BOWDENS SILVER

Part 12
Land and Soil Capability Assessment

State Significant Development No. 5765

Prepared by:

Soil Management Designs

May 2020

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Land and Soil Capability Assessment

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May 2020

CONTENTS

CONTENTS

CONTENTS

Page

COMMONLY USED ACRONYMS

AHD	Australian Height Datum
ASC	Australian Soil Classification
ASWAT	Aggregate Stability in Water
BoM	Bureau of Meteorology
BSAL	Biophysical Strategic Agricultural Land
CEC	Cation Exchange Capacity
cm	centimetre
CPC	Calcium Phosphate – Charcoal
CPSS	Certified Professional Soil Scientist
DTPA	Diethylenetriamine Pentaacetic Acid
EC	Electrical conductivity
ECe	Electrical Conductivity Extract
EIS	Environmental Impact Statement
ESI	Electrochemical Stability Index
ESP	Exchangeable Sodium Percentage
eSPADE	Soil Profile Attribute Data Environment
GCL	geosynthetic clay liner
ha	hectare
LSC	Land and Soil Capability
mm	millimetre
NAF	non-acid forming
NATA	National Association of Testing Authorities
SEARs	Secretary's Environmental Assessment Requirements
SILO	Scientific Information for Land Owners
SVC	Site Verification Certificate
TAW	Total Available Water
TSF	tailings storage facility
WRE	waste rock emplacement

EXECUTIVE SUMMARY

Bowdens Silver Pty Limited (Bowdens Silver) proposes to construct and operate an open cut mine to recover mineralised rock (ore) containing silver and small percentages of zinc and lead (the Bowdens Silver Project; the Project), approximately 26 kilometres (km) east of Mudgee and 2km northeast of Lue in the NSW Mid-Western Region Local Government Area. The open cut pits and mine-related components would be located within an area referred to as the "Mine Site" which covers an area of approximately 1 000 hectares (ha) and within which, approximately 420ha would be disturbed as the result of activities associated with the development and operation of the Project.

A site soil survey was carried out at the Mine Site in mid-February 2017. At that time, the area of the Mine Site under consideration covered 1,220ha, with boundaries beyond the extent of the current Mine Site. The objectives of the site soil survey were to:

- determine whether 'Biophysical Strategic Agricultural Land' (BSAL) is present[1] in the Mine Site using procedures from the NSW Government 'Interim Protocol';
- assess agricultural productivity and erosion hazards of the existing landscape;
- plan the soil stripping process in disturbance areas, including amelioration of topsoil and subsoil before being placed in stockpiles for use in rehabilitation activities; and
- provide recommendations about soil management requirements during and after rehabilitation.

Forty-one soil test pits were excavated using a backhoe across the seven 'Soil Landscape Units' that were defined based on geology, position in landscape and slope.

Most of the Mine Site area is hilly and on 'sedimentary' and 'acid (felsic) volcanic' parent materials with poor conditions for plant growth. Consequently, cropping is unlikely to succeed. Pasture production is also limited significantly by strong soil acidity, and poor water holding capacity that is associated with rock being close to the surface. The small areas in which Ordovician shale parent material is present are less acidic, but these areas are mostly shallow. Poor pasture growth means that the soils can easily be overgrazed, leading to a lack of surface protection against water erosion. This limitation is most problematic in the steeper areas.

Sodicity (high exchangeable sodium percentage) is not a widespread problem in the soils at the Mine Site, except for some of the alluvial soils near creeks. However, the inadequate soil organic carbon concentrations and very low electrolyte concentrations mean that removal of the vegetation cover through disturbance such as Mine Site development or cropping would make the untreated soil very prone to water erosion losses.

None of the Soil Landscape Units exhibited soils of sufficient quality and quantity to be regarded as BSAL in accordance with the Interim Protocol. Whilst four of the 41 soil test pits had soil with the BSAL characteristics detailed in the Interim Protocol, they were not adjacent to each other.

[1] an absence of significant areas of BSAL meant that the approval requests proceeded through use of a 'Site Verification Certificate' (SVC) rather than via the Gateway process.

In addition, none of the Soil Landscape Units had at least 70% of sampling sites being BSAL, which is the Interim Protocol threshold for an area to be declarable BSAL.

The scattered soil test pits which exhibited BSAL characteristics within the Mine Site were as follows:

- Site 48 is the only soil test pit in the 'Sedimentary - gentle slope (<10%)' Soil Landscape Unit that was classified as being BSAL. The likely reason for this unusually good soil is that the underlying sedimentary rock has pockets of mudstone within the dominant poorer quality sandstone and conglomerate that dominate this type of parent material.
- Site 68 is part of the 'Ordovician shale' Soil Landscape Unit which is classified as being a non-BSAL unit as two of the three soil test pits are non-BSAL due to the presence of rock at shallow depths (<75cm).
- Sites 52 and 82 are part of the 'acid (felsic) volcanic – gentle slope (<10%)' Soil Landscape Unit where the remaining twelve soil test pits were non-BSAL.

Soil test pits 51, 55 and 62 are recently deposited high-quality alluvium ,classified via the Australian Soil Classification (ASC) as being Stratic Rudosols, which the Interim Protocol considers to be non-BSAL. Even if these sites were given a high-fertility ASC classification, the narrow strip of alluvium under consideration for this study has an area less than the minimum contiguous BSAL soil unit threshold of 20ha.

BSAL mapped by NSW Government occurs approximately 1.5km west of the south-western corner of the Mine Site along Lawsons Creek, and along its tributary Wet Swamp Creek.

The small area of alluvium along Price Creek has several metres of soil profile and therefore has the potential to be a very important source of rehabilitation material. Where it proposed to be removed and stockpiled, the alluvium in the vicinity of the junction of Hawkins and Price Creeks would benefit from the addition of coarse-grade gypsum immediately prior to each scraping pass and subsequent stockpiling.

A preliminary estimation of depth for soil stripping in the proposed disturbance areas is:

- 70 centimetres (cm) (~20cm topsoil / ~50cm subsoil) – for most of the disturbance area, including areas with shallow soils and/or extreme subsoil acidity (i.e. all of the 'Sedimentary', 'Acid (felsic) volcanic' and 'Ordovician shale' Soil Landscape Units); or
- 200cm (~20cm topsoil / at least 180cm subsoil) – for the minor areas of alluvium (i.e. 'Alluvium – high quality' and 'Alluvium – medium quality' Soil Landscape Units).

Stockpiled topsoil and subsoil would be made available for use during progressive rehabilitation of the Mine Site. Material balance calculations, based on the recommended soil stripping depths, indicate an approximate topsoil volume of 840 000m^3 and an approximate subsoil volume of 1 585 000m^3 would require removal and stockpiling over the Project life. The soil stockpiles would be managed in a way that avoids degradation when stockpiled. Where possible, scraped subsoil and topsoil would be transferred directly to rehabilitation areas so that soil biological activity is maintained in the best possible condition.

Most of the soil on the acid (felsic) volcanic and sedimentary parent materials (i.e. majority of the hill country) is strongly acidic and would benefit from lime application. It is recommended that, in order to optimise pasture growth in rehabilitation areas, these soils should be treated via lime spreading (rates determined via the pH_{CaCl2} and CEC data), prior to each scraper pass. This would ensure thorough mixing of the lime with topsoil and subsoil prior to stockpiling. In addition to correction of acidity, lime application provides a mild electrolyte concentration that reduces soil dispersion in water. The Ordovician Shale Soil Landscape Unit is more alkaline, so this soil has less of a requirement for lime treatment.

Soil in the hilly areas is also prone to being pulverised when dry so dust generation represents a potential hazard during dry weather earthmoving. Dust suppression therefore would be a high priority so that wind erosion is minimised.

Working of the soil when it is wet is likely to aggravate dispersion problems, which makes the soil being worked more prone to erosion. Excessive compaction and/or moulding of the soil by heavy machinery under wet conditions may also present a major problem due to the destruction of soil structure. A Rehabilitation Management Plan is recommended to address these potential land management hazards.

During rehabilitation, the stockpiled topsoil and subsoil would be used to cover the tailings storage facility (TSF) and waste rock emplacement (WRE) with a vegetated store-and-release cover system that would encapsulate the materials contained in order to promote geochemical stability. The cover design includes a minimum 30cm of topsoil and 30cm of subsoil to be placed on top of a minimum 40cm fine non-acid forming (NAF) material (crushed NAF material 0.5cm-30cm diameter, graded upwards). This 100cm thick root zone profile would overlie up to 160cm of coarse NAF material (30cm-40cm diameter) overlying 40cm of compacted subsoil. This design would provide significant water holding capacity in the capping profile and encourage vigorous growth of pasture to protect the surface of the rehabilitated areas from erosion, whilst keeping roots away from the compacted zone, which would minimise the risk of oxygen and/or water ingress, via root channels and/or shrinkage cracks, into the encapsulated materials.

A high priority would need to be given to maximising soil quality from the moment that soil scraping commences through to completion and maintenance of rehabilitation across the Mine Site via the following measures.

- Soil acidity would be corrected via lime application, which would improve conditions for soil micro-organisms and make soil nutrients more available for uptake by plants. However, where native plant species selected for revegetation have a requirement for strongly acidic conditions, some of the topsoil and underlying subsoil should not be limed prior to scraping.
- Physical damage to soil structure during scraping, storage and re-spreading of soil for the reinstated root zone would be minimised by only working the soil when its moisture content is suitable, i.e. not too wet or too dry.
- The amount of time when the Mine Site soil is lacking drought-tolerant vegetative protection would be minimised so that soil erosion is controlled and soil biological activity is maximised.

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1. INTRODUCTION

The Project, which is owned and managed by Bowdens Silver Pty Limited (Bowdens Silver), is situated 26km east of Mudgee NSW and 2km northeast of Lue (see **Figure 1**). The Project would incorporate conventional open cut pits (one main and two smaller, satellite pits), from which overburden/waste rock would be removed from above and around the silver-zinc-lead ore and in the case of non-acid forming (NAF) material, used for on-site construction activities, or be stockpiled in the southern barrier for use in rehabilitation activities, whilst potentially-acid forming (PAF) material would be placed in an out-of-pit waste rock management area (WRE). The mined ore would be transported by haul trucks to the on-site processing plant where it would be crushed, milled and processed to liberate the silver, zinc and lead minerals. These minerals would be collected by conventional froth flotation to produce two concentrates that would be dewatered and transported off site by truck. The residual materials from processing (tailings) would be pumped in the form of a slurry to a tailings storage facility (TSF) located to the west of the main open cut pit.

The Project would require the development of seven principal components within the Mine Site, namely:

- i) a main open cut pit and two satellite open cut pits, collectively covering approximately 52ha;
- ii) a processing plant and related infrastructure covering approximately 22ha;
- iii) a WRE covering approximately 77ha;
- iv) a low grade ore stockpile covering approximately 14ha (9ha above WRE);
- v) an oxide ore stockpile covering approximately 8ha;
- vi) a TSF covering approximately 117ha; and
- vii) the southern barrier to stockpile NAF waste rock for later use in rehabilitation activities and provide visual and acoustic protection to properties south of the Mine Site covering approximately 32ha.

Figure 2 displays the indicative locations of the principal mine components.

The Project would require a site establishment and construction period of approximately 18 months during which the processing plant and all related infrastructure and the initial embankment of the TSF would be constructed. Once operational, Bowdens Silver anticipates the mine would produce concentrates for approximately 15 years. In total, it is proposed the mine life would be approximately 16.5 years, i.e. from the commencement of the site establishment and construction stage to the completion of concentrate production. It is envisaged rehabilitation activities would be completed over a period of approximately 7 years, i.e. from Year 16 to Year 23. The duration of each of the main components throughout the mine life and Project life are displayed in the following schematic. **Figure 3** displays the duration of each of the main components throughout the mine life and Project life.

Figure 1 Locality Plan

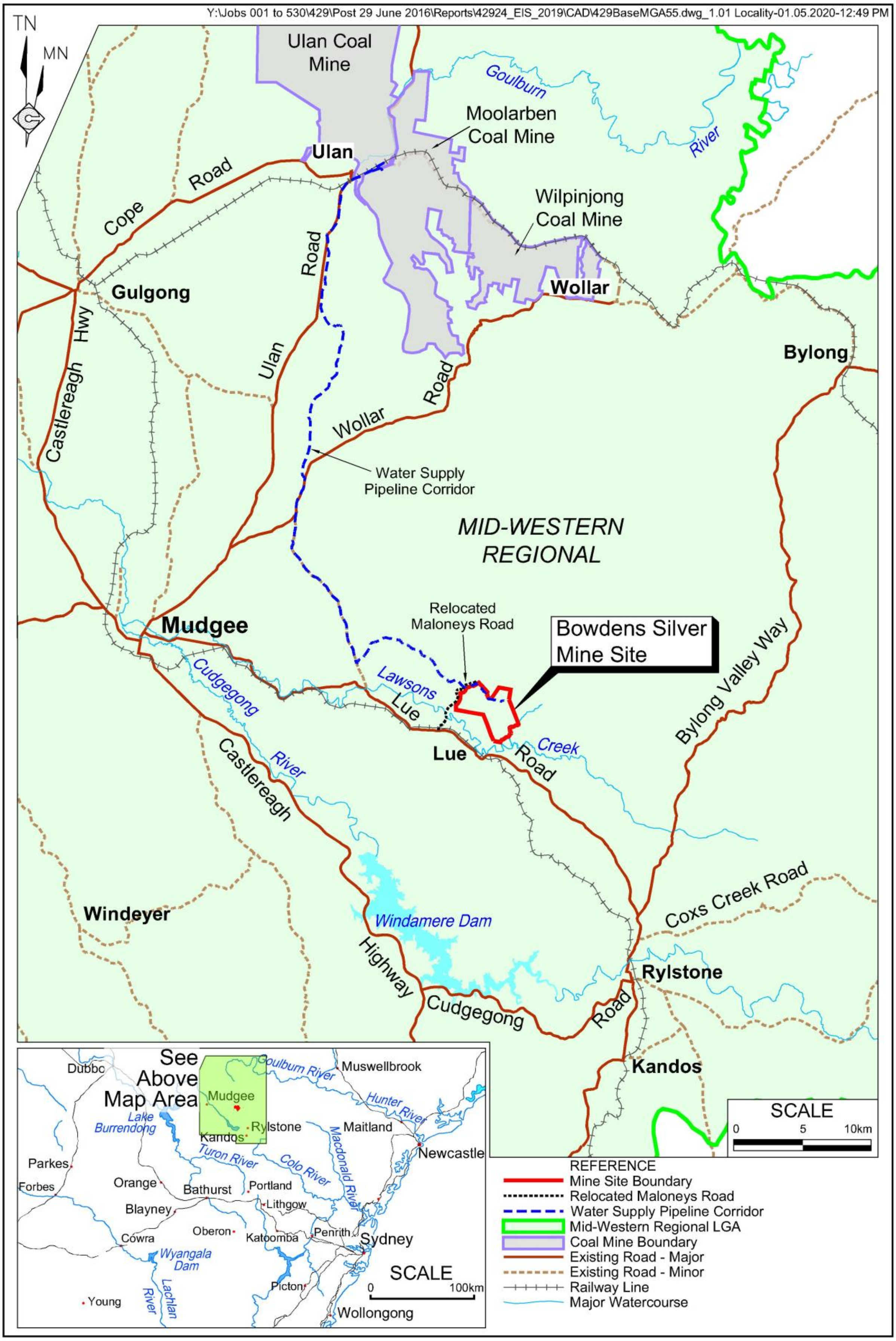


Figure 2 Mine Site Layout

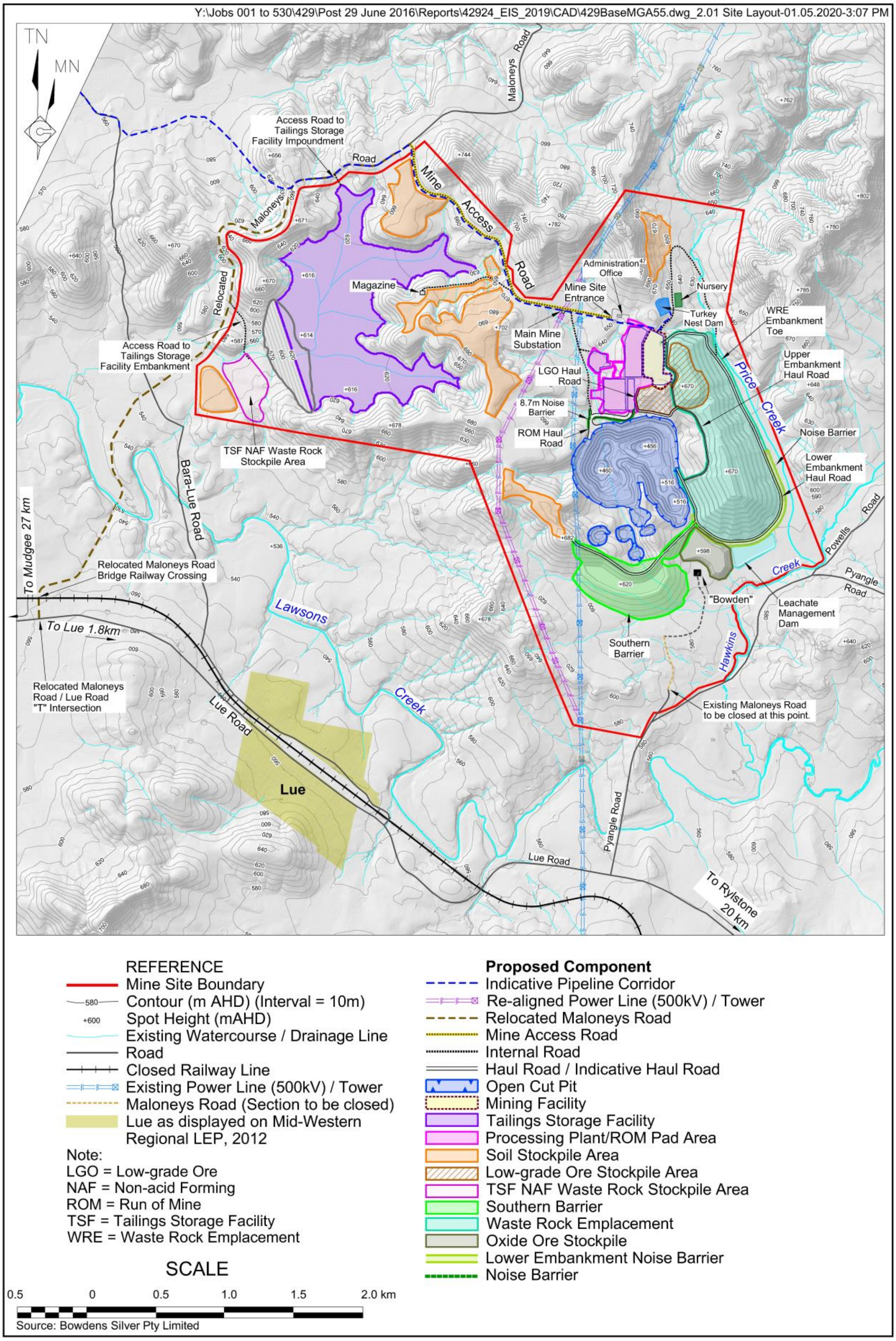
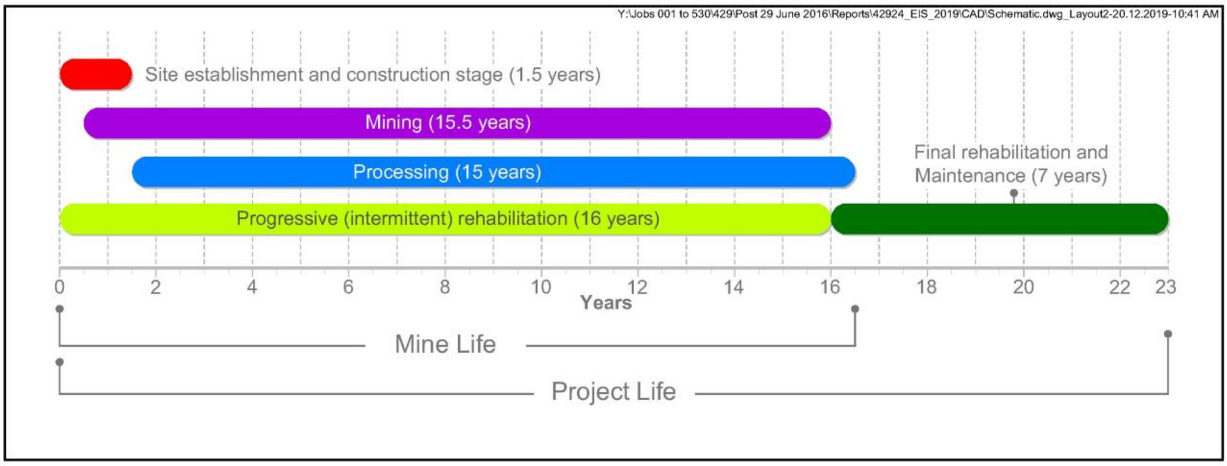


Figure 3 Schematic Display of Mine Life and Project Life



The on-site mine components would be supported by a range of on-site and off-site infrastructure. The on-site infrastructure comprises haul roads, water management structures, power/water reticulation, workshops, stores, compounds and offices/amenities. The off-site infrastructure comprises a relocated section of Maloneys Road (including a new railway bridge, crossing and new crossing of Lawsons Creek), a 132kV power line and a water supply pipeline for the delivery of water from the Ulan and/or Moolarben Coal Mines to the Mine Site. It is noted that the 132kV power line required for the mine power supply would be the subject of a Part 5 application submitted under the EP&A Act by the relevant energy provider.

R.W. Corkery & Co. Pty Limited, on behalf of Bowdens Silver, commissioned Soil Management Designs to carry out a 'Soils and Land Capability Assessment' for the Project.

A site soil survey (including the description and sampling of 41 test pits) was carried out at the Mine Site in mid-February 2017.

The objectives of the site soil survey were to:

- determine whether or not 'Biophysical Strategic Agricultural Land' (BSAL) is present in the Mine Site using procedures documented in the NSW Government 'Interim Protocol'. An absence of significant areas of BSAL meant that the approval requests proceeded through use of a 'Site Verification Certificate' (SVC). Where declarable BSAL is identified, a 'Gateway Certificate' is required (www.planning.nsw.gov.au/Policy-and-Legislation/Mining-and-Resources/Gateway-Assessment-and-Site-Verification) – via a process that requires more thorough scrutiny by regulators than granting of a SVC.
- assess agricultural productivity and erosion hazards of the existing landscape – this includes a consideration of land and soil capability;
- plan the soil stripping process in disturbance areas, including amelioration of topsoil and subsoil before being placed in stockpiles for use in rehabilitation activities; and
- provide recommendations about soil management requirements during and after rehabilitation.

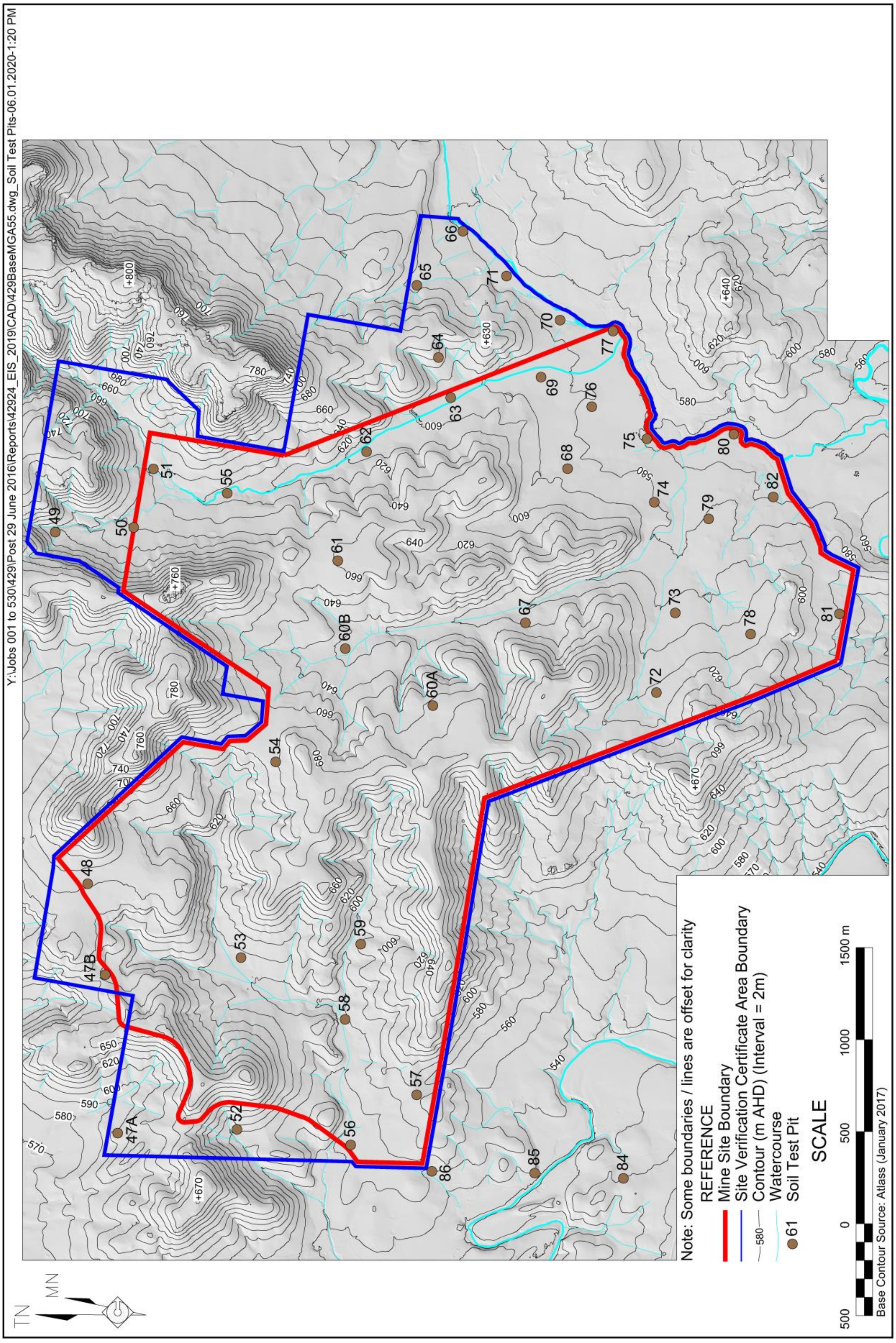
These objectives allow for the 'Secretary's Environmental Assessment Requirements' (SEARs) (see **Table 1**) for the Project to be addressed.

The soil test pit locations are shown in **Figure 4**. The sequence of soil test pit numbers follows on from the soil test pits investigations historically undertaken in the vicinity of the Mine Site. Soil pits 83-86 were located well beyond the current study area (defined by the Mine Site Boundary in **Figure 4**) and are not considered in detail in this report.

Table 1
Coverage of SEARs and Other Government Agency Requirements

Relevant Requirement(s)		**Coverage in Report**
Secretary's Environmental Assessment Requirements		
The EIS must include an assessment of: • the likely impacts of the development on soils and land capability of the site and surrounds;		
Relevant Requirements Nominated by Other Government Agencies		
Environment Protection Authority 14/05/19	The EIS should include the following.	
	• An assessment of potential impacts on soil and land resources should be undertaken, being guided by *Soil and Landscape Issues in Environmental Impact Assessment* (DLWC 2000).	Section 7
	• An assessment of soil erosion and sediment transport - in accordance with *Managing urban stormwater: soils and construction,* vol. 1 (Landcom 2004) and vol. 2 (A. Installation of services; B Waste landfills; C. Unsealed roads; D. Main Roads; E. Mines and quarries) (DECC 2008).	Section 7
	• An assessment of urban and regional salinity – in accordance with guidance given in the Local Government Salinity Initiative booklets which includes *Site Investigations for Urban Salinity* (Lillicrap and McGhie, 2002).	Section 5.6
Department of Primary Industries – Agriculture 16/05/19	The EIS should include the following. • A description of the mitigation and management options that will be used to prevent, control, abate or minimise identified soil and land resource impacts associated with the project.	Section 7
	• an *Agricultural Impact Statement* in accordance with the *NSW Government Guideline for Agricultural Impact Statements* (2012) and *Agricultural Impact Statement Technical Notes 2013*	SCSC Part 14
	• The pipeline route planning and construction should consider the construction impacts on areas of erosion and salinity, including steep lands.	EIS Section 4.13
	• An assessment of agricultural land uses and production values along the pipeline route, along with estimates of loss of land. Agricultural production information can be used to provide relevant agricultural baseline data for rehabilitated land outcomes.	EIS Section 4.18
	• Any land identified as cropping or special use land (such as viticulture) should have the pipeline depths adjusted to deal with these land uses in consultation with stakeholders so as not to impact on agricultural operations.	EIS Section 4.18
	• A landholder consultation process should be outlined in relation to pipeline access, construction and ongoing maintenance.	EIS Section 3.2.2
Office of Environment & Heritage 14/05/19	The EIS must map features relevant to soils including …acid sulfate soils (Class 1, 2, 3 or 4 on the Acid Sulfate Soil Planning Map).	Maps 1-11
Mid-Western Regional Council 14/02/13	Assess impacts on adjoining agricultural lands that are likely to occur as a result of the mine including soil resources and land capabilities.	Section 7.4

Figure 4 Soil Test Pit Locations



2. REGIONAL AND LOCAL CONTEXT

This section summarises the environmental and agricultural setting of the Mine Site and the Lue district, as described in Section 4 of the Environmental Impact Statement (EIS) for the Project (RWC, 2020).

2.1 TOPOGRAPHY AND DRAINAGE

2.1.1 Regional and Local Topography and Drainage

The Mine Site is situated on the outer western flanks of the Great Dividing Range with the regional topography of the area dominated by elevated rocky ridges and broad flat alluvial valleys. The topography generally ranges in elevation from approximately 770m Australian Height Datum (AHD) within peaks and ridges associated with the Great Dividing Range in the northeast, to elevations below 550m AHD within the alluvial valleys to the south of the Mine Site (**Figures 3** to **5**).

Drainage typically follows the topography of the regional area in that the higher elevations to the north of the Mine Site direct water downslope towards the south and southwest, where surface water flows in ephemeral drainage lines before entering Hawkins Creek. Hawkins Creek joins Lawsons Creek approximately 750m south of the Mine Site, before meandering westwards and joining the Cudgegong River on the northern outskirts of Mudgee, approximately 26km west of the Mine Site (**Figure 1**).

2.1.2 Mine Site Topography and Drainage

The topography of the Mine Site is primarily influenced by two north-south orientated spurs with small intermediate valleys in the central and eastern sections of the Mine Site, two west-east orientated spurs in the western section of the Mine Site, and a broad, flat valley to the south of the Mine Site containing Hawkins Creek (**Figure 4**).

The eastern spur, in the eastern section of the Mine Site, has the highest elevation (approximately 770m AHD) within the Mine Site. The small valley to the east of this spur, which contains Price Creek, falls to an elevation of approximately 600m AHD. Blackmans Gully, a small valley containing Maloneys Road, lies to the west of the eastern spur. The western spur (at an elevation of up to 670m AHD) is located in the centre of the Mine Site and directs runoff into either Blackmans Gully or into one of the headwaters (northern and southern) of Walkers Creek, that is located in the western section of the Mine Site. The ephemeral northern and southern headwaters of Walkers Creek drain the western section of the Mine Site. The valley containing Walkers Creek and its headwaters has a minimum elevation of 570m AHD and rises to a maximum elevation of approximately 680m AHD near the centre of the Mine Site.

The drainage lines within the small valleys between the spurs in the eastern section of the Mine Site each drain to the south where they join differing sections of Hawkins Creek which in turn joins Lawsons Creek approximately 750m from the southernmost point of the Mine Site. In the western section, drainage occurs to the west where drainage lines join Lawsons Creek approximately 1km to the west of the Site.

The western spur extends southwards along the centre of the Mine Site and joins a near east-west ridge referred to as the 'southwest ridge' and is prominent local topographic feature between the Site and Lue. It is understood that this ridge is referred to locally as 'Bingman Hill'. The ridge rises to elevations of between 630m AHD and 678m AHD. Elevations within Lue vary from approximately 550m AHD to 600m AHD. Lawson Creek flows in a northwesterly direction immediately north of Lue.

2.2 METEOROLOGY

2.2.1 Climate Data

The closest Bureau of Meteorology (BoM) weather station that provides long term climatic information suitable for use in describing the local climate is located at Mudgee Airport AWS (Station No. 062101), 26km west of the Mine Site.

Additional climate information was sourced from the two Bowdens Silver weather stations, Lue Met 01 in the eastern section of the Mine Site and Lue Met 02 in Lue, between March 2013 and November 2018 to provide Site-based weather data and conditions.

Table 2 provides the historical climate data from the BoM, Met 01 and Met 02 with the maximum and minimum values highlighted in **bold** text.

Table 2
Historic Climatic Data

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Temperature (°C) Mudgee Airport Station (Station # 062101) Period of Record 27 Years													
Mean maximum temperature	31.0	29.5	26.8	23.0	18.6	15.0	14.4	16.3	19.6	23.1	26.4	28.8	22.7
Mean minimum temperature	16.1	15.6	12.8	8.0	4.0	2.4	1.1	1.5	4.3	7.7	11.3	13.8	8.2
Relative Humidity (%) Mudgee Airport Station (Station # 062101) Period of Record 19 Years													
Mean 9:00am relative humidity	63	70	72	71	80	87	87	78	70	61	63	62	72
Mean 3:00pm relative humidity	37	42	42	41	49	57	55	47	44	41	40	37	44
Rainfall (mm) Mudgee Airport Station (Station # 062101) Period of Record 24 Years													
Mean monthly rainfall	67.6	63.1	58.9	33.2	37.9	45.0	43.4	35.2	54.6	51.1	75.4	**80.7**	663.2
Highest monthly rainfall	195.6	233.0	187.0	108.4	124.0	127.2	143.8	112.2	197.4	135.8	162.8	**241.6**	1152.4
Lowest monthly rainfall	10.0	2.2	**0.0**	**0.0**	0.4	1.4	2.6	1.0	0.8	0.2	9.4	15.0	349.6
Highest daily rainfall	65.0	**174.2**	72.0	46.2	44.4	37.0	51.2	51.2	61.0	51.0	57.2	100.8	-
Average Rain Days (>1mm)	7.3	6.9	6.9	4.8	6.3	10.1	9.9	7.6	7.4	8.0	9.3	8.6	93.1
Rainfall (mm) Lue Met01 - Period of Record 5 Years													
Mean monthly rainfall	41.2	57.2	65.2	38.6	36.4	58.2	36.6	29.1	53.4	39.6	53.0	61.5	635.3
Highest daily rainfall	45.2	81	50.6	31.4	26.8	29.2	41.6	19	50	24.6	49.2	51.6	-
Rainfall (mm) Lue Met02 - Period of Record 5 Years													
Mean monthly rainfall	34.3	56.2	58.0	31.6	31.1	59.2	44.4	32.4	57.8	45.0	56.6	71.5	632.2
Highest daily rainfall	41.8	125.6	52	32.4	25.8	29.8	41.2	20.8	60.8	30.6	56	58.2	-

2.2.2 Temperature and Humidity

Temperature and humidity data were sourced from the Mudgee Airport BoM station and show that January is the warmest month with a mean maximum temperature of 31.0°C and mean minimum temperature of 16.1°C. July is the coldest month with a mean maximum temperature of 14.4°C and a mean minimum temperature of 1.1°C.

The lowest average relative humidity generally occurs in the summer months, with January and December sharing the lowest relatively humidity values throughout the year. The highest average relative humidity occurs in June.

2.2.3 Rainfall

Rainfall data were sourced both from Mudgee Airport BoM and the two on-site Met Stations. Whilst the on-site Met Stations have a limited dataset (2013-2018), the rainfall records at the Met Stations generally reflects rainfall trends displayed in the Mudgee Airport dataset, albeit at slightly lesser amounts and with the exception of Met 01 which returns average monthly rainfall above that returned for Mudgee Airport in March, April and May. Average annual rainfall at Mudgee Airport BoM is 663.2mm. The average annual rainfall generated for the two on-site stations is considered less reliable due to the short timeframe covered in the dataset.

Rainfall can be variable, with infrequent, high intensity rainfall events occurring. This is evidenced by the highest daily rainfall values shown in **Table 2** and the fact that the maximum daily rainfall values can be as high as 2 times the average monthly rainfall values (e.g. 125.6mm, Met 02, 25 February 2018). An example of this rainfall variability is the high intensity rainfall event recorded at Met 01 (81mm) and Met 02 (125.6mm) on 25 February 2018 with no rainfall recorded at Mudgee Airport on the same date.

2.2.4 Evaporation

Evaporation data have been sourced from the Scientific Information for Land Owners (SILO) Climate Database which provides data of historical climate records by accessing grids of data (grid reference -32.65, 149.85) that were interpolated from point observations by the Bureau of Meteorology. Evaporation has been calculated using Class A Evaporation (post 1970) and synthetic pan evaporation (pre 1970).

Mean monthly evaporation for the Mine Site varies throughout the year, from approximately 220mm in January and December to 42.6mm in June, typically following the seasons throughout the year (**Table 3**). The annual evaporation rate of 1 514.2mm exceeds the average annual rainfall averaged calculated from data collected at Met 01 and Met 02 by a factor of approximately 2.4.

Table 3
Historic Climatic Data (SILO)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Class A Evaporation (mm) SILO Climate Data - Period of Record 129 Years (pre 1970: synthetic pan evaporation)													
Mean monthly evaporation	220.3	174.6	151.3	97.7	62.9	42.6	47.1	69.9	103.3	144.9	180.1	219.5	1 514.2
Mean daily evaporation	7.1	6.2	4.9	3.3	2.0	1.4	1.5	2.3	3.4	4.7	6.0	7.1	-

2.2.5 Land Uses

Apart from Lue, all land surrounding the Mine Site comprises a combination of rural properties and hobby farms / lifestyle blocks with limited grazing. Grazing is the predominant land use in the Lue district. **Figure 5** shows the existing land uses within and immediately surrounding the Lue district.

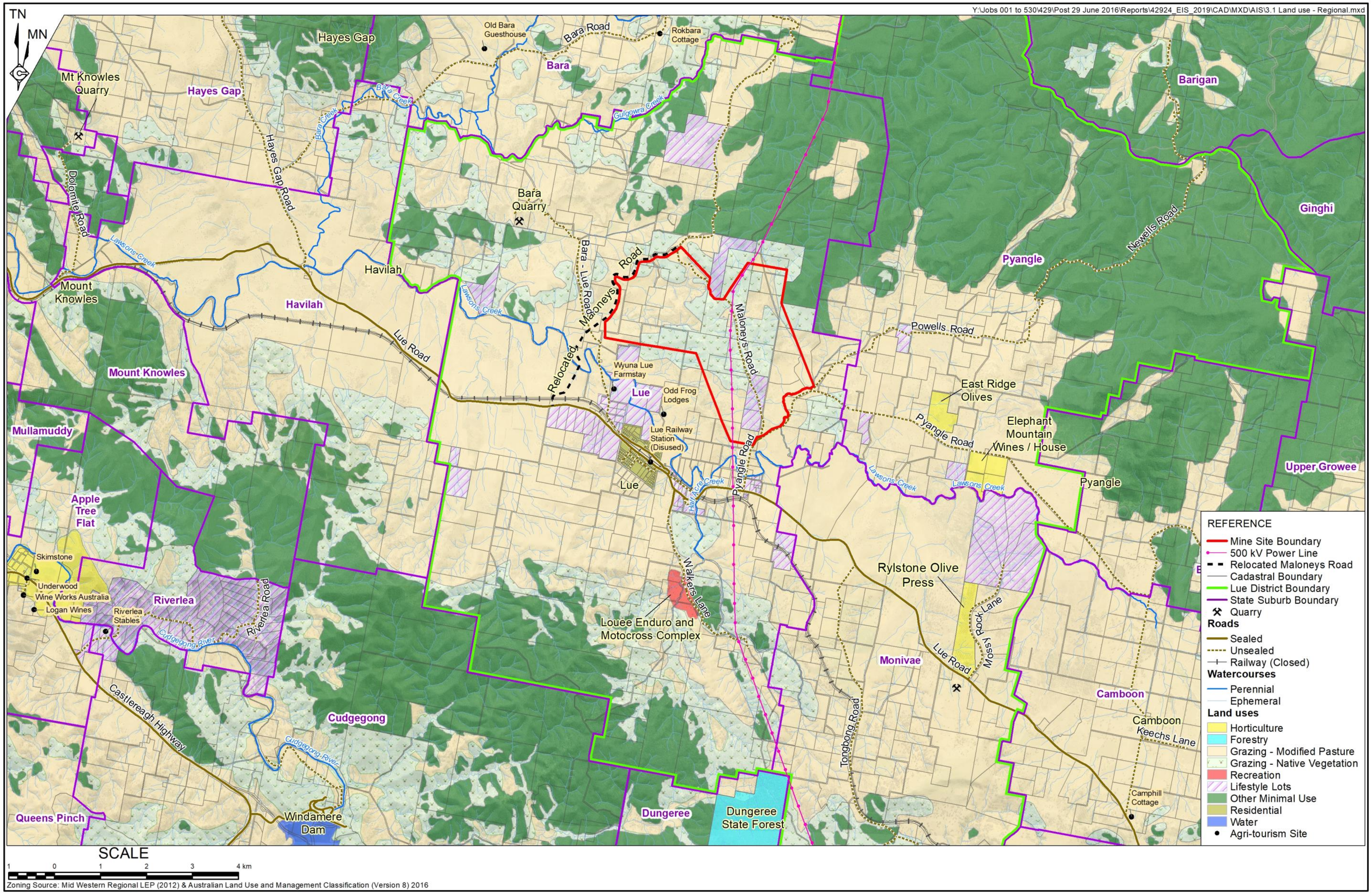
Minor areas within the Lue district are utilised for horticultural activities, in particular the Rylstone Olive Press and East Ridge Olives which are both notable olive growers in the Lue district. These two enterprises are located approximately 7.5km and 4.5km from the Mine Site respectively. Viticulture enterprises are also established within the Lue district, with Pyangle Estate being the closest vineyard to the Mine Site (7km to the east). Pyangle Estate also operates a B&B known as Elephant Mountain House. Several vineyards are located on the Castlereagh Highway immediately south of Mudgee with the closest being approximately 16km from the Mine Site.

Other land uses that occur within and immediately surrounding the Lue district include the extractive industry with three quarries located near the Mine Site. These quarries include the Mt Knowles Quarry, the Bara Quarry and a privately-owned quarry on the southern side of Lue Road opposite the Rylstone Olive Press. The Mt Knowles and Bara Quarries are located approximately 14km and 5km to the northwest of the Mine Site, respectively. The privately-owned quarry is located approximately 7.5km to the southeast of the Mine Site.

Large tracts of land also remain heavily vegetated within and surrounding the Lue district, primarily on steep, hilly terrain. The closest forestry reserve is the Dungeree State Forest which is located approximately 10km to the south of the Mine Site.

The Windamere Dam, which collects the natural flow of the Cudgegong River, is located approximately 14km southwest of the Mine Site. The dam supplies water for both agricultural production and town water within the Mid-Western Regional LGA. It also provides for flood mitigation and recreational activities.

Figure 5 Surrounding Land Uses



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3. SOIL RESOURCES

3.1 REVIEW OF EXISTING SOIL SURVEY INFORMATION

The following existing soil resource information relevant to the Mine Site and surrounding area was reviewed for this report.

- Geology data provided by Bowdens Silver.
- Soil Profile Attribute Data Environment (eSPADE) soil profiles (NSW Natural Resource Atlas 2016).
- Regional soil type and landscape mapping (Murphy and Lawrie, 1998).
- Acid sulfate soil risk map data (NSW Natural Resource Atlas 2016).

A summary of relevant information from these sources is provided in the following subsections.

3.1.1 Geology / Parent Materials for Soil Formation

Geology information for the Mine Site (Bowdens Silver, pers. comm.) is shown in **Figure 6**.

3.1.2 eSPADE Soil Profile Database

A search of the NSW Government's 'eSPADE' website (NSW Natural Resource Atlas 2016) was conducted to identify any existing soil profile information in the Study Area. No eSPADE soil profiles were located within the Mine Site.

3.1.3 Soil Types and Landscapes

Figure 7 shows the soil landscape units as mapped and described by Murphy and Lawrie (1998) within the Mine Site and region.

Six soil landscape units were identified within or close to the Mine Site (i.e. Barrigan Creek Yellow Podzolic Soils, Lees Pinch Shallow Soils, Rylstone Siliceous Sands, Botobolar Non-Calcic Brown Soils, Munghorn Plateau Siliceous Sands and Bald Hill Soils). Further information relating to the soil landscape units in the vicinity of the Mine Site and land capability constraints is presented in **Table 4**.

Figure 6 Mine Site Geology

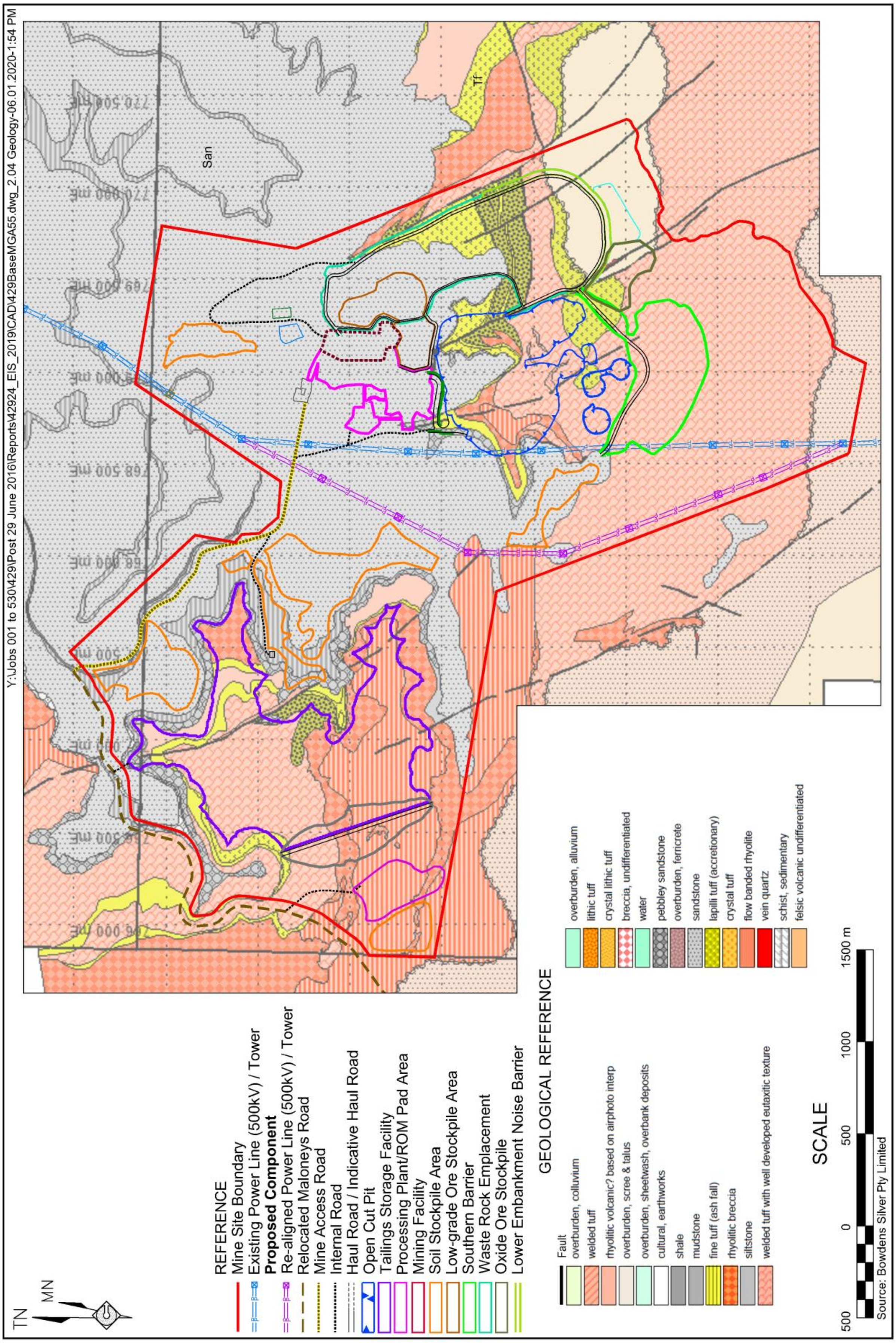

Figure 7 Regional Soil Landscapes

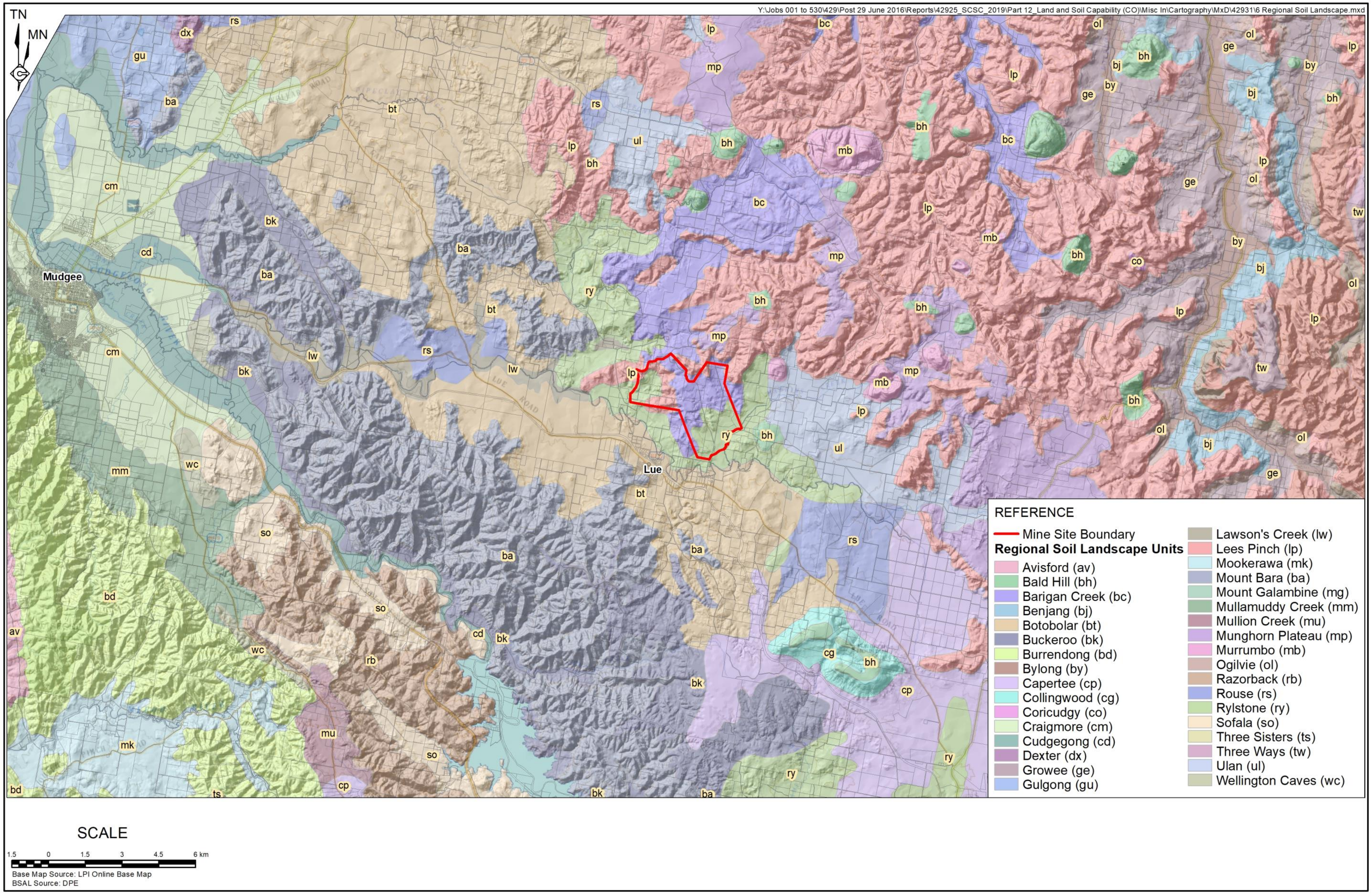

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Table 4
Soil Landscape Units Mapped in the Vicinity of the Mine Site[1]

Soil Landscape Unit	Parent Materials and Soil Types Present	Land Capability Constraints
Barrigan Creek Yellow Podzolic Soils (bc)	Shale, sandstone, siltstone, conglomerate, chert. Undulating low rises and flats. Common soils include Yellow and Red Podzolic Soils.	High erosion hazard under cropping or where there is low surface cover. Salinity in localised areas in drainage depressions.
Lees Pinch Shallow Soils (lp)	Shallow Siliceous Sands. Some Yellow and Brown Earths on footslopes. Yellow and Grey Soloths in breaks of slope. Yellow Podzolic Soils and Earthy Sands on some upper slopes.	Very poor water holding capacity, acidity and a lack of nutrients. Prone to water erosion when bare.
Rylstone Siliceous Sands (ry)	Rhyolite and dacitic tuff. Mainly shallow siliceous sands and bleached sands. Some Yellow and Red Podzolic Soils on sloping areas and Solodic Soils / Soloths in drainage lines.	Shallow soils, rock outcrop, low waterholding capacity, seasonal waterlogging, sodic subsoils in depressions, very high erosion hazard under cultivation.
Botobolar Non-Calcic Brown Soils (bt)	Slate, phyllite, limestone, rhyolite, dacite, shale, sandstone and minor alluvial and colluvial derivatives. Soils include Non-Calcic Brown Soils, Shallow Soils near hill tops and Yellow Podzolic-Solodic Soils on poorly drained soils.	High to very high erosion hazard and low surface cover. Weakly structured surface soils. Moderate waterholding capacity.
Munghorn Plateau Siliceous Sands (mp)	Narrabeen Sandstone. Mainly shallow siliceous sands. Yellow Earths and Yellow Podzolic Soils on lower slopes and in depressions.	Low waterholding capacity, rock outcrop, seasonal waterlogging, high permeability, acid surface soil.
Bald Hill (bh)	Basalt: Euchrozems on crests; Brown Clays on lower slopes. .	Steep slopes, rock outcrop and stoniness, but moderate to high fertility and waterholding capacity. .
Note[1] : Source Murphy and Lawrie (1998)		

3.1.4 Acid Sulfate Soil Mapping

The acid sulfate soil risk map (NSW Natural Resource Atlas) was reviewed. No acid sulfate soils are mapped within the vicinity of the Mine Site and therefore mapping has not been reproduced in this report. No acid sulfate soils were observed during the site soil survey conducted for this assessment.

3.2 SITE SOIL SURVEY

A detailed site soil survey was carried out across the Mine Site in mid-February 2017.

The survey was conducted by accredited soil scientists, Dr David McKenzie and Mr Adrian Harte, in conjunction with Mr Tom Purcell and Ms Sally Mayberry from Bowdens Silver. Dr McKenzie has Certified Professional Soil Scientist (CPSS) accreditation (http://www.cpss.com.au/) from Soil Science Australia and a PhD in soil science. Dr McKenzie also has ‘Chartered Scientist’ accreditation with British Society of Soil Science. Mr Harte also has CPSS accreditation.

The following subsection provides a description of the methodologies and objectives used for the site soil survey in February 2017.

3.2.1 Site Soil Survey Methodology

The methodology for the survey conducted by Soil Management Designs was designed to:

1. establish the presence or otherwise of Biophysical Strategic Agricultural Land (BSAL); and
2. determine the physical and chemical characteristics of the soils of the Mine Site to identify soil types and assess their suitability for use in rehabilitation; this includes the design and implementation of suitable soil stripping, handling and stockpiling strategies.

The site soil survey considered the requirements of the *Interim protocol for site verification and mapping of biophysical strategic agricultural land* (Interim Protocol; NSW Government 2013).

The following soil information is regarded by Ward (1998) as being important for soil assessment associated with mine site rehabilitation, and was incorporated into the methodology for this assessment:

- Soil classification (structure, texture, etc.): allows existing data and experience on managing similar soils elsewhere to be incorporated into a surface soil management strategy.
- Dispersion index and particle size analysis: indicate soil structural stability and erodibility.
- pH: required to identify extreme ranges for treatment with lime or selection of suitable plant species.
- Electrical conductivity (EC): indicates soluble salt status.
- Macro- and micro-nutrients.

More specifically, Elliott and Reynolds (2007) recommend that the following soil factors should also be considered when assessing suitability of soil for mine site rehabilitation.

- Structure grade, which affects the ability of water and oxygen to enter soil.
- The ability of a soil to maintain structure grade following mechanical work associated with its extraction, transportation and spreading.
- The ability of soil peds to resist deflocculation when moist.
- Macrostructure - where soil peds are larger than 100 mm in the subsoil, they are likely to slake or be hard-setting and prone to surface sealing.
- Mottling - its presence may indicate reducing conditions and poor soil aeration.
- Texture - soil with textures equal to or coarser than sandy loam are considered unsuitable as topdressing materials as they are extremely erodible and have low water holding capacities.
- Material with a gravel and sand content greater than 60% is unsuitable.
- Saline material is unsuitable.

3.2.2 Site Soil Survey Locations

The locations of the 41 soil test pits (see **Figure 4**) were identified based on geology (see **Figure 5**) and position in the landscape and slope (see **Map 1**). A Garmin '*GPSmap 62S*' instrument with an accuracy of approximately ±4 m was used to record the pit coordinates (**Annexure A**).

Of the 41 soil test pit locations, 29 are located within the Mine Site. Of these, 14 are located within areas of disturbance associated with open cut pit development, the TSF, internal roads, the processing plant, stockpiling of topsoil, subsoil and NAF waste rock and the WRE. An additional soil test pit location is in an area of disturbance associated with the development of the relocated Maloneys Road. The remaining soil test pit locations (soil test pits 49, 52, 84, 85 and 86) are situated outside of the Mine Site. Soil test pit 83 was not excavated and examined because of access problems.

The soil depth intervals sampled in this survey were 0 to 5 centimetres (cm), 5 to 15 cm, 15 to 30 cm, 30 to 60 cm, and 60 to 100 cm, as per the Interim Protocol. Where important horizon boundaries did not coincide with the prescribed depth intervals, additional samples were collected to ensure that distinctive horizons (e.g. A2 horizons) were kept separate for analysis.

3.2.3 Site Soil Survey Observations and Testing

The field description methods were as detailed the '*Australian Soil and Land Survey Field Handbook*' (National Committee on Soil and Terrain 2009) and the '*Guidelines for Surveying Soil and Land Resources, Chapter 29*' (McKenzie *et al*. 2008). The soil profiles have been classified according to the Australian Soil Classification (ASC) (Isbell 2002).

A 1.4m deep soil test pit profile (shallower where hard rock was encountered) was excavated with a backhoe and trimmed with a geological pick to allow high resolution photography and descriptions of the *in situ* soil structure, mottling and root growth.

The following characteristics were assessed for the layers identified in each of the soil profiles:

- thickness of each layer (horizon);
- soil moisture status at the time of sampling;
- pH (using Raupach test kit);
- colour of moistened soil (using Munsell reference colours) and mottle characteristics (e.g. oxidation colouring);
- pedality (aggregation) of the soil;
- amount and type of coarse fragments (gravel, rock, manganese oxide nodules);
- texture (proportions of sand, silt and clay), estimated by hand;
- presence/absence of free lime and gypsum;
- root frequency; and
- soil dispersibility and the degree of slaking (dis-aggregation) in de-ionised water (after 10 minutes).

Factors noted at each soil test pit included the current land use, landform (landscape position and element), slope (measured with a SUUNTO clinometer), aspect, vegetative groundcover and surface rock outcrop where relevant.

The field observations recorded at each soil test pit are presented in **Annexure A, B** and **C**.

The soil structure information (**Annexure C**) has been summarised to give 'SOILpak compaction severity' scores (McKenzie 2001) for each horizon. This allows for deep tillage recommendations to be made from the soil structure observations. The SOILpak score is on a scale of 0.0 to 2.0, with a score of 0.0 indicating very poor structure for crop root growth and water infiltration/storage. Ideally, the SOILpak score of the root zone would be in the range 1.5 to 2.0. Where the soil depth intervals shown in **Annexure C** included two horizons, for conservatism the smallest (i.e. the most limiting for root growth) of the two SOILpak scores was used for mapping (see **Map 6**).

Hand texturing (National Committee on Soil and Terrain, 2009) provides an approximation of the clay content of the soil in conjunction with an estimation of coarse fragment (gravel) content, to provide an alternative to particle size analysis.

Total available water (TAW) for the upper 1 m of soil (**Annexure A**) was estimated using texture, structure and coarse fragment content observation (McKenzie *et al*., 2008).

3.2.4 Laboratory Analysis

All soil test pits were sampled for laboratory analysis. The samples were analysed by the Incitec-Pivot Laboratory at Werribee Victoria, a National Association of Testing Authorities (NATA) accredited facility. The following physio-chemical parameters formed the analytical suite:

- exchangeable cations;
- pH;
- EC;
- chloride;
- nutrient status (nitrate-nitrogen, phosphorus, sulfur, zinc, copper, boron); and
- organic matter content

An ammonium acetate method was used for the extraction of exchangeable cations. The cation exchange capacity (CEC) values are the sum of exchangeable sodium, potassium, calcium, magnesium and aluminium. Exchangeable sodium data are presented as exchangeable sodium percentage (ESP). Phosphorus was determined using the Colwell method, sulphur by the Calcium Phosphate – Charcoal (CPC) method, boron by a calcium chloride ($CaCl_2$) extraction and zinc/copper by a Diethylenetriamine Pentaacetic Acid (DTPA) extraction (see Rayment and Lyons [2011] for further details). The results of the laboratory analyses are provided in **Annexure D**.

Soil dispersibility, as measured by the Aggregate Stability in Water (ASWAT) test (Field *et al.* 1997), was assessed by Soil Management Designs in Orange, NSW. The results are presented in **Annexure D**. The ASWAT test has been related to the well-known Emerson aggregate stability test by Hazelton and Murphy (2007) – see **Table 5**. An advantage of the

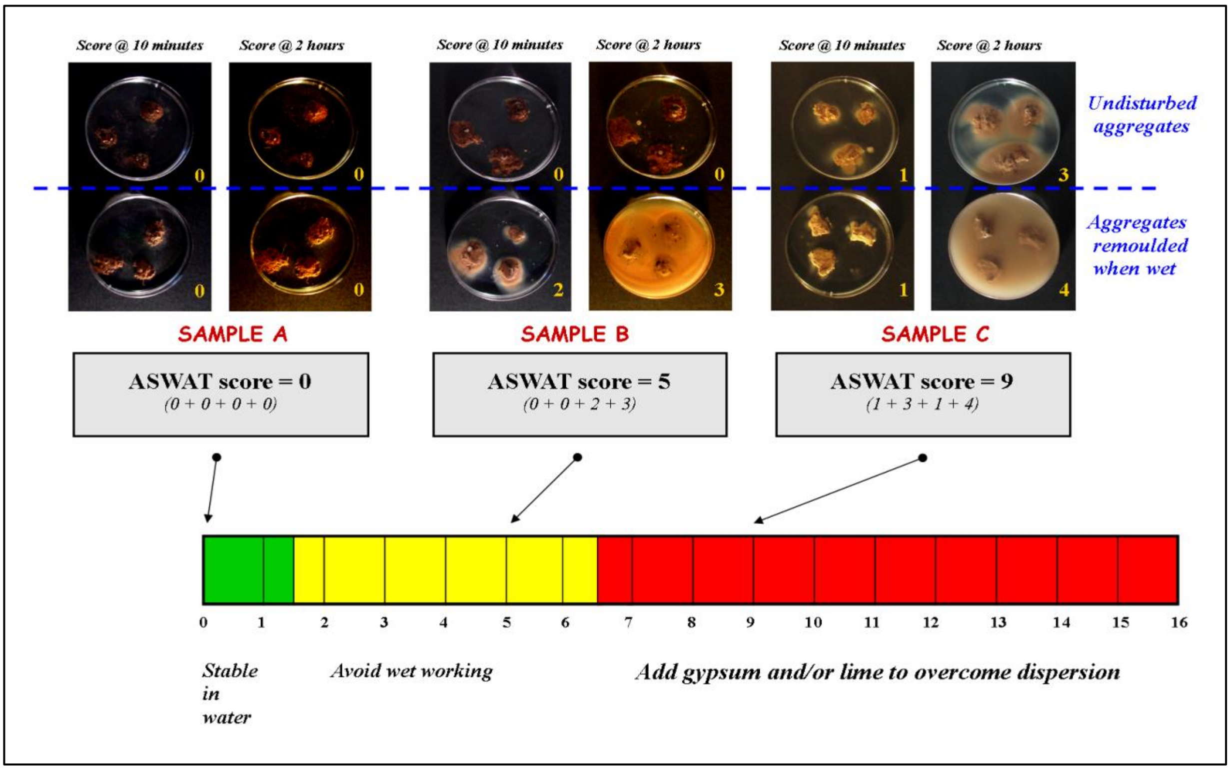
ASWAT test is that the results can be linked with management issues such as the need for gypsum application and the avoidance of wet working (McKenzie 2013) (see **Figure 8**). The conversion factors of Slavich and Petterson (1993) allow for the electrical conductivity of saturated paste extracts (ECe) to be calculated from the EC of 1:5 soil:water suspensions ($EC_{1:5}$) and texture.

The laboratory results are presented in **Annexure D**.

Table 5
Relationship between the Emerson Aggregate Stability Test and the ASWAT Test

Dispersibility	Emerson Aggregate Classes	Probable Score for the ASWAT Test[1]
Very high	1 and 2(3)	12-16
High	2(2)	10-12
High to moderate	2(1)	9-10
Moderate	3(4) and 3(3)	5-8
Slight	3(2), 3(1) and 5	0-4
Negligible/aggregated	4, 6, 7, 8	0
Note [1] see Field *et al*, 1997		

Figure 8 Link Between ASWAT Results and Soil Management Options



The following key soil factors are attached in the form of colour coded maps:

Map 2 Soil Types - Australian Soil Classification

Map 3 Plant Available Water (TAW)

Map 4 Depth to Mottled Layer

Map 5a Dispersion (ASWAT score)

Map 5b Dispersion (Exchangeable Sodium Percentage (ESP) Value)

Map 5c Dispersion (Electrochemical Stability Index (ESI) Value)

Map 6 Compaction Severity (SOILpak Score)

Map 7 Cation Exchange Capacity (CEC)

Map 8 Salinity (Electrical Conductivity - ECe)

Map 9 pH ($CaCl_2$)

Map 10 Phosphorus (Colwell P)

Map 11 Organic Carbon

4. SOIL TYPES AND MAPPING

A discussion about the soil types and land capability, based on the results of the soil test pits, is presented below.

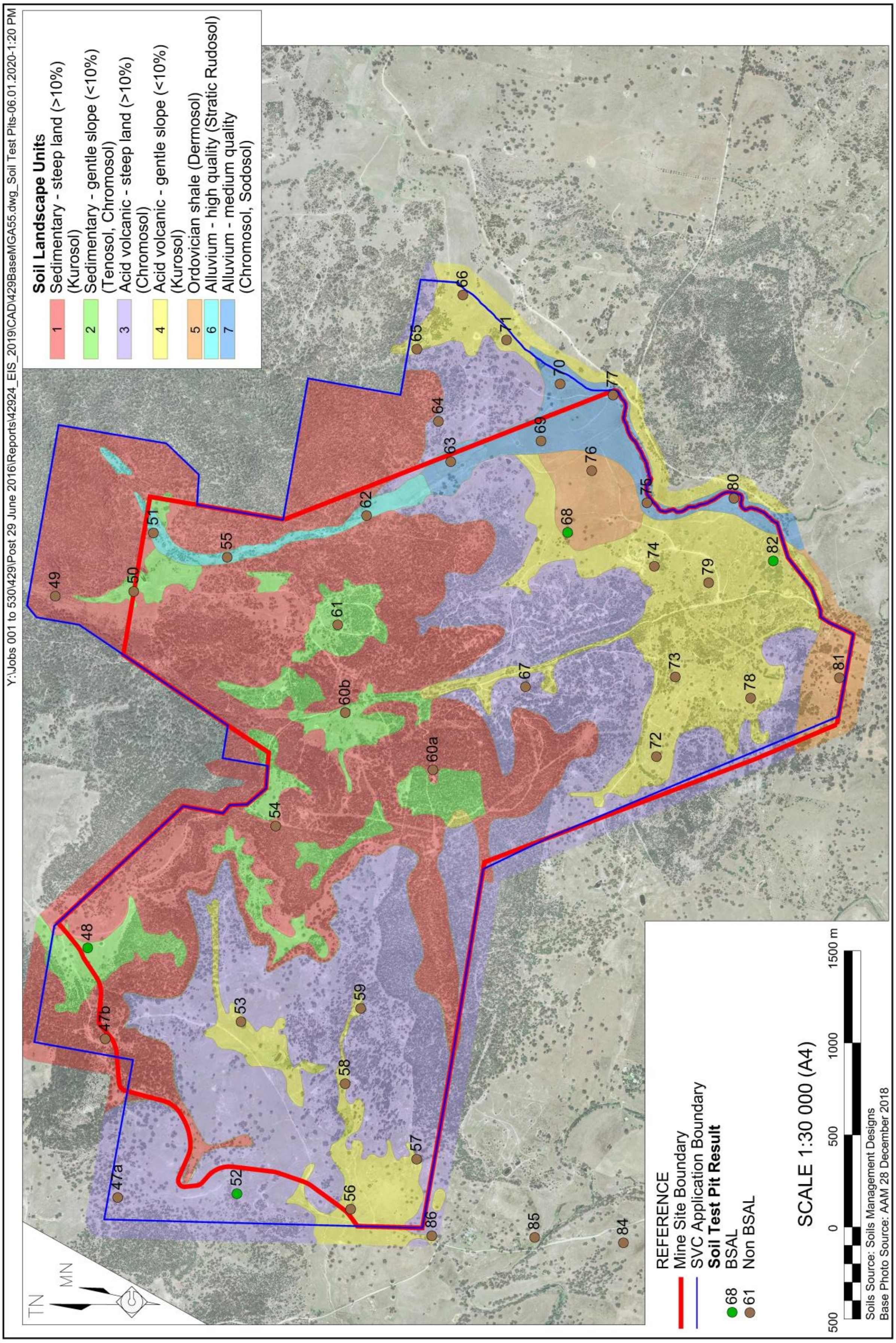
4.1 SOIL LANDSCAPE UNITS

Soil Landscape Units identified within the Mine Site which host the soil types described in the following section are shown in **Table 6** and presented in **Figure 9**. Soil Landscape Units are the associations of soils described and delineated by means of landforms (Dent and Young 1981). The terminology of the Soil Landscape Units used by Murphy and Lawrie (1998) was considered too broad for use in this assessment. Revised descriptions based on the results of the site soil survey therefore were developed for the Project.

Table 6
Soil Types Associated with the Soil Landscape Units

Soil Landscape Unit	Number of soil test pits	Dominant soil type(s)	Sub-Dominant soil type(s)	Land Capability Constraints
Sedimentary – steep land	3	Kurosol (2 of 3 soil test pits)	Tenosol (1)	Strong water erosion hazard; Acidity; Stony soil with poor water holding capacity
Sedimentary – gentle slope (<10%)	5	Tenosol (2) Chromosol (2)	Kurosol (1)	Water erosion hazard; Acidity
Acid (felsic) volcanic – steep land	4	Chromosol (2)	Dermosol (1) Rudosol (1)	Strong water erosion hazard; Acidity; Poor water holding capacity
Acid (felsic) volcanic – gentle slope (<10%)	14	Kurosol (4)	Sodosol (3) Dermosol (3) Tenosol (2) Chromosol (1) Rudosol (1)	Water erosion hazard; Acidity; Poor water holding capacity
Ordovician shale	3	Dermosol (3)		Despite shallowness of the soil, the water holding capacity would be favourable because of steeply dipping and partially decomposed shale parent material
Alluvium – high quality	3	Stratic Rudosol (3)		Deep young soil with favourable physical subsoil conditions for root growth; derived from alluvium associated with Price Creek
Alluvium – medium quality	6	Chromosol (2) Sodosol (2)	Dermosol (1) Hydrosol (1)	Deep; slow drainage associated with subsoil sodicity. The alluvium is derived mainly from Hawkins Creek.

Figure 9 Mine Site Soil Landscape Units



4.2 AUSTRALIAN SOIL CLASSIFICATION SOIL TYPES

The Australian Soil Classification (ASC) (Isbell, 2002) has been used to determine the soil types at each of the 41 soil test pits (**Map 2**). Photographs of the representative soil profiles identified during the survey are presented in **Figure 10A**, **Figure 10B** and **Figure 10C** (for each Soil Landscape Unit and ASC soil type described below). All of the soil test pits have three photographs to record the following:

a) Landscape view,

b) Trimmed soil profile, and

c) Close-up view of soil surface and associated vegetation where required. The Landscape view and Trimmed soil profile photographs for all of the soil test pits are shown in the Site Verification Certificate report associated with **Annexure E**.

ASC soil types, and the equivalent “Great Soil Group” (Stace *et al.* 1968) terminologies, are shown in **Table 7**.

Table 7
Soil Types Identified; Classified According to the ASC and Great Soil Groups

ASC Soil Type	Number of soil test pits	Great Soil Group Equivalent
Dermosol	11	Prairie soils, chocolate soils, some red and yellow podzolic soils
Kurosol	7	Many podzolic soils and soloths
Chromosol	7	Red-Brown Earths, Non-calcic brown soils
Sodosol	5	Soloths and Solodic Soils
Tenosol	5	Lithosols
Stratic Rudosol	3	Alluvial
Other Rudosol	2	Lithosol
Hydrosol	1	Some alluvial soils

The soil types in **Table 7** exhibit the following characteristics (Isbell, 2002):

- Dermosols: lack a strong texture contrast between the topsoil and the subsoil, which is structured.
- Kurosols: have a strong texture contrast between the A and B horizons, and a non-sodic subsoil with pH_{water} less than pH 5.5.
- Chromosols: have a strong texture contrast between the A and B horizons, and a non-sodic subsoil with pH_{water} greater than pH 5.5.
- Sodosols: have a strong texture contrast between the topsoil and the subsoil, and the B horizon is sodic (ESP of 6 or greater).
- Tenosols: weak pedological development (with the exception of the A horizons).
- Rudosols: are derived from recently deposited materials and with only minimal profile development evident.
- Hydrosols: are soils with prolonged seasonal saturation.

Figure 10A Photographs of Soil Types Associated with each Soil Landscape Unit

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Sedimentary Steep Land (Kurosol: Dominant)
Test Pit 47B Profile

Sedimentary Steep Land
Test Pit 47B Landscape View

Sedimentary Gentle Slope (Tenosol: Co-dominant)
Test Pit 61 Profile

Sedimentary Gentle Slope
Test Pit 61 Landscape View

Sedimentary Gentle Slope (Chromosol: Co-dominant)
Test Pit 48 Profile

Sedimentary Gentle Slope
Test Pit 48 Landscape View

Figure 10B

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Acid Volcanic Steep Land (Chromosol: Dominant)
Test Pit 47A Profile

Acid Volcanic Steep Land
Test Pit 47A Landscape View

Acid Volcanic Gentle Slope (Kurosol: Dominant)
Test Pit 58 Profile

Acid Volcanic Gentle Slope
Test Pit 58 Landscape View

Ordovician Shale (Dermosol: Dominant)
Test Pit 68 Profile

Ordovician Shale
Test Pit 68 Landscape View

Figure 10C

Alluvium High Quality (Stratic Rudosol: Dominant)
Test Pit 62 Profile

Alluvium High Quality
Test Pit 62 Landscape View

Alluvium Moderate Quality (Chromosol: Co-dominant)
Test Pit 69 Profile

Alluvium Moderate Quality
Test Pit 69 Landscape View

Alluvium Moderate Quality (Sodosol: Co-dominant)
Test Pit 70 Profile

Alluvium Moderate Quality
Test Pit 70 Landscape View

5. SOIL CONDITIONS FOR PLANT GROWTH

5.1 SOIL DEPTH, TEXTURE AND WATER HOLDING CAPACITY

The influence of soil profile shallowness/stoniness and sandiness on the soil's ability to store plant available water (measured as TAW) is shown on **Map 3**. As a soil becomes shallower, stonier and/or sandier, its ability to store water declines (White, 2006).

Plants are more likely to suffer drought stress where soil has a poor water storage capacity, particularly in hot weather with extended dry periods between rainfall events. Within the Mine Site, the lack of water holding capacity in shallow/stony soils is a significant constraint to agricultural productivity.

The deeper alluvial soil exhibited very good water holding capacity (**Map 3**) due to a combination of minimal coarse fragments, favourable soil structure in the soil profile and a great depth to rock.

5.2 WATERLOGGING HAZARD

Much of the shallow soil in non-alluvial sections of the Mine Site showed signs of waterlogging. When a soil is waterlogged, several adverse processes can take place (Batey, 1988):

- The lack of oxygen reduces the ability of plant roots to function properly.
- Anaerobic conditions can cause large losses of soil nitrogen to the atmosphere.
- Near-surface waterlogging is associated with inefficient storage of water due to excessive evaporation losses.

An indicator of waterlogging in the field is the presence of mottling (**Map 4**). Mottles are blotches of sub-dominant colours that are different to the soil matrix colour; for example, grey or yellow blotches within a reddish-brown subsoil. The impedance of subsurface drainage which leads to mottling is usually caused either by the presence of impermeable rock close to the surface or dispersive subsoil. Mottling sometimes is associated with the presence of black manganiferous nodules or concretions.

5.3 DISPERSION AND SLAKING

Poor soil structure in the Mine Site was found to be associated with instability in water due to dispersion. Dispersion is the separation of soil micro-aggregates into sand, silt and clay particles, which tend to block soil pores and create problems with poor aeration (Levy, 2000). Soils therefore may become excessively hard upon drying as a consequence of dispersion. Dispersion has the potential to reduce root growth and therefore can adversely affect productivity and profitability of crop and pasture enterprises.

Dispersion may be associated with slaking, which is the collapse of soil aggregates to form micro-aggregates under moist conditions (So and Aylmore, 1995). Slaking is associated with a lack of organic matter, which is important for the binding of soil micro-aggregates.

Soils prone to slaking, and particularly dispersion, are much more prone to losses from water erosion than stable soils. This is because the soil tends to seal over under moist conditions and lose water as runoff, rather than taking in the water for storage in the subsoil (So and Aylmore, 1995).

Three maps relating to soil stability in water are presented (**Maps 5a, 5b and 5c**). The ASWAT score (**Map 5a**) shows how prone the soil was to dispersion under the conditions that existed at the time of sampling (Field *et al*. 1997). The 'working when wet' procedure that is part of the ASWAT test, is a simulation of processes such as raindrop impact on wet soil and the cutting/stockpiling of moist soil. Dispersion was evident in the topsoil (0-15cm), sub-surface (15-30cm) and subsoil (30-60cm) across the Mine Site (**Map 5a**). These near-surface dispersion issues can be overcome by using lime (calcium carbonate) where the existing soil pH is acidic or neutral, or through gypsum (calcium sulfate) application.

Seriously high sodicity (see **Map 5b**) was not identified as a widespread problem in the Mine Site, except for some of the alluvial soil near the junction of Price and Hawkins Creeks. The most sodic soil profile (soil test pit 77), would require gypsum applied at the rate of 1.0 tonne per hectare (t/ha) to ameliorate the topsoil (0-20cm) and 15.0t/ha to ameliorate the subsoil (20-70t/ha) (White 2006) if used as a rehabilitation material (**Figure 2** indicates that soil in that area would not require major disturbance).

5.4 COMPACTION STATUS

Soil compaction was assessed using the SOILpak scoring system. Serious compaction was not an issue to a depth of 30cm, and only about 10% of sites displayed compacted subsoil (see **Map 6**).

Soil compaction can strongly restrict plant growth due to poor water entry, poor efficiency of water storage, waterlogging when moist, and poor access to nutrients by plant roots (McKenzie, 1998). Minimisation of soil compaction would be an important objective at the Mine Site during topsoil and subsoil stockpiling and subsequent re-placement as part of the proposed rehabilitation program (see Section 7.2.3).

5.5 SOIL STRUCTURAL RESILIENCE

The capability of a soil to overcome compaction through shrinking and swelling induced by wet-dry cycles (soil structural resilience) can be estimated via CEC values (McKenzie 1998). Soils with CEC values greater than 15 milliequivalents per 100 grams (meq/100g) tend to be associated with significant shrinkage. Much of the non-alluvial soil within the Mine Site had a poor capacity for structural resilience via shrink-swell processes (see **Map 7**). This suggests that should the soil be compacted, soil structure recovery by natural processes would be very slow and mechanical loosening would be required.

5.6 SALINITY

In the 'Alluvium – medium quality' soil landscape to the east of the Mine Site boundary (see **Map 8**), subsoil salinity was a moderately severe constraint to plant growth at Sites 70 and 71 (Grey Sodosols). Within the Mine Site, however, almost all of the soil profiles were non-saline. Only at Sites 57, 77 and 80 were slightly saline subsoil layers evident. No field indicators of salinity outbreaks were observed when undertaking the field work. This salinity assessment is consistent with the soil sampling and interpretation requirements described by Lillicrap and McGhie (2002).

5.7 pH

Most of the soils of the 'Acid (Felsic) Volcanic' and 'Sedimentary' Soil Landscape Units (i.e. majority of the soil on areas of high topography) are strongly acidic (see **Map 9**) and would benefit from lime application. The optimal treatment of the soil with lime (rates determined via the pH_{CaCl2} and CEC data), to ensure that plant growth in rehabilitation areas is optimised, would be to spread lime prior to each scraper pass. This would ensure thorough mixing of the lime with topsoil and subsoil prior to stockpiling. In addition to buffering any soil acidity, lime application provides a mild electrolyte concentration that helps reduce the soil's susceptibility to dispersion in water. The results of pH_{CaCl2} analyses indicate that the 'Ordovician shale' soil landscape unit tends to be more alkaline with the soil of this unit having reduced requirements for lime treatment.

A challenge with the application of lime to overcome soil acidity at the Mine Site is that the required amount varies greatly. **Tables 8** and **9** respectively show the lime requirements calculated for topsoil and subsoil for the most acidic soil test pits and for the least acidic sites within each of the Soil Landscape Units identified on the Mine Site. It is recommended that further testing of soil profile pH/CEC within areas proposed for topsoil and subsoil removal and stockpiling occurs at an intensity of one sampling site per hectare so that variable-rate lime application maps can be prepared prior to commencement of soil stripping.

Table 8
Recommended Lime Application Rates[1] for Topsoil (0-20cm) and Subsoil (20-70cm) at the Most Acidic Soil Test Pits Within Each of the Soil Landscape Units

	Topsoil			Subsoil		
Soil Landscape Unit	**Most acidic soil test pit (5cm – 15cm) pH $CaCl_2$**	**CEC**	**Lime requirement, (t/ha, 0cm - 20cm)[1] (target pH = 5.5)**	**Most acidic soil test pit (30cm - 60cm) pH $CaCl_2$**	**CEC**	**Lime requirement, (t/ha, 20cm - 70cm)[1] (target pH = 5.5)**
Sedimentary – steep land	4.0 (Site 54)	7.1	14.6	4.1 (Site 47B)	3.6	13.5
Sedimentary – gentle slope (<10%)	4.0 (Site 60A)	5.3	10.8	4.1 (Site 61)	3.0	12.0
Acid (felsic) volcanic – steep land	4.7 (Site 64)	7.4	4.8	4.7 (Site 64)	8.8	9.0
Acid (felsic) volcanic – gentle slope (<10%)	4.2 (Site 56)	2.2	3.2	4.1 (Site 72)	3.8	13.5
Ordovician shale	4.7 (Site 68)	5.2	3.6	5.1 (Site 81)	7.3	3.0
Alluvium – high quality	4.7 (Site 55)	8.1	5.4	5.1 (Site 51)	4.6	2.1
Alluvium – medium quality	4.5 (Site 70)	10.5	11.8	4.6 (Site 69)	1.2	1.5
Note [1]: Calculated according to Fenton, 2003						

Table 9
Recommended Lime Application Rates[1] for Topsoil (0-20cm) and Subsoil (20-70cm) at the Least Acidic Soil Test Pits Within Each of the Soil Landscape Units

	Topsoil			Sub-soil		
Soil Landscape Unit	Least acidic soil test pit (5cm – 15cm) pH $CaCl_2$	CEC	Lime requirement, t/ha (0cm - 20cm)[1] (target pH = 5.5)	Least acidic soil test pit (30cm - 60cm) pH $CaCl_2$	CEC	Lime requirement, t/ha (20cm - 70cm)[1] (target pH = 5.5)
Sedimentary – steep land	4.7 (Site 49)	7.5	5.4	4.5 (Site 49)	5.2	7.5
Sedimentary – gentle slope (<10%)	5.8 (Site 50)	13.0	zero	6.2 (Site 50)	5.0	zero
Acid (felsic) volcanic – steep land	5.4 (Site 67)	5.4	1.0	5.7 (Site 47A)	24.7	zero
Acid (felsic) volcanic – gentle slope (<10%)	5.1 (Site 52)	13.9	6.0	6.7 (Site 53)	19.3	zero
Ordovician shale	6.9 (Site 76)	8.9	zero	5.1 (Site 81)	7.3	3.0
Alluvium – high quality	5.0 (Site 51)	4.7	2.0	5.5 (Site 55)	10.6	zero
Alluvium – medium quality	5.9 (Site 63)	8.8	zero	6.4 (Site 70)	15.3	zero
Note [1]: Calculated according to Fenton, 2003						

Where native plant species selected for revegetation have a requirement, however, for strongly acidic conditions, some of the topsoil and underlying subsoil should not be limed prior to scraping.

5.8 NUTRIENTS

Apart from the more fertile alluvium, the topsoil and subsoil within the Mine Site was strongly deficient (from an agricultural point of view) in phosphorus (P) (**Map 10**). Application of phosphate-fertiliser would likely produce significant improvements in pasture productivity, particularly if exotic species are being used. Nutrient data in **Annexure D** also indicates there is a lack of sulphur and nitrogen within the soils of the Mine Site. The sulphur deficiency can be overcome through the application of 0.5t/ha coarse grade mined gypsum across all of the disturbed soil at the Mine Site during scraping. The correction of acidity constraints via lime application and mixing during scraping (see previous section) is likely to alleviate nitrogen deficiency by stimulating nitrogen fixing soil organisms.

5.9 SOIL CARBON AND SOIL BIOLOGICAL HEALTH

The relatively high organic carbon concentrations in much of the topsoil (0-15 cm) in the Mine Site (**Map 11**) provide beneficial soil organisms with a ready supply of food. However, the organic carbon content of deeper layers (30 to 60cm and 60 to 100cm), where sampled, mostly was very low (<0.8%).

5.10 SUMMARY OF SOIL LIMITATIONS

Most of the Mine Site is hilly, with soils located on ‘Sedimentary’ and ‘Acid (Felsic) Volcanic’ parent materials that provide poor conditions for plant growth. Cropping therefore is unlikely to succeed in most areas of the Mine Site. Pasture production is also limited significantly by strong soil acidity, and poor water holding capacity that is associated with rock being close to the surface. Whilst the small areas of soil with Ordovician shale parent material are non-acidic, the soil profile is shallow.

Poor pasture growth means that the soils of the Mine Site can easily be overgrazed, leading to a lack of surface protection against water erosion. This problem is most apparent in the steeper areas of the Mine Site.

6. AGRICULTURAL RESOURCES

6.1 BIOPHYSICAL STRATEGIC AGRICULTURAL LAND

Figure 11 shows the location of two areas of BSAL mapped by the NSW Office of Environment and Heritage (OEH). One of these areas is located approximately 1.5km west of the western edge of the Mine Site, along Lawsons Creek, with another area mapped along Wet Swamp Creek, northwest of the Mine Site.

It has been concluded via **Table 10** (using the flow chart shown in **Figure 12**) that none of the Soil Landscape Units at the Mine Site have soil of sufficient quality to be regarded as BSAL. Four of the 41 soil test pit sites had soils displaying BSAL characteristics (see **Figure 2**), however no two BSAL soil test pits were adjacent to each other. In addition, none of the Soil Landscape Units identified within the Mine Site had at least 70% of sampling sites being BSAL, which is the threshold for Soil Landscape Unit to be declarable BSAL.

The scattered sites with BSAL characteristics within the Mine Site (**Figure 13**) were as follows:

- Site 48 is the only site in the '<10% slope sedimentary (conglomerate/sandstone)' zone that has BSAL characteristics. The likely reason for this unusually good soil is that the underlying sedimentary rock has pockets of mudstone within the dominant poorer quality sandstone and conglomerate that dominate this type of parent material.
- Site 68 is part of the 'Ordovician shale' soil landscape unit; it is a non-BSAL unit because two of the three sites are non-BSAL because of rock shallower than 75cm.
- Sites 52 and 82 are part of the '<10% slope acid (felsic) volcanics' soil landscape unit where most of the fourteen soil test pit sites were non-BSAL.

Soil test pits 51, 55 and 62 are recent high-quality alluvium and classified as Stratic Rudosols, using ASC which the Interim Protocol considers to be non-BSAL. Even if these sites were given a high-fertility ASC classification, alluvium under consideration has an area less than the BSAL threshold of 20ha.

Therefore, upon review of the results of the site soil survey conducted in accordance with the Interim Protocol on 8 November 2017, DPE provided Bowdens Silver with a Site Verification Certificate stating that the land within the Mine Site is not considered BSAL. A copy of the Site Verification Certificate is presented in **Annexure E**.

6.2 LAND AND SOIL CAPABILITY

The *Land and Soil Capability Assessment Scheme – Second Approximation* (OEH, 2012) uses the biophysical features of the land and soil including landform position, slope gradient, drainage, climate, soil type and soil characteristics to derive detailed rating tables for a range of land and soil hazards (OEH, 2012). The Land and Soil Capability (LSC) class derived from the scheme provides an indication of the land management practices that can be applied to a parcel of land. The LSC classes are outlined below.

Table 10
BSAL Status of All Soil Test Pits

Soil Landscape Unit	Map ID	Slope (%)	Rock Outcrop	Rock Frag. %	size (mm)	Gilgai	Phys. Barrier Depth to >90% rock	Waterlogging Depth to >10% mottles	Depth to >20% Mn	Depth to waterlogged layer	Acidity pH CaCl2 0-5 cm	5-15 cm	15-30 cm	30-60 cm	Chemical Barrier ESP 0-5 cm	5-15 cm	15-30 cm	30-60 cm	Salinity ECe, dS/m 0-5 cm	5-15 cm	15-30 cm	30-60 cm	Australian Soil Classification Great Group	Suborder	Order	Fertility Status	BSAL Status	SLU with >70% of pits BSAL?	LSC Class
Sedimentary - steep	47B	12	0	2	20	no	140	60	-	60	4.3	4.3	4.3	4.1	0.8	0.5	0.6	1.1	0.41	0.28	0.10	0.10	Magnesic	Red	Kurosol	Moderately Low	No	No	5
Sedimentary - steep	49	18	0	0	0	no	140	60	-	60	4.7	4.9	4.9	4.5	1.1	0.4	0.6	3.7	0.55	0.55	0.41	0.41	Magnesic	Brown	Kurosol	Moderately Low	No		4
Sedimentary - steep	54	23	0	0	0	no	100	-	-	-	4.0	4.0	4.1		2.0	3.0	2.1		0.41	1.93	0.43		Lithic	Leptic	Tenosol	Low	No		6
Sedimentary - gentle slope	48	8	0	0	-	no	140+	120	-	120	5.1	5.2	5.7	6.2	0.7	0.1	0.1	0.5	0.97	0.55	0.17	0.17	Eutrophic	Red	Chromosol	Moderately High	YES	No	3
Sedimentary - gentle slope	50	4	0	0	-	no	140+	45	-	45	5.8	6.4	5.9	6.2	2.0	1.9	1.3	1.6	0.76	0.67	0.38	0.18	Eutrophic	Grey	Chromosol	Moderately High	No		6
Sedimentary - gentle slope	60A	5	0	1	60	no	30	-	-	-	4.0	4.0	4.0		2.4	2.7	3.3		0.19	0.29	0.29		Lithic	Leptic	Tenosol	Low	No		6
Sedimentary - gentle slope	60B	4	0	0	0	no	70	40	-	40	5.4	4.8	4.7	4.5	1.4	1.8	2.4	4.4	0.67	0.76	0.26	0.52	Mesotrophic	Red	Kurosol	Moderate	No		6
Sedimentary - gentle slope	61	3	0	5	20	no	50	-	-	-	4.2	4.1	4.0	4.1	0.3	0.3	1.0	0.3	0.41	0.28	0.19	0.19	Lithic	ached - Leptic	Tenosol	Low	No		5
Acid volcanic - steep	47A	14	0	15	30	no	100	50	-	50	5.3	5.7	6.0	5.7	0.1	0.1	0.1	0.4	0.69	0.69	0.26	0.26	Eutrophic	Red	Chromosol	Moderately High	No	No	4
Acid volcanic - steep	59	14	0	0	-	no	30	-	-	-	5.3	4.5	4.2		0.1	0.2	0.6		1.14	0.45	0.14		-	Leptic	Rudosol	Low	No		6
Acid volcanic - steep	64	26	0	20	25	no	100	-	-	-	4.7	4.6	4.4	4.7	0.3	0.1	0.5	0.6	0.55	0.55	0.28	0.14	Mesotrophic	Yellow	Dermosol	Moderately High	No		6
Acid volcanic - steep	67	17	0	0	-	no	130	-	40	40	5.4	5.1	5.2	5.4	1.2	0.2	0.2	1.1	0.55	0.41	0.26	0.26	Mesotrophic	Red	Chromosol	Moderately High	No		6
Acid volcanic - gentle slope	52	9	0	5	20	no	140+	-	-	-	5.1	5.6	5.9	5.9	0.1	0.1	0.3	0.1	0.57	0.57	0.29	0.18	Eutrophic	Red	Dermosol	Moderately High	YES	No	3
Acid volcanic - gentle slope	53	8	0	0	-	no	140+	30	-	30	4.5	4.6	5.5	6.7	1.3	1.1	1.3	3.7	2.76	0.69	0.41	0.47	Eutrophic	Brown	Chromosol	Moderately High	No		6
Acid volcanic - gentle slope	56	3	0	0	0	no	60	40	-	40	4.2	4.3	4.4	5.7	1.6	2.2	2.0	6.0	0.41	0.28	0.28	0.17	1ottled-Subnatri	Brown	Sodosol	Moderately Low	No		6
Acid volcanic - gentle slope	57	4	0	20	10-40	no	90	70	-	70	4.6	5.0	4.6	4.3	0.2	0.2	1.7	5.0	0.97	0.55	0.30	1.50	Eutrophic	Red	Kurosol	Moderate	No		5
Acid volcanic - gentle slope	58	8	0	0	-	no	140	-	-	-	4.9	5.3	5.3	4.2	1.8	1.8	1.7	4.0	0.55	0.41	0.28	0.23	Mesotrophic	Grey	Kurosol	Moderate	No		4
Acid volcanic - gentle slope	65	3	0	0	0	no	80	-	-	-	4.5	4.3	4.6	4.7	3.1	2.1	2.2	2.4	0.10	0.38	0.17	0.09	Mesotrophic	Grey	Dermosol	Moderately High	No		4
Acid volcanic - gentle slope	66	8	0	0	-	no	110	-	-	-	4.7	4.7	4.4	4.8	0.3	0.5	3.4	13.8	0.41	0.28	0.19	0.43	Mesonatric	Red	Sodosol	Moderately Low	No		4
Acid volcanic - gentle slope	71	1	0	0	-	no	140+	100	-	110	5.0	5.3	5.8	6.6	4.8	16.1	25.5	31.7	1.05	2.66	4.82	4.04	ottled-Hypernat	Grey	Sodosol	Moderately Low	No		4
Acid volcanic - gentle slope	72	7	0	1	20	no	80	45	-	45	4.4	4.0	4.2	4.1	0.9	0.3	1.2	2.5	0.97	0.55	0.41	0.26	Mesotrophic	Grey	Kurosol	Moderate	No		6
Acid volcanic - gentle slope	73	6	0	1	30	no	65	40	-	40	4.7	4.5	4.6	4.3	0.2	0.2	0.2	0.3	0.83	0.55	0.28	0.17	Mesotrophic	Grey	Kurosol	Moderate	No		6
Acid volcanic - gentle slope	74	8	0	1	40	no	45	-	-	-	4.4	4.4	4.3	4.2	0.2	0.2	0.2	0.2	0.69	0.55	0.41	0.14	Lithic	Leptic	Tenosol	Low	No		6
Acid volcanic - gentle slope	78	6	0	2	40	no	30	-	-	-	5.0	4.6	4.5	4.3	1.9	0.1	0.2	0.3	1.52	0.97	0.69	0.10	-	Leptic	Rudosol	Low	No		6
Acid volcanic - gentle slope	79	4	0	1	30	no	35	-	-	-	4.2	4.3	4.2		0.2	0.1	0.1		0.55	0.55	0.26		Lithic	Leptic	Tenosol	Low	No		6
Acid volcanic - gentle slope	82	5	0	0	-	no	100	-	-	-	5.1	4.7	4.9	4.9	0.7	0.2	0.3	0.3	0.38	0.38	0.28	0.10	Mesotrophic	Red	Dermosol	Moderately High	YES		3
Ordovician shale	68	8	0	0	0	no	90	-	-	-	4.7	5.4	5.4	5.8	0.2	0.2	0.2	0.2	0.43	0.34	0.17	0.17	Mesotrophic	Red	Dermosol	Moderately High	YES	No	3
Ordovician shale	76	6	0	1	40	no	70	35	-	35	4.7	4.8	5.1	6.9	0.8	1.2	2.1	3.3	1.52	1.05	0.67	0.86	Mesotrophic	Red	Dermosol	Moderately High	No		6
Ordovician shale	81	7	0	1	30	no	30	-	-	-	5.7	4.9	5.1	5.1	2.6	1.6	7.4	16.5	0.60	0.45	0.26	0.52	Mesotrophic	Brown	Dermosol	Moderately High	No		6
Alluvium - high quality	51	3	0	0	-	no	140+	-	-	-	5.0	5.2	5.0	5.1	0.2	0.2	0.3	0.2	0.69	0.41	0.28	0.45	-	Stratic	Rudosol	Moderately Low	No	No	4
Alluvium - high quality	55	2	0	1	30	no	140+	-	-	-	4.7	5.0	5.2	5.5	0.1	0.4	0.1	0.3	0.97	0.41	0.28	0.19	-	Stratic	Rudosol	Moderately Low	No		4
Alluvium - high quality	62	2	0	1	40	no	140+	-	-	-	4.8	4.7	5.1	5.5	1.4	0.3	0.1	0.2	1.14	0.45	0.28	0.28	-	Stratic	Rudosol	Moderately Low	No		5
Alluvium - moderate quality	63	3	0	0	-	no	100+	80	-	80	5.9	4.5	4.7	5.5	4.9	3.7	3.4	3.5	2.47	1.52	1.05	0.80	Chromosolic	Oxyaquic	Hydrosol	Moderately Low	No	No	3
Alluvium - moderate quality	69	2	0	0	-	no	140+	50	-	50	4.7	4.4	4.4	4.6	0.7	2.4	1.1	1.3	1.24	0.55	0.28	0.17	Mesotrophic	Grey	Chromosol	Moderately High	No		4
Alluvium - moderate quality	70	1	0	0	-	no	140+	110	-	110	4.5	4.7	5.0	6.4	3.8	3.3	5.0	15.0	2.00	0.76	0.34	0.53	Mesonatric	Grey	Sodosol	Moderately Low	No		5
Alluvium - moderate quality	75	1	0	0	-	no	130+	35	-	35	4.9	4.6	4.9	5.3	1.0	1.0	0.7	2.4	2.49	0.86	0.34	0.23	Mesotrophic	Black	Dermosol	Moderately High	No		6
Alluvium - moderate quality	77	2	0	0	0	no	130+	60	-	60	4.7	4.8	4.9	6.3	4.4	6.9	8.4	16.4	1.14	0.95	0.67	2.39	ottled-Mesonatr	Black	Sodosol	Moderately Low	No		4
Alluvium - moderate quality	80	1	0	0	-	no	140+	70	-	70	4.8	4.7	5.0	5.4	1.2	2.0	2.2	4.6	0.86	0.43	0.26	0.20	Mesotrophic	Black	Chromosol	Moderately High	No		4
Road	84	8	0	10	50-100	no	40	-	-	-	4.5	4.6	4.6		0.2	0.4	0.6		0.83	0.41	0.17		Dystrophic	Red	Dermosol	Moderate	No	No	6
Road	85	2	0	0	-	no	140+	-	-	-	5.0	5.1	5.0	4.9	0.1	0.2	0.1	0.2	0.43	0.26	0.17	0.09	Mesotrophic	Black	Dermosol	Moderately High	YES		3
Road	86	7	0	2	50	no	60	-	-	-	4.5	4.4	4.7	5.4	0.4	1.3	1.0	1.6	0.55	0.41	0.28	0.10	Dystrophic	Brown	Dermosol	Moderate	No		4

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Figure 11 Regional BSAL Map

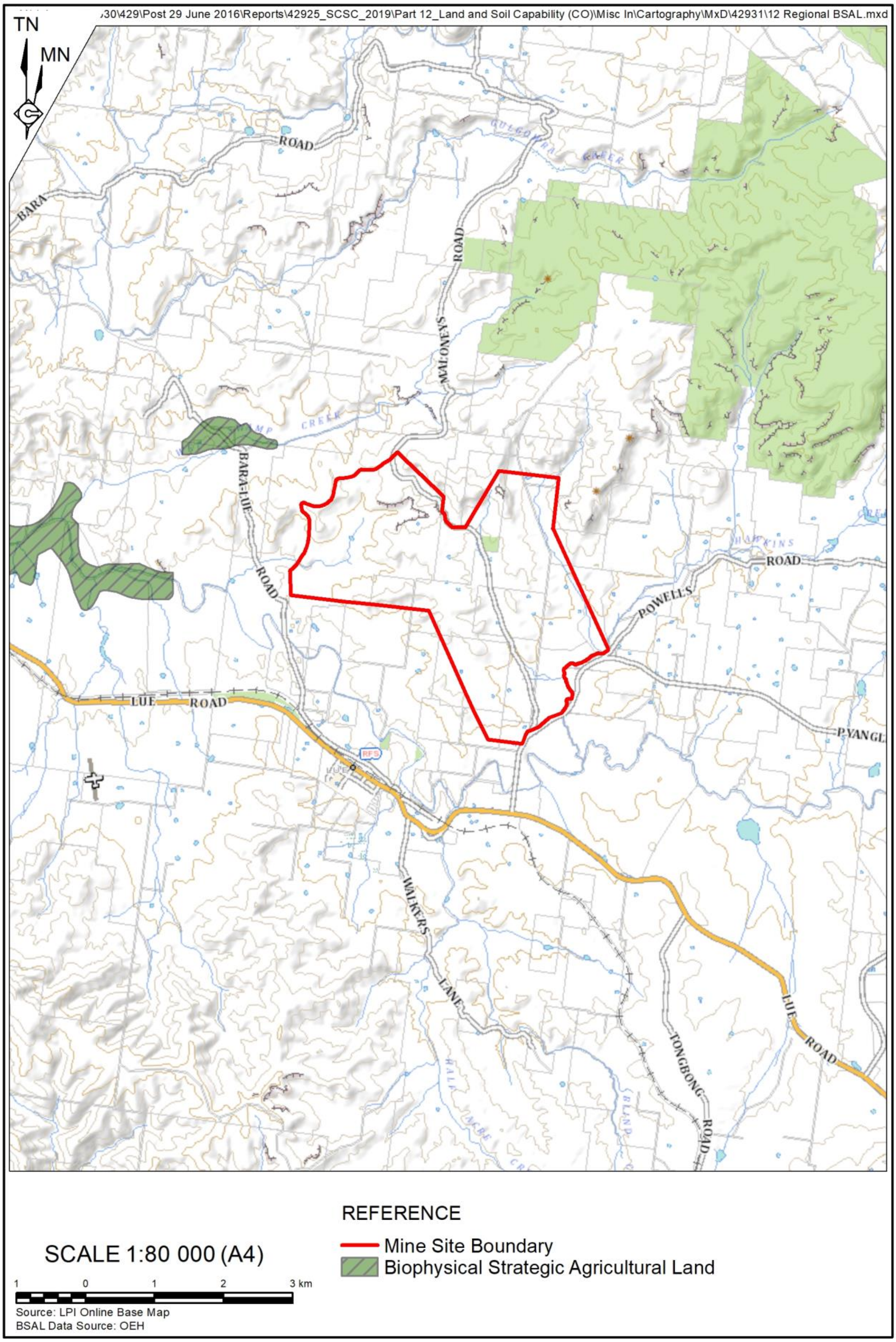


Figure 12 Flow Chart for Site Assessment of BSAL

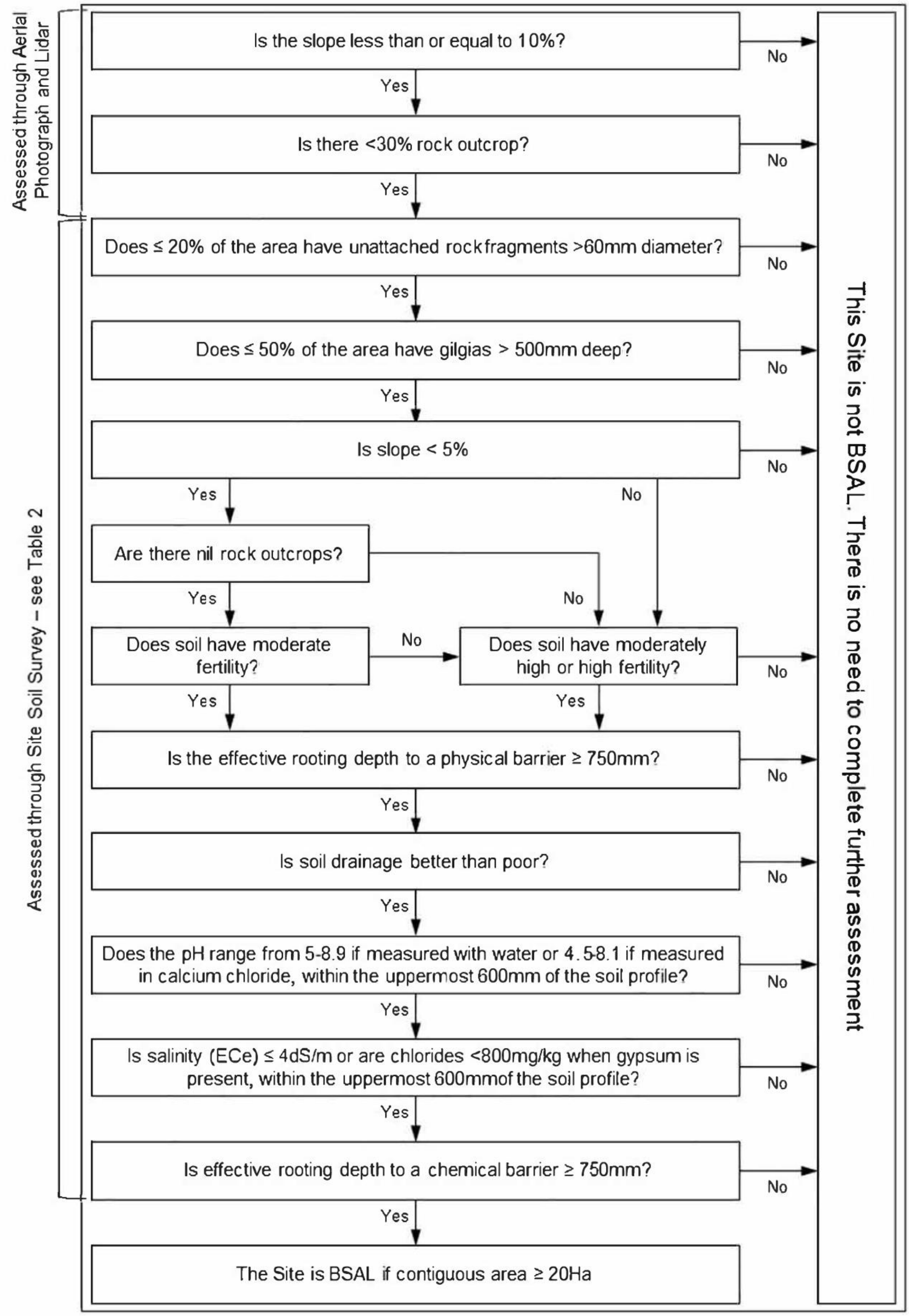
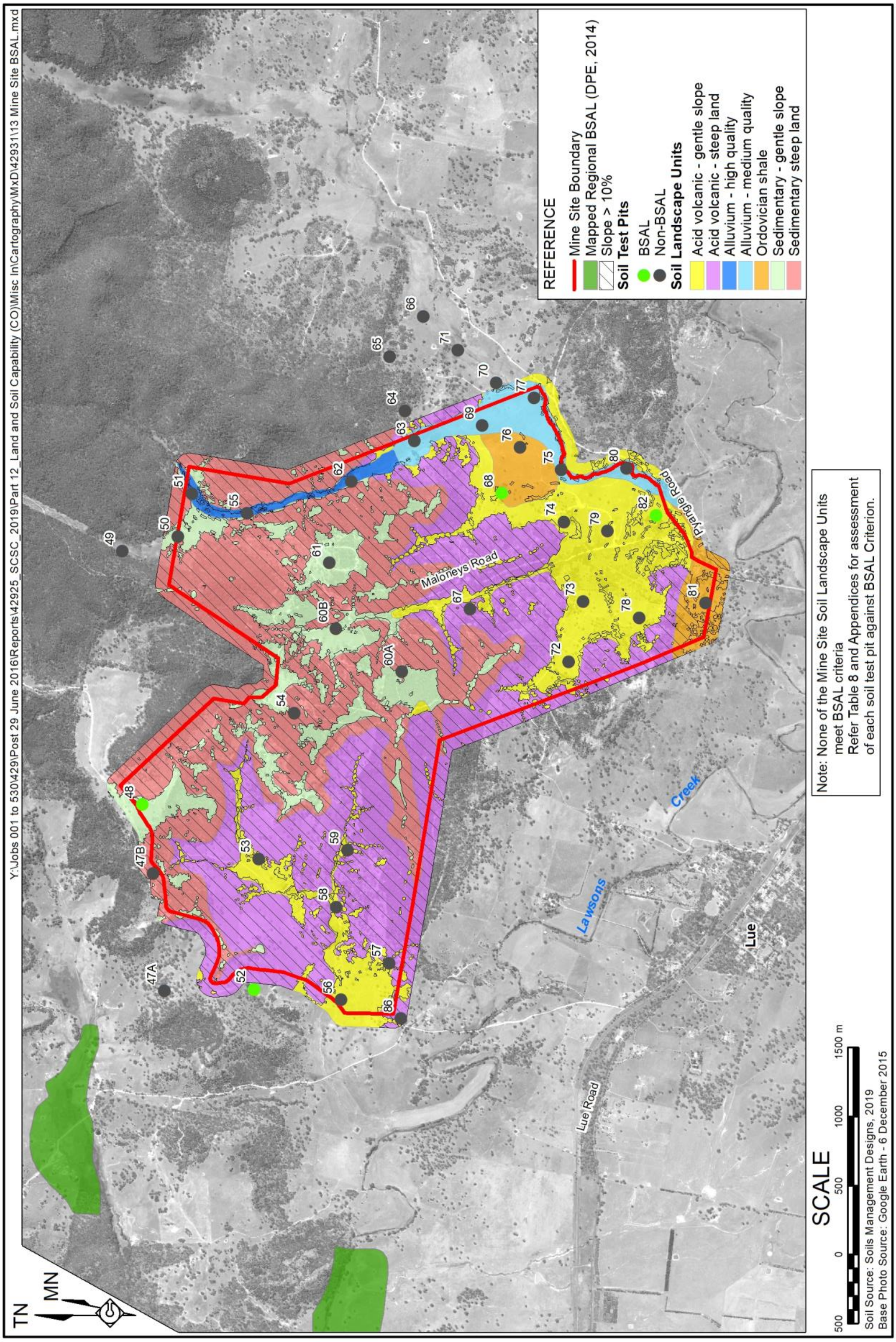


Figure 13 Mine Site BSAL Mapping



Land capable of a wide variety of land uses (cropping, grazing, horticulture, forestry, nature conservation)

Class 1: Extremely high capability land: Land has no limitations. No special land management practices required. Land capable of all rural land uses and land management practices.

Class 2: Very high capability land: Land has slight limitations. These can be managed by readily available, easily implemented management practices. Land is capable of most land uses and land management practices, including intensive cropping with cultivation.

Class 3: High capability land: Land has moderate limitations and is capable of sustaining high-impact land uses, such as cropping with cultivation, using more intensive, readily available and widely accepted management practices. However, careful management of limitations is required for cropping and intensive grazing to avoid land and environmental degradation.

Land capable of a variety of land uses (cropping with restricted cultivation, pasture cropping, grazing, some horticulture, forestry, nature conservation)

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

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

Land capable for a limited set of land uses (grazing, forestry and nature conservation, some horticulture)

Class 6: Low capability land: Land has very high limitations for high-impact land uses. Land use restricted to low-impact land uses such as grazing, forestry and nature conservation. Careful management of limitations is required to prevent severe land and environmental degradation.

Land generally incapable of agricultural land use (selective forestry and nature conservation)

Class 7: Very low capability land: Land has severe limitations that restrict most land uses and generally cannot be overcome. On-site and off-site impacts of land management practices can be extremely severe if limitations not managed. There should be minimal disturbance of native vegetation.

Class 8: Extremely low capability land: Limitations are so severe that the land is incapable of sustaining any land use apart from nature conservation. There should be no disturbance of native vegetation.

Regional LSC mapping prepared by the OEH is presented in **Figure 14**. The Study Area is mapped primarily as LSC Classes 5, 6 and 7. LSC values determined via this study ranged from 3 to 6 (**Figure 15**).

Figure 14 Regional Land and Soil Capability

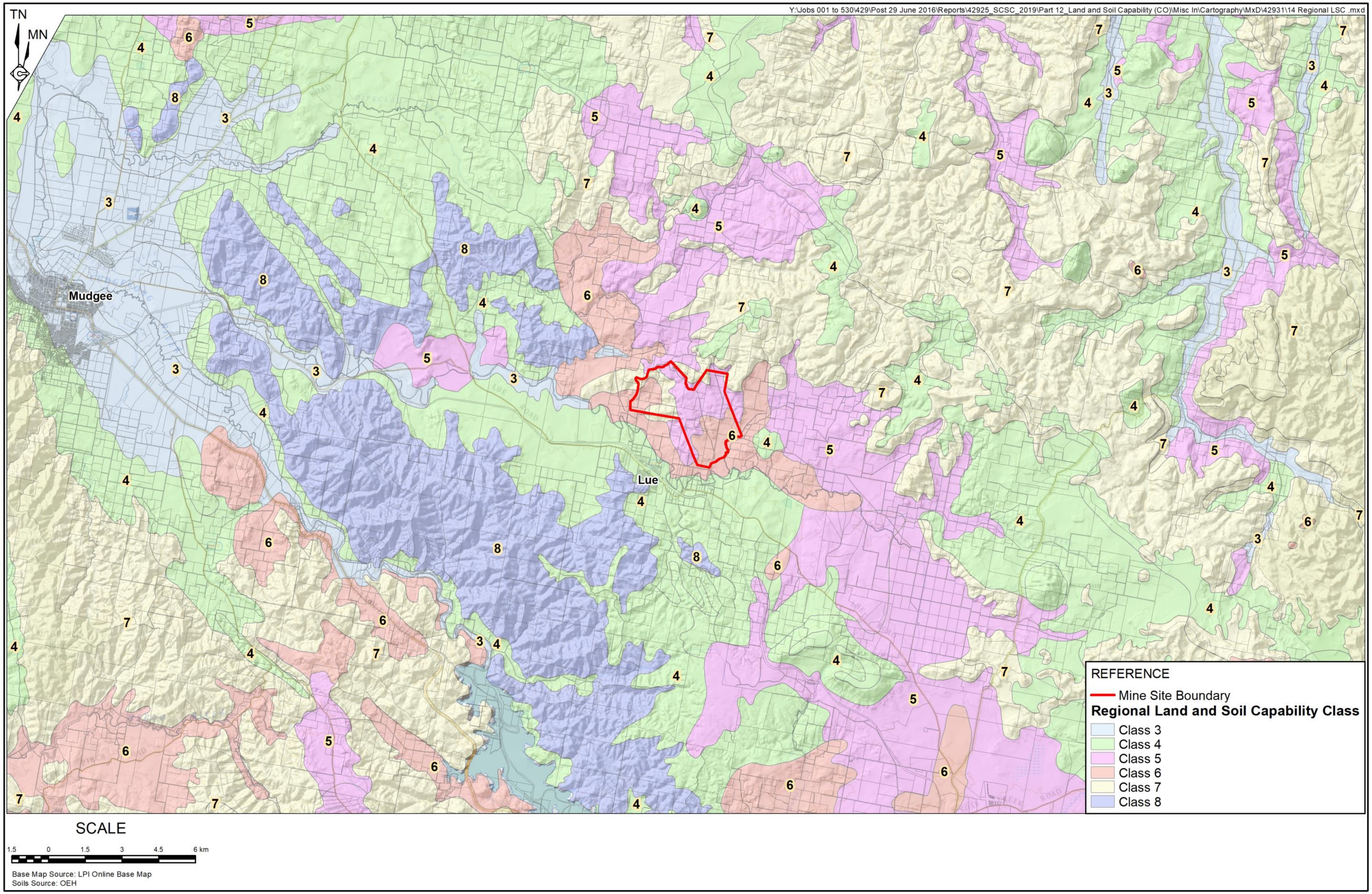


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Figure 15 Land and Soil Capability Mapping

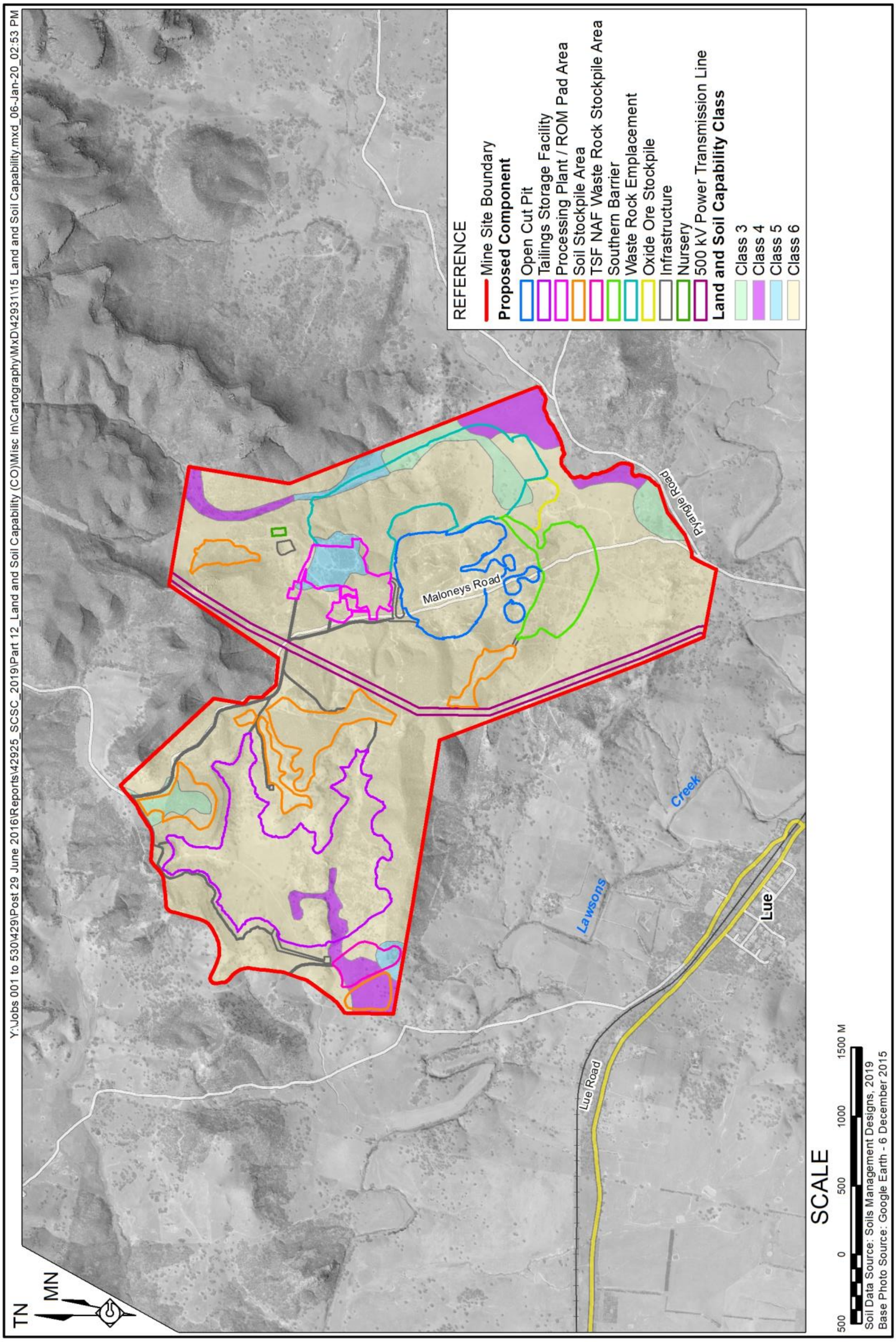


Table 11 lists the key components within the Mine Site and the appropriate area of each LSC value in component area.

Table 11
Land and Soil Capability Values within Proposed Disturbance Areas

Component	Total Area (ha)	Approximate LSC Areas			
		Class 3	Class 4	Class 5	Class 6
Open Cut Pits	52.0				52.0
Processing Plant / Mining Facility	22.3			10.4	11.8
Waste Rock Emplacement *	87.1	12.7	1.7	5.0	67.6
Tailings Storage Facility	117.4		6.6		110.8
Southern Barrier	32.1				32.1
Oxide Ore Stockpile	7.5	1.1			6.4
TSF NAF Waste Rock Stockpile	9.2		4.6	2.1	2.5
Re-aligned 500kV Power Transmission Line	21.2				21.2
Roads and Water Infrastructure	9.3	0.4	0.0		8.9
Nursery	0.5				0.5
Soil Stockpiles					
S1	6.4		6.0		0.4
S2	12.8	7.0			5.8
S3	7.1				7.1
S4	6.4				6.4
S5	22.8				22.8
S6	6.4				6.4
Total	**420.5**	**21.2**	**18.9**	**17.6**	**362.8**
* Includes the low grade ore stockpiles and leachate management dam					

7. IMPACT ASSESSMENT

7.1 POTENTIAL IMPACTS

There is potential for the following soil degradation issues to occur at the Mine Site.

- Poor plant growth and unsatisfactory groundcover associated with soil acidity and nutrient deficiencies, which results in soil surfaces being prone to erosion losses.
- Physical damage to soil structure during scraping, storage and/or re-spreading of soil for the re-instated root zone.
- Loss of soil biological activity through unsatisfactory storage of topsoil and subsoil.
- A poor capacity for the rehabilitated landscape to tolerate drought because of poor soil waterholding capacity and/or poor root growth in the planted vegetation.

7.2 MITIGATION MEASURES

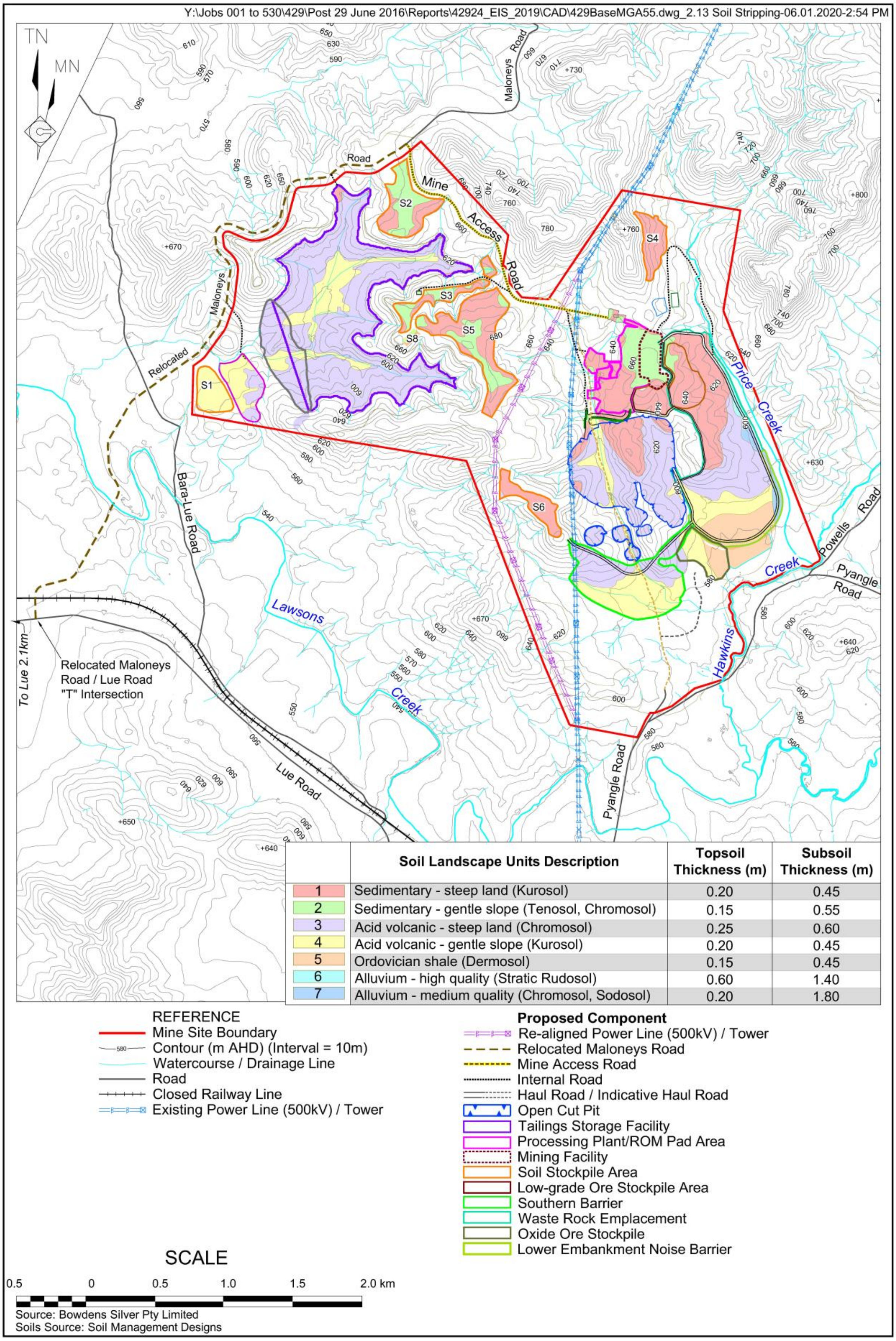
7.2.1 Soil Stripping Guidelines

Indicative depths for topsoil and subsoil stripping for the Soil Landscape Units and volumes to be stripped from the areas of proposed disturbance are shown in **Table 12**. The topsoil and subsoil volumes were calculated by R.W. Corkery & Co. Pty Limited. It is noted that soils would not need to be stripped from approximately 35ha of the component areas as they are devoid of soil (e.g. existing roads and tracks) or soil stripping would not be required (within the bulk of the corridor for the re-aligned 500kV power transmission line). **Figure 16** displays the disturbance area boundaries together with the corresponding soil landscape unit data drawn from **Figure 9**.

Table 12
Indicative Stripping Depths and Volumes for the Mine Site Soil Landscape Units

Soil Landscape Unit	Area of Topsoil Stripping (ha)	Indicative Topsoil Depth (m)	Indicative Stripped Topsoil Volume (m^3)	Area of subsoil Stripping (ha)	Indicative Subsoil Depth (m)	Indicative Stripped Subsoil Volume (m^3)
Sedimentary – steep land	93.7	0.2	187 391	55.8	0.45	251 030
Sedimentary – gentle slope (<10%)	31.4	0.15	47 162	13.9	0.55	76 422
Acid (felsic) volcanic – steep land	170.7	0.25	426 652	151.9	0.6	911 234
Acid (felsic) volcanic – gentle slope (<10%)	65.4	0.2	130 750	36.4	0.45	163 614
Ordovician shale	18.2	0.15	27 234	18.2	0.45	81 703
Alluvium – high quality	1.9	0.6	11 693	1.9	1.4	27 284
Alluvium – medium quality	4.1	0.2	8 109	4.1	1.8	72 982
Other Areas *	35.1	0.0	0	138.3	0.0	0
Total	420.5		**838 992**	**420.5**		**1 584 269**
* Areas not requiring soil stripping						

Figure 16 Indicative Soil Stripping and Stockpiling Activities



	Soil Landscape Units Description	Topsoil Thickness (m)	Subsoil Thickness (m)
1	Sedimentary - steep land (Kurosol)	0.20	0.45
2	Sedimentary - gentle slope (Tenosol, Chromosol)	0.15	0.55
3	Acid volcanic - steep land (Chromosol)	0.25	0.60
4	Acid volcanic - gentle slope (Kurosol)	0.20	0.45
5	Ordovician shale (Dermosol)	0.15	0.45
6	Alluvium - high quality (Stratic Rudosol)	0.60	1.40
7	Alluvium - medium quality (Chromosol, Sodosol)	0.20	1.80

To ensure that soil resources requiring stripping prior to disturbance are managed in a manner that would maintain soil health and structure during stockpiling, the following measures are recommended.

In order to maintain preferred pH levels, lime should be added to the soil prior to scraping to overcome acidity and dispersion/sodicity constraints. This would maximise the chances of the rehabilitated soil being more suitable for plant growth after rehabilitation than the pre-development soil, and make it less prone to erosion during stockpiling. Application of lime prior to each scraping pass would ensure thorough mixing of the lime with topsoil and subsoil prior to stockpiling. In addition to buffering of acidity, lime application provides a mild electrolyte concentration that reduces soil dispersion in water.

The alluvial Soil Landscape Units have up to several metres of soil profile and therefore have the potential to be an important source of rehabilitation material, if carefully removed and stockpiled. It is recommended that the 'Alluvium – medium quality' Soil Landscape Unit, particularly in areas close to the junction of Hawkins and Price Creeks, would benefit from the addition of coarse-grade gypsum prior to scraping and stockpiling to assist with the maintenance of soil structure.

Soil in elevated areas exhibit characteristics that indicate they are prone to being pulverised when dry therefore, dry earthmoving of soil in these areas is not recommended. The elevated concentrations of zinc (and presumably lead) in some of the soil (ore body derived, presumably) means that dust suppression would be a high priority so that wind erosion is minimised. However, the addition of lime to the soil would increase pH and reduce the bioavailability of these metals. Test pits 67, 68 and 75 have zinc concentrations greater than 50mg/kg; Sites 76 and 80 have zinc concentrations in the range 20-50mg/kg.

However, mechanical working of the soil when wet is likely to aggravate dispersion issues, and thus make soils more prone to erosion. Excessive compaction and/or moulding of the soil by heavy machinery under wet conditions should be avoided.

7.2.2 Soil Stockpile Management

Based on the approximate disturbance areas and indicative depths listed in **Table 12**, approximately 840 000m^3 of topsoil and 1 580 000m^3 of subsoil would be stripped from the proposed disturbance areas and either transferred directly to an active rehabilitation area or stockpiled for use during progressive rehabilitation and closure activities. These topsoil and subsoil reserves should be managed in a way that avoids degradation when stockpiled. Where possible, scraped subsoil and topsoil should be transferred directly to rehabilitation areas so that soil biological activity is maintained in the best possible condition. In addition, it is anticipated that a quantity of the subsoil stripped from the footprint of the TSF and meeting engineering specifications, would be re-worked to form part of the low permeability, compacted clay liner in the TSF impoundment area and also within the store-and-release cover on the TSF and WRE.

Where soil stockpiles are required, they would be managed to avoid degradation when stockpiled. Topsoil stockpile heights should be limited to under two metres and should be sown with a well-fertilised non-persistent cover crop to encourage organic carbon accumulation, promote microbial activity and minimise erosion. Subsoil stockpiles should be no higher than 5m in height and overlain by 1m of topsoil which, similar to topsoil only stockpiles, should also be sown with a well-fertilised non-persistent cover crop.

Based on the progressive rehabilitation of the WRE, which would reduce the required volumes of long-term stockpiles, it is anticipated that a total of six soil stockpiles would be required over the Project life, with the details of each shown in **Table 13** and their respective locations shown on **Figure 2**. The topsoil and subsoil volumes were calculated by R.W. Corkery & Co. Pty Limited. It is noted that these stockpile volumes exclude the volumes of soil to be directly transferred throughout the Project life or stockpiled within the footprint of an area to be disturbed later in the Project life, e.g. within the southern footprint of the WRE and the southern barrier. It is also noted that the volumes allocated for stockpiling topsoil and subsoil are indicative. Overall, there would be sufficient storage area to stockpile the stripped soil to the heights nominated in Section 7.2.2.

Table 13
Soil Stockpile Areas

Stockpile ID*	Area (ha)	Topsoil Volume (m^3)	Subsoil Volume (m^3)
S1	6.4	54 000	281 200
S2	12.8	106 800	561 800
S3	7.1	110 800	Topsoil only
S4	6.4	108 500	Topsoil only
S5	22.8	185 100	971 900
S6	6.4	100 400	Topsoil only
Total	**61.9**	**665 600**	**1 814 900**

* see: **Figure 2**

Source: R.W. Corkery & Co. Pty Limited

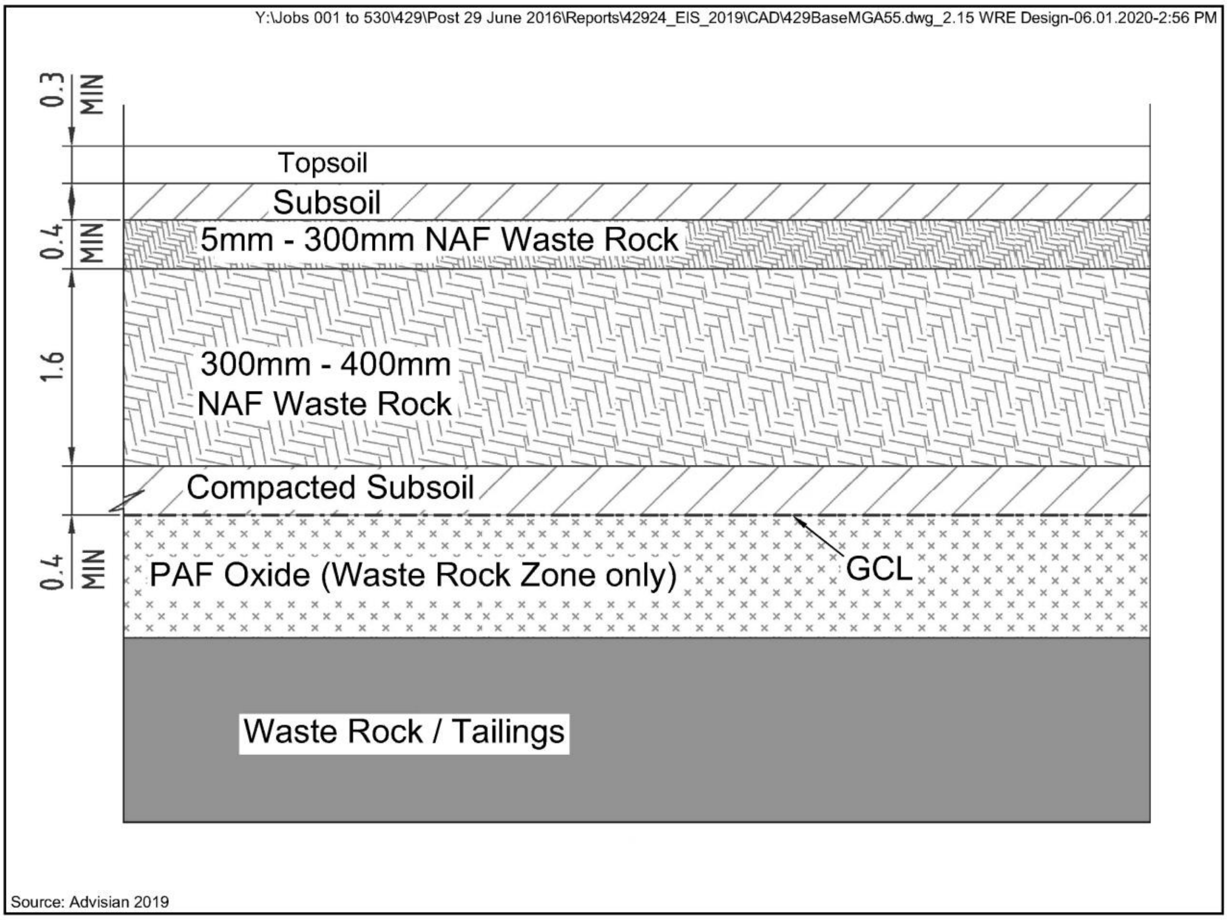
The following management measures are recommended to be implemented during the stockpiling/storage of soils in the Mine Site.

- Wherever practicable, soil should not be trafficked, deep ripped or removed in wet conditions to avoid breakdown of the soil structure.
- No vehicle access should be allowed on soil stockpiles, except where required for soil quality monitoring, seeding, the possible top-up addition of soil ameliorants or should weed control be required.
- Soil stockpiles should be located in areas away from surface water flow. Silt-stop fencing should be placed immediately down-slope of all stockpiles until stable vegetation cover is established. All material recovered from the silt-stop fencing should be returned to the stockpile.
- In the event that unacceptable weed generation is observed on soil stockpiles, a weed eradication program should be implemented.
- An inventory of topsoil and subsoil resources (available and stripped) on the Mine Site should be maintained and regularly reconciled with rehabilitation requirements.

7.2.3 Topsoil and Subsoil Placement as Capping and Cover of TSF and WRE

The available reserves of stockpiled soil would allow for the placement of approximately 0.3m of topsoil and 0.3m of subsoil to be placed on top of 0.4m fine NAF material (crushed NAF material 0.5cm-30cm diameter, graded upwards) (see **Figure 17**). This 1m thick root zone profile would overlie 1.6m of coarse NAF material (30cm-40cm diameter) and 0.4m of compacted subsoil. Below a depth of 3m, a geosynthetic clay liner (GCL) would be placed over the impounded tailings or PAF waste rock in order to encapsulate stored material and promote geochemical stability.

Figure 17 Indicative Cover and Capping Design



The capping and cover system design would provide significant profile water holding capacity and encourage the establishment of vegetation on the capping that would assist in protecting the rehabilitated surfaces from erosion. The plant rooting depth would be approximately 1m. The underlying 30cm to 40cm diameter NAF layer would have a coarseness that would minimise the risk of plant roots entering the compacted subsoil and GCL zone. This would limit the risk of the downward percolation of oxygen and/or water incursions (Vriens *et al.* 2018) via root channels and/or shrinkage cracks into the encapsulated waste.

It is recommended that the capping and cover system utilise the subsoil with low CEC values (see **Map 7**) for the 0.4m compacted subsoil layer, as shown in **Figure 17**. Use of subsoil with low CEC would limit the potential for shrinkage crack development (where CEC is greater than about 15 meq/100g) should the soil in the compacted zone become very dry.

Following the completion of topsoil placement, the completed slope would be hydromulched with a seed mix of pasture groundcovers, fertiliser, binder and straw.

7.2.4 Topsoil and Subsoil Placement over Remaining Mine Areas

For the Southern Barrier, It is proposed that, as each 10m vertical section of the southern face of each barrier is constructed, the exposed face would be covered with up to 1m of subsoil and 0.2m of topsoil. The quantity of subsoil placed on each barrier would be comparatively high as the southern faces of the barrier would be relatively highly visible and it is important that sufficient material is placed on the slope to enable a high level of revegetation to be achieved. Furthermore, a sufficient thickness of subsoil and topsoil can be easily removed from the southern face of the initial barrier and as the barrier is deconstructed to allow it to be used in the final rehabilitation of the Mine Site. Given the outer face of both the initial and extended barriers would be a slope between approximately 1:3 (V:H) and 1:4 (V:H), it should be feasible for small agricultural equipment to sow pasture grasses with fertiliser. In the event seasonal conditions do not result in sufficient rainfall, Bowdens Silver would install an irrigation system to assist in the germination and continued growth of the pasture grasses on the southern faces of the barriers. Once the topsoil is spread across each 10m section, it would be hydromulched with either the autumn/winter or spring/summer seed mix and fertilised. Emphasis in vegetation selection would be upon grasses and small shrubs given the barrier would be fully removed at the end of the Project life. Upon completion of the removal of the southern barrier during mine closure, the residual subsoil would be ripped parallel to contour and the stockpiled topsoil spread across the ripped surface after which it would be scarified and sown with pasture seed and fertiliser.

For the processing area following mine closure, an earthmoving program would be undertaken after clearance of unwanted infrastructure to re-establish an undulating landform principally by pushing/placing the previous fill materials across the geometric platform areas. Emphasis would be placed upon replacing at least 1m of weathered material or broken rock on the former horizontal surfaces after which up to 0.4m of subsoil and 0.2m of topsoil would be placed on the final landform. Once the topsoil is in place on the final landform, the land surface would either be hydromulched (mainly the slopes) or seeded and fertilised with conventional farming equipment. Emphasis would be placed upon the re-establishment of native trees and shrubs on the rehabilitated landform.

The soil stockpile areas themselves would be rehabilitated, As the topsoil and subsoil is removed and the original ground surface is exposed, the ground would be scarified and then seeded with a pasture mix and fertiliser. The stockpile areas previously vegetated with native trees and shrubs would be planted with a range of appropriated species whereas those areas previously used for grazing, with or without pasture improvement, would be returned for that use as part of the farm.

7.3 POST-MINE SOIL CONDITION AND LAND CAPABILITY

Table 14 describes the predicted changes in soil condition and land capability on the final landform following rehabilitation (see EIS Section 2.16 and EIS Appendix 4).

Table 14
Predicted Changes in Soil Condition for the Disturbed Areas

Disturbed Area Component	Total Area (ha)	Predicted changes in soil condition for plant growth and risk of erosion
Tailings Storage Facility	117.4	Improved conditions for plant growth in the upper 60cm of soil would occur following lime and nutrient application; gentler slopes with reduced water erosion hazard; but with tree and shrub root growth not encouraged deeper than 100cm (pasture production areas).
Waste Rock Emplacement*	87.1	Improved conditions for plant growth in the upper 60cm of soil would occur following lime and nutrient application; but with slope increases in some sections, and tree and shrub root growth not encouraged deeper than 100cm (pasture production areas).
Soil stockpiles	61.9	No major long term changes in soil condition are anticipated.
Open Cut Pits	52.0	This area would become a final void that would be retained as a lake with some tree growth on the upper benches above the final water level, i.e. less potential for plant growth than before.
Southern Barrier	32.1	While the Southern Barrier is in place, the 20cm of topsoil and 100cm of subsoil would provide excellent chemical, physical, nutritional and biological soil conditions for plant growth. Slope would be greater than 10% across much of the structure, but soil in the rootzone otherwise is likely to be BSAL quality. No major long term changes in soil condition are anticipated after removal of this temporary barrier, relative to pre-mining conditions.
Processing Plant / Mining Facility and Nursery	22.8	No major long term changes in soil condition are anticipated. Where native plants are to be established post-mining, lime and nutrient application to the replaced topsoil and subsoil would be minimised so that their inherent soil requirements are met.
Re-aligned 500kV Power Line	21.2	No major long term changes in soil condition are anticipated.
Roads and Water Infrastructure	9.3	This area would be partly reduced as retained roads are narrowed and subsoil and topsoil placed on ripped areas.
TSF NAF Waste Rock Stockpile	9.2	No major long term changes in soil condition are anticipated. This area would largely be returned to pre – mining conditions.
Oxide Ore Stockpile	7.5	Assuming this stockpile remains beyond the end of the Project life, the vegetated steeper side slopes would be more prone to erosion than the existing area. The subsoil and topsoil replaced on the upper surface would easily support plant growth.
Total	**420.5**	
* Includes the low grade ore stockpiles and leachate management dam		

7.4 ASSESSMENT OF IMPACTS

The key outcomes from the land and soil capability assessment are as follows, assuming the full implementation of all of the mitigation measures outlined in Section 7.2 and the predicted changes in land and soil capability as a result of the Project.

- No biophysical strategic agricultural land would be impacted by the Project as none were identified within the Mine Site.

- Apart from the final void area, the soils in the rootzones of the modified landscapes would retain or improve their qualities required for the long-term rehabilitation of the Mine Site.
- The topsoil and subsoil resources throughout the Mine Site would enable suitable substrates to be created on the final landform to sustain an appropriate level of vegetation across the Mine Site for minimisation of the risk of soil erosion.
- No soil resource impacts from the Project are anticipated on adjoining agricultural lands.

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Maps

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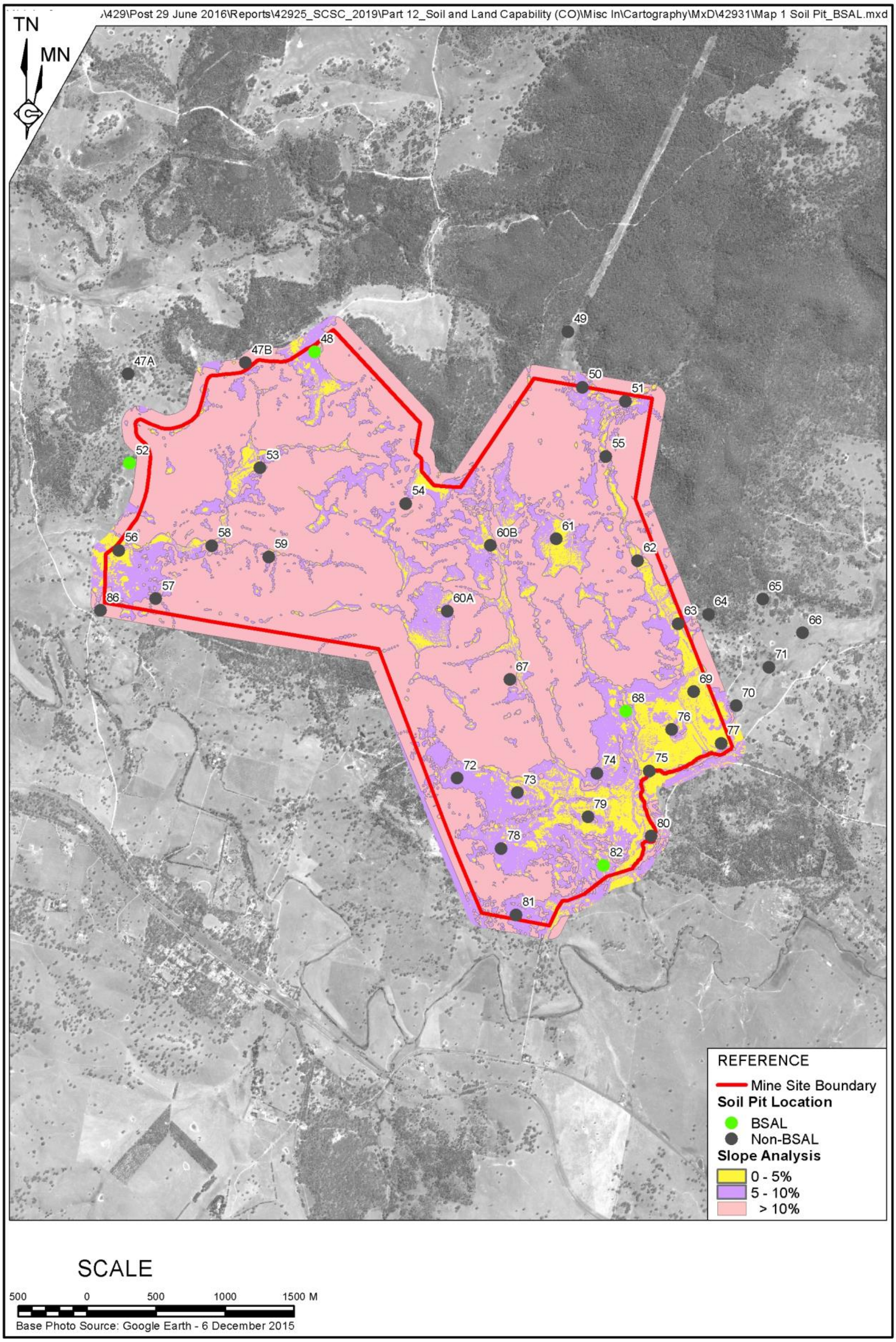
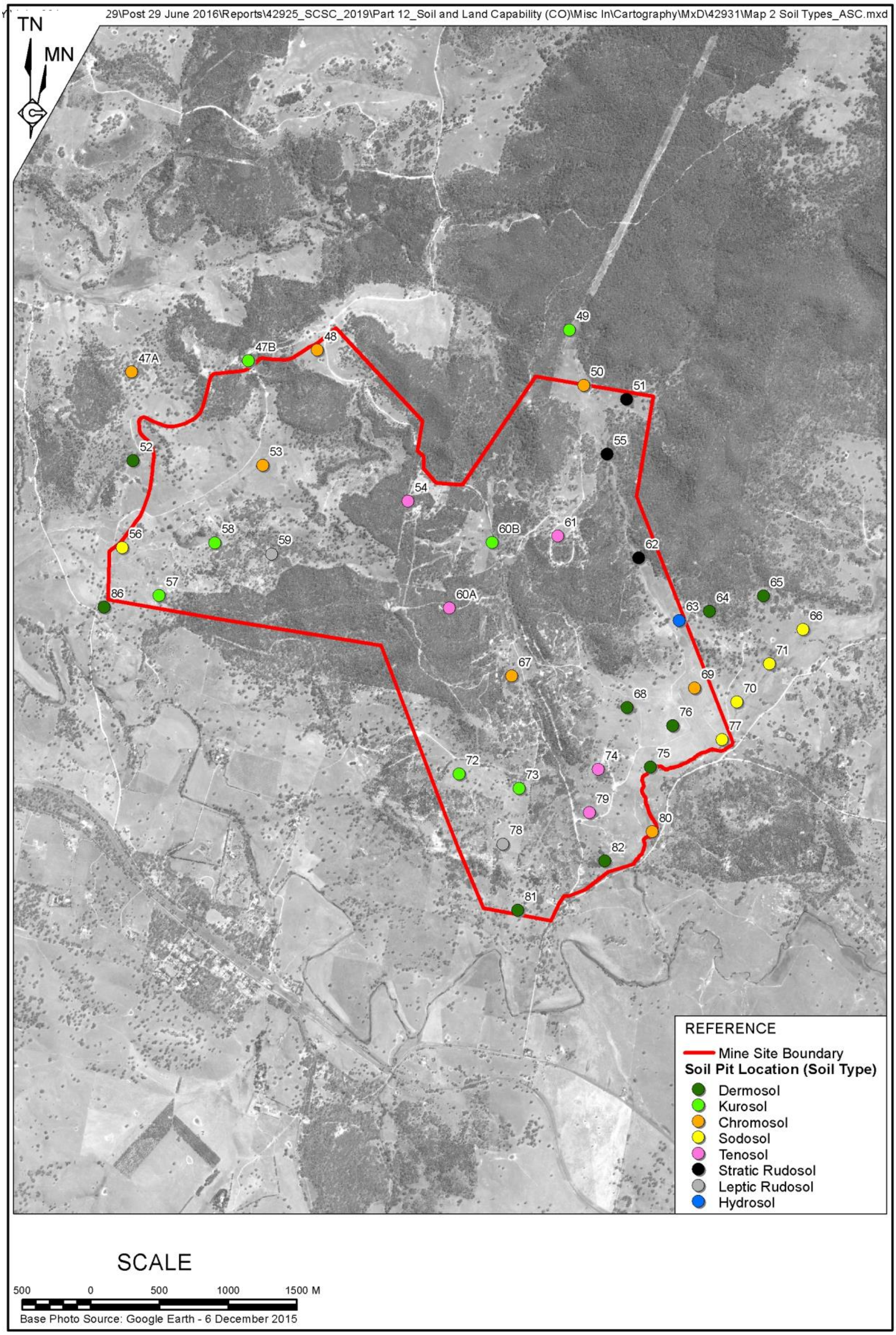
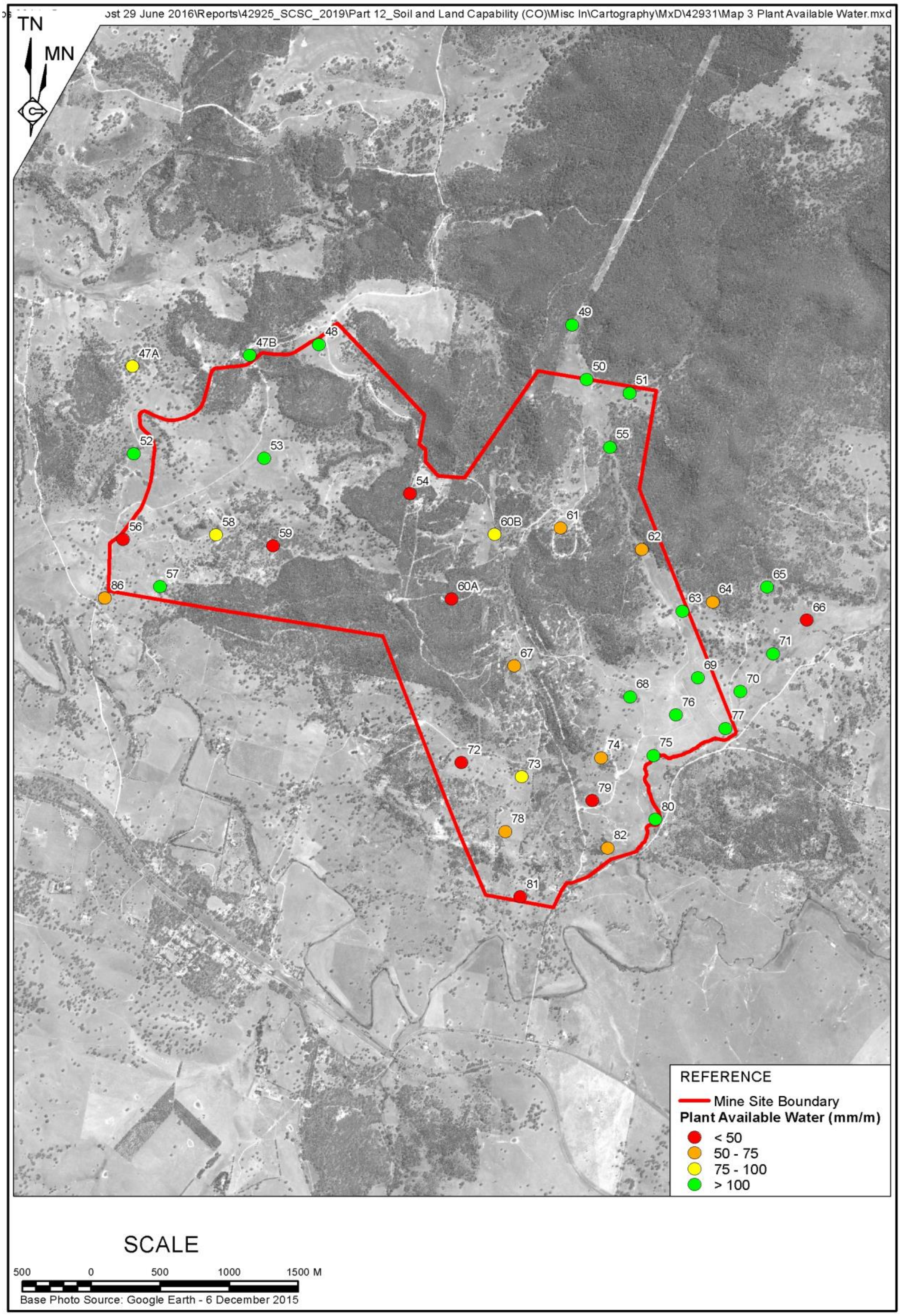
Map 1 Soil Pit Locations in Relation to BSAL Slope Categories



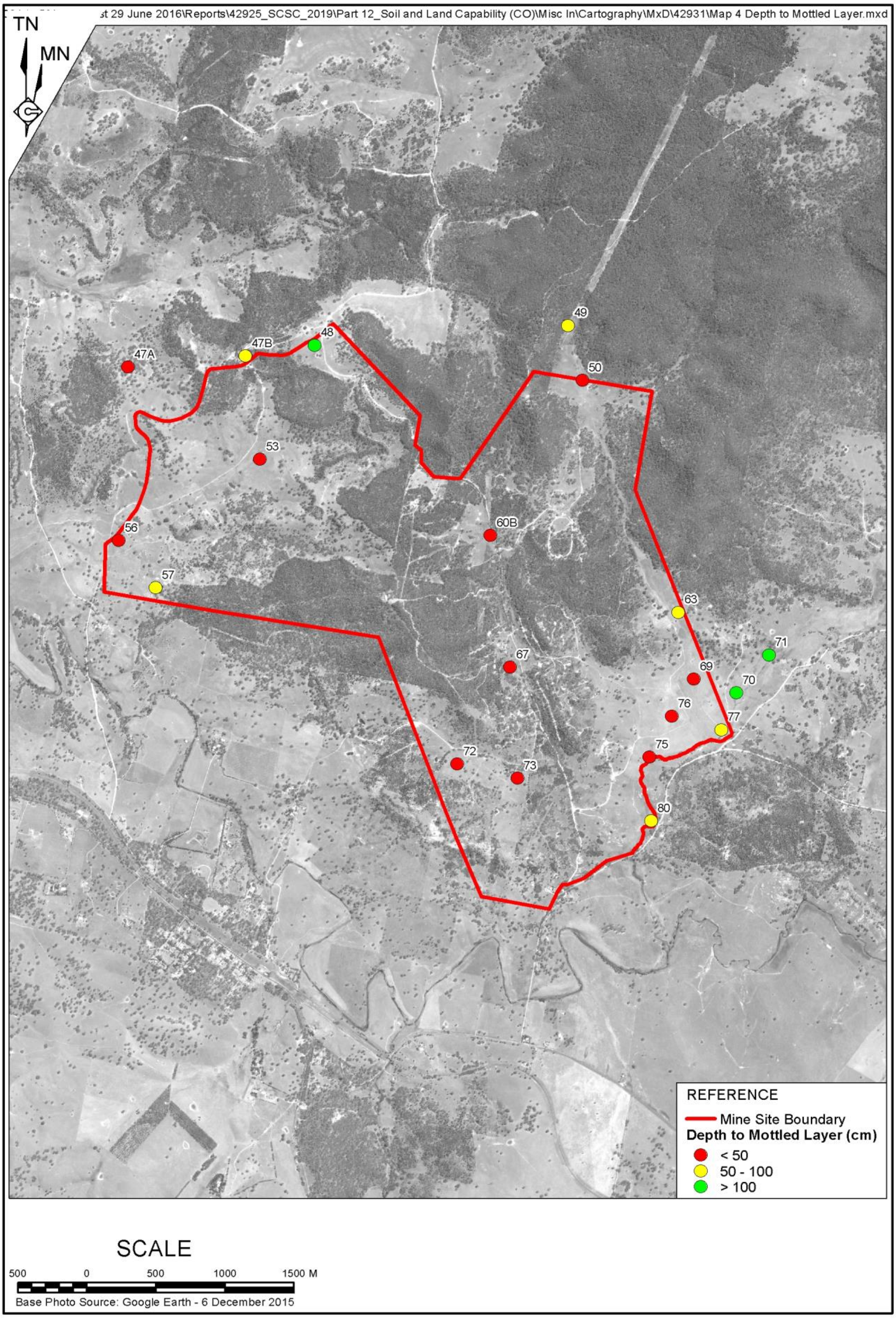
Map 2 Mine Site Soil Types – Australian Soil Classification



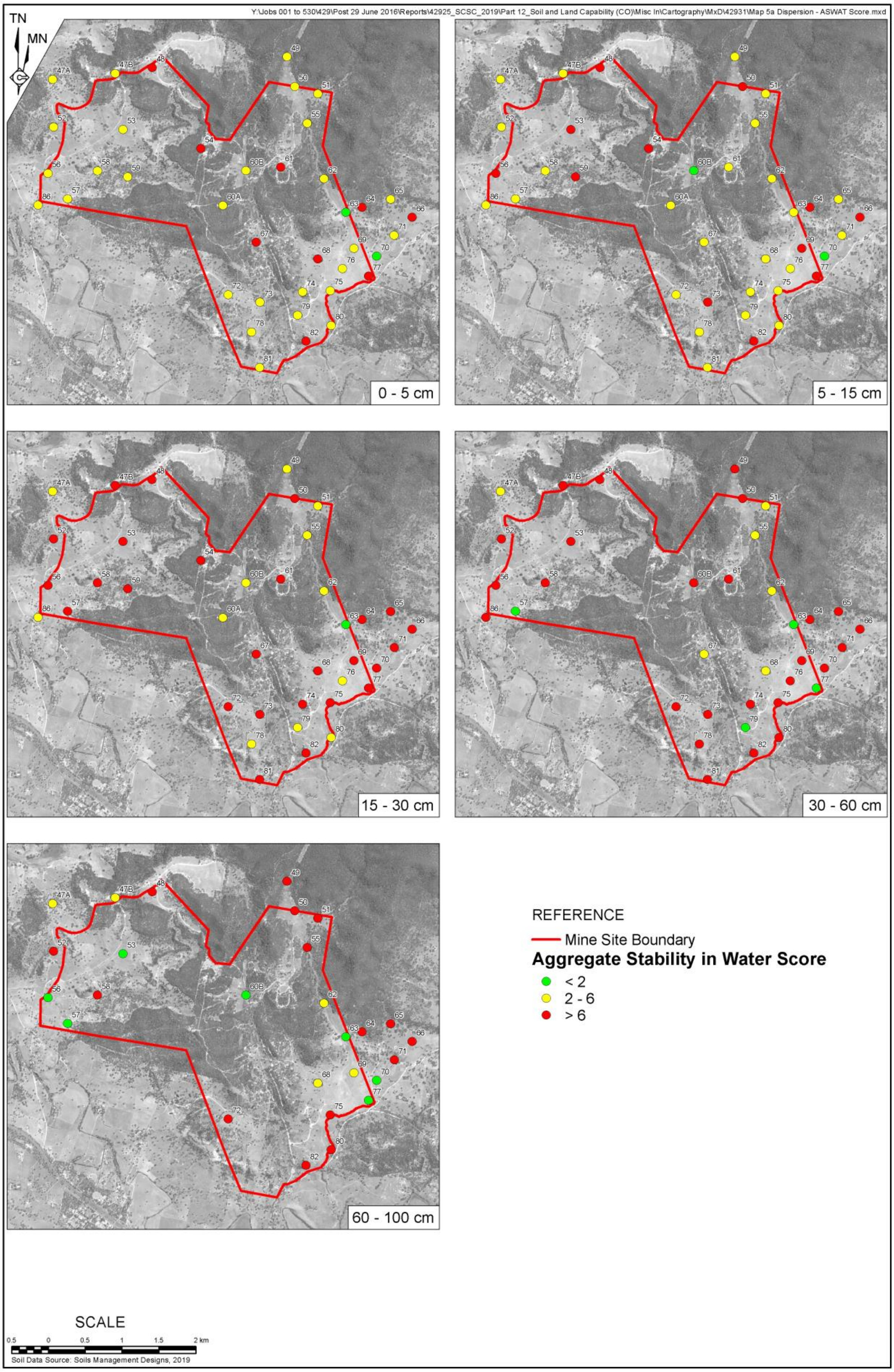
Map 3 Plant Total Available Water



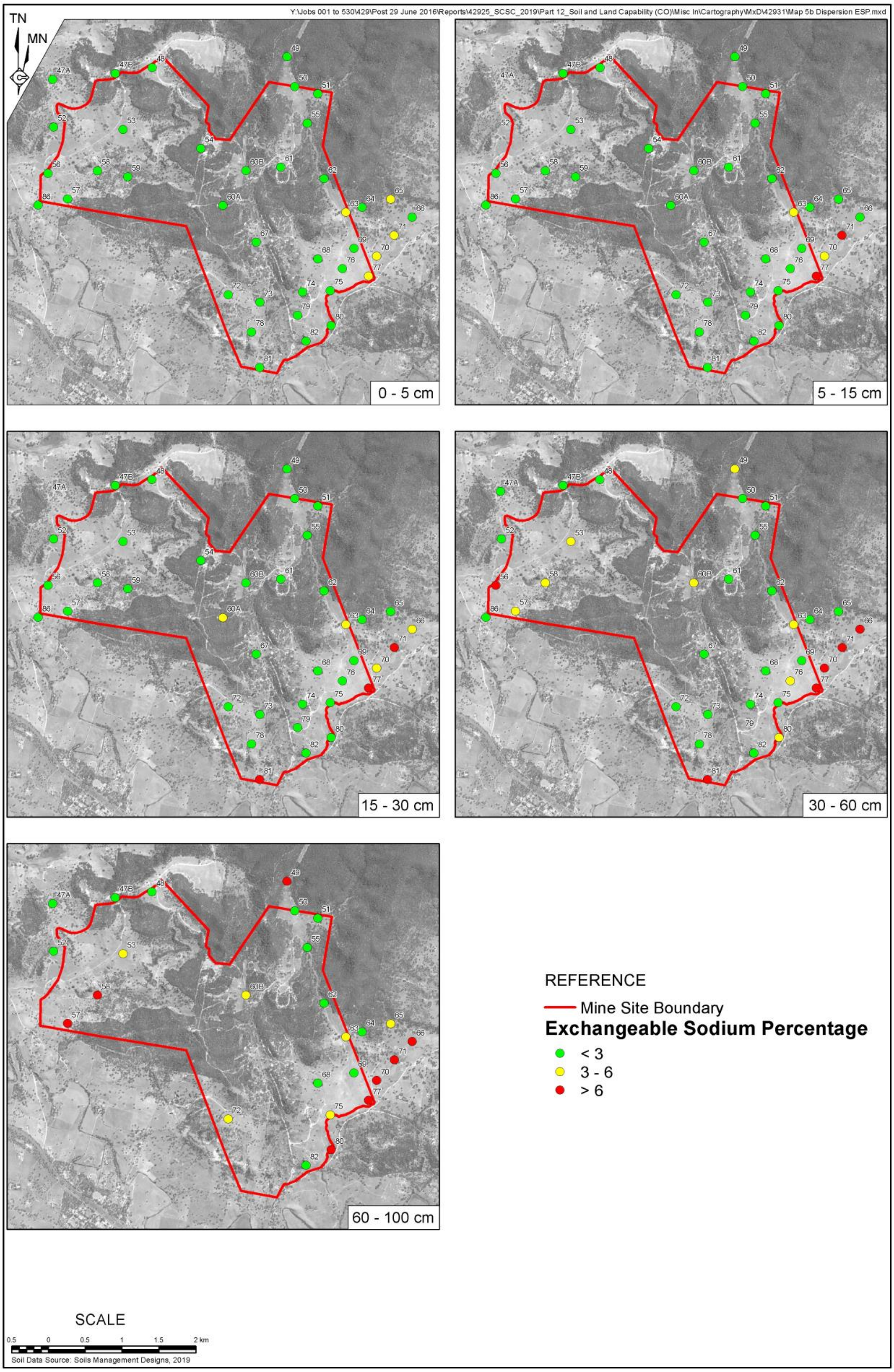
Map 4 Depth to Mottled Layer



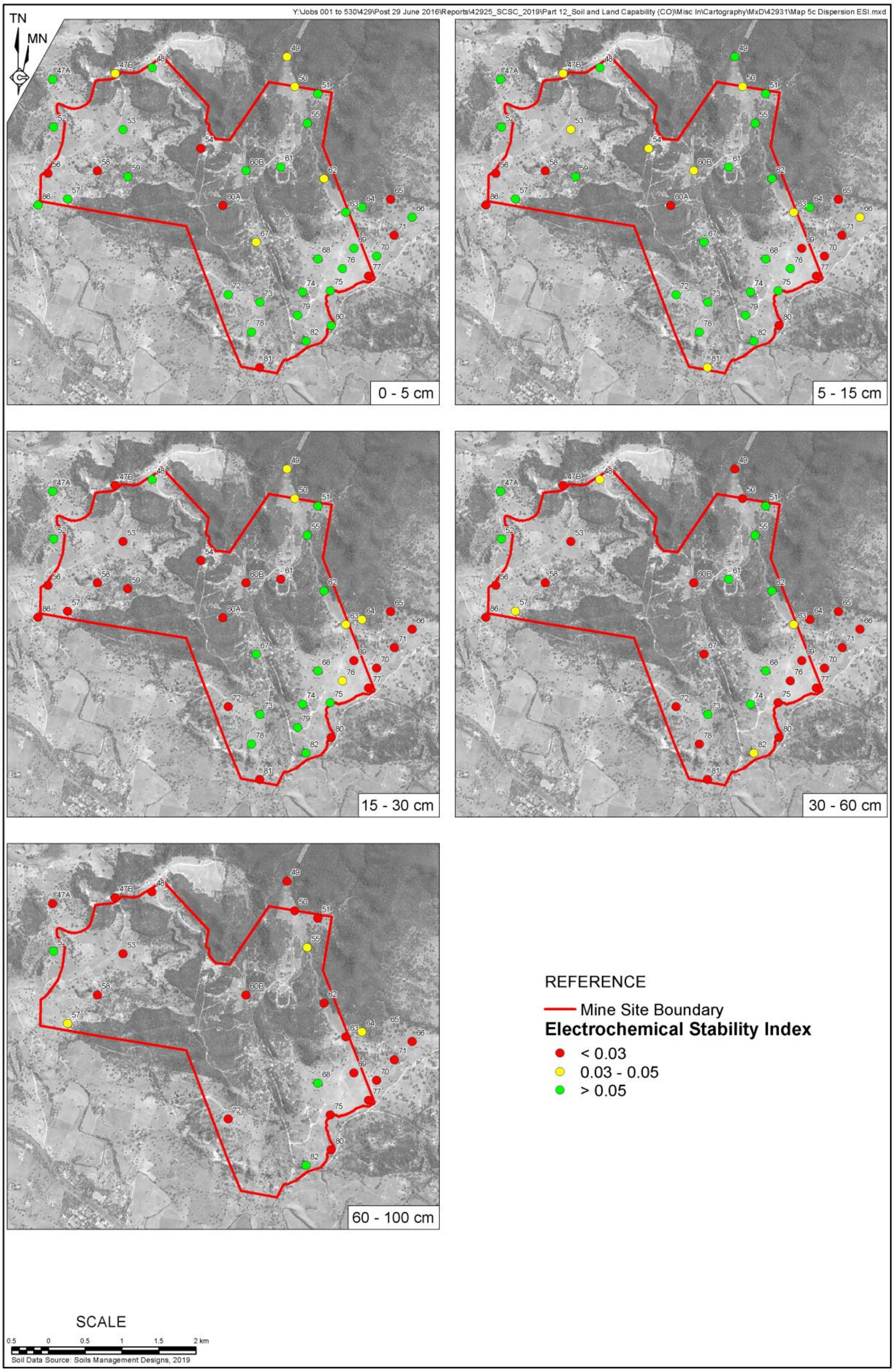
Map 5A Dispersion – Aggregate Stability in Water Score



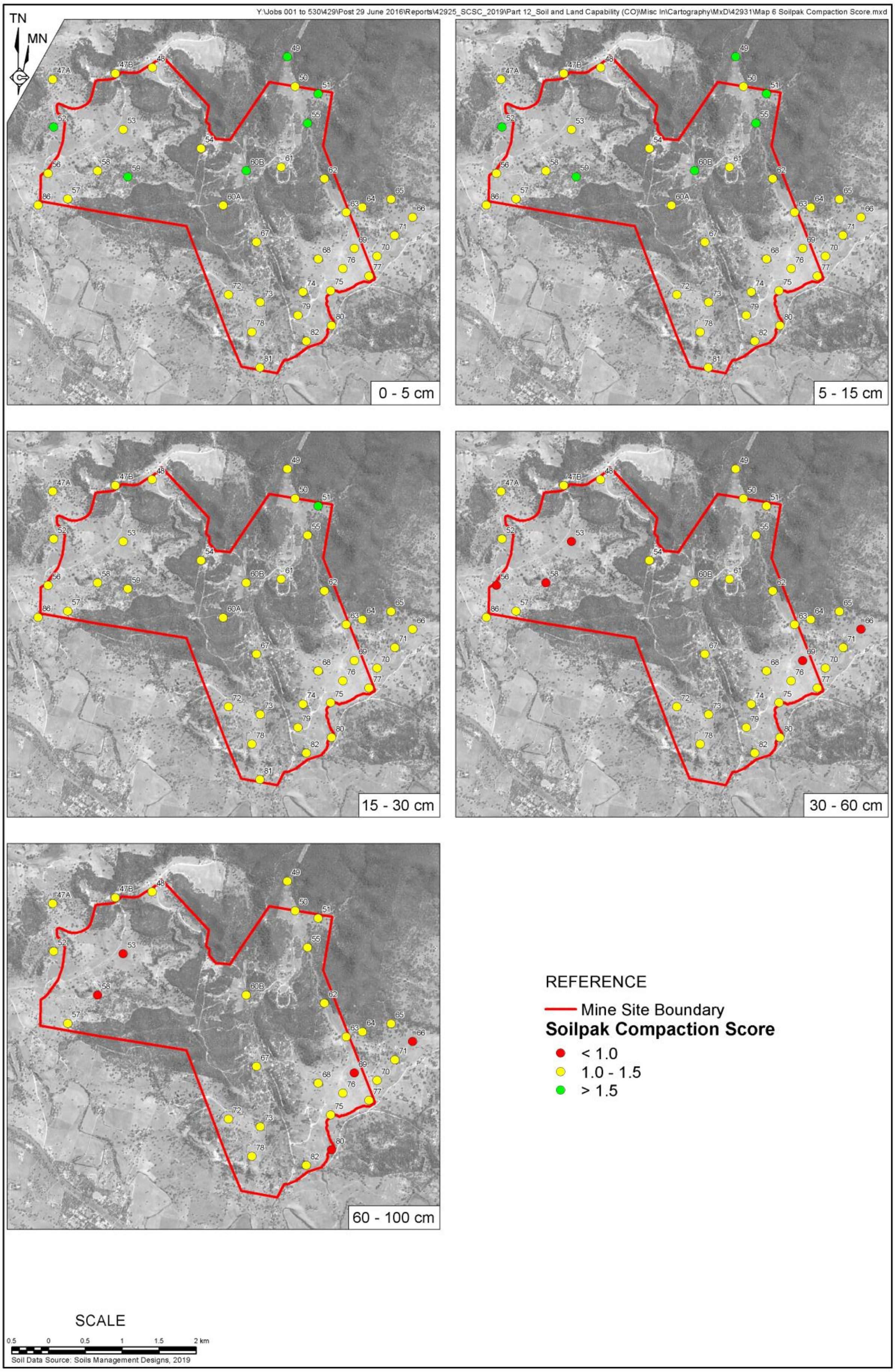
Map 5B Dispersion – Exchange Sodium Percentage Value



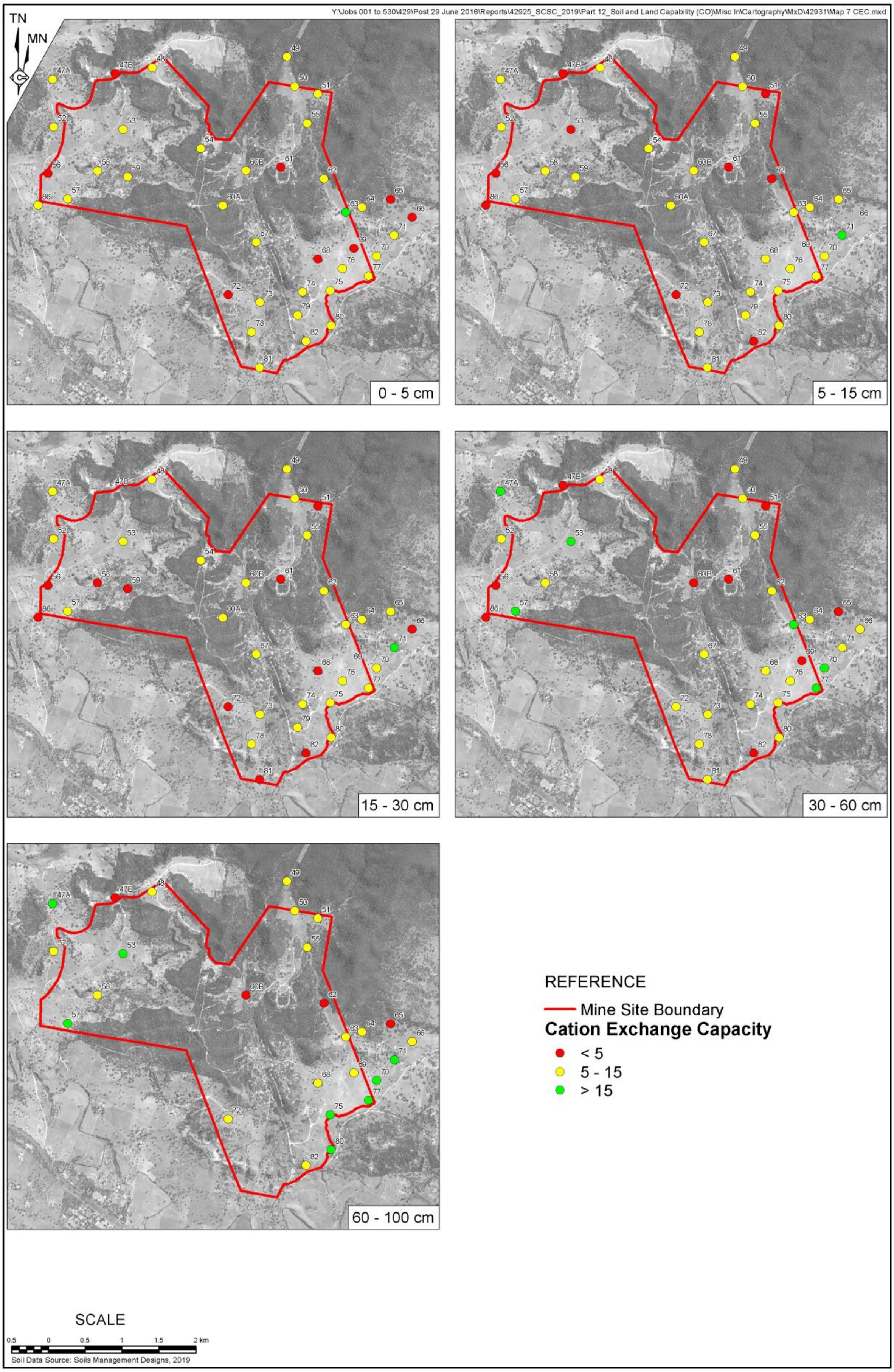
Map 5CDispersion – Electrochemical Stability Index



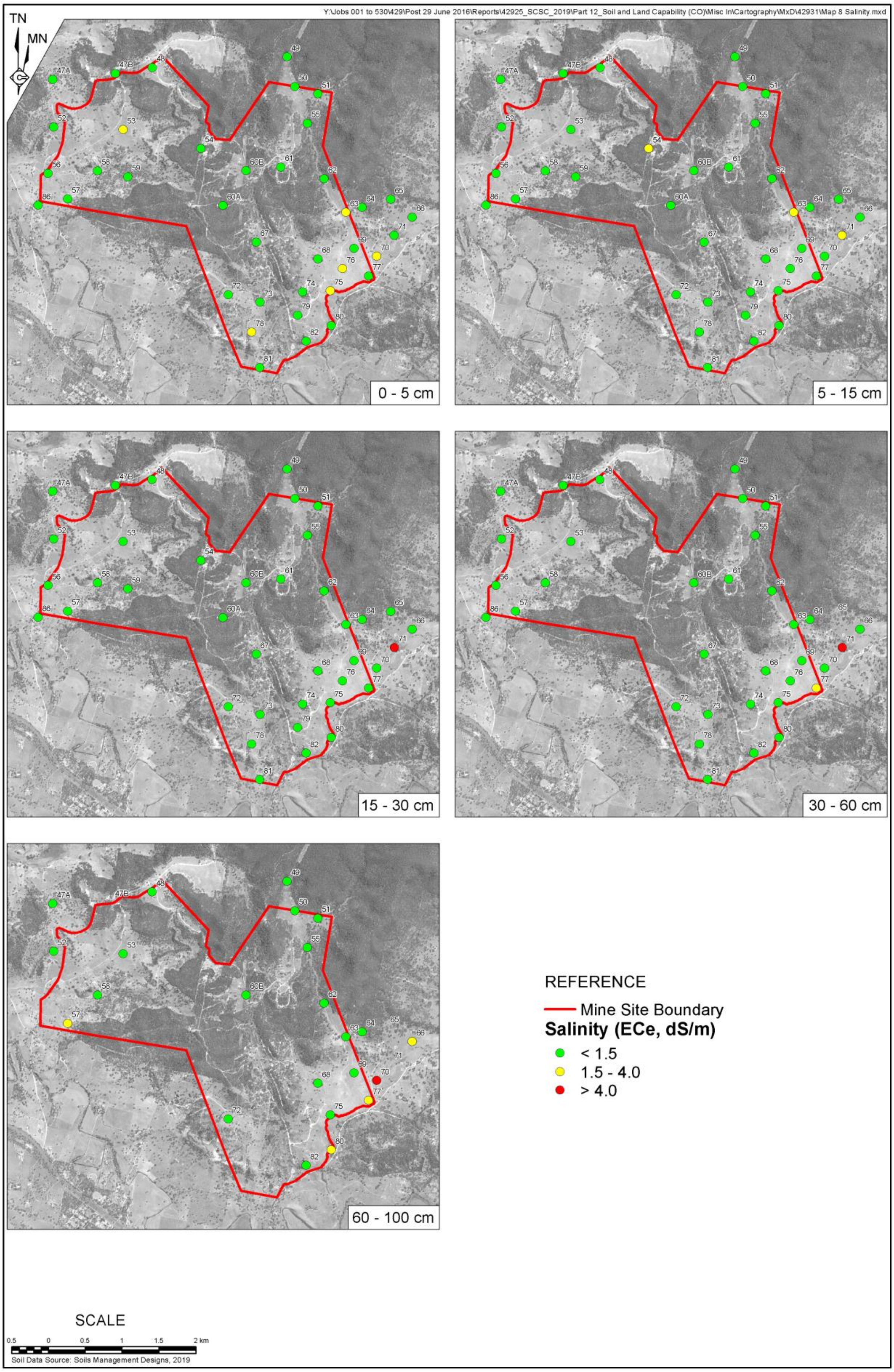
Map 6 Compaction Severity – SOILpak Score



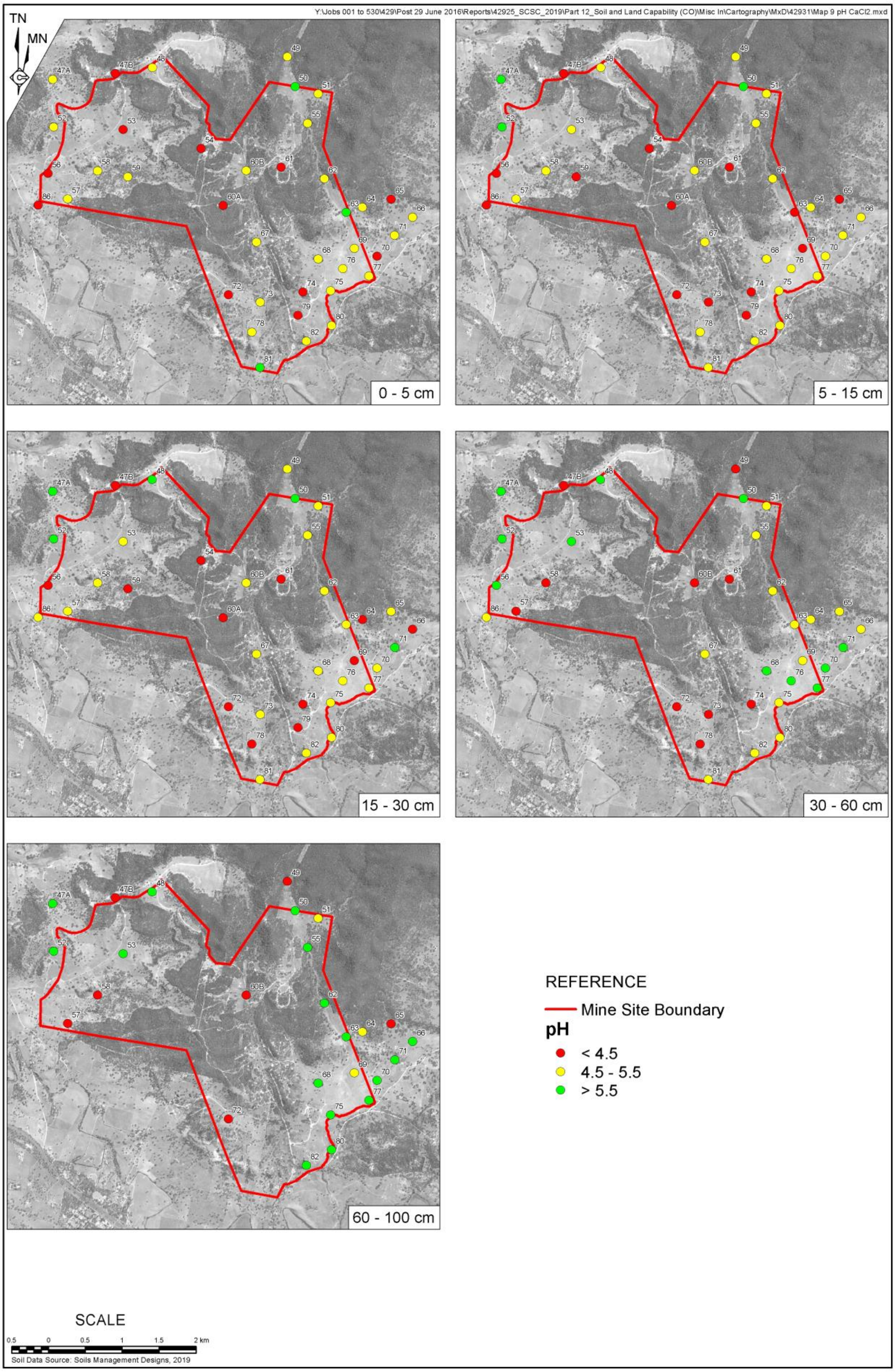
Map 7 Cation Exchange Capacity



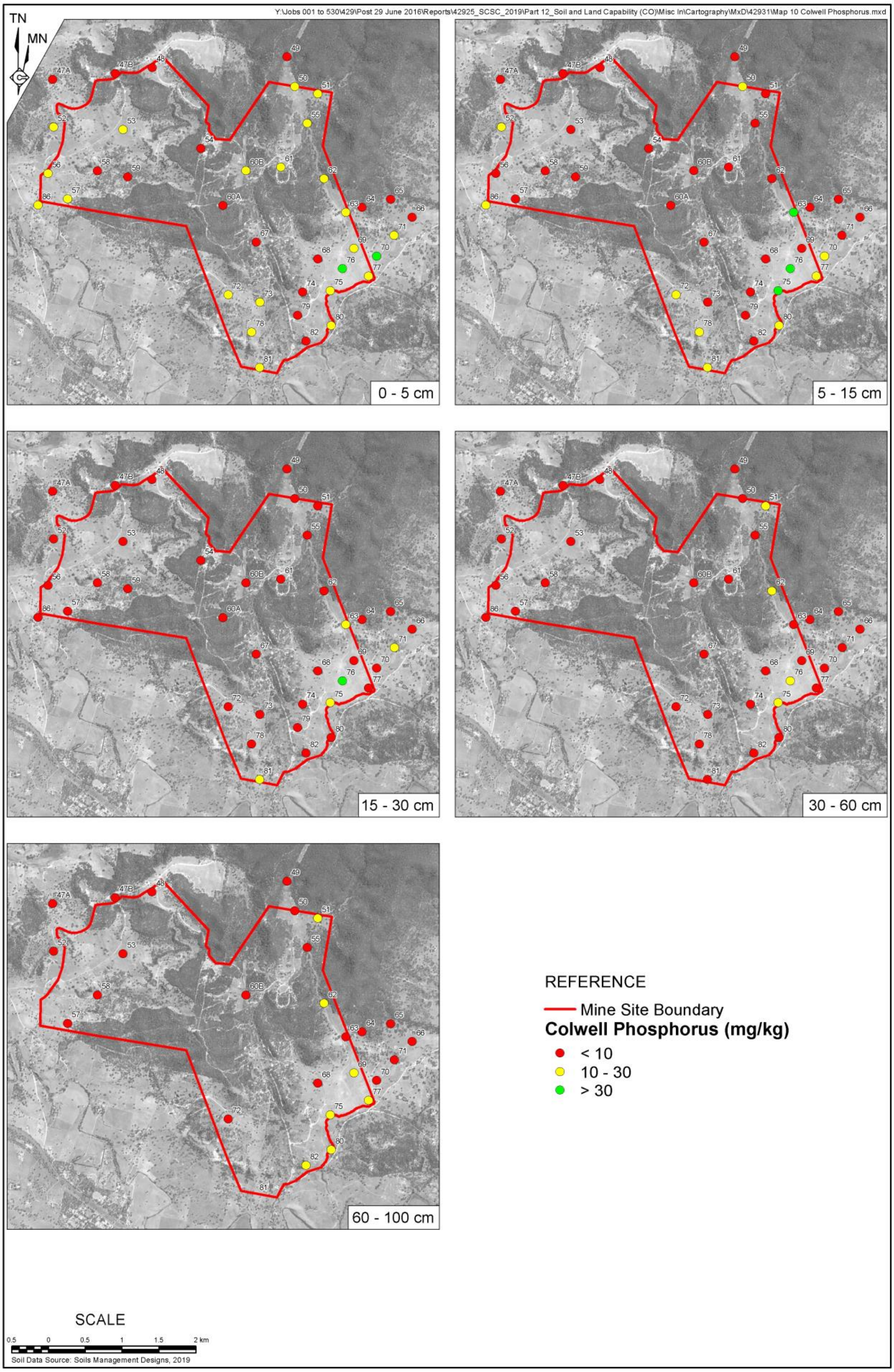
Map 8 Salinity (Electrical Conductivity; ECe)



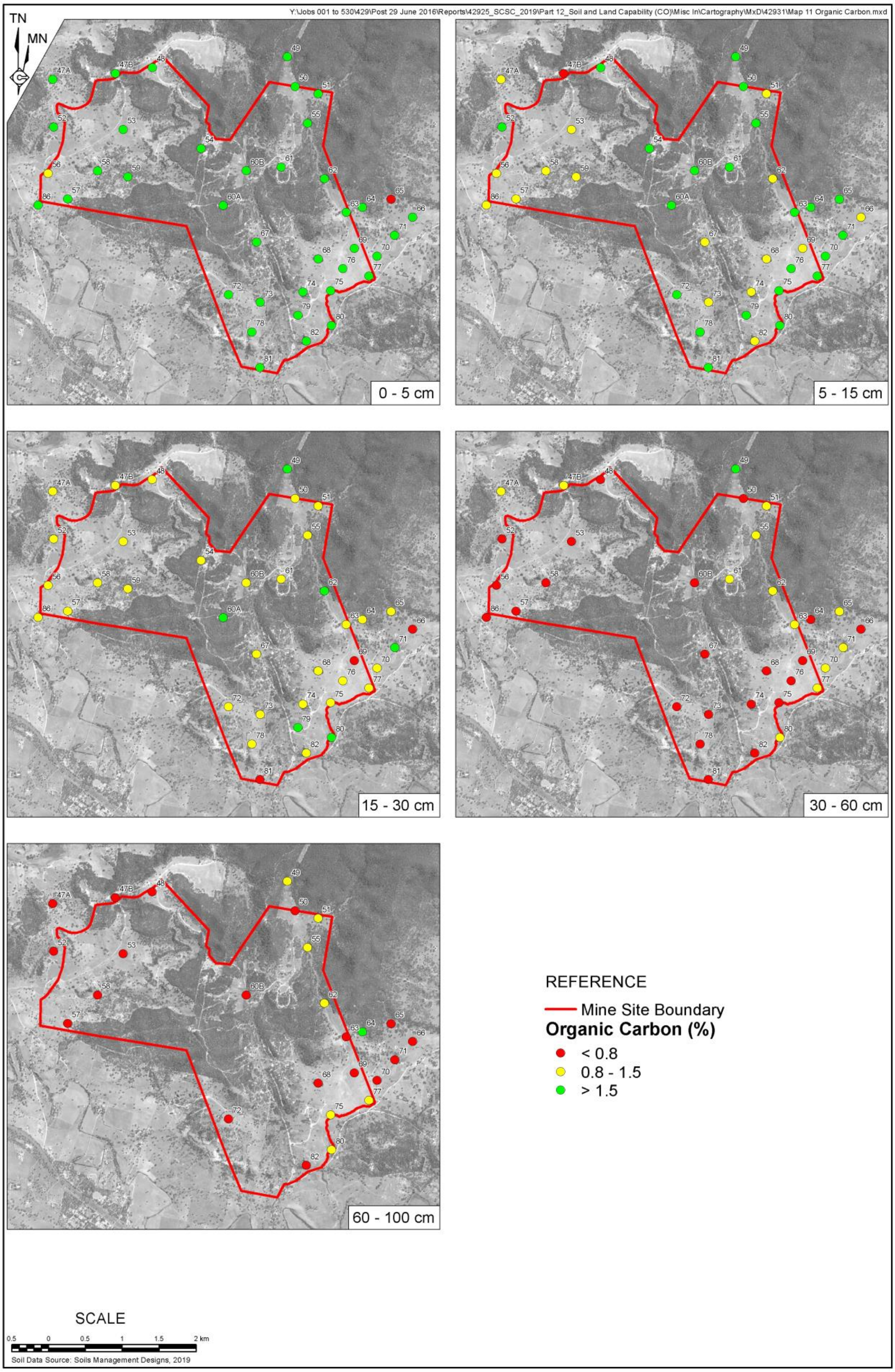
Map 9 pH ($CaCl_2$)



Map 10 Phosphorus (Colwell P)



Map 11 Organic Carbon



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Annexures

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Annexure A

Field Overview Data

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Map ID	Easting, m	Northing,	Slope	Australian Soil Classification (ASC)				BSAL	Depth to	Depth to	Depth to	Depth to	Depth to	TAW	Water	Lithology	Surface Rock	Surface Rock	Ground Cover
	WGS84	WGS84	%	Subgroup	Great Group	Suborder	Order		rock >90%	mottled layer >10%	Mn layer >20%	water-logged layer	Lime	(0-100 cm)	in Pit	Parent Material	%	mm	%
	m	m							cm	cm	cm	cm	cm	mm	dS/m				
47A	765989	6387696	14	Mottled	Eutrophic	Red	Chromosol	No	100	50	-	50	-	84		acid volcanics	15	30	80
47B	766841	6387777	12	Mottled	Magnesic	Red	Kurosol	No	140	60	-	60	-	121		congl./sandstone	2	20	80
48	767342	6387857	8	Haplic	Eutrophic	Red	Chromosol	YES	140+	120	-	120	-	162		congl./sandstone	0	-	80
49	769179	6388002	18	Mottled	Magnesic	Brown	Kurosol	No	140	60	-	60	-	168		congl./sandstone	0	-	80
50	769285	6387599	4	Bleached-Mottled	Eutrophic	Grey	Chromosol	No	140+	45	-	45	-	164		congl./sandstone	0	-	100
51	769597	6387498	3	Basic	-	Stratic	Rudosol	No	140+	-	-	-	-	113		mixed	0	-	100
52	766001	6387048	9	Haplic	Eutrophic	Red	Dermosol	YES	140+	-	-	-	-	181		acid volcanics	5	20	100
53	766947	6387014	8	Bleached-Mottled	Eutrophic	Brown	Chromosol	No	140+	30	-	30	-	101		acid volcanics	0	-	100
54	768004	6386756	23	Acidic	Lithic	Leptic	Tenosol	No	100	-	-	-	-	44		congl./sandstone	0	-	80
55	769455	6387098	2	Basic	-	Stratic	Rudosol	No	140+	-	-	-	-	146		mixed	1	30	90
56	765924	6386417	3	Dystrophic	Mottled-Subnatric	Brown	Sodosol	No	60	40	-	40	-	43		acid volcanics	0	-	70
57	766191	6386066	4	Mottled-Sodic	Eutrophic	Red	Kurosol	No	90	70	-	70	-	104		acid volcanics	20	10-40	80
58	766598	6386451	8	Mottled-Sodic	Mesotrophic	Grey	Kurosol	No	140	-	-	-	-	77		acid volcanics	0	-	100
59	767009	6386369	14	Acidic	-	Leptic	Rudosol	No	30	-	-	-	-	15		acid volcanics	0	-	80
60A	768305	6385977	5	Acidic	Lithic	Leptic	Tenosol	No	30	-	-	-	-	31		congl./sandstone	1	60	60
60B	768618	6386453	4	Bleached-Mottled	Mesotrophic	Red	Kurosol	No	70	40	-	40	-	85		congl./sandstone	0	-	100
61	769094	6386500	3	Acidic	Lithic	Bleached - Leptic	Tenosol	No	50	-	-	-	-	66		congl./sandstone	5	20	50
62	769683	6386342	2	Basic	-	Stratic	Rudosol	No	140+	-	-	-	-	63		mixed	1	40	90
63	769978	6385884	3	Eutrophic	Chromosolic	Oxyaquic	Hydrosol	No	100+	80	-	80	-	206	0.55	mixed	0	-	20
64	770198	6385952	26	Haplic	Mesotrophic	Yellow	Dermosol	No	100	-	-	-	-	73		acid volcanics	20	25	50
65	770591	6386063	3	Acidic	Mesotrophic	Grey	Dermosol	No	80	-	-	-	-	142		acid volcanics	0	-	100
66	770882	6385819	8	Mesotrophic	Mesonatric	Red	Sodosol	No	110	-	-	-	-	46		acid volcanics	0	-	90
67	768759	6385480	17	Haplic	Mesotrophic	Red	Chromosol	No	130	-	40	40	-	62		acid volcanics	0	-	100
68	769599	6385251	8	Haplic	Mesotrophic	Red	Dermosol	YES	90	-	-	-	-	126		Ordovician volcanics	0	-	100
69	770090	6385392	2	Bleached-Mottled	Mesotrophic	Grey	Chromosol	No	140+	50	-	50	-	115		mixed	0	-	100
70	770399	6385290	1	Eutrophic	Mesonatric	Grey	Sodosol	No	140+	110	-	110	-	198		mixed	0	-	100
71	770638	6385570	1	Eutrophic	Mottled-Hypernatric	Grey	Sodosol	No	140+	100	-	100	-	191		acid volcanics	0	-	100
72	768377	6384764	7	Bleached-Mottled	Mesotrophic	Grey	Kurosol	No	80	45	-	45	-	45		acid volcanics	1	20	80
73	768812	6384659	6	Mottled	Mesotrophic	Grey	Kurosol	No	65	40	-	40	-	79		acid volcanics	1	30	90
74	769390	6384800	8	Acidic	Lithic	Leptic	Tenosol	No	45	-	-	-	-	55		acid volcanics	1	40	80
75	769768	6384818	1	Mottled	Mesotrophic	Black	Dermosol	No	130+	35	-	35	-	167		mixed	0	-	100
76	769931	6385118	6	Mottled	Mesotrophic	Red	Dermosol	No	70	35	-	35	-	110		Ordovician volcanics	1	40	100
77	770290	6385017	2	Eutrophic	Mottled-Mesonatric	Black	Sodosol	No	130+	60	-	60	-	206		mixed	0	-	100
78	768696	6384255	6	Acidic	-	Leptic	Rudosol	No	30	-	-	-	-	55		acid volcanics	2	40	100
79	769324	6384483	4	Acidic	Lithic	Leptic	Tenosol	No	35	-	-	-	-	35		acid volcanics	1	30	100
80	769781	6384344	1	Mottled-Sodic	Mesotrophic	Black	Chromosol	No	140+	70	-	70	-	156		mixed	0	-	100
81	768804	6383773	7	Sodic	Mesotrophic	Brown	Dermosol	No	30	-	-	-	-	23		Ordovician volcanics	1	30	100
82	769438	6384132	5	Haplic	Mesotrophic	Red	Dermosol	YES	100	-	-	-	-	72		acid volcanics	0	-	100
86	765790	6385982	7	Haplic	Dystrophic	Brown	Dermosol	No	60	-	-	-	-	69		acid volcanics	2	50	90

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Annexure B

Field Soil Profile Layer Data

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Note: This Annexure is only available on the digital version of this document

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Table B-1 Field Soils Profile Layer Data

Map ID	Horizon	Lower depth cm	Texture	pH water	Moist soil colour (Munsell)	Colour from Munsell sheet	Mottles	Mn	SOILpak compaction score	Coarse fragments % (GV)	Coarse fragments Size (GV)	Dispersion 10 minutes	Moisture	Lime %	Lime Type	Root score
47A	A1	15	SL	5.5	5YR3/2	Dark reddish brown	-	-	1.4	30	10	0	D	0		3
47A	B2	50	LC	5.5	2.5YR4/3	Reddish brown	-	-	1.2	50	5	0	D	0		2
47A	BC	100	LC	5.5	7.5YR6/2	Pinkish grey	30% red distinct	-	1.1	60	5	0	D	0		2
47A	C	105+														
47B	A1	20	SL	4.5	7.5YR4/4	Brown	-	-	1.3	2	5	0	D	0		3
47B	B1	60	SCL	4.5	7.5YR4/3	Brown	-	-	1.2	5	5	0	D	0		3
47B	BC1	90	LMC	4.0	5YR5/6	Yellowish red	20% grey + 20% yellow distinct	-	1.2	50	25	0	D	0		2
47B	BC2	140	LMC	4.0	5YR7/1	Light Grey	20% grey + 20% yellow distinct	-	1.1	70	25	0	D	0		2
47B	C	145+														
47B																
48	A1	20	SL	5.5	7.5YR4/3	Brown	-	-	1.3	2	5	0	D	0		3
48	B11	40	CL	6.0	5YR4/4	Reddish brown	-	-	1.2	5	20	0	D	0		2
48	B12	120	LMC	6.0	5YR4/6	Yellowish red	-	-	1.1	10	5	0	D	0		1
48	B13	140+	LMC	7.0	5YR6/2	Pinkish grey	25% red + 20% yellow distinct	-	1.2	-	-	0	S	0		0
49	A11	20	SL	5.5	7.5YR2.5/1	Black	-	-	1.6	-	-	0	D	0		4
49	A12	60	SL	5.0	7.5YR2.5/1	Black	-	-	1.3	-	-	0	D	0		3
49	B21	80	LC	4.5	7.5YR5/2	Brown	15% grey	-	1.2	-	-	2	D	0		2
49	B22	140	LMC	4.0	7.5YR5/6	Strong brown	30% grey + 20% red distinct	-	1.2	-	-	1	S	0		2
49	C	140+														

Table B-1 Field Soils Profile Layer Data (Cont'd)

Map ID	Horizon	Lower depth cm	Texture	pH water	Moist soil colour (Munsell)	Colour from Munsell sheet	Mottles	Mn	SOILpak compaction score	Coarse fragments % (GV)	Coarse fragments Size (GV)	Dispersion 10 minutes	Moisture	Lime %	Lime Type	Root score
50	A1	20	SCL	5.5	7.5YR3/2	Dark brown	-	-	1.3	-	-	0	D	0		3
50	A2	45	SCL	5.5	7.5YR5/2	Brown	-	3% Size 4 Mn/Fe	1.1	-	-	1	D	0		2
50	B21	100	LMC	6.0	7.5YR5/2	Brown	15 % grey	8% Size 5 Mn/Fe	1.1	3	20	2	D	0		2
50	B22	140+	MC	6.0	7.5YR5/2	Brown	30% grey + 10% yellow distinct	8% Size 10 Mn/Fe	1	-	-	1	D	0		2
51	A1	30	SL	5.5	7.5YR2.5/2	Very dark brown	-	-	1.6	10	5	0	D	0		4
51	A3	80	CS	5.5	7.5YR2.5/2	Very dark brown	-	-	1.4	1	5	0	D	0		3
51	B1	140+	LC	5.5	7.5YR2.5/1	Black	-	-	1.3	-	-	0	S	0		2
52	A1	20	SCL	5.0	7.5YR2.5/2	Very dark brown	-	-	1.7	10	10 angular	0	D	0		3
52	A2	45	SCL	5.0	5YR4/2	Dark reddish grey	-	-	1.3	-	-	0	D	0		3
52	B11	70	LC	5.5	5YR4/4	Reddish brown	-	-	1.2	2	50 angular	1	D	0		2
52	B12	140+	SLC	5.5	5YR4/3	Reddish brown	-	-	1.1	5	10 angular	0	S	0		2
53	A1	15	SL	5.5	7.5YR2.5/3	Very dark brown	-	-	1.5	-	-	0	S	0		3
53	A2	30	SL	5.0	7.5YR6/2	Pinkish grey	-	10% Size 5 Mn/Fe	1.3	-	-	0	D	0		3
53	B2	110	MHC	7.5	10YR5/4	Yellowish brown	15% grey	-	0.9	2	20	1	M	0		2
53	B3	140+	MHC	8.0	10YR6/2	Light brownish grey	30% yellow distinct	-	1.1	10	20	2	M	0		1
54	A1	15	SL	4.5	7.5YR3/3	Dark brown	-	-	1.5	40	12	0	D	0		4
54	B2	40	LC	5.0	5YR5/4	Reddish brown	-	-	1.3	30	5	0	D	0		3
54	BC	100					-	-		100	-					1
54	C	105+														

Table B-1 Field Soils Profile Layer Data (Cont'd)

Page 3 of 8

Map ID	Horizon	Lower depth cm	Texture	pH water	Moist soil colour (Munsell)	Colour from Munsell sheet	Mottles	Mn	SOILpak compaction score	Coarse fragments % (GV)	Coarse fragments Size (GV)	Dispersion 10 minutes	Moisture	Lime %	Lime Type	Root score
55	A11	20	SL	5.0	10YR2/2	Very dark brown	-	-	1.6	5	10	0	D	0		4
55	A12	40	SL	5.5	10YR2/2	Very dark brown	-	-	1.4	20	11	0	D	0		4
55	B1	110	SCL	6.0	7.5YR2.5/1	Black	-	-	1.3	5	10	0	D	0		3
55	BC	140+	SL	6.0	7.5YR2.5/2	Very dark brown	-	-	1.1	70	10	0	D	0		2
56	A1	20	SL	4.5	7.5YR4/3	Brown	-	-	1.4	5	5	0	D	0		3
56	A2	40	SL	4.5	7.5YR5/3	Brown	-	-	1.3	50	15	0	D	0		3
56	B2	60	LMC	6.5	7.5YR5/4	Brown	20% red distinct	-	0.7	70	20	3	D	0		2
56	C	65+														
57	A1	20	SL	4.5	7.5YR3/3	Dark brown	-	-	1.3	50	10-20	0	D	0		3
57	B21	70	MC	4.5	2.5YR4/4	Reddish brown	5% grey faint	-	1.3	10	10	0	D	0		3
57	B22	90	LC	4.0			40% grey	-	1.1	70	20	0	S	0		2
57	C	100+														
58	A1	25	SL	5.0	10YR3/1	Very dark grey	-	-	1.5	10	10	0	D	0		3
58	A2	40	SL	5.0	7.5YR6/2	Pinkish grey	-	-	1.2	10	10	0	D	0		2
58	B2	100	MC	4.5	7.5YR4/2	Brown	-	-	1	30	10	0	D	0		2
58	BC	140	SCL	4.5	10YR5/2	Greyish brown	5% yellow	-		95		0		0		
58	C	145+														
59	A1	15	LS	5.0	7.5YR3/2	Dark brown	-	-	1.6	40	50	0	D	0		3
59	A3	30	SL	4.5	7.5YR6/3	Light brown	-	-	1.4	60	80	0	D	0		3
59	C	35+														
60A	A1	10	ZL	4.5	5YR3/2	Dark reddish brown	-	-	1.5	25	15 angular	0	D	0		4
60A	B1	30	ZL	4.5	7.5YR4/3	Brown	-	-	1.4	50	25 angular	0	D	0		3
60A	C	35+														

Table B-1 Field Soils Profile Layer Data (Cont'd)

Map ID	Horizon	Lower depth cm	Texture	pH water	Moist soil colour (Munsell)	Colour from Munsell sheet	Mottles	Mn	SOILpak compaction score	Coarse fragments % (GV)	Coarse fragments Size (GV)	Dispersion 10 minutes	Moisture	Lime %	Lime Type	Root score
60B	A1	20	ZL	4.5	7.5YR2.5/2	Very dark brown	-	-	1.6	-	-	0	D	0		3
60B	A2	40	ZCL	4.5	7.5YR5/2	Brown	-	-	1.2	3	5	0	D	0		2
60B	B2	70	LMC	4.0	5YR6/6	Reddish yellow	40% grey prominent	-	1.1	70	up to 400 boulders	0	D	0		2
60B	C	75+														
61	A1	12	SL	4.5	7.5YR2.5/2	Very dark brown	-	-	1.3	-	-	0	D	0		3
61	A2	20	SL	4.5	7.5YR2.5/2	Very dark brown	-	-	1.2	2	3	0	D	0		3
61	B2	50	SCL	4.0	7.5YR4/4	Brown	-	-	1.2	10	20	0	D	0		2
61	C	55+														
62	A11	15	CS	5.5	7.5YR2.5/2	Very dark brown	-	-	1.4	2	8	0	D	0		4
62	A12	35	SL	5.0	5YR2.5/1	Black	-	-	1.2	-	-	0	D	0		3
62	2A	45	S	5.0	7.5YR5/2	Brown	-	-	1.5	15	12	0	D	0		3
62	3A	60	SL	5.5	7.5YR2.5/2	Very dark brown	-	-	1.3	10	20	0	D	0		3
62	4A	110	S	5.5	7.5YR5/2	Brown	-	-	1.5	70	5-50	0	D	0		3
62	5A	140+	LC	5.5	5YR2.5/1	Black	-	-	1.3	-	-	0	S	0		3
63	A1	30	ZL	5.0	7.5YR2.5/2	Very dark brown	-	-	1.2	-	-	0	D	0		3
63	B2	80	MHC	5.5	10YR2/1	Black	-	-	1.1	5	5	0	M	0		3
63	B3	100+	MHC (S)	6.0	7.5YR4/6	Strong brown	30% grey	5% Size 5 Mn	1.1	-	-	0	M	0		2
63																
64	A1	30	SL	5.0	7.5YR2.5/2	Very dark brown	-	-	1.3	20	12	0	D	0		4
64	B1	100	SL	4.0	7.5YR6/4	Light brown	-	-	1.3	50	15	0	D	0		3
64	C	130+														
65	A1	20	ZL	4.0	7.5YR2.5/2	Very dark brown	-	-	1.5	10	30	0	D	0		4
65	A2	40	ZCL	5.0	7.5YR2.5/2	Very dark brown	-	-	1.3	10	30	2	D	0		3
65	B2	80	LC	4.0	7.5YR5/2	Brown	5% grey faint	2% Size 3 Mn	1.1	5	15	3	D	0		2
65	BC	130+								95						1

Table B-1 Field Soils Profile Layer Data (Cont'd)

Page 5 of 8

Map ID	Horizon	Lower depth cm	Texture	pH water	Moist soil colour (Munsell)	Colour from Munsell sheet	Mottles	Mn	SOILpak compaction score	Coarse fragments % (GV)	Coarse fragments Size (GV)	Dispersion 10 minutes	Moisture	Lime %	Lime Type	Root score
66	A1	10	SL	5.0	7.5YR5/3	Brown	-	-	1.4	40	30 round.	0	D	0		4
66	A2	30	SCL	5.0	5YR5/4	Reddish brown	-	-	1.2	50	15 round.	3	D	0		2
66	B2	110	SLC	6.5	5YR5/6	Yellowish red	5% grey faint	-	0.5	60	10 round.	4	D	0		0
66	BC	140+								95				0		0
67	A11	15	SL	4.5	5YR4/3	Reddish brown	-	5% Size 5 Fe/Mn pebbles	1.5	10	30 round.	0	D	0		3
67	A12	40	CL	4.5	5YR4/4	Reddish brown	-	15% Size 5 Fe/Mn	1.3	10	30 round.	0	D	0		3
67	B1	70	LC	4.5	5YR4/4	Reddish brown	-	35% Size 5 Mn	1.3	35	5-60	0	D	0		2
67	BC1	90		4.0			-	70% Size 10 Mn		15	20					
67	BC2	130		4.0			-			95						
67	C	140+														
68	A1	10	CL	4.5	7.5YR3/4	Dark brown	-	-	1.2	20	20	0	D	0		3
68	B1	40	CL	5.5	2.5YR4/4	Reddish brown	-	-	1.2	8	10	0	D	0		3
68	B2	90	LC (subplastic)	6.0	5YR4/6	Yellowish red	-	-	1.2	40	10	2	D	0		2
68	BC	95+								95						
69	A1	15	SL	4.5	7.5YR2.5/3	Very dark brown	-	-	1.3	-	-	0	D	0		3
69	A2	50	SL	4.5	7.5YR7/3	Pink	-	-	1.2	3	15	1	D	0		2
69	B2	110	LC	5.0	7.5YR5/2	Brown	30% brown	-	0.8	5	5	1	D	0		2
69	BC	140+	CS	6.0	7.5YR3/4	Dark brown	-	-	1.5	20	15	0	M	0		1
70	A1	20	ZL	4.5	7.5YR3/2	Dark brown	-	-	1.5	-	-	0	D	0		4
70	A2	40	ZCL	5.5	7.5YR3/1	Very dark grey	-	-	1.3	-	-	0	D	0		3
70	B21	110	MHC	7.5	7.5YR4/1	Dark grey	-	-	1.2	-	-	1	D	0		3
70	B22	140+	MC	6.0	7.5YR4/1	Dark grey	20% yellow prominent	-	1	-	-	1	M	0		0

Table B-1 Field Soils Profile Layer Data (Cont'd)

Map ID	Horizon	Lower depth cm	Texture	pH water	Moist soil colour (Munsell)	Colour from Munsell sheet	Mottles	Mn	SOILpak compaction score	Coarse fragments % (GV)	Coarse fragments Size (GV)	Dispersion 10 minutes	Moisture	Lime %	Lime Type	Root score
71	A1	10	ZL	4.5	7.5YR3/1	Very dark grey	-	-	1.5	-	-	0	D	0		4
71	B11	50	ZCL	4.5	7.5YR2.5/1	Black	-	-	1.3	-	-	0	D	0		3
71	B12	100	MHC	8.5	7.5YR4/1	Dark grey	10% grey faint	1% Size 3 Mn	1.1	-	-	1	M	0		2
71	B2	140+	LMC (S)	8.5	7.5YR6/2	Pinkish grey	40% yellow distinct	-	0.7	-	-	2	M	0		0
72	A1	10	SL	5.0	7.5YR3/2	Dark brown	-	-	1.5	50	10-40	0	D	0		4
72	A2	45	SL	4.5	7.5YR5/2	Brown	-	-	1.3	70	20-50	0	D	0		1
72	B2	80	LMC	4.0	7.5YR5/2	Brown	40% yellow prominent	-	1.3	60	5-20	3	D	0		1
72	C	95+														
73	A11	10	SL	4.5	5YR4/3	Reddish brown	-	-	1.3	-	-	0	D	0		2
73	A12	40	SL	5.5	5YR6/3	Light reddish brown	-	-	1.1	25	20	0	D	0		2
73	B2	65	LC	4.0	10YR7/2	Light grey	40% yellow prominent	-	1.2	40	20	0	D	0		1
73	C	70+														
74	A1	15	SL	4.0	5YR3/3	Dark reddish brown	-	-	1.3	5	5	0	D	0		3
74	B1	45	SL	4.0	5YR4/4	Reddish brown	-	-	1.2	10	10 angular	0	D	0		3
74	C	50+														
75	A11	20	ZCL	5.0	5YR2.5/2	Dark Reddish Brown	-	-	1.5	-	-	0	D	0		4
75	A12	35	ZCL	4.5	7.5YR2.5/1	Black	-	-	1.3	-	-	0	D	0		2
75	B2	130+	MC	6.0	7.5YR2.5/1	Black	30% yellow prominent	15% Size 8 Mn	1.2	-	-	2	D	0		1

Table B-1 Field Soils Profile Layer Data (Cont'd)

Map ID	Horizon	Lower depth	Texture	pH	Moist soil	Colour from	Mottles	Mn	SOILpak	Coarse	Coarse	Dispersion	Moisture	Lime	Lime	Root score
		cm		water	colour	Munsell sheet			compaction	fragments	fragments	10 minutes		%	Type	
					(Munsell)				score	% (GV)	Size (GV)					
76	A11	20	SCL	5.0	7.5YR4/4	Brown	-	-								
76	A12	35	SCL	5.5	10YR6/3	Pale brown	-	1% Size 3 Mn	1.5	5	5	0	D	0		4
76	B2	70	LC	7.5	2.5YR3/4	Dark reddish brown	30% yellow prominent	10% Size 3 Mn	1.2	10	50	3	D	0		3
76	C	75+							1.1	3	5	3	D	0		1
77	A1	25	ZL	4.5	5YR3/2	Dark reddish brown	-	-	1.2	-	-	0	D	0		4
77	B21	60	MHC	6.0	5YR2.5/1	Black	10% red distinct	-	1.3	-	-	2	M	0		3
77	B22	130+	MHC	6.0	5YR4/1	Dark grey	30% red distinct	1% Size 5 Mn	1.5	-	-	0	M	0		1
78	A1	30	SL	5.0	7.5YR2.5/2	Very dark brown	-	-	1.5	5	10	0	D	0		2
78	A2	70	SL	4.0	7.5YR5/3	Brown	-	-	1.5	95	10	0	D	0		2
78	C	75+														
79	A1	20	SL	4.0	5YR4/3	Reddish brown	-	-	1.4	10	15	0	D	0		4
79	B1	35	LC	4.0	5YR4/4	Reddish brown	-	-	1.2	50	8	0	D	0		3
79	BC	60								95						
79	C	65+														
80	A11	25	ZCL	4.0	7.5YR2.5/1	Black	-	-	1.5	-	-	0	D	0		3
80	A12	40	ZCL	5.0	5YR2.5/1	Black	-	-	1.3	-	-	1	D	0		2
80	B21	70	MHC	5.5	5YR2.5/1	Black	-	-	1.2	-	-	3	D	0		2
80	B22	140+	MHC	7.0	5YR3/1	Very Dark Gray	15% yellow faint	-	0.7	-	-	1	S	0		1

Table B-1 Field Soils Profile Layer Data (Cont'd)

Map ID	Horizon	Lower depth cm	Texture	pH water	Moist soil colour (Munsell)	Colour from Munsell sheet	Mottles	Mn	SOILpak compaction score	Coarse fragments % (GV)	Coarse fragments Size (GV)	Dispersion 10 minutes	Moisture	Lime %	Lime Type	Root score
81	A1	10	FSCL	5.5	5YR4/3	Reddish brown	-	-	1.5	5	5 angular	0	D	0		2
81	A2	20	SCL	5.5	7.5YR5/3	Brown	-	-	1.3	70	15 angular	3	D	0		1
81	B2	30	LC	5.5	7.5YR5/6	Strong brown	-	-	1.2	80	10-50	3	S	0		1
81	BC	50								95						
81	C	85+														
82	A11	10	ZL	4.5	5YR2.5/2	Dark Reddish Brown	-	-	1.3	-	-	0	D	0		4
82	A12	40	SL	5.5	7.5YR6/3	Light brown	-	-	1.2	10	30 angular	0	D	0		1
82	B1	100	SCL	5.5	5YR5/4	Reddish brown	-	-	1.2	80	5-40	3	D	0		1
82	C	105+														
84	A1	10	SL	5.5	2.5YR3/1	Dark reddish grey	-	-	1.5	30	10-20 shale	0	D	0		2
84	B2	40	SLC	5.0	5YR4/6	Yellowish red	-	-	1.4	60	20-50	0	D	0		2
84	BC	80								95						
84	C	90+														
85	A1	15	ZCL	6.0	5YR2.5/2	Dark Reddish Brown	-	-	1.3	-	-	0	D	0		3
85	B11	70	ZCL	5.5	5YR2.5/1	Black	-	-	1.1	-	-	0	D	0		3
85	B12	140+	LC	5.5	5YR2.5/1	Black	-	-	1.5	-	-	2	S	0		2
86	A1	20	SL	4.5	7.5YR3/2	Dark brown	-	-	1.3	-	-	0	D	0		3
86	A2	40	SL	5.5	7.5YR4/4	Brown	-	-	1.2	5	10	0	D	0		3
86	B2	60	SCL	5.5	7.5YR4/4	Brown	-	5% Size 5 Mn/Fe	1.2	45	20	1	D	0		2
86	C	65+														

Annexure C

Soil Structural Form Data

(Total No. of pages including blank pages = 6)

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Map ID	Horizon	Lower Depth	Grade	Type	Size	Fabric	Consistence	SOILpak
		cm						Compaction Score
47A	A1	15	M	PO	5	RP	3	1.4
47A	B2	50	M	PO	5	RP	3	1.2
47A	BC	100	W	PO	10	RP	4	1.1
47A	C	105+						
47B	A1	20	M	PO	8	RP	2	1.3
47B	B1	60	M	PO	10	RP	3	1.2
47B	BC1	90	W	PO	10	RP	3	1.2
47B	BC2	140	M	PO/SB	10	RP	4	1.1
47B	C	145+						
48	A1	20	M	PO	8	RP	3	1.3
48	B11	40	M	PO	10	RP	4	1.2
48	B12	120	W	AB/PO	10	RP	4	1.1
48	B13	140+	M	PO	10	RP	3	1.2
49	A11	20	M	PO	8	RP	3	1.6
49	A12	60	M	PO	10	RP	3	1.3
49	B21	80	W	PO	10	RP	3	1.2
49	B22	140	M	PO/AB	10	RP	3	1.2
49	C	140+						
49								
50	A1	20	M	PO	8	RP	2	1.3
50	A2	45	M	PO	10	RP	3	1.1
50	B21	100	M	PO	20	RP	4	1.1
50	B22	140+	W	PO	20	RP	4	1.0
51	A1	30	W	PO	5	E	2	1.6
51	A3	80	W	PO	8	E	3	1.4
51	B1	140+	W	PO	15	E	3	1.3
52	A1	20	M	PO/SB	5	RP	3	1.7
52	A2	45	M	PO	10	RP	3	1.3
52	B11	70	M	PO	15	RP	4	1.2
52	B12	140+	W	PO	10	RP	3	1.1
53	A1	15	M	PO	5	RP	2	1.5
53	A2	30	W	PO	5	E	3	1.3
53	B2	110	W	PO	10	RP	4	0.9
53	B3	140+	W	PO	10	RP	3	1.1
54	A1	15	M	PO	15	RP	3	1.5
54	B2	40	M	PO	10	RP	3	1.3
54	BC	100						
54	C	105+						
55	A11	20	M	PO	5	RP	3	1.6
55	A12	40	W	PO	10	E	3	1.4
55	B1	110	W	PO	10	E	3	1.3
55	BC	140+	G			E		1.1

Map ID	Horizon	Lower Depth	Grade	Type	Size	Fabric	Consistence	SOILpak
		cm						Compaction Score
56	A1	20	M	SB/PO	10	RP	3	1.4
56	A2	40	W	PO	5	E	2	1.3
56	B2	60	W	PO	10	RP	4	0.7
56	C	65+						
57	A1	20	M	SB/PO	5	RP	3	1.3
57	B21	70	S	SB/PO	10	RP	4	1.3
57	B22	90	W	SB	5	E	3	1.1
57	C	100+						
58	A1	25	M	PO	5	RP	3	1.5
58	A2	40	W	PO	10	E	3	1.2
58	B2	100	W	PO	10	E	3	1.0
58	BC	140						
58	C	145+						
59	A1	15	W	PO	5	E	2	1.6
59	A3	30	W	PO	10	E	2	1.4
59	C	35+						
60A	A1	10	W	PO	8	E	2	1.5
60A	B1	30	W	PO	5	E	1	1.4
60A	C	35+						
60B	A1	20	M	PO/SB	5	RP	3	1.6
60B	A2	40	W	PO	8	E	4	1.2
60B	B2	70	M	PO	10	RP	4	1.1
60B	C	75+						
61	A1	12	W	PO	5	E	2	1.3
61	A2	20	W	PO	10	E	3	1.2
61	B2	50	W	PO	10	E	3	1.2
61	C	55+						
62	A11	15	M	PO	8	RP	3	1.4
62	A12	35	W	SB/PO	10	E	2	1.2
62	2A	45	G	apedal		G		1.5
62	3A	60	M	PO	15	RP	3	1.3
62	4A	110	G	apedal		G		1.5
62	5A	140+	M	PO/AB	10	RP	3	1.3
63	A1	30	W	PO	20	E	3	1.2
63	B2	80	M	SB/PO	20	RP	3	1.1
63	B3	100+	W	PO	15	RP	2	1.1
64	A1	30	M	PO	8	RP	3	1.3
64	B1	100	W	PO	8	E	1	1.3
64	C	130+						

Map ID	Horizon	Lower Depth	Grade	Type	Size	Fabric	Consistence	SOILpak
		cm						Compaction Score
65	A1	20	S	PO	8	RP	3	1.5
65	A2	40	M	PO	8	RP	3	1.3
65	B2	80	W	PO	10	RP	3	1.1
65	BC	130+						
66	A1	10	M	PO	10	RP	2	1.4
66	A2	30	W	PO	15	E	3	1.2
66	B2	110	V					0.5
66	BC	140+						
67	A11	15	M	PO	8	RP	2	1.5
67	A12	40	M	PO	12	RP	3	1.3
67	B1	70	W	PO	12	E	3	1.3
67	BC1	90						
67	BC2	130						
67	C	140+						
68	A1	10	W	PO	5	E	2	1.2
68	B1	40	M	PO	8	RP	3	1.2
68	B2	90	W	PO	8	RP	3	1.2
68	BC	95+						
69	A1	15	W	PO	8	E	2	1.3
69	A2	50	W	PO	10	E	2	1.2
69	B2	110	M	AB	15	RP	4	0.8
69	BC	140+						1.5
70	A1	20	M	PO	8	RP	3	1.5
70	A2	40	M	PO	8	RP	4	1.3
70	B21	110	M	PO	15	RP	4	1.2
70	B22	140+	W	PO	15	RP	2	1.0
71	A1	10	M	PO	8	RP	3	1.5
71	B11	50	M	PO	10	RP	3	1.3
71	B12	100	W	PO	20	RP/SP	3	1.1
71	B2	140+	V					0.7
72	A1	10	M	PO	5	RP	1	1.5
72	A2	45	W	PO	5	E	1	1.3
72	B2	80	M	PO	8	RP	3	1.3
72	C	95+						
73	A11	10	W	PO	8	E	1	1.3
73	A12	40	W	AB/PO	10	E	2	1.1
73	B2	65	M	PO	5	RP	2	1.2
73	C	70+						
74	A1	15	W	AB/PO	15	E	2	1.3
74	B1	45	W	PO	10	E	2	1.2
74	C	50+						

Map ID	Horizon	Lower Depth	Grade	Type	Size	Fabric	Consistence	SOILpak
		cm						Compaction Score
75	A11	20	S	PO	8	RP	2	1.5
75	A12	35	W	PO	10	E	3	1.3
75	B2	130+	W	PO	10	RP	4	1.2
76	A11	20	W	PO	10	E	2	1.5
76	A12	35	W	PO	12	E	2	1.2
76	B2	70	W	PO	15	RP	4	1.1
76	C	75+						
77	A1	25	S	PO	10	RP	4	1.2
77	B21	60	S	PO	10	RP/SP	3	1.3
77	B22	130+	W	PO	10	RP/SP	3	1.5
78	A1	30	M	PO	5	RP	2	1.5
78	A2	70	apedal					1.5
78	C	75+						
79	A1	20	M	PO	8	RP	2	1.4
79	B1	35	M	PO	8	RP	2	1.2
79	BC	60						
79	C	65+						
80	A11	25	M	PO	8	RP	2	1.5
80	A12	40	M	PO	12	RP	3	1.3
80	B21	70	S	LE	8	RP/SP	4	1.2
80	B22	140+	M	AB	15	RP	5	0.7
81	A1	10	M	PO	8	RP	1	1.5
81	A2	20	W	PO	10	E	3	1.3
81	B2	30	M	PO/AB	10		2	1.2
81	BC	50						
81	C	85+						
82	A11	10	W	AB/PO	8	E	2	1.3
82	A12	40	W	AB	15	E	1	1.2
82	B1	100	M	PO	20	RP	2	1.2
82	C	105+						
86	A1	20	W	PO	5	E	2	1.3
86	A2	40	W	PO/SB	5	E	2	1.2
86	B2	60	W	PO/SB	8	E	3	1.2
86	C	65+						

Annexure D

Laboratory Data

(Total No. of pages including blank pages = 12)

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Table D-1
Laboratory Data

Site	Depth	pH water	pH CaCl2	EC 1:5	ECe	Chloride	Ca	Mg	K	Na	Al	CEC	ESP	ESI	Ca/Mg	ASWAT	NO3-N	Colwell P	PBI	SO4-S	Zn	Cu	Boron	Org C	Lab ID
Units	cm			dS/m	dS/m	mg/kg	meq/100g	meq/100g	meq/100g	meq/100g	meq/100g	meq/100g					mg/kg	mg/kg		mg/kg	mg/kg	mg/kg	mg/kg	%	
47A	0 to 5	6.2	5.3	0.05	0.69	5	8.8	1.5	0.8	0.0	0.0	11.1	0.1	0.55	5.9	4	6	8	41	2	2.2	0.3	0.3	2.0	21526251
47A	5 to 15	6.5	5.7	0.05	0.69	5	11.0	1.5	0.7	0.0	0.0	13.2	0.1	0.66	7.3	4	4	5	37	3	0.4	0.3	0.3	1.5	21526252
47A	15 to 30	6.9	6.0	0.03	0.26	5	12.0	1.9	0.6	0.0	0.0	14.5	0.1	0.43	6.3	6	2	3	47	1	0.1	0.1	0.3	0.7	21526253
47A	30 to 60	6.7	5.7	0.03	0.26	5	20.0	3.9	0.7	0.1	0.0	24.7	0.4	0.07	5.1	6	1	3	100	1	0.1	0.0	0.3	0.4	21526254
47A	60 to 100	7.0	5.8	0.03	0.26	5	21.0	4.4	0.7	0.4	0.0	26.4	1.3	0.02	4.8	6	2	3	53	1	0.1	0.0	0.1	0.1	21526255
47B	0 to 5	5.3	4.3	0.03	0.41	5	1.2	0.6	0.4	0.0	1.5	3.8	0.8	0.04	1.9	4	3	10	87	4	1.6	0.5	0.3	2.5	21526256
47B	5 to 15	5.5	4.3	0.02	0.28	5	0.2	0.2	0.2	0.0	1.4	2.0	0.5	0.04	0.8	6	2	6	50	1	0.3	0.3	0.1	0.4	21526257
47B	15 to 30	5.4	4.3	0.01	0.10	5	0.0	0.2	0.2	0.0	1.4	1.8	0.6	0.02	0.1	8	2	3	57	2	0.1	0.3	0.1	0.5	21526258
47B	30 to 60	5.2	4.1	0.01	0.10	5	0.0	0.3	0.2	0.0	3.1	3.6	1.1	0.01	0.1	8	0	3	170	1	0.2	0.4	0.2	1.1	21526259
47B	60 to 100	5.5	4.1	0.01	0.09	5	0.0	0.5	0.1	0.1	3.3	4.1	2.2	0.00	0.0	5	0	3	170	1	0.0	0.3	0.2	0.3	21526260
48	0 to 5	5.9	5.1	0.07	0.97	5	6.5	1.3	1.0	0.1	0.1	9.0	0.7	0.10	5.0	7	10	9	73	4	7.1	0.7	0.6	3.2	21526261
48	5 to 15	6.1	5.2	0.04	0.55	5	5.8	1.4	0.8	0.0	0.1	8.1	0.1	0.32	4.1	7	2	3	46	3	3.3	0.8	0.5	2.1	21526262
48	15 to 30	6.8	5.7	0.02	0.17	5	4.7	1.4	0.7	0.0	0.1	6.9	0.1	0.14	3.4	12	2	3	37	1	0.4	0.7	0.3	0.8	21526263
48	30 to 60	7.3	6.2	0.02	0.17	5	4.5	2.8	0.6	0.0	0.1	8.0	0.5	0.04	1.6	12	2	3	62	1	0.1	0.8	0.3	0.3	21526264
48	60 to 100	7.5	6.4	0.04	0.34	16	4.6	3.7	0.5	0.1	0.1	9.1	1.4	0.03	1.2	12	1	3	70	4	0.1	0.4	0.4	0.2	21526265
49	0 to 5	5.9	4.7	0.04	0.55	5	3.7	1.8	0.6	0.1	0.2	6.3	1.1	0.04	2.1	5	4	7	80	3	0.9	0.3	0.5	2.2	21526266
49	5 to 15	6.1	4.9	0.04	0.55	5	4.2	2.5	0.6	0.0	0.1	7.5	0.4	0.10	1.7	4	4	6	110	1	0.9	0.2	0.6	2.9	21526267
49	15 to 30	6.2	4.9	0.03	0.41	5	2.9	2.9	0.6	0.0	0.2	6.6	0.6	0.05	1.0	4	4	3	130	1	0.7	0.2	0.4	2.1	21526268
49	30 to 60	6.1	4.5	0.03	0.41	5	0.4	2.6	0.8	0.2	1.2	5.2	3.7	0.01	0.1	8	3	5	200	1	0.5	0.3	0.4	1.9	21526269
49	60 to 100	5.7	4.4	0.08	0.69	28	0.1	5.2	0.9	0.6	1.0	7.8	7.7	0.01	0.0	12	3	3	74	17	0.9	0.6	0.7	0.4	21526270
50	0 to 5	6.6	5.8	0.08	0.76	38	8.7	2.1	0.8	0.2	0.0	11.8	2.0	0.04	4.1	5	2	14	61	6	6.6	1.5	0.6	2.9	21526271
50	5 to 15	7.1	6.4	0.07	0.67	13	9.6	2.6	0.6	0.3	0.0	13.0	1.9	0.04	3.7	7	2	12	45	3	4.4	1.3	0.5	2.5	21526272
50	15 to 30	6.8	5.9	0.04	0.38	5	5.7	2.1	0.4	0.1	0.0	8.3	1.3	0.03	2.7	7	2	5	39	4	2.3	1.2	0.4	1.3	21526273
50	30 to 60	7.3	6.2	0.02	0.18	5	2.8	1.8	0.3	0.1	0.0	5.0	1.6	0.01	1.6	12	3	3	39	1	0.1	0.6	0.2	0.3	21526274
50	60 to 100	7.3	6.1	0.02	0.17	5	3.9	3.0	0.4	0.2	0.0	7.4	2.0	0.01	1.3	12	2	3	71	3	0.1	0.4	0.3	0.3	21526275
51	0 to 5	6.1	5.0	0.05	0.69	5	3.9	1.1	0.4	0.0	0.0	5.4	0.2	0.27	3.5	4	5	11	24	3	4.8	0.4	0.3	2.1	21526276
51	5 to 15	6.3	5.2	0.03	0.41	5	3.2	1.2	0.3	0.0	0.0	4.7	0.2	0.14	2.7	6	3	10	28	1	1.0	0.3	0.2	1.1	21526277
51	15 to 30	6.2	5.0	0.02	0.28	5	2.8	0.9	0.2	0.0	0.0	3.9	0.3	0.08	3.3	6	3	7	24	1	0.7	0.3	0.1	0.8	21526278
51	30 to 60	6.4	5.1	0.02	0.45	5	3.5	0.9	0.2	0.0	0.0	4.6	0.2	0.09	4.0	6	3	12	29	1	0.3	0.4	0.1	0.8	21526279
51	60 to 100	6.7	5.3	0.02	0.31	5	7.7	4.7	0.1	0.1	0.0	12.6	0.8	0.03	1.6	13	3	11	71	1	1.0	1.1	0.2	1.4	21526280
52	0 to 5	6.0	5.1	0.06	0.57	5	8.3	1.3	0.8	0.0	0.0	10.4	0.1	0.62	6.4	4	7	11	20	5	5.9	0.5	0.4	2.7	21526281
52	5 to 15	6.4	5.6	0.06	0.57	5	12.0	1.4	0.5	0.0	0.0	13.9	0.1	0.84	8.6	3	9	11	35	4	3.2	0.6	0.5	2.1	21526282
52	15 to 30	6.8	5.9	0.03	0.29	5	9.5	1.3	0.5	0.0	0.0	11.3	0.3	0.11	7.3	7	2	6	33	1	0.5	0.6	0.3	1.0	21526283
52	30 to 60	7.1	5.9	0.02	0.18	5	6.3	1.2	0.6	0.0	0.0	8.1	0.1	0.16	5.3	12	1	8	32	1	0.1	0.4	0.2	0.3	21526284
52	60 to 100	7.5	6.2	0.02	0.17	5	7.9	1.5	0.7	0.0	0.0	10.1	0.3	0.07	5.3	11	1	6	39	1	0.0	0.3	0.2	0.3	21526285
53	0 to 5	5.1	4.5	0.20	2.76	18	4.1	0.8	1.2	0.1	0.2	6.4	1.3	0.16	5.1	4	100	11	58	15	6.3	0.8	0.4	3.5	21526286
53	5 to 15	5.4	4.6	0.05	0.69	5	3.1	0.7	0.6	0.1	0.2	4.6	1.1	0.05	4.6	8	18	8	52	6	1.1	0.6	0.3	1.2	21526287
53	15 to 30	6.5	5.5	0.03	0.41	5	4.3	1.3	0.5	0.1	0.0	6.2	1.3	0.02	3.3	12	7	3	35	2	0.3	0.5	0.3	0.6	21526288
53	30 to 60	7.8	6.7	0.07	0.47	5	11.0	6.8	0.7	0.7	0.0	19.3	3.7	0.02	1.6	13	2	3	130	10	0.1	0.3	0.5	0.4	21526289
53	60 to 100	8.2	7.3	0.15	1.00	5	11.0	9.0	0.6	1.2	0.0	21.8	5.5	0.03	1.2	0	2	3	110	44	0.1	0.2	0.2	0.3	21526290
54	0 to 5	5.1	4.0	0.03	0.41	15	0.7	1.0	0.6	0.1	4.1	6.5	2.0	0.02	0.7	8	1	7	210	5	1.4	0.3	0.4	4.1	21526291
54	5 to 15	4.8	4.0	0.14	1.93	150	0.8	1.6	1.2	0.2	3.3	7.1	3.0	0.05	0.5	8	1	10	190	10	2.1	0.6	0.8	5.0	21526292
54	15 to 30	5.1	4.1	0.05	0.43	34	0.0	0.8	0.7	0.1	3.6	5.2	2.1	0.02	0.0	12	1	3	190	3	0.8	0.8	0.4	1.2	21526293

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Table D-1 (Cont'd)
Laboratory Data

Site	Depth	pH water	pH CaCl2	EC 1:5	ECe	Chloride	Ca	Mg	K	Na	Al	CEC	ESP	ESI	Ca/Mg	ASWAT	NO3-N	Colwell P	PBI	SO4-S	Zn	Cu	Boron	Org C	Lab ID
Units	cm			dS/m	dS/m	mg/kg	meq/100g	meq/100g	meq/100g	meq/100g	meq/100g	meq/100g					mg/kg	mg/kg		mg/kg	mg/kg	mg/kg	mg/kg	%	
55	0 to 5	5.6	4.7	0.07	0.97	5	5.4	1.2	0.5	0.0	0.0	7.1	0.1	0.49	4.5	4	25	15	37	3	10.0	0.5	0.4	3.0	21526294
55	5 to 15	6.2	5.0	0.03	0.41	5	6.2	1.3	0.5	0.0	0.0	8.1	0.4	0.08	4.8	4	3	9	31	2	5.7	0.4	0.4	2.1	21526295
55	15 to 30	6.4	5.2	0.02	0.28	5	5.9	1.1	0.3	0.0	0.0	7.3	0.1	0.15	5.4	4	2	10	35	1	1.8	0.4	0.3	1.2	21526296
55	30 to 60	6.7	5.5	0.02	0.19	5	8.8	1.5	0.2	0.0	0.0	10.6	0.3	0.07	5.9	6	1	10	37	1	1.4	0.5	0.3	1.4	21526297
55	60 to 100	7.1	5.9	0.01	0.10	5	9.8	2.3	0.1	0.0	0.0	12.2	0.2	0.04	4.3	7	1	9	55	1	1.0	0.5	0.2	1.5	21526298
56	0 to 5	5.1	4.2	0.03	0.41	5	0.9	0.3	0.3	0.0	0.4	1.9	1.6	0.02	3.5	6	5	12	43	4	0.4	0.1	0.2	1.2	21526299
56	5 to 15	5.4	4.3	0.02	0.28	5	1.0	0.3	0.4	0.1	0.5	2.2	2.2	0.01	2.9	8	3	9	39	3	0.6	0.1	0.1	1.0	21526300
56	15 to 30	5.5	4.4	0.02	0.28	5	0.8	0.3	0.3	0.0	0.6	2.0	2.0	0.01	3.2	8	2	6	33	2	0.1	0.1	0.1	0.5	21526301
56	30 to 60	7.1	5.7	0.02	0.17	5	1.7	2.4	0.4	0.3	0.0	4.8	6.0	0.00	0.7	14	1	3	35	1	0.1	0.1	0.1	0.2	21526302
57	0 to 5	5.5	4.6	0.07	0.97	5	3.5	1.3	0.9	0.0	0.0	5.7	0.2	0.40	2.7	6	14	14	33	6	5.3	0.3	0.2	2.8	21526303
57	5 to 15	6.0	5.0	0.04	0.55	11	3.8	1.5	0.8	0.0	0.0	6.2	0.2	0.25	2.5	6	9	8	28	3	1.7	0.1	0.2	1.1	21526304
57	15 to 30	5.9	4.6	0.04	0.30	11	5.3	5.5	1.2	0.2	0.5	12.7	1.7	0.02	1.0	12	3	3	66	2	0.2	0.1	0.2	0.6	21526305
57	30 to 60	5.2	4.3	0.20	1.50	96	7.1	10.0	1.1	1.1	2.7	22.0	5.0	0.04	0.7	2	1	3	170	57	0.1	0.1	0.1	0.2	21526306
57	60 to 100	5.1	4.3	0.25	2.15	130	7.3	11.0	0.8	1.7	3.8	24.6	6.9	0.04	0.7	0	1	3	130	67	0.1	0.1	0.1	0.2	21526307
58	0 to 5	6.0	4.9	0.04	0.55	5	5.3	1.6	0.9	0.1	0.0	8.0	1.8	0.02	3.3	4	2	9	51	4	3.6	0.3	0.4	2.4	21526308
58	5 to 15	6.3	5.3	0.03	0.41	12	2.8	1.8	0.8	0.1	0.0	5.5	1.8	0.02	1.6	4	1	7	25	4	0.4	0.1	0.3	0.9	21526309
58	15 to 30	6.5	5.3	0.02	0.28	5	2.2	1.7	0.6	0.1	0.0	4.6	1.7	0.01	1.3	11	1	5	27	1	0.1	0.0	0.2	0.5	21526310
58	30 to 60	5.8	4.2	0.03	0.23	5	1.9	6.5	0.8	0.5	2.9	12.6	4.0	0.01	0.3	11	1	3	160	2	0.1	0.0	0.3	0.3	21526311
58	60 to 100	5.3	4.0	0.07	0.53	5	1.0	5.0	0.5	1.0	3.1	10.6	9.3	0.01	0.2	13	1	3	120	4	0.1	0.1	0.1	0.1	21526312
59	0 to 5	6.2	5.3	0.05	1.14	5	8.0	1.8	1.0	0.0	0.0	10.8	0.1	0.54	4.4	6	5	6	57	4	2.6	0.2	0.4	3.0	21526313
59	5 to 15	5.6	4.5	0.02	0.45	5	2.6	1.3	0.5	0.0	0.7	5.1	0.2	0.10	2.0	8	3	3	70	2	0.5	0.1	0.1	1.1	21526314
59	15 to 30	5.6	4.2	0.01	0.14	5	1.3	1.3	0.6	0.0	1.7	4.9	0.6	0.02	1.0	11	2	3	62	1	0.1	0.0	0.1	0.5	21526315
60A	0 to 5	5.2	4.0	0.02	0.19	12	0.5	1.1	0.3	0.1	3.2	5.3	2.4	0.01	0.5	6	1	3	280	3	0.4	0.2	0.5	3.3	21526316
60A	5 to 15	5.0	4.0	0.03	0.29	5	0.0	1.3	0.2	0.2	4.6	6.3	2.7	0.01	0.0	6	1	3	290	3	0.6	0.2	0.6	2.7	21526317
60A	15 to 30	5.1	4.0	0.03	0.29	5	0.0	1.2	0.2	0.2	4.8	6.4	3.3	0.01	0.0	6	1	3	340	4	0.3	0.2	0.6	2.0	21526318
60B	0 to 5	6.2	5.4	0.07	0.67	11	10.0	4.0	0.6	0.2	0.0	14.8	1.4	0.05	2.5	4	3	12	130	16	13.0	1.7	0.8	3.9	21526319
60B	5 to 15	5.6	4.8	0.08	0.76	44	6.1	3.6	0.6	0.2	0.1	10.6	1.8	0.04	1.7	0	3	9	220	14	11.0	2.0	0.8	3.7	21526320
60B	15 to 30	6.0	4.7	0.03	0.26	5	2.9	2.5	0.2	0.1	0.2	5.9	2.4	0.01	1.2	4	1	3	140	6	3.3	1.1	0.4	1.2	21526321
60B	30 to 60	5.4	4.5	0.06	0.52	5	1.1	2.3	0.1	0.2	0.5	4.1	4.4	0.01	0.5	11	1	3	66	30	0.7	0.6	0.2	0.3	21526322
60B	60 to 100	5.2	4.4	0.07	0.60	11	1.1	2.4	0.1	0.2	0.6	4.3	4.4	0.02	0.5	0	1	3	66	36	0.7	0.5	0.2	0.2	21526323
61	0 to 5	5.3	4.2	0.03	0.41	5	1.0	0.3	0.4	0.0	1.2	2.9	0.3	0.09	3.1	8	6	11	84	4	1.1	0.1	0.3	2.5	21526324
61	5 to 15	5.0	4.1	0.02	0.28	5	0.5	0.1	0.2	0.0	2.3	3.2	0.3	0.06	4.0	6	3	7	140	3	0.5	0.1	0.3	2.8	21526325
61	15 to 30	4.7	4.0	0.02	0.19	5	0.0	0.1	0.1	0.0	2.9	3.1	1.0	0.02	0.4	7	2	3	170	4	0.4	0.2	0.3	1.1	21526326
61	30 to 60	4.9	4.1	0.02	0.19	5	0.0	0.1	0.1	0.0	2.8	3.0	0.3	0.06	0.2	7	1	3	150	4	0.5	0.2	0.3	0.9	21526327
62	0 to 5	5.8	4.8	0.05	1.14	5	3.6	0.9	0.5	0.1	0.0	5.1	1.4	0.04	4.0	5	13	13	25	3	4.4	0.3	0.3	2.0	21526328
62	5 to 15	6.0	4.7	0.02	0.45	5	2.2	0.8	0.4	0.0	0.0	3.4	0.3	0.07	2.6	6	6	9	26	2	1.5	0.2	0.2	0.8	21526329
62	15 to 30	6.3	5.1	0.02	0.28	5	5.2	2.3	0.4	0.0	0.0	7.9	0.1	0.16	2.3	6	4	6	33	2	2.8	0.4	0.2	1.6	21526330
62	30 to 45	6.7	5.6	0.01	0.227	5	1.1	0.5	0.1	0.0	0.0	1.7	0.6	0.02	2.1	5	1	7	10	1	0.3	0.1	0.1	0.1	21526331
62	45 to 60	6.7	5.5	0.02	0.276	5	3.7	1.5	0.2	0.0	0.0	5.4	0.2	0.11	2.5	6	4	17	20	1	0.6	0.3	0.2	0.8	21526332
62	60 to 100	7.2	6.1	0.02	0.45	5	2.8	1.4	0.1	0.0	0.0	4.4	0.7	0.03	2.0	6	2	11	22	1	0.3	0.3	0.1	0.4	21526333
63	0 to 5	6.5	5.9	0.26	2.47	190	11.0	4.6	0.5	0.8	0.0	16.9	4.9	0.05	2.4	1	21	24	170	42	5.0	1.9	0.6	2.7	21526334
63	5 to 15	5.2	4.5	0.16	1.52	49	5.2	2.8	0.4	0.3	0.2	8.8	3.7	0.04	1.9	3	27	32	210	44	6.6	2.0	0.7	2.4	21526335
63	15 to 30	5.6	4.7	0.11	1.05	20	6.0	5.3	0.4	0.4	0.1	12.3	3.4	0.03	1.1	1	9	12	140	36	3.6	2.2	0.6	1.3	21526336
63	30 to 60	6.4	5.5	0.12	0.80	15	7.8	8.0	0.5	0.6	0.0	16.9	3.5	0.03	1.0	0	1	3	150	43	0.5	1.3	0.6	0.8	21526337
63	60 to 100	6.8	5.8	0.08	0.53	5	4.7	5.7	0.2	0.5	0.0	11.1	4.1	0.02	0.8	0	1	9	72	31	0.2	1.1	0.3	0.4	21526338

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Table D-1 (Cont'd)
Laboratory Data

Site	Depth	pH water	pH CaCl2	EC 1:5	ECe	Chloride	Ca	Mg	K	Na	Al	CEC	ESP	ESI	Ca/Mg	ASWAT	NO3-N	Colwell P	PBI	SO4-S	Zn	Cu	Boron	Org C	Lab ID
Units	cm			dS/m	dS/m	mg/kg	meq/100g	meq/100g	meq/100g	meq/100g	meq/100g	meq/100g					mg/kg	mg/kg		mg/kg	mg/kg	mg/kg	mg/kg	%	
64	0 to 5	5.8	4.7	0.04	0.55	5	5.2	2.3	0.9	0.0	0.2	8.6	0.3	0.11	2.3	7	4	3	66	5	2.6	0.2	0.2	3.1	21526339
64	5 to 15	5.7	4.6	0.04	0.55	21	4.6	1.7	0.7	0.0	0.4	7.4	0.1	0.30	2.7	7	1	3	85	4	0.5	0.2	0.2	2.3	21526340
64	15 to 30	5.8	4.4	0.02	0.28	5	4.7	2.0	0.5	0.1	2.1	9.4	0.5	0.04	2.4	11	0	3	160	1	0.1	0.0	0.1	1.5	21526341
64	30 to 60	6.2	4.7	0.01	0.14	5	5.0	2.6	0.5	0.1	0.7	8.8	0.6	0.02	1.9	12	0	3	49	1	0.0	0.0	0.1	0.3	21526342
64	60 to 100	5.7	4.6	0.04	0.55	5	4.5	2.3	0.7	0.1	0.6	8.1	1.0	0.04	2.0	12	5	8	130	7	4.5	0.6	0.3	2.8	21526343
65	0 to 5	6.3	4.5	0.01	0.10	5	0.6	2.1	0.2	0.1	0.5	3.5	3.1	0.00	0.3	5	1	3	63	1	0.2	0.7	0.1	0.3	21526344
65	5 to 15	5.4	4.3	0.04	0.38	13	3.1	1.7	0.7	0.2	1.4	7.0	2.1	0.02	1.8	5	2	8	280	8	7.9	1.4	0.4	3.7	21526345
65	15 to 30	6.0	4.6	0.02	0.17	5	2.9	2.5	0.4	0.1	0.4	6.3	2.2	0.01	1.2	9	1	3	130	2	2.8	1.2	0.3	1.5	21526346
65	30 to 60	6.3	4.7	0.01	0.09	5	1.5	1.9	0.3	0.1	0.3	4.1	2.4	0.00	0.8	12	1	3	62	1	0.3	0.7	0.2	0.4	21526347
65	60 to 100	6.2	4.5	0.01	0.09	5	0.6	2.1	0.2	0.1	0.6	3.7	3.3	0.00	0.3	14	2	3	57	1	0.2	0.7	0.1	0.3	21526348
66	0 to 5	5.9	4.7	0.03	0.41	5	1.7	0.7	0.6	0.0	0.2	3.2	0.3	0.09	2.4	8	0	8	50	2	1.2	0.3	0.2	1.8	21526349
66	5 to 15	5.8	4.7	0.02	0.28	5	0.7	0.6	0.3	0.0	0.2	1.8	0.5	0.04	1.3	12	4	3	40	3	0.2	0.1	0.1	0.7	21526350
66	15 to 30	5.9	4.4	0.02	0.19	5	0.5	1.5	0.4	0.1	1.0	3.5	3.4	0.01	0.3	13	1	3	65	2	0.1	0.2	0.1	0.3	21526351
66	30 to 60	6.4	4.8	0.05	0.43	12	0.7	3.9	0.2	0.8	0.3	6.0	13.8	0.00	0.2	15	1	3	55	11	0.0	0.3	0.1	0.2	21526352
66	60 to 100	8.3	7.3	0.41	3.53	240	1.0	5.5	0.3	3.7	0.2	10.7	34.7	0.01	0.2	14	1	3	55	160	0.0	0.3	0.1	0.1	21526353
67	0 to 5	6.4	5.4	0.04	0.55	16	4.1	1.5	0.9	0.1	0.0	6.6	1.2	0.03	2.7	7	1	3	53	6	97.0	0.7	0.4	1.9	21526354
67	5 to 15	6.1	5.1	0.03	0.41	5	3.5	1.1	0.8	0.0	0.0	5.4	0.2	0.16	3.2	4	1	10	61	5	95.0	0.8	0.4	1.4	21526355
67	15 to 30	6.4	5.2	0.03	0.26	11	3.6	1.2	0.6	0.0	0.1	5.5	0.2	0.17	3.0	7	0	9	68	3	59.0	0.5	0.2	0.8	21526356
67	30 to 60	6.5	5.4	0.03	0.26	5	2.7	2.3	0.6	0.1	0.0	5.6	1.1	0.03	1.2	6	0	3	89	10	160.0	0.5	0.2	0.3	21526357
68	0 to 5	5.6	4.7	0.05	0.43	5	3.1	0.8	0.7	0.0	0.0	4.6	0.2	0.23	3.9	7	6	7	53	8	59.0	3.2	0.4	2.5	21526358
68	5 to 15	6.4	5.4	0.04	0.34	5	3.1	1.2	0.9	0.0	0.0	5.2	0.2	0.21	2.6	6	4	7	53	4	17.0	8.6	0.5	1.1	21526359
68	15 to 30	6.6	5.4	0.02	0.17	5	2.6	1.1	0.9	0.0	0.0	4.6	0.2	0.09	2.4	8	2	9	71	2	13.0	6.7	0.4	0.5	21526360
68	30 to 60	6.9	5.8	0.02	0.17	5	2.9	1.4	0.7	0.0	0.1	5.1	0.2	0.10	2.1	6	0	3	68	4	8.0	4.1	0.3	0.2	21526361
68	60 to 100	6.9	5.8	0.02	0.17	5	2.7	2.1	0.4	0.0	0.0	5.2	0.2	0.10	1.3	6	0	5	62	6	12.0	3.0	0.3	0.1	21526362
69	0 to 5	5.6	4.7	0.09	1.24	13	2.3	1.2	0.7	0.0	0.0	4.3	0.7	0.13	1.9	4	6	27	90	9	7.1	0.4	0.4	3.1	21526363
69	5 to 15	5.4	4.4	0.04	0.55	14	0.9	0.4	0.1	0.0	0.2	1.6	2.4	0.02	2.0	8	4	5	40	3	1.2	0.2	0.2	0.9	21526364
69	15 to 30	5.6	4.4	0.02	0.28	5	0.4	0.2	0.1	0.0	0.2	1.0	1.1	0.02	1.8	12	2	7	13	2	0.4	0.1	0.1	0.3	21526365
69	30 to 50	5.7	4.4	0.02	0.28	5	0.4	0.3	0.1	0.0	0.3	1.2	0.9	0.02	1.2	12	0	8	24	2	0.3	0.3	0.1	0.1	21526366
69	50 to 60	6.0	4.6	0.02	0.17	5	1.8	2.1	0.2	0.1	0.3	4.5	1.3	0.01	0.9	14	0	9	64	2	0.3	1.4	0.3	0.2	21526367
69	60 to 100	6.5	5.1	0.02	0.17	5	2.7	3.4	0.2	0.2	0.2	6.7	2.8	0.01	0.8	3	0	12	74	5	0.3	1.3	0.3	0.2	21526368
70	0 to 5	5.0	4.5	0.21	2.00	25	5.5	2.5	0.5	0.4	0.2	9.1	3.8	0.05	2.2	0	86	50	230	18	13.0	1.0	0.7	6.2	21526369
70	5 to 15	5.6	4.7	0.08	0.76	36	6.8	2.9	0.3	0.4	0.2	10.5	3.3	0.02	2.3	0	15	14	210	6	10.0	2.1	0.6	3.1	21526370
70	15 to 30	6.4	5.0	0.04	0.34	5	7.7	3.4	0.2	0.6	0.1	12.0	5.0	0.01	2.3	11	3	10	140	2	4.7	1.8	0.6	1.5	21526371
70	30 to 60	7.9	6.4	0.08	0.53	32	7.6	5.1	0.2	2.3	0.1	15.3	15.0	0.01	1.5	16	0	3	76	4	0.7	1.3	0.3	0.7	21526372
70	60 to 100	8.3	7.5	0.75	4.99	580	10.0	9.1	0.3	7.3	0.2	26.8	27.2	0.03	1.1	0	0	6	99	220	0.1	1.0	0.1	0.3	21526373
71	0 to 5	5.8	5.0	0.11	1.05	20	8.0	4.7	0.7	0.7	0.0	14.0	4.8	0.02	1.7	5	9	24	120	17	16.0	1.7	0.7	5.7	21526374
71	5 to 15	6.2	5.3	0.28	2.66	270	7.2	5.7	0.2	2.5	0.0	15.6	16.1	0.02	1.3	3	3	10	130	29	5.2	1.7	0.7	2.7	21526375
71	15 to 30	6.7	5.8	0.56	4.82	570	7.5	5.4	0.1	4.5	0.1	17.6	25.5	0.02	1.4	11	2	12	98	110	3.1	1.3	0.4	1.9	21526376
71	30 to 60	7.7	6.6	0.47	4.04	420	5.1	3.1	0.1	3.9	0.1	12.3	31.7	0.01	1.6	12	2	8	45	140	0.4	0.7	0.2	0.9	21526377
71	60 to 100	8.2	7.5	1.06	7.05	820	7.2	6.8	0.3	9.5	0.2	24.0	39.6	0.03	1.1	11	0	3	72	350	0.1	1.4	0.2	0.2	21526378

Table D-1 (Cont'd)
Laboratory Data

Site	Depth	pH water	pH CaCl2	EC 1:5	ECe	Chloride	Ca	Mg	K	Na	Al	CEC	ESP	ESI	Ca/Mg	ASWAT	NO3-N	Colwell P	PBI	SO4-S	Zn	Cu	Boron	Org C	Lab ID
Units	cm			dS/m	dS/m	mg/kg	meq/100g	meq/100g	meq/100g	meq/100g	meq/100g	meq/100g					mg/kg	mg/kg		mg/kg	mg/kg	mg/kg	mg/kg	%	
72	0 to 5	5.3	4.4	0.07	0.97	11	2.6	0.8	0.9	0.0	0.3	4.6	0.9	0.08	3.2	6	16	21	49	3	7.4	0.2	0.3	3.4	21526379
72	5 to 15	5.0	4.0	0.04	0.55	21	0.8	0.6	0.6	0.0	1.5	3.5	0.3	0.14	1.5	6	5	12	63	6	1.9	0.1	0.2	1.8	21526380
72	15 to 30	5.5	4.2	0.03	0.41	12	0.8	0.7	0.5	0.0	1.3	3.3	1.2	0.02	1.1	7	3	6	59	2	0.3	0.0	0.2	0.5	21526381
72	30 to 45	5.6	4.3	0.02	0.28	15	0.7	1.2	0.5	0.1	1.4	3.8	1.6	0.01	0.6	13	1	6	66	2	0.2	0.0	0.2	0.3	21526382
72	45 to 60	5.5	4.1	0.03	0.26	22	0.9	2.1	0.6	0.2	2.4	6.1	2.5	0.01	0.4	13	0	3	72	3	0.3	0.0	0.1	0.2	21526383
72	60 to 100	5.2	3.9	0.05	0.43	29	0.4	3.0	0.8	0.4	3.6	8.2	4.5	0.01	0.1	13	0	8	120	12	1.1	0.1	0.1	0.1	21526384
73	0 to 5	5.5	4.7	0.06	0.83	14	4.3	1.4	0.7	0.0	0.2	6.7	0.2	0.40	3.1	4	13	13	51	8	7.1	0.2	0.3	2.6	21526385
73	5 to 15	5.5	4.5	0.04	0.55	15	3.4	1.3	0.6	0.0	0.4	5.7	0.2	0.23	2.6	7	5	6	50	7	2.6	0.1	0.2	1.2	21526386
73	15 to 30	5.7	4.6	0.02	0.28	13	3.3	1.8	0.4	0.0	0.4	5.9	0.2	0.12	1.8	7	4	3	34	4	0.9	0.1	0.1	0.4	21526387
73	30 to 60	5.6	4.3	0.02	0.17	5	3.2	4.1	0.4	0.0	3.2	10.9	0.3	0.07	0.8	13	0	3	100	3	0.3	0.0	0.1	0.1	21526388
74	0 to 5	5.3	4.4	0.05	0.69	5	3.4	1.5	0.6	0.0	0.5	6.0	0.2	0.30	2.3	6	11	8	60	6	3.0	0.3	0.2	2.0	21526389
74	5 to 15	5.5	4.4	0.04	0.55	16	3.4	1.4	0.5	0.0	0.6	5.9	0.2	0.24	2.4	4	12	8	54	4	0.9	0.2	0.2	1.0	21526390
74	15 to 30	5.3	4.3	0.03	0.41	5	2.8	1.2	0.3	0.0	1.4	5.7	0.2	0.17	2.3	7	9	3	67	1	0.1	0.1	0.1	0.4	21526391
74	30 to 60	5.5	4.2	0.01	0.14	5	1.3	1.8	0.2	0.0	2.3	5.7	0.2	0.06	0.7	11	2	5	90	1	0.1	0.1	0.1	0.3	21526392
75	0 to 5	5.3	4.9	0.29	2.49	58	8.4	3.8	1.4	0.1	0.0	13.7	1.0	0.28	2.2	4	110	28	94	18	170.0	1.5	0.7	6.5	21526393
75	5 to 15	5.5	4.6	0.10	0.86	41	5.4	2.3	1.4	0.1	0.1	9.3	1.0	0.10	2.3	3	13	36	170	15	100.0	1.3	0.7	3.8	21526394
75	15 to 30	6.1	4.9	0.04	0.34	10	6.1	2.6	1.3	0.1	0.0	10.1	0.7	0.06	2.3	7	5	15	100	3	130.0	2.2	0.5	1.5	21526395
75	30 to 60	6.7	5.3	0.03	0.23	5	6.1	4.2	0.9	0.3	0.0	11.5	2.4	0.01	1.5	12	0	19	130	6	7.6	1.3	0.3	0.4	21526396
75	60 to 100	6.9	5.6	0.04	0.30	5	8.2	6.5	0.7	0.6	0.1	16.1	3.6	0.01	1.3	12	0	18	86	11	3.8	1.3	0.2	0.8	21526397
75	200	7.1	5.8	0.04	0.30	12	8.2	6.2	0.6	0.5	0.0	15.5	3.2	0.01	1.3	14	0	16	57	8	13.0	2.1	0.1	0.5	21526398
75	300	7.1	5.9	0.03	0.23	14	4.0	3.3	0.3	0.2	0.0	7.7	2.2	0.01	1.2	15	0	8	28	5	5.1	1.4	0.1	0.2	21526399
76	0 to 5	5.4	4.7	0.16	1.52	29	5.6	1.5	1.5	0.1	0.1	8.8	0.8	0.20	3.7	6	51	160	94	12	25.0	2.9	0.5	3.9	21526400
76	5 to 15	5.5	4.8	0.11	1.05	46	6.8	1.5	0.5	0.1	0.0	8.9	1.2	0.09	4.5	6	22	220	98	5	40.0	3.9	0.6	2.9	21526401
76	15 to 30	6.0	5.1	0.07	0.67	26	6.1	1.5	0.4	0.2	0.0	8.1	2.1	0.03	4.1	5	10	160	64	3	22.0	3.6	0.6	1.5	21526402
76	30 to 60	7.9	6.9	0.10	0.86	23	4.2	3.8	2.1	0.4	0.0	10.5	3.3	0.03	1.1	13	1	26	98	7	0.3	2.4	1.2	0.3	21526403
77	0 to 5	5.5	4.7	0.12	1.14	67	6.7	3.4	0.5	0.5	0.2	11.2	4.4	0.03	2.0	8	13	19	140	15	11.0	1.7	0.6	5.0	21526404
77	5 to 15	5.9	4.8	0.10	0.95	63	6.4	3.1	0.2	0.7	0.0	10.4	6.9	0.01	2.1	8	3	12	99	10	5.3	1.8	0.5	2.3	21526405
77	15 to 30	6.2	4.9	0.07	0.67	35	6.4	3.2	0.1	0.9	0.0	10.6	8.4	0.01	2.0	12	3	6	84	7	3.9	1.7	0.5	1.5	21526406
77	30 to 60	7.2	6.3	0.36	2.39	320	9.2	7.4	0.2	3.3	0.0	20.1	16.4	0.02	1.2	1	0	6	100	62	0.3	1.3	0.6	0.7	21526407
77	60 to 100	7.0	6.3	0.57	3.79	590	8.2	7.1	0.2	4.3	0.0	19.8	21.7	0.03	1.2	0	0	13	86	100	0.7	1.2	0.1	0.6	21526408
78	0 to 5	5.7	5.0	0.11	1.52	5	5.2	2.2	1.2	0.2	0.0	8.8	1.9	0.06	2.4	5	34	22	53	7	12.0	0.3	0.3	2.5	21526409
78	5 to 15	5.5	4.6	0.07	0.97	15	3.7	1.8	1.0	0.0	0.2	6.7	0.1	0.47	2.1	6	21	15	65	6	7.5	0.2	0.3	2.1	21526410
78	15 to 30	5.5	4.5	0.05	0.69	19	2.8	1.7	1.0	0.0	0.4	5.9	0.2	0.29	1.6	6	14	10	68	3	3.7	0.2	0.2	1.3	21526411
78	30 to 60	5.8	4.3	0.01	0.10	5	1.9	4.0	0.7	0.0	2.3	8.9	0.3	0.03	0.5	13	0	6	78	1	1.4	0.1	0.1	0.2	21526412
79	0 to 5	5.1	4.2	0.04	0.55	11	2.3	1.3	0.7	0.0	2.3	6.6	0.2	0.26	1.8	6	7	3	170	6	1.5	0.2	0.3	2.8	21526413
79	5 to 15	5.3	4.3	0.04	0.55	12	3.0	1.6	1.0	0.0	1.7	7.3	0.1	0.29	1.9	4	0	7	130	7	1.3	0.2	0.4	2.2	21526414
79	15 to 30	5.3	4.2	0.03	0.26	12	1.9	1.2	0.9	0.0	4.1	8.1	0.1	0.24	1.6	6	0	6	260	4	0.4	0.1	0.4	1.6	21526415

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Table D-1 (Cont'd)
Laboratory Data

Page 5 of 5

Site	Depth	pH water	pH CaCl2	EC 1:5	ECe	Chloride	Ca	Mg	K	Na	Al	CEC	ESP	ESI	Ca/Mg	ASWAT	NO3-N	Colwell P	PBI	SO4-S	Zn	Cu	Boron	Org C	Lab ID
Units	cm			dS/m	dS/m	mg/kg	meq/100g	meq/100g	meq/100g	meq/100g	meq/100g	meq/100g					mg/kg	mg/kg		mg/kg	mg/kg	mg/kg	mg/kg	%	
80	0 to 5	5.6	4.8	0.10	0.86	18	7.9	2.0	0.7	0.1	0.0	10.8	1.2	0.08	4.0	4	28	19	95	6	38.0	1.2	0.6	3.9	21526416
80	5 to 15	5.8	4.7	0.05	0.43	15	9.0	2.4	0.6	0.3	0.0	12.2	2.0	0.02	3.8	6	5	13	90	4	34.0	1.1	0.5	3.6	21526417
80	15 to 30	6.2	5.0	0.03	0.26	5	7.8	2.3	0.4	0.2	0.0	10.7	2.2	0.01	3.4	6	4	10	61	2	23.0	1.2	0.4	1.9	21526418
80	30 to 60	6.9	5.4	0.03	0.20	5	6.3	2.5	0.2	0.4	0.1	9.6	4.6	0.01	2.5	13	2	6	56	1	18.0	1.2	0.3	1.1	21526419
80	60 to 100	7.8	7.0	0.40	2.66	190	8.6	7.3	0.4	3.7	0.0	20.0	18.5	0.02	1.2	13	0	12	100	150	13.0	0.8	0.2	0.6	21526420
81	0 to 5	6.4	5.7	0.07	0.60	5	6.9	1.6	0.4	0.2	0.0	9.1	2.6	0.03	4.3	6	17	25	100	5	2.6	2.3	0.2	2.4	21526421
81	5 to 15	5.8	4.9	0.05	0.45	5	4.0	1.2	0.3	0.1	0.0	5.6	1.6	0.03	3.3	5	15	24	120	4	1.4	2.8	0.2	2.0	21526422
81	15 to 30	6.6	5.1	0.03	0.26	10	1.6	1.7	0.1	0.3	0.0	3.6	7.4	0.00	0.9	13	5	12	66	1	0.1	1.8	0.1	0.4	21526423
81	30 to 60	6.6	5.1	0.06	0.52	23	0.7	5.2	0.1	1.2	0.1	7.3	16.5	0.00	0.1	15	0	9	75	1	0.1	2.6	0.1	0.4	21526424
82	0 to 5	6.1	5.1	0.04	0.38	5	4.1	1.2	0.7	0.0	0.0	6.0	0.7	0.06	3.4	7	6	9	27	3	5.8	0.3	0.3	2.0	21526425
82	5 to 15	5.7	4.7	0.04	0.38	5	3.2	0.7	0.5	0.0	0.0	4.4	0.2	0.18	4.6	13	14	3	33	2	1.0	0.1	0.2	0.8	21526426
82	15 to 30	6.0	4.9	0.02	0.28	5	2.5	0.6	0.5	0.0	0.0	3.6	0.3	0.07	4.4	11	9	3	21	1	0.4	0.2	0.3	0.5	21526427
82	30 to 60	6.2	4.9	0.01	0.10	5	2.8	0.4	0.4	0.0	0.0	3.5	0.3	0.04	7.4	13	3	10	12	1	0.0	0.3	0.1	0.2	21526428
82	60 to 100	6.8	5.6	0.01	0.10	5	4.5	1.0	0.4	0.0	0.0	5.9	0.2	0.06	4.5	14	0	11	16	1	0.0	0.3	0.1	0.1	21526429
86	0 to 5	5.5	4.5	0.04	0.55	5	3.2	0.9	1.3	0.0	0.1	5.5	0.4	0.11	3.7	6	14	11	38	5	4.4	0.3	0.2	2.1	21526438
86	5 to 15	5.5	4.4	0.03	0.41	5	2.7	0.6	0.9	0.1	0.2	4.5	1.3	0.02	4.7	6	10	11	51	3	1.0	0.2	0.2	1.1	21526439
86	15 to 30	5.8	4.7	0.02	0.28	5	2.3	0.5	0.9	0.0	0.1	3.8	1.0	0.02	5.1	6	6	10	37	1	0.0	0.1	0.1	0.4	21526440
86	30 to 60	6.5	5.4	0.01	0.10	5	2.1	0.6	0.4	0.1	0.0	3.2	1.6	0.01	3.3	11	3	8	21	1	0.1	0.1	0.1	0.2	21526441

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Annexure E

Site Verification Certificate

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Site Verification Certificate
Bowdens Silver Project

Part 4AA, Division 3 of *State Environmental Planning Policy (Mining, Petroleum Production and Extractive Industries) 2007*

Pursuant to clause 17C(1) of *State Environmental Planning Policy (Mining, Petroleum Production and Extractive Industries) 2007*, I determine the application made by Bowdens Silver Pty Limited by issuing this certificate.

I certify that in my opinion, having regard to the criteria in the *Interim Protocol for site verification and mapping of biophysical strategic agricultural land*, the land specified in Schedule 1 is not Biophysical Strategic Agricultural Land.

The reason for forming the opinion on each of the relevant criteria are contained in Schedule 2.

DKitto

David Kitto
Executive Director
Resource Assessments and Business Systems
as delegate of the Secretary

Date certificate issued: 8 NOVEMBER 2017

This certificate will remain current for 5 years from the date of issue.

Schedule 1:

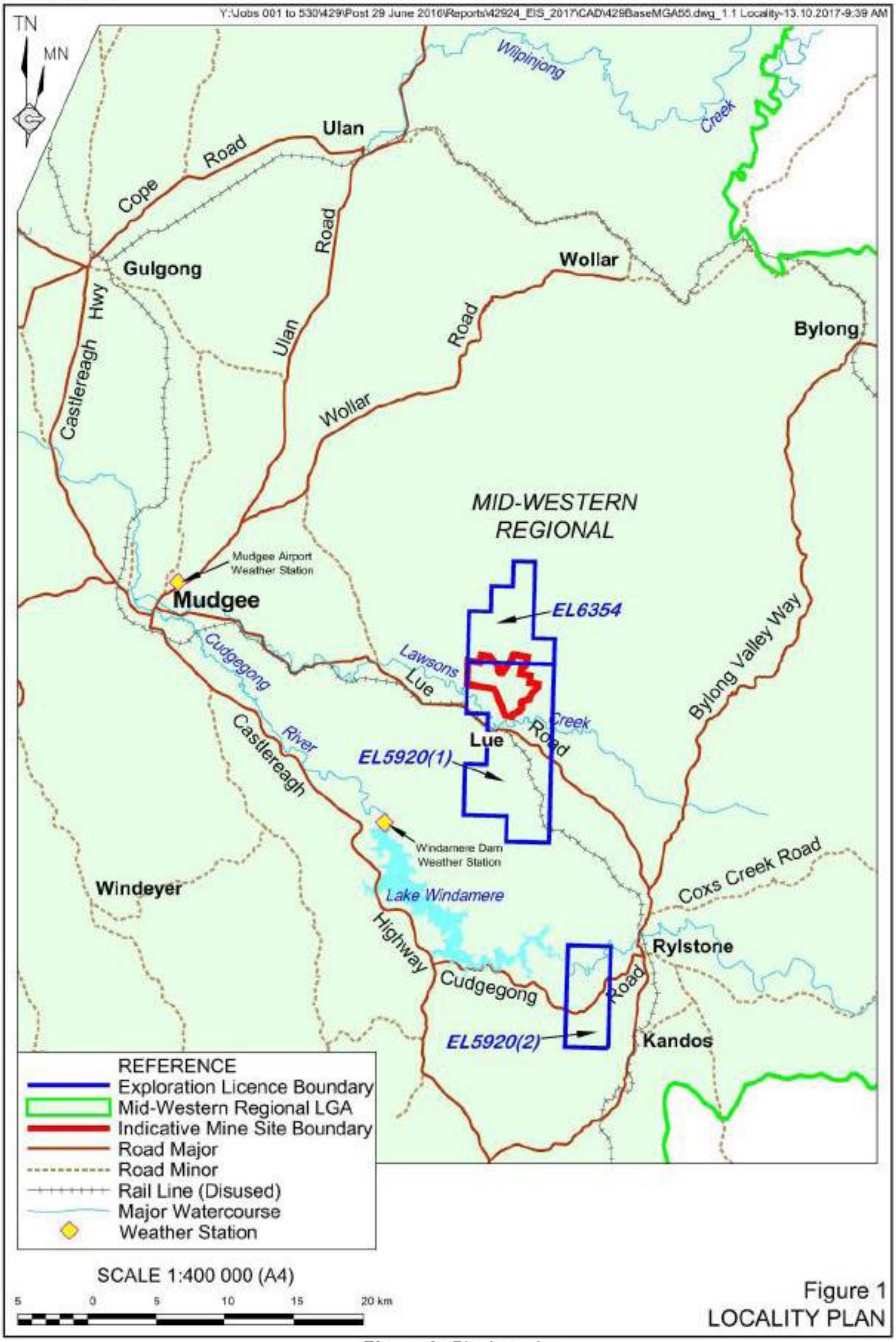

Figure 1: *Site Location*

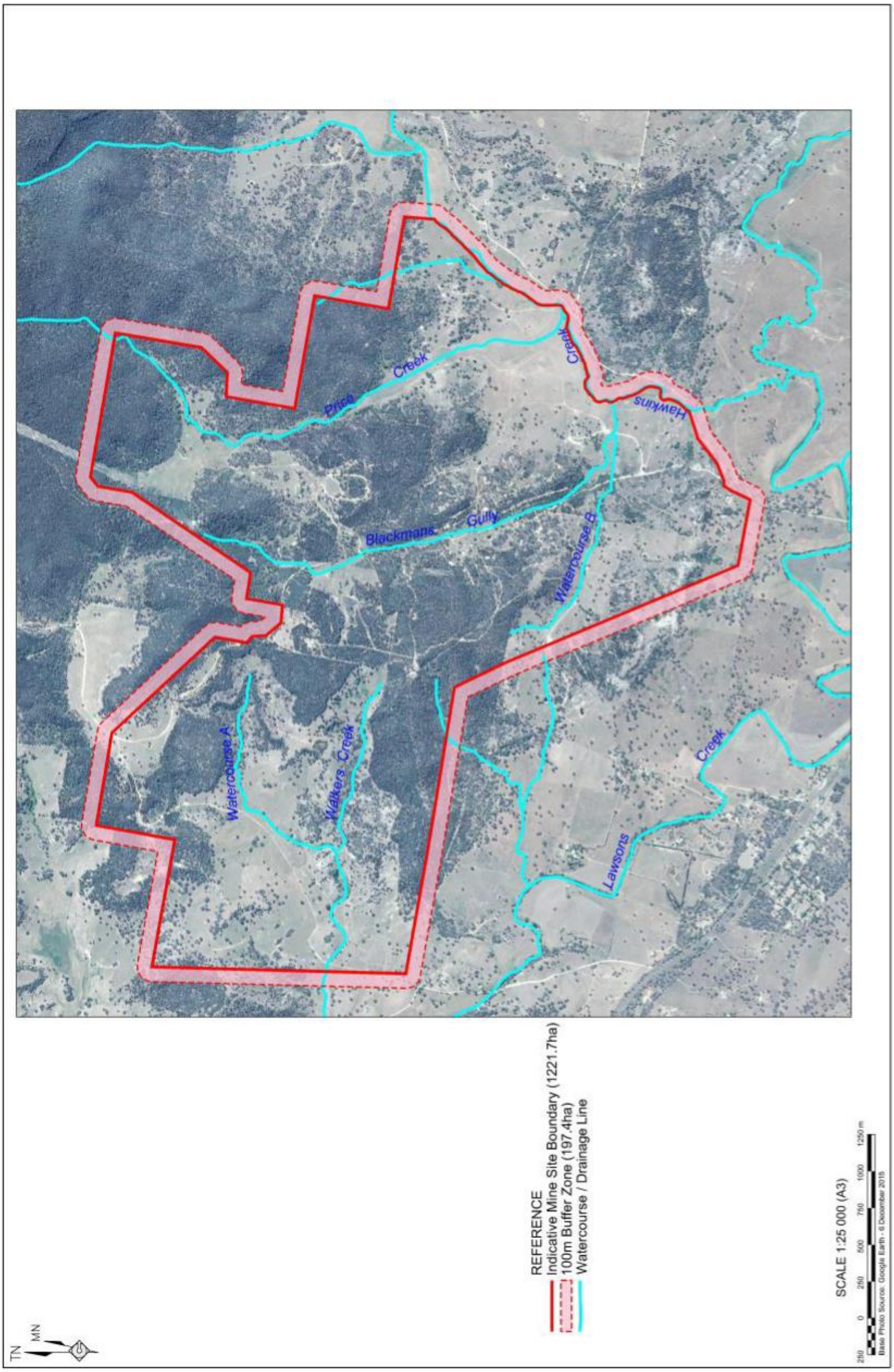

Figure 2: *Site Boundary*

Schedule 2:

Relevant Criteria	***Consideration***
Slope	Ground slope is greater than 10% on large portions of the project area
Contiguity	There are no contiguous areas of 20 hectares or more of soil that meets the BSAL criteria.