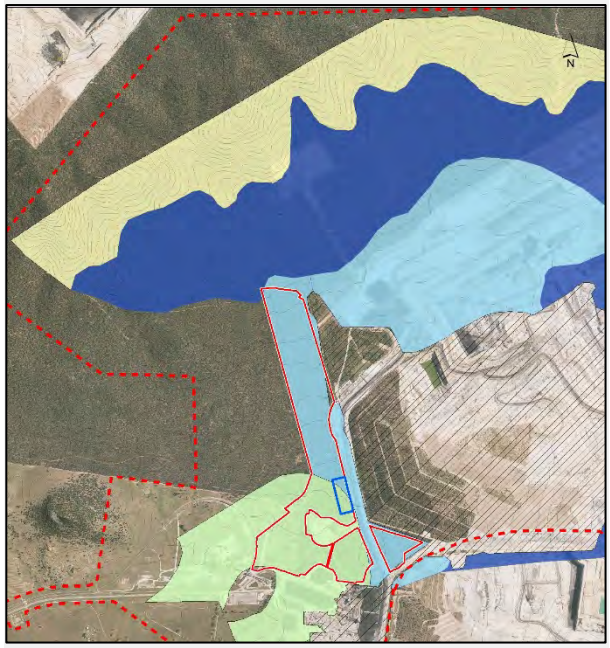
Appendix N

Soils Assessment

Boggabri Coal Mine Modification 8

Soils Assessment



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Client: Hansen Bailey, on behalf of its client Boggabri Coal Operations Pty Ltd

Review History

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CONTENTS

1 INTRODUCTION

Landloch was engaged by Hansen Bailey, on behalf of its client Boggabri Coal Operations Pty Ltd (BCOPL), to provide technical support for the evaluation of proposed modifications (Modification 8) at Boggabri Coal Mine (BCM) and to assist with a review of organic products to be used in their mine rehabilitation program.

1.1 Purpose

BCM Extension was granted Project Approval (PA) 09_0182 (which is now known as State Significant Development [SSD] 09_0182) is supported by the '*Continuation of Boggabri Coal Mine Environmental Assessment*' (Hansen Bailey, 2010) and is valid to December 2033. SSD 09_0182 has been modified on six occasions.

Currently BCOPL intends to seek a modification to SSD 09_0182 (MOD 8) under Section 4.55 of the Environmental Planning and Assessment Act. The changes involve:

a) increasing the approved maximum depth of mining down to the Templemore Coal Seam (and associated mine plan amendments) to recover an additional 61.6 Million tonnes (Mt) of Run of Mine (ROM) coal resource within the currently approved Mine Disturbance Boundary, resulting in a six year extension to mine life (i.e. from 31 December 2033 to 31 December 2039); and
b) construction of a specifically designed fauna movement crossing of the existing haul road between the mining area and the Mine Infrastructure Area (MIA) to encourage the movement of fauna from the Leard State Forest to the Southern Rehabilitation Area (SRA).

The application will be supported by a Modification Report prepared by Hansen Bailey.

This assessment considers the potential impacts of MOD 8 on the soil resources within the area to be disturbed by MOD 8.

1.2 Scope of Work

The scope of works included, but was not limited to:

- Review of all available background data and relevant reports.
- Inspection of the MOD 8 Soil Survey Area to validate current soils information.
- An assessment of the impacts of construction activities on the available soil resources (within the Survey Area).
- Development of assessment, mitigation and management recommendations.

1.3 Proposed Changes

The main changes to soil resources for Modification 8 are the construction of a specifically designed fauna movement crossing of the existing haul road between the mining area and the Mine Infrastructure Area (MIA). The intent is to encourage the movement of fauna from the Leard State Forest through the Southern Rehabilitation Area (SRA).

The indicative location of the fauna crossing is presented in Figure 1. The associated MOD 8 Survey Area for this soil assessment is 110 ha.

For the purposes of the impact assessments included within this modification application and to provide flexibility for the detailed design process, a Modification 8 Disturbance Footprint of 3.3 ha has been assessed. However, the ultimate design of the fauna movement crossing will be determined during the detailed design process, post approval of Modification 8. It is proposed that the crossing will be a minimum of 50 m wide and will be located generally within and to the east of the MOD 8 Disturbance Footprint. Existing concepts for the fauna crossing infrastructure indicate that the additional disturbance will be less than 1.21 ha outside the approved disturbance area. Figure 1 illustrates the Survey Area and MOD 8 Disturbance Footprint.

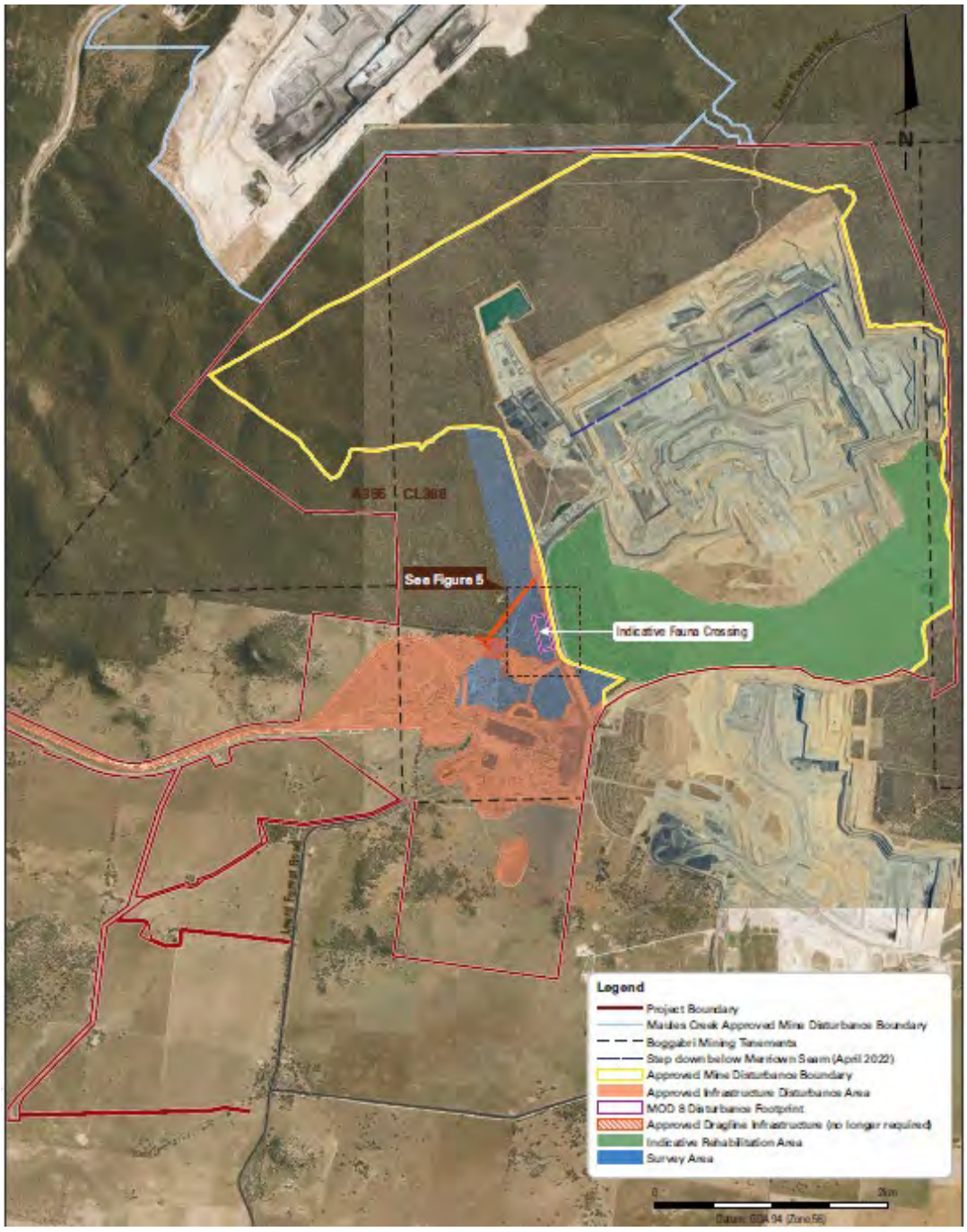

Figure 1. Conceptual Project Layout showing Mod 8 Survey Area and indicative location of fauna crossing and MOD 8 disturbance footprint (Source: Hansen Bailey, 2021).

2 METHODOLOGY

Soils of the southern portion of the MOD 8 Survey Area were described and mapped by Landloch previously and reported in *Boggabri Coal Project - Soil Survey and Growth Media Inventory for Rehabilitation* (Landloch, 2014). In that study soils were mapped at a density of approximately one site per 20 ha with 108 sites across 1987 ha (survey scale 1:25,000).

Fieldworks in this current campaign focused on the northern portion of the MOD 8 Survey Area encompassing an area of 50.3 ha that had not been covered by the previous soil surveys (Figure 2).

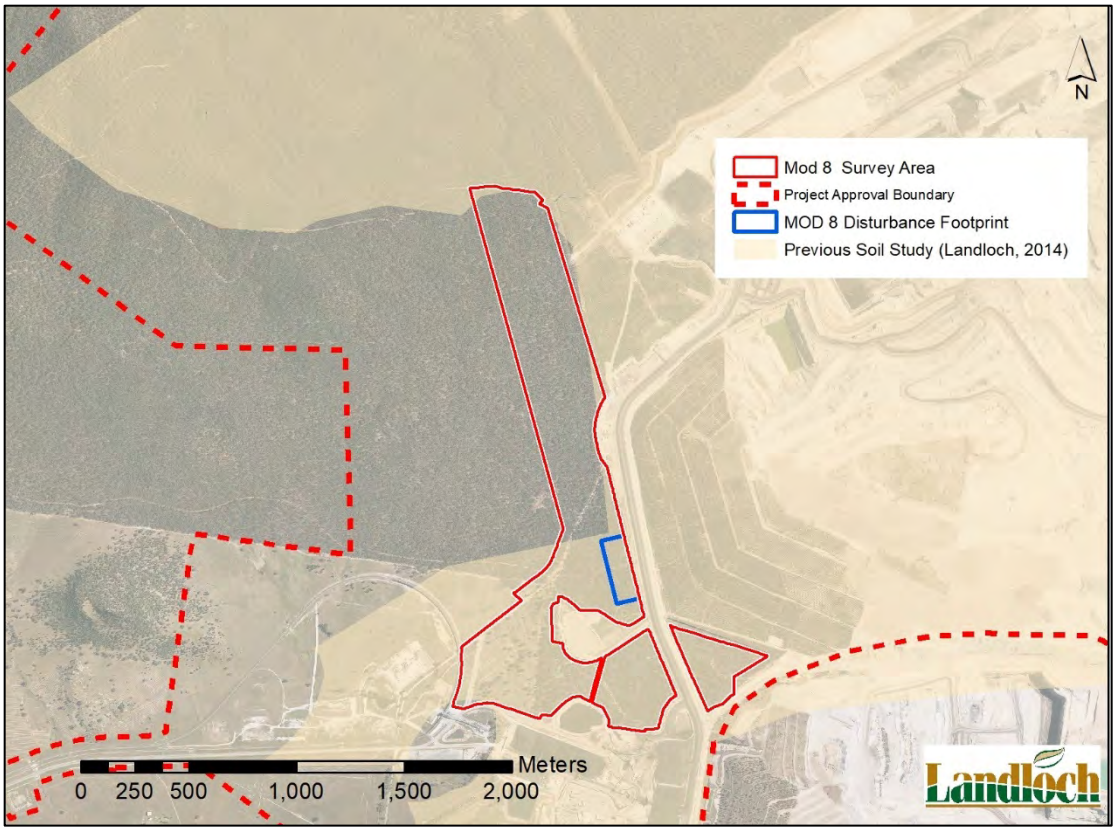

Figure 2. Fieldworks targeted the northern portion of the MOD 8 Survey Area. The southern portion was mapped previously by Landloch (Landloch, 2014).

2.1 References and Guidelines

The soil survey of the northern portion of the MOD 8 Survey Area was developed in reference to the following guidelines:

- Australian Soil and Land Survey: Guidelines for Surveying Soil and Land Resources (McKenzie, et al., 2008);
- Australian Soil Classification (Isbell, 2002);
- Australian Soil Survey and Land Survey Field Handbook (The National Committee on Soil and Terrain, 2009); and

- Soil and Landscape Issues in Environmental Impact Assessment (NSW Department of Land and Water Conservation, 2000).

2.2 Desktop Assessment

A desktop assessment was undertaken prior to commencing fieldworks, to construct a baseline conceptual model of the soil and landscape characteristics of the MOD 8 Survey Area. It identified the preliminary mapping units that would require ground observations during the fieldwork. This included:

- Reviewing the available topographic, geological, vegetation, soil mapping and associated reports for the survey area and surrounding region;
- Reviewing the aerial imagery of the MOD 8 Survey Area; and
- Drafting the preliminary mapping units for validation during fieldwork.

2.2.1 Information sources

Listed below are the information sources that were referred to during the desktop assessment.

- *Soil and Land Resources of the Liverpool Plains Catchment* interactive DVD (Office of Environment and Heritage, 2012).
- *Gunnedah Coalfield (North) Regional Geology 1:100,000*. Geological Series Sheet (Geological Survey of NSW, 1998).
- *The Bioregions of New South Wales: Their biodiversity, conservation and history (NSW Parks and Wildlife Service, 2003)*.
- *Continuation of Boggabri Coal Mine - Biodiversity Impact Assessment* (Parsons Brinkenhoff, 2010).
- Aerial imagery 20cm Digital Elevation Model and satellite imagery of the site at, supplied by the Client (dated June 2018).
- Continuation of Boggabri Coal Environmental Assessment (Hansen Bailey, 2010).
- *Boggabri Coal Project: Soil Survey and Growth Media Inventory for Rehabilitation* (Landloch, 2014).

2.2.2 Preliminary Mapping

The drafting of preliminary mapping units for the MOD 8 Survey Area was based on spatial analysis and a review of existing information. Existing mapping of topography, geology and soils was analysed through the use of a geographic information system (GIS). The preliminary mapping identified tracts of land that are expected to share similar soil landscape attributes. Each mapping unit can be separated from a neighbouring tract of land due to its different pattern of similar attribute values.

2.3 Fieldwork

The fieldwork targeted preliminary mapping units for ground observations.

2.3.1 Ground observation densities for the soil survey

A total of four sites were described for the northern portion of the MOD 8 Survey Area (50.4 ha). This density results in a survey scale constant with the previous soils study of 1:25 000.

2.3.2 Surface descriptions

Data were collected from all ground observation sites in accordance with the *Australian Soil and Land Survey Field Handbook* (Landloch, 2014). At all sites, this data included, but were not limited to:

- Geospatial location;
- Land use management;
- Landscape attributes (landform, vegetation, erosion, micro-relief, rock outcrops etc.); and
- Soil surface condition.

Details of surface descriptions collected in the field are included in Appendix A.

2.3.3 Morphological descriptions

Brief mapping observations were undertaken to confirm soil type, mapping boundaries, and distributions. Adequate information was collected to correlate the site with a soil type where a 'detailed' ground observation had occurred. Information collected included:

- Horizon depths and designation;
- Horizon boundary type and distinctness;
- Field texture and pH;
- Colour (field) and mottles;
- Pedality and structure; and
- Coarse fragments and segregations.

Details of profile descriptions collected in the field are included in Appendix A.

2.4 Laboratory Analysis

No laboratory analysis was undertaken for this campaign given the depth of existing laboratory data available for the surrounding areas from the 2014 soil work (Landloch, 2014). In the previous soil assessment (Landloch, 2014) laboratory data was obtained for 19 full profiles (18 %) and 13 partial profiles (12 %). This rate exceeded that recommend by published guidelines of 1-5% of sites (McKenzie, et al., 2008). The 2014 laboratory data has been relied upon in this assessment. It included:

- Topsoil suite: pH (1:5 water), electrical conductivity (EC) (1:5 water), chloride, exchangeable cations, cation exchange capacity (CEC) and organic carbon,

total nitrogen, available phosphorus, available sulfur, and trace metals (B, Cu, Zn, Mn and Fe);

- Subsoil suite: pH, EC, chloride, exchangeable cations and CEC;
- Basic suite: pH, EC, and chloride; and
- Emerson aggregate test (EAT).

2.5 Soil Classification

The soil at each site was classified using the Australian Soil Classification system (Isbell, 2002), generally to a suborder level. Soil types were determined by similarity of morphological and physico-chemical properties as well as by parent material, representative landforms and geomorphological position in the landscape (McKenzie, et al., 2008).

2.6 Mapping

Mapping was completed following the fieldwork to refine and modify the preliminary mapping units and to develop 'soil mapping units'. The soil mapping units contained one or more dominant soil classes, and some contained one or more sub-dominant soil classes. Soil types are not considered to be unique, as the same soil types may be encountered more than once in different soil mapping units.

3 SITE SETTING

The predominant land use in the North West Region of NSW is agriculture. This includes sheep and cattle production as well as irrigated and dry land cropping of cotton and wheat along suitable floodplains. The construction of Keepit Dam in the 1960s and Split Rock Dam in 1987 ensures a constant water supply for irrigation is available along the Namoi River during periods of prolonged dry weather.

BCM is situated in the Gunnedah Basin Coalfield (Gunnedah Basin). The Gunnedah Basin supports several small to medium sized coal mines including the Maules Creek Mine, Tarrawonga Coal Mine, Narrabri Coal, Rocglen Mine, and Werris Creek Mine.

The Leard State Forest bounds the northern, eastern and western perimeters of BCM. It encompasses an area of approximately 8,134 ha and is utilised for forestry, recreational and mining purposes. In recent years, the forestry industry has substantially declined, as large areas of previously forested land have been afforded environmental protection under the *Brigalow and Nandewar Community Conservation Act 2005* (Hansen Bailey, 2010).

The native vegetation communities of Leard State Forest are dominated by iron bark (*Eucalyptus crebra* and *E. melanophloia*), white box (*E. albens*) and white cyprus pine (*Callitris glaucophylla*).

Approximately 7 km west of BCM is the Namoi River and its associated alluvial floodplain that supports some of the most productive and fertile land within the district (Hansen Bailey, 2010). This floodplain is the most significant tributary in the region for both dry land and irrigated cropping, with water drawn from the Namoi River or

underlying groundwater aquifers. The lighter soils on the slopes and foothills adjacent to the Namoi River floodplain are used primarily for grazing sheep and cattle.

3.1 Climate

The BCM project exists within a sub-humid climate, with no dry season and a hot summer (NSW Parks and Wildlife Service, 2003). Average temperatures in the summer months tend to have a minimum 17–19 °C and maximum 30–34 °C. In the winter months, average temperatures tend to be between a minimum 3–6 °C and maximum 17–22 °C. Mean annual rainfall is approximately 530 mm. In the summer, rainfall is approximately 50–75 mm per month, decreasing throughout winter to approximately 30–40 mm per month (BoM, 2020).

3.2 Landforms, Topography and Drainage

The MOD 8 Survey Area is located on the footslopes of the Leard State Forest. Total relief is 40 m, ranging from 270 m to 310 m RL (Figure 3). Most of the MOD 8 Survey Area has gradients between 1–3 % (Figure 4). In the southern portion there are small areas with gradients less than 1 %.

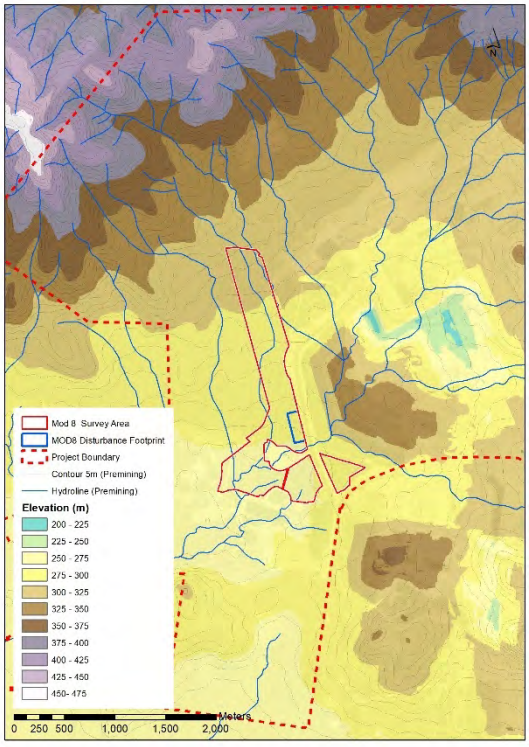

Figure 3. Topography of the Study Area and surrounds. (Derived from 2011 elevation data courtesy of Geoscience Australia).

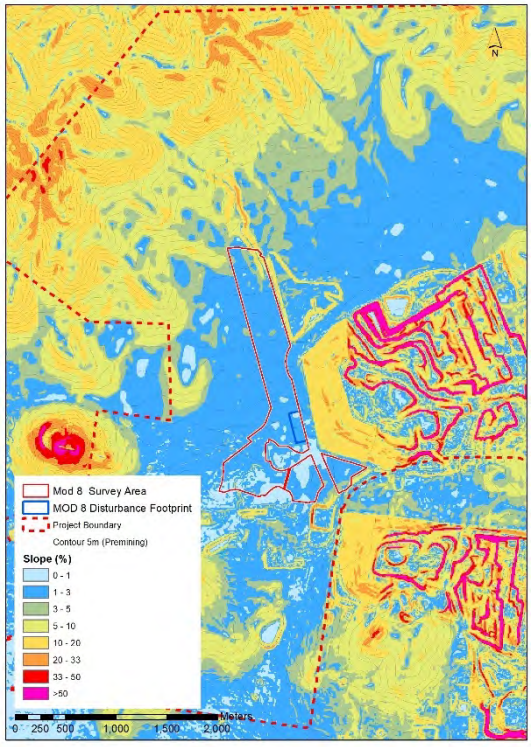

Figure 4. Slope analysis of the Study Area and surrounds. (Derived from 2011 elevation data courtesy of Geoscience Australia).

3.3 Geology and Soil Landscapes

The MOD 8 Survey Area is situated in the north-east of the Gunnedah Basin Coalfield (Gunnedah Basin) within the early Permian Bellata Group and coal bearing sequence.

The Bellata group is divided into two sub-basins, the Maules Creek Sub-basin and the Mullaley Sub-basin. These sub-basins are separated by a volcanic intrusion commonly referred to as the Boggabri Ridge.

Published geological mapping of the region has a scale of 1:100 000 (Pratt, 1998). The entire MOD 8 Survey Area is included in the Maules Creek Formation and details of the geological units in the vicinity are provided in Table 1 and Figure 5.

Soil landscapes reflect variations in soil type, geology, landform, drainage and vegetation within the MOD 8 Survey Area. The soil landscapes of the region are detailed in the *Soil and Land Resources of the Liverpool Plains Catchment* (DPIE, 2018). The spatial distribution of these published mapped soil landscapes is presented in Figure 6.

Table 1. Geological units relevant to the MOD 8 Survey Area (Pratt, 1998)

Geological unit	Map code	Description
Maules Creek Formation	Pmx	Basal carbonaceous claystone, pelletoidal clay sandstone, minor coal, passing upwards into upward-fining cycles of sandstone, thinly bedded siltstone / sandstone and coal. Conglomerate dominant towards top.
Boggabri Volcanics	Pbr	Rhyolitic to dacitic lavas and ash flow tuffs with inter-bedded shale. Rare trachyte and andesite.
Leard Formation	Plf	Buff coloured flint (pelletoidal) claystone, conglomerate, sandstone, and siltstone.
Quaternary Undifferentiated Sediments	Qx	Undifferentiated alluvial deposits. Includes Holocene alluvial channels and overbank deposits of sand, silt, and clay.

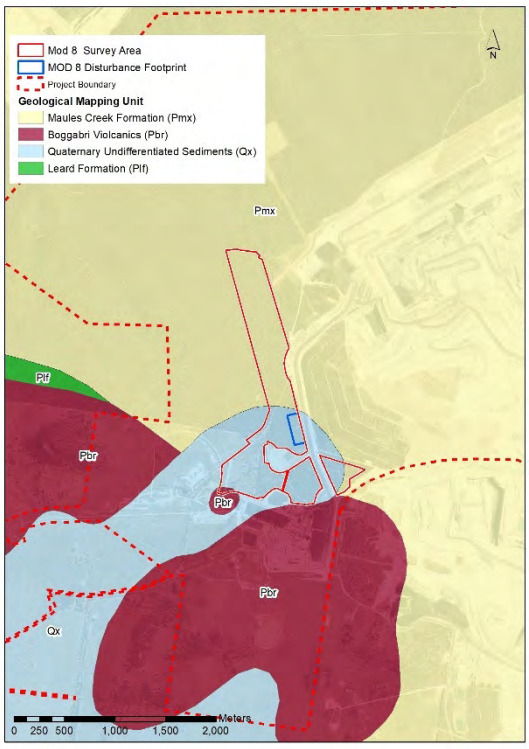

Figure 5. Geological units in the vicinity of the MOD 8 Survey Area (Pratt, 1998).

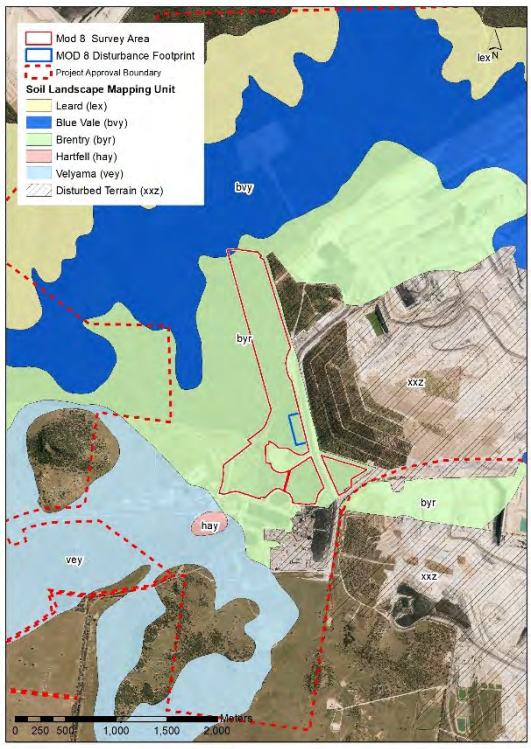

Figure 6. Published soil landscapes of the MOD 8 Survey Area (DPIE, 2018).

The previous soil survey at BCM, partly within and adjacent to the Study Area, described six soil landscape mapping units in the vicinity (Landloch, 2014). Summary details of the soil landscapes are provided in Table 2.

Table 2. Summary descriptions of the Soil Landscapes in the vicinity of the MOD 8 Survey Area (Landloch, 2014).

Soil Landscapes	Landform and Geology	Soil Profile Class(es)	Main Related Soil Types
Leard	Crests and upper slopes of low hills on the Maule's Creek Formation, sometimes extending to mid slopes. Moderately inclined slopes with to 8–30 % gradient.	Complex of Maules Gravelly Sands and Maules Gravelly Loams	Leptic Tenosols; Brown, Red and Grey Kandosols; Grey and Brown Dermosols
Blue Vale - Slopes	Mid to lower slopes of low hills on the Maule's Creek Formation. Gently inclined slopes of 3–10 % gradient.	Dominantly Maules Gravelly Duplex. Subdominant Maules Gravelly Sands /Maules Gravelly Loams	Brown, Grey, and Red Chromosols; Brown, Grey, and Red Sodosols; Brown/Red/Yellow Orthic Tenosols; Red and Grey Kandosols;
Blue Vale - Footslopes	Drainage fans and flats derived from the Maule's Creek Formation. Footslopes of < 4 % gradient.	Dominantly Maules Sodic Duplex Soils with Subdominant Maules Gravelly Sands /Maules Gravelly Loams	Brown and Grey Sodosols; Grey Chromosols and Red Dermosols Brown/Red/Yellow Orthic Tenosols; Red and Grey Kandosols.
Brentry	Drainage plains and fans formed on Quaternary alluvium derived from the Maule's Creek Formation. Footslopes of < 4 % gradient.	Mostly Maules Sodic Duplex Soils	Brown and Grey Sodosols; Grey Chromosols and Red Dermosols
Hartfell	Crests and slopes of low hills on the Boggabri Volcanics. Gently and moderately inclined slopes with 4–20 % gradient.	Volcanic Cobbly Clay and Duplex Soils	Red Sodosols, Red Chromosols; Black Vertosols; Red, Brown and Grey Dermosols
Velyama Footslopes	Drainage plains and fans formed on Quaternary alluvium derived from the Boggabri Volcanics. Footslopes with gradient < 4 %.	Velyama Deep Sodic Duplex Soils	Red, Brown, and Grey Sodosols; Red, Brown, and Grey Chromosols

4 SOILS

Existing soil mapping (Landloch, 2014) was extended by using data gathered in this campaign relevant to the MOD 8 Survey Area. Records of field descriptions from this campaign are provided in Appendix A. Details of soil profiles from former campaigns undertaken by Landloch at BCM are provided in:

- *Boggabri Coal Project – Soil Survey and Growth Media Inventory for Rehabilitation* (Landloch, 2014); and
- *Boggabri Coal Mine Site Verification Assessment of Biophysical Strategic Agricultural Land* (Landloch, 2020).

The MOD 8 Survey Area incorporates two soil mapping units (Figure 7):

1. The northern portion is the Blue Vale Footslopes SMU covering an area of 61 ha and
2. The southern portion is the Brently SMU and encompasses the remaining 49 ha of the MOD 8 Survey Area

The MOD8 Disturbance Footprint is situated at the transition zone between these two soil mapping units.

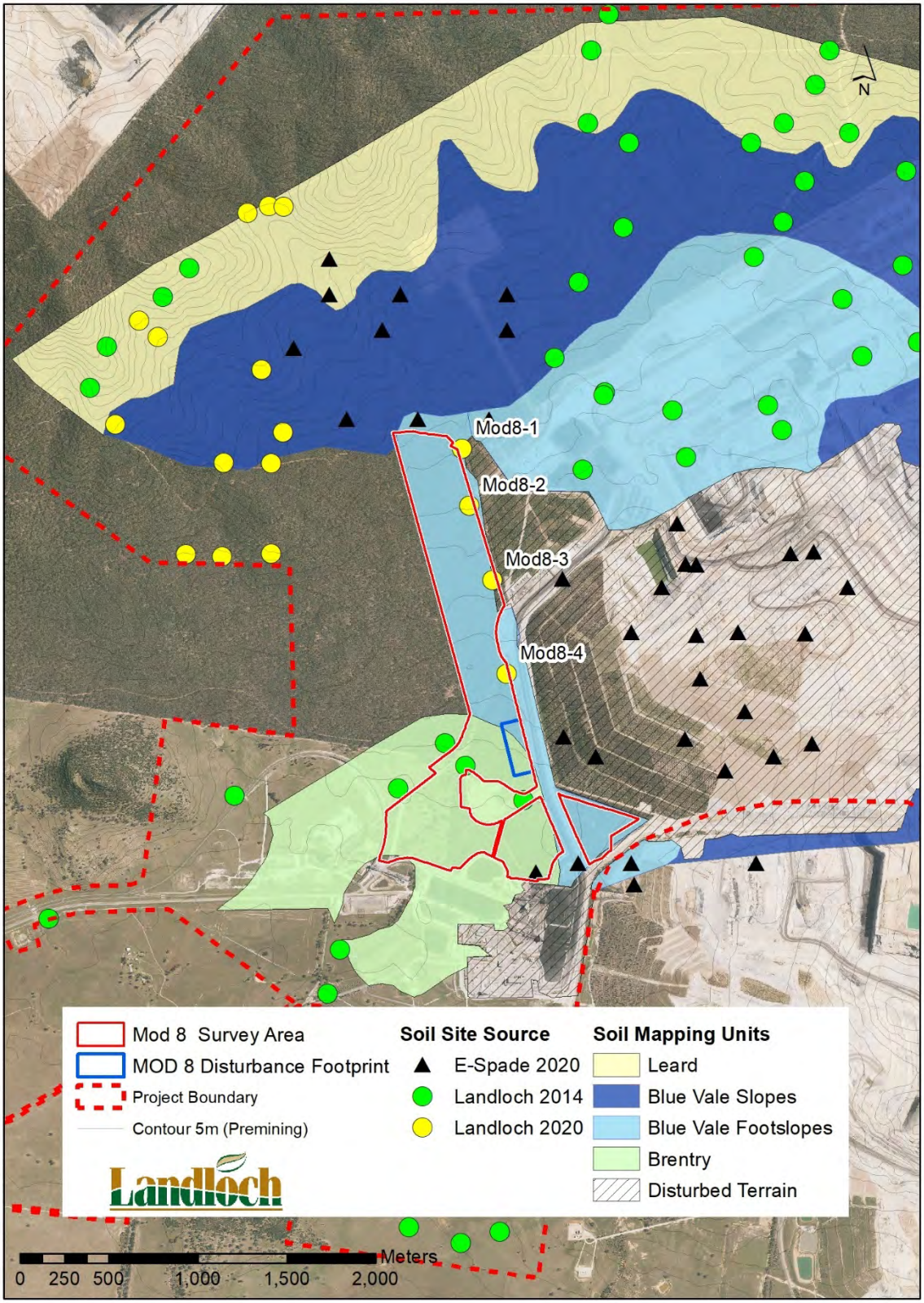

Figure 7. Soil Mapping Units of the MOD 8 Survey Area and surrounds.

4.1 Soil Salvaging and Gypsum Amelioration

Topsoil stripping should intentionally salvage the seed bank and upper soil layers that generally have the highest fertility, organic matter and biological health of the materials available. It should also aim to avoid hazardous materials that would pose limitations to plant growth such as saline, acidic, highly alkaline, or highly dispersive layers.

Good quality subsoil/substrate materials may also be required for rehabilitation. Appreciable levels of nutrients and organic matter will generally be required if subsoils are to be used as a primary growth media. Materials that are sodic or acidic will need amelioration with gypsum and/or lime.

Table 3 provides the growth media suitability, stripping depths and gypsum amelioration rates for each SMU. It assumes that all soil materials will require the addition of starter fertiliser at the commencement of rehabilitation. For materials rated as either *marginal* or *poor* suitability as growth media, the primary limitations are noted in parenthesis.

Table 3. Summary of growth media qualities of soils. Limitations are noted in parenthesis.

SMU	Layer*	Depth (m)	Growth Media Suitability		Gypsum Rate (t/ha)
			Primary	Secondary	
Blue Vale Footslopes	TS	0 to 0.2	Good	Good	2
	USS	0.2 to 0.5	Marginal *(low fertility, dispersive)*	Good	7
	LSS	0.5 to 1.2	Marginal *(low fertility, highly alkaline, highly dispersive)*	Marginal *(highly dispersive)*	To be determined
Brentry	TS	0 to 0.15	Good	Good	3
	USS	0.15 to 0.4	Marginal *(low fertility, high acidity, and dispersive)*	Marginal *(highly dispersive)*	To be determined
	LSS	0.4 to 1.0	Poor *(low fertility, extremes of pH, highly dispersive, sometimes saline)*	Marginal *(highly dispersive, sometimes saline)*	To be determined

*Notes: Topsoil (TS), Upper Subsoil (USS), Lower Subsoil (LSS).

4.2 Growth Media Inventory

Estimates of the growth media volumes available are provided in Table 4. The growth media volumes were estimated by calculating the area of the soil landscape surface and multiplying it by the average depth of available soil. Actual soil depth may vary due to

changes in the landscape of each soil type. An error factor of ± 20 % is recommended to be applied to these volumes.

It is important to note these are estimates of the potential available growth media across the MOD 8 Survey Area, and quantities should be considered with awareness of this. Bulk earthworks and handling of materials have the potential to mix different soil layers and materials and either improve or degrade the quality of materials as growth media.

Table 4. Growth media inventory.

SMU	Area (ha)	Growth Media Volumes +/- 20% (x 1000 m^3)			
		Primary		Secondary	
		Good	Marginal	Good	Marginal
Blue Vale Footslopes	1.1	2.2	11	5.5	7.7
Brentry	2.2	3.3	5.5	3.3	18.7

5 IMPACTS AND MITIGATION MEASURES

The construction of the fauna crossing over the existing haul road between the mining area and the Mine Infrastructure Area will require disturbance to land and soil within and partly outside of the approved disturbance area at BCM. Relative to the mining activity, the disturbances will be small and are expected to include:

- Geotechnical assessment – Either test pitting and or drilling to describe soil and collect samples necessary to assess the mechanical properties of soils. Limited vegetation clearing and ground surface grubbing (clear and grub) activities may be required to provide access to vehicles and plant.
- Construction – Further clearing and grubbing activities will be required to prepare the ground for construction and provide access to vehicles and plant. Topsoil from previously undisturbed areas will need to be recovered for will need to be recovered for later use in rehabilitation. Bulk earthworks will be undertaken to provide the desired landform and required drainage. Drilling of piers may be necessary to host the poles for aerial crossings for fauna.
- Rehabilitation – Disturbed areas will need to be rehabilitated post construction to provide a stable and non-polluting surface. The vegetation established will need to support the fauna that intend to use the crossing.

A summary of the potential soil impacts and mitigation measures are provided in Table 5.

Table 5. Summary of potential soil impacts and mitigation measures.

Task	Activity	Potential Soil Impacts	Mitigation Measure
Geotechnical Assessment	Limited clearing and grub	Accelerated erosion because of removal of ground cover.	Prepare an Erosion and Sediment Control Plan with appropriate erosion and sediment controls in accordance with the requirements of the currently approved *BCM Surface Water Management Plan* (BCOPL, 2017) and *Managing Urban Stormwater: Soils and Construction Volume 1* (Landcom, 2004) and *Volume 2 E. Mines and Quarries (DECC, 2008).*
	Drilling	Negligible	N/A
	Test pitting	Dilution of topsoil quality by mixing with poor quality subsoil materials.	Refer to the soil recovery and handling requirements in the *Boggabri Coal Soil Management Protocol* (BCPL, 2018).
Construction	Clearing and grub	Accelerated erosion because of removal of ground cover.	Prepare an Erosion and Sediment Control Plan with appropriate erosion and sediment controls in accordance with the requirements of the currently approved *BCM Surface Water Management Plan* (BCOPL, 2017) and *Managing Urban Stormwater: Soils and Construction Volume 1* (Landcom, 2004) and *Volume 2 E. Mines and Quarries (DECC, 2008).*
	Topsoil stripping	Dilution of topsoil quality by mixing with poor quality subsoil materials.	Refer to the soil recovery and handling requirements in the *Boggabri Coal Soil Management Protocol* (BCPL, 2018).
	Drilling, excavation, and bulk earthworks		
Rehabilitation	Soil reinstatement	Dilution of topsoil quality by mixing with poor quality subsoil materials.	As above

Task	Activity	Potential Soil Impacts	Mitigation Measure
		Accelerated erosion because of removal of ground cover.	Implement soil preparation and vegetation establishment measures as per the *Boggabri Coal Soil Management Protocol* (BCOPL, 2018), *Boggabri Coal Rehabilitation Management Plan (BCOPL, 2020)*, and *Boggabri Coal* Mining *Operations Plan* (BCOPL, 2020).

6 CONCLUDING REMARKS

The information within this report provides technical soil and landscape details relevant to the Boggabri Coal Operations Pty Ltd application to modify SSD 09_0182 (Modification 8).

This assessment extended the existing soil mapping of BCM. The soils encountered during fieldworks were correlated with previous assessments and mapping conducted by Landloch.

As such, the documents and procedures relating to soil management and rehabilitation for the mine that are already maintained by BCPOL are applicable to the additional 1.21 ha disturbance associated with the Mod 8 Survey Area. These include:

- *Boggabri Coal* Mining *Operations Plan* (BCOPL, 2020).
- *Boggabri Coal Soil Management Protocol* (BCOPL, 2018), and the
- *Boggabri Coal Rehabilitation Management Plan* (BCOPL, 2020)

The details within these documents are relevant to the additional disturbances associated with the construction of the fauna crossing and can be readily implemented to manage the associated disturbances.

7 REFERENCES

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APPENDIX A: SOIL DESCRIPTION RECORDS

Table A1. Site surface descriptions part 1 of 2.

Site ID	Soil Profile Class	Australian Soil Classification	Landform	Landform Element	Morphological Type	Slope (%)	Geology Unit	Groundcover % (veg)	Veg/Litter	Cracks (width)	Stoniness (abundance)	Stoniness (size)	Surface Condition	Rock Outcrop (abundance and size)	Gilgai and Microrelief (type, depth, size)	Erosion Severity
Mod 8.1	Maules Gravelly Loams	Red KANDOSOL	Hills	Footslope	Flat	2	Pmx	80-100%	80/20	<5mm	2-10%	<60mm	Firm	Nil	nil	Nil
Mod 8.2	Maules Gravelly Loams	Grey Orthic TENOSOL	Hills	Footslope	Flat	2	Pmx	80-100%	80/20	<5mm	10-20%	<60mm	Firm	Nil	nil	Nil
Mod8.3	Maules Gravelly Loams	Brown KANDOSOL	Hills	Footslope	Flat	2	Pmx	80-100%	80/20	<5mm	50-90%	<60mm	Firm	Nil	nil	Nil
Mod 8.4	Maules Gravelly Loams	Brown KANDOSOL	Hills	Footslope	Flat	2	Pox	80-100%	80/20	<5mm	10-20%	<60mm	Soft	Nil	nil	Nil

Table A2. Site surface descriptions part 2 of 2.

Site ID	Runoff	Drainage	Permeability	Inundation	Land Use	Site Disturbance	Vegetation (dominant stratum)	Vegetation Height (upper stratum)	Comments/notes	UTM	Observation Type
Mod 8.1	<20%	Moderate (week)	Moderate (50-500 mm/day)	Never	Forestry	Limited Clearing (selective logging)	Cypress Pine regrowth and Ironbark	5-10m		56 J 226251.53 6610823.976	Check
Mod 8.2	<20%	Well (days)	Moderate (50-500 mm/day)	Never	Forestry	Limited Clearing (selective logging)	Ironbark, Cypress Pine regrowth, Forbes and grasses	5-10m		56 J 226291.39 6610502.431	Check
Mod8.3	<20%	Moderately-Well (<week)	Moderate (50-500 mm/day)	Never	Forestry	Limited Clearing (selective logging)	Ironbark, Cypress Pine regrowth, Forbes and grasses	5-10m		56 J 226421.54 6610081.949	Check
Mod 8.4	<20%	Moderately-Well (<week)	Moderate (50-500 mm/day)	Never	Forestry	Limited Clearing (selective logging)	Ironbark, Cypress Pine regrowth, Forbes and grasses	10-20m		56 J 226502.48 6609555.255	Check

Table A3. Soil profile descriptions part 1 of 2.

Site ID	ASC Classification	Soil Profile Class	Excavation Depth (m)	Layer	Horizon	Lower Depth (m)	Boundary	Texture	Colour (rapid)				pH (Field)	Pedality		
									Primary	Secondary	Mottles	Streaks		Grade	Size (mm)	Type
Mod8-1	Red KANDOSOL	Maules Gravelly Loams	0.6	1	A1	0.15	Clear	Sandy Loam	Dark Brown		Nil	Nil	6.5	Moderate	5-10	Polyhedral
				2	B21	0.25	Gradual	Clay Loam	Red	Brown	Nil	Nil	5.5	Weak	5-10	Polyhedral
				3	B22	0.4	Gradual	Clay Loam	Pale Red	Brown	Nil	Nil	5	Weak	5-10	Polyhedral
				4	B23	>0.6		Clay Loam	Pale Red	Pale Brown	Nil	Nil	5	Weak	5-10	Polyhedral
Mod8-2	Grey Orthic TENOSOL	Maules Gravelly Sand	0.5	1	A1	0.1	Gradual	Clayey Sand	Dark Brown		Nil	Nil	6.5	Moderate	5-10	Polyhedral
				2	A2	0.2	Gradual	Clayey Sand	Brown		Nil	Nil	5.5	Weak	5-10	Polyhedral
				3	A3	>0.5		Clayey Sand	Pale Yellow	Grey	Nil	Nil	5.5	Weak	5-10	Polyhedral
Mod8-3	Brown KANDOSOL	Maules Gravelly Loam	0.6	1	A1	0.1	Clear	Sandy Clay Loam	Dark Brown		Nil	Nil	6	Moderate	5-10	Polyhedral
				2	A2	0.2	Clear	Sandy Clay Loam	Brown		Nil	Nil	6	Weak	5-10	Polyhedral
				3	A3	>0.6		Sandy Clay Loam	Pale Yellow	Grey	Nil	Nil	7	Weak	5-10	Polyhedral
Mod8-4	Brown KANDOSOL	Maules Gravelly Loam	0.6	1	A1	0.1	Clear	Sandy Clay Loam	Dark Brown		Nil	Nil	7	Moderate	5-10	Polyhedral
				2	A2	0.2	Clear	Sandy Clay Loam	Brown		Nil	Nil	5.5	Weak	5-10	Polyhedral
				3	B2	>0.5		Clay Loam Sandy	Pale Yellow	Grey	Nil	Nil	5	Weak	5-10	Polyhedral

Table A4. Soil profile descriptions part 2 of 2.

Site ID	Roots	Consistence		Gravel	Coarse Fragments 1°			Coarse Fragments 2°			Pan	Comments	Samples	Observation Type
		Moisture	Strength	Total (%)	Proportion (%)	Size (mm)	Shape	Proportion (%)	Size (mm)	Shape	Present			
Mod8-1	Common	Mod Moist	Weak	10	5-10	2-6	Sub-rounded	5-10	6-20	Sub-rounded	Nil		Nil	
	Common	Mod Moist	Weak	10	5-10	2-6	Sub-rounded	5-10	6-20	Sub-rounded	Nil			Check
	Common	Mod Moist	Weak	10	5-10	2-6	Sub-rounded	5-10	6-20	Sub-rounded	Nil			
	Few	Dry	Weak	20	10-20	2-6	Sub-rounded	10-20	6-20	Sub-rounded	Nil	Refusal at 0.6m		
Mod8-2	Common	Mod Moist	Weak	40-60	20-30	6-20	Sub-rounded	20-30	20-60	Sub-rounded	Nil		Nil	
	Common	Mod Moist	Weak	40-60	20-30	6-20	Sub-rounded	20-30	20-60	Sub-rounded	Nil			Check
	Few	Dry	Weak	40-60	20-30	6-20	Sub-rounded	20-30	20-60	Sub-rounded	Nil	Limit of investigation with HA		
Mod8-3	Common	Mod Moist	Weak	20	10-20	6-20	Sub-rounded	10-20	20-60	Sub-rounded	Nil		Nil	
	Common	Mod Moist	Weak	20	10-20	6-20	Sub-rounded	10-20	20-60	Sub-rounded	Nil			Check
	Few	Dry	Weak	20	10-20	6-20	Sub-rounded	10-20	20-60	Sub-rounded	Nil	Limit of investigation with HA		
Mod8-4	Common	Mod Moist	Weak	20	10-20	6-20	Sub-rounded	10-20	20-60	Sub-rounded	Nil		Nil	
	Common	Mod Moist	Weak	20	10-20	6-20	Sub-rounded	10-20	20-60	Sub-rounded	Nil			Check
	Few	Dry	Weak	20	10-20	6-20	Sub-rounded	10-20	20-60	Sub-rounded	Nil	Limit of investigation with HA		

Photograph 1. Landscape at Site Mod 8.1.

Photograph 2. Soil profile at Site Mod 8.1.

Photograph 3. Landscape at Site Mod 8.2.

Photograph 4. Soil profile at Site Mod 8.2.

Photograph 5. Landscape at Site Mod 8.3.

Photograph 6. Soil profile at Site Mod 8.3.

Photograph 7. Landscape at Site Mod 8.4.

Photograph 8. Soil profile at Site Mod 8.4.

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