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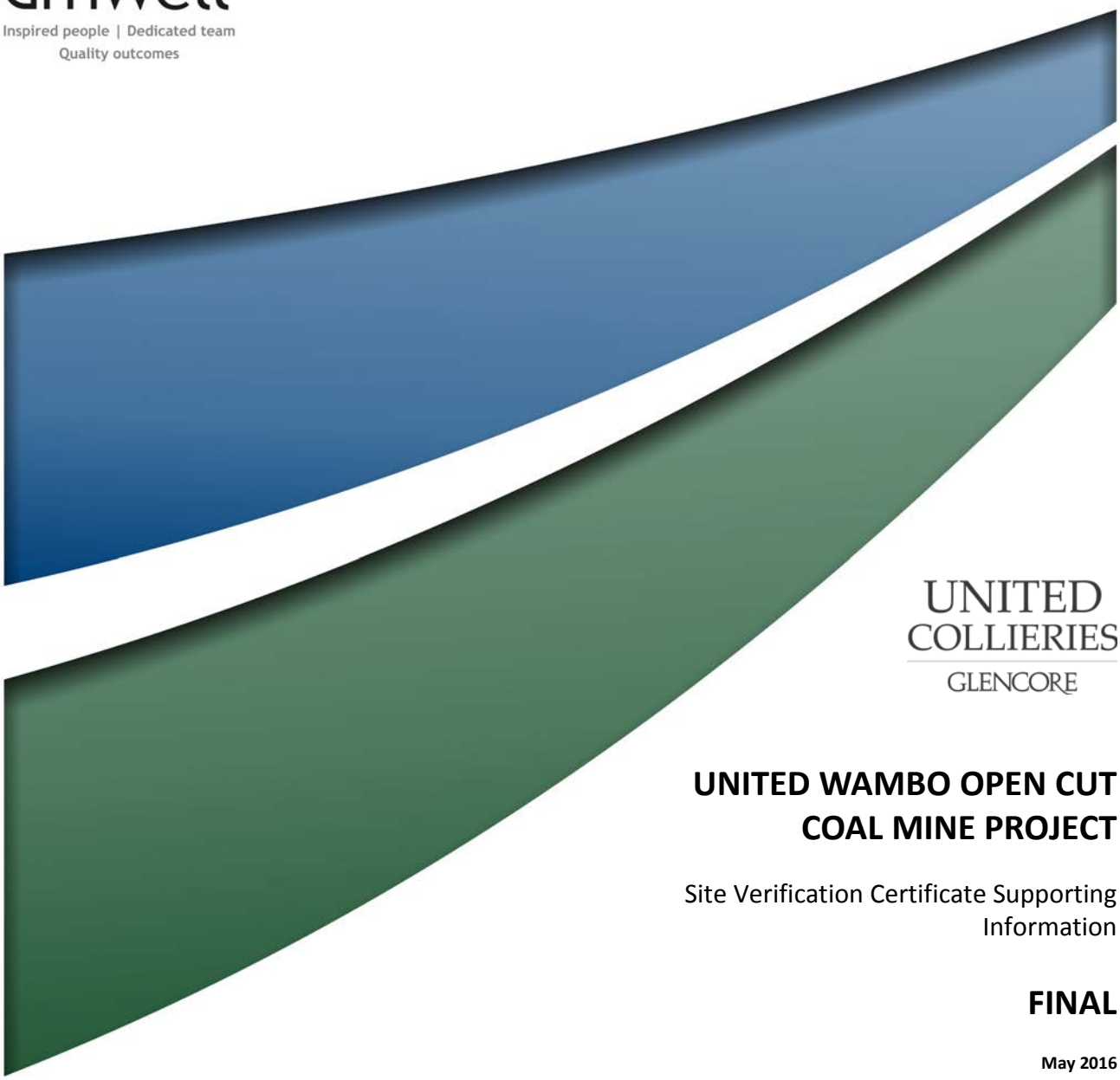

UNITED COLLIERIES
GLENCORE

# UNITED WAMBO OPEN CUT COAL MINE PROJECT

Site Verification Certificate Supporting Information

**FINAL**

**May 2016**

UNITED COLLIERIES
GLENCORE

# UNITED WAMBO OPEN CUT COAL MINE PROJECT

Site Verification Certificate Supporting Information

## FINAL


Prepared by
Umwelt (Australia) Pty Limited
on behalf of
United Collieries Pty Limited


| | |
|---|---|
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| Report No. | 3509/R01/V3 |
| Date: | May 2016 |


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# Executive Summary

This detailed assessment and verification of soil types in the proposed United Wambo Open Cut Coal Mine Project Area has been completed to determine whether or not any Biophysical Strategic Agricultural land (BSAL) is present within the area over which a new mining lease application is required.

The assessment has been conducted in accordance with the requirements of the *Interim Protocol for Site Verification and Mapping of Biophysical Strategic Agricultural land* (NSW Government 2013).

A small area of BSAL (14.7 ha) is mapped at the regional scale in the north-west corner of the Project Area. This area is covered by surface mining lease ML1572. A new subsurface mining lease is required for an area within the Project Area to allow for mining of deeper coal seams. Considering the areas requiring new mining leases and relevant exclusions in accordance with the Protocol, the outcomes of the detailed investigations, the assessment shows that no BSAL exists in the proposed Mining Lease Application Area.

A verification certificate should be provided in accordance with the Mining SEPP.

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# Tables



# Appendices

# 1.0 Introduction

The United and Wambo mines are neighbouring mining operations located approximately 16 kilometres (km) west of Singleton in the Hunter Valley region of New South Wales (NSW) (refer to **Figure 1.1**). United Collieries Pty Limited (United) the operator of United mine and Wambo Coal Pty Limited (Wambo) the operator of Wambo mine, have formed a Joint Venture which includes the proposed development of the United Wambo Open Cut Coal Mine Project (the Project).

The Project proposes open cut coal mining for a period of 23 years, with mining in a new open cut mine at United (the United Open Cut) combined with ongoing mining at the existing, approved Wambo Open Cut under a modified mine plan. The Project will optimise future mining operations across these two adjoining open cut mining areas, maximising coal recovery and the efficient use of existing mining infrastructure, while providing the operational flexibility required to actively manage the mine to minimise environmental impacts.

The Project is State Significant Development as defined under State Environmental Planning Policy (State and Regional Development) 2011 and requires development consent under Part 4 of the *Environmental Planning and Assessment Act 1979* (EP&A Act). The Project will also require a modification to the existing Wambo development consents under section 75W of the EP&A Act to harmonise these consents with the Project. An Environmental Impact Statement (EIS) has been prepared to accompany these applications.

The Project Area is within the landscape covered by the Upper Hunter Strategic Regional Land Use Plan (SRLUP) (DP&I, 2012). *The State Environmental Planning Policy (Mining, Petroleum Production and Extractive Industries) 2007* (Mining SEPP) requires detailed examination of land and soil characteristics of State Significant mining developments that require a new mining lease. The intent of the Mining SEPP and the SRLUP is to ensure that high quality agricultural land and resources that may be impacted by mining proposals are identified early and subject to a rigorous and independent assessment before the development application can be determined.

The NSW government has prepared an *Interim Protocol for Verification of Biophysical Strategic Agricultural Land* (the Interim Protocol) (NSW government, 2013) which outlines the process for verification of whether or not land mapped as Biophysical Strategic Agricultural Land (BSAL) at the regional scale meets the BSAL criteria when assessed at the site or project scale. This report has been prepared to address the requirements of the NSW Interim Protocol.

Further information about the broader soil assessment for the Project, outside areas with potential for BSAL, is included in the Agricultural Impact Assessment.


FIGURE 1.1

Locality Plan

## 1.1 The Project

Mining has been occurring at Wambo since the late 1960's and at United since 1989, with both mines previously undertaking both open cut and underground mining operations. Over this time the two mines have regularly cooperated, including sharing access to coal resources where appropriate, to provide for more efficient recovery of the State's coal resources. The two mines have also shared some mining infrastructure including the joint use of the Wambo train loading facility and share water to minimise external water demand.

Building on this long history of cooperative operations, in November 2014 United and Wambo announced a 50:50 Joint Venture between the two companies. The Joint Venture agreement outlines how the two companies will work together to further develop open cut coal resources held by the two mines.

Whilst open cut coal mining has previously been undertaken at United, over the last two decades the focus has been on underground mining. Underground longwall mining operations were approved to provide up to 2.95 million tonnes per annum (Mtpa) of saleable coal. Mining operations were suspended at United in March 2010 with the mine entering a period of care and maintenance. At that time, exploration and pre-feasibility works were commenced to determine the potential for future mining activities within United's mining lease. Ongoing exploration has identified substantial reserves of coal suitable for open cut mining.

Ongoing open cut and underground mining is occurring at Wambo, with the mine having approval to extract up to 8 million tonnes per annum (Mtpa) of run of mine (ROM) coal by open cut methods. The combined Wambo underground and open cut operations have approval to extract up to 14.7 Mtpa ROM coal, and to transport up to 15 Mtpa of product coal via the train loading facility.

As discussed above, the Project includes open cut mining operations in two areas, the proposed United Open Cut and modified operations in the approved Wambo Open Cut for a period of approximately 23 years. The existing Wambo Open Cut has approval for continued open cut mining until March 2017 (with a modification lodged to extend this to 2020). Due to the progression of mining being slower than originally planned, there will be substantial coal resources remaining in this approved mining area at March 2017 and the Project proposes to continue mining in this approved area. The Project also seeks some minor extensions to the approved Wambo Open Cut surface mining area and will seek approval to mine deeper resources below the approved Wambo Open Cut area.

The Project will produce up to 10 Mtpa of ROM coal. The existing Wambo CHPP and train loading facility will be utilised for the Project. These facilities will also continue to receive coal from the ongoing Wambo underground mine (that is not the subject of this Project).

The Project also requires a number of changes to the layout of existing mining, public and private infrastructure within the Project Area.

The key aspects of the Project are shown on **Figure 1.2** and a summary of the key Project details is provided in **Table 1.1**.

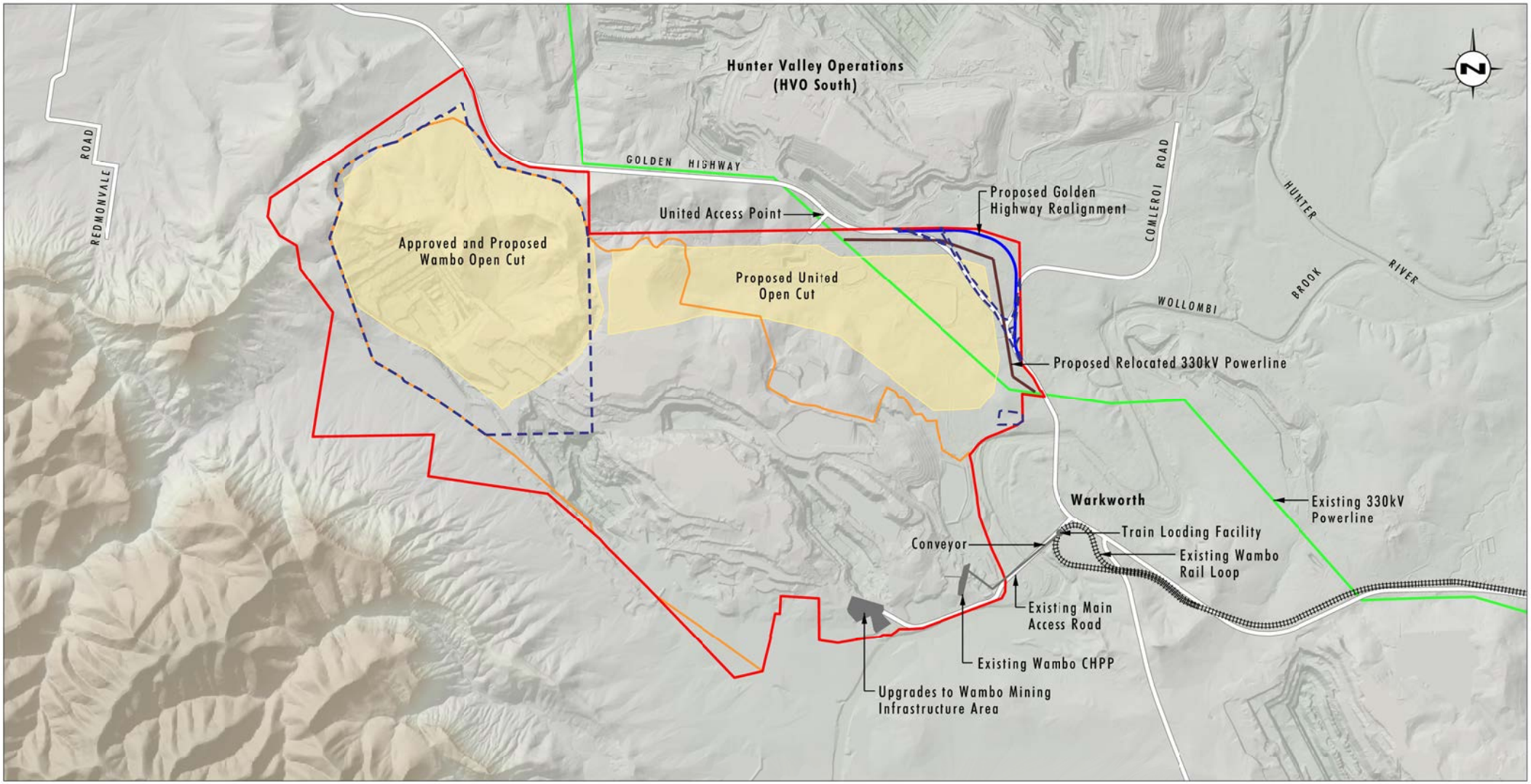


Image Source: United LiDAR (2015)
Data Source: Glencore (2015)

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## Legend

- Project Area
- Proposed Cpnceptual Extraction Area
- Approved Wambo Surface Development Area
- Proposed Golden Highway Realignment
- Existing 330kV Powerline
- Proposed Relocated 330kV Powerline
- Mining Lease Application Areas

FIGURE 1.2

**Overview of The Project**

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**Table 1.1 Summary of Key Project Details**

| Key Project Components/Aspects | Proposed Operations |
|---|---|
| **Key feature of the Project** | The operation of a multi-seam open cut mining operation integrating the existing and approved Wambo Open Cut under a modified mine plan and the proposed United Open Cut |
| **Total Economically Recoverable Reserve** | Approximately 176 Mt of ROM coal recovered from the two open cut mining operations, made up of:<br>• approximately 110 Mt of ROM coal from the United Open Cut<br>• approximately 66 Mt of ROM coal in total from the Wambo Open Cut, including an additional 40 Mt accessed from the increased depth of mining. |
| **Extraction Rates** | Up to 10 Mtpa ROM coal |
| **Life-of- Mine** | Approximately 23 years from the date of Project approval |
| **Operating Hours** | 24 hours per day, 7 days per week |
| **Number of Employees** | Up to approximately 500 total operational employees (at peak production) |
| **Mining Methods** | Open cut mining using a truck and excavator/shovel fleet |
| **Extent of Mining Areas** | Refer to **Figure 1.2** for the proposed extent of open cut mining.<br>The Project proposes to modify the Wambo Open Cut boundary to maximise resource recovery. The modification to the approved Wambo Open Cut boundary will result in a minor surface adjustment of approximately 3.8 hectares of additional disturbance. The modification also includes accessing deeper seams within the existing Wambo Open Cut. |
| **Infrastructure** | Initial use and upgrades of existing United Mine Infrastructure Area prior to its decommissioning and demolition/removal due to the progression of the United Open Cut<br>Construction of temporary facilities during the construction phase of the Project<br>Ongoing use, expansion and upgrade of the Wambo Mining Infrastructure Area<br>Use of existing Wambo CHPP and train loading facility within their currently approved annual capacities of 14.7 Mtpa ROM coal and 15 Mtpa product coal respectively |

| Key Project Components/Aspects | Proposed Operations |
|---|---|
| **Tailings and Rejects Strategy** | Decommissioning and capping of existing tailings storage facilities located in areas proposed for overburden emplacement and ongoing use of existing tailings storage facilities and storages established in other mine voids as required<br><br>Coarse rejects from coal preparation to be transported by truck to the open cut overburden areas for emplacement and subsequent covering by overburden material. Coarse rejects will continue to be co-disposed within the open cut overburden areas for the life of operations |
| **External Coal Transport** | Product coal will continue to be transported off site via train from the existing Wambo train loading facility. Product coal transport rates proposed to increase from a maximum of six to eight trains per day. No change to total approved 15 Mtpa product coal tonnage transported by train. |
| **Roads** | Realignment of a 2 kilometre section of the Golden Highway to accommodate the proposed United Open Cut<br><br>The main entrance to the Project will be via the existing entrance to Wambo. The existing United access road will be used in the initial phase of the Project for construction and ancillary services with limited ongoing use as a property access point |
| **Power Infrastructure** | An existing 330 kV transmission line which traverses the proposed United Open Cut mining area is proposed to be relocated as part of the Project. Several other 66 kV and 11kV power lines will also require relocation to outside of proposed mining areas<br><br>Some existing telecommunications and associated infrastructure are located adjacent to the existing alignment of the Golden Highway and will also require relocation as part of the Project |
| **Water Management** | Construction of mine water management controls including dams<br><br>Use of the previously mined United underground voids for water storage |

United Collieries is owned 95 per cent by Abelshore Pty Limited, a wholly owned subsidiary of Glencore Coal Pty Limited (Glencore) and 5 per cent by the Construction, Forestry, Mining and Energy Union (CFMEU) and is managed by Glencore. Wambo Coal is a subsidiary of Peabody Energy Australia Pty Limited (Peabody).

## 1.2 Project land and soil context

High quality agricultural land is generally in Land and Soil Capability Classes 1, 2 or 3, which is suitable for sustained cropping or improved pasture uses, without significant degradation. The Office of Environment and Heritage (OEH) has mapped this quality land, termed Biophysical Strategic Agricultural Land (BSAL) at the regional scale for the Upper Hunter SRLUP. BSAL identified in the OEH mapping in the vicinity of the Project is shown in **Figure 1.3**.

The land and soil in the vicinity of, and including, the Project Area has been part of multiple soil surveys and mapping projects over several decades. The mapping of BSAL at the regional scale draws on these previous surveys and reports. These include:

- CSIRO Hunter Land Systems Mapping (1960s)
- Soil Landscape mapping (1991)
- Land and Soil Capability assessments (OEH second approximation 2012)
- Site specific soil profile descriptions for individual development assessments and/or site management plans, including erosion control plans, topsoil stripping plans and remediation plans.

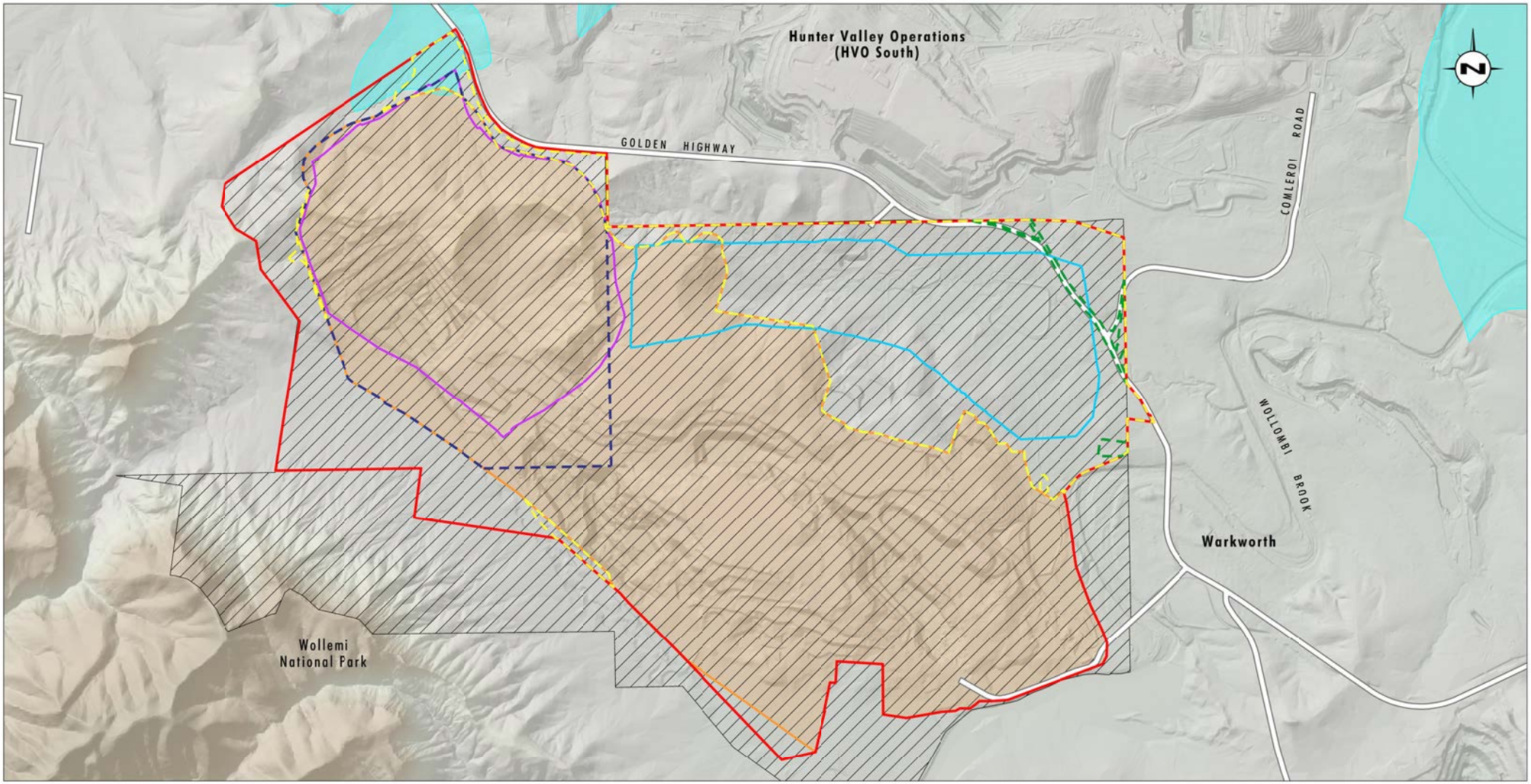


Image Source: United LiDAR (2015)
Data Source: Glencore (2014)

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## Legend

- Project Area
- Proposed Conceptual United Open Cut Pit
- Proposed Conceptual Wambo Open Cut Modification
- Conceptual Additional Disturbance Area
- Approved Wambo Surface Development Area
- Area Requiring New Subsurface Mining Lease
- Area requiring New Surface Mining Lease
- Regionally Mapped Biophysical Strategic Agricultural Land
- Existing Surface Lease

FIGURE 1.3

**Regionally Mapped Biophysical Strategic Agricultural Land and Areas Requiring New Mining Leases**

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These previous surveys and reports, whilst not necessarily at the project scale, provide a consistent story about the quality of soil in the area, constraints associated with the soils and the overall potential for the landscape to support high value, intensive agricultural production.

**Table 1.2** provides a summary of the relevant soil landscape mapping for this area and illustrates the generally poor structure, low fertility and high sodicity of soils in the area. The distribution of these soil landscapes is shown in **Figure 1.4**. The distribution of land and soil capability is also noted in **Table 1.2** and shown in **Figure 1.5**.

**Table 1.2 Land and soil characteristics of the Project Area (Soil landscapes of the Singleton 1:250,000 sheet)**

| Mapping unit | Description |
|---|---|
| **Jerrys Plains soil landscape – most extensive soil landscape in the Project Area** | The main soils are soloths on the crests to midslopes, with solodic soils on the lower slopes and in the drainage depressions.<br>Profile depth 60-300 cm<br>Soils typically have a pH 6.0-8.5 and low soil fertility<br>Soils are poorly to moderately well drained, with moderate water holding capacity.<br>Soils are susceptible to severe gully erosion in some drainage lines with areas of severe salting also occur in many of the drainage lines.<br>Susceptible to minor sheet erosion on some disturbed areas on hillslopes.<br>Land capability classes 4, 5 and 6 occur in this soil landscape. |
| **Hunter soil landscape – for less than 20ha in the northwest corner of the Project Area** | The main soils in this landscape are all formed on alluvium from the Hunter River and its tributaries. The primary terrain within the landscape is the floodplain and terraces of the Hunter River, with slopes of less than 3% and local relief of less than 10m. The small area of this soil landscape within the Project Area is therefore at the outer margin of the landscape, being situated on the alluvial fan area of a small tributary system, where it interfaces with the edge of the Hunter floodplain.<br>The landforms and soils have been fully cleared, and are used for intensive agriculture and/or improved pasture. Soils include brown cracking clays, black earths (both with moderate to high fertility), alluvial soils (sands and loams – low fertility) and non calcic brown soils (moderate fertility), with some texture contrast profiles on terraces. Land capability classes 1, 2 and 3 are represented in this soil landscape H |
| **Bulga soil landscape** | This soil landscape occurs on colluvial slopes and undulating rises on the Narrabeen group of the Singleton Coal measures. It is mapped across the southern part of the Project Area. Soils generally have strong texture contrast and include yellow and brown solodic soils, yellow soloths and brown earths. They may have mottled B horizons. Most profile types have high salinity and low fertility. Minor to moderate sheet erosion is common; the erosion hazard is high and there is frequently structural degradation. Land and soil capability class 4 land dominates the soil landscape |

| Mapping unit | Description |
|---|---|
| **Benjang soil landscape** | This soil landscape is mapped in the western part of the Project Area, between the Bulga soil landscape and the Jerrys Plains soil landscape. Occurs on rolling hills, with some sandstone or conglomerate outcrop at the crests. Near horizontal bedding of the Narrabeen group rocks results in benched slope forms and poor drainage. Typical profiles include red, brown and yellow solodic soils, with some non calcic brown soils. All soils in this landscape have low fertility, moderate to high salinity and moderate to high erodibility. Land and soil capability is in Classes 4 and 5. |
| **Warkworth soil landscape** | A small area of this landscape is located within the Project Area, almost entirely outside the conceptual additional disturbance area. This soil landscape covers the linear sand dunes found on the old river terraces of the Hunter River downstream from Warkworth. The main soils are Siliceous Sands. Soils within this landscape are of low soil fertility, rapidly drained, with low water holding capacity, susceptible to minor sheet erosion where disturbed. This soil landscape is generally land and soil capability Class 3 to 5. |

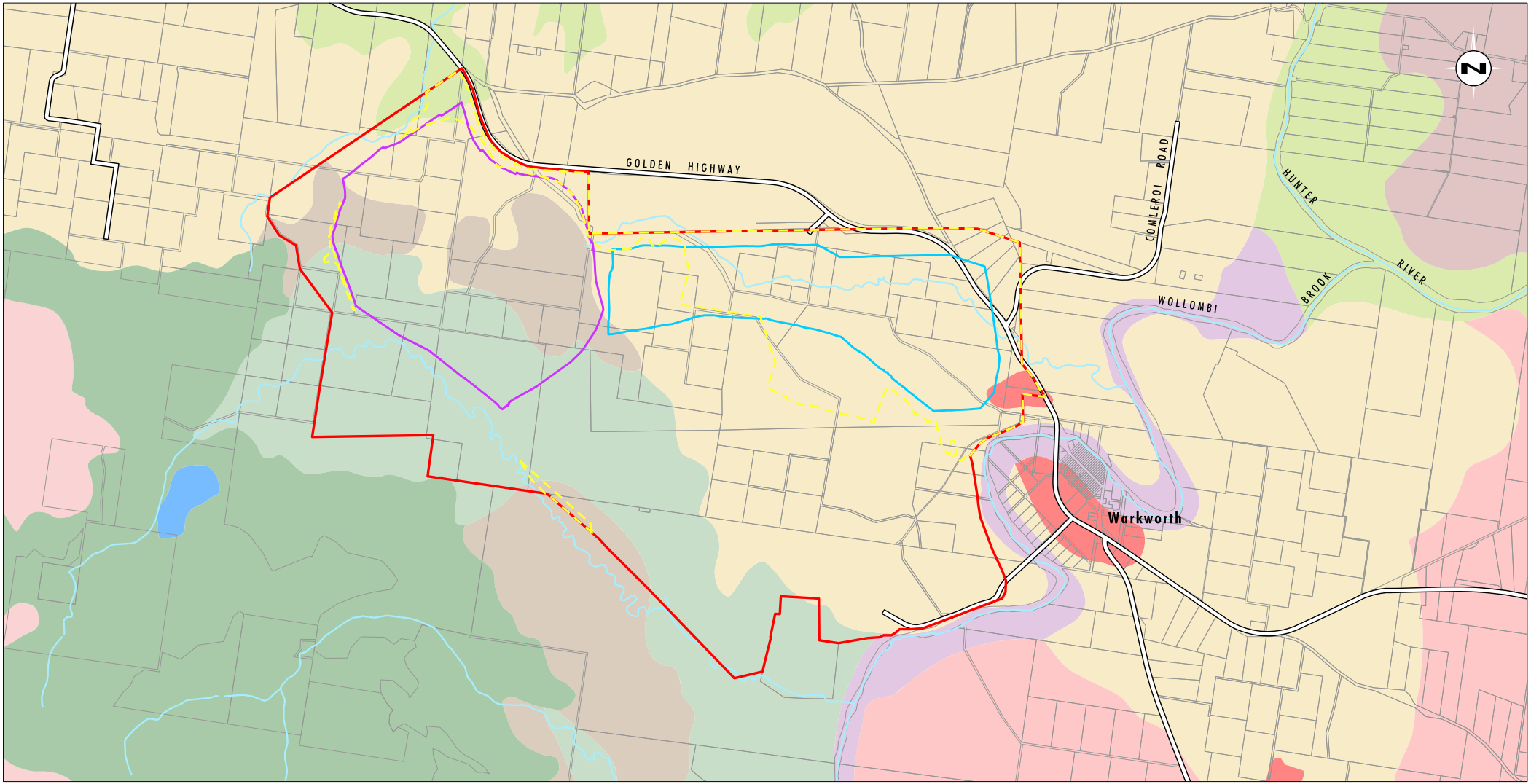


Image Source: United (2015)
Data Source: LPMA (2009), OEH (2013)

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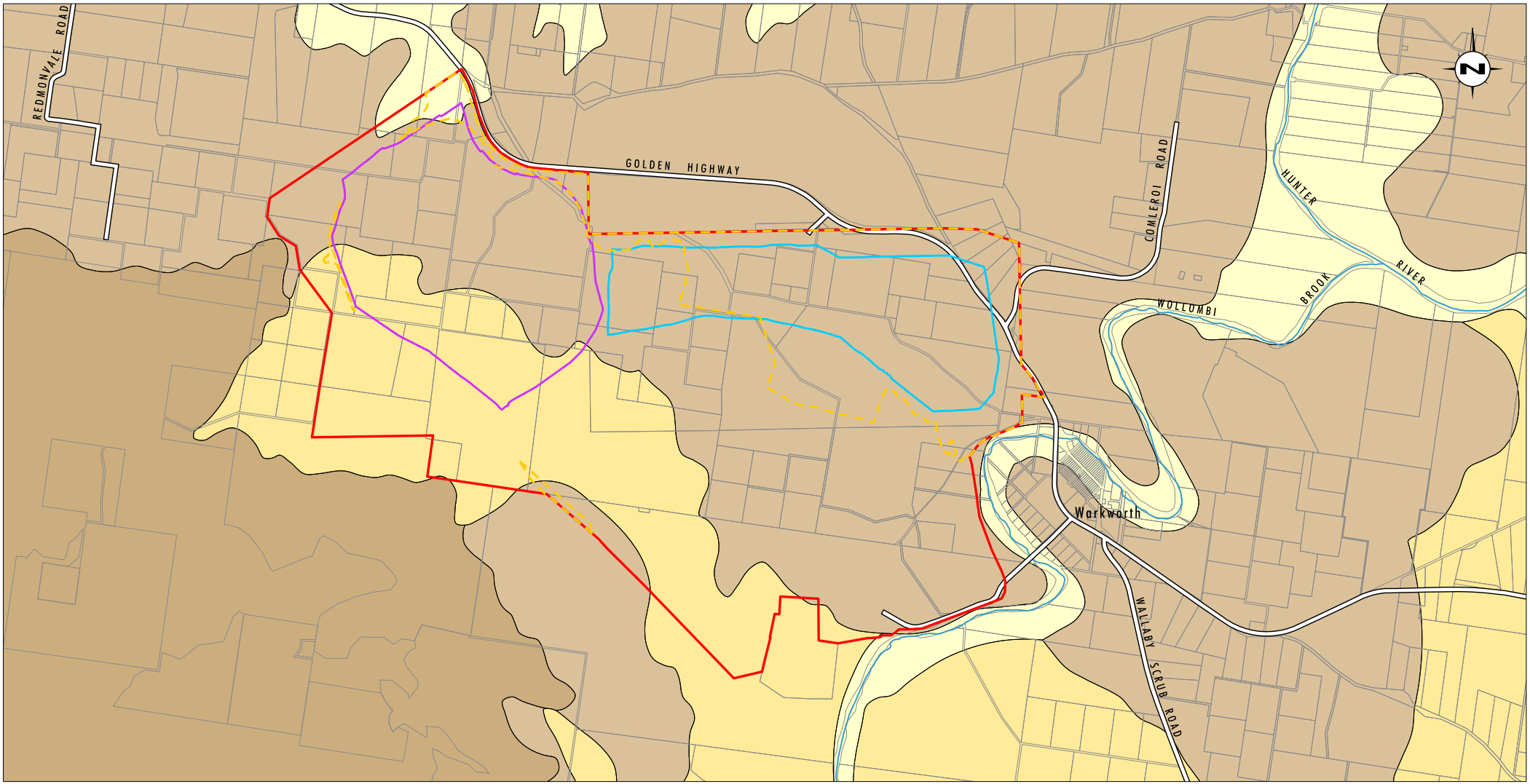
1:60 000

## Legend

- Project Area
- Proposed Conceptual United Open Cut Pit
- Proposed Conceptual Wambo Open Cut Modification
- Conceptual Additional Disturbance Area
- Benjang Soil Landscape
- Branxton Soil Landscape
- Bulga Soil Landscape
- Hunter Soil Landscape
- Jerrys Plains Soil Landscape
- Lees Pinch Soil Landscape
- Ogilvie Soil Landscape
- Three Ways Soil Landscape
- Warkworth Soil Landscape

FIGURE 1.4

**Soil Landscapes**




Data Source: LPMA (2009), OEH (2013)

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## Legend

- Project Area
- Conceptual Additional Disturbance Area
- Proposed Conceptual United Open Cut Pit
- Proposed Conceptual Wambo Open Cut Modification

Regional Land and Soil Capability:

- 3 - Moderate Limitations
- 4 - Moderate to Severe Limitations
- 5 - Severe Limitations
- 7 - Extremely Severe Limitations

FIGURE 1.5

# Regional Land and Soil Capability

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Parts of the Project Area have historically been used for grazing (sheep and cattle). Historical aerial photos of the locality demonstrate that the previous use of the land resulted in extensive sheet erosion. This erosion has affected the depth and structure of topsoil on hillslopes and rapid sedimentation followed by incision of tributary valley fills.

This existing information suggests that there is a low level of uncertainty associated with the soil mapping in the area. It is very unlikely that any soil materials not previously identified as BSAL occur in the specific areas outside the existing mining lease, or anywhere across the Project Area.

There is also a low risk to agriculture (in the sense of any potential impact on high value cropping land) as described in the Agricultural Impact Assessment.

Notwithstanding the low risk of BSAL occurring, the Interim Protocol requires detailed soil sampling and testing to provide further evidence about soil quality and constraints affecting the soil materials in areas where a new mining lease is required.

This report provides evidence of the soil types and an assessment of the presence of BSAL in the Verification Application Area (VAA), in accordance with the requirements of the Interim Protocol.

## 1.3 Verification Application Area and exclusions

The majority of the Project Area is located within existing mining lease areas, however further mining leases are required for the Project (refer to **Figure 1.3**). There are small portions of land within the boundary of CCL775 over which United does not hold relevant surface mining leases, primarily associated with the current route of the Golden Highway and small parcels of land in the south east corner of CCL775, EL5264 and EL139 apply to these areas respectively. These areas are shown as (A), (B) and (C) in **Figure 1.6**.

A new mining lease is required for the proposed deeper mining below ML1572 although the area is already disturbed and covered by an existing surface mining lease

The areas over which a new mining lease will be required have been refined as the Project has developed, to take into account the iterative refinement of the project design, including consideration of environmental values and to minimise conflicts with potential BSAL land.

In this report, the areas requiring new mining leases are referred to as the 'Verification Application Area (VAA)' (refer to **Figure 1.6**).

As shown in **Figure 1.6**, the VAA is comprised of three distinct areas within the Project Area. The VAA aligns with the areas that require a mining lease as a result of the Project, including:

- the existing alignment of the Golden Highway and intersection with Comleroi Road which will be relocated as part of the Project (10.2 hectares) (Area (A) and (B))
- a small section in the south east corner of CCL775 which is within the Project disturbance boundary but will not be subject to coal extraction (3.5 hectares) (Area (C)). This area may be subject to disturbance related to ancillary infrastructure including transmission lines and road realignments
- an area of 741.1 hectares below ML1572 (existing surface mining lease) to allow for the mining of lower coal seams held by the Joint Venture. (Area (D) is the part of this area not excluded from the detailed verification assessment, as outlined below).

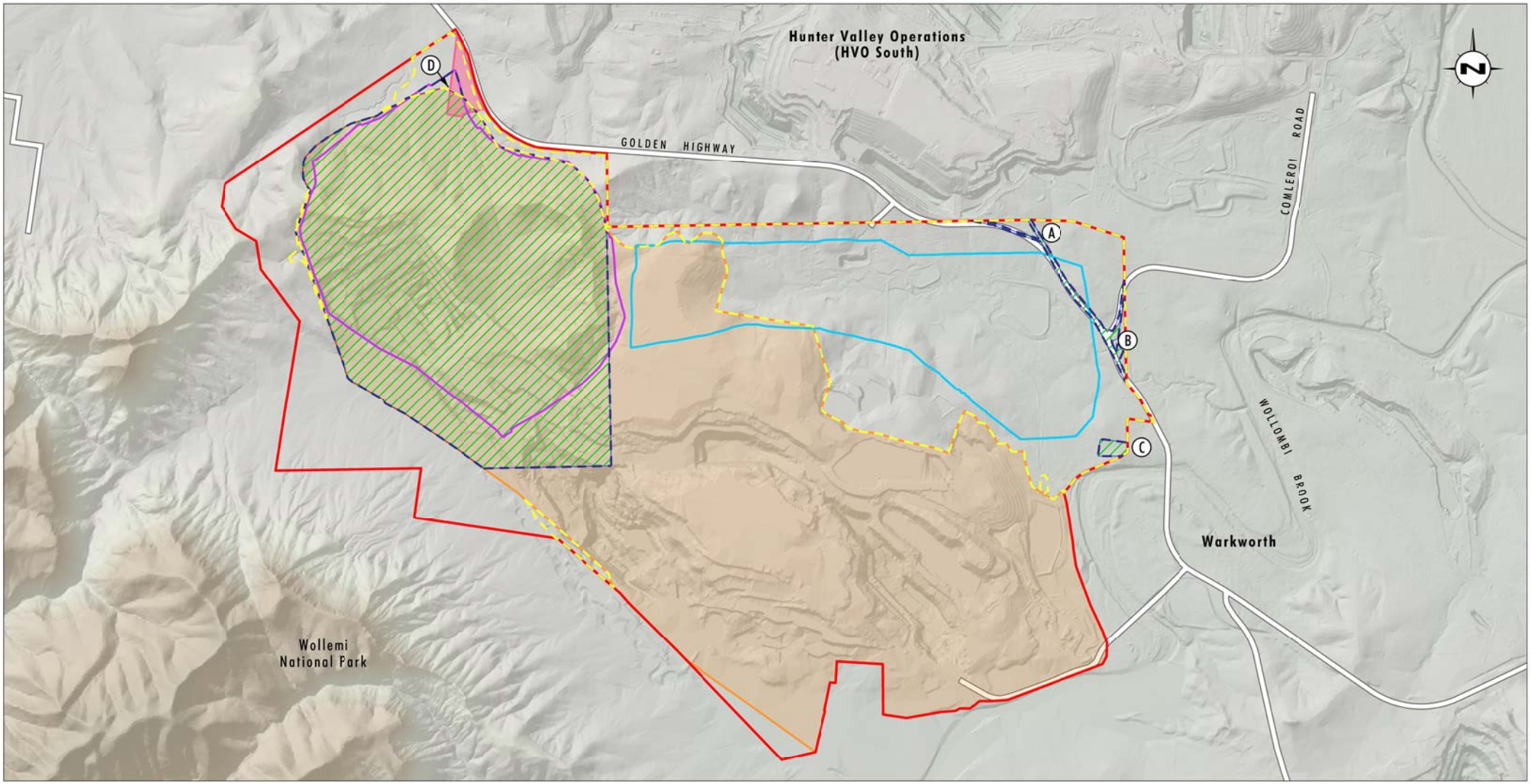



Image Source: United LiDAR (2015)
Data Source: Glencore (2014)

0 1.0 2.0 2.5km
1:50 000

## Legend

- Project Area
- Proposed Conceptual United Open Cut Pit
- Proposed Conceptual Wambo Open Cut Modification
- Conceptual Additional Disturbance Area
- Approved Wambo Surface Development Area
- New Mining Lease Application Areas - Verification Application Area (Areas A, B, C & D)
- Areas excluded from the Assessment
- Crown Land

FIGURE 1.6

**Verification Application Area and Exclusion Areas**

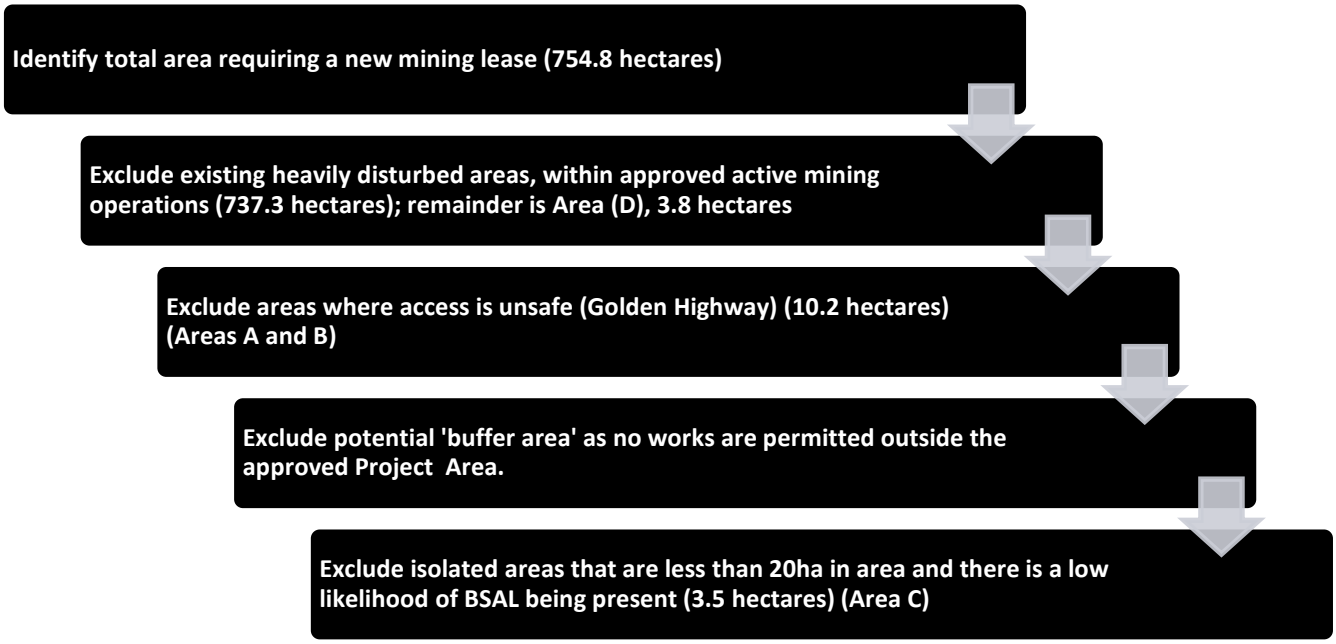
Within the total area of 754.8 hectares included in the VAA, approximately 737.3 hectares is an existing approved open cut mining operation. This includes existing operational areas (open cut pits and associated works) which are heavily disturbed and not used for agriculture, and areas approved for disturbance in the existing consent for Wambo. This existing approved mining area has been excluded from the assessment (refer to **Section 2.3** for details). **Section 2.3** also explains the rationale for exclusion of other parts of the overall VAA from the assessment process, in accordance with the Interim Protocol (NSW Government 2013). With these areas excluded from the assessment, the area which requires detailed verification assessment, within the proposed new mining lease, is 3.8 hectares.

An area of 31.6 hectares within the Project Area boundary (refer to **Figure 1.3** and **Figure 1.7**) was mapped as BSAL in the Upper Hunter SRLUP. As the Project has been refined, the area of potential BSAL within the detailed VAA assessment area has reduced, such that only 3.0 hectares lies within the detailed VAA assessment area. This area of BSAL is at the margin of a larger area of BSAL, which extends towards the Hunter River, over land that is outside the Project Area. In accordance with the Interim Protocol, the verification assessment has investigated the character of soils across the boundaries of the mapped BSAL, the detailed VAA assessment area and the Project Area to ensure sufficient information is available to assess impacts on potentially high value soil resources suitable for agriculture.

### 1.3.1 Summary of areas excluded from the detailed verification assessment

The logic process for determining the areas included and excluded in the full BSAL verification assessment is summarised below.

When the areas excluded from the assessment are taken into account the detailed VAA assessment area for the Project is **3.8 hectares.** This area is shown in **Figure 1.7** and is the subject of the remainder of this assessment.



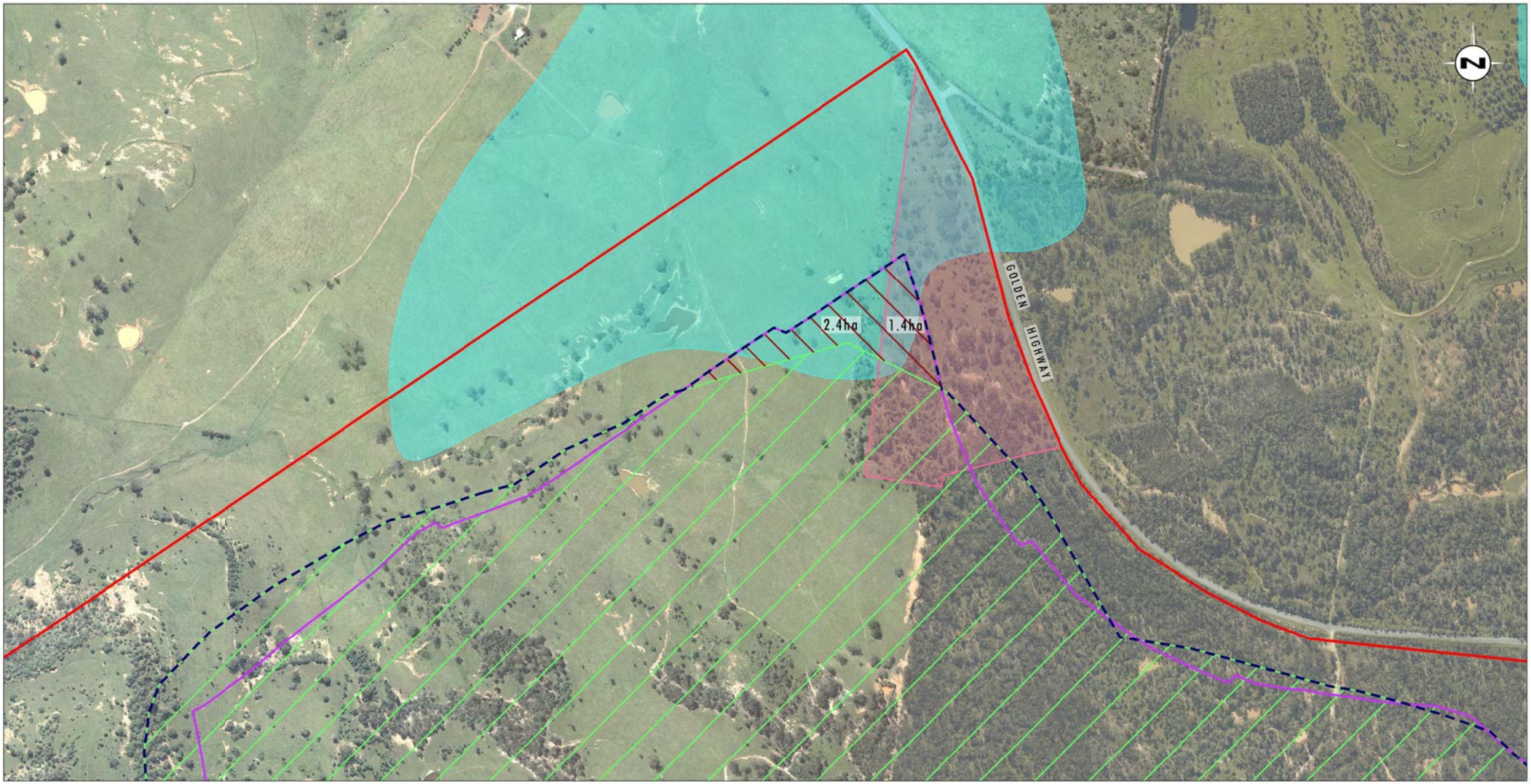



Image Source: AAM (2012), United (2015)
Data Source: Glencore (2014)

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## Legend

- Project Area
- Proposed Open Cut Area
- Overall Verification Application Area
- Areas excluded from the Assessment
- Detailed Verification Assessment Area
- Regionally Mapped Biophysical Strategic Agricultural Land
- Crown Land

FIGURE 1.7

**Detailed VAA Assessment Area**

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# 2.0 Interim Protocol Requirements

## 2.1 Mining SEPP Direction

The Mining SEPP and the Interim protocol state:

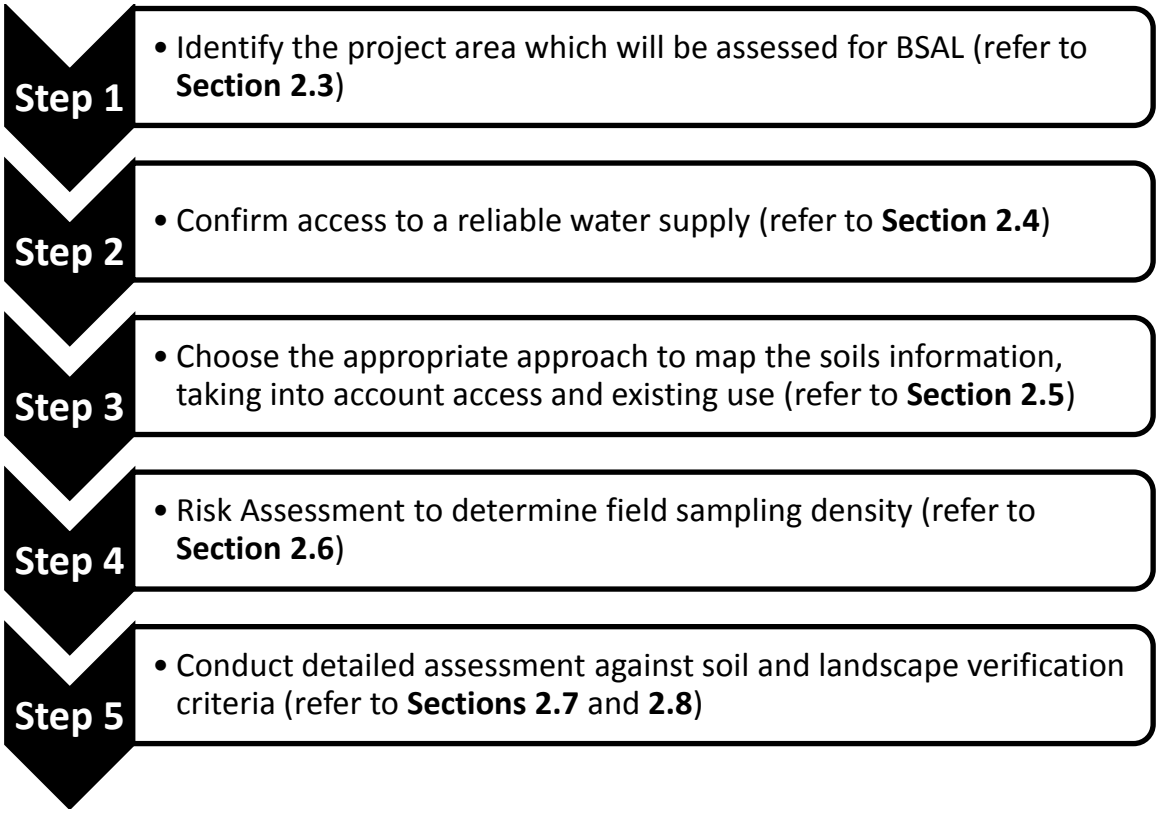
> For applicants of State Significant mining and coal seam gas proposals that are located '*outside the mining area of an existing mining lease*' and are '*not located on BSAL*', the applicant may:
>
> - Apply for a site verification certificate to determine if any part of the project area meets the BSAL site criteria and would therefore be subject to the Gateway process; or
>
> - Elect to proceed straight away to the Gateway process on the basis that their project area or part of the project area does contain BSAL.

Under Division 1 (2) these requirements '*do not apply to land that is outside the mining area of a proposed mining lease*'.

**The information in this report is provided in relation to an application for a site verification certificate confirming there is no BSAL present in any part of the Project Area requiring a new mining lease**.

## 2.2 Key assessment steps

As outlined in the Interim Protocol, the following key steps are required to verify BSAL:



A minimum area of 20 hectares is required for classification as BSAL. If due to exclusion of lands that do not meet the assessment requirement criteria, the study area falls below 20 hectares, there is no need for further assessment. For this Project, the ML requirements and therefore the VAA area were initially larger and were reviewed and refined during the assessment process.

## 2.3 Step 1: Identify the project area which will be assessed for BSAL

Item 5 of the Interim Protocol discusses areas to be included and excluded in the project area to be assessed for BSAL. Specific requirements and exclusions for the project are:

**Entire area covered by the Project, plus a buffer**

- The assessment should be conducted for the entire project area that is not covered by the existing mining lease, plus a 100 metre buffer area, to take into account minor changes in design. As stated on P2 of the Interim Protocol, the 'project area' for the purpose of the verification assessment does not include land that is outside the area of a proposed mining lease and will be used for ancillary works outside the proposed lease area that is the subject of the application. On ground assessment of soil characteristics is only required for the relevant part of the development application area, subject to the above exclusions.

  In the current case, the Project Area includes a large area which is covered by an existing relevant mining lease and development consent. As discussed in **Sections 1.3**, and **1.3.1**, this area has been excluded from the assessment.

  The proposed disturbance area for the Project is shown in **Figure 1.6**. The proposed disturbance area is entirely within the Project Area and includes allowance for associated works required to support the mining activities. For this reason a general buffer outside the Project Area boundary has not been included in this application.

  As discussed below, the detailed VAA assessment area includes the non excluded parts of the new mining lease application area. This area is 3.8 hectares.

**Contiguous BSAL**

- Where BSAL within the Project Area is part of a larger contiguous mass of BSAL, the boundary of the larger area must be identified (Step 1, page 3 of the Interim Protocol).

  There is land mapped at the regional scale as BSAL located within the north-west portion of the Project Area (refer to **Figure 1.3** and **Figure 1.7**). The area mapped as BSAL and/or high soil fertility in regional maps continues in the Hunter Soil Landscape, outside the Project Area. The area of BSAL mapped at the regional scale within the Project Area is 31.6 hectares, of which approximately 3.0 ha lies within the detailed VAA assessment area defined by the Interim Protocol. Both of these areas are less than the threshold area for assessment.

  Most of the area mapped as BSAL at this location within the Project Area is already covered by a surface lease (ML1572). Nevertheless, the Interim Protocol requires the area to be assessed due to a subsurface mining lease being required for this area.

  For clarity about the extent of BSAL at the Project scale, the north-west corner of the Project Area where BSAL is mapped at the regional scale, but no new mining lease is required has also been sampled as part of the detailed assessment and results are discussed in this report.

Further information about soils in the Project Area generally is provided in the Agricultural Impact Statement which is part of the Environmental Impact Statement for the Project.

**Land not used for agriculture**

The Project Area is predominantly utilised for mining operations and not presently used for any form of agriculture, other than approximately 50 hectares used for grazing (on Wambo land, under lease) in the northwest corner of the Project Area. No part of the Project Area is cultivated. The total area of the VAA includes areas that are mostly disturbed or approved for disturbance, for example the Golden Highway and approved mining areas. The areas not used for agriculture and excluded from the assessment include:

- Active mining areas. These lands are heavily disturbed by existing approved mining development (refer to **Figure 1.6**).

- Areas that currently have approval for disturbance under existing development consents (i.e. the Approved Wambo Surface Development Area), but not yet developed have been excluded from this application (refer to **Figure 1.6**).

- The Project includes realignment of an approximately 2 kilometre section of the Golden Highway approximately 1.5 km north of Warkworth. The current road reserve within the Project Area covers an area of approximately 10.2 hectares. This area is less than the contiguous area requirement in the Interim Protocol. This area is also within the Jerrys Plains soil landscape which has soils with multiple moderately severe constraints for agriculture and no BSAL is mapped at the regional scale is mapped within 5km. In addition, United and Wambo have limited access to the Golden Highway and associated road reserve as it is an active State highway it is impractical and unsafe to excavate soil pits in this area and the soil resources in the Golden Highway alignment have been greatly disturbed by the road construction process. Accordingly, the existing Golden Highway corridor has been excluded from this application (**Figure 1.6**). The exclusion of this area from the VAA was discussed with OEH (phone conversations with David Morand) and was also discussed in correspondence with DPE on 7 July 2015.

### 2.3.1 Minimum area requirements

Areas assessed and verified must have a minimum contiguous area of land of 20 hectares (Section 6 of the Interim Protocol). Two small parcels of land that require new mining leases do not meet this BSAL criterion. These are:

- Golden Highway corridor: 10.2 ha (as noted above, this area is also excluded because of unsafe access and heavy disturbance) (Areas (A) and (B))

- Corner block in the south east corner (Area (C): 3.5 ha.

Neither of these areas is indicated to include BSAL in regional scale maps (refer to **Figure 1.4** and **Figure 1.7**).

These areas have not been included in the detailed verification assessment.

The area which has been assessed in this report as the detailed VAA assessment area (3.8 hectares) is also less than the 20 hectare threshold. However, this area includes approximately 3.0 ha of BSAL mapped at the regional scale, which is contiguous with a larger area of regionally mapped BSAL. For this reason, the detailed VAA assessment was prepared, to clarify the actual boundary of BSAL at the project scale.

## 2.4 Step 2 - Access to reliable water

**Item 5 (Step 2)** of the Interim Protocol (NSW Government 2013) notes that the entire area covered by the Upper Hunter SRLUP is regarded as having access to a reliable water supply.

## 2.5 Step 3 - Mapping approach

The assessment and mapping process includes:

- Desktop assessment of existing information
- Field based assessment.

**Item 5 (Step 3** of the Interim Protocol (NSW Government 2013)**)** provides the following exclusions from the field based assessment. These areas must be included in the desktop assessment.

**Access and forested areas**

The verification process, following Section 6 of the Interim Protocol (on site soil assessment), must be conducted across all parts of the VAA to which the proponent has access.

- United and Wambo do not have access to an area of Crown Land in the northwest portion of the VAA to conduct soil tests (refer to **Figure 1.7**). Project personnel applied to Crown lands for access to this area and followed up on a number of occasions, but the required approvals were not forthcoming in sufficient time for this assessment.
- The Crown land area discussed above is also densely vegetated (Narrow leaved Ironbark-Grey Box Grassy Woodland of the Central and Upper Hunter Critically Endangered Ecological Community) and not used for agriculture. The BSAL status of this area (1.4 hectares, as shown in **Figure 1.7**) is assessed using desktop and field sourced information from adjacent areas, and the similarity of underlying geology, terrain and previous regional mapping.

The conceptual scope of the assessment is summarised below.

## 2.6 Step 4 - Risk assessment

The Interim Protocol (NSW Government 2013) (Step 4, page 4) refers to a risk assessment process to provide guidance on the appropriate sampling density.

Appendix 3 (Risk Assessment) of the Interim Protocol firstly provides examples of proposals which are low risk and high risk. These are noted below (**Table 2.1**), with a brief explanation of their relevance to the current project. Based on these examples, the current Project is generally a low risk in relation to BSAL, with a small part of the Project Area potentially a moderate risk.

For the purpose of a risk assessment in relation to BSAL, the key issue is the potential consequences of the Project on high quality agricultural resources, land and industries (BSAL is generally Land and Soil Capability Classes 1, 2 and 3). Specifically, Table 9 in Appendix 3 of the Interim protocol provides descriptions of different levels of consequences and their implications.

**Table 2.2** shows the rationale for a low risk result from the preliminary risk assessment for BSAL in the VAA. The table lists the descriptions of minor to major consequences, for the matters relevant to the VAA. It should be noted that this risk assessment is based on desktop information prior to consideration of detailed site surveys.

**Table 2.1 Risk considerations, BSAL and Land and soil capability**

| Considerations noted in Appendix 3 | Application to VAA |
|---|---|
| **The activity is located in an area where no agricultural land uses exist such as in a well forested area** | The area of Crown land is well forested and not used for agriculture. A total of 2.4 hectares of the detailed VAA assessment area is mine owned land currently leased for grazing.<br>Low risk |
| **The duration of the activity is short (1-3 months) and any disturbance of the resource is minor** | The activity will continue for up to 23 years, although rehabilitation will be progressive. A very small area (3 hectares identified at the regional scale)of potentially BSAL land is impacted within the 3.8 hectare detailed assessment area for the VAA<br>Low or moderate risk |
| **The proposal is located on rural land with a low potential for commercial agricultural land use and there is a low risk of conflict with adjoining agricultural lands** | The land and soil capability of the full VAA is Class 4 and Class 5. The soils in the Jerrys Plains Soil Landscape are shallow, duplex profiles, poorly drained and subject to both sheet and rill erosion, with gullying of drainage lines. The Project Area is surrounded by other mining sites or conservation lands, other than the connection from the very small actual verification assessment area to the high quality agricultural lands in the floodplain and terraces of the Hunter River. The risk of conflict with adjoining agricultural lands is low.<br>Low risk |

| Considerations noted in Appendix 3 | Application to VAA |
|---|---|
| **The activity will not result in permanent impacts on water or land resources** | It is proposed to rehabilitate key parts of the VAA and the Project Area to land and soil capability broadly consistent to the current resources (i.e. majority Land and Soil Capability classes in the range 4 to 5 in the northwest corner of the Project Area and Land and Soil Capability class 4 and 5 along a section of North Wambo Creek) and there is demonstrated evidence that this is achievable in the Hunter valley. While there will be medium to long term impacts during the operation of the project, they are not permanent.<br>Low risk |
| **Activities which are located on or near land which is highly likely to be BSAL such as fertile alluvial soils** | A very small area of the detailed VAA assessment area (3.0 hectares) is mapped as BSAL at the regional scale, based on the proximity of the fertile alluvial soils of the Hunter Soil Landscape, which are mapped as BSAL. A total of 31.6 hectares of BSAL is mapped within the Project Area boundary, at the regional scale. The sub-catchment draining to this area may be considered to be a low to moderate risk.<br>Generally low risk |
| **A proposed open cut mine on fertile alluvial soils** | No part of the Project Area is located on 'fertile alluvial soils' (although 31.6 hectares of the Project Area is mapped as BSAL and/or Class 3 land at the regional scale). 3.0 hectares of the detailed VAA assessment area is mapped at the regional scale as being BSAL and contiguous with BSAL that is based on the alluvial soils of the Hunter soil landscape. The area that is mapped as BSAL within the Project Area is the alluvial fan and footslopes of a tributary catchment, draining very low fertility country, where it interfaces with the outer margin of the Hunter floodplain.<br>Low risk |

**Table 2.2 Consequence descriptors from the Interim Protocol**

| Consequence description | Implications | Relevance to VAA |
|---|---|---|
| **Level 2 – Major**<br>**Significant and/or long term impact to agricultural resources or industries**<br>**Long term management implications**<br>**Serious detrimental impact on the community** | Water and/or soil impacted. Possibly in the long term (e.g. 20 years)<br>Long term displacement or serious impacts on agricultural industries | To qualify as BSAL at the project scale, a parcel of land must have an area of 20 hectares or more. The area that is mapped as BSAL in the detailed VAA assessment area (3.0ha of the 3.8 hectares of the detailed assessment area) is less than 20 hectares but is contiguous with a larger area of BSAL, including a total of 31.6 hectares of BSAL mapped at the regional scale within the Project Area. The area of the detailed VAA assessment area from which agricultural industries could potentially be displaced is up to 3.8 hectares. Other land parcels included in the VAA have areas of less than 20 hectares and are not mapped as quality agricultural soil.<br>**In terms of quality soil and water resources, not consistent with these descriptors** |

| Consequence description | Implications | Relevance to VAA |
|---|---|---|
| **Level 3 – Moderate**<br>**Moderate and/or medium term impact to agricultural resources or industries**<br>**Some ongoing management implications**<br>**Minor damage but over the long term** | Water and/or soil known to be affected probably in the short to medium term (<5years). Management could include significant change of management needed for agricultural enterprises to continue. | To qualify as BSAL at the project scale, a parcel of land must have an area of 20 hectares or more. In relation to BSAL, the impacts are minor in terms of area. Other than an area of 31.6 hectares the north west corner, it is very unlikely that BSAL occurs within the Project Area and the land parcels included in the Project Area are not used for agriculture and are not identified as having or being near quality agricultural soils.<br>The detailed VAA assessment area has an area of only 3.8 hectares, of which 3 hectares are mapped as BSAL at the regional scale.<br>**In terms of quality soil and water resources, not consistent with these descriptors** |
| **Level 4 – Minor**<br>**Minor damage and/or short term impact to agricultural resources or industries**<br>**Can be effectively managed as part of normal operations** | Theoretically could affect the agricultural resource or industry in short term, but no impacts demonstrated<br>Minor erosion, compaction or water quality impacts that can be mitigated (e.g. noise or dust impacts on extensive grazing enterprises for 12 months) | Within the detailed assessment area for the VAA, there could be minor (very small area – 3.8 hectares), but long term impacts on soil and water resources.<br>**The VAA most closely aligns with these descriptors of consequence.** |

Overall, this analysis indicates that the risk to high quality agricultural resources which would qualify as BSAL (which are the focus of the VAA assessment) is low.

Appendix 3 of the Interim Protocol notes that sampling densities should be linked to risk:

- Sampling density 1 site per 25 to 400 hectares for low risk to agriculture
- Sampling density 1 site per 5 to 25 hectares for high risk to agriculture.

The detailed VAA assessment area for this Project is considered to present a low risk to high quality agricultural soils. However, a very small area of BSAL is mapped in the Project Area and within the detailed VAA assessment area; however it is noted that this BSAL area extends beyond the limits of the Project Area. Field sampling was conducted to verify the range of soil types present and their relationship to the local terrain in the transition from hillslope soils, through tributary valley fills to the alluvial soils of the Hunter Soil Landscape. The distribution of detailed soil samples was targeted in the critical transition from non BSAL to BSAL, within the VAA and outside the VAA but within the Project Area.

Although a sampling density of 1 site per 25 hectares would meet the criteria of the Interim Protocol (NSW Government 2013), a denser sampling network has been applied, to address the site specific landform variability and the Project need to clearly define the actual extent of BSAL. The sampling density in the north-west corner of the Project Area is approximately 1 site per hectare. Mapping has been prepared at 1:10,000 to provide sufficient resolution of local terrain and soil features.

## 2.7 Soil and landscape verification criteria

The soil and landscape verification criteria are designed to identify soils which have no permanent limitations to plant growth and are suitable for cropping. A minimum of 20 hectares of contiguous land area and soil meeting the BSAL criteria is required (including contiguous areas inside and outside the Project Area), reflecting the area necessary for feasibly conducting a viable cropping enterprise.

The Project Area does not include 20 hectares of BSAL mapped at the regional scale and the verification process has identified that the regional mapping over-estimates the area of BSAL within the Project Area.

## 2.8 Assessment requirements

Figure 2 of the Interim Protocol (copied below) shows the twelve criteria to be applied in the site specific assessment of land and soil that have not been excluded in desktop steps 1-4 of the Interim Protocol (NSW Government 2013) (as discussed in **Sections 2.3**, **2.4**, **2.5** and **2.6**).

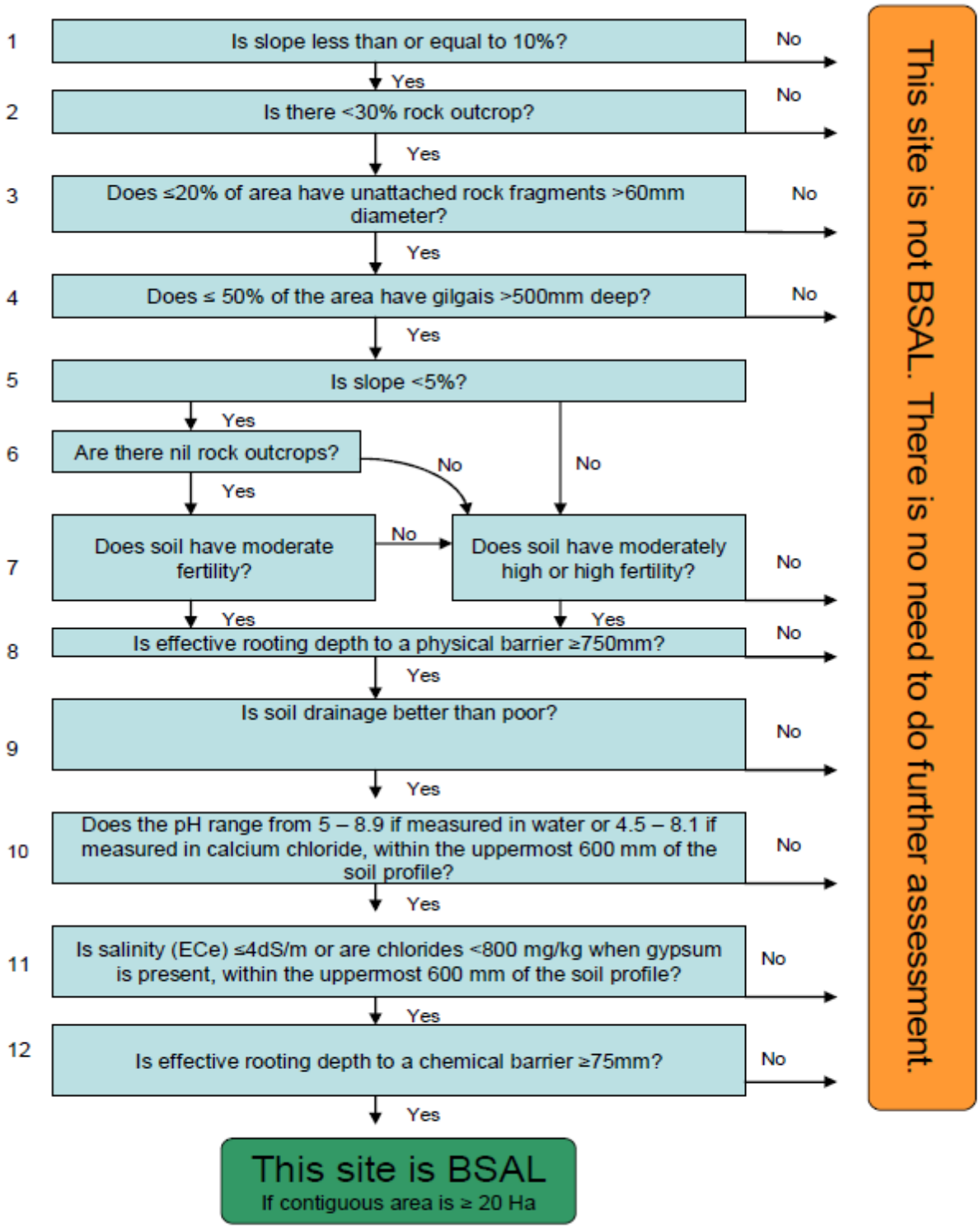



**Figure 2.1**

12 criteria for assessment from the Interim Protocol (NSW Government 2013

**Table 2.3** lists these site-based BSAL assessment criteria, and notes any criterion which would exclude part of the VAA from the assessment, based on existing data or non field based data (desktop assessment). This relates particularly to Criteria 1 to 5. Criteria 6 to 12 (shown in **Table 2.4**) require field observations and data.

### 2.8.1 Slope (Criteria 1 and 5)

Slope assessment for this project is based on a DTM prepared from LiDAR data. The DTM is based on a contour interval of 1 metre.

The LiDAR results were supplemented with field observations for each detailed soil profile site and check site.

**Figure 2.2** shows the distribution of slopes less than or equal to 10% across the entire Project area and the distribution of slopes of less than 5% across the entire Project area.

Within the small area that is the subject of the detailed verification assessment, slopes are entirely less than 10%, and about 60% of the area has a slope of less than 5%.

### 2.8.2 Surface characteristics (Criteria 2, 3 and 4)

Observations of rock outcrop, surface rockiness (float) and the potential presence of gilgai features were made from aerial photos and review of previous reports. The desktop review was confirmed later in the field at each detailed soil profile site, including a radius of 10m around each site.

No rock outcrop occurs within the detailed assessment area of the VAA.

Occasional (rare) sandstone or ironstone cobbles were observed as surface float in the detailed assessment area of VAA. Many of these have a diameter greater than 60mm. However, the frequency of occurrence is low.

No gilgai micro relief was identified anywhere in any part of the VAA.

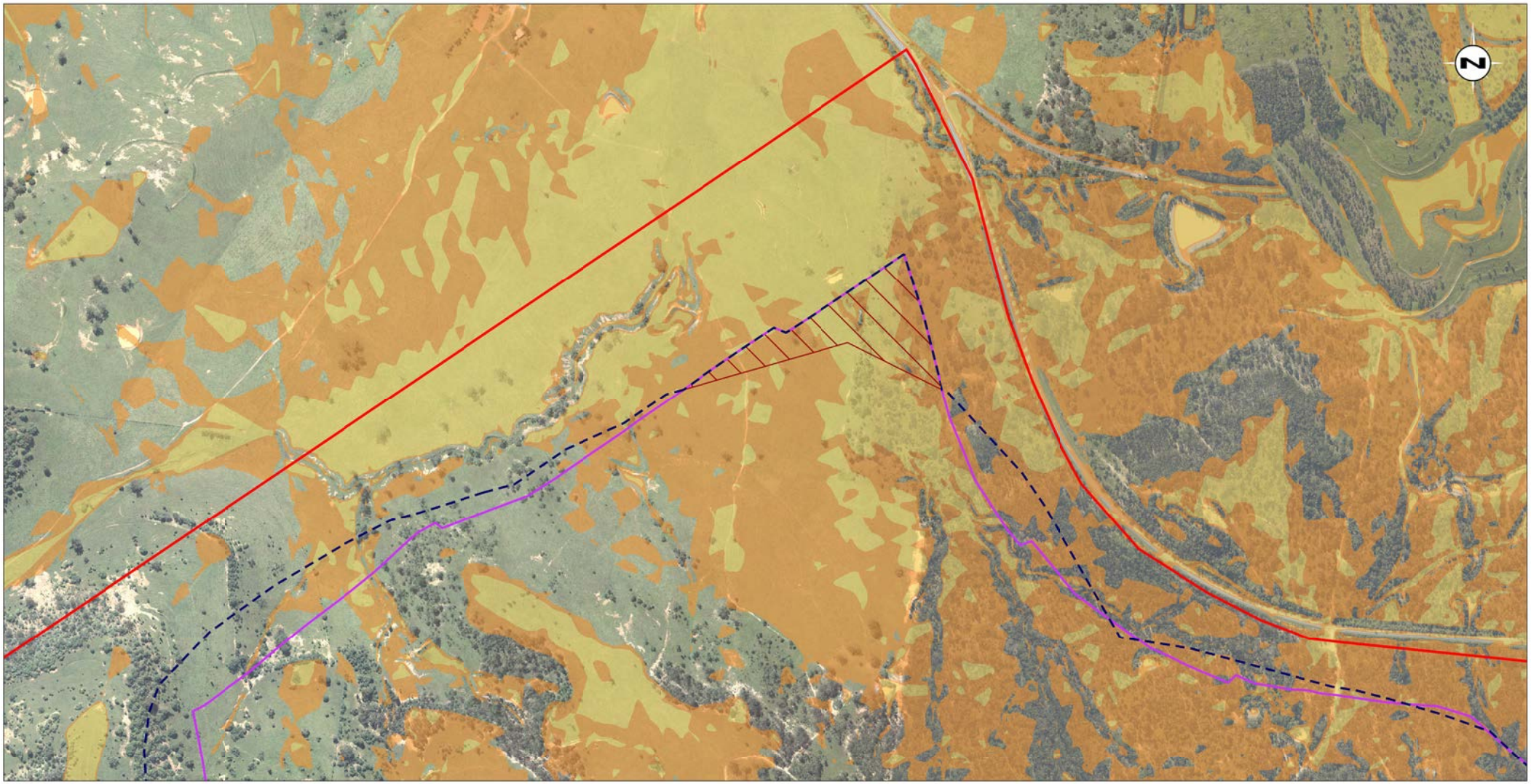


Image Source: AAM (2012), United (2015)
Data Source: Glencore (2014)

0 100 250 500m
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## Legend

- Project Area
- Proposed Open Cut Area
- Overall Verification Application Area
- Detailed Verfication Assessment Area
- Slopes less than 5%
- Slopes Less than or equal to 10%

FIGURE 2.2

Slopes (<5% and </=10%)

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**Table 2.3 Site based verification criteria – preliminary assessment**

| Criteria assessed with desktop information | Information from preliminary assessment |
|---|---|
| **Does the land to be assessed have a contiguous area equal to or greater than 20ha?** | Refer to areas excluded from the detailed assessment in **Section 2.3**<br><br>Two of the parcels of land in the Project Area which do not have relevant mining leases do not meet the area threshold for BSAL. These are:<br>• Areas A and B - Golden Highway corridor: 10.2 ha<br>• Area C – Southeast corner block: 3.5 ha<br><br>Neither of these areas is mapped as BSAL at the regional scale.<br><br>The detailed assessment area comprises 3.8 hectares. |
| **1. Is slope less than or equal to 10%** | Slope data is provided in **Figure 2.2**. The detailed VAA assessment area in the north west corner of the Project is exclusively on slopes of less than 10%, with the majority having slopes of less than 3% or less than 5%. |
| **2. Is there less than 30% rock outcrop (on slopes of more than 10%)?** | Rock outcrop in the detailed VAA assessment area does not exceed 30% at any point. |
| **3. Does less than or equal to 20% of the area have unattached rock fragments that are more than 60mm in diameter?** | Surface float of coarse fragments across the detailed VAA assessment area does not exceed 20% at any point |
| **4. Does less than or equal to 50% of the area have gilgais greater than 500mm deep?** | No gilgai is present in any part of the detailed VAA assessment area. |
| **5. Is the slope less than 5%** | Areas of less than 5% slope in the detailed VAA assessment area and the adjoining Project Area are shown in **Figure 2.2**. The low gradient areas follow the valley fills/alluvial fans of the tributary drainage lines that traverse the detailed VAA assessment area in the north west corner of the Project. |
| **6. Are there nil rock outcrops (with slope > 5%)** | There are no rock outcrops on slopes of less than 5% |

**Table 2.4 Site based criteria requiring field assessment**

| Criteria to be assessed with additional field data | Information from preliminary assessment |
|---|---|
| **1. (a) Does the soil have moderate fertility?**<br><br>**(b) Does the soil have moderately high or high fertility (with slope less than 5%)**<br><br>**Note soil fertility takes into account inherent fertility, permeability, structure, tilth and typical soil depth. Kurosols, Sodosols and Rudosols all have low or moderately low fertility ranking.**<br><br>**Soils with moderately low fertility can only support plants suited to grazing; large inputs of fertiliser are required to make the soils suitable for arable purposes (refer to Table 1 in the Interim Protocol, from Murphy 2007)** | **Requires field information**<br><br>Field based soil testing (refer to **Section 3.2** and **Section 4**) have been completed to provide Project scale data for verification.<br><br>The fertility of soils in the VAA is generally low or moderately low (refer to Table 6 in Appendix 2 of the Interim Protocol).<br><br>Regional scale mapping (soil landscapes (**Figure 1.4**) and land and soil capability (**Figure 1.5**)) indicates the soils in the VAA are primarily within the Jerrys Plains Soil Landscape, Bulga Soil Landscape and Warkworth Soil Landscape (not including the areas excluded because they are existing approved mining lands). A small area within the Hunter Soil Landscape is located in the north west corner of the Project, and included in the VAA.<br><br>Soils of the Jerrys Plains Soil Landscape generally have a profile depth of 60-300 cm (but generally less than 200cm, pH 6.0 to 8.5 and are sodosols or kurosols. These soils are assessed as low to moderately low fertility. They are low quality grazing country.<br><br>Soils of the Hunter Soil Landscape generally have a profile depth of 40-300 cm, pH 5.5 to 7.5.These soils are often vertosols of ASC groups which are assessed as moderately high or high fertility. The best quality land in the Hunter Soil Landscape is on the Hunter floodplain, not on the valley fills of tributaries that drain low fertility catchments (this is the case in the VAA). |
| **2. Is effective rooting depth to a physical barrier greater than or equal to 750 millimetres?**<br><br>**Physical barriers include bedrock, weathered bedrock, hard pans and continuous gravel layers and the type of barrier must be described. Effective rooting depth must be reported to the nearest 50 millimetres increment.** | **Requires field information**<br><br>Some profiles in mid slope positions have a soil depth to bedrock (weathered conglomerate and/or mudstones) of less than 750mm. On the footslopes and low gradient extensions of spurs, bedrock may also be encountered at depths of less than 750mm. Soils consistently greater than 750mm profile in depth are located on valley fill materials and at the interface with the Hunter alluvial soils. |

| Criteria to be assessed with additional field data | Information from preliminary assessment |
|---|---|
| 3. **Is soil drainage better than poor?**<br><br>**Look for grey and gley colours in dominant and subdominant mottles (not bioturbation mottling). Mottles must be distinct or prominent, with specific value/chroma ratings.** | **Requires field information**<br><br>In regional mapping, soil drainage in these soil landscapes is moderate. Generally, no grey or gley soil colours are reported in B horizons, although some B horizons are described as mottled. Where strong texture contrast exists in the profile, a bleached A2 horizon may be present.<br><br>Soils in valley fill of the lower reaches of tributary drainage lines, and particularly the clay soils at the interface with the Hunter Soil landscape, may be seasonally waterlogged.<br><br>Further information about drainage, based on field observations, is in **Section 4.1.**<br><br>Drainage is generally impeded but better than poor. |
| 4. **Is salinity (ECe) less than or equal to 4dS/M or are chlorides <800mg/kg when gypsum is present, within the uppermost 600mm of the soil profile?** | This cannot be determined without soil testing. Profiles have been sampled for ECe at multiple depths, up to greater than 750mm. Results are shown in **Section 4.2.1**.<br><br>Sites 14, 18, 23 and 24 have ECe values greater than 4. |
| 5. **Is effective rooting depth to a chemical barrier greater than or equal to 750 millimetres? Effective rooting depth must be reported to the nearest 50 millimetres increment.**<br><br>**A chemical barrier is defined as poor fertility, or elevated salinity or pH outside the range 5.0 to 8.9 (measured in water).** | This cannot be determined without field testing.<br><br>Profiles have been sampled for fertility indicators at multiple depths in the profile, from A0 horizon, through A1, A2, B1 and B2. Results of soil testing are included in **Section 4.2.1**.<br><br>Other than Site 21, which is outside the VAA, all soil profiles tested have an effective rooting depth (chemical barrier) less than 750mm. These soil materials have one or more of elevated ECe, pH and occasionally ESP. |

# 3.0 Field Assessment Method

This section describes the field based soil sampling process and laboratory testing conducted on soil samples from the VAA. The field based sampling provides detailed information about soil texture, structure, fabric, colour and assessment criteria such as drainage, salinity, pH, sodium and exchangeable cations.

## 3.1 Soil sampling sites

The distribution of detailed soil sites and check sites described in the field is shown in **Figure 3.1**. The sites cover the detailed VAA assessment areas, and an adjoining section of the Project Area which is mapped as including BSAL and is contiguous with a larger area of BSAL extending to the Hunter River.

Key factors in the soil sampling rationale include:

- Field sampling has been designed to provide representative coverage of the detailed VAA assessment area and adjoining land within the Project Area. Detailed sampling has been conducted to refine the boundary of soil mapped as BSAL at the regional scale. Approximately 3.0 hectares within the detailed VAA assessment area and 31.6 hectares within the overall Project Area, is mapped at the regional scale as BSAL in the north-west corner of the Project Area.

- The Interim Protocol requires three detailed soil sampling sites for each soil type. A total of 12 detailed soil sampling pits were excavated, consistent with four main soil types. Soil type is taken to mean one ASC to great group level (as per p14 of the Interim Protocol). While all soil types have some internal variability, the dominant soil types on which the BSAL status is determined should comprise more than 70% of a soil map unit. Where there is considerable variability, the Interim Protocol requires that soil map units should be split.

  In the detailed VAA assessment area and its immediate context within the Project Area, there is local variability in soil types. This reflects the geomorphology of the area which includes hill slope and low angle bedrock spurs extending into and under colluvial and alluvial valley fill materials. Both the bedrock spurs and tributary valley fill materials interface with the alluvial materials of the Hunter floodplain. This occurs outside the VAA. The geomorphic transition commences in the north-west extremity of the Project Area and continues outside the Project Area. Additional detailed sites have been sampled in this transition area to facilitate collection of samples for testing, as the BSAL status is dependent on soil chemistry.

- Eight check sites have been recorded in the detailed VAA assessment area and its immediate context area within the Project Area.

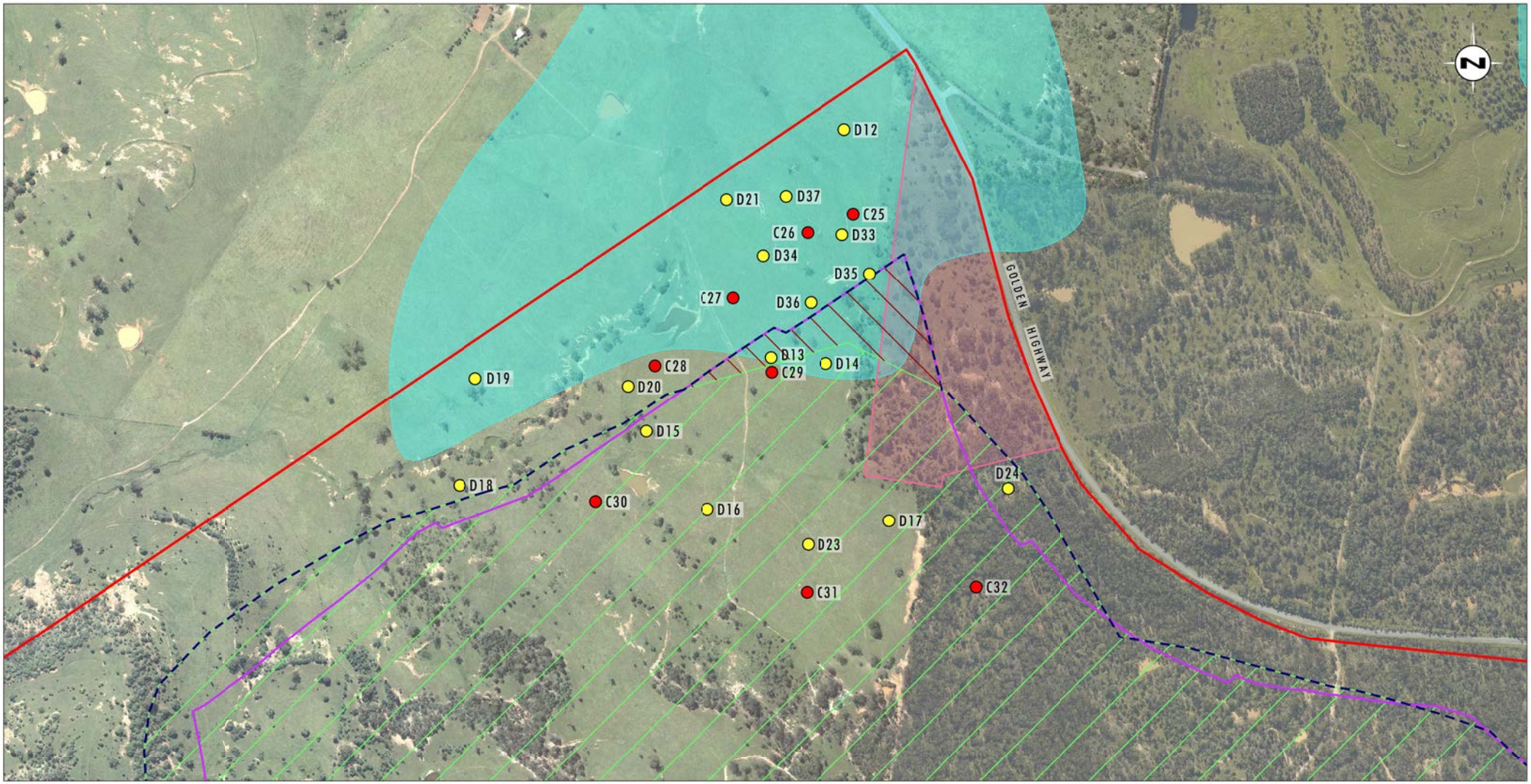


Image Source: AAM (2012), United (2015)
Data Source: Glencore (2014)

0 100 250 500m
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## Legend

- Project Area
- Proposed Open Cut Area
- Overall Verification Application Area
- Areas excluded from the Assessment
- Detailed Verification Assessment Area
- Regionally Mapped Biophysical Strategic Agricultural Land
- Crown Land
- Detailed Sites
- Check Sites

FIGURE 3.1

**Location of Detailed Soil Assessment Sites and Check Sites**

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## 3.2 Soil sampling method

This section outlines the soil description and sampling process for detailed sites and check sites and in the Project Area.

### 3.2.1 Field methods

Sixteen detailed soil description pits were excavated using a backhoe within the detailed VAA assessment area and its immediate context area within the Project Area for the purpose of clarifying the actual extent of BSAL and for use in the Agricultural Impact Assessment. These sites also help define the transition from non BSAL soils to BSAL soils.

Soil pits were excavated to at least 750 millimetres, or less where bedrock was encountered at shallow depth. Profile descriptions were recorded for soil materials from the surface to the base of each pit, with information recorded on SALIS soil data sheets. The following information was recorded for the A and B horizon.

- Site ID and GPS coordinates
- Photos of the surface soil at the site and the landscape context (ground cover, vegetation community) of the site
- Soil profile data was recorded using the SALIS soil data cards:
    - General site condition, including run-on, run-off, surface condition, ground cover, evidence of erosion etc
    - Layer status, depth and boundary conditions
    - Colour and mottles (Munsell)
    - Bedrock type where evident
    - Texture
    - pH (Raupach)
    - Structure and fabric
    - Consistence
    - Presence of coarse fragments
    - Presence of roots
    - Evidence of drainage condition.

#### 3.2.1.1 Soil sample collection

The Interim protocol requires soil samples to be collected and analysed from the detailed soil description and sampling sites.

Samples are required to be entirely from within a single soil horizon and to be identified by soil profile layer as well as by depth. The recommended soil sampling depths are 0-50mm, 50-150mm, 250-300mm, 300-600mm and 600-1000mm.

For the soils in this survey area, horizon boundaries cross some of these sampling depths at multiple sites. Sampling depths have therefore been modified to ensure that samples are entirely from within a single soil horizon.

#### 3.2.1.2 Laboratory testing

Laboratory testing was conducted to provide data for the following parameters, related to fertility and chemical barriers in the profile:

- Salinity (EC, converted to ECe)
- pH
- Exchangeable sodium percentage (ESP)
- Cation Exchange capacity (CEC)
- Ca:Mg ratio.

Results from the laboratory testing are presented in **Appendix A** and discussed in **Section 4.2.1**.

### 3.2.2 Check sites

In accordance with Section 10.0 of the Interim Protocol, check sites were recorded from hand augering, into the upper B-horizon or 500 millimetres (whichever came first. The check sites are located on a selection of terrain units and slopes, to provide representative descriptions of soil types across the landscape.

For each check site, the following information was recorded for the A and B horizon.

- Site ID and GPS coordinates
- Photos of the surface soil at the site and the landscape context of the site
- Soil profile data was recorded using the SALIS soil data cards:
    - General site condition, including run-on, run-off, surface condition, ground cover, evidence of erosion etc
    - Layer status, depth and boundary conditions
    - Colour and mottles (Munsell)

- Texture
- pH
- structure and fabric
- consistence
- presence of coarse fragments
- presence of roots.

Samples were also collected from some check sites for laboratory testing, to supplement the field evidence, particularly in relation to salinity, ESP and CEC in the upper B horizon.

# 4.0 Soil Verification Results and Assessment

The recorded land and soil information from field observations and laboratory analyses for each soil sampling site have been uploaded to the OEH Electronic Digital Infield Regolith Tool (eDIRT). The profile summaries for each soil sampling site (check sites) have been submitted to the NSW Soil and Land Information System (SALIS), with the applicable survey number. The accompanying laboratory data is included in **Appendix A**.

## 4.1 Drainage

Two types of intermittent poor drainage leading to waterlogging of soil materials are present within the VAA:

- In some shallow sodosol profiles, where the light textured A horizon overlies heavy clay (often over shallow bedrock), the vegetation or understory includes melaleuca species, suggesting that on occasions, water accumulates in the lower A horizon, being not able to infiltrate through the B horizon. These soils may set hard at the surface (so runoff rates are high), but when infiltration does occur it is held up at the texture contrast interface. Mottling of the B horizon is present in some profiles; and the A2 horizon is bleached. These soils have poor drainage.

- In the vertosol profiles which occur on low lying land at the interface of the bedrock country and the deep alluvial soils of the Hunter Soil Landscape (e.g. , standing water is intermittently present around shallow drainage depressions, but not for extended periods sufficient to generate gleyed or mottled B horizons. Some rush species are present in these areas. These soils have moderately good infiltration capacity (cracking when dry), but become saturated. Value/Chroma ratings do not meet the suggested criteria in the Interim Protocol (Munsell Value 5 or more with Chroma 2 or less).

## 4.2 Australian Soil Classification and fertility

Four broad soil groups (ASC order) are represented in the VAA and adjacent land in the Project Area. These are distributed in the landscape as follows (**Table 4.1**). The distribution of soils by Great Group is shown in **Figure 4.1**.

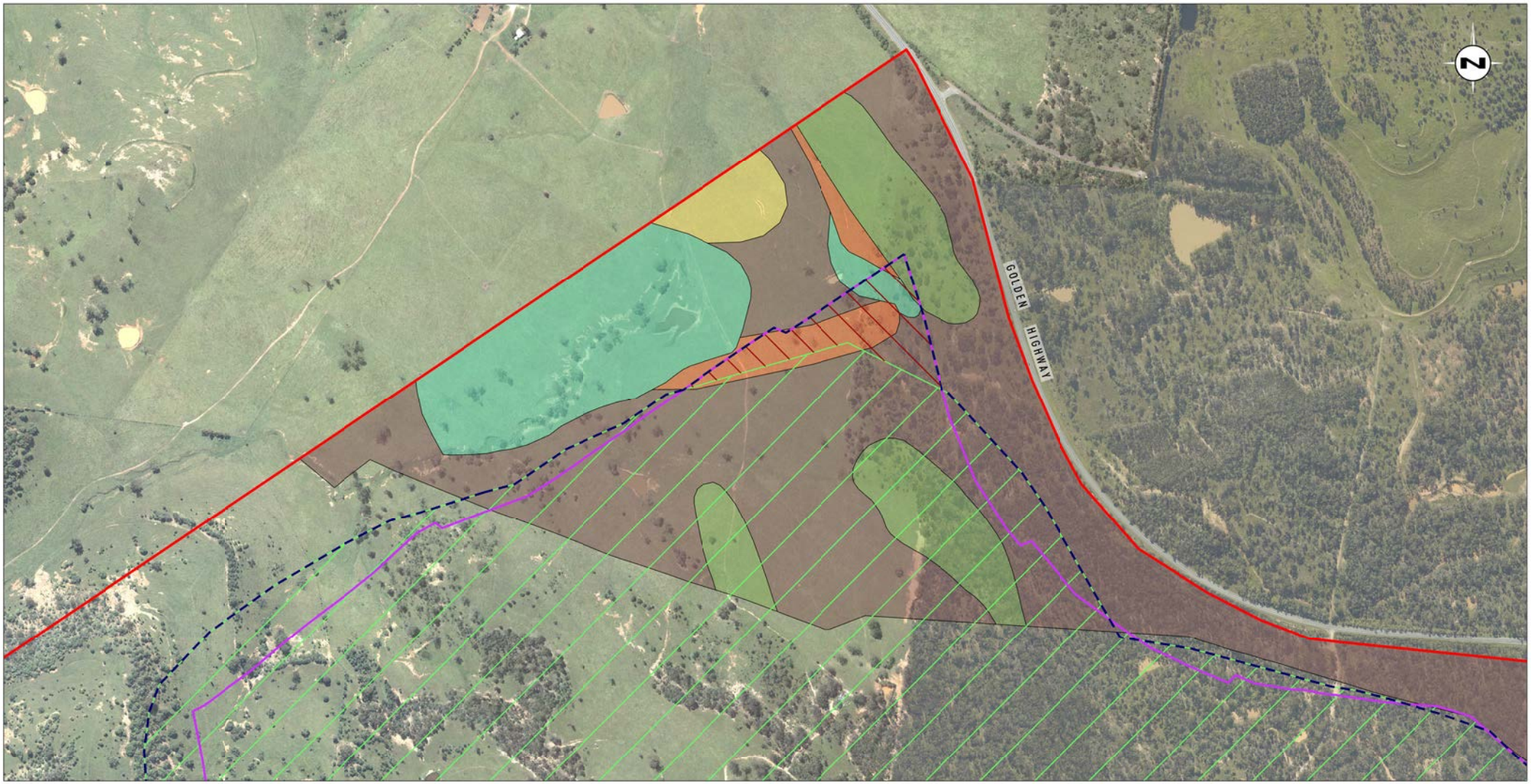



Image Source: AAM (2012), United (2015)
Data Source: Glencore (2014)

0 100 250 500m
1:10 000

## Legend

- Project Area
- Proposed Open Cut Area
- Overall Verification Application Area
- Areas excluded from the Assessment
- Detailed Verification Assessment Area
- Epipedal Vertosol
- Eutrophic Dermosol
- Eutrophic Chromosol
- Mesonatric Sodosol
- Subnatric Sodosol

FIGURE 4.1

**Soil Types by Great Soil Group**

File Name (A4): R01/3509_368.dgn
20160429 14.18

**Table 4.1 Broad soil groups in the detailed VAA assessment area**

| ASC Order | ASC Great groups | Landscape context | Fertility (as per Table 6 of the Interim Protocol) |
|---|---|---|---|
| **Sodosol**<br>**Subnatric: D15, D18, D23, D24, D34, D35, D36, D37, C30 and C31**<br>**Mesonatric: D19, D20, C27 and C28** | Brown subnatric and mesonatric, rarely mottled.<br>Strong texture contrast soils, elevated ESP, high pH, elevated ECe; may have rock at less than 750mm. | Most common soil type in the VAA, occurs on mid and lower slopes, underlain by sandstone, conglomerate and mudstone. | Moderately low. Defined in Table 6 of the Interim Protocol and confirmed with laboratory testing.<br>Refer also to **Section 4.2.1** |
| **Chromosol**<br>**D12, D16, D17, C25, C26 and C32** | Brown Eutrophic<br>Texture contrast soils, with B2 not strongly acid (pH >5.5), CEC>15 | Small areas of upper slope or ridge and spur crest (approximately 0.2 hectares). | May be moderately high in Table 6 of the Interim Protocol<br>Refer also to **Section 4.2.1** – field results indicate low to moderate fertility |
| **Dermosol**<br>**D13, D14, C29, D33** | Red/brown eutrophic<br>Gradational soil profiles with pedal B horizon but the texture contrast is not abrupt or clear | Colluvial materials at the boundary between low angle slopes and the valley flats | May be moderately high in Table 6 of the Interim Protocol<br>Field results indicate fertility constrained by sodicity. |
| **Vertosol**<br>**Refer to Profile D21** | Brown Epipedal<br>Uniform or gradational clay profiles, cracking, with moderate pedality in A horizon | Alluvial soils at interface of tributary valley fills and Hunter alluvium. Within the detailed VAA assessment area, there is 2.7 ha of vertosol. These soils are occasionally waterlogged. | May be moderately high (in Table 6 of the Interim Protocol )<br>Refer also to **Section 4.2.1** for actual field results |

**Tables 4.2** to **4.6** provide descriptions of typical profiles for each of the ASC Great Groups represented in the detailed VAA assessment area and its context within the Project Area, including contextual information, profile information and laboratory results.

**Table 4.2 Brown Eutrophic Chromosol**

| Typical Site Description | |
|---|---|
| **Australian Soil Classification Order and Suborder:** | Brown Eutrophic **Chromosol** |
| **Soil Landscape Units:** | Jerrys Plains and Hunter |
| **Slope Class :** | Occurs on slopes of less than 5% and 5 – 10% |
| **Landscape position:** | Spur crests and bedrock controlled benches on slopes |
| **Field sites:** | D12, D16, D17, C25, C26 and C32 |
| **LSC Class:** | Class 4 at best; limitation due to shallow depth and structural decline |
| **Soil Fertility:** | Based on Table 6 of the Interim Protocol: Moderately-high |
| **BSAL:** | Not mapped as BSAL at the regional scale; confirmed Not BSAL |
| **Soil profile characteristics** | Mid slope or low angle spur crest, fully cleared area and 100% ground cover, grassland. Currently grazed. Occasional cobble float on the surface, comprising ironstone and indurated sandstone or conglomerate.<br>Surface sets hard when dry.<br>A0: 0-9cm. 7.5YR3/3 (slightly moist) clay loam, includes scattered coarse angular stones and abundant roots); pH 6.0; weak polyhedral peds; abrupt horizon boundary.<br>A1: 9-45cm. 7.5YR4/4 (slightly moist) clay loam with faint root lines and burrows; pH 6.5. Strongly pedal (polyhedral); few scattered stones; clear boundary<br>B1: 45-63cm. 10YR5/4 (slightly moist) heavy clay; pH 8.5; moderate pedality, polyhedral peds, few scattered stones; pH 8.5.<br>Rock as base – weathered sandstone with fossils. |

| Typical Site Description | | |
|---|---|---|
| **Photos of context and excavated pit**<br>**Site 16 (left), Site 12 (right)** |  <br>  |  <br>  |

**Table 4.3 Epipedal Vertosol**

| Typical site description, based on D21 | |
|---|---|
| **Australian Soil Classification Order and Suborder:** | Brown epipedal vertosol |
| **Soil Landscape Units:** | Hunter Soil Landscape |
| **Slope Class :** | <5% |
| **Landscape position:** | Alluvium/alluvial fan associated with tributary drainage line, at interface with outer extremity of Hunter River floodplain. |
| **Field sites:** | D21 |
| **LSC Class:** | Class 3 |
| **Soil Fertility:** | Moderate |
| **BSAL:** | D21 is located close to the northwestern margin of the Project Area, outside of the VAA. It is the closest soil site to the floodplain of the Hunter River floodplain and is mapped as BSAL at the regional scale; it passes the BSAL criteria. |

| Typical site description, based on D21 | |
|---|---|
| **Soil profile characteristics: The vertosols meet the BSAL criteria** | D21<br><br>Valley flat, with very low gradient, within transition from bedrock sols to alluvial soils. Extensively cleared grassland, probably not cultivated; 100% ground cover. Imperfectly drained (intermittently ponded water in this area).<br><br>No surface float; surface cracks up to 15mm wide when dry; surface sets hard when dry.<br><br>A1: 0-19cm. 7.5YR5/2 medium clay, whole coloured; no stones, abundant roots; pH 6.0. Strong pedality, subangular blocky peds. Gradual boundary.<br><br>B1: 19-73cm. 10YR3/4, with faint yellow/grey mottle (10%), mostly following root lines. No stones. pH 7.0. Strong pedality with sub angular blocky peds; gradual boundary.<br><br>B2 73-90cm (and continues). 7.5YR3/4 with faint yellow/grey mottle, medium heavy clay. Strong pedality, smooth faced, subangular blocky. |
| **Photos of pit and context (D21)** |   |

**Table 4.4 Dermosol**

| Profile description based on D13 and D33 | |
|---|---|
| **Australian Soil Classification Order and Suborder:** | Brown eutrophic dermosol |
| **Soil Landscape Units:** | Hunter |
| **Slope Class :** | <5% |
| **Landscape position:** | Lower footslope, on colluviums, at transition from bedrock based soils to mixed alluvial washout and main valley alluvium |
| **Field sites:** | D13, D14, D33 |
| **LSC Class:** | Class 4 |
| **Soil Fertility:** | Moderate |
| **BSAL:** | No. Profile D13 is too shallow. Profile D33 has elevated ESP |

| Profile description based on D13 and D33 | |
|---|---|
| **Profile description (D13, D33)** | **D13**<br><br>Lower footslope, grading to tributary alluvium; slope <5%. Cleared area with native pasture, not cultivated. 100% ground cover.<br><br>Rare surface float of sandstone cobbles. Surface sets firm to hard and cracks when dry.<br><br>A0: 0-9cm. 7.5YR4/3 (slightly moist) light medium clay; pH 6.5. Abundant roots; no mottles. Moderate pedality, polyhedral. Abrupt boundary.<br><br>A1: 9-35cm. 7.5YR3/3 (slightly moist) medium heavy clay. pH 7.5; no mottles, no stones; strong pedality; subangular blocky. Gradual wavy boundary, following disturbance by roots.<br><br>B1: 35-50cm. 10YR5/4 (slightly moist) medium heavy clay, whole coloured. No stones; pH 9.0; moderate pedality – very large primary peds/clods (200mm), subangular blocky; gradual boundary.<br><br>B2: 50-70cm. 10YR4/4 (slightly moist); medium heavy clay, whole coloured; no stones; pH 9.0; moderate pedality, subangular blocky. Sharp boundary at base to rock<br><br>**D33**<br><br>Profile in slight depression in drainage flat of tributary drainage line. Shallow pool and channel are located between this profile and Profile D37 and occasional pools are scattered across the landform. Slope less than 3%. Imperfectly to poorly drained. Cleared woodland with grassy understory. 100% groundcover, mixed pasture grasses. Surface sets hard when dry.<br><br>A1, 0-15cm. 10YR5/3 (dry) clay loam. Many roots. No mottles, no segregations, no stones. pH 6.0. Weak pedality, rough faced. Abrupt boundary. Clear boundary<br><br>A2, 15-28cm. 10YR5/3 fine sandy loam, with pale fleck throughout, but not bleached. A few stones (angular gravel). pH 6.5. Likely part of an alluvial deposit (a1 and A2) overlying clay B. Clear boundary.<br><br>B1, 28-52cm. 7.5YR4/4 (very slightly moist) light clay red brown with 10-20% faint yellow grey mottle. Includes a few stones. pH 7.5. Moderate pedality<br><br>B2, 52-80cm and continuing. 5YR4/6 (slightly moist) medium clay. Strong colour and fabric contrast to materials above. No stones, whole coloured, no concretions. pH 8.0. Moderate pedality, smooth faced peds. |

| Profile description based on D13 and D33 | |
|---|---|
| Photos of Site D13 |  |

**Table 4.5 Mesonatric Sodosol**

| Typical soil profile description (based on D 19)<br>Sodosols are the most extensive profile type in the VAA and the Project Area<br>Note that mesonaric and subnatric soil profiles are similar (both sodic texture contrast profile), but one has higher ESP. | |
|---|---|
| Australian Soil Classification Order and Suborder: | Brown mesonatric sodosol |
| Soil Landscape Units: | Jerrys Plains |
| Slope Class : | 0-5% and 5-10% |
| Landscape position: | Local alluvial fill of tributary drainage line |
| Field sites: | D19, D20, C27, C28 |

| Typical soil profile description (based on D 19)<br>Sodosols are the most extensive profile type in the VAA and the Project Area<br>Note that mesonaric and subnatric soil profiles are similar (both sodic texture contrast profile), but one has higher ESP. | |
|---|---|
| **LSC Class:** | Class 4 |
| **Soil Fertility:** | Low to moderate |
| **BSAL:** | These soils are not BSAL. Refer to **Table 4.7** for soil chemistry details. |
| **Soil profile characteristics** | Valley flat with valley fill alluvium associated with Waterfall Creek. Incised alluvium on creek bank nearby shows exposure of similar profile and materials. Very low gradient (<5%). Extensively cleared, with occasional remnant ironbark specimen. 100% ground cover.<br>Surface is form in slightly moist condition, would set hard if dry.<br>A1: 0-7cm (most likely on wash from nearby slopes, not original soil form). 10YR5/4 (dry) clay loam, whole coloured, no stones. Lifts off the underlying materials. Roots abundant; pH 6.0. Weak pedality, sub angular blocky. Sharp boundary.<br>A2: 9-24cm. 10YR6/3 (bleached and hard set) with faint orange mesh of root stains; clay loam; no stones. Roots common. Lifts off the B horizon. pH 6.5. Moderate pedality, sub angular blocky; sharp boundary.<br>B1: 24-57cm. 10YR3/3 dark brown medium heavy clay, dry, whole coloured; pH 7.0. Roots common. Gravel lense from 60-70cm, with 10-20% gravel in size range 2-6mm and 6-20mm. Strong pedality, subangular blocky. Abrupt boundary.<br>B2: 62-80cm. 10YR4/4 (very slightly moist) medium heavy clay, whole coloured, no stones. Roots rare, pH 8.0. Moderate pedality |

| Typical soil profile description (based on D 19)<br>Sodosols are the most extensive profile type in the VAA and the Project Area<br>Note that mesonaric and subnatric soil profiles are similar (both sodic texture contrast profile), but one has higher ESP. | |
|---|---|
| Photos of site context and profile for (Site D19) |   |

**Table 4.6 Subnatric Sodosol**

| Typical soil profile description<br>Sodosols are the most extensive profile type in the VAA<br>Note that mesonaric and subnatric soil profiles are similar (both sodic texture contrast profile), but one has higher ESP. | |
|---|---|
| Australian Soil Classification Order and Suborder: | Brown subnatric sodosol |
| Soil Landscape Units: | Jerrys Plains soil landscape |
| Slope Class : | May occur on slopes of less than or equal to 10% and less than 5% |

| **Typical soil profile description**<br>**Sodosols are the most extensive profile type in the VAA**<br>**Note that mesonaric and subnatric soil profiles are similar (both sodic texture contrast profile), but one has higher ESP.** | |
|---|---|
| **Landscape position:** | Undulating mid to lower slopes |
| **Field sites:** | D15, D18, D23, D24, D34, D35, D36, D37, C30, C31, |
| **LSC Class:** | Class 4 or class 5 |
| **Soil Fertility:** | All sodosols are classed as having moderately low fertility (Table 6 of the Interim Protocol). This is confirmed in site specific soil tests (refer to **Table 4.7**) |
| **BSAL:** | Some of these soils are mapped as BSAL at the regional scale, but are confirmed to be not BSAL |
| **Soil profile characteristics (based on site D23). A profile description is also provided for D36.** | **D23** (**sodosol profile on hillslope**)<br>Profile on undulating hillslope, in mid slope position. The area is former woodland with grass understory but has been extensively cleared. Current vegetation is voluntary or native pasture. There is no rock outcrop, although outcrop (sandstone and conglomerate) does occur further up slope. There is moderately high run-on and the profile is imperfectly drained.<br>The surface sets hard when dry. Surface float, comprising very few sandstone and ironstone fragments, is present.<br>A1: 0-12cm. 7.5YR5/2 (dry), whole coloured, sticky sandy clay loam; pH 5.5. Abundant roots and animal (invertebrate) burrows. Moderate pedality, rough faced, sub angular blocky. Sharp boundary. A horizon lifts off the B horizon at the texture boundary when dry. Some cracks from the B horizon extend though the A horizon.<br>B1: 12-31cm. 7.5YR4/3 (dry) medium clay, whole coloured; pH 8.0. Fine roots are present, creating a fine 'fleck' throughout in terms of colour. Cracks 1mm to 3mm. Strong pedality, subangular blocky (almost prismatic), some with slick look on faces. A very few stones and concretions are present. Abrupt boundary. |

| Typical soil profile description<br>Sodosols are the most extensive profile type in the VAA<br>Note that mesonaric and subnatric soil profiles are similar (both sodic texture contrast profile), but one has higher ESP. | |
|---|---|
| | B2: 31-65cm. 5YR (dry) medium clay, whole coloured; pH 8.5. A few stones and segregations are present. Moderate pedality with subangular blocky peds. Abrupt boundary to weathering rock at 85cm.<br><br>**D36 – sodosol profile on valley flat**<br><br>Profile situated on slightly undulating, very low relief flat (alluvial /colluvial material from small tributary drainage line), slope less than 3%. Imperfectly drained. Flat low elevation spur is located to the north and also slightly to the north west of the site. Shallow exposures in drainage depressions to the north show gravelly clay B horizon and also a small area of sandstone cobbles.<br><br>Land is cleared former ironbark woodland, grass understory, now with 100% ground cover of grass, not cultivated.<br><br>Surface sets hard when dry.<br><br>A1, 0-19cm. 7.5YR5/4 (dry) sandy clay loam (gritty to coarse sand); very few stones, no concretions, no mottles. pH 6.5. Faint horizontal bedding features. Abundant roots and burrows. Moderate pedality with subangular blocky, rough faced peds, 100-200mm breaking to 50-100mm and 20-50mm. Abrupt boundary.<br><br>A2, 19-26cm. 7.5YR7/3 (dry), patchily bleached sandy clay loam. Darker material infills root lines and burrows. No stones, no concretions, no mottles. pH 5.5. Moderate pedality, subangular blocky, rough faced, 100-200mm, breaking to 50-100mm and 20-50mm. Abrupt boundary.<br><br>B1, 26-44cm. 7.5YR4/6 (dry), light medium clay; no stones, no concretions, no mottles. pH 6.5. Weak to moderate pedality, polyhedral, rough faced, 50-100mm. Abundant fine cracks. Clear boundary.<br><br>B2, 44-80cm and continuing; 5YR 4/6 (slightly moist) sticky medium clay. Occasional faint dull yellow mottle. Very few stones, no concretions. pH 7.0. Weak to moderate pedality, polyhedral, rough faced. |

| Typical soil profile description<br>Sodosols are the most extensive profile type in the VAA<br>Note that mesonaric and subnatric soil profiles are similar (both sodic texture contrast profile), but one has higher ESP. | |
|---|---|
| Photos of site context and profile form (D23) |   |

### 4.2.1 Fertility, salinity and pH assessment

Soil pH was recorded in the field for all profiles, and also tested in the laboratory (Rayment and Lyons 2011 method).

Salinity was tested in the laboratory (EC1:5) for all soil samples and converted to ECe using the conversion factors noted in the Interim Protocol (p25). In relation to BSAL, if the ECe threshold is exceeded anywhere in the upper 600mm of the profile, the soil is not BSAL.

The Interim Protocol (p26) (NSW Government 2013) states that effective rooting depth to a chemical barrier is the depth of soil material from the surface to a depth where limiting values of pH, chloride content, electrical conductivity exchangeable sodium percentage and the calcium to magnesium ratio exist. These may occur individually or in combination. Exchangeable cations, including Exchangeable sodium percentage (ESP), Cation Exchange Capacity (CEC) and Ca:Mg ratio were obtained from laboratory tests.

The data for pH, ECe, ESP, CEC and Ca/Mg ratio are summarised in **Table 4.7**.

In relation to CEC, DPI Agriculture advises that a figure above 10 cmol (+)/kg is preferred for plant production. Soils with high levels of swelling clay and organic matter can have a CEC of 30 cmol(+)/kg or more. CEC is not used as a threshold by itself to determine BSAL, but is used to calculate other values. Fertile soils will have a CEC of at least 10, linked to relatively low sodium. The desirable ranges for exchangeable cations are: calcium 65–80% of CEC, magnesium 10–15%, potassium 1–5%, sodium 0–1% and aluminium 0%.

The relevant criteria for BSAL (effective rooting depth), as set out in the Interim Protocol (NSW Government 2013), are:

- pH in water - must be within the range 5.0-8.9, or in CaCl2, 4.5-8.1
- salinity ECe must be less than 4dS/m
- ESP – must be less than 15
- Ca:Mg ratio – must be >0.1, noting that an Ca:Mg ratio of less than 1.0 indicates a tendency to disperse.

Shading indicates values that fail BSAL fertility criteria.

**Table 4.7 Soil fertility, pH and salinity data**

| Site<br><br>Threshold | ECe<br><br></=4dS /m | pH<br><br>5.0-8.9 in water | pH $CaCl_2$<br><br>4.5 -8.1 | ESP<br><br><15 | Ca/Mg<br><br>>0.1 | CEC<br><br>Used to calculate other values | Depth to physical barrier<br><br>750mm | Possible BSAL?<br>Must meet all criteria to pass as BSAL |
|---|---|---|---|---|---|---|---|---|
| Site 12, A0 0-100mm | 1.81 | 5.9 | 5.2 | 0.85 | 2.30 | 23.6 | N/A | **Site 12** is on a low relief bedrock spur, extending into the area mapped as BSAL at the regional scale<br>This site is shallower than the specified 750mm depth to a physical barrier (bedrock reached at 600 mm).<br>Soil texture is light clay and clay loam over medium heavy clay<br>The soil materials would meet requirements on other criteria.<br>Soil Type – **Brown Eutrophic Chromosol**:<br>• Not sodic – ESP<6 in B Horizon<br>• Not strongly acid – pH (1:5 Soil:Water) is >5.5 and ; and pH (1:5 Soil:$CaCl_2$) is >4.6<br>• Abrupt B-horizon, texture contrast<br>• CEC – Base status >15cmol(+)$kg^{-1}$ in B Horizon<br>• 10YR 5/4 = Brown<br>This site has moderately-high fertility.<br>**This site is not BSAL.** |
| Site 12, A1 100-150mm | 0.34 | 6.0 | 5.1 | 0.87 | 1.83 | 23.1 | N/A | |
| Site 12, A1 150-300mm | 0.15 | 6.6 | 5.5 | 1.08 | 1.64 | 27.9 | N/A | |
| Site 12, A1 300-450mm | 1.05 | 8.5 | 7.9 | 1.29 | 2.00 | 30.9 | N/A | |
| Site 12, B 450-600mm | 1.05 | 8.8 | 8.0 | 2.40 | 1.50 | 29.2 | Bedrock at 600mm | |

| Site<br><br>Threshold | ECe<br><br></=4dS/m | pH<br><br>5.0-8.9 in water | pH $CaCl_2$<br><br>4.5 -8.1 | ESP<br><br><15 | Ca/Mg<br><br>>0.1 | CEC<br><br>Used to calculate other values | Depth to physical barrier<br><br>750mm | Possible BSAL?<br>Must meet all criteria to pass as BSAL |
|---|---|---|---|---|---|---|---|---|
| Site 13, A0 0-90mm | 0.6 | 6.0 | 5.2 | 1.68 | 1.36 | 17.9 | N/A | **Site 13** is on the lower slope, on the margin of the area mapped as BSAL at the regional scale<br>This site fails on both chemical constraints with results in the B-horizon being above criteria for pH.<br>This site also fails on depth to a physical barrier being greater or equal to 750 mm (bedrock reached at 600 mm).<br>Soil Type – **Brown Eutrophic dermosol**:<br>• Sodic – ESP>6 in B Horizon<br>• Not strongly acid – pH (1:5 Soil:Water) is >5.5 and ; and pH (1:5 Soil:$CaCl_2$) is >4.6<br>• Uniform texture profile (medium clay) (ECe conversion 7.5)<br>• CEC – Base status >15cmol(+)$kg^{-1}$ in B Horizon<br>• 10YR 4/4 = Brown<br>This site has moderately-high fertility.<br>**This site is not BSAL.** |
| Site 13, A1 90-150mm | 0.6 | 6.0 | 5.2 | 2.70 | 0.82 | 18.5 | N/A | |
| Site 13, A1 150-350mm | 2.02 | 8.7 | 8.0 | 6.67 | 0.61 | 36.0 | N/A | |
| Site 13, B1 350-500mm | 2.77 | **9.2** | **8.4** | 9.03 | 0.56 | 32.1 | N/A | |
| Site 13, B2 350-600mm | 3.97 | **9.4** | **8.4** | 11.44 | 0.49 | 30.6 | Bedrock at 600mm | |

| Site<br><br>Threshold | ECe<br><br></=4dS/m | pH<br><br>5.0-8.9 in water | pH $CaCl_2$<br><br>4.5 -8.1 | ESP<br><br><15 | Ca/Mg<br><br>>0.1 | CEC<br><br>Used to calculate other values | Depth to physical barrier<br><br>750mm | Possible BSAL?<br>Must meet all criteria to pass as BSAL |
|---|---|---|---|---|---|---|---|---|
| Site 14, A0 0-100mm | 0.52 | 6.3 | 5.7 | 1.81 | 1.54 | 22.1 | N/A | **Site 14** is on the lower slope, just outside the area mapped as BSAL at the regional scale.<br>This site fails the BSAL criterion for pH (up to 600mm), ESP (up to 750mm) and ECe (up to 600mm) with results in the B-horizon being above criteria.<br>Soil Type –Brown Eutrophic Dermosol:<br>• Sodic – ESP>6 in B Horizon<br>• Not strongly acid – pH (1:5 Soil:Water) is >5.5 and ; and pH (1:5 Soil:$CaCl_2$) is >4.6<br>• Uniform texture profile (medium clay)<br>• CEC – Base status >15cmol(+)$kg^{-1}$ in B Horizon<br>• Clear colour change B-horizon<br>• 7.5YR 4/6 = Brown<br>This site has moderately-high fertility.<br>**This site is not BSAL.** |
| Site 14, A1 100-200mm | 0.3 | 6.5 | 5.7 | 2.80 | 1.48 | 21.5 | N/A | |
| Site 14, A1 200-300mm | 0.52 | 8.1 | 6.7 | 7.09 | 0.86 | 38.1 | N/A | |
| Site 14, A1 300-400mm | **4.3** | **9.0** | **8.2** | 12.94 | 0.79 | 39.4 | N/A | |
| Site 14, A2 400-600mm | **5.68** | **9.0** | **8.3** | 14.93 | 0.74 | 37.5 | N/A | |
| Site 14, B1 600-700mm | **8.64** | 8.9 | **8.3** | 14.78 | 0.73 | 34.5 | N/A | |
| Site 14, B1 700-900mm | **9.22** | 8.9 | **8.3** | **15.02** | 0.68 | 36.6 | N/A | |
| Site 15, A1 0-100mm | 0.25 | 5.6 | 4.6 | 4.17 | 1.41 | 9.6 | N/A | **Site 15** is on the lower slope, within the alluvial/colluvial fan associated with Waterfall Creek. It is not mapped as BSAL at the regional scale.<br>As a Sodosol profile, this site is deemed to fail |
| Site 15, A2 100-150mm | 0.172 | 5.6 | 4.5 | 4.05 | 0.82 | 7.4 | N/A | |

| Site<br><br>Threshold | ECe<br><br></=4dS/m | pH<br><br>5.0-8.9 in water | pH $CaCl_2$<br><br>4.5 -8.1 | ESP<br><br><15 | Ca/Mg<br><br>>0.1 | CEC<br><br>Used to calculate other values | Depth to physical barrier<br><br>750mm | Possible BSAL?<br>Must meet all criteria to pass as BSAL |
|---|---|---|---|---|---|---|---|---|
| Site 15, B1 200-300mm | 0.525 | 5.9 | 4.8 | 7.14 | 0.37 | 19.6 | N/A | the BSAL criteria, based on fertility. However, laboratory results appear to meet both chemical and physical criteria for BSAL. ESP is elevated, but is below the threshold value of 15.<br>ECe exceeds the threshold in the lower B horizon, but not in the upper 600mm as required.<br>Soil Type – **Red Subnatric Sodosol**:<br>• Sodic – ESP>6 in B Horizon<br>• Not strongly acid – pH (1:5 Soil:Water) is >5.5 and ; and pH (1:5 Soil:$CaCl_2$) is >4.6<br>• CEC – Base status >15cmol(+)$kg^{-1}$ in B Horizon<br>• ESP 6-15 in B horizon<br>• Clear B-horizon, texture contrast and colour<br>• 5YR 4/4= Red<br>This site has moderately-low fertility.<br>**This site is not BSAL.** |
| Site 15, B1 300-450mm | 0.825 | 5.7 | 4.7 | 8.29 | 0.30 | 19.3 | N/A | |
| Site 15, B 450-600mm | 1.725 | 5.9 | 5.0 | 11.83 | 0.26 | 18.6 | N/A | |
| Site 15, B 600-900mm | **4.35** | 7.7 | 6.6 | 12.50 | 0.24 | 19.2 | N/A | |
| Site 16, A1 0-100mm | 0.276 | 5.8 | 4.9 | 2.38 | 1.60 | 8.4 | N/A | **Site 16** is located mid slope, in an area not mapped as BSAL at the regional scale. |

| Site<br><br>Threshold | ECe<br><br></=4dS/m | pH<br><br>5.0-8.9 in water | pH $CaCl_2$<br><br>4.5 -8.1 | ESP<br><br><15 | Ca/Mg<br><br>>0.1 | CEC<br><br>Used to calculate other values | Depth to physical barrier<br><br>750mm | Possible BSAL?<br>Must meet all criteria to pass as BSAL |
|---|---|---|---|---|---|---|---|---|
| Site 16, A2 100-250mm | 0.138 | 6.3 | 5.0 | 1.96 | 0.93 | 5.1 | N/A | The lower B horizon of this site is not within the BSAL limits for pH (up to 600mm).<br>Importantly, this site is also shallower than the specified 750mm depth to a physical barrier (bedrock reached at 550 mm).<br>Soil Type – **Brown Eutrophic Chromosol**:<br>• Not sodic – ESP<6 in B Horizon<br>• Not strongly acid – pH (1:5 Soil:Water) is >5.5 and ; and pH (1:5 Soil:$CaCl_2$) is >4.6<br>• Abrupt B-horizon, strong texture contrast<br>• ESP <6 in B horizon<br>• CEC – Base status >15cmol(+)$kg^{-1}$ in B Horizon<br>• 10YR 5/6= Brown<br>This site has moderately-high fertility.<br>**This site is not BSAL.** |
| Site 16, B1 250-400mm | 0.375 | 8.4 | 7.2 | 3.61 | 0.32 | 19.4 | N/A | |
| Site 16, B1 400-550mm | 1.05 | **9.0** | **8.2** | 5.65 | 0.40 | 17.7 | Bedrock at 550mm | |
| Site 17, B 0-150mm | 0.225 | 6.4 | 5.4 | 1.92 | 0.90 | 20.8 | N/A | **Site 17** is located on the mid to lower slope, approximately 100m from a severely eroded drainage line<br>The lower B horizon and C horizon of this site do not meet the BSAL thresholds for pH (up to |
| Site 17, B 150-300mm | 0.3 | 7.5 | 6.3 | 2.49 | 0.95 | 25.1 | N/A | |

| Site<br><br>Threshold | ECe<br><br></=4dS/m | pH<br><br>5.0-8.9 in water | pH $CaCl_2$<br><br>4.5 -8.1 | ESP<br><br><15 | Ca/Mg<br><br>>0.1 | CEC<br><br>Used to calculate other values | Depth to physical barrier<br><br>750mm | Possible BSAL?<br>Must meet all criteria to pass as BSAL |
|---|---|---|---|---|---|---|---|---|
| Site 17, B/C 300-450mm | 1.65 | 8.8 | 8.1 | 5.11 | 1.16 | 31.3 | N/A | 600mm).<br>Importantly, this site is also shallower than the depth to a physical barrier being greater or equal to 750 mm (bedrock reached at 450 mm).<br>Soil Type – **Brown Eutrophic Chromosol (noted erosion of A horizon)**:<br>• Not sodic – ESP<6 in B Horizon<br>• Not strongly acid – pH (1:5 Soil:Water) is >5.5 and ; and pH (1:5 Soil:$CaCl_2$) is >4.6<br>• CEC – Base status >15cmol(+)$kg^{-1}$ in B Horizon<br>• Clear B-horizon (colour), uniform texture profile<br>• 7.5YR 3/4= Brown<br>This site has moderately-high fertility.<br>**This site is not BSAL.** |
| Site 17, C 450-550mm | 2.625 | **9.2** | **8.4** | 7.14 | 1.05 | 29.4 | Bedrock at 450mm | |
| Site 18 0-100mm | 0.26 | 6.3 | 5.3 | 1.75 | 1.8 | 11.4 | N/A | **Site 18** is located on the lower slope, in an area not mapped as BSAL at the regional scale.<br>This site fails the BSAL criterion for ECe (up to 600mm) and pH (up to 600mm) with results in the B-horizon being above criteria. |
| Site 18, B1 200-300mm | 0.75 | 7.8 | 6.7 | 8.43 | 0.76 | 24.9 | N/A | |

| Site<br><br>Threshold | ECe<br><br></=4dS/m | pH<br><br>5.0-8.9 in water | pH $CaCl_2$<br><br>4.5 -8.1 | ESP<br><br><15 | Ca/Mg<br><br>>0.1 | CEC<br><br>Used to calculate other values | Depth to physical barrier<br><br>750mm | Possible BSAL?<br>Must meet all criteria to pass as BSAL |
|---|---|---|---|---|---|---|---|---|
| Site 18, B1 300-400mm | 3.90 | **8.9** | 8.1 | 10.59 | 1.37 | 32.1 | N/A | Soil type – **Brown Mottled-Subnatric Sodosol**:<br>• Sodic – ESP>6 in B Horizon<br>• Not strongly acid – pH (1:5 Soil:Water) is >5.5 and ; and pH (1:5 Soil:$CaCl_2$) is >4.6<br>• Clear B-horizon, texture contrast profile<br>• CEC – Base status >15cmol(+)$kg^{-1}$ in B Horizon<br>• 7.5YR 4/4 = Brown<br>This site has moderately-low fertility.<br>**This site is not BSAL.** |
| Site 18, B1 400-550mm | **5.03** | **9.1** | **8.3** | 11.65 | 1.60 | 30.9 | N/A | |
| Site 18, B2 550-700mm | **6.23** | **9.1** | **8.3** | 12.46 | 1.57 | 32.1 | N/A | |
| Site 18, C 700+mm | **8.25** | **9.2** | **8.3** | **17.30** | 1.52 | 31.8 | N/A | |
| Site 19, A1 0-100mm | 0.52 | 5.8 | 4.9 | 3.79 | 1.41 | 13.2 | N/A | **Site 19** is located in a flat area, in an area mapped as BSAL at the regional scale.<br>The B-horizon of this site does not meet the BSAL thresholds for ESP (up to 750mm) and ECe (up to 600mm).<br>Soil type – **Brown Mesonatric Sodosol**:<br>• Sodic – ESP>6 in B Horizon<br>• Not strongly acid – pH (1:5 Soil:Water) is >5.5 and ; and pH (1:5 Soil:$CaCl_2$) is >4.6<br>• Abrupt B-horizon, texture contrast profile<br>• CEC – Base status >15cmol(+)$kg^{-1}$ in B Horizon |
| Site 19, A2 100-200mm | 0.60 | 6.4 | 5.1 | 10.32 | 0.78 | 12.6 | N/A | |
| Site 19, B1 300-400mm | 2.03 | 6.0 | 4.9 | **18.64** | 0.49 | 23.6 | N/A | |
| Site 19, B1 400-500mm | 3.83 | 7.1 | 6.2 | **21.12** | 0.45 | 25.1 | N/A | |
| Site 19, B2 500-600mm | **6.08** | 8.0 | 7.0 | **24.30** | 0.39 | 25.1 | N/A | |

| Site<br><br>Threshold | ECe<br><br></=4dS/m | pH<br><br>5.0-8.9 in water | pH $CaCl_2$<br><br>4.5 -8.1 | ESP<br><br><15 | Ca/Mg<br><br>>0.1 | CEC<br><br>Used to calculate other values | Depth to physical barrier<br><br>750mm | Possible BSAL?<br>Must meet all criteria to pass as BSAL |
|---|---|---|---|---|---|---|---|---|
| Site 19, B2 600-700mm | **8.33** | 8.3 | 7.4 | **24.16** | 0.37 | 29.8 | N/A | • 10YR 3/3 = Brown<br>This site has moderately-low fertility.<br>**This site is not BSAL.** |
| Site 20, A1 0-100mm | 0.14 | 5.5 | 4.5 | 1.59 | 2.00 | 6.3 | N/A | **Site 20** is located on the lower slope, in an area not mapped as BSAL at the regional scale.<br>As a sodosol, this profile has a moderately low fertility (Table 6 of the Interim Protocol) and is not BSAL<br>Field data indicate that the B-horizon of this site does not meet the BSAL thresholds for ESP (up to 750mm).<br>Soil type – **Brown Mesonatric Sodosol**:<br>• Sodic – ESP>6 in B Horizon<br>• Not strongly acid – pH (1:5 Soil:Water) is >5.5 and ; and pH (1:5 Soil:$CaCl_2$) is >4.6<br>• CEC – Base status >15cmol(+)$kg^{-1}$ in B Horizon<br>• Strong texture contrast, bleached A2<br>• 7.5YR 4/4 = Brown<br>This site has moderately-low fertility.<br>**This site is not BSAL.** |
| Site 20, A2 100-200mm | 0.14 | 6.1 | 5.0 | 1.85 | 1.67 | 5.4 | N/A | |
| Site 20, A2 200-300mm | 0.14 | 6.3 | 5.0 | 4.55 | 1.44 | 4.4 | N/A | |
| Site 20, A2 300-400mm | 0.97 | 7.0 | 5.7 | 12.42 | 0.34 | 15.3 | N/A | |
| Site 20, B1 400-500mm | 0.83 | 7.5 | 6.1 | 14.45 | 0.33 | 17.3 | N/A | |
| Site 20, B2 500-750mm | 2.33 | 8.7 | 7.3 | **21.53** | 0.22 | 20.9 | N/A | |

| Site<br><br>Threshold | ECe<br><br></=4dS/m | pH<br><br>5.0-8.9 in water | pH $CaCl_2$<br><br>4.5 -8.1 | ESP<br><br><15 | Ca/Mg<br><br>>0.1 | CEC<br><br>Used to calculate other values | Depth to physical barrier<br><br>750mm | Possible BSAL?<br>Must meet all criteria to pass as BSAL |
|---|---|---|---|---|---|---|---|---|
| Site 21, A1 0-100mm | 0.38 | 5.9 | 5.0 | 1.29 | 1.44 | 15.3 | N/A | **Site 21** is in a flat area, in an area mapped as BSAL at the regional scale<br>This site appears to meet both chemical and physical criteria for BSAL. ESP is elevated, but is just below the threshold value of 15. ECe is only just below the 4dS/m threshold in the B horizon.<br>Soil type – **Brown Epipedal Vertosol**:<br>• Sodic – ESP>6 in B Horizon<br>• Not strongly acid – pH (1:5 Soil:Water) is >5.5 and ; and pH (1:5 Soil:$CaCl_2$) is >4.6<br>• Clear B-horizon (colour change), gradual texture profile<br>• CEC – Base status >15cmol(+)$kg^{-1}$ in B Horizon<br>• 7.5YR 3/4 = Brown<br>This site has moderately-high fertility.<br>**This site meets the BSAL criteria.**<br>**This site is within the Project Area, but outside the verification application area.** |
| Site 21, A1 100-180mm | 0.15 | 6.1 | 5.0 | 2.09 | 1.49 | 14.3 | N/A | |
| Site 21, B1 180-300mm | 0.45 | 7.5 | 6.3 | 5.58 | 1.21 | 21.5 | N/A | |
| Site 21, B1 300-400mm | 0.45 | 7.7 | 6.4 | 6.64 | 0.90 | 21.1 | N/A | |
| Site 21, B1 400-500mm | 1.95 | 8.0 | 7.1 | 13.41 | 0.87 | 24.6 | N/A | |
| Site 21, B1 500-600mm | 3.98 | 7.8 | 7.1 | 14.73 | 0.66 | 25.8 | N/A | |
| Site 21, B1 600-750mm | 3.45 | 8.5 | 7.6 | 13.22 | 0.75 | 22.7 | N/A | |
| Site 23, A1 0-120mm | 0.09 | 6.3 | 5.2 | 1.12 | 1.19 | 8.9 | N/A | **Site 23** is located on the lower slope, in an area not mapped as BSAL at the regional scale. No |

| Site<br><br>Threshold | ECe<br><br></=4dS /m | pH<br><br>5.0-8.9 in water | pH $CaCl_2$<br><br>4.5 -8.1 | ESP<br><br><15 | Ca/Mg<br><br>>0.1 | CEC<br><br>Used to calculate other values | Depth to physical barrier<br><br>750mm | Possible BSAL?<br>Must meet all criteria to pass as BSAL |
|---|---|---|---|---|---|---|---|---|
| Site 23, B1 120-200mm | 0.15 | 7.0 | 5.6 | 0.44 | 0.53 | 22.6 | N/A | sodosol profiles are considered to meet the fertility criteria for BSAL.<br>The B-horizon of this site does not meet the BSAL thresholds for ESP (up to 750mm), pH (up to 600mm) and ECe (up to 600mm).<br>Soil type – **Brown Subnatric Sodosol**:<br>• Sodic – ESP>6 in B Horizon<br>• Not strongly acid – pH (1:5 Soil:Water) is >5.5 and ; and pH (1:5 Soil:$CaCl_2$) is >4.6<br>• Abrupt B-horizon, strong texture contrast<br>• CEC – Base status >15cmol(+)$kg^{-1}$ in B Horizon<br>• 7.5YR 4/4 = Brown<br>This site has moderately-low fertility.<br>**This site is not BSAL.** |
| Site 23, B1 200-300mm | 0.38 | 7.8 | 6.5 | 2.02 | 0.49 | 24.7 | N/A | |
| Site 23, B2 300-450mm | 2.03 | 8.8 | 8.0 | 6.80 | 0.47 | 25.0 | N/A | |
| Site 23, B2 450-600mm | **6.38** | **9.1** | **8.3** | 9.94 | 0.80 | 33.2 | N/A | |
| Site 23, C 650-800mm | **8.63** | **9.1** | **8.4** | 13.36 | 0.39 | 30.7 | N/A | |
| Site 24, A2 0-100mm | 0.95 | 7.2 | 6.7 | 2.38 | 0.69 | 8.4 | N/A | **Site 24** is located on the crest of a low angle spur, in an area not mapped as BSAL at the regional scale.<br>The B-horizon of this site does not meet the BSAL threshold for ECe (<4 up to 750mm).<br>Soil type – **Brown Subnatric Sodosol**:<br>• Sodic – ESP>6 in B Horizon |
| Site 24, B1 200-300mm | 2.63 | 6.3 | 5.7 | 6.36 | 0.33 | 22.0 | N/A | |
| Site 24, B1 400-550mm | 2.85 | 6.1 | 5.4 | 8.80 | 0.35 | 25.0 | N/A | |

| Site<br><br>Threshold | ECe<br><br></=4dS/m | pH<br><br>5.0-8.9 in water | pH $CaCl_2$<br><br>4.5 -8.1 | ESP<br><br><15 | Ca/Mg<br><br>>0.1 | CEC<br><br>Used to calculate other values | Depth to physical barrier<br><br>750mm | Possible BSAL?<br>Must meet all criteria to pass as BSAL |
|---|---|---|---|---|---|---|---|---|
| Site 24, B2<br>650+mm | **5.33** | **9.0** | 8.1 | 12.27 | 0.72 | 32.6 | N/A | • Not strongly acid – pH (1:5 Soil:Water) is >5.5 and ; and pH (1:5 Soil:$CaCl_2$) is >4.6<br>• CEC – Base status >15cmol(+)$kg^{-1}$ in B Horizon<br>• Clear B-horizon, strong texture contrast profile<br>• 10YR 4/4 = Brown<br>This site has moderately-low fertility.<br>**This site is not BSAL.** |
| Site 33, A1 | 0.17 | 6.2 | | 1.5 | 1.74 | 13.6 | | Soil type - Red brown eutrophic dermosol<br>At outer margin of BSAL |
| Site 33, A2 | 0.09 | 6.5 | | 2.1 | 1.85 | 14.3 | | |
| Site 33, B1 | 0.52 | 7.1 | | 6.1 | 1.12 | 11.5 | n/a | |
| Site 34, A1 | 0.38 | 6.1 | | 4.0 | 1.0 | 12.5 | | Soil type - **Brown mesonatric sodosol**<br>Site has moderately low fertility.<br>This site is not BSAL |
| Site 34, B1 | 0.38 | 7.9 | | 6.8 | 0.69 | 23.6 | | |
| Site 34, B2 | **4.7** | **8.9** | | 15.2 | 0.66 | 23.0 | **Bedrock at 63cm** | |
| Site 35, A1 | 0.26 | 6.0 | | 4.2 | 1.3 | 9.4 | | Soil type - **Brown subnatric sodosol**<br>Site has moderately low fertility.<br>This site is not BSAL |
| Site 35, B1 | 0.75 | 7.2 | | 10.3 | 0.67 | 15.4 | | |
| Site 35, B2 | 1.35 | 6.7 | | 10.3 | 0.63 | 16.5 | n/a | |

| Site | ECe | pH | pH $CaCl_2$ | ESP | Ca/Mg | CEC | Depth to physical barrier | Possible BSAL? Must meet all criteria to pass as BSAL |
|---|---|---|---|---|---|---|---|---|
| **Threshold** | **</=4dS /m** | **5.0-8.9 in water** | **4.5 -8.1** | **<15** | **>0.1** | **Used to calculate other values** | **750mm** | |
| Site 36, A1 | 0.28 | 6.2 | | 1.5 | 1.7 | 13.1 | | Soil type - **Brown subnatric sodosol**<br>Site has moderately low fertility.<br>This site is not BSAL |
| Site 36, A2 | 0.09 | 5.9 | | 1.8 | 1.5 | 10.9 | | |
| Site 36, B1 | 0.17 | 6.5 | | 5.0 | 1.1 | 12.0 | | |
| Site 36, B2 | 0.82 | 6.3 | | 7.6 | 0.8 | 15.6 | n/a | |
| Site 37, A1 | 0.17 | 6.0 | | 1.7 | 1.6 | 17.1 | | Soil type - **Brown subnatric sodosol**<br>Site has moderately low fertility.<br>This site is not BSAL |
| Site 37, A2 | 0.09 | 6.9 | | 2.9 | 1.9 | 13.5 | | |
| Site 37, B1 | 0.45 | 8.1 | | 8.8 | 1.01 | 18.1 | | |
| Site 37, B2 | 2.9 | 8.7 | | 2.7 | 0.82 | 24.1 | n/a | |

## 4.3 Summary of verification criteria

**Table 4.8** summarises the application of the VAA criteria (from the Interim Protocol) to the Project.

None of the soils in the relevant parts of the detailed VAA assessment area meet the criteria for BSAL. The indicative area that meets the BSAL criteria is shown in **Figure 4.2**.

**Table 4.8 Site BSAL Verification Summary for VAA**

| Site Sample Number | Australian Soil Classification | 1. Is Slope <10%? | 2. Is there <30% Rock Outcrop? | 3 <20% Unattached Rock Fragments >60mm? | 4. Does <50% have Gilgais >50mm deep? | 5. Is Slope <5%? | 6. Are there nil rock outcrops? | 7a. Does soil have Moderate fertility? | 7b. Does soil have Moderately-High or High fertility? | 8. Is Effective Rooting Depth (ERD) to a physical barrier >750mm? | 9. Is drainage better than poor? | 10. Is pH between 5.0 and 8.9? | 11. Is salinity (ECe) <4dS/m? | 12. Is ERD to a chemical barrier >750mm? | Is the Site BSAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 12 | Brown Eutrophic Chromosol | Yes[1] | Yes | Yes | Yes | Yes[2] | Yes | Yes | Yes | No | Yes | Yes | Yes | No[3] | No |
| 13 | Brown eutrophic dermosol | Yes[1] | Yes | Yes | Yes | Yes[2] | Yes | Yes | Yes | No | Yes | Yes | Yes | No[3] | No |
| 14 | Brown eutrophic dermosol | Yes[1] | Yes | Yes | Yes | Yes[2] | Yes | Yes | Yes | Yes | Yes | Yes | Yes | No[3] | No |
| 15 | Red Subnatric Sodosol | Yes[1] | Yes | Yes | Yes | Yes[2] | Yes | No | No | Yes | Yes | Yes | Yes | No[3] | No |
| 16 | Brown Eutrophic Chromosol | Yes[1] | Yes | Yes | Yes | Yes[2] | Yes | Yes | Yes | No | Yes | Yes | Yes | No[3] | No |
| 17 | Brown Eutrophic Chromosol | Yes[1] | Yes | Yes | Yes | Yes[2] | Yes | Yes | Yes | Yes | Yes | Yes | Yes | No[3] | No |
| 18 | Brown Mottled-Subnatric Sodosol | No[1] | Yes | Yes | Yes | No[2] | Yes | No | No | Yes | Yes | No | No | No[3] | No |
| 19 | Brown Mesonatric Sodosol | Yes[1] | Yes | Yes | Yes | Yes[2] | Yes | No | No | Yes | Yes | Yes | No | No[3] | No |

| Site Sample Number | Australian Soil Classification | 1. Is Slope <10%? | 2. Is there <30% Rock Outcrop? | 3 <20% Unattached Rock Fragments >60mm? | 4. Does <50% have Gilgais >50mm deep? | 5. Is Slope <5%? | 6. Are there nil rock outcrops? | 7a. Does soil have Moderate fertility? | 7b. Does soil have Moderately-High or High fertility? | 8. Is Effective Rooting Depth (ERD) to a physical barrier >750mm? | 9. Is drainage better than poor? | 10. Is pH between 5.0 and 8.9? | 11. Is salinity (ECe) <4dS/m? | 12. Is ERD to a chemical barrier >750mm? | Is the Site BSAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 20 | Brown Mesonatric Sodosol | Yes[1] | Yes | Yes | Yes | Yes[2] | Yes | No | No | Yes | Yes | Yes | Yes | No[3] | No |
| 21 | Brown Epipedal Vertosol | Yes[1] | Yes | Yes | Yes | Yes[2] | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes[3] | Yes |
| 23 | Brown Subnatric Sodosol | Yes[1] | Yes | Yes | Yes | No[2] | Yes | No | No | Yes | Yes | No | No | No[3] | No |
| 24 | Brown Subnatric Sodosol | Yes[1] | Yes | Yes | Yes | Yes[2] | Yes | No | No | Yes | Yes | No | No | No[3] | No |
| 33 | Eutrophic dermosol | Yes | Yes | Yes | Yes | Yes | Yes | Yes | No | Yes | No | Yes | Yes | Yes | Possible margin |
| 34 | Brown mesonatric sodosol | Yes | Yes | Yes | Yes | Yes | Yes | No | No | No | No | No | No | Yes | No |
| 35 | Brown subnatric sodosol | Yes | Yes | Yes | Yes | Yes | Yes | No | No | Yes | No | Yes | Yes | Yes | No |
| 36 | Brown subnatric sodosol | Yes | Yes | Yes | Yes | Yes | Yes | No | No | No | No | Yes | Yes | Yes | No |

| Site Sample Number | Australian Soil Classification | 1. Is Slope <10%? | 2. Is there <30% Rock Outcrop? | 3 <20% Unattached Rock Fragments >60mm? | 4. Does <50% have Gilgais >50mm deep? | 5. Is Slope <5%? | 6. Are there nil rock outcrops? | 7a. Does soil have Moderate fertility? | 7b. Does soil have Moderately-High or High fertility? | 8. Is Effective Rooting Depth (ERD) to a physical barrier >750mm? | 9. Is drainage better than poor? | 10. Is pH between 5.0 and 8.9? | 11. Is salinity (ECe) <4dS/m? | 12. Is ERD to a chemical barrier >750mm? | Is the Site BSAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **37** | **Brown subnatric sodosol** | Yes | Yes | Yes | Yes | Yes | Yes | No | No | Yes | No | Yes | Yes | Yes | No |

Note 1: Refer to **Figure 2.2**

Note 2: Refer to **Figure 2.2**

Note 3: Refer to **Table 4.1**.

*Sites 25 to 32 are Check sites

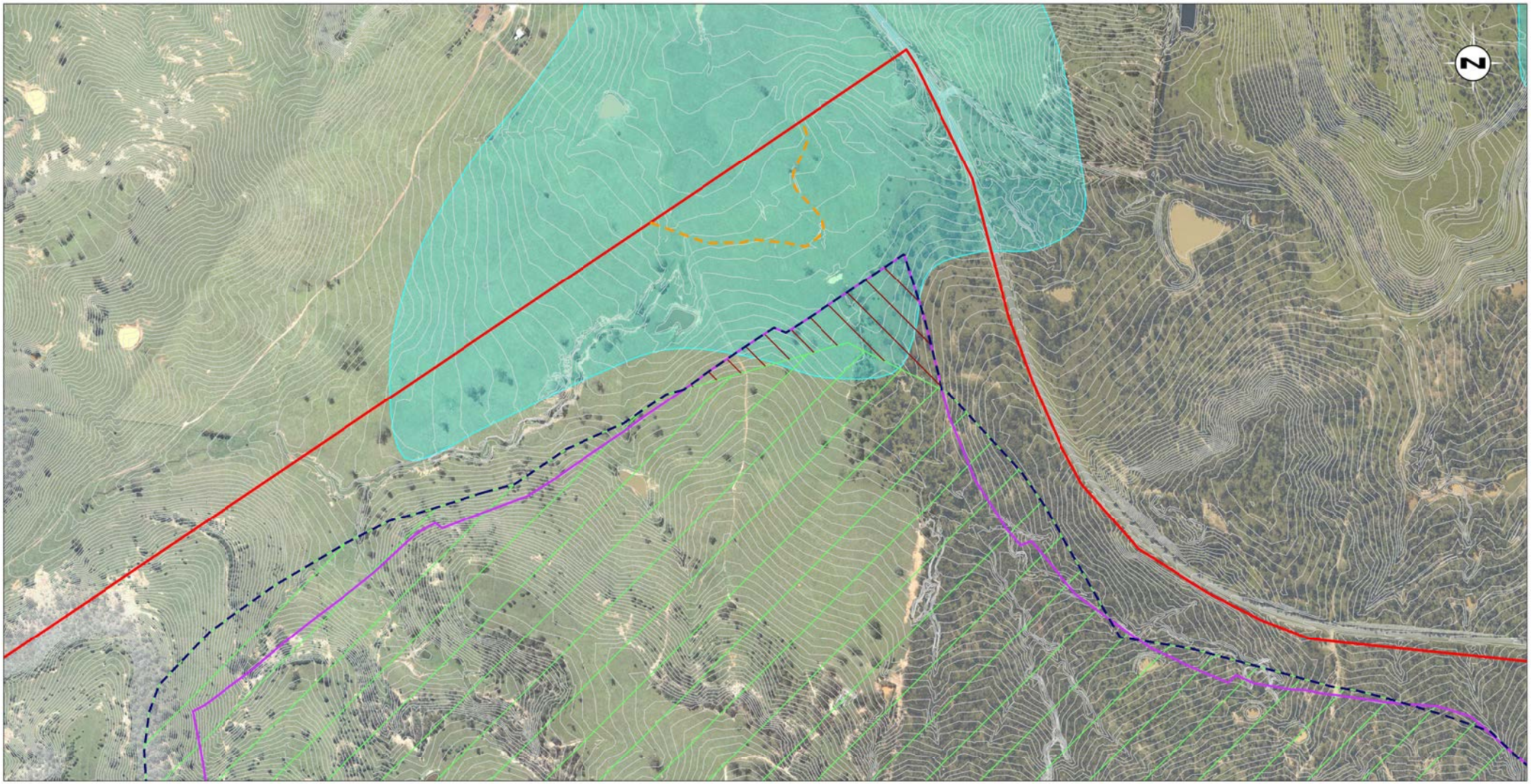



Image Source: AAM (2012), United (2015)
Data Source: Glencore (2014)
Note: 1m Contour Interval

0 100 250 500m
1:10 000

## Legend

- Project Area
- Proposed Open Cut Area
- Overall Verification Application Area
- Areas excluded from the Assessment
- Detailed Verification Assessment Area
- Regionally Mapped Biophysical Strategic Agricultural Land
- Confirmed Actual BSAL - within Project Area

FIGURE 4.2

**Actual BSAL**

File Name (A4): R01/3509_366.dgn
20160429 14.49

# 5.0 Conclusion

Based on a detailed verification assessment of land and soils occurring in the northwest corner of the Project Area, including 3.8 hectares where a new sub-surface mining lease is required and adjacent areas within the Project Area, the following can be concluded:

- Detailed assessment has shown that the actual area of BSAL in the northwest corner of the Project Area is less than the area mapped as BSAL at the regional scale. The terrain in the assessment area is a transition from the hillslope and tributary valley fill materials that occur in the Jerrys Plains soil landscape and the outer margin of the clay soils on the Hunter soil landscape.

- Where the transition is from low angle footslope colluvium to the outer margin of the floodplain, the transition involves increasing profile depth (from gradational Dermosol profiles) to a small area of Epipedal Vertosol soils, which are at the outer edge of main Hunter river alluvium (Hunter Soil Landscape). Footslope soils also tend to not meet the BSAL fertility criteria.

- Alluvial fill materials associated with tributary drainage lines (Waterfall Creek) have texture contrast profiles and some gravel lenses present. These soils are deposited from low fertility and saline catchments and do not meet BSAL fertility criteria. These are mesonatric sodosols. They are not BSAL.

- Some soils that were mapped as BSAL at the regional scale are shallow texture contrast profiles located on low gradient bedrock spurs (chromosols). They are not BSAL because the profile depth to bedrock (physical barrier) is less than 750mm.

- Epipedal vertosols that are most likely to meet the BSAL criteria are located at the northern extremity of the Project Area (in the vicinity of site D21), where the alluvial contributions flowing out of the Waterfall Creek tributary catchment have, over a long period, merged with the outer margins of the Hunter floodplain clay soils. Site D33 (Eutrophic Dermosol) meets most of the BSAL criteria, but does not have moderately high fertility and may be seasonally waterlogged. It is not BSAL, but is the closest profile to BSAL and is considered to indicate the outer edge of soil that meets BSAL criteria.

The indicative area that meets the BSAL criteria, at a scale of 1:10,000 is shown in **Figure 4.2**. The figure shows contours at 1.0m intervals, to capture minor relief features across the transition area. The actual area of BSAL within the Project Area has an area of approximately 3.6 hectares. This area of likely BSAL is within the area of the existing surface mining lease and is entirely outside the area requiring a new subsurface mining lease.

In summary, the detailed assessment of soils in the north-west corner of the Project area, where BSAL has been mapped at the regional scale has shown that:

- No BSAL exists in the proposed Mining Lease Application Area

- A verification certificate should be provided in accordance with the requirements of the Mining SEPP.

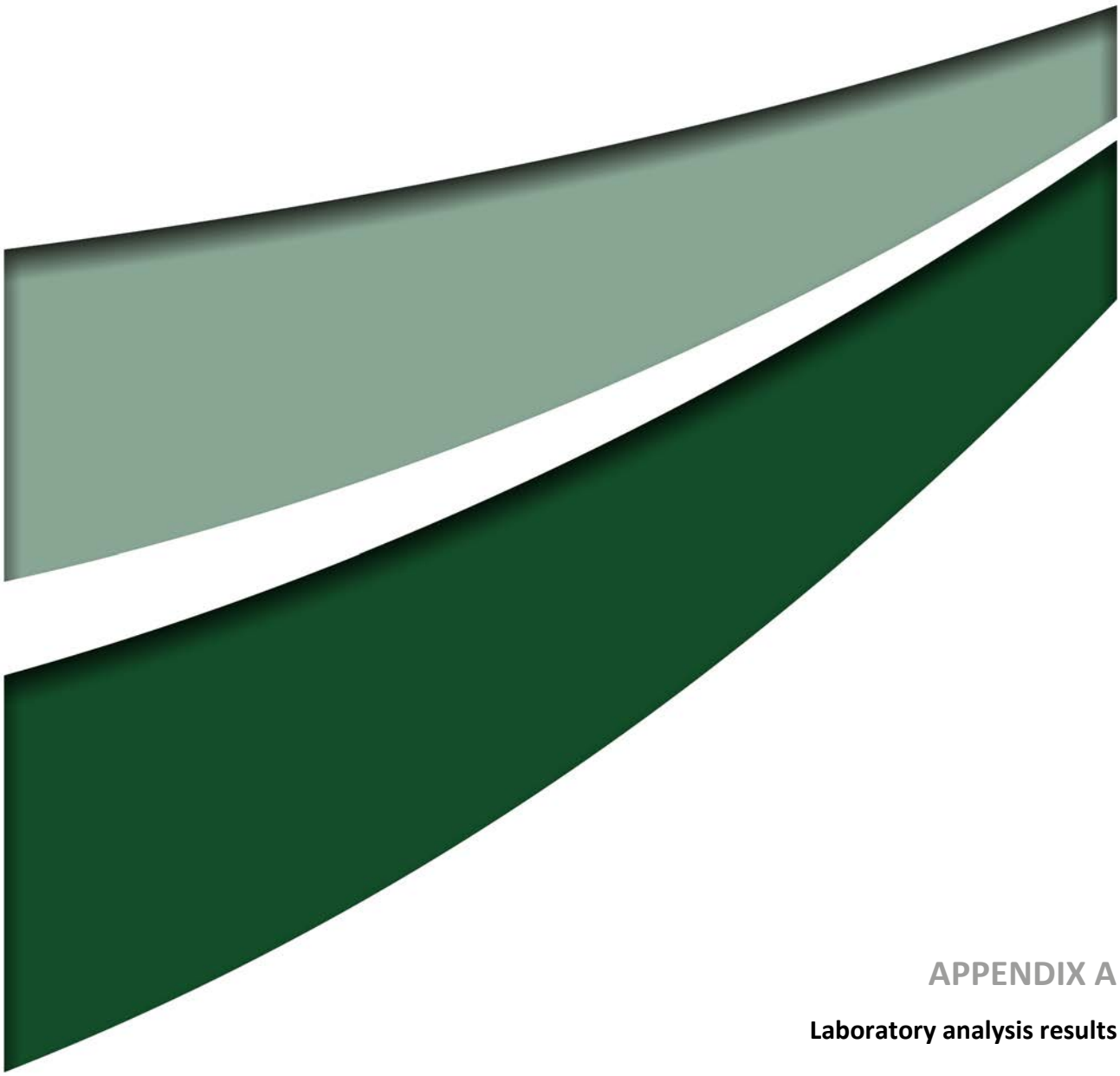
# 6.0 References

Department of Planning and Infrastructure (DP&I), (2013). *Strategic Regional Land Use Policy*, State of New South Wales through the Department of Planning and Infrastructure

Kovac M and Lawrie JW, 1991. *Soil Landscapes of the Singleton 1:250 000 Sheet*. Soil Conservation Service of NSW, Sydney.

NSW Government, 2013. *Interim Protocol for site verification and mapping of biophysical strategic agricultural land*, published by the NSW Government

Office of Environment and Heritage, 2012. *The Land and Soil Assessment Scheme: second approximation. A general rural land evaluation system for NSW.*



# APPENDIX A

**Laboratory analysis results**

Department of Primary Industries
Soil Conservation Service

# SOIL TEST REPORT



**Scone Research Centre**

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| | |
|---|---|
| REPORT NO: | SCO15/044R1 |
| REPORT TO: | Pam Dean-Jones<br>Umwelt (Australia)<br>75 York Street<br>Teralba NSW 2284 |
| REPORT ON: | Sixteen soil samples<br>Your ref: MGA56 |
| PRELIMINARY RESULTS ISSUED: | Not issued |
| REPORT STATUS: | Final |
| DATE REPORTED: | 30 March 2015 |
| METHODS: | Information on test procedures can be obtained from Scone Research Centre |

TESTING CARRIED OUT ON SAMPLE AS RECEIVED


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SR Young
(Laboratory Manager)

**SOIL CONSERVATION SERVICE**
**Scone Research Centre**



Report No: SCO15/044R1
Client Reference: Pam Dean-Jones
Umwelt (Australia)
75 York Street
Teralba NSW 2284

| Lab No | Method | C1A/5 | C2A/4 | C2B/4 | C5A/4 CEC & exchangeable cations (cmol (+) kg) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Sample Id | EC (dS/m) | pH | pH ($CaCl_2$) | CEC | Na | K | Ca | Mg | Al |
| 1 | Site 1 (A) A0-A1 0-7 cm | 0.07 | 5.2 | 4.3 | 10.7 | 0.4 | 0.5 | 2.5 | 3.9 | <0.5 |
| 2 | Site 1 (A) A2 7-18 cm | 0.07 | 5.3 | 4.3 | 6.5 | 0.5 | 0.2 | 1.0 | 3.0 | <0.5 |
| 3 | Site 1 (A) A3 18-25 cm | 0.05 | 5.4 | 4.4 | 6.5 | 0.5 | 0.1 | 1.0 | 3.1 | <0.5 |
| 4 | Site 1 (B) B1 25+cm | 0.14 | 6.0 | 5.2 | 20.5 | 1.5 | 0.5 | 1.6 | 12.7 | <0.5 |
| 5 | Site 3 (A) A2 0-13 cm | 0.03 | 5.4 | 4.2 | 6.2 | 0.3 | 0.1 | 1.0 | 2.6 | <0.5 |
| 6 | Site 3 (A) A3 13-20 cm | 0.02 | 5.7 | 4.2 | 4.6 | 0.4 | <0.1 | 0.1 | 2.2 | <0.5 |
| 7 | Site 3 (B) B 20+cm | 0.15 | 5.6 | 4.5 | 15.4 | 2.2 | 0.1 | 0.1 | 9.9 | <0.5 |
| 8 | Site 4 (A) A2 0-15 cm | 0.02 | 5.6 | 4.4 | 7.1 | 0.2 | 0.5 | 1.6 | 3.2 | <0.5 |
| 9 | Site 4 (B) B 15-40 cm | 0.15 | 6.1 | 5.1 | 18.6 | 1.9 | 0.5 | 3.1 | 10.2 | <0.5 |
| 10 | Site 6 (A) A1 0-9 cm | 0.04 | 5.9 | 4.7 | 9.1 | 0.5 | 0.4 | 1.7 | 4.7 | <0.5 |
| 11 | Site 6 (B) B1 12+cm | 0.13 | 6.0 | 4.9 | 17.2 | 1.7 | 0.5 | 1.4 | 10.7 | <0.5 |
| 12 | Site 7 (A) A1 0-21cm | 0.01 | 6.1 | 4.8 | 11.8 | 0.2 | 0.4 | 5.2 | 2.4 | <0.5 |
| 13 | Site 7 (B) B1 21-49cm | 0.04 | 7.2 | 6.1 | 24.7 | 1.6 | 0.3 | 11.2 | 7.0 | nt |
| 14 | Site 7 (B) B2 49-60+cm | 0.09 | 7.8 | 6.1 | 24.5 | 2.1 | 0.3 | 10.5 | 6.8 | nt |
| 15 | Site 11 (A) A 0-5cm | 0.12 | 5.4 | 4.6 | 8.7 | 0.4 | 0.5 | 1.6 | 3.8 | <0.5 |
| 16 | Site 11 (B) B1 5-20+cm | 0.54 | 6.3 | 5.4 | 32.1 | 4.2 | 0.3 | 4.4 | 19.3 | <0.5 |

nt=not tested

**SOIL CONSERVATION SERVICE**
**Scone Research Centre**



Report No: SCO15/044R1
Client Reference: Pam Dean-Jones
Umwelt (Australia)
75 York Street
Teralba NSW 2284

| Lab No | Method | P9B/2 | C8A/3 | | P7B/2 Particle Size Analysis (%) | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Sample Id | EAT | P (mg/kg) | Texture | clay | silt | f sand | c sand | gravel |
| 1 | Site 1 (A) A0-A1 0-7 cm | 8 | 3 | Loam | 18 | 12 | 21 | 41 | 8 |
| 2 | Site 1 (A) A2 7-18 cm | 8 | 2 | Loam | 17 | 11 | 26 | 35 | 11 |
| 3 | Site 1 (A) A3 18-25 cm | 8 | 2 | nt | nt | nt | nt | nt | nt |
| 4 | Site 1 (B) B1 25+cm | 2(1) | nt | Medium clay | nt | nt | nt | nt | nt |
| 5 | Site 3 (A) A2 0-13 cm | 7 | 3 | Loam sand | 15 | 18 | 30 | 32 | 5 |
| 6 | Site 3 (A) A3 13-20 cm | na | 3 | Silty loam | 9 | 10 | 20 | 27 | 34 |
| 7 | Site 3 (B) B 20+cm | 2(3) | nt | Sandy clay | nt | nt | nt | nt | nt |
| 8 | Site 4 (A) A2 0-15 cm | 7 | 3 | Loam | 16 | 14 | 38 | 29 | 3 |
| 9 | Site 4 (B) B 15-40 cm | 2(2) | nt | Light clay | nt | nt | nt | nt | nt |
| 10 | Site 6 (A) A1 0-9 cm | 7 | 1 | Loam | 18 | 14 | 36 | 25 | 7 |
| 11 | Site 6 (B) B1 12+cm | 2(2) | nt | Medium clay | nt | nt | nt | nt | nt |
| 12 | Site 7 (A) A1 0-21cm | 7 | 1 | Silty loam | 25 | 33 | 32 | 10 | <1 |
| 13 | Site 7 (B) B1 21-49cm | 2(3) | nt | Light clay | nt | nt | nt | nt | nt |
| 14 | Site 7 (B) B2 49-60+cm | 2(3) | nt | Medium clay | nt | nt | nt | nt | nt |
| 15 | Site 11 (A) A 0-5cm | 7 | 3 | Silty loam | 18 | 17 | 32 | 20 | 13 |
| 16 | Site 11 (B) B1 5-20+cm | 2(1) | nt | Heavy clay | nt | nt | nt | nt | nt |

nt=not tested: na=not applicable

END OF TEST REPORT

Department of Primary Industries
Soil Conservation Service

# SOIL TEST REPORT



**Scone Research Centre**

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| | |
|---|---|
| REPORT NO: | SCO16/033R2 |
| REPORT TO: | Pam Dean-Jones<br>Umwelt (Australia) Pty Limited<br>75 York Street<br>Teralba NSW 2284 |
| REPORT ON: | Eighteen soil samples<br>Your ref: United Open Cut Coal Mine Project |
| PRELIMINARY RESULTS ISSUED: | Not issued |
| REPORT STATUS: | Final |
| DATE REPORTED: | 10 March 2016 |
| METHODS: | Information on test procedures can be obtained from Scone Research Centre |

TESTING CARRIED OUT ON SAMPLE AS RECEIVED


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SR Young
(Laboratory Manager)

**SOIL CONSERVATION SERVICE**
**Scone Research Centre**



Report No: SCO16/033R2
Client Reference: Pam Dean-Jones
Umwelt (Australia) Pty Limited
75 York Street
Teralba NSW 2284

| Lab No | Method | C1A/5 | C2A/4 | C2B/4 | C5A/4 CEC & exchangeable cations (cmol (+)/kg) | | | | | C8A/3 | C6A/2 | P9B/2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Sample Id | EC (dS/m) | pH | pH ($CaCl_2$) | CEC | Na | K | Ca | Mg | P (mg/kg) | OC (%) | EAT |
| 1 | MGA56 Site D33 A1 0-150mm | 0.02 | 6.2 | 4.9 | 13.6 | 0.2 | 0.8 | 6.8 | 3.9 | 3 | 1.68 | 7 |
| 2 | MGA56 Site D33 A2 150-250mm | 0.01 | 6.5 | 5.2 | 14.3 | 0.3 | 0.4 | 7.6 | 4.1 | 2 | 1.21 | 3(2) |
| 3 | MGA56 Site D33 B1 300-450mm | 0.01 | 7.1 | 5.5 | 11.5 | 0.7 | 0.2 | 5.5 | 4.9 | <1 | 0.43 | 2(1) |
| 4 | MGA56 Site D33 B1 550-750mm | 0.07 | 7.8 | 6.2 | 17.9 | 1.4 | 0.4 | 7.0 | 7.7 | 1 | 0.46 | 2(3) |
| 5 | MGA56 Site D34 A1 0-100mm | 0.04 | 6.1 | 5.2 | 12.5 | 0.5 | 1.4 | 5.0 | 5.0 | 3 | 1.75 | 8 |
| 6 | MGA56 Site D34 B1 150-400mm | 0.05 | 7.9 | 6.2 | 23.6 | 1.6 | 0.3 | 8.1 | 11.6 | <1 | 0.47 | 2(1) |
| 7 | MGA56 Site D34 B2 400-600mm | 0.82 | 8.9 | 7.9 | 23.0 | 3.5 | <0.1 | 7.7 | 11.6 | 2 | 0.18 | 2(3) |
| 8 | MGA56 Site D35 A1 0-150mm | 0.03 | 6.0 | 5.4 | 9.4 | 0.4 | 0.8 | 4.2 | 3.2 | 1 | 1.67 | 3(2) |
| 9 | MGA56 Site D35 B1 250-400mm | 0.10 | 7.2 | 6.0 | 15.4 | 1.6 | 0.3 | 5.5 | 8.2 | 2 | 0.40 | 2(3) |
| 10 | MGA56 Site D35 B2 600-750mm | 0.18 | 6.7 | 5.9 | 16.5 | 1.7 | 0.5 | 4.6 | 7.2 | <1 | 0.37 | 2(1) |
| 11 | MGA56 Site D36 A1 0-150mm | 0.03 | 6.2 | 5.5 | 13.1 | 0.2 | 1.0 | 5.9 | 3.4 | 5 | 1.89 | 3(1) |
| 12 | MGA56 Site D36 A2 200-250mm | 0.01 | 5.9 | 4.9 | 10.9 | 0.2 | 0.5 | 4.6 | 3.0 | 2 | 0.89 | 2(1) |
| 13 | MGA56 Site D36 B1 300-400mm | 0.02 | 6.5 | 5.1 | 12.0 | 0.6 | 0.2 | 4.7 | 4.4 | <1 | 0.48 | 2(3) |
| 14 | MGA56 Site D36 B2 600-750mm | 0.11 | 6.3 | 5.2 | 15.6 | 1.2 | 0.3 | 4.5 | 5.5 | 2 | 0.35 | 2(3) |
| 15 | MGA56 Site D37 A1 0-200mm | 0.02 | 6.0 | 5.1 | 17.1 | 0.3 | 0.6 | 8.0 | 5.1 | 2 | 1.68 | 2(1) |
| 16 | MGA56 Site D37 A2 200-250mm | 0.01 | 6.9 | 5.5 | 13.5 | 0.4 | 0.1 | 7.0 | 3.7 | 1 | 1.15 | 2(1) |
| 17 | MGA56 Site D37 B1 300-500mm | 0.06 | 8.1 | 6.4 | 18.1 | 1.6 | 0.2 | 6.7 | 6.6 | <1 | 0.56 | 2(2) |
| 18 | MGA56 Site D37 B2 550-750mm | 0.39 | 8.7 | 7.6 | 24.1 | 3.7 | 0.1 | 7.3 | 8.9 | 1 | 0.27 | 2(3) |

END OF TEST REPORT

Department of Primary Industries
Soil Conservation Service

# SOIL TEST REPORT



**Scone Research Centre**

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| | |
|---|---|
| REPORT NO: | SCO15/165R1 |
| REPORT TO: | Pam Dean-Jones<br>Umwelt (Australia)<br>75 York Street<br>Teralba NSW 2284 |
| REPORT ON: | Thirty-one soil samples<br>Your ref: MGA56 United Open Cut Coal Mine Project |
| PRELIMINARY RESULTS ISSUED: | Not issued |
| REPORT STATUS: | Final |
| DATE REPORTED: | 11 September 2015 |
| METHODS: | Information on test procedures can be obtained from Scone Research Centre |

TESTING CARRIED OUT ON SAMPLE AS RECEIVED


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Lynette Dunn
(Senior Technical Officer)

Scone Research Centre, PO Box 283 Scone 2337, 709 Gundy Road Scone 2337
Ph: 02 6545 1666 Email: scone.lab@scs.nsw.gov.au

**SOIL CONSERVATION SERVICE**
**Scone Research Centre**



Report No: SCO15/165R1
Client Reference: Pam Dean-Jones
Umwelt (Australia)
75 York Street
Teralba NSW 2284

| Lab No | Method | C1A/5 | C2A/4 | C2B/4 | C8A/3 | C5A/4 CEC & exchangeable cations (cmol (+) kg) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Sample Id | EC (dS/m) | pH | pH ($CaCl_2$) | P (mg/kg) | CEC | Na | K | Ca | Mg | Al |
| 1 | Site D12 (A) A0 0-100mm | 0.21 | 5.9 | 5.2 | 11 | 23.6 | 0.2 | 2.6 | 12.9 | 5.6 | <0.5 |
| 2 | Site D12 (A) A1 100-150mm | 0.04 | 6.0 | 5.1 | 3 | 23.1 | 0.2 | 1.8 | 11.7 | 6.4 | <0.5 |
| 3 | Site D12 (A) A1 150-300mm | 0.02 | 6.6 | 5.5 | 2 | 27.9 | 0.3 | 1.7 | 13.8 | 8.4 | <0.5 |
| 4 | Site D12 (A) A1 300-450mm | 0.14 | 8.5 | 7.9 | <1 | 30.9 | 0.4 | 1.3 | 18.8 | 9.4 | nt |
| 5 | Site D12 (B) B450-600mm | 0.14 | 8.8 | 8.0 | 2 | 29.2 | 0.7 | 1.2 | 15.6 | 10.4 | nt |
| 6 | Site D13 (A) A0 0-90mm | 0.08 | 6.0 | 5.2 | 3 | 17.9 | 0.3 | 1.5 | 7.6 | 5.6 | <0.5 |
| 7 | Site D13 (A) A1 90-150mm | 0.08 | 6.0 | 5.2 | 2 | 18.5 | 0.5 | 1.4 | 6.2 | 7.6 | <0.5 |
| 8 | Site D13 (A) A1 150-350mm | 0.27 | 8.7 | 8.0 | <1 | 36.0 | 2.4 | 1.1 | 12.0 | 19.6 | nt |
| 9 | Site D13 (B) B1 350-500mm | 0.37 | 9.2 | 8.4 | 1 | 32.1 | 2.9 | 0.7 | 10.0 | 17.9 | nt |
| 10 | Site D13 (B) B2 500-600mm | 0.53 | 9.4 | 8.4 | 1 | 30.6 | 3.5 | 1.2 | 8.5 | 17.4 | nt |
| 11 | Site D14 (A) A0 0-100mm | 0.07 | 6.3 | 5.7 | 7 | 22.1 | 0.4 | 1.2 | 10.6 | 6.9 | nt |
| 12 | Site D14 (A) A1 100-200mm | 0.04 | 6.5 | 5.7 | 1 | 21.5 | 0.6 | 0.6 | 10.5 | 7.1 | nt |
| 13 | Site D14 (A) A1 200-300mm | 0.07 | 8.1 | 6.7 | 1 | 38.1 | 2.7 | 0.4 | 14.2 | 16.6 | nt |
| 14 | Site D14 (A) A1 300-400mm | 0.58 | 9.0 | 8.2 | 1 | 39.4 | 5.1 | 0.3 | 14.3 | 18.1 | nt |
| 15 | Site D14 (A) A2 400-600mm | 0.98 | 9.0 | 8.3 | <1 | 37.5 | 5.6 | 0.3 | 13.0 | 17.5 | nt |

nt = not tested

**SOIL CONSERVATION SERVICE**
**Scone Research Centre**



Report No: SCO15/165R1
Client Reference: Pam Dean-Jones
Umwelt (Australia)
75 York Street
Teralba NSW 2284

| Lab No | Method | C1A/5 | C2A/4 | C2B/4 | C8A/3 | C5A/4 CEC & exchangeable cations (cmol (+) kg) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Sample Id | EC (dS/m) | pH | pH ($CaCl_2$) | P (mg/kg) | CEC | Na | K | Ca | Mg | Al |
| 16 | Site D14 (B) B1 600-700mm | 1.49 | 8.9 | 8.3 | <1 | 34.5 | 5.1 | 0.4 | 11.9 | 16.4 | nt |
| 17 | Site D14 (B) B1 700-900mm | 1.59 | 8.9 | 8.3 | <1 | 36.6 | 5.5 | 0.5 | 11.9 | 17.4 | nt |
| 18 | Site D15 (A) A1 0-100mm | 0.03 | 5.6 | 4.6 | 21 | 9.6 | 0.4 | 0.7 | 3.8 | 2.7 | <0.5 |
| 19 | Site D15 (A) A2 100-150mm | 0.02 | 5.6 | 4.5 | 10 | 7.4 | 0.3 | 0.5 | 1.8 | 2.2 | 0.6 |
| 20 | Site D15 (B) B1 200-300mm | 0.07 | 5.9 | 4.8 | 1 | 19.6 | 1.4 | 0.5 | 3.7 | 10.0 | 0.6 |
| 21 | Site D15 (B) B1 300-450mm | 0.11 | 5.7 | 4.7 | 1 | 19.3 | 1.6 | 0.5 | 2.9 | 9.8 | <0.5 |
| 22 | Site D15 (B) B 450-600mm | 0.23 | 5.9 | 5.0 | 1 | 18.6 | 2.2 | 0.5 | 2.6 | 9.9 | <0.5 |
| 23 | Site D15 (B) B 650-900mm | 0.58 | 7.7 | 6.6 | 1 | 19.2 | 2.4 | 0.6 | 2.4 | 10.0 | nt |
| 24 | Site D16 (A) A1 0-100mm | 0.02 | 5.8 | 4.9 | 4 | 8.4 | 0.2 | 0.9 | 3.2 | 2.0 | <0.5 |
| 25 | Site D16 (A) A2 100-250mm | <0.01 | 6.3 | 5.0 | 2 | 5.1 | 0.1 | 0.6 | 1.4 | 1.5 | nt |
| 26 | Site D16 (A) B1 250-400mm | 0.05 | 8.4 | 7.2 | <1 | 19.4 | 0.7 | 0.7 | 3.6 | 11.1 | nt |
| 27 | Site D15 (A) B1 400-550mm | 0.14 | 9.0 | 8.2 | 1 | 17.7 | 1.0 | 0.5 | 4.0 | 10.1 | nt |
| 28 | Site D17 (B) B 0-150mm | 0.03 | 6.4 | 5.4 | 2 | 20.8 | 0.4 | 0.9 | 7.4 | 8.2 | <0.5 |
| 29 | Site D17 (B) B 150-300mm | 0.04 | 7.5 | 6.3 | 1 | 25.1 | 0.8 | 0.7 | 10.4 | 10.9 | nt |
| 30 | Site D17 (B) B/C 300-450mm | 0.22 | 8.8 | 8.1 | 1 | 31.3 | 1.6 | 0.9 | 14.3 | 12.3 | nt |
| 31 | Site D17 (B) C 550+mm | 0.35 | 9.2 | 8.4 | 1 | 29.4 | 2.1 | 0.5 | 12.4 | 11.8 | nt |

nt = not tested

END OF TEST REPORT

Department of Primary Industries
Soil Conservation Service

# SOIL TEST REPORT



**Scone Research Centre**

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| | |
|---|---|
| REPORT NO: | SCO15/252R1 |
| REPORT TO: | Pam Dean-Jones<br>Umwelt (Australia) Pty Limited<br>75 York Street<br>Teralba NSW 2284 |
| REPORT ON: | Thirty-five soil samples<br>Your ref: United Open Cut Coal Mine Project |
| PRELIMINARY RESULTS ISSUED: | Not issued |
| REPORT STATUS: | Final |
| DATE REPORTED: | 13 January 2016 |
| METHODS: | Information on test procedures can be obtained from Scone Research Centre |

TESTING CARRIED OUT ON SAMPLE AS RECEIVED


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SR Young
(Laboratory Manager)

**SOIL CONSERVATION SERVICE**
**Scone Research Centre**



Report No: SCO15/252R1
Client Reference: Pam Dean-Jones
Umwelt (Australia) Pty Limited
75 York Street
Teralba NSW 2284

| Lab No | Method | C1A/5 | C2A/4 | C2B/4 | C8A/3 | C5A/4 CEC & exchangeable cations (cmol (+)/kg) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Sample Id | EC (dS/m) | pH | pH ($CaCl_2$) | Avail P (mg/kg) | CEC | Na | K | Ca | Mg |
| 1 | MGA56 Site D18 0-100mm | 0.03 | 6.3 | 5.3 | 1 | 11.4 | 0.2 | 0.6 | 5.4 | 3.0 |
| 2 | MGA56 Site D18 B1 200-300mm | 0.10 | 7.8 | 6.7 | <1 | 24.9 | 2.1 | 0.6 | 8.0 | 10.5 |
| 3 | MGA56 Site D18 B1 300-400mm | 0.52 | 8.9 | 8.1 | <1 | 32.1 | 3.4 | 0.4 | 16.8 | 12.3 |
| 4 | MGA56 Site D18 B1 400-550mm | 0.67 | 9.1 | 8.3 | <1 | 30.9 | 3.6 | 0.5 | 18.2 | 11.4 |
| 5 | MGA56 Site D18 B2 550-700mm | 0.83 | 9.1 | 8.3 | <1 | 32.1 | 4.0 | 0.6 | 18.2 | 11.6 |
| 6 | MGA56 Site D18 C 700+mm | 1.10 | 9.2 | 8.3 | <1 | 31.8 | 5.5 | 0.7 | 17.3 | 11.4 |
| 7 | MGA56 Site D19 A1 0-100mm | 0.06 | 5.8 | 4.9 | 18 | 13.2 | 0.5 | 0.9 | 5.2 | 3.7 |
| 8 | MGA56 Site D19 A2 100-200mm | 0.07 | 6.4 | 5.1 | 4 | 12.6 | 1.3 | 0.4 | 3.8 | 4.9 |
| 9 | MGA56 Site D19 B1 300-400mm | 0.27 | 6.0 | 4.9 | 3 | 23.6 | 4.4 | 0.5 | 5.1 | 10.4 |
| 10 | MGA56 Site D19 B1 400-500mm | 0.51 | 7.1 | 6.2 | 4 | 25.1 | 5.3 | 0.3 | 4.7 | 10.5 |
| 11 | MGA56 Site D19 B2 500-600mm | 0.81 | 8.0 | 7.0 | 1 | 25.1 | 6.1 | 0.3 | 4.3 | 11.0 |
| 12 | MGA56 Site D19 B2 600-700mm | 1.11 | 8.3 | 7.4 | 1 | 29.8 | 7.2 | 0.4 | 4.6 | 12.4 |

**SOIL CONSERVATION SERVICE**
**Scone Research Centre**



Report No: SCO15/252R1
Client Reference: Pam Dean-Jones
Umwelt (Australia) Pty Limited
75 York Street
Teralba NSW 2284

| Lab No | Method | C1A/5 | C2A/4 | C2B/4 | C8A/3 | C5A/4 CEC & exchangeable cations (cmol (+)/kg) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Sample Id | EC (dS/m) | pH | pH ($CaCl_2$) | Avail P (mg/kg) | CEC | Na | K | Ca | Mg |
| 13 | MGA56 Site D20B 0-100mm | 0.01 | 5.5 | 4.5 | 5 | 6.3 | 0.1 | 0.5 | 2.0 | 1.0 |
| 14 | MGA56 Site D20B 100-200mm | <0.01 | 6.1 | 5.0 | 3 | 5.4 | 0.1 | 0.4 | 1.5 | 0.9 |
| 15 | MGA56 Site D20B 200-300mm | <0.01 | 6.3 | 5.0 | 3 | 4.4 | 0.2 | 0.2 | 1.3 | 0.9 |
| 16 | MGA56 Site D20B 300-400mm | 0.07 | 7.0 | 5.7 | 1 | 15.3 | 1.9 | 0.4 | 2.3 | 6.7 |
| 17 | MGA56 Site D20B 400-500mm | 0.11 | 7.5 | 6.1 | <1 | 17.3 | 2.5 | 0.4 | 2.6 | 8.0 |
| 18 | MGA56 Site D20B 500-750mm | 0.31 | 8.7 | 7.3 | <1 | 20.9 | 4.5 | 0.4 | 2.0 | 9.2 |
| 19 | MGA56 Site D21 0-100mm | 0.05 | 5.9 | 5.0 | 6 | 15.5 | 0.2 | 1.0 | 5.9 | 4.1 |
| 20 | MGA56 Site D21 100-180mm | 0.02 | 6.1 | 5.0 | 1 | 14.3 | 0.3 | 0.4 | 5.8 | 3.9 |
| 21 | MGA56 Site D21 180-300mm | 0.06 | 7.5 | 6.3 | <1 | 21.5 | 1.2 | 0.3 | 8.6 | 7.1 |
| 22 | MGA56 Site D21 300-400mm | 0.06 | 7.7 | 6.4 | <1 | 21.1 | 1.4 | 0.3 | 7.4 | 8.2 |
| 23 | MGA56 Site D21 400-500mm | 0.26 | 8.0 | 7.1 | <1 | 24.6 | 3.3 | 0.3 | 7.8 | 9.0 |
| 24 | MGA56 Site D21 500-600mm | 0.53 | 7.8 | 7.1 | <1 | 25.8 | 3.8 | 0.3 | 6.3 | 9.5 |
| 25 | MGA56 Site D21 600-750mm | 0.46 | 8.5 | 7.6 | <1 | 22.7 | 3.0 | 0.2 | 6.2 | 8.3 |

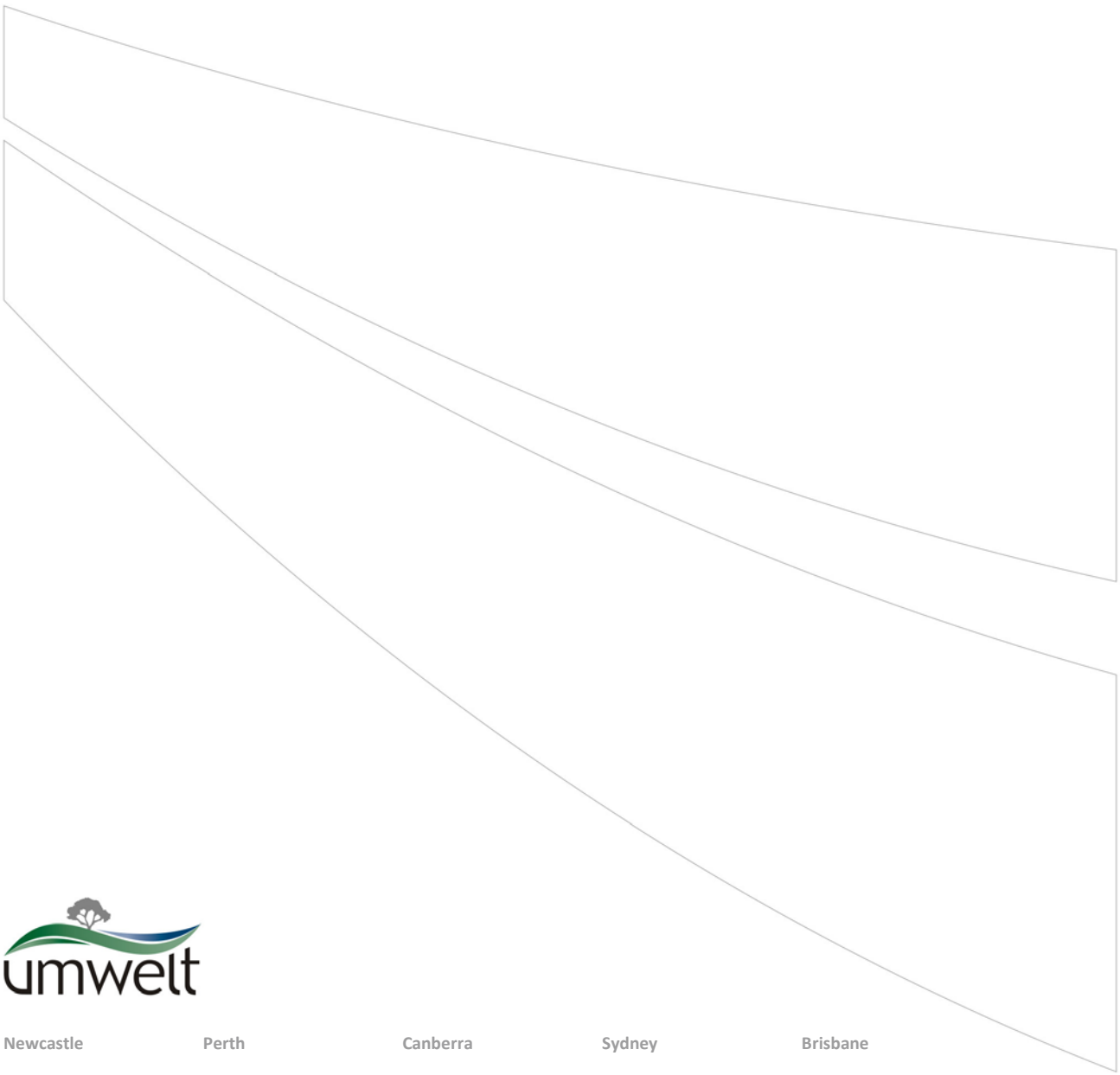
**SOIL CONSERVATION SERVICE**
**Scone Research Centre**



Report No: SCO15/252R1
Client Reference: Pam Dean-Jones
Umwelt (Australia) Pty Limited
75 York Street
Teralba NSW 2284

| Lab No | Method | C1A/5 | C2A/4 | C2B/4 | C8A/3 | C5A/4 CEC & exchangeable cations (cmol (+)/kg) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Sample Id | EC (dS/m) | pH | pH ($CaCl_2$) | Avail P (mg/kg) | CEC | Na | K | Ca | Mg |
| 26 | MGA56 Site D23 A1 0-120mm | 0.01 | 6.3 | 5.2 | 2 | 8.9 | 0.1 | 0.5 | 3.1 | 2.6 |
| 27 | MGA56 Site D23 B1 120-200mm | 0.02 | 7.0 | 5.6 | <1 | 22.6 | 0.1 | 0.7 | 5.7 | 10.8 |
| 28 | MGA56 Site D23 B1 200-300mm | 0.05 | 7.8 | 6.5 | <1 | 24.7 | 0.5 | 0.6 | 6.0 | 12.2 |
| 29 | MGA56 Site D23 B2 300-450mm | 0.27 | 8.8 | 8.0 | <1 | 25.0 | 1.7 | 0.4 | 6.0 | 12.8 |
| 30 | MGA56 Site D23 B2 450-600mm | 0.85 | 9.1 | 8.3 | 1 | 33.2 | 3.3 | 0.3 | 13.4 | 16.7 |
| 31 | MGA56 Site D23 C 650-800mm | 1.15 | 9.1 | 8.4 | <1 | 30.7 | 4.1 | 0.5 | 7.0 | 18.1 |
| 32 | MGA56 Site D24 A2 0-100mm | 0.11 | 7.2 | 6.7 | 1 | 8.4 | 0.2 | 0.2 | 2.4 | 3.5 |
| 33 | MGA56 Site D24 B1 200-300mm | 0.35 | 6.3 | 5.7 | 1 | 22.0 | 1.4 | 0.2 | 3.6 | 10.9 |
| 34 | MGA56 Site D24 B1 400-550mm | 0.38 | 6.1 | 5.4 | <1 | 25.0 | 2.2 | 0.2 | 4.4 | 12.5 |
| 35 | MGA56 Site D24 C 650+mm | 0.71 | 9.0 | 8.1 | 2 | 32.6 | 4.0 | 0.3 | 10.9 | 15.1 |

END OF TEST REPORT

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