate Soluble (NEPM)								
Sulfate as SO4 2-	14808-79-8	50	mg/kg	<50	<50	230	<50	<50
ED045G: Chloride Discrete analyser								
Chloride	16887-00-6	10	mg/kg	<10	50	950	80	460
EP004: Organic Matter								
Organic Matter	----	0.5	%	1.2	0.7	<0.5	1.0	<0.5
Total Organic Carbon	----	0.5	%	0.7	<0.5	<0.5	0.6	<0.5

Analytical Results

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

Compound	CAS Number	LOR	Unit	Client sample ID: Karra 13 (75)	Karra 14 (5)	Karra 14 (25)	Karra 14 (45)	Karra 14 (75)
Client sampling date / time				[21-AUG-2014]	[21-AUG-2014]	[21-AUG-2014]	[21-AUG-2014]	[21-AUG-2014]
				EM1408549-016	**EM1408549-017**	**EM1408549-018**	**EM1408549-019**	**EM1408549-020**
EA001: pH in soil using 0.01M CaCl extract								
pH (CaCl2)	----	0.1	pH Unit	**8.5**	**8.0**	**8.1**	**8.4**	**8.6**
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	**2900**	**148**	**145**	**778**	**1780**
EA055: Moisture Content								
Moisture Content (dried @ 103°C)	----	1.0	%	**13.6**	**6.8**	**7.3**	**7.6**	**10.0**
ED008: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	**30.2**	**28.1**	**29.4**	**28.8**	**23.3**
Exchangeable Magnesium	----	0.1	meq/100g	**9.3**	**2.6**	**2.6**	**5.7**	**10.7**
Exchangeable Potassium	----	0.1	meq/100g	**0.5**	**0.8**	**0.6**	**0.2**	**0.4**
Exchangeable Sodium	----	0.1	meq/100g	**4.8**	<0.1	<0.1	**0.4**	**3.4**
Cation Exchange Capacity	----	0.1	meq/100g	**44.9**	**31.6**	**32.7**	**35.1**	**37.8**
Exchangeable Sodium Percent	----	0.1	%	**10.7**	**0.2**	**0.2**	**1.0**	**9.1**
ED040N: Sulfate - Calcium Phosphate Soluble (NEPM)								
Sulfate as SO4 2-	14808-79-8	50	mg/kg	**1320**	<50	<50	**140**	**610**
ED045G: Chloride Discrete analyser								
Chloride	16887-00-6	10	mg/kg	**3820**	**20**	**40**	**1060**	**2510**
EP004: Organic Matter								
Organic Matter	----	0.5	%	<0.5	**2.5**	**2.1**	**1.0**	**0.6**
Total Organic Carbon	----	0.5	%	<0.5	**1.4**	**1.2**	**0.6**	<0.5

Analytical Results

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

Compound	CAS Number	LOR	Unit	Client sample ID	Tin Tin15 (15)	Tin Tin15 (30)	Tin Tin15 (75)	Karra 23 (5)	Karra 23 (75)
				Client sampling date / time	[21-AUG-2014]	[21-AUG-2014]	[21-AUG-2014]	[21-AUG-2014]	[21-AUG-2014]
					EM1408549-021	EM1408549-022	EM1408549-023	EM1408549-024	EM1408549-025
EA001: pH in soil using 0.01M CaCl extract									
pH (CaCl2)	----	0.1	pH Unit		**7.8**	**8.0**	**8.3**	**7.8**	**8.4**
EA010: Conductivity									
Electrical Conductivity @ 25°C	----	1	µS/cm		**111**	**198**	**525**	**139**	**1750**
EA055: Moisture Content									
Moisture Content (dried @ 103°C)	----	1.0	%		**8.2**	**12.3**	**11.8**	**12.5**	**13.8**
ED008: Exchangeable Cations									
Exchangeable Calcium	----	0.1	meq/100g		**11.3**	**29.0**	**26.3**	**32.5**	**28.7**
Exchangeable Magnesium	----	0.1	meq/100g		**4.3**	**8.6**	**11.0**	**8.0**	**12.3**
Exchangeable Potassium	----	0.1	meq/100g		**1.4**	**1.2**	**0.7**	**1.8**	**0.6**
Exchangeable Sodium	----	0.1	meq/100g		**0.3**	**1.0**	**2.7**	**0.4**	**5.2**
Cation Exchange Capacity	----	0.1	meq/100g		**17.3**	**39.8**	**40.7**	**42.6**	**46.8**
Exchangeable Sodium Percent	----	0.1	%		**1.6**	**2.5**	**6.7**	**0.8**	**11.2**
ED040N: Sulfate - Calcium Phosphate Soluble (NEPM)									
Sulfate as SO4 2-	14808-79-8	50	mg/kg		<50	<50	<50	<50	**730**
ED045G: Chloride Discrete analyser									
Chloride	16887-00-6	10	mg/kg		**40**	**90**	**360**	**20**	**2480**
EP004: Organic Matter									
Organic Matter	----	0.5	%		**1.1**	**0.7**	**0.5**	**2.0**	**0.8**
Total Organic Carbon	----	0.5	%		**0.6**	<0.5	<0.5	**1.1**	<0.5

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	Karra 24 (5)	Karra 24 (25)	Karra 24 (45)	Karra 24 (75)	Hughdale 25 (15)
			Client sampling date / time	[21-AUG-2014]	[21-AUG-2014]	[21-AUG-2014]	[21-AUG-2014]	[21-AUG-2014]
Compound	CAS Number	LOR	Unit	EM1408549-026	EM1408549-027	EM1408549-028	EM1408549-029	EM1408549-030
EA001: pH in soil using 0.01M CaCl extract								
pH (CaCl2)	----	0.1	pH Unit	5.6	8.2	8.6	8.4	8.1
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	63	559	2260	3090	290
EA055: Moisture Content								
Moisture Content (dried @ 103°C)	----	1.0	%	9.7	14.5	13.4	11.8	13.8
ED008: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	4.6	22.9	27.8	27.5	34.8
Exchangeable Magnesium	----	0.1	meq/100g	5.8	11.3	11.2	10.7	11.6
Exchangeable Potassium	----	0.1	meq/100g	1.1	1.1	0.6	0.5	1.5
Exchangeable Sodium	----	0.1	meq/100g	1.3	4.3	6.1	3.7	2.4
Cation Exchange Capacity	----	0.1	meq/100g	12.8	39.7	45.6	42.4	50.3
Exchangeable Sodium Percent	----	0.1	%	10.4	10.8	13.3	8.8	4.6
ED040N: Sulfate - Calcium Phosphate Soluble (NEPM)								
Sulfate as SO4 2-	14808-79-8	50	mg/kg	<50	<50	640	1290	<50
ED045G: Chloride Discrete analyser								
Chloride	16887-00-6	10	mg/kg	110	550	3520	4550	130
EP004: Organic Matter								
Organic Matter	----	0.5	%	2.6	0.7	0.7	<0.5	1.3
Total Organic Carbon	----	0.5	%	1.5	<0.5	<0.5	<0.5	0.8

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	Hughdale 25 (75)	Hughdale 32 (5)	Hughdale 32 (25)	Hughdale 32 (45)	Hughdale 32 (75)
			Client sampling date / time	[21-AUG-2014]	[21-AUG-2014]	[21-AUG-2014]	[21-AUG-2014]	[21-AUG-2014]
Compound	CAS Number	LOR	Unit	EM1408549-031	EM1408549-032	EM1408549-033	EM1408549-034	EM1408549-035
EA001: pH in soil using 0.01M CaCl extract								
pH (CaCl2)	----	0.1	pH Unit	8.6	8.4	8.6	8.4	8.5
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	1070	417	3160	5340	5390
EA055: Moisture Content								
Moisture Content (dried @ 103°C)	----	1.0	%	14.9	10.1	18.0	14.8	12.4
ED008: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	28.9	24.6	29.4	33.1	26.2
Exchangeable Magnesium	----	0.1	meq/100g	12.4	7.1	9.7	9.6	10.1
Exchangeable Potassium	----	0.1	meq/100g	1.0	1.2	1.0	0.6	0.4
Exchangeable Sodium	----	0.1	meq/100g	9.7	4.6	5.8	2.4	4.2
Cation Exchange Capacity	----	0.1	meq/100g	52.0	37.4	46.0	45.7	40.9
Exchangeable Sodium Percent	----	0.1	%	18.6	12.2	12.6	5.1	10.3
ED040N: Sulfate - Calcium Phosphate Soluble (NEPM)								
Sulfate as SO4 2-	14808-79-8	50	mg/kg	270	<50	2650	4420	2770
ED045G: Chloride Discrete analyser								
Chloride	16887-00-6	10	mg/kg	1100	260	3280	6520	7760
EP004: Organic Matter								
Organic Matter	----	0.5	%	0.7	1.1	0.5	<0.5	<0.5
Total Organic Carbon	----	0.5	%	<0.5	0.6	<0.5	<0.5	<0.5

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	Hughdale 33 (5)	Hughdale 33 (20)	Hughdale 33 (35)	Hughdale 33 (75)	Hughdale 35 (15)
			Client sampling date / time	[21-AUG-2014]	[21-AUG-2014]	[21-AUG-2014]	[21-AUG-2014]	[21-AUG-2014]
Compound	CAS Number	LOR	Unit	EM1408549-036	EM1408549-037	EM1408549-038	EM1408549-039	EM1408549-040
EA001: pH in soil using 0.01M CaCl extract								
pH (CaCl2)	----	0.1	pH Unit	6.9	7.7	8.3	8.4	7.7
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	326	171	376	1300	155
EA055: Moisture Content								
Moisture Content (dried @ 103°C)	----	1.0	%	4.0	10.0	11.3	10.8	11.0
ED008: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	6.2	16.6	28.4	26.7	19.3
Exchangeable Magnesium	----	0.1	meq/100g	2.2	8.0	10.4	11.4	4.2
Exchangeable Potassium	----	0.1	meq/100g	0.8	0.9	0.7	0.7	1.9
Exchangeable Sodium	----	0.1	meq/100g	<0.1	1.6	2.2	2.7	<0.1
Cation Exchange Capacity	----	0.1	meq/100g	9.4	27.0	41.8	41.4	25.4
Exchangeable Sodium Percent	----	0.1	%	0.6	5.8	5.4	6.5	0.2
ED040N: Sulfate - Calcium Phosphate Soluble (NEPM)								
Sulfate as SO4 2-	14808-79-8	50	mg/kg	340	<50	<50	1100	<50
ED045G: Chloride Discrete analyser								
Chloride	16887-00-6	10	mg/kg	<10	40	160	1400	20
EP004: Organic Matter								
Organic Matter	----	0.5	%	1.5	1.3	1.1	0.5	4.8
Total Organic Carbon	----	0.5	%	0.8	0.8	0.6	<0.5	2.8

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	Hughdale 35 (30)	Hughdale 35 (70)	Hughdale 35 (75)	Hughdale 37 (40)	Hughdale 37 (75)
			Client sampling date / time	[21-AUG-2014]	[21-AUG-2014]	[21-AUG-2014]	[21-AUG-2014]	[21-AUG-2014]
Compound	CAS Number	LOR	Unit	EM1408549-041	EM1408549-042	EM1408549-043	EM1408549-044	EM1408549-045
EA001: pH in soil using 0.01M CaCl extract								
pH (CaCl2)	----	0.1	pH Unit	7.8	7.9	8.0	7.0	8.0
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	142	146	155	47	88
EA055: Moisture Content								
Moisture Content (dried @ 103°C)	----	1.0	%	12.6	13.7	13.3	4.8	6.0
ED008: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	14.0	27.9	32.3	31.5	32.2
Exchangeable Magnesium	----	0.1	meq/100g	13.1	13.0	12.1	2.7	2.8
Exchangeable Potassium	----	0.1	meq/100g	0.6	0.5	0.5	1.0	0.3
Exchangeable Sodium	----	0.1	meq/100g	3.5	3.8	2.4	<0.1	<0.1
Cation Exchange Capacity	----	0.1	meq/100g	31.3	45.2	47.3	35.2	35.3
Exchangeable Sodium Percent	----	0.1	%	11.2	8.3	5.0	<0.1	<0.1
ED040N: Sulfate - Calcium Phosphate Soluble (NEPM)								
Sulfate as SO4 2-	14808-79-8	50	mg/kg	<50	<50	<50	<50	<50
ED045G: Chloride Discrete analyser								
Chloride	16887-00-6	10	mg/kg	30	30	20	40	20
EP004: Organic Matter								
Organic Matter	----	0.5	%	1.4	0.9	0.7	<0.5	<0.5
Total Organic Carbon	----	0.5	%	0.8	0.5	<0.5	<0.5	<0.5

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	Hughdale 38 (5)	Hughdale 38 (25)	Hughdale 38 (50)	Hughdale 38 (75)	Hughdale 44 (5)
				Client sampling date / time	[21-AUG-2014]	[21-AUG-2014]	[21-AUG-2014]	[21-AUG-2014]	[21-AUG-2014]
Compound	CAS Number	LOR	Unit		EM1408549-046	EM1408549-047	EM1408549-048	EM1408549-049	EM1408549-050
EA001: pH in soil using 0.01M CaCl extract									
pH (CaCl2)	----	0.1	pH Unit		6.8	7.9	8.4	8.5	6.6
EA010: Conductivity									
Electrical Conductivity @ 25°C	----	1	µS/cm		57	166	464	1150	42
EA055: Moisture Content									
Moisture Content (dried @ 103°C)	----	1.0	%		6.0	14.7	12.0	12.4	4.2
ED008: Exchangeable Cations									
Exchangeable Calcium	----	0.1	meq/100g		28.2	6.8	13.0	27.9	30.1
Exchangeable Magnesium	----	0.1	meq/100g		6.1	7.3	12.5	13.8	1.9
Exchangeable Potassium	----	0.1	meq/100g		0.3	2.0	1.4	0.9	1.0
Exchangeable Sodium	----	0.1	meq/100g		0.4	2.7	6.3	4.6	<0.1
Cation Exchange Capacity	----	0.1	meq/100g		35.0	18.8	33.2	47.2	33.0
Exchangeable Sodium Percent	----	0.1	%		1.2	14.4	18.9	9.7	<0.1
ED040N: Sulfate - Calcium Phosphate Soluble (NEPM)									
Sulfate as SO4 2-	14808-79-8	50	mg/kg		<50	<50	<50	630	<50
ED045G: Chloride Discrete analyser									
Chloride	16887-00-6	10	mg/kg		30	50	240	1050	40
EP004: Organic Matter									
Organic Matter	----	0.5	%		1.6	1.3	0.8	1.0	1.6
Total Organic Carbon	----	0.5	%		1.0	0.7	<0.5	0.6	1.0

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	Hughdale 44 (25)	Hughdale 44 (40)	Hughdale 44 (75)	Hughdale 46 (10)	Hughdale 46 (35)
				Client sampling date / time	[21-AUG-2014]	[21-AUG-2014]	[21-AUG-2014]	[21-AUG-2014]	[21-AUG-2014]
Compound	CAS Number	LOR	Unit		EM1408549-051	EM1408549-052	EM1408549-053	EM1408549-054	EM1408549-055
EA001: pH in soil using 0.01M CaCl extract									
pH (CaCl2)	----	0.1	pH Unit		8.2	8.5	8.4	7.8	8.4
EA010: Conductivity									
Electrical Conductivity @ 25°C	----	1	µS/cm		605	1430	2000	107	488
EA055: Moisture Content									
Moisture Content (dried @ 103°C)	----	1.0	%		14.0	12.6	12.8	6.0	9.8
ED008: Exchangeable Cations									
Exchangeable Calcium	----	0.1	meq/100g		28.9	28.0	27.2	22.7	30.4
Exchangeable Magnesium	----	0.1	meq/100g		3.1	5.3	7.5	6.3	9.2
Exchangeable Potassium	----	0.1	meq/100g		0.8	0.5	0.4	1.1	1.0
Exchangeable Sodium	----	0.1	meq/100g		<0.1	0.4	1.8	1.0	6.0
Cation Exchange Capacity	----	0.1	meq/100g		32.8	34.2	36.8	31.1	46.7
Exchangeable Sodium Percent	----	0.1	%		0.1	1.1	4.8	3.1	12.8
ED040N: Sulfate - Calcium Phosphate Soluble (NEPM)									
Sulfate as SO4 2-	14808-79-8	50	mg/kg		100	710	1190	<50	<50
ED045G: Chloride Discrete analyser									
Chloride	16887-00-6	10	mg/kg		540	1750	2490	10	270
EP004: Organic Matter									
Organic Matter	----	0.5	%		1.0	0.7	0.7	1.0	1.4
Total Organic Carbon	----	0.5	%		0.6	<0.5	<0.5	0.6	0.8

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	Hughdale 46 (75)	Hughdale 56 (10)	Hughdale 56 (45)	Hughdale 56 (75)	Hughdale 57 (15)
			Client sampling date / time	[21-AUG-2014]	[21-AUG-2014]	[21-AUG-2014]	[21-AUG-2014]	[21-AUG-2014]
Compound	CAS Number	LOR	Unit	EM1408549-056	EM1408549-057	EM1408549-058	EM1408549-059	EM1408549-060
EA001: pH in soil using 0.01M CaCl extract								
pH (CaCl2)	----	0.1	pH Unit	8.6	8.3	6.1	8.3	8.0
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	1670	583	27	732	138
EA055: Moisture Content								
Moisture Content (dried @ 103°C)	----	1.0	%	12.9	12.7	3.1	6.3	10.1
ED008: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	30.8	30.0	30.3	29.4	24.7
Exchangeable Magnesium	----	0.1	meq/100g	9.5	2.6	2.7	5.9	11.0
Exchangeable Potassium	----	0.1	meq/100g	0.6	0.8	0.6	0.2	0.4
Exchangeable Sodium	----	0.1	meq/100g	4.8	<0.1	<0.1	0.4	3.4
Cation Exchange Capacity	----	0.1	meq/100g	45.7	33.4	33.7	35.8	39.5
Exchangeable Sodium Percent	----	0.1	%	10.6	0.1	0.2	1.0	8.7
ED040N: Sulfate - Calcium Phosphate Soluble (NEPM)								
Sulfate as SO4 2-	14808-79-8	50	mg/kg	1080	150	<50	190	<50
ED045G: Chloride Discrete analyser								
Chloride	16887-00-6	10	mg/kg	1780	420	10	780	10
EP004: Organic Matter								
Organic Matter	----	0.5	%	1.0	<0.5	0.7	1.1	1.5
Total Organic Carbon	----	0.5	%	0.6	<0.5	<0.5	0.6	0.9

Analytical Results

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

Compound	CAS Number	LOR	Unit	Client sample ID	Hughdale 57 (40)	Hughdale 57 (75)	Hughdale 69 (20)	Hughdale 69 (75)	Hughdale 70 (15)
				Client sampling date / time	[21-AUG-2014]	[21-AUG-2014]	[21-AUG-2014]	[21-AUG-2014]	[21-AUG-2014]
					EM1408549-061	EM1408549-062	EM1408549-063	EM1408549-064	EM1408549-065
EA001: pH in soil using 0.01M CaCl extract									
pH (CaCl2)	----	0.1	pH Unit		8.3	8.6	6.5	8.2	6.7
EA010: Conductivity									
Electrical Conductivity @ 25°C	----	1	µS/cm		422	1460	16	644	17
EA055: Moisture Content									
Moisture Content (dried @ 103°C)	----	1.0	%		13.5	14.3	1.6	5.6	1.5
ED008: Exchangeable Cations									
Exchangeable Calcium	----	0.1	meq/100g		11.8	30.4	28.6	33.5	29.4
Exchangeable Magnesium	----	0.1	meq/100g		4.3	8.9	11.2	8.0	12.3
Exchangeable Potassium	----	0.1	meq/100g		1.4	1.2	0.7	1.8	0.6
Exchangeable Sodium	----	0.1	meq/100g		0.3	1.0	2.7	0.4	5.1
Cation Exchange Capacity	----	0.1	meq/100g		17.8	41.5	43.2	43.7	47.5
Exchangeable Sodium Percent	----	0.1	%		1.5	2.5	6.2	0.8	10.8
ED040N: Sulfate - Calcium Phosphate Soluble (NEPM)									
Sulfate as SO4 2-	14808-79-8	50	mg/kg		<50	1160	<50	240	<50
ED045G: Chloride Discrete analyser									
Chloride	16887-00-6	10	mg/kg		240	1670	<10	510	<10
EP004: Organic Matter									
Organic Matter	----	0.5	%		0.8	<0.5	<0.5	<0.5	<0.5
Total Organic Carbon	----	0.5	%		<0.5	<0.5	<0.5	<0.5	<0.5

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	Hughdale 70 (45)	Hughdale 70 (75)	Pine Lodge 85 (15)	Pine Lodge 85 (50)	Pine Lodge 85 (75)
				Client sampling date / time	[21-AUG-2014]	[21-AUG-2014]	[21-AUG-2014]	[21-AUG-2014]	[21-AUG-2014]
Compound	CAS Number	LOR	Unit		EM1408549-066	EM1408549-067	EM1408549-068	EM1408549-069	EM1408549-070
EA001: pH in soil using 0.01M CaCl extract									
pH (CaCl2)	----	0.1	pH Unit		7.8	8.1	7.3	8.3	8.4
EA010: Conductivity									
Electrical Conductivity @ 25°C	----	1	µS/cm		95	131	40	1030	1070
EA055: Moisture Content									
Moisture Content (dried @ 103°C)	----	1.0	%		2.8	6.0	2.5	8.5	6.6
ED008: Exchangeable Cations									
Exchangeable Calcium	----	0.1	meq/100g		4.7	24.7	29.4	28.3	36.4
Exchangeable Magnesium	----	0.1	meq/100g		5.8	11.5	11.3	10.9	11.7
Exchangeable Potassium	----	0.1	meq/100g		1.1	1.2	0.6	0.5	1.5
Exchangeable Sodium	----	0.1	meq/100g		1.3	4.2	6.3	3.7	2.3
Cation Exchange Capacity	----	0.1	meq/100g		13.0	41.5	47.6	43.4	51.9
Exchangeable Sodium Percent	----	0.1	%		9.9	10.0	13.2	8.5	4.4
ED040N: Sulfate - Calcium Phosphate Soluble (NEPM)									
Sulfate as SO4 2-	14808-79-8	50	mg/kg		<50	<50	<50	280	430
ED045G: Chloride Discrete analyser									
Chloride	16887-00-6	10	mg/kg		30	10	20	1210	1280
EP004: Organic Matter									
Organic Matter	----	0.5	%		<0.5	<0.5	0.7	<0.5	<0.5
Total Organic Carbon	----	0.5	%		<0.5	<0.5	<0.5	<0.5	<0.5

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	Illuka 101 (40)	Illuka 101 (75)	Wompo 7 (20)	Wompo 7 (35)	Wompo 7 (75)
			Client sampling date / time	[21-AUG-2014]	[21-AUG-2014]	[21-AUG-2014]	[21-AUG-2014]	[21-AUG-2014]
Compound	CAS Number	LOR	Unit	EM1408549-071	EM1408549-072	EM1408549-073	EM1408549-074	EM1408549-075
EA001: pH in soil using 0.01M CaCl extract								
pH (CaCl2)	----	0.1	pH Unit	7.7	8.5	6.0	7.9	8.3
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	102	947	38	240	640
EA055: Moisture Content								
Moisture Content (dried @ 103°C)	----	1.0	%	4.7	8.7	1.8	5.2	7.0
ED008: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	30.3	26.2	32.0	35.4	28.0
Exchangeable Magnesium	----	0.1	meq/100g	12.6	7.2	9.9	10.4	10.8
Exchangeable Potassium	----	0.1	meq/100g	1.1	1.2	1.0	0.7	0.5
Exchangeable Sodium	----	0.1	meq/100g	9.2	4.4	5.9	2.5	4.3
Cation Exchange Capacity	----	0.1	meq/100g	53.2	39.0	48.9	49.1	43.6
Exchangeable Sodium Percent	----	0.1	%	17.2	11.2	12.1	5.1	9.9
ED040N: Sulfate - Calcium Phosphate Soluble (NEPM)								
Sulfate as SO4 2-	14808-79-8	50	mg/kg	<50	340	<50	<50	310
ED045G: Chloride Discrete analyser								
Chloride	16887-00-6	10	mg/kg	120	910	30	<50	440
EP004: Organic Matter								
Organic Matter	----	0.5	%	<0.5	<0.5	<0.5	<0.5	<0.5
Total Organic Carbon	----	0.5	%	<0.5	<0.5	<0.5	<0.5	<0.5

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	Wompo 8 (10)	Wompo 8 (30)	Wompo 8 (75)	Wintong 24 (10)	Wintong 24 (55)
			Client sampling date / time	[21-AUG-2014]	[21-AUG-2014]	[21-AUG-2014]	[21-AUG-2014]	[21-AUG-2014]
Compound	CAS Number	LOR	Unit	EM1408549-076	EM1408549-077	EM1408549-078	EM1408549-079	EM1408549-080
EA001: pH in soil using 0.01M CaCl extract								
pH (CaCl2)	----	0.1	pH Unit	5.7	7.7	8.4	6.9	8.0
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	12	297	638	67	85
EA055: Moisture Content								
Moisture Content (dried @ 103°C)	----	1.0	%	1.9	6.2	6.0	1.4	1.7
ED008: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	6.7	18.1	30.1	28.5	21.5
Exchangeable Magnesium	----	0.1	meq/100g	2.3	8.3	11.0	12.1	4.5
Exchangeable Potassium	----	0.1	meq/100g	0.9	1.0	0.8	0.8	2.0
Exchangeable Sodium	----	0.1	meq/100g	<0.1	1.6	2.3	2.8	<0.1
Cation Exchange Capacity	----	0.1	meq/100g	10.0	28.9	44.2	44.2	28.2
Exchangeable Sodium Percent	----	0.1	%	0.6	5.5	5.2	6.4	0.3
ED040N: Sulfate - Calcium Phosphate Soluble (NEPM)								
Sulfate as SO4 2-	14808-79-8	50	mg/kg	<50	60	120	<50	<50
ED045G: Chloride Discrete analyser								
Chloride	16887-00-6	10	mg/kg	<10	110	470	<10	10
EP004: Organic Matter								
Organic Matter	----	0.5	%	<0.5	<0.5	<0.5	0.5	<0.5
Total Organic Carbon	----	0.5	%	<0.5	<0.5	<0.5	<0.5	<0.5

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	Wintong 24 (75)	Wintong 31 (15)	Wintong 31 (30)	Wintong 31 (75)	Wompo 43 (5)
				Client sampling date / time	[21-AUG-2014]	[21-AUG-2014]	[21-AUG-2014]	[21-AUG-2014]	[21-AUG-2014]
Compound	CAS Number	LOR	Unit		EM1408549-081	EM1408549-082	EM1408549-083	EM1408549-084	EM1408549-085
EA001: pH in soil using 0.01M CaCl extract									
pH (CaCl2)	----	0.1	pH Unit		8.1	6.5	8.0	8.5	7.2
EA010: Conductivity									
Electrical Conductivity @ 25°C	----	1	µS/cm		86	17	218	674	155
EA055: Moisture Content									
Moisture Content (dried @ 103°C)	----	1.0	%		2.1	1.4	3.6	5.7	1.4
ED008: Exchangeable Cations									
Exchangeable Calcium	----	0.1	meq/100g		15.8	3.7	12.4	26.6	9.0
Exchangeable Magnesium	----	0.1	meq/100g		1.6	1.2	3.2	4.8	2.2
Exchangeable Potassium	----	0.1	meq/100g		0.3	0.5	0.7	0.8	0.5
Exchangeable Sodium	----	0.1	meq/100g		<0.1	<0.1	0.8	1.4	0.3
Cation Exchange Capacity	----	0.1	meq/100g		17.7	5.4	17.2	33.6	12.0
Exchangeable Sodium Percent	----	0.1	%		<0.1	<0.1	4.9	4.0	2.8
ED040N: Sulfate - Calcium Phosphate Soluble (NEPM)									
Sulfate as SO4 2-	14808-79-8	50	mg/kg		<50	<50	<50	260	<50
ED045G: Chloride Discrete analyser									
Chloride	16887-00-6	10	mg/kg		10	20	100	380	50
EP004: Organic Matter									
Organic Matter	----	0.5	%		<0.5	0.7	<0.5	<0.5	0.8
Total Organic Carbon	----	0.5	%		<0.5	<0.5	<0.5	<0.5	<0.5

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	Wompo 43 (20)	Wompo 43 (35)	Wompo 43 (75)	Wompo 47 (20)	Wompo 47 (35)
			Client sampling date / time	[21-AUG-2014]	[21-AUG-2014]	[21-AUG-2014]	[21-AUG-2014]	[21-AUG-2014]
Compound	CAS Number	LOR	Unit	EM1408549-086	EM1408549-087	EM1408549-088	EM1408549-089	EM1408549-090
EA001: pH in soil using 0.01M CaCl extract								
pH (CaCl2)	----	0.1	pH Unit	8.0	8.4	8.4	8.0	8.3
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	659	831	1010	82	388
EA055: Moisture Content								
Moisture Content (dried @ 103°C)	----	1.0	%	4.6	6.1	7.2	3.5	4.7
ED008: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	21.5	27.2	27.3	28.7	28.2
Exchangeable Magnesium	----	0.1	meq/100g	3.6	4.2	5.5	1.4	3.5
Exchangeable Potassium	----	0.1	meq/100g	0.6	0.6	0.8	0.8	1.1
Exchangeable Sodium	----	0.1	meq/100g	1.4	1.6	2.2	<0.1	0.6
Cation Exchange Capacity	----	0.1	meq/100g	27.1	33.7	35.9	31.0	33.4
Exchangeable Sodium Percent	----	0.1	%	5.3	4.7	6.2	<0.1	1.7
ED040N: Sulfate - Calcium Phosphate Soluble (NEPM)								
Sulfate as SO4 2-	14808-79-8	50	mg/kg	180	500	550	<50	<50
ED045G: Chloride Discrete analyser								
Chloride	16887-00-6	10	mg/kg	470	640	850	10	290
EP004: Organic Matter								
Organic Matter	----	0.5	%	<0.5	0.5	0.5	1.3	0.7
Total Organic Carbon	----	0.5	%	<0.5	<0.5	<0.5	0.7	<0.5

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	Wompo 47 (75)	Wompo 49 (15)	Wompo 49 (40)	Wompo 49 (75)	----
			Client sampling date / time	[21-AUG-2014]	[21-AUG-2014]	[21-AUG-2014]	[21-AUG-2014]	----
Compound	CAS Number	LOR	Unit	EM1408549-091	EM1408549-092	EM1408549-093	EM1408549-094	----
EA001: pH in soil using 0.01M CaCl extract								
pH (CaCl2)	----	0.1	pH Unit	8.5	8.0	8.2	8.5	----
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	986	103	335	1500	----
EA055: Moisture Content								
Moisture Content (dried @ 103°C)	----	1.0	%	6.1	5.9	8.1	5.1	----
ED008: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	28.1	32.6	30.0	25.3	----
Exchangeable Magnesium	----	0.1	meq/100g	4.7	4.1	8.8	7.5	----
Exchangeable Potassium	----	0.1	meq/100g	1.3	1.0	0.3	0.3	----
Exchangeable Sodium	----	0.1	meq/100g	1.0	<0.1	1.7	1.7	----
Cation Exchange Capacity	----	0.1	meq/100g	35.2	37.6	40.8	34.8	----
Exchangeable Sodium Percent	----	0.1	%	2.8	<0.1	4.1	4.9	----
ED040N: Sulfate - Calcium Phosphate Soluble (NEPM)								
Sulfate as SO4 2-	14808-79-8	50	mg/kg	340	<50	<50	250	----
ED045G: Chloride Discrete analyser								
Chloride	16887-00-6	10	mg/kg	1070	<10	150	580	----
EP004: Organic Matter								
Organic Matter	----	0.5	%	<0.5	1.4	0.8	<0.5	----
Total Organic Carbon	----	0.5	%	<0.5	0.8	<0.5	<0.5	----

CERTIFICATE OF ANALYSIS

Work Order	: **EM1408597**	Page	: 1 of 9
Client	: **EMGA MITCHELL MCLENNAN**	Laboratory	: Environmental Division Melbourne
Contact	: MR TIMOTHY ROHDE	Contact	: Client Services
Address	: 1/4 87 WICKHAM TERRACE SPRING HILL QLD 4000	Address	: 4 Westall Rd Springvale VIC Australia 3171
E-mail	: trohde@emgamm.com	E-mail	: Melbourne.Enviro.Services@alsglobal.com
Telephone	: 07 3839 1800	Telephone	: +61-3-8549 9600
Facsimile	: 07 3839 1866	Facsimile	: +61-3-8549 9601
Project	: Balranald (J12011)	QC Level	: NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Order number	: ----		
C-O-C number	: ----	Date Samples Received	: 22-AUG-2014
Sampler	: KL	Issue Date	: 10-SEP-2014
Site	: ----		
		No. of samples received	: 35
Quote number	: BNBQ/083/14	No. of samples analysed	: 35

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

NATA Accredited Laboratory 825

Accredited for compliance with ISO/IEC 17025.

Signatories

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

Signatories	*Position*	*Accreditation Category*
Hamish Murray	Supervisor - Soils	Newcastle - Inorganics

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

- **PSD (EA150H/EA152) conducted by ALS Newcastle, NATA accreditation no. 825, site no 1656.**
- **This is a split batch with EM1408549 due to the longer turnaround required for PSD analysis.**

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	Karra 10 (5)	Karra 10 (25)	Karra 10 (75)	Karra 14 (5)	Karra 14 (25)
			Client sampling date / time	[21-AUG-2014]	[21-AUG-2014]	[21-AUG-2014]	[21-AUG-2014]	[21-AUG-2014]
Compound	CAS Number	LOR	Unit	EM1408597-001	EM1408597-002	EM1408597-003	EM1408597-004	EM1408597-005
EA150: Particle Sizing								
+75µm	----	1	%	40	26	26	45	45
+150µm	----	1	%	18	13	14	25	27
+300µm	----	1	%	4	4	5	11	15
+425µm	----	1	%	2	1	2	9	14
+600µm	----	1	%	<1	<1	<1	7	12
+1180µm	----	1	%	<1	<1	<1	6	12
+2.36mm	----	1	%	<1	<1	<1	4	10
+4.75mm	----	1	%	<1	<1	<1	2	8
+9.5mm	----	1	%	<1	<1	<1	<1	3
+19.0mm	----	1	%	<1	<1	<1	<1	<1
+37.5mm	----	1	%	<1	<1	<1	<1	<1
+75.0mm	----	1	%	<1	<1	<1	<1	<1
EA150: Soil Classification based on Particle Size								
Clay (<2 µm)	----	1	%	23	32	18	16	18
Silt (2-60 µm)	----	1	%	34	39	52	37	30
Sand (0.06-2.00 mm)	----	1	%	43	29	30	43	42
Gravel (>2mm)	----	1	%	<1	<1	<1	4	10
Cobbles (>6cm)	----	1	%	<1	<1	<1	<1	<1
EA152: Soil Particle Density								
Soil Particle Density (Clay/Silt/Sand)	----	0.01	g/cm3	2.67	2.60	2.75	2.54	2.61

Analytical Results

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

Compound	CAS Number	LOR	Unit	Client sample ID	Karra 14 (45)	Karra 14 (75)	Tin Tin 15 (15)	Tin Tin 15 (30)	Tin Tin 15 (75)
				Client sampling date / time	[21-AUG-2014]	[21-AUG-2014]	[21-AUG-2014]	[21-AUG-2014]	[21-AUG-2014]
					EM1408597-006	EM1408597-007	EM1408597-008	EM1408597-009	EM1408597-010
EA150: Particle Sizing									
+75µm	----	1	%		40	35	50	40	26
+150µm	----	1	%		23	17	29	23	14
+300µm	----	1	%		14	6	9	8	4
+425µm	----	1	%		12	4	3	3	2
+600µm	----	1	%		11	2	1	2	<1
+1180µm	----	1	%		10	1	<1	<1	<1
+2.36mm	----	1	%		8	<1	<1	<1	<1
+4.75mm	----	1	%		5	<1	<1	<1	<1
+9.5mm	----	1	%		2	<1	<1	<1	<1
+19.0mm	----	1	%		<1	<1	<1	<1	<1
+37.5mm	----	1	%		<1	<1	<1	<1	<1
+75.0mm	----	1	%		<1	<1	<1	<1	<1
EA150: Soil Classification based on Particle Size									
Clay (<2 µm)	----	1	%		17	9	21	29	45
Silt (2-60 µm)	----	1	%		38	52	24	30	27
Sand (0.06-2.00 mm)	----	1	%		37	39	55	40	28
Gravel (>2mm)	----	1	%		8	<1	<1	1	<1
Cobbles (>6cm)	----	1	%		<1	<1	<1	<1	<1
EA152: Soil Particle Density									
Soil Particle Density (Clay/Silt/Sand)	----	0.01	g/cm3		2.68	2.72	2.66	2.71	2.71

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	Hughdale 25 (15)	Hughdale 25 (75)	Hughdale 35 (15)	Hughdale 35 (30)	Hughdale 35 (70)
			Client sampling date / time	[21-AUG-2014]	[21-AUG-2014]	[21-AUG-2014]	[21-AUG-2014]	[21-AUG-2014]
Compound	CAS Number	LOR	Unit	EM1408597-011	EM1408597-012	EM1408597-013	EM1408597-014	EM1408597-015
EA150: Particle Sizing								
+75µm	----	1	%	34	18	26	27	23
+150µm	----	1	%	24	9	13	17	14
+300µm	----	1	%	11	3	5	5	4
+425µm	----	1	%	6	1	3	2	2
+600µm	----	1	%	4	<1	2	<1	<1
+1180µm	----	1	%	2	<1	<1	<1	<1
+2.36mm	----	1	%	<1	<1	<1	<1	<1
+4.75mm	----	1	%	<1	<1	<1	<1	<1
+9.5mm	----	1	%	<1	<1	<1	<1	<1
+19.0mm	----	1	%	<1	<1	<1	<1	<1
+37.5mm	----	1	%	<1	<1	<1	<1	<1
+75.0mm	----	1	%	<1	<1	<1	<1	<1
EA150: Soil Classification based on Particle Size								
Clay (<2 µm)	----	1	%	30	32	33	43	41
Silt (2-60 µm)	----	1	%	33	48	42	29	34
Sand (0.06-2.00 mm)	----	1	%	36	20	25	28	25
Gravel (>2mm)	----	1	%	1	<1	<1	<1	<1
Cobbles (>6cm)	----	1	%	<1	<1	<1	<1	<1
EA152: Soil Particle Density								
Soil Particle Density (Clay/Silt/Sand)	----	0.01	g/cm3	2.70	2.75	2.53	2.68	2.71

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	Hughdale 35 (75)	Hughdale 44 (5)	Hughdale 44 (25)	Hughdale 44 (40)	Hughdale 44 (75)
				Client sampling date / time	[21-AUG-2014]	[21-AUG-2014]	[21-AUG-2014]	[21-AUG-2014]	[21-AUG-2014]
Compound	CAS Number	LOR	Unit		EM1408597-016	EM1408597-017	EM1408597-018	EM1408597-019	EM1408597-020
EA150: Particle Sizing									
+75µm	----	1	%		17	52	30	22	23
+150µm	----	1	%		10	28	15	12	12
+300µm	----	1	%		3	8	4	3	4
+425µm	----	1	%		1	4	2	1	2
+600µm	----	1	%		<1	1	<1	<1	<1
+1180µm	----	1	%		<1	<1	<1	<1	<1
+2.36mm	----	1	%		<1	<1	<1	<1	<1
+4.75mm	----	1	%		<1	<1	<1	<1	<1
+9.5mm	----	1	%		<1	<1	<1	<1	<1
+19.0mm	----	1	%		<1	<1	<1	<1	<1
+37.5mm	----	1	%		<1	<1	<1	<1	<1
+75.0mm	----	1	%		<1	<1	<1	<1	<1
EA150: Soil Classification based on Particle Size									
Clay (<2 µm)	----	1	%		30	14	21	32	31
Silt (2-60 µm)	----	1	%		53	31	44	45	44
Sand (0.06-2.00 mm)	----	1	%		17	55	35	23	25
Gravel (>2mm)	----	1	%		<1	<1	<1	<1	<1
Cobbles (>6cm)	----	1	%		<1	<1	<1	<1	<1
EA152: Soil Particle Density									
Soil Particle Density (Clay/Silt/Sand)	----	0.01	g/cm3		2.70	2.60	2.62	2.68	2.71

Analytical Results

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

Compound	CAS Number	LOR	Unit	Client sample ID	Hughdale 46 (10)	Hughdale 46 (35)	Hughdale 46 (75)	Hughdale 69 (20)	Hughdale 69 (75)
				Client sampling date / time	[21-AUG-2014]	[21-AUG-2014]	[21-AUG-2014]	[21-AUG-2014]	[21-AUG-2014]
					EM1408597-021	EM1408597-022	EM1408597-023	EM1408597-024	EM1408597-025
EA150: Particle Sizing									
+75µm	----	1	%		**55**	**35**	**29**	**90**	**76**
+150µm	----	1	%		**31**	**20**	**16**	**65**	**56**
+300µm	----	1	%		**12**	**8**	**7**	**17**	**15**
+425µm	----	1	%		**6**	**4**	**4**	**3**	**2**
+600µm	----	1	%		**2**	**1**	**1**	<1	<1
+1180µm	----	1	%		<1	<1	<1	<1	<1
+2.36mm	----	1	%		<1	<1	<1	<1	<1
+4.75mm	----	1	%		<1	<1	<1	<1	<1
+9.5mm	----	1	%		<1	<1	<1	<1	<1
+19.0mm	----	1	%		<1	<1	<1	<1	<1
+37.5mm	----	1	%		<1	<1	<1	<1	<1
+75.0mm	----	1	%		<1	<1	<1	<1	<1
EA150: Soil Classification based on Particle Size									
Clay (<2 µm)	----	1	%		**13**	**29**	**33**	**6**	**11**
Silt (2-60 µm)	----	1	%		**27**	**35**	**34**	**3**	**11**
Sand (0.06-2.00 mm)	----	1	%		**60**	**36**	**33**	**91**	**78**
Gravel (>2mm)	----	1	%		<1	<1	<1	<1	<1
Cobbles (>6cm)	----	1	%		<1	<1	<1	<1	<1
EA152: Soil Particle Density									
Soil Particle Density (Clay/Silt/Sand)	----	0.01	g/cm3		**2.63**	**2.65**	**2.69**	**2.64**	**2.65**

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	Wompo 7 (20)	Wompo 7 (35)	Wompo 7 (75)	Wintong 31 (15)	Wintong 31 (30)
			Client sampling date / time	[21-AUG-2014]	[21-AUG-2014]	[21-AUG-2014]	[21-AUG-2014]	[21-AUG-2014]
Compound	CAS Number	LOR	Unit	EM1408597-026	EM1408597-027	EM1408597-028	EM1408597-029	EM1408597-030
EA150: Particle Sizing								
+75µm	----	1	%	78	72	70	83	75
+150µm	----	1	%	59	56	56	59	55
+300µm	----	1	%	25	25	25	22	21
+425µm	----	1	%	11	11	10	6	6
+600µm	----	1	%	4	4	2	1	1
+1180µm	----	1	%	<1	<1	<1	<1	<1
+2.36mm	----	1	%	<1	<1	<1	<1	<1
+4.75mm	----	1	%	<1	<1	<1	<1	<1
+9.5mm	----	1	%	<1	<1	<1	<1	<1
+19.0mm	----	1	%	<1	<1	<1	<1	<1
+37.5mm	----	1	%	<1	<1	<1	<1	<1
+75.0mm	----	1	%	<1	<1	<1	<1	<1
EA150: Soil Classification based on Particle Size								
Clay (<2 µm)	----	1	%	10	13	19	10	10
Silt (2-60 µm)	----	1	%	9	14	9	5	10
Sand (0.06-2.00 mm)	----	1	%	81	73	72	85	80
Gravel (>2mm)	----	1	%	<1	<1	<1	<1	<1
Cobbles (>6cm)	----	1	%	<1	<1	<1	<1	<1
EA152: Soil Particle Density								
Soil Particle Density (Clay/Silt/Sand)	----	0.01	g/cm3	2.65	2.66	2.66	2.64	2.60

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	Wintong 31 (75)	Wompo 43 (5)	Wompo 43 (20)	Wompo 43 (35)	Wompo 43 (75)
			Client sampling date / time	[21-AUG-2014]	[21-AUG-2014]	[21-AUG-2014]	[21-AUG-2014]	[21-AUG-2014]
Compound	CAS Number	LOR	Unit	EM1408597-031	EM1408597-032	EM1408597-033	EM1408597-034	EM1408597-035
EA150: Particle Sizing								
+75µm	----	1	%	66	81	72	67	68
+150µm	----	1	%	49	64	53	49	53
+300µm	----	1	%	20	25	19	18	25
+425µm	----	1	%	7	8	6	6	12
+600µm	----	1	%	3	2	1	2	8
+1180µm	----	1	%	1	<1	<1	<1	6
+2.36mm	----	1	%	<1	<1	<1	<1	6
+4.75mm	----	1	%	<1	<1	<1	<1	5
+9.5mm	----	1	%	<1	<1	<1	<1	4
+19.0mm	----	1	%	<1	<1	<1	<1	<1
+37.5mm	----	1	%	<1	<1	<1	<1	<1
+75.0mm	----	1	%	<1	<1	<1	<1	<1
EA150: Soil Classification based on Particle Size								
Clay (<2 µm)	----	1	%	18	11	14	18	20
Silt (2-60 µm)	----	1	%	12	6	11	13	9
Sand (0.06-2.00 mm)	----	1	%	69	83	75	69	65
Gravel (>2mm)	----	1	%	1	<1	<1	<1	6
Cobbles (>6cm)	----	1	%	<1	<1	<1	<1	<1
EA152: Soil Particle Density								
Soil Particle Density (Clay/Silt/Sand)	----	0.01	g/cm3	2.66	2.60	2.61	2.63	2.66

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