DEPARTMENT OF
LAND RESOURCE MANAGEMENT

Agricultural Land Suitability Series – Report 3
DLRM Technical Report 9/2016D

Soil and Land Capability Assessment for Irrigated Agriculture on Kurnturlpara and Part of Warumungu Aboriginal Land Trusts July 2016

Rangelands Division
Department of Land Resource Management
PO Box 496
Palmerston NT 0831

Grealish G, Carnavas M, and Burley P

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Department of Land Resource Management
Land Assessment Branch
PO Box 496
Palmerston NT 0831

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The map series accompanying this report can be downloaded from the NR Maps website.

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Executive Summary

This soil and land capability assessment was conducted for Northern Territory Portions 502 (Warumungu Aboriginal Land Trust) and 4802 (Kurnturlpara Aboriginal Land Trust), covering a total area of 17,232 ha.

The study area covers two very different landscapes: level clay-rich soil plains in the north, typical of the Barkly Tableland Mitchell Grass Plains, and level to undulating sandy semi-desert country in the south.

Approximately 2,490 ha were considered to have moderate capability, consisting of deep, well drained, sandy or loamy texture soils. Approximately 14,450 ha, were considered to have marginal capability, and to develop these areas would require management to overcome shallow soils, imperfect drainage or gilgai microrelief. The remaining 290 ha were considered not suitable due to shallow soils or poor drainage.

An Agricultural Crop Suitability framework that determines suitability for specific crops was not considered appropriate in this study due to no examples or experience of crop production in this part of the Barkly region.

The 400 ha area of interest identified by the stakeholder for irrigated agriculture development (adjacent to the Barkly Highway) was found to have approximately 118 ha of land with moderate capability for irrigated agriculture. The significance of this will depend on the crops to be grown and their plant rooting depth needs. A suitably qualified professional should conduct investigations of the specific areas prior to development.

A concurrent investigation of the groundwater resources in the Gum Ridge and Anthony Lagoon Formations between Daly Waters and Tennant Creek was undertaken by Water Resources between April and December 2015. The investigation identified viable aquifers in both formations with good potential for horticultural development of the resources in the Gum Ridge Formation due to high individual bore yields (>40 L/s). The Anthony Lagoon Formation however, is not extensive across the region, its high yield zones are somewhat inconsistent and possible water quality issues makes it less prospective for large scale horticultural development.

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- Stuart Smith (DPIF) for providing crop suitability information.

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List of Acronyms

ALT	Aboriginal Land Trust
ASC	Australian Soil Classification
ASPAC	Australian Soil and Plant Analysis Council
ASRIS	Australian Soil Resource Information System
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DEM	Digital Elevation Model
DLRM	Department of Land Resource Management
DSITIA	Department of Science, Information, Technology, Innovation and the Arts (Queensland)
DSCAVI	Executive Steering Committee for Australian Vegetation Information
GDA	Geocentric Datum of Australia, 1994
MGA	Map Grid of Australia
NATA	National Association of Testing Authorities (Australia)
NCST	National Committee on Soil and Terrain
NTG	Northern Territory Government
NVIS	National Vegetation Information System
SALInfo	Soil and Land Information System (NT)
VSDNT	Vegetation Site Database, Northern Territory

1. Introduction

The soil and land capability assessment was conducted for Northern Territory Portions 502 (Warumungu Aboriginal Land Trust) and 4802 (Kurnturlpara Aboriginal Land Trust), covering a total area of 17,232 ha (Figure 1.1). The area is also locally known as Frewena. This general purpose survey mapped land units at a medium intensity cartographic scale of 1:50,000 to provide a broad range of information considered to have both current and future uses. Land evaluation to determine the land unit capability for agriculture was conducted against an explicit set of criteria, that can be updated as new information and technologies become available. This report and the accompanying map present findings from field survey conducted in October 2015 and March 2016); data from a previous soil assessment (Lennartz, 2006); and interpretation of other available spatial datasets (geology, imagery, radiometrics, and digital elevation model data).

This work was financed from funds allocated in the Northern Territory Government Budget 2015/16 that aimed to identify and promote areas of soil, land and water resource assets with potential for irrigated agriculture on Indigenous Lands and adjacent areas. A number of potential areas of interest for future agricultural development were identified across the Northern Territory based on broad scale land and water resource information (e.g. Pascoe-Bell *et al.*, 2014), consultation with relevant government personnel, peak industry bodies and Indigenous stakeholders. This Warumungu and Kurnturlpara Aboriginal Land Trust area was one of the identified locations.

Detailed soil and land capability information is critical to identify potential new agricultural areas in northern Australia. The information underpins agricultural development opportunities by providing potential investors and land managers with a high level of confidence when making investment decisions, and assists with significantly reducing the economic, social and environmental risks associated with such developments.

1.1 Objectives

The specific objectives of the soil and land capability assessment were to:

1. Conduct soil, vegetation and landscape assessment across the entire study area, with more intensive work conducted on the selected area of interest identified by the stakeholder.
2. Map and describe the land units at a cartographic map scale of 1:50,000.
3. Generate agricultural land capability outcomes based on assessment of soil and landscape attributes against an explicit set of criteria.
4. Produce a technical report, spatial data and map products that detail soil, vegetation and land capability findings for the study area.

1.2 Study area

The study location was adjacent to and north of the Barkly Highway, 135 km east of Threeways Roadhouse and 55 km west of Barkly Homestead Wayside Inn (Figure 1.1).

The study area boundary was defined by the extent of the Northern Territory Portions 502 (Warumungu Aboriginal Land Trust) and 4802 (Kurnturlpara Aboriginal Land Trust). That occurred approximately between latitudes 19°14' and 19°26' south and longitudes 135°22' and 135°28' east.

The total area was 17,232 ha, with Portion 502 covering 10,866 ha and Portion 4802 covering 6,366 ha.

Land use was identified as *Traditional Indigenous Uses* according to the Revised Land Use Mapping of the Northern Territory (Berghout, 2008). At the time of the survey there was rangeland grazing of cattle on Portion 4802 and a small area where the Aboriginal community lived that consisted of a few houses, sheds, and related infrastructure.

The entire study area was considered. However, most of the field work effort was conducted on the potential agriculture area of interest identified by the stakeholder. That was located in the southwest corner of Portion 4802, adjacent to the Barkly Highway and covering an area approximately 2 x 2 km (400 ha).

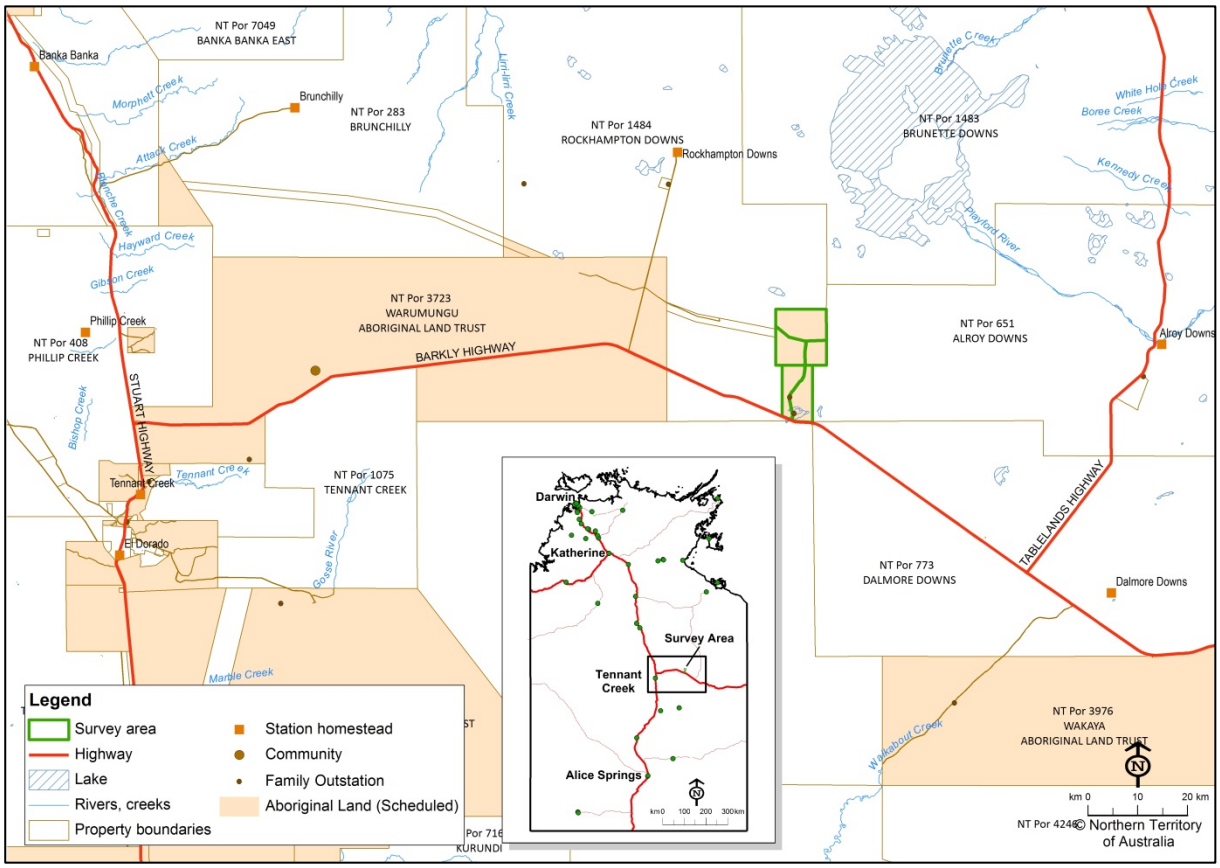


Figure 1.1. Map showing the location of the soil and land assessment study area.

2. Background Information

2.1 Previous soil and land resource assessments

2.1.1 *Frewena Land Resources Assessment for Potential Horticulture Development*

The field work conducted in 2004 (Lennartz, 2004) covered a similar footprint to this current soil and land assessment. The area was identified and selected as having suitable soils with the potential for the development of irrigated horticulture. The objectives of the assessment were to measure baseline soil properties through field work and soil sampling, to determine the value and practical application of airborne radiometrics data to predict soil properties, and to evaluate the suitability of soils for potential horticulture development.

Twenty sites were distributed throughout the study area, the soil and vegetation described and the surface soil layers were sampled and underwent limited chemistry analysis (pH, electrical conductivity, and exchangeable cations). Soil classes identified included Vertosols, Calcarosols, Kandosols and Tenosols. These were mapped into 5 land units based on soil depth, clay content and the presence or absences of lateritic gravel and calcrete.

It was identified that large areas in the southern parts were severely affected by annual rains, causing soil waterlogging issues that may limit access. On the higher plains there was a sandy veneer overlying a rocky calcrete substrate, commonly encountered within 0.80 m depth, along with outcrops of chert and calcrete. To the north there were large areas of heavy clay soil. The assessment recommended that prior to developing a specific area for irrigated horticulture further investigations should be conducted to determine soil depth extent and underlying soil characteristics.

2.1.2 *The Land Resources of Alroy Downs Station*

The assessment conducted between August and November (1992) covers the land to the east of this study area, with the western map boundary stopping at the eastern boundary (Edgoose and Lehman, 1996). The purpose of the work was to provide a land resource inventory to compliment local pastoralists' knowledge. This was achieved by formally documenting the types of country, accurately mapping their distribution, and indicating the potential productivity and land management hazards. Documented evidence was provided to support property management and development decisions.

Five broad landform units were identified, namely: Plains (palaeoplains or gilgai plains), Downs Plains, Alluvial Plains, Swamps, and Drainage Systems, and 25 land units were mapped at a scale of 1:100,000. Soil classes recognised include: Rudosols, Red Kandosols, Brown Kandosols, Calcarosols, Brown Dermosols, Grey Vertosols, and Brown Vertosols. The cracking clays found on the 'downs' country occur as alluvial soils (Brown Vertosols) or in-situ (Grey Vertosols). The lighter clay to sandier soils on the lateritic palaeoplain were generally red in colour, with the sandier soils representing aeolian sand transported onto the lateritic plain and the clay soils being non-cracking. The main vegetation contrast was between those of the grasslands in the 'downs' country and those of the woodlands or shrublands in the red lateritic country. For each of the 25 land units, landform, soil and vegetation descriptions were provided along with soil management and pasture management recommendations.

Seven of the 25 land units are mapped as occurring adjacent to this study area; they are listed and described in Table 2.1.

Table 2.1. Alroy-Downs Station land resources map units that occur adjacent to the eastern study area boundary.

Land unit code	Description
Plains	
1.2	Partially stripped; level lateritic palaeoplain. Red earths (Red Kandosols). *Atalaya hemiglauca; Acacia ancistrocarpa; Eucalyptus pruinos*a and *Grevillea striata* mid high open woodland.
1.3	Level plains, Red earths (Brown Kandosols). *Eucalyptus pruinosa* or *Corymbia terminalis* mid high open woodland with mixed spp. annual and perennial grasses.
1.4	Rocky limestone and calcrete plain with irregular surface but negligible overall slope. Red earths (Red Kandosols). *Atalaya hemiglauca; Corymbia terminalis* and *Corymbia bella* mid high open woodland.
1.5	Gently undulating plains with scattered limestone outcrop or gravelly surface. Brown clays (Calcarosols). *Ventilago viminalis; Atalaya hemiglauca* and *Corymbia terminalis* low open woodland.
Downs plains	
2.1	Level clay plains with normal gilgai surface. Grey clays (Grey Vertosols). *Astrebla pectinate* and *Iseilema vaginiflorum* with *Aristida latifolia* mid high tussock grassland.
2.3	Level clay plains with linear gilgai surface. Grey clays (Grey Vertosols). *Astrebla pectinate* and *Iseilema vaginiflorum* with *Aristida latifolia* mid high tussock grassland.
Alluvial plains	
4.2	Very gently sloping alluvial plain; extending up to several kilometres from drainage lines. Grey clays (Grey Vertosols). *Panicum decompositum*; *panicum laevinoides* and *Iseilerna spp*. mid high grassland.
Drainage systems	
6.2	Shallow; very broad drainage channels. Grey clays (Grey Vertosols). Mixed annual spp. mid high sparse grasslands.

2.1.3 ***Survey of the Barkly Region, Northern Territory and Queensland***

The field survey conducted in 1947 and 1948 by Christian *et al.* (1954) was at a broad scale of 1:1,000,000 and included this study area. This was one of a series of surveys initiated by CSIRO at the request of the Northern Australia Development Committee in order that an accurate knowledge of the nature of the country and its potential might be made available for the formulation of policies concerning development. The objectives were to describe, classify and map the country including its surface geology, topography, soils, vegetation, and broadly assess the land-use potentials.

Five of the 38 land systems were mapped as occurring within this study area; they are listed and described in Table 2.2.

Table 2.2. Barkly Region Land Systems map units that occur with this study area.

Land System	Description
Austral	Gently undulating Mitchell grass plains. Mostly heavy clay soils formed on portions of exposed Tertiary Lake Limestones.
Barkly	Very gently undulating to nearly flat Mitchell grass plains covering the area referred to as Barkly Tableland. One of the Tertiary Swamp land systems, composed of material derived from calcareous rocks overlain by, or intermixed with, fine-textured swamp alluvium.
Prentice	Gently undulating country carrying scrubby vegetation. Part of the Tertiary Lateritic Plain on which wind-blown calcareous material has been deposited.
Tobermorey	Sparsely timbered undulating to gently undulating country with some low hills. Exposed Tertiary Lake Limestones and other limestones. Shallow soils with good external drainage and minimal weathering.
Wonorah	Gently undulating country with deep lateritic soil and low scrubby vegetation. Part of the Tertiary Lateritic Plain formed on parent materials which were not highly arenaceous.

2.2 Geology

2.2.1 *Alroy, N.T. Geological Series Explanatory Notes*

This report was prepared as part of the 1:250,000 scale Geological Series (compiled by Randal, 1966). It was based on earlier work conducted and reported by Randal and Nichols (1963), with field work conducted in 1962. The purpose of the work was to systematically map the area to provide information to assist in the exploration and development of mineral resources.

This work was updated and reported in a second edition that is discussed in the following section.

2.2.2 *Alroy, N.T. (Second Edition) Geological Map Series and Explanatory Notes*

The Alroy map produced at a broad scale of 1:250,000 (Kruse and Maier, 2010) provides information on the study area geology that is discussed in the accompanying explanatory notes (Kruse *et al*., 2010). Field work and remapping using new spatial data sets was conducted in 2007. The Alroy second edition was a completely new map.

A marginally higher undulating peneplain/sand plain rims the Barkly Tableland, and is generally devoid of surface drainage, with the partly wind-blown red and yellow quartz sand sourced from shedding of the Davenport Range to the south. Calcrete forms a relatively prominent plateau adjacent to the Barkly Tableland. The Barkly Tablelands are flat to gently undulating tussock grasslands with few trees and grey to grey-black and brown, smectite-dominated medium to heavy clay soils. The regional elevation descends toward the Lake Sylvester system on Brunette Downs Station forming an extensive internal drainage system. The study area occurs to the south of the lakes and straddles the margins between the upper peneplain/sand plain and the Barkly Tablelands.

The study area is almost entirely mapped as Cenozoic surficial deposits, with areas of isolated claypans and a minor occurrence of older Anthony Lagoon Formation. Geological units that occur in this study area are listed and described in Table 2.3 and their distribution is presented in Figure 2.1.

Table 2.3. Geological units and descriptions that occur in this study area.

		Unit Code	Legend Description (Kruse and Maier, 2010)	Other Information Notes (Kruse *et al.*, 2010)
CENOZOIC	QUATERNARY	Qa	Alluvium: sand, minor gravel, silt and clay	Deposited in the beds and banks of watercourses. Flat Qa floodplains are generally demarked from adjacent colluvial sand (Czs) by a break in slope. In floodout areas the boundary may become arbitrary
		Qp	Claypans, sheetwash: silt, clay	Clay and silt rich fine sediment accumulates in poorly drained depressions on floodplains and along relict drainage lines and interdune corridors. Non-linear drainage depressions are included, even in those cases where the depression is floored by cracked clay-rich soil indistinguishable from the surrounding Czb. Claypans are also recognised with Czs sand.
	PALAEOGENE AND NEOGENE	Czf	Ferricrete, manganocrete and ferruginised rock	Common atop topographic highs. Most ferricrete is quartz sandstone with a ferruginous matrix, incorporating materials from the underlying formation. Is common on the Anthony Lagoon Formation
		Czk	Calcrete	A prominent plateau of continuous exposure and shallow subcrop (beneath Czs sand). Characteristically a pale to light grey to pink-grey calcimudstone. Lithology represents a rejuvenated colluvial sand environment. Reworked chert pebbles are occasionally incorporated.
		Czb	Grey-black clay-rich soil	Plains of the Barkly Tableland. Developed by the surface accumulation of residual clays due to weathering of the underlying Cambrian carbonate rocks. Windblown sand provides a surficial veneer. Seasonal wetting and drying of these soils produces local gilgai. The heave and settlement appears in some areas to transport upwards to the surface larger fragments, where surficial accumulations of chert pebbles occur.
		Czb_y	Surficial Cmy chert rubble	Rubble on the surface derived from the Anthony Lagoon Formation due to the upward transport.
		Czs	Unconsolidated colluvial and aeolian sand; minor silt, red earth	From the Proterozoic rocks of the Tennant Region to the southwest.
		Cz	Regolith, skeletal shallow soil on bedrock	In situ weathering products directly derived from the underlying from underlying shallow subcrop, with little active transport.
PALAEOZOIC	CAMBRIAN MIDDLE	Cmy	Dolomudstone/dolosparstone, dolomitic-siliciclastic siltstone and mudstone, dolomitic sandstone-interbeds; nodular and bedded evaporate, chert concretions; minor intraclast and oncoid dolostone, microbial dololaminite, dolomitic quartz sandstone	Incorporates a variety of lithologies as listed in the map legend. When at the surface it occurs as pebble to boulder rubble tracts on undulating plains and low rises, in which chert concretions predominate.

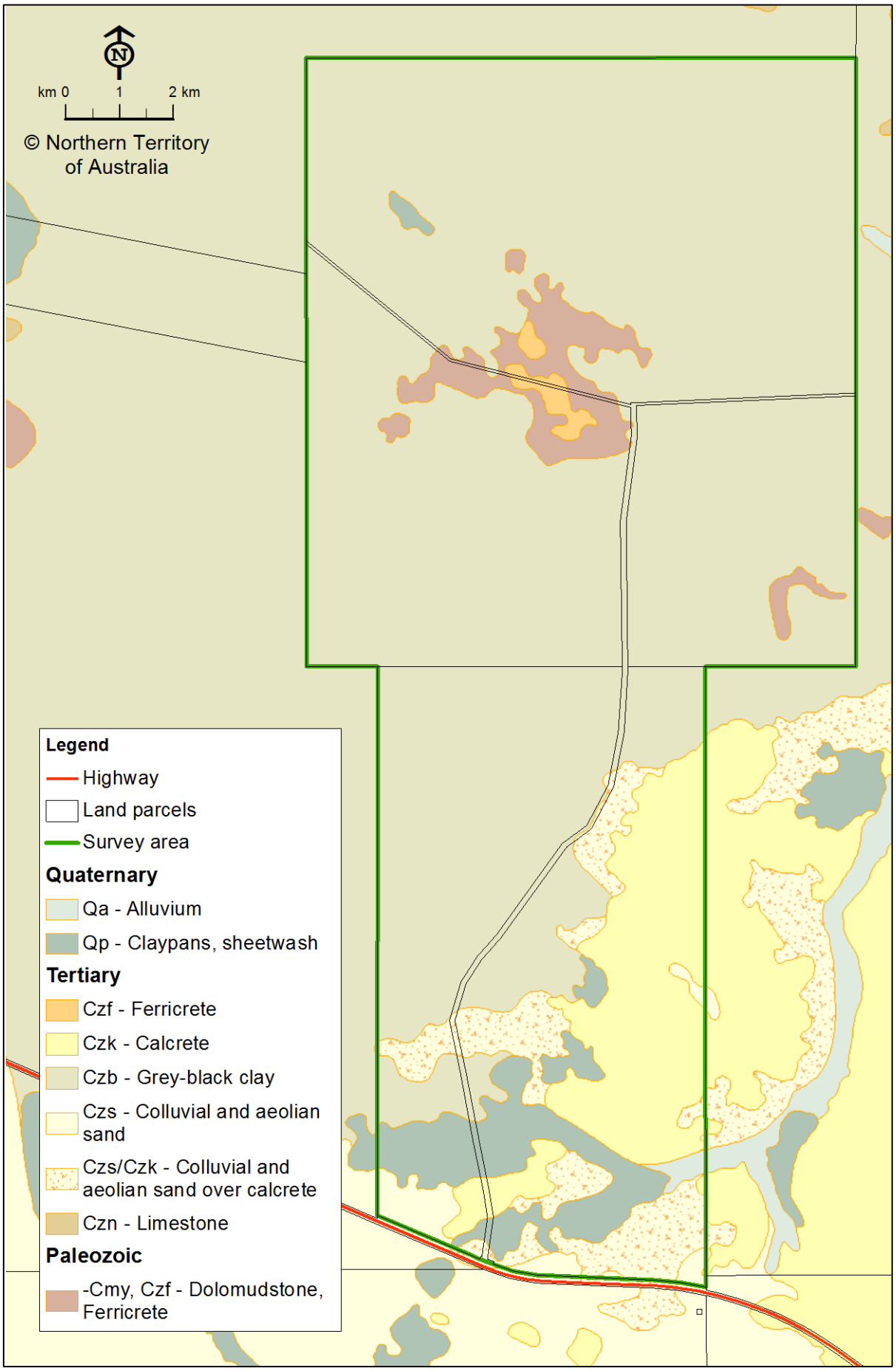


Figure 2.1. Map showing the distribution of geological units for this study area (from Kruise and Maier, 2010).

2.3 Groundwater

The Georgina Basin is a geological basin which underlies most of the Barkly Tablelands region. In hydrogeological terms, it is known for the groundwater resources in Anthony Lagoon Formation and the Gum Ridge Formation. The Anthony Lagoon Formation represents the majority source of the stock water across the region. The Gum Ridge Formation is largely unexplored as it is at depths beyond the interests for most stock bores. However, it is of significance that both aquifers are in hydraulic connection with the Tindall Limestone Formation of the Daly Basin to the north. This system eventually discharges into the Roper River.

An investigation of the groundwater resources in both the Gum Ridge and Anthony Lagoon Formations between Daly Waters and Tennant Creek was undertaken by Water Resources between April and December 2015. The project focussed on the western margin of the Georgina Basin and sought to gather information which would improve the hydrogeological understanding and provide a firm basis for assessment of the groundwater resources in the basin. The project involved the drilling of twelve investigation bores to obtain better stratigraphic definition, improve regional aquifer mapping and to extend the water level monitoring network in the Georgina Basin. The study region is approximately bounded by the four major highways in the region. That is, the Carpentaria Highway in the north and the Barkly Highway in the south. The western boundary is coincident with the shallow basement of the Tennant Creek Block approximately aligning with the Stuart Highway and the eastern boundary aligns with the Tablelands Highway where the basin abuts the basement highs represented by the Wonarah Formation and the shallow McArthur Basin sediments.

This work has identified viable aquifers in the weathered units of both the Gum Ridge and Anthony Lagoon Formations. There is good potential for horticultural development of the resources in the Gum Ridge Formation due to high individual bore yields (>40 L/s) available from appropriately constructed bores. This resource is indicated to be continuous across the Georgina Basin but experiences limited recharge as it is overlain by the confining beds of the Anthony Lagoon Formation. Significant bore yields (~15 L/s) from the Anthony Lagoon Formation may also be possible. However, the Anthony Lagoon Formation is not extensive across the region, its high yield zones are somewhat inconsistent and possible water quality issues makes it less prospective for large scale horticultural development.

2.4 Topography

The elevation of this study area is between about 214 to 225 m above sea level (Figure 2.2). The gradient change was gradual across the landscape, with small height changes occurring across large horizontal distances. The higher areas occurred on the western margins, decreasing in height to the east where an ephemeral watercourse has cut through and formed a channel, then disappears into the broad lower-lying areas to the east.

Near the southern study area boundary there are locations where intermittent water accumulation occurs, this is likely due to the constriction of the watercourse channel forcing water from the catchment area to back up. The surrounding catchment can clearly be seen from the elevation data and appears to be ‘eating’ back into the higher landscape. Near the north and north-eastern boundary the elevation is relatively lower, where the ‘Barkly Tablelands’ begins. The landscape is flat with most slopes less than 0.5%, and very few isolated areas with slopes between 0.5 and 3% (Figure 2.3). Noticeable slope or relative

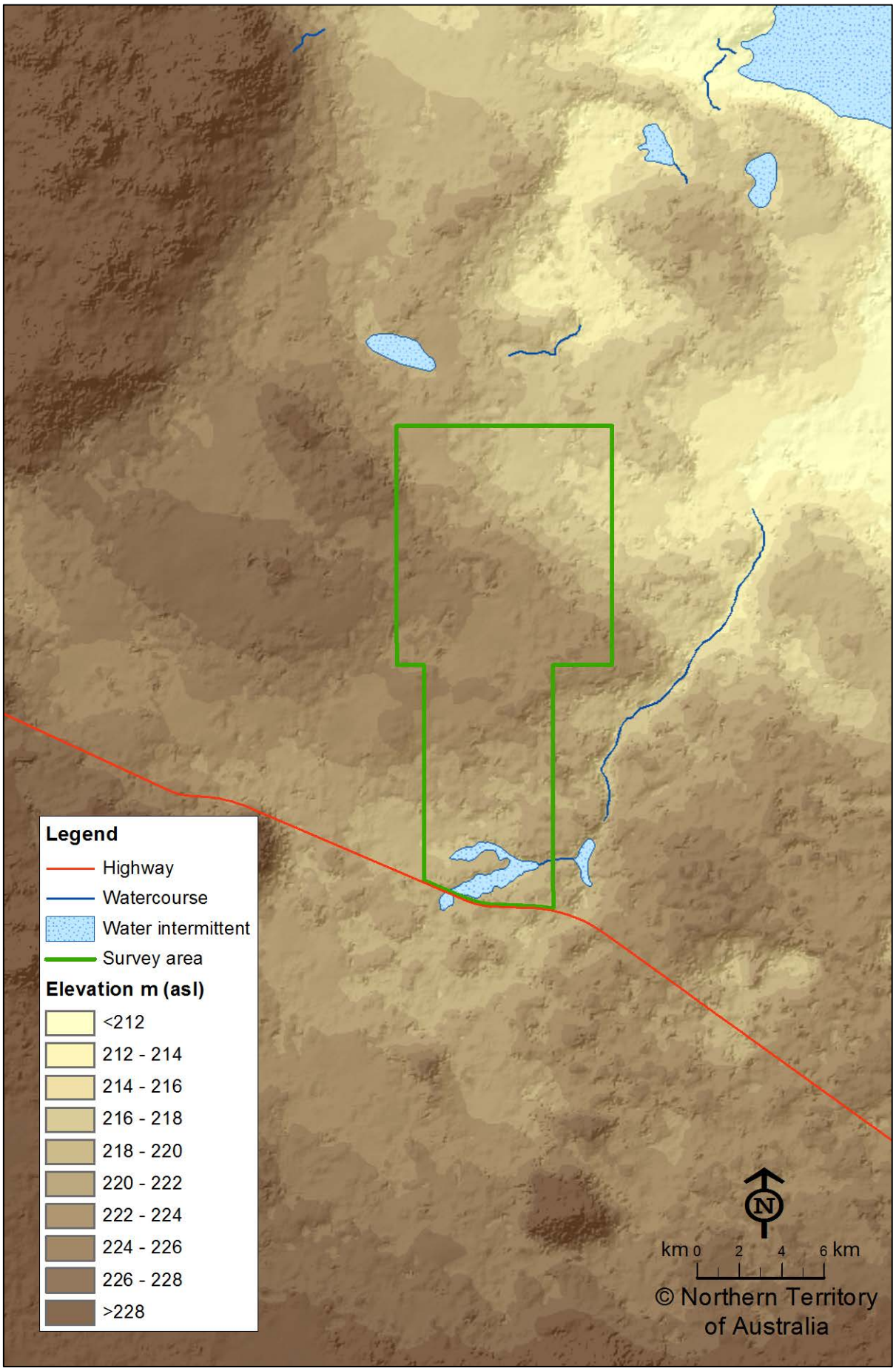


Figure 2.2. Map showing topography in and surrounding this study area (generated from Digital Elevation Model).

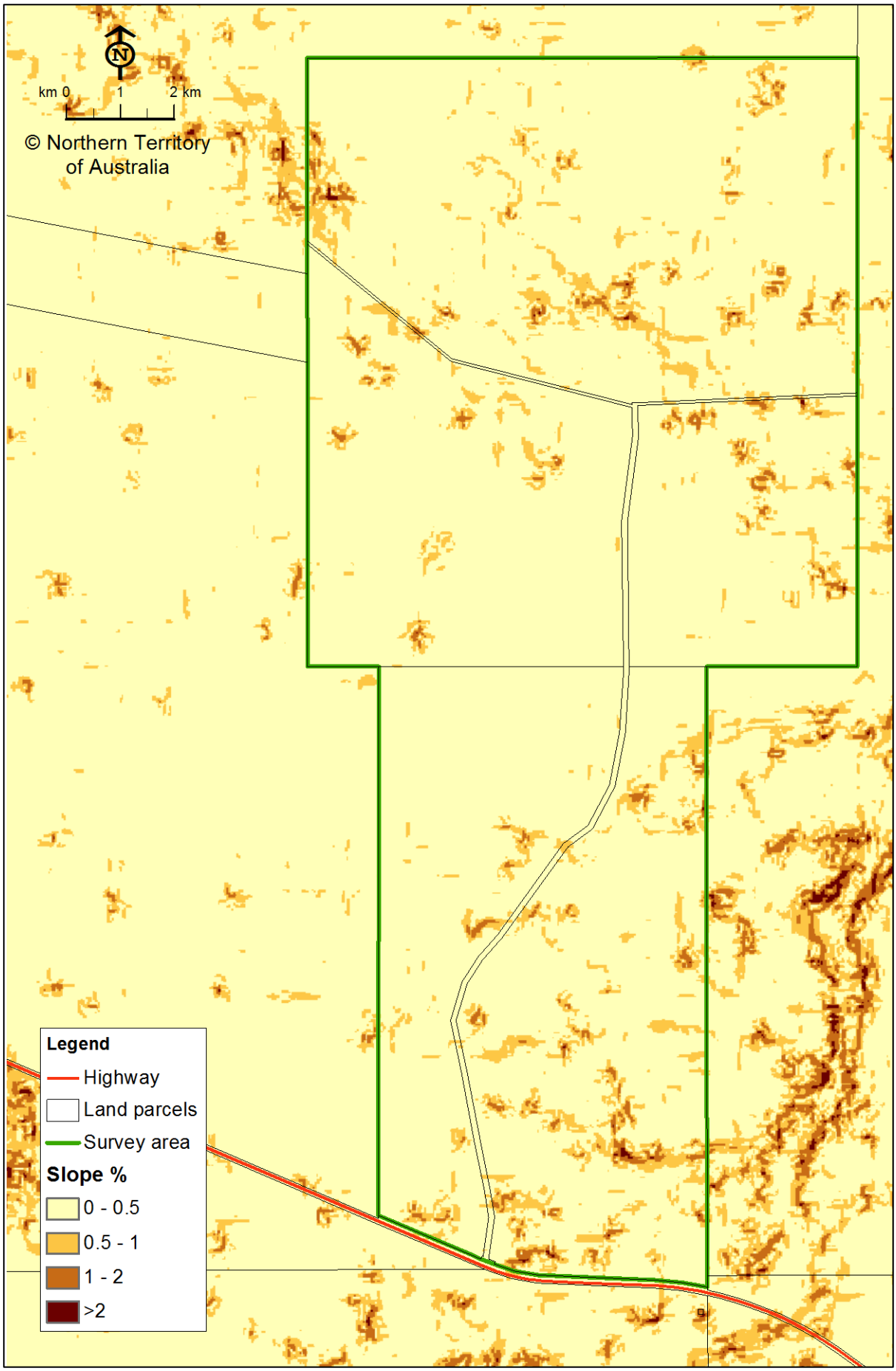


Figure 2.3. Map showing the slope gradient for this study area (generated from Digital Elevation Model).

elevation differences tend to be associated with locations of harder rocks, either a ferricrete cap, or outcrops of quartz and calcrete.

The elevation and slope maps were derived from 1 second SRTM Level 2 Derived Digital Surface Model (DSM) and Digital Elevation Model (DEM) Version 1.0. The 1 second SRTM derived DEM Version 1.0 is a 1 arc second (~30m) grided digital elevation model (DEM). The DEM represents ground surface topography, and excludes vegetation features.

2.5 Vegetation

The study area overlaps the shared boundary of two biogeographic regions according to both the *Terrestrial Ecoregions of Australia* (Commonwealth of Australia, 2013) and the *Interim Biogeographic Regionalisation for Australia, Version 7* (IBRA7) (Commonwealth of Australia, 2012). Table 2.4 summarises the regions occurring within this study area.

Table 2.4. Biogeographic regions found within this study area.

Ecoregion *Terrestrial Ecoregions of Australia*	**Bioregion (subregion)** *Interim Biogeographic Regionalisation for Australia, Version 7* (IBRA7)	**Location within study area**
Tropical and subtropical grassland, savannas and shrublands	Mitchell Grass Downs (MGD01)	North-western three quarters
Deserts and xeric shrublands	Davenport Murchison Ranges (DMR03 – Barkly)	South-eastern quarter

2.5.1 *Vegetation Survey of the Northern Territory, Australia*

This broad scale 1:1,000,000 vegetation mapping survey (Wilson *et al.,* 1990) was undertaken through compilation of existing data and interpretation of satellite imagery, in combination with extensive field work. Structural and floristic classification were based on the structural formations of, and methods used by, Specht (*Structural Formation in Major Plant Communities in Australia – An Objective Assessment* (In prep. at time of reporting)).

Vegetation map units that occur in this study area are listed and described in Table 2.5.

Table 2.5. Vegetation map units occurring in this study area (Wilson *et al.,* 1990).

Map unit	**Dominant community**	**Dominant species (frequency)**	**Habitat description**
96	*Astrebla pectinata* (Barley Mitchell) grassland	*Astrebla pectinata* (70%), *Iseilema vaginiflorum* (50%), *Iseilema membranaceum* (29%)	Plains with deep cracking clays over Tertiary alluvium
42	*Corymbia terminalis* (Bloodwood) low open-woodland with *Triodia pungens* (Soft Spinifex) hummock grassland understorey	*Corymbia terminalis* (42%), *Eucalyptus pruinosa* (33% to the north), *Corymbia aparrerinja* (42%), *Carissa lanceolata* (42%), *Atalaya hemiglauca* (42%), *Acacia lysiphloia* (33%), *Triodia pungens* (42%), *Eulalia aurea* (33%), *Enneapogon polyphyllus* (25%)	Slightly elevated, gently undulating peneplain.

2.5.2 *Land Types of the Southern Part of the Northern Territory*

This polygon spatial dataset provides information on land types over the southern part of the NT, providing land type boundaries and describing their dominant landform, soil and vegetation (Brocklehurst and Trueman, 2015). This is an ongoing cumulative mapping project that is under development on a region by region basis. The dataset is mapped at a nominal scale of 1:250,000. The polygon boundaries are derived from remotely sensed imagery with pixel resolution of approximately 30 m. The boundaries were created using an automated segmentation process that groups like-pixels into polygon segments. These segments were subsequently classified into land types. The final dataset has not been validated in the field and users are advised that attribute accuracy varies.

The five land types occurring within this study area are summarised in Table 2.6.

Table 2.6. Land types occurring in this study area (Brocklehurst and Trueman, 2015).

Land type	Landscape class	Dominant vegetation group	ASC soil order	NVIS vegetation structure	Vegetation species
barklyA	Clay plains	*Astrebla* tussock grassland	Vertosol	Tussock grassland	*Astrebla pectinata, Aristida latifolia, Eulalia aurea*
barklyB	Clay plains	*Astrebla* tussock grassland	Vertosol	Tussock grassland	*Astrebla pectinata, Aristida latifolia, Eulalia aurea*
barklyC	Clay plains	Mixed species tussock grassland	Vertosol	Tussock grassland	*Aristida latifolia, Astrebla pectinata, Brachyachne convergens*
tobN	Limestone plains and rises	Mixed species open tussock grassland	Calcarosol	Open tussock grassland	*Dactyloctenium radulans*, *Enneapogon polyphyllus*, *Enneapogon avenaceus*
prentice2	Lateritic plains and rises	*Corymbia* spp. low open woodland over tussock grassland	Kandosol	Low open woodland	*Corymbia terminalis, Atalaya hemiglauca, Corymbia aparrerinja*

2.6 Climate

The climate of the study area, within the Barkly region, is generally semi-arid with minimal monsoonal influence. The thermal climate zone is classified as “hot dry summer, mild winter” and the seasonal rainfall zone is classified as “arid” (BOM, 2015). According to a modified Köppen climate classification, the key climate group is “Grassland” and the climate class is “winter drought” (BOM, 2015).

Climate data in this report is summarised from daily observations for the period 1889–2014. Data consists of spatially-interpolated estimates from gridded datasets for the point location of the study area (Lat, Long: -19.35 135.40) (Qld Department of Science, Information Technology and Innovation, 2015).

Rainfall is summer-dominant with the period from October to March characterised by higher temperatures and greater rainfall. The period from April to September is characterised by lower temperatures and minimal rainfall. Total annual rainfall is dependent on the influence of

the northern monsoonal effect and associated cyclonic events during the summer period (Wilson *et al.* 1990). There are characteristic differences between the climatic conditions affecting the Barkly region and the more humid, strongly monsoonal areas to the north. Most obvious is average annual rainfall, which for the project area is less than one third that recorded at Katherine. Relative humidity is also consistently much lower in comparison (BOM 2015).

2.6.1 *Rainfall and potential evapotranspiration*

The mean annual rainfall for the study area for the period 1889 to 2014 was 345 mm, and the mean annual number of rain days was 67. The median annual rainfall was lower than the mean, at 308 mm, and represents the preferred measure of 'typical' annual rainfall due to annual rainfall variability (BOM, 2015). The 6 month period from October to March experiences almost 90 percent of the mean annual rainfall. On average, 308 mm of rainfall occurs over a total of 58 rain days during the October to March period, while 37 mm falls over 9.5 rain days during the April to September period. Figure 2.4 presents mean monthly rainfall, median monthly rainfall and mean monthly days of rain for the study area.

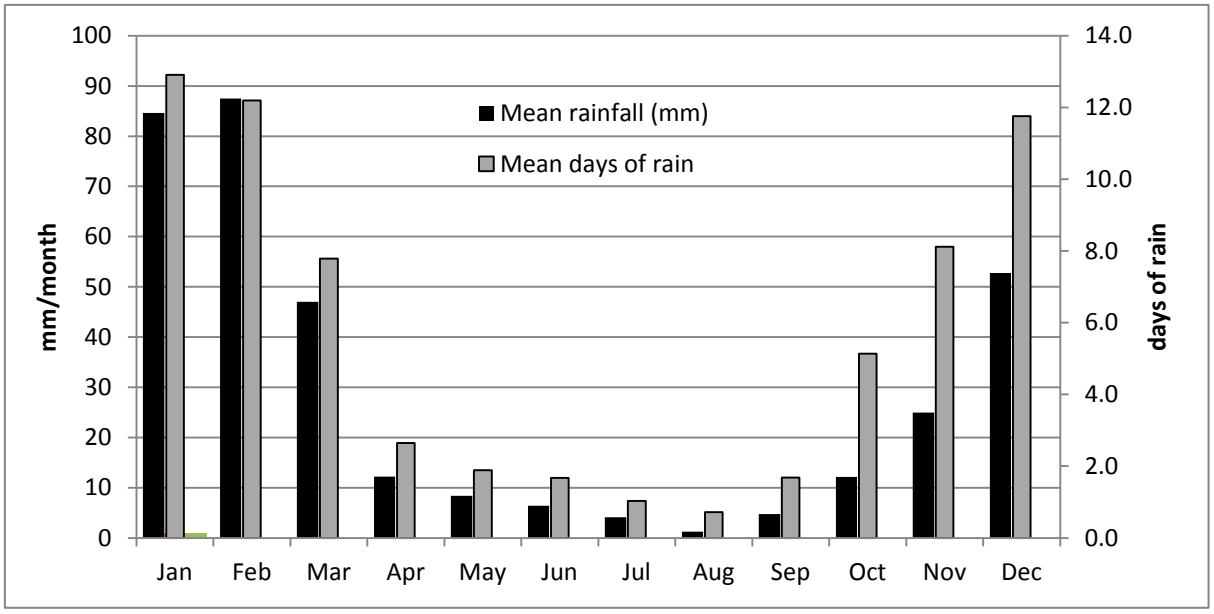


Figure 2.4. Mean monthly rainfall, median monthly rainfall and days of rain for the period 1889-2014.

Mean rainfall values mask the considerable variation in annual rainfall, especially during the wetter summer period. Figure 2.5 highlights this by comparing annual rainfall with 10-year mean annual rainfall for the period 1889 to 2014. Figure 2.6 displays monthly rainfall percentiles which highlight the monthly variation in rainfall from year to year, particularly in the wetter months during October to March.

Mean annual potential evapotranspiration at the study area for the period 1889 to 2014 was 2,147 mm. Mean monthly potential evapotranspiration ranges from a maximum of 224 mm in December to a minimum of 118 mm in June.

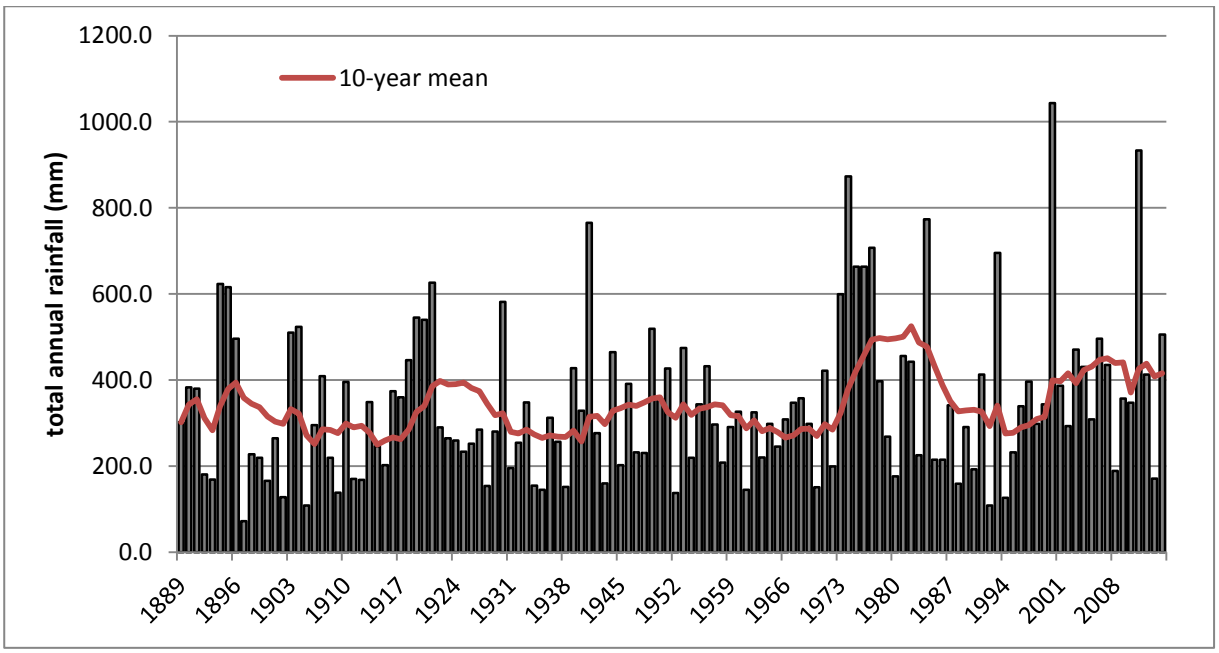


Figure 2.5. Annual rainfall and 10-year mean annual rainfall for the period 1889-2014

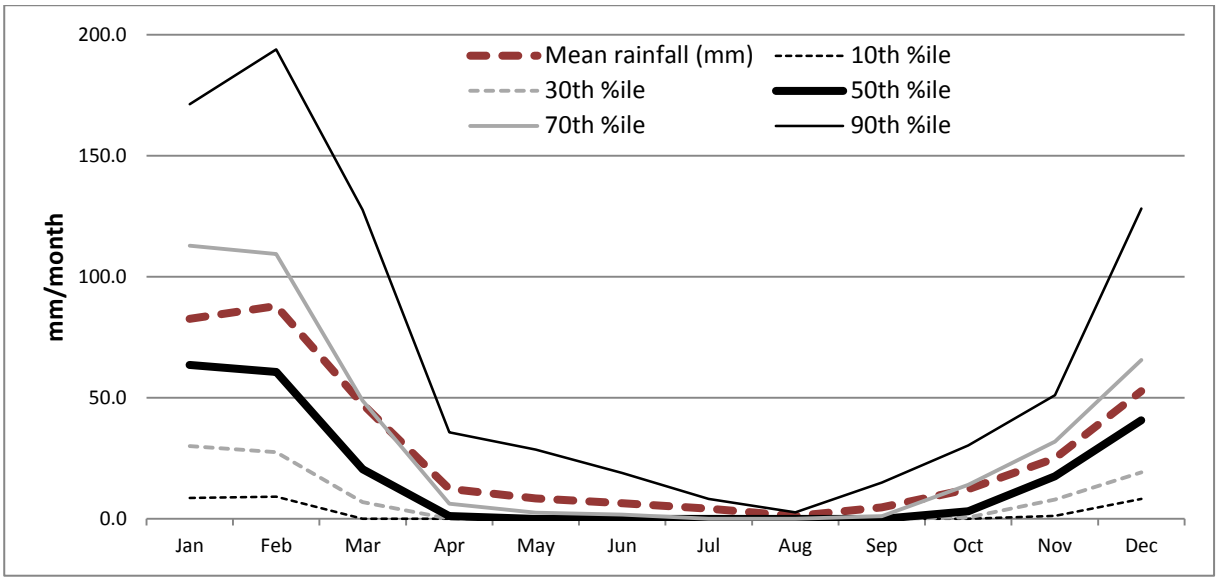


Figure 2.6. Mean monthly rainfall in comparison to 10th, 30th, 50th (median), 70th and 90th monthly rainfall percentiles for the period 1889-2014.

2.6.2 *Temperature and humidity*

Mean maximum monthly temperature for the study area was greater than 32.9°C for the period September to April, and reaches a maximum of 38.5°C in December. During May to August, mean monthly maximums decline, reaching a low of 26°C in July. Similarly, mean minimum monthly temperatures reach a maximum of 24.7°C in January and a minimum of 10.4°C in July (Figure 2.7).

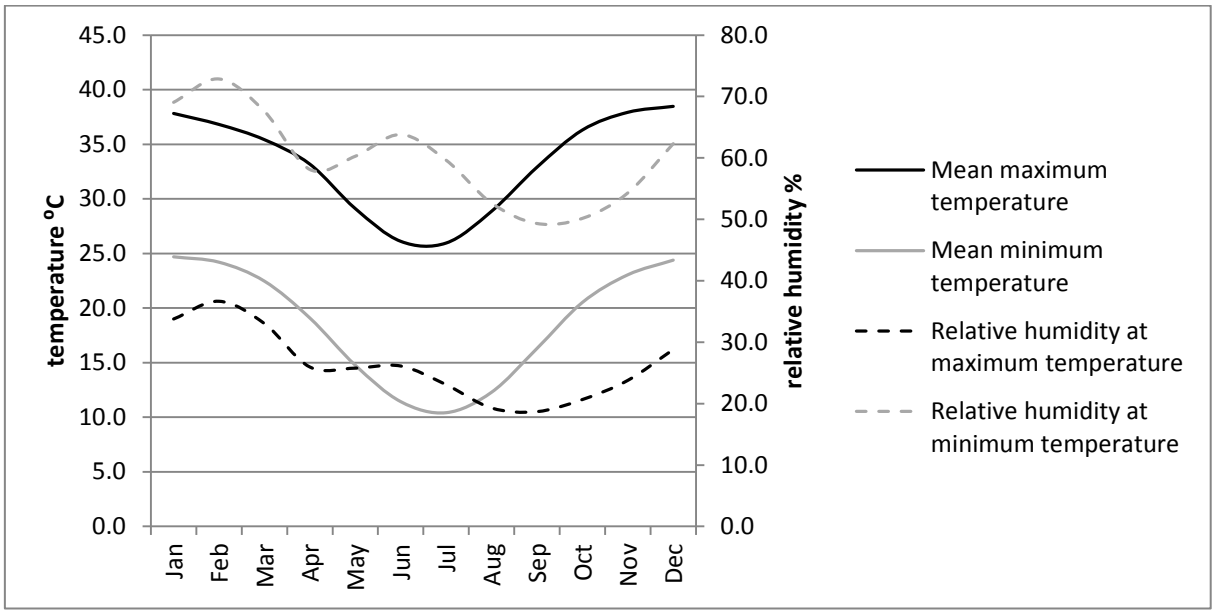


Figure 2.7. Mean monthly maximum, mean minimum temperature and relative humidity for the period 1889-2014.

On average, maximum monthly temperatures are 30°C or more for 265 days of the year, 35°C or more for 165 days and 40°C or more for 37 days. Conversely, frosts are unlikely as minimum monthly temperature rarely drops below 2°C. Table 2.7 presents the mean number of days above or below defined minimum and maximum temperature ranges for the study area.

Table 2.7. Average monthly number of temperature days for the period 1889 to 2014.

°C	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
≥ 40	9	5	1	0	0	0	0	0	0	3	8	11	**37**
≥ 35	26	22	20	9	1	0	0	1	9	23	26	28	**165**
≥ 30	30	27	30	27	14	4	4	13	25	30	30	31	**265**
≤ 15	0	0	0	3	17	26	29	26	11	2	0	0	**114**
≤ 10	0	0	0	0	3	11	15	8	1	0	0	0	**38**
≤ 2	0	0	0	0	0	0	0	0	0	0	0	0	**0**

3. Methodology

3.1 Strategy and rationale

The entire **study area** of 17,232 ha was considered for assessment. However, most field investigative work was conducted on the potential agriculture area of interest identified by the stakeholder, located in the southwest corner of Portion 4802, adjacent to the Barkly Highway and covering an area approximately 2 x 2 km (400 ha).

Field work consisted of one trip of 8 field survey days in October 2015 and a follow-up 3 days in March 2016 to fill in gaps, refine the soil and vegetation characterisation and verify land unit mapping. Mapping achieved was at a medium intensity scale that provides information for agricultural planning. It is not at a level for on-site management. For areas to be developed it is recommended that further site investigations are conducted by a suitably qualified person to confirm the finer scale soil distribution.

Survey design was determined by information provided from the geology map (Kruse and Maier, 2010), previous land resource assessment (Lennartz, 2004), imagery (that was poor quality and not of sufficient resolution for the scale of mapping), and senior surveyor experience. There was no lead-in time to prepare preliminary land units and delineate map boundaries to field characterise, therefore **site placement** was determined each day in the field depending on what was observed in the landscape. In general the northern portion was deemed to be more homogenous and of lesser interest for agricultural development, few sites were placed there. The southern portion contained a range of geology and complex topography; more sites were placed here to better understand the soil landscape relationship and pattern. For the approximate 400 ha area of interest identified by the Stakeholder there were no data features at the time to assist with selecting site locations, nor did an initial free survey identify a predictable pattern to investigate. Therefore a transect approach was followed, with five transects along which sites were placed at regular approximate 300 m intervals.

The **mapping** determined the extent of **Land Units**. A land unit is defined as “a relatively homogenous part of a land surface that is distinct from surrounding terrain and has consistent landform, soil and vegetation properties” (Hooper, 1970). Mapped land units typically exhibit a uniform pattern on imagery and represent a repeatable and recognisable combination of landscape terrain, soil type and associate vegetation community. While some degree of variation is normally present within any land unit, such variation is usually too small or too inconsistent to map separately at the given survey scale. Land unit mapping within the Northern Territory is commonly mapped at scales of 1:25,000, 1:50,000 or 1:100,000.

Cartographic **map scale** was 1:50,000, which is a medium intensity that provides approximate minimum resolution of 25 ha. This is the recommended minimum size of land that the map can be used for. The cartographic map scale is determined by the number of sites investigated, and the information that could be derived from other datasets such as geology and a digital elevation model. Additional field time to acquire more site data would be required to map at a higher resolution. There was sufficient information to prepare a 1:50,000 scale map to assist with broad agricultural planning.

A **map legend** that listed land units and their characteristics was determined after the field work by clustering similar sites based on soil class, vegetation communities, and topography. **Map line-work** to delineate the extent of the land units was then placed based on satellite

image pattern, topographic position, surveyor knowledge gained from travelling over the landscape, the site data, and soil classification and vegetation community. This was later refined once more detailed imagery became available.

Land evaluation was conducted by accessing the soil and land characteristics against an explicit set of criteria. This allows the land evaluation to be updated and refined over time as new information or revised interpretation of existing information becomes available. Because of the broad scale nature of the mapping, land evaluation was conducted to determine the **land capability for irrigated agriculture**. Land evaluation to determine **land suitability for specific crops** or land uses was not considered because for this region there was no information available on crop performance on these types of soils and land units that could be applied to develop the necessary criteria and rules. For the purposes of current planning and use of this survey work, an evaluation to determine the capability of areas for irrigated agriculture should be sufficient to assist with targeting selected areas. These areas can then be accessed with future detailed investigations by qualified people prior to implementing investment and land use changes.

Technical work that includes: field survey approach and specifications, soil and vegetation characterisation, soil and vegetation classification, all followed the established Australian national standards and guidelines. This facilitates uniformity of work with other Australian studies, assists with providing a level of quality and confidence in the work, allows the data to be included in national databases, and allows national linkages to draw on a wider knowledge base to evaluate the data.

Outputs that include: report, map, land evaluation, primary field and analytical data were prepared and managed according to the standards and guidelines of the Land Assessment Branch, Department of Land Resource Management; Northern Territory Government.

3.2 Operational standards

Technical work followed the established Australian national standards and guidelines. These are documented in the following publications:

Soil survey approach and specifications

McKenzie NJ, Grundy MJ, Webster R and Ringrose-Voase AJ, 2008. *Guidelines for Surveying soil and land resources*. *2nd Edition.* CSIRO Publishing, Melbourne

Soil drilling

Department of Land Resource Management, 2014. *EZIPROBE standard operating procedures.* Northern Territory Government, Darwin.

EXIPROBE Pty Ltd., 2013. *Operation, maintenance and spare parts manual for Department of Land Resource Management.* EZIPROBE, Victoria.

Soil and land characterisation

National Committee on Soil and Terrain, 2009. *Australian soil and land survey field handbook. 3rd Edition.* CSIRO Publishing, Melbourne.

Vegetation characterisation

Hnatiuk RJ, Thackway R and Walker J, 2009 *Vegetation.* In *Australian soil and land survey field handbook. 3rd Edition.* National Committee on Soil and Terrain. CSIRO Publishing, Melbourne.

Brocklehurst P, Lewis D, Napier D and Lynch D, 2007. *Northern Territory Guidelines and Field Methodology for Vegetation Survey and Mapping*. Technical Report No. 02/2007D. Department of Natural Resources, Environment and the Arts, Palmerston, Northern Territory.

Soil classification

Isbell RF, 2002. *The Australian soil classification. Revised Edition.* CSIRO Publishing, Melbourne.

Vegetation classification

Executive Steering Committee for Australian Vegetation Information, 2003. *Australian vegetation attribute manual: National vegetation information system (NVIS), Version 6.0.* Department of the Environment and Heritage, Canberra.

Soil laboratory analysis

Rayment GE and Lyons D, 2011. *Soil chemical methods – Australasia.* CSIRO Publishing, Melbourne.

McKenzie NJ, Coughlan KJ and Cresswell HP, 2002. *Soil physical measurement and interpretation for land evaluation.* CSIRO Publishing, Melbourne.

Database

SALInfo, 2015. The Soil and Land Information System (SALInfo) is the corporate data storage facility for soil and land site data managed by the Department of Land Resource Management, Northern Territory Government.

VSD, 2015. Vegetation Site Database (VSD) Northern Territory is the corporate data storage facility for vegetation survey data managed by the Department of Land Resource Management, Northern Territory Government.

Land evaluation

Department of Natural Resources and Mines/Department of Science, Information, Technology, Innovation and the Arts, 2013. *Guidelines for agricultural land evaluation in Queensland. 2nd Edition.* Queensland Government, Brisbane.

Hazelton P and Murphy B, 2007. *Interpreting soil test results: what do all the numbers mean? 2nd Edition.* CSIRO Publishing, Melbourne.

3.3 General approach

The general approach to characterizing the major soil types, vegetation communities, land units, land resource maps, and the land evaluation process is described briefly here. For detailed information the above referenced text should be consulted as that information will not be repeated here.

- Base information was gathered prior to the field survey. This included the reports and data sets referred to in Section *2 Background Information*.

- Access permission to the Aboriginal Land Trust properties was obtained from the Northern Land Council, with assistance from members of the Manungurra Aboriginal Corporation.
- Location of an area of interest for potential agricultural development within the survey area was identified by Members from the Manungurra Aboriginal Corporation. A greater field survey effort was focused on this area to obtain more data.
- Soil survey was carried out by a team of 3 people. Site locations were determined in the field, a trailer-mounted soil core rig was used to obtain soil samples, and the soils were described and classified in the field. All data was recorded on field sheets. See Section *3.4.1 Soil sampling and descriptions*, for more information.
- Soil samples for laboratory analysis were collected at selected sites that at the time were determined to be of significant extent or representative of a soil class. Soil samples were obtained from standard fixed depth intervals following Northern Territory soil survey approach. See Section *3.5 Laboratory analysis of soil*, for more information and analyses conducted.
- Vegetation was described at all sites. Structural and floristic descriptions included identification of strata, measurement of stratum height and cover, identification of plant species, and measurement of species height and cover. Information was recorded on field sheets. See Section *3.4.2 Vegetation sampling and descriptions*, for more information
- Photographs were taken at every site using digital cameras to record the soil core, ground surface condition, surrounding landscape, and vegetation.
- Databases for soil (SALInfo, 2016) and vegetation (VSD, 2016) operated by the Department of Land Resource Management for the Northern Territory Government were used to store the primary field data. Field sheet records were entered, along with selected photographs, and if obtained, the laboratory data.
- Map legend that describes the Land Units was developed after the field work by clustering similar sites based on soil class, vegetation communities, and considering the topography.
- Map line-work to delineate the extent of the land units was based on interpretation of image pattern, topographic position, observed landscape knowledge from field work, and the site soil classification and vegetation community. Line-work was digitised into the Department of Land Resource Management spatial database using ArcGIS. This was later refined once more detailed imagery became available.
- Land evaluation was applied to the land units that occurred in the survey area to determine their capability for irrigated agriculture. This is an explicit process, correct at the time of reporting, however, interpretation may change over time depending on changes in technology or understanding of crop and soil behaviour. The process can be updated if required to provide a revised land evaluation.
- Report and accompanying land unit map prepared. These were reviewed by peers and updated as necessary. They form part of the Land Resource Assessment library of technical reports and spatial data documents produced by the Rangelands Division, Department of Land Resource Management.

3.4 Field survey

3.4.1 *Soil sampling and descriptions*

Site location placement was determined in the field by the soil surveyors based on available spatial information and observed landscape changes. A field computer with real-time GPS locations was used to compare the observed landscape with mapped geology, slope, and elevation to assist with developing the soil landscape relationship.

Geo-referencing of all site locations was conducted using a hand held Garmin GPSMAP 62 device. Site location was obtained using the *mark averaging function*, which took between about 2 and 10 minutes to reach a stable coordinate. Readings were given to a precision of one metre however the accuracy provided would be expected to be about 10 metres.

Soil cores for description and sampling were obtained using a trailer-mounted EZIPROBE soil coring rig that was towed by a 4-wheel-drive vehicle. The EZIPROBE rig is a top-drive hydraulically-operated percussion rig capable of capturing and extracting 38 mm internal diameter relatively intact soil cores. Operations of the drill rig followed the guidelines of EZIPROBE (2013) and Department of Land Resource Management (2014). Drilling obtained intact soil cores to 1.5 m below the surface or until penetration refusal due to hard underlying substrate, gravels, or a tightly packed hard clay soil. Compression of the soil material in the core from the drilling process was usually less than 10%, having minimal impact on determining true horizon depths of the deeper layers. Soil was extruded from the core into sample trays for description and sampling in the field. For the surface layers, usually a small shovel-excavated pit was used to observe the upper 20 to 30 cm of soil layers where finer depth resolution was required.

Describing soil and landform was conducted in the field according to the *Australian soil and land survey field handbook* (National Committee on Soil and Terrain, 2009). Soil descriptions focussed on horizon designation, depth, colour (dry, moist), texture, structure, coarse fragments, segregations, mottles and field pH. Site descriptions focussed on GPS location, microrelief, surface condition, surface coarse fragments, drainage, landform element and pattern. Information was recorded on standard field sheets.

Classifications of all soils to family level of *The Australian soil classification* (Isbell, 2002) were conducted in the field. Generally this field classification carried through to the final classification placed in the database. For some sites this was revised during the data evaluation and mapping, with the revised classification placed in the database and noted on the field card.

3.4.2 *Vegetation sampling and descriptions*

Measurement and identification of vegetation structure and floristics at each survey site was undertaken within 20 m x 20 m (400 m^2) sample plots. Ground, ± middle and ± upper strata were identified and the average height, height ranges, predominant growth form and percentage covers were either measured or estimated. In addition, species in each stratum were identified and, for dominant species only, percentage cover, average height and height ranges were also recorded for each stratum.

Assessment of crown cover varied depending on the strata being assessed. Due to the open to sparse nature of the upper and mid strata, crown cover percentage at all field sites was

estimated. Ground strata covers were estimated using foliar intercepts along a 50 m line transect.

Description and classification of the vegetation communities was undertaken using standard conventions and terminology defined by the National Vegetation Information System (NVIS) (ESCAVI, 2003). In particular, recorded height categories, cover classes and growth forms are compliant with the definitions and conventions described in the NVIS (ESCAVI, 2003). A basal sweep using a basal wedge (Bitterlich gauge) was undertaken to determine dominance (m^2/ha) of woody species in woodlands.

Species identification was undertaken in the field using several field identification guides for the Central Australia and Barkly regions. Where identification was uncertain in the field, photographs and samples were collected and subsequently identified using published keys and with reference to the NT Herbarium collection.

Following field measurement and description, vegetation communities were classified according to the Broad Floristic Formation level (Level III), as defined by NVIS (ESCAVI, 2003). Classification to this level includes only the dominant stratum genus, growth form, cover and height class (e.g., "*Eucalyptus* mid open woodland"). However, for reporting purposes, descriptions were often widened to include dominant and co-dominant upper strata species, as well as dominant or characteristic mid strata and ground strata species.

3.5 Laboratory analysis of soil

Selected sites had soil samples collected from pre-determined depths. Samples were collected for whole of soil (not sieved) and bagged in the field. Sites were selected to cover the range of soil type classifications encountered and land units identified. These samples were used to provide quantitative laboratory data on soil properties and assist with characterising representative soil profiles.

Soil samples were obtained from the same regular fixed depth intervals at all sites, following the Northern Territory soil survey approach. Every 10 cm for the upper 30 cm, and then a 10 cm interval at every 30 cm increment down the soil profile; these depths were: 0.0-0.1, 0.1-0.2, 0.2-0.3, 0.5-0.6, 0.8-0.9, 1.1-1.2, 1.4-1.5 m. Variation to the sample depth interval occasionally occurred where the sample intervals crossed a significant soil change e.g. at the surface where a thin horizon occurred (often a 0.0-0.05 m interval was sampled), or samples not collected at depth due to soil core drilling refusal due to layers too difficult to penetrate.

A comprehensive and standard set of chemical and physical analyses were undertaken, based on previous Northern Territory soil survey experience, to provide a broad suite of characterisation data for this general purpose soil assessment. All samples underwent the same suite of analysis, and surface layer samples having additional soil fertility parameters measured. A test to estimate gypsum concentration was conducted on a few selected samples to determine the concentration.

A brief explanation of the key soil analysis and how they are interpreted is provided in Table 3.1. Analysis conducted, methods, and their details are provided in Table 3.2.

Laboratory analysis was conducted by the Department of Science, Information Technology and Innovation (DSITI), Natural Resource Sciences Chemistry Centre, Queensland. A total of 102 soil samples from 18 profiles were analysed. Results were provided on 29/03/2016 for Batch 1 and 29/06/2016 for Batch 2.

Table 3.1. Laboratory analysis and what the data interpretation describes.

Laboratory analysis	Interpretation of analysis
pH (1:5 soil/water)	Measure of the relative acidity or alkalinity of soil material. It affects the availability of nutrient, toxic elements, and chemical species to root plants. Soil pH is important as it influences many other soil characteristics.
Electrical conductivity	Estimate of the concentration of total soluble salts in the soil solution. The electrical conductance increases with soluble salt content and thus allows simple interpretation of readings. Plants vary considerably in their tolerance to salt. Sodium chloride is usually the dominant salt in soils and its high mobility makes it a valuable indicator of the direction of salt and water movement.
Soluble chloride	Measure of the level of soluble chloride in the soil solution; provides a direct estimate of the soluble sodium chloride concentration in the soil solution. It is specifically toxic to some plants.
Nitrate nitrogen	Measure of the amount of nitrogen readily available to plants.
Cation exchange capacity	Cation exchange capacity is a measure of the soil capacity to retain cations based on the surface area and surface charge of the clay fraction. Influences physical and chemical properties particularly in the clay subsoil.
Exchangeable calcium	Measure of the amount of Ca on the clay exchange complex.
Exchangeable magnesium	Measure of the amount of Mg on the clay exchange complex.
Exchangeable sodium	Measure of the amount of Na on the clay exchange complex.
Exchangeable potassium	Measure of the amount of K on the clay exchange complex.
Base status	Measure of leaching status and capacity to retain nutrients; calculated as the sum of exchangeable cations (Ca, Mg, K, Na) divided by the clay fraction and expressed as a percentage.
Ca/Mg ratio	Measure of the relative dominance of magnesium, useful in explaining soil physical behaviour.
Clay activity ratio	Used to infer clay mineralogy and reactivity of the clay fraction.
Exchangeable sodium percentage	Measure of soil sodicity, which affects the physical behaviour (permeability/density/strength) and dispersive nature of soils. Exchangeable sodium percentage measures the relative abundance of Na on the exchange complex.
Dispersion ratio (R1)	Measure of soil dispersion based on the amount of dispersed silt and clay during testing compared with total silt and clay levels.
% Coarse sand (0.2 – 2 mm)	Visible sand range, open pore spaces, friable, permeable.
% Fine sand (0.02 – 0.2 mm)	Non-visible sand, causes packing, increased density, intractable, “bulldust”, hardsetting, erodible.
% Silt (0.002 - 0.02 mm)	Causes increased packing and density, highly erosive fraction, surface sealing, intractable, dilatancy, “bulldust”, hardsetting.
% Clay (< 0.002 mm)	Colloidal fraction, determines cation exchange capacity, moisture holding capacity, shrink-swell characteristics, soil structure and cracking behaviour.
Air dry moisture content	Used for conversion of air dry data (30-40°C) to an oven dry (105°C) basis.
15 bar	Estimate of moisture retention at approximate wilting point.
1/3 bar	Estimate of moisture retention at approximate field capacity.
Total organic carbon	Provides an estimate of the total carbon store in the surface soil; used to calculate to surrogate organic matter estimates. Levels are commonly higher in the upper surface horizons and can affect water retention and soil bulk density.

Laboratory analysis	Interpretation of analysis
Kjedahl nitrogen	Provides an estimate of the total store of nitrogen in the surface soil that can potentially be mineralised.
Bicarbonate extractable phosphorus	Provides a reliable and consistent estimate of plant available phosphorus in the surface soil across a range of pH conditions.
Acid extractable phosphorus	Alternate measure of plant available phosphorus in the surface soil; developed for fertility assessment in the Queensland cane industry.
Replaceable potassium	Provides an estimate of the relative abundance of potentially available potassium within the fine earth fraction.
Extractable sulfate Sulfur	Provides a reliable and consistent estimate of plant available sulfate sulphur.
Exchangeable calcium	Provides an estimate of the relative abundance of potentially available calcium within the fine earth fraction.
Extractable trace elements - Cu, Fe, Mn, Zn	Provides a reliable and consistent estimate of plant available trace elements. These nutrients often act as catalysts in chemical reactions. It is possible to have toxicities, as well as deficiencies.

Table 3.2. Soil analysis conducted, methods used, and description (from DSITI Chemistry Centre).

Name	Analyte	Method Code*	Uncertainty %	PQL**	Unit	Method Description
All samples						
Air Dried Moisture Content	ADMC	2A1	8	1.5	%	Moisture air dry, oven dry 48 hours at 105°C
Electrical conductivity	EC	3A1	10	0.01	dS/m	pH EC Aqueous (1:5)
pH	pH	4A1	5	0.1		pH EC Aqueous (1:5)
Chloride	Cl	5A2	10	20	mg/kg	Cl NO3-N Aqueous (1:5)
Nitrate-nitrogen	NO3-N	7B1	15	1	mg/kg	Cl NO3-N Aqueous (1:5)
Organic Carbon	OC	6A1	10	0.03	%	C organic (Walkley & Black)
Exchangeable calcium	Ca	15C1_Ca	10	0.18	cmol_c/kg	Cations exchangeable alcoholic NH4Cl pH8.5
Exchangeable magnesium	Mg	15C1_Mg	8	0.3	cmol_c/kg	Cations exchangeable alcoholic NH4Cl pH8.5
Exchangeable sodium	Na	15C1_Na	10	0.09	cmol_c/kg	Cations exchangeable alcoholic NH4Cl pH8.5
Exchangeable potassium	K	15C1_K	12	0.02	cmol_c/kg	Cations exchangeable alcoholic NH4Cl pH8.5
Effective cation ex.capacity	ECEC	15J1			cmol_c/kg	Sum of exchangeable cations
Exchangeable Na%	ESP	15N1	0	0.1	%	Cations exchangeable alcoholic NH4Cl pH8.5 calculations
Coarse sand: Sieve 0.2-2.0 mm	Coarse sand	2Z2_CS	10	1	%	Particle size analysis
Fine sand: Sieve 0.02-0.2 mm	Fine sand	2Z2_FS	8	1	%	Particle size analysis
Silt: hydrometer 2-20 um	Silt	2Z2_Silt	8	1	%	Particle size analysis
Clay: hydrometer <2 um	Clay	2Z2_Clay	5	1	%	Particle size analysis
Dispersion Ratio (R1)	R1	2Z2_R1	8	0.1	%	R1 Dispersion Ratios
Permanent wilting point (15 Bar)	15 Bar	2E1	15	1.5	%	Moisture 15 Bar pressure plate
Field capacity moisture (1/3 Bar)	1/3 Bar	2E2	15	0.3	%	Moisture 1/3 Bar pressure plate
Surface samples only						
Kjeldahl nitrogen	TKN	7A2	10	0.013	%	N Kjedahl digest AA
Phosphorous (Colwell)	P	9B2	10	2	mg/kg	P extractable 0.5M NaHCO3 AA
Sulfur	S	10B3	10	1	mg/kg	Sextractable 0.01M Ca(H2PO4)2 ICP
Copper	Cu	12A1_Cu	10	0.1	%	Cu Fe Mn Zn (trace) 0.005M DTPA ICP
Zinc	Zn	12A1_Zn	10	0.1	%	Cu Fe Mn Zn (trace) 0.005M DTPA ICP
Manganese	Mn	12A1_Mn	10	2	%	Cu Fe Mn Zn (trace) 0.005M DTPA ICP
Iron	Fe	12A1_Fe	10	2	%	Cu Fe Mn Zn (trace) 0.005M DTPA ICP
Replaceable potassium	K	18B1	8	0.1	cmol_c/kg	Replaceable K 0.05M: HCl: ICP

*Method Code from *Soil Chemical Methods – Australasia* (Rayment and Lyons, 2011) **PQL – minimum Practical Quantitation Limit

3.5.1 *Number of sites*

Field survey consisted of 8 days in October 2015 and a follow-up 3 days in March 2016 to fill-in gaps. During this time the survey area was traversed by vehicle to observe the landform and vegetation pattern to assist with mapping. All existing tracks were followed, and where necessary off-track to get to selected areas. Most of the time was used to describe 92 sites in detail for landform, soil and vegetation characteristics; and collect soil samples for laboratory analysis (Table 3.3). The distribution of sites is presented in Figure 3.1.

Table 3.3. Observation type, data obtained, and number of sites assessed.

Observation Type (according to Schoknecht *et al.*, 2008)	**Data obtained**	**Number of Sites**
Detailed soil profile and vegetation descriptions	Detailed morphological and site descriptions that can be used to characterise the main soil and landscapes in a survey area. Detailed description of the vegetation floristics and structure.	72
Deep borings	Examine material below the normal depth of soil descriptions and provides information on subsolum and substrate properties for land use.	0
Profiles for soil sampling	Where soil samples are taken for laboratory analyses. Provides information on chemical and physical properties to characterise typical or reference soils in a survey area. Also, includes the data collected for the *detailed soil profile description* observation type.	18
Mapping observations	Brief observations to confirm mapping boundaries, soil-type distributions or other characteristics being mapped.	2 (plus many other not recorded observations)
Total from this field survey		**92**
Previous work	From Lenarrtz (2004). Includes landscape description, soil morphology, vegetation description and limited soil laboratory analysis. Considered equivalent to observation type – *detailed soil profile and vegetation descriptions.*	20
Total sites available		**112**

3.5.2 *Sampling density, survey intensity and cartographic map scale*

Sampling cost and time available will limit the number of ground observations. The minimum density of ground observations will depend on the purpose and scale of the survey, prior knowledge of the region, surveyor's experience, the complexity of the region and the sampling scheme chosen (Schoknecht *et al.*, 2008).

Industry guidance is provided to assist in determining the effort (sampling density) required and survey intensity that the number of ground observations can support for a particular cartographic scale. For a 1:50,000 scale soil map the recommended area per observation is between 25 ha per observation (upper recommended range) to 100 ha per observation (minimum acceptable) (Table 14.4 in Schoknecht *et al.*, 2008; after Gunn *et al.*, 1988).

For this survey with a total area of 17,232 ha, that equates to approximately 689 (upper recommended range) to 172 observations (minimum acceptable) where required and to be distributed proportionally across the observation types as outline in Table 3.4.

Review of Table 3.4 indicates that observation types – *detailed soil profile descriptions* and *profiles for sampling* – fall within the required range, e.g. *profiles for sampling* the range spans 2 to 34 observations: 18 were sampled; and *detailed soil profile descriptions* the range spans 26 to 241 observations: 90 (+20) were observed. *Deep borings* are deficient in numbers, due to not having the required drilling equipment. If an area was to be developed for irrigated agriculture then deep drilling assessment should be conducted as a priority to provide an improved understanding of the substrate and the impact on water movement.

Two *mapping observations* were undertaken. However, many mental observations were made throughout the survey that were not recorded but used to support map-line placement. Additionally, these guidelines were established more than 25 years ago (e.g. Gunn *et al.,* 1988) when map-line placement relied heavily on field observation and interpretation of stereo air photographs. For this survey we had access to high resolution spectral imagery and digital elevation model data, which provided exceptional information on spatial patterns to support map unit boundary placement. The survey area was relatively undisturbed with the presence of remnant vegetation; this vegetation could be observed with the high resolution imagery and was a useful predictor for the soil type and delineation of the land unit boundaries. Also, the relatively low vegetation cover allowed the surface soil colour to be readily determined, this was a useful predictor given the marked soil colour differences between grey and red soils. The digital elevation model data provided guidance on topography and landform structure. The spatial data available allowed the surveyor to remotely determine boundaries in an efficient way, allowing field work time to be spent on observations that provided detailed soil profile and vegetation data to enable characterisation of the land unit, rather than mapping observations to ground truth map unit boundaries.

The field data provides truth of ground conditions. The observation density of detailed soil types to characterise land units is within the recommended lower range to support the production of a cartographic scale soil map of 1:50,000. The high resolution spatial data available allowed the land unit boundary lines to be delineated with reasonable confidence for a 1:50,000 scale soil map. This was verified by the follow-up field work that checked boundaries crossing tracks and confirmed placement was reasonable.

The area of interest had an increased site density that could support a more detailed map scale. Evaluation of the data determined that the land unit detail was sufficient to delineate that landscape variation. The extra site data did allow land unit map boundaries to be placed with more confidence and show finer detail. Therefore it was decided not to increase the map scale for this area of interest as the detail could be observed on the 1:50,000 scale map.

Table 3.4. Number of actual soil observations compared with recommended for a soil map with cartographic scale of 1:50,000.

Observation type	Recommended percentage of observations	Number of observations for survey area of 17,232 ha based on			Actual number of obs.
Total	100%	172 – minimum acceptable 1 obs per 100 ha	345 – lower range 1 obs per 50 ha	689 - upper range 1 obs per 25 ha	
Detailed soil profile and vegetation descriptions	15-35%	**26**-60	52-121	103-**241**	90 (+20)
Deep borings	1-5%	**2**-9	3-17	7-**34**	0
Profiles for sampling	1-5%	**2**-9	3-17	7-**34**	18
Mapping observations	55-83%	**95**-143	190-286	379-**572**	2 (many not recorded)

3.6 Data storage and availability

Field site records describing landform, soil morphology, soil chemistry, physical soil data and photographs are stored in the Northern Territory's Soil and Land Information system (SALInfo). Vegetation information from each site is stored in the Vegetation Site Database, Northern Territory (VSDNT).

Spatial data and map products are stored in the Department's corporate spatial library and are available on request. The report for this project is available electronically from the Northern Territory library, while technical data, project findings and derived map products can be accessed and downloaded from the Department's web-enabled data and information centre, *NR Maps*. http://nrmaps.nt.gov.au

The metadata for the spatial dataset is at:

http://www.ntlis.nt.gov.au/metadata/export_data?type=html&metadata_id=255394F9C1858055E050CD9B214427D3

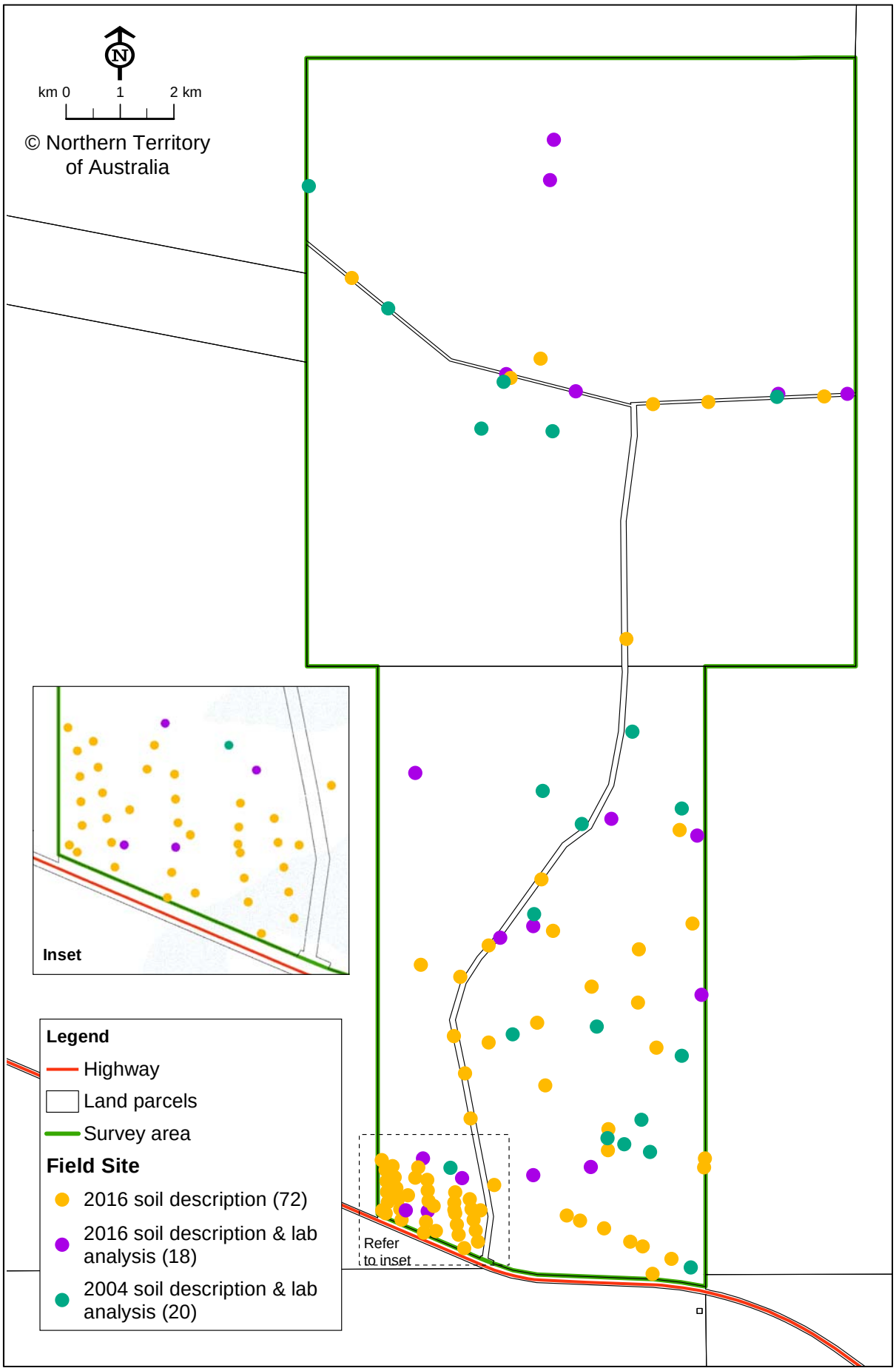


Figure 3.1. Map showing the location of the described and sampled sites for the study area.

4. Landscapes

At a broad level, the study area covers two very different major landscapes: level clay-rich soil plains in the north (~13,200 ha), and level to undulating sandy semi-desert country in the south (~3,150 ha). The boundary between the two landscapes has been documented both geologically (Kruse and Maier, 2010) and bioregionally (Commonwealth of Australia, 2012; 2013; Wilson *et al.*, 1990). A third minor landscape – poorly drained depressions – occurs in the south-west (~850 ha).

4.1 Clay-rich soil plains

The clay-rich plains are associated with the Cenozoic grey-black *clay-rich soil* (Czb) geology, and are typical of the "Barkly Tableland – Mitchell Grass Plains". Soils are dominated by Grey Vertosols (self-mulching cracking clays) and are characterised by the formation of gilgai. Vegetation is typically treeless and dominated by Mitchell grass (*Astrebla* spp.) tussock grassland. Extensive very level areas (<0.2% gradient) occur in this landscape

Two other minor and distinct landscapes occur within the clay-rich plains:

- Gravelly red loamy plains on an outcrop of Paleozoic sedimentary geology of the *Anthony Lagoon Formation* (Cmy) (~800 ha). Soils are Red Kandosols (massive earths) with ironstone surface gravel. Vegetation is tussock grasslands with isolated clumps of Ghost Gum (*Corymbia aparrerinja*) trees.
- Drainage systems (~800 ha) in the north-east consisting of shallow, very broad drainage channels. Soils are Grey Vertosols, (self-mulching cracking clays). Vegetation is mid tussock grassland.

4.2 Sandy semi-desert country

The sandy semi-desert country is associated with Cenozoic *calcrete* (Czk) and *unconsolidated sand* (Czs) geology and consists of level to gently undulating peneplains and sand plains. The calcrete formation enters the study area from the south-east and contains outcrops of low discontinuous rubble tracts and isolated rises. The unconsolidated sand moves in from the south where it blankets the country and consists of sand and silt colluvium. Soils vary and include Kandosols (massive earths), Tenosols (earthy sands) and Calcarosols (calcareous earths). Vegetation is typically low open woodland of Bloodwood (*Corymbia terminalis*) or Smooth-Barked Coolibah (*Eucalyptus victrix*), and tussock grassland.

4.3 Poorly drained depressions

The poorly drained depressions are a low-lying landscape within the study area and are closely delineated by the geological unit defined as Quaternary *claypans* (Qp). The accumulation of water is likely to occur every one to five years, causing intermittent ponding. These depressions consist of clay and silt-rich fine sediments that form Grey and Brown Vertosol (cracking clay) soils. Vegetation is typically Smooth-Barked Coolibah (*Eucalyptus victrix*) low open woodland and Brown Silkytop (*Eulalia aurea*) tall tussock grassland.

5. Land units

This section provides a summary of the land units mapped for the Kurnturlpara and Warumungu Aboriginal Land Trusts study area. Landform is used to initially separate the landscape, and further separation is then based on soil and vegetation to determine a unique Land Unit. This allows for a simplification of land areas to have a relative degree of homogeneity in often variable and complex landscapes.

Land Unit codes comprise a primary number defined by a Northern Territory wide landform classification (Hill and Napier, 2015), e.g. Landform Class – *8 Plains (0-9 m relief)*. A second letter and third numeric code is used to signify the finer detail that denotes a unique combination of soil and vegetation (e.g. 8G1). It should be noted that the map unit code e.g. 8G1 and its definition only applies to this study area Land Unit map, it does not imply the 'same' or is correlated to other Land Units of the same code reported and mapped elsewhere, only the first primary number (e.g. 8) is defined and consistent across the Northern Territory and implies a similar landform.

5.1 Map legend and distribution of Land Units

The Kurnturlpara and Warumungu Aboriginal Land Trusts study area Land Units map legend (Table 5.1) provides a summary description for each area delineated on the Land Unit map (Figure 5.1).

The representative sites and the land units that they occur in are listed in Table 5.2.

5.2 Land units, sites described, and map quality

In generally the delineated map units 'honoured' nearly all of the ground truth sites (i.e. the field described site soil classification matched the named land unit soil description classification). At the order level of soil classification 106 out of 110 sites (96%) matched the land unit description, and at the more detailed suborder level 76 out of 90 sites (84%). Indicating that at this scale of mapping, the quality of mapping is good for the ground truth data set collected during the survey. However, the true test of map quality would now be to locate a random set of sites and test with this separate dataset. This is not normally conducted because of the added cost and time.

Review of the outlier sites indicate that they occurred in areas too small to map at this broad scale or they differed only marginally in terms of soil from those named for the land unit class. These outliers, while they differed in classification, had similar properties to those named in the land unit and would not have any significant difference on land use.

The map quality and land unit descriptions are considered to be appropriate and fit for purpose.

5.3 Conceptual toposequence

A conceptual toposequence was constructed to convey our understanding of the landscape and shows the relationship of Land Units with each other and describes their main characteristics; this is presented in Figure 5.2.

Table 5.1. The Land Unit map legend for Kurnturlpara and Warumungu ALT trusts study area.

Land unit code	Landform	Soil	Vegetation	Area (ha)
Plains				
8P1	Level plain with many ferruginous gravels on surface	Moderately deep, red, loam, containing ferruginous fragments	*Aristida contorta*, *Dactyloctenium radulans*, *Sporobolus australasicus* low open tussock grassland	436
8P2	Level to gently undulating plain with termitaria microrelief	Shallow, brown, loam grading to clay loam	*Aristida inaequiglumis*, *Eriachne obtusa* tall open tussock grassland with *Corymbia aparrerinja* isolated clumps of trees	274
8P3	Level plain with loose surface conditions	Deep, sand grading to red, massive, sandy loam	*Aristida holathera*, Aristida inaequiglumis, *Chrysopogon fallax* mid tussock grassland	19
8P4	Level plain with termitaria microrelief	Moderately deep, loamy sand grading to red, massive, clay loam	*Aristida hygrometrica*, *Chrysopogon fallax*, *Aristida holathera* mid tussock grassland	122
8P5	Level plain	Shallow, brown, loamy sand grading to sandy loam	*Eucalyptus victrix* low open woodland	73
8P6	Level plains and low rises of quartz and limestone outcrops	Shallow, sandy loam, containing many quartz and calcrete fragments	*Eriachne obtusa*, *Aristida holathera*, *Enneapogon purpurescens* mid tussock grassland	1,157
8P7	Level to gently undulating plain	Moderately deep, red, loamy sand grading to clay loam	*Corymbia terminalis*, ± *Hakea arborescens*, ± *Ventilago viminalis* low open woodland	1,389
8P8	Level plain with termitaria microrelief	Deep, red, sandy loam grading to clay loam	*Corymbia terminalis*, ± *Eucalyptus victrix* low open woodland	297
8P9	Level plain with termitaria microrelief	Deep, loamy sand grading to red, massive, clay loam	*Triodia schinzii*, *Paraneurachne muelleri* tall hummock grassland	229
Drainage Systems				
10A1	Level plain, shallow broad alluvial plain, with gilgai microrelief	Very deep, cracking, grey, clay	*Astrebla elymoides*, *Iseilema vaginiflorum*, *Polymeria longifolia* mid tussock grassland	789
10D1	Drainage channel	Moderately deep, brown, massive, sand	*Eucalyptus victrix*, *Atalaya hemiglauca*, *Acacia elachantha* low open woodland	40
Inland Wetlands				
13S1	Closed drainage depression, with gilgai microrelief, subject to temporary inundation	Very deep, cracking, grey, mottled, clay	*Eulalia aurea* tall tussock grassland	276
13S2	Margin areas of drainage depression, with gilgai microrelief	Moderately deep, cracking, grey, clay	*Aristida latifolia*, *Eulalia aurea*, *Iseilema vaginiflorum* mid tussock grassland	558
13S3	Level plain, with many surface gravels	Very shallow, clay loam	*Aristida contorta*, *Aristida holathera*, *Fimbristylis dichotoma* low tussock grassland	16
Downs Plains				
14G1	Level plain with gilgai microrelief	Very deep, cracking, grey, clay, gypsum and sodic at depth	*Astrebla pectinata*, *Aristida latifolia* mid open tussock grassland	10,399
14G2	Level plain with no gilgai microrelief	Very deep, imperfectly drained, cracking, grey, clay	*Iseilema vaginiflorum*, *Fimbristylis dichotoma*, *Chloris pectinata* low open tussock grassland	1,158

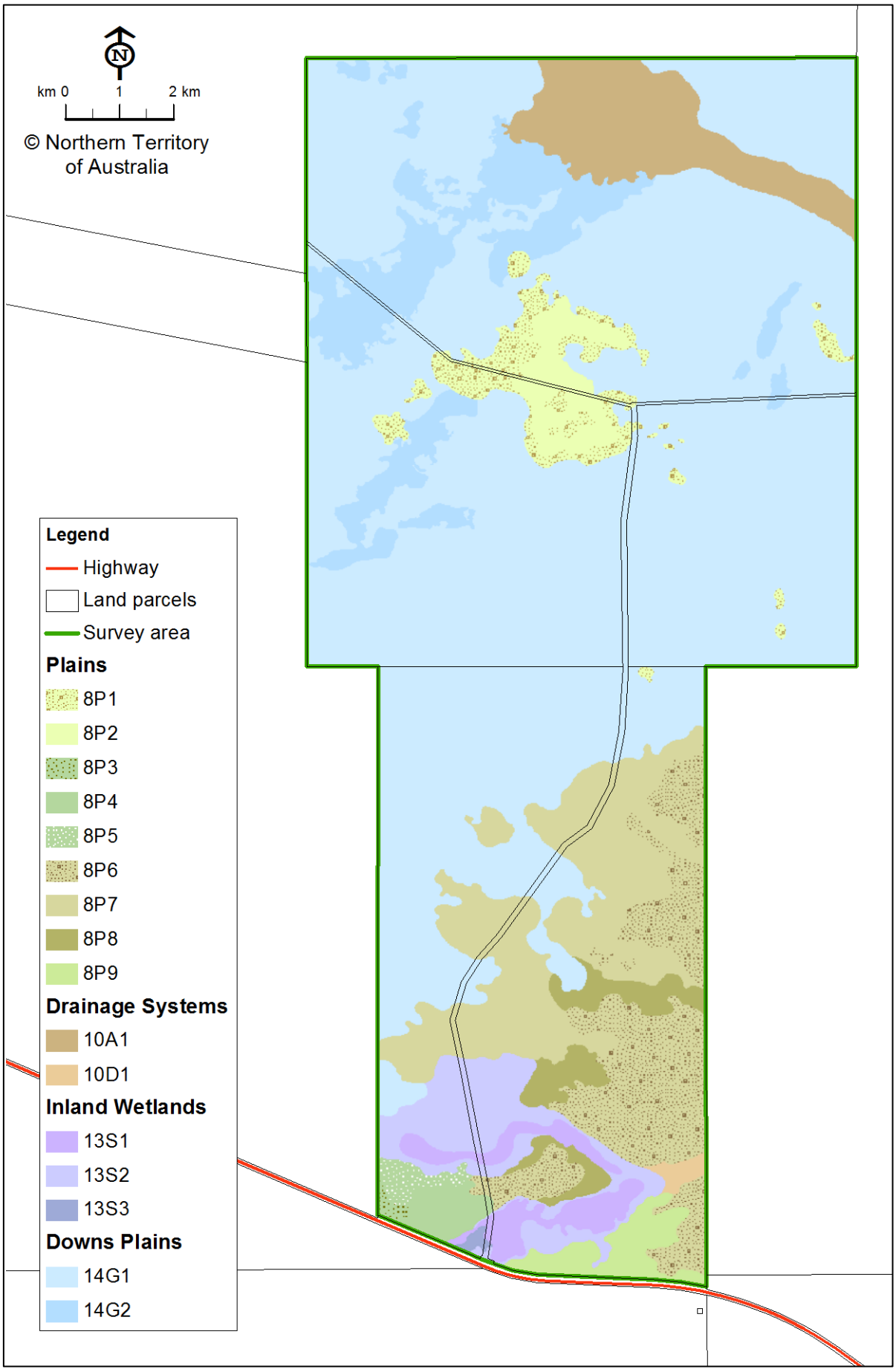


Figure 5.1. Distribution of Land Units in the Kurnturlpara and Warumungu Aboriginal Land Trusts study area.

Table 5.2. Land units, representative site numbers and number of sites described.

Land unit map code	Type site number usually with laboratory data	Total number of sites described in the Land unit
Plains		
8P1	187	4
8P2	143	2
8P3	107	5
8P4	163	18
8P5	192	13
8P6	177, 181	16
8P7	127, 191, 131	12
8P8	180, 182	5
8P9	115 not sampled for analysis	3
Drainage Systems		
10A1	188	1
10D1	116 not sampled for analysis	3
Inland Wetlands		
13S1	103	4
13S2	122 not sampled for analysis	4
13S3	175 not sampled for analysis	3
Downs Plains		
14G1	129, 147	15
14G2	140, 189	4

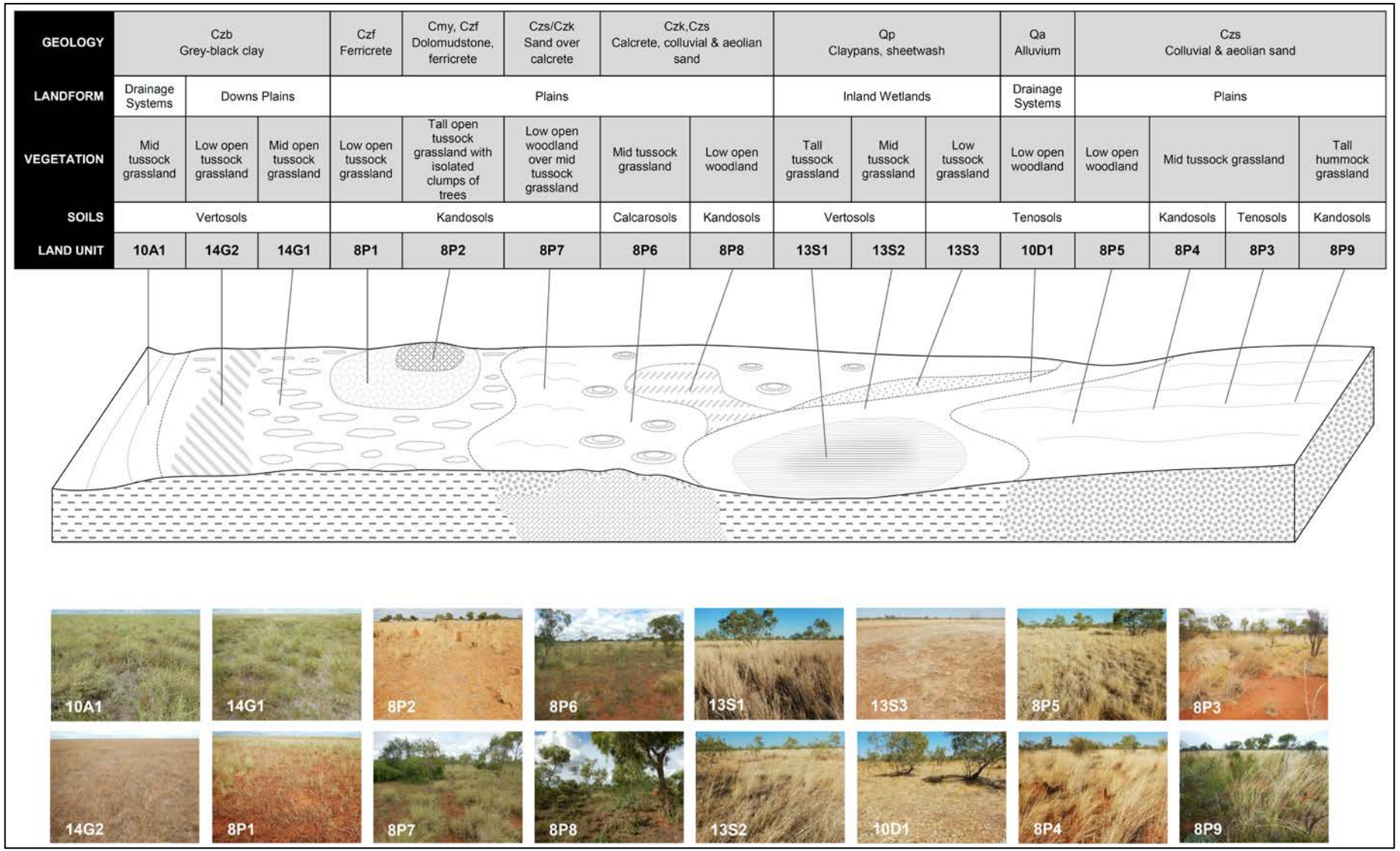


Figure 5.2. Conceptual toposequence diagram showing the relationship of land units with each other and their characteristics.

5.4 Land unit descriptions

This section presents a description of each land unit identified and defined in this study.

The following one page format summaries include information on:

- Land unit map code
- Summary description of the land unit, including geology, landform, soil classification, and vegetation classification
- General site landscape characteristic and photograph
- General soil profile description and photograph
- Description of soil analytical properties, usually based on a representative site
- Agricultural land capability class
- Other comments

Land unit 8P1	Plains	Sites: 4	Area: 436 ha

Summary: Level ferruginous plain; a moderately deep, red, loam, containing ferruginous fragments, with low open tussock grassland.

Geology: Czf: Ferricrete, manganocrete and ferruginised rock.

Landform: Level plain, with many ferruginous fragments on the surface.

Soil Classification: Ferric, Eutrophic, Red Kandosol; medium, moderately gravelly, loamy A, loamy B, moderate depth.

Vegetation: *Aristida contorta*, *Dactyloctenium radulans*, *Sporobolus australasicus* low open tussock grassland.

Landscape

Slope: 0-1%

Surface gravels: 30-70%

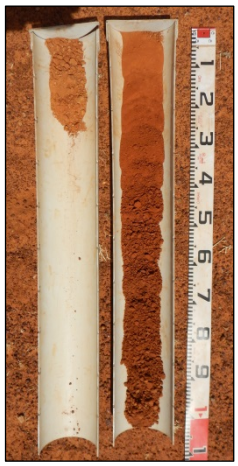
Rock outcrop: 0%

Drainage: Well drained

Runoff: Slow

Permeability: Slow

General Soil Profile Description



Moderately deep, well drained, red, loam, few to common ferruginous fragments (Ferric, Red Kandosols), overlying sediments of clay and ferruginous fragments. Many ferruginous fragments armouring the surface.

Surface Soil: A1: Reddish brown, loam or clay loam; moderate subangular blocky structure; no mottles; 15-25% ferruginous fragments; field pH 6.0-7.0. Lower depth ranges 0.05-0.20 m with a gradual horizon change.

Sub-surface layer: Not present.

Subsoil layer: B2: Red, yellowish red or reddish brown; loam or clay loam; massive structure; 0-20% ferruginous fragments; field pH 6.0-8.0. Lower depth ranges 0.4-0.6 m.

Substrate layer: BC (C): Red or yellowish red; clay loam or light clay; massive; 20-60% ferruginous fragments; field pH 6.5-8.5.

Soil Analytical Properties (representative site number FRE15: 187)

Low fertility and moderate nutrient holding capacity. Low total nitrogen at the surface (0.03%). Extremely low organic carbon (OC 0.33%) at the surface, decreasing with depth. Clay content was 30.5% at the surface, increasing with depth to 41% in the substrate. Neutral pH at the surface and grades to strongly alkaline at depth. Salinity levels were negligible (EC 0.02-0.09 dS/m) throughout. Moderate CEC levels (22-23 cmol/kg). Available soil water holding capacity was very low. Subsoil laboratory dispersion (R1) was moderate.

General Land Capability Class: Class 2 – Moderate

Comments

Land unit distingusihed by lack of vegetation and many ferruginous fragments armouring the surface.

Land unit 8P2	Plains	Sites: 2	Area: 274 ha

Summary: Level to gently undulating plains, with termitaria microrelief; a shallow, brown, loam grading to clay loam, with tall open tussock grassland.

Geology: Cmy, Czf: Pebble to boulder rubble tracts, in which chert concretions predominate, Ferricrete, manganocrete and ferruginised rock.

Landform: Level to gently undulating plain with termitaria microrelief.

Soil Classification: Haplic, Eutrophic, Brown Kandosol; thin, non-gravelly, loamy A, clay loamy B, shallow.

Vegetation: *Aristida inaequiglumis*, *Eriachne obtusa* tall open tussock grassland.

Landscape

Slope: 0-2%

Surface gravels: 0-5%

Rock outcrop: 0%

Drainage: Well drained

Runoff: Slow

Permeability: Slow

General Soil Profile Description

Shallow, well drained, strong brown, loam grading to clay loam (Brown Kandosols), overlying sediments of clay and/or ferruginous fragments.

Surface Soil: A1: Strong brown, loam; massive structure; 2-10% ferruginous fragments; field pH 6.0-6.5. Lower depth ranges 0.05-0.15 m with a gradual horizon change.

Sub-surface layer: Not present.

Subsoil layer: B2: Strong brown; clay loam; massive structure; 2-10% ferruginous fragments; field pH 6.0-6.5. Lower depth ranges 0.25-0.5 m.

Substrate layer: Cr: Yellowish red; light clay; massive; 30-60% ferruginous fragments; field pH 6.5-7.5.

Soil Analytical Properties (representative site number FRE15: 143)

Low fertility and low nutrient holding capacity. Low total nitrogen at the surface (0.06%). Low organic carbon (OC 0.77%) at the surface, decreasing with depth. Clay content was 17.5% at the surface, increasing with depth to 55% in the substrate. Neutral pH at the surface and grades to slightly acid at depth. Salinity levels were negligible (EC 0.02-0.04 dS/m) throughout. Low ECEC levels (6-10 cmol/kg). Available soil water holding capacity was low. Subsoil laboratory dispersion (R1) was moderate.

General Land Capability Class: **Class 3 – Marginal**

Comments

Land unit 8P3 Plains Sites: 5 Area: 19 ha

Summary: Level plain, with loose surface conditions; a deep, brown to red, sand grading to massive, sandy loam, with mid tussock grassland.

Geology: Czs: unconsolidated colluvial and aeolian sand.

Landform: Level plain.

Soil Classification: Basic, Paralithic, Red-Orthic Tenosol; thin, non-gravelly, sandy A1, loamy B, moderate depth.

Vegetation: *Aristida holathera*, *Aristida inaequiglumis*, *Chrysopogon fallax* mid tussock grassland.

Landscape

Slope: 0-1%

Surface gravels: 0%

Rock outcrop: 0%

Drainage: Well drained

Runoff: Very slow

Permeability: Slow

General Soil Profile Description

Deep, well drained, brown, sand grading to yellowish red, massive, sandy loam (Red-Orthic Tenosols), and occasionally grading to sandy clay loam (Kandosols), overlying weathered clay substrate.

Surface Soil: A1: Brown; sand; massive structure; 0% gravels; field pH 6.0-6.5. Lower depth 0.05-0.10 m with a gradual horizon change.

Sub-surface layer: B1: Strong brown; loamy sand or sandy loam; massive structure; 0% gravels; field pH 6.0-6.5. Lower depth 0.05-0.25 m.

Subsoil layer: B2: Yellowish red; fine sandy loam; massive structure; 0% gravels; field pH 6.0-6.5. Lower depth 1-1.5 m.

Substrate layer: BC and Cr: Yellowish brown, light or medium clay, massive, very strong; field pH 6.0-7.5.

Soil Analytical Properties (representative site number FRE15: 107)

Low fertility and low nutrient holding capacity. Very low total nitrogen at the surface (0.02%). Extremely low organic carbon (OC 0.22%) at the surface, decreasing with depth. Clay content was 6% at the surface, increasing with depth to 35% in the substrate. Mildly alkaline pH at the surface grading to neutral at depth. Salinity levels were negligible (EC 0.01-0.03 dS/m) throughout. Low ECEC levels (4-7 cmol/kg). Available soil water holding capacity was low. Subsoil laboratory dispersion (R1) was moderate.

General Land Capability Class: Class 2 – Moderate

Comments

This land unit grades into Land Unit 8P4 where the subsoil is loamy (Red Kandosol) or into Land Unit 8P5 where the soil is shallow and brown (Leptic Tenosol).

Land unit 8P4	Plains	Sites: 18	Area: 122 ha

Summary: Level plain, with termitaria microrelief; a moderately deep, yellowish red to red, loamy sand grading to massive, clay loam, with mid tussock grassland.

Geology: Czs: unconsolidated colluvial and aeolian sand.

Landform: Level plain with termitaria microrelief.

Soil Classification: Haplic, Eutrophic, Red Kandosol; thin, non-gravelly, sandy A1, clay loamy B, moderate or deep depth.

Vegetation: *Aristida hygrometrica, Chrysopogon fallax, Aristida holathera* mid tussock grassland.

Landscape

Slope: 0-1%

Surface gravels: 0-5%

Rock outcrop: 0%

Drainage: Well drained

Runoff: Very slow

Permeability: Slow

General Soil Profile Description

Moderately deep, well drained, yellowish red, loamy sand grading to red, massive, sandy clay loam or clay loam (Red Kandosols), overlying weathered sediments of clay and ferruginous fragments. In some areas the subsoil is sandy loam (Red-Orthic Tenosols).

Surface Soil: A1: Yellowish red; loamy sand; massive structure; 0% gravels; field pH 5.5-6.5. Lower depth 0.05-0.10 m with a gradual horizon change.

Sub-surface layer: A3: Yellowish red; loamy sand or sandy loam; single grain structure; 0% gravels; field pH 6.0-6.5. Lower depth 0.2-0.4 m.

Subsoil layer: B2: Red; sandy clay loam or clay loam; massive structure; earthy fabric; 0% gravels; 0-20% ferruginous nodules; field pH 5.50-6.5. Lower depth 0.6-1.3 m.

Substrate layer: Cr: Strong; weathered sediments of clay and ferruginous segregations.

Soil Analytical Properties (representative site number FRE15: 163)

Low fertility and low nutrient holding capacity. Low total nitrogen at the surface (0.020%). Extremely low organic carbon (OC 0.19%) at the surface, decreasing with depth. Clay content was 7% at the surface, increasing with depth to 26% in the subsoil. Mildly alkaline pH at the surface to neutral at depth. Negligible salinity levels (EC 0.01-0.02 dS/m) throughout. Low ECEC levels (3-7 cmol/kg) throughout. Available soil water holding capacity was low. Subsoil laboratory dispersion (R1) was low.

General Land Capability Class: **Class 2 – Moderate**

Comments

This land unit grades into Land Unit 8P3 where the subsoil is sandy (Red-orthic Tenosol).

Red-Orthic Tenosols also occur in some areas of this land unit.

Land unit 8P5 Plains Sites: 13 Area: 73 ha

Summary: Level plains; a shallow, brown to yellowish brown, loamy sand grading to sandy loam, with low open woodland.

Geology: Czs: unconsolidated colluvial and aeolian sand.

Landform: Level plain.

Soil Classification: Basic, Paralithic, Leptic Tenosols; thin, non-gravelly, sandy A1, sandy (loamy or clay loamy) B, shallow (or very shallow) depth.

Vegetation: *Eucalyptus victrix* low open woodland.

Landscape

Slope: 0-1%

Surface gravels: 0-10% quartz

Rock outcrop: 0%

Drainage: Imperfectly drained

Runoff: Very slow

Permeability: Slow

General Soil Profile Description

Shallow, imperfectly drained, brown, loamy sand grading to yellowish brown sandy loam (Leptic Tenosols), overlying unconsolidated clayey substrate.

Surface Soil: A1: Brown, loamy sandy; single grain; 0% gravels; field pH 5.5-7.0. Lower depth 0.05-0.40 m with a gradual horizon change.

Sub-surface layer: Not present.

Subsoil layer: B2: Yellowish brown; sandy loam, sandy clay loam, or clay loam; massive structure; 0% gravels; field pH 6.5-7.5. Lower depth 0.2-0.5 m.

Substrate layer: BC (C or Cr): Brown, light clay or clay loam; very strong; 20-60% distinct yellow and/or red mottles, weathered sediments.

Soil Analytical Properties (representative site number FRE15: 192)

Low fertility and low nutrient holding capacity. Very low total nitrogen at the surface (0.02%). Extremely low organic carbon (OC 0.31%) at the surface, decreasing with depth. Clay content was 8% at the surface, increasing with depth to 30% in the subsoil. Moderately acid pH at the surface to neutral at depth. Negligible salinity levels (EC 0.01-0.03 dS/m) throughout. Very low to low ECEC levels (2-7 cmol/kg) throughout. Available soil water holding capacity was very low. Subsoil laboratory dispersion (R1) was high.

General Land Capability Class: Class 3 – Marginal

Comments

This land unit grades into Land Unit 8P3 and 8P4 where the soils are deeper and redder.

Land unit 8P6	Plains	Sites: 16	Area: 1,157 ha

Summary: Level plains with low rises of quartz and calcrete outcrops; a shallow, reddish brown sandy loam, containing many quartz and calcrete gravels, in the lower landscape areas the soil was deeper with few gravels, with mid tussock grassland.

Geology: Czk,Czs: Calcrete and unconsolidated colluvial and aeolian sand.

Landform: Level plain and low rises of quartz and limestone outcrops.

Soil Classification: Ceteric, Paralithic, Calcic Calcarosol; thin, non-gravelly, clayey A, clayey B, shallow to moderate depth.

Vegetation: *Eriachne obtusa*, *Aristida holathera*, *Enneapogon purpurescens* mid tussock grassland.

Landscape

Slope: 0-3%

Surface gravels: 0-60%

Rock outcrop: 0-10% calcrete or quartz

Drainage: Moderately well drained

Runoff: Very slow (lower slope) moderately rapid (on rises)

Permeability: Slow

General Soil Profile Description

Shallow, moderately well drained, red sandy loam, many quartz and calcrete fragments (Calcic Calcarosols), overlying weathered calcrete, or in the lower landscape position between rises the soil is deeper with few gravels (Red-OrthicTenosols).

Surface Soil: A1: Reddish brown, loamy sand, weak subangular blocky, 0-5% gravels; 0% segregations, moderately calcareous effervescence; field pH 7.5-8.5. Lower depth 0.05-0.10 m with a gradual horizon change.

Sub-surface layer: Generally not present, if present similar to surface soil layer.

Subsoil layer: Bk: Reddish brown, sandy loam or sandy clay loam; weak subangular blocky or massive; 5-60% quartz and calcrete gravels; 0-5% calcareous soft segregations; moderately calcareous effervescence; field pH 8.0-8.5. Lower depth 0.2-0.7 m.

Substrate layer: Ckr: White; very strong, calcrete fragments; very highly calcareous effervescence; field pH 8.0-9.0.

Soil Analytical Properties (representative profile number FRE15: 177, 181)

Low fertility and low nutrient holding capacity. Very low total nitrogen at the surface (0.03%). Very low organic carbon (OC 0.4%) at the surface, decreasing with depth. Clay content was 10% at the surface, slightly increasing with depth to 12% in the subsoil. Strongly alkaline pH at the surface and at depth. Negligible salinity levels (EC 0.06-0.08 dS/m) throughout. Low CEC levels (6-7 cmol/kg) throughout. Available soil water holding capacity was very low. Laboratory dispersion (R1) was high.

General Land Capability Class: **Class 3 – Marginal**

Comments

Land unit is similar to Alroy Map Unit 1.4 (Edgoose and Lehman, 1996).

Land unit 8P7 | Plains | Sites: 12 | Area: 1,389 ha

Summary: Level to gently undulating plains; a moderately deep, reddish brown to red, sandy loam grading to clay loam, with low open woodland or mid tussock grassland.

Geology: Czs/Czk: Unconsolidated colluvial and Aeolian sand over calcrete.

Landform: Level to gently undulating plain.

Soil Classification: Haplic, Eutropic, Red Kandosol; thin, non-gravelly, sandy or loamy A1, clay loamy B, moderate depth.

Vegetation: *Corymbia terminalis,* ± *Hakea arborescens,* ± *Ventilago viminalis* low open woodland or *Chrysopogon fallax*, *Aristida holathera*, ± *Eragrostis xerophila* mid tussock grassland.

Landscape

Slope: 0-2%

Surface gravels: 0-10%

Rock outcrop: 0%

Drainage: Well drained

Runoff: Very slow

Permeability: Slow

General Soil Profile Description

Moderately deep, well drained, red, sandy loam grading to clay loam (Red Kandosols), overlying calcareous substrate.

Surface Soil: A1: Dark reddish brown, sandy loam or loamy fine sandy; weak subangular blocky or platy structure; 0% gravels; field pH 6.5-8.0. Lower depth variation 0.00-0.10 m with a gradual horizon change.

Sub-surface layer: A2 (or B1): Reddish brown; sandy clay loam; weak subangular blocky structure; 0% gravels; field pH 6.5-8.5. Lower depth 0.1-0.3 m.

Subsoil layer: B2: Red or yellowish red; clay loam or light clay; massive structure; earthy fabric; 0% gravels; field pH 6.0-8.0. Lower depth 0.6-1.0.

Substrate layer: Cr: White, Very strong; calcareous weathered sediments.

Soil Analytical Properties (representative site number FRE15: 127, 191)

Low fertility and low nutrient holding capacity. Low total nitrogen at the surface (0.038%). Extremely low organic carbon (OC 0.19%) at the surface, decreasing with depth. Clay content was 5% at the surface, increasing with depth to 30% in the subsoil. Mildly alkaline pH at the surface to neutral at depth. Negligible salinity levels (EC 0.01-0.02 dS/m) throughout. Low ECEC levels (5-11 cmol/kg). Available soil water holding capacity was low. Subsoil laboratory dispersion (R1) was moderate.

General Land Capability Class: Class 2 – Moderate

Comments

Similar to Alroy Map Unit 1.4 (Edgoose and Lehman, 1996). In some areas soils may be calcareous (Calcic Calcarosols), a representative profile is site no. 131.

Land unit 8P8	Plains	Sites: 5	Area: 297 ha

Summary: Level plains, with termitaria microrelief; a deep, yellowish red to red, sandy loam grading to clay loam, with low open woodland.

Geology: Qp: claypans, sheetwash; silts and clays, and Czk, Czs: calcrete and unconsolidated colluvial and aeolian sand.

Landform: Level plain, that occurs in a lower position compared to surrounding landscape.

Soil Classification: Haplic, Eutrophic, Red Kandosol; Thin, non-gravelly, loamy A1, clayey B, moderate depth.

Vegetation: *Corymbia terminalis*, ± *Eucalyptus victrix* low open woodland.

Landscape

Slope: 0-1%

Surface gravels: 0-10% quartz

Rock outcrop: 0%

Drainage: Well drained

Runoff: Very slow

Permeability: Slow

General Soil Profile Description

Deep, well drained, red, sandy loam grading to clay loam (Red Kandosols), overlying weathered sediments of silts, clay, calcrete, and aeolian sand.

Surface Soil: A1: Yellowish red, sandy loam; weak subangular blocky structure; 0% gravels; field pH 6.0-6.5. Lower depth variation 0.00-0.10 m with a gradual horizon change.

Sub-surface layer: B1 (if present): Red or yellowish red; sandy clay loam; weak blocky structure or massive; 0% gravels; field pH 6.0-7.0.

Subsoil layer: B2: Red; clay loam; massive structure; earthy fabric; 0% gravels; field pH 7.0-8.0. Lower depth 0.6-1.1 m.

Substrate layer: C: White, strong; moderately calcareous; weathered sediments silts, clay, calcrete, and aeolian sand.

Soil Analytical Properties (representative site number FRE15: 180, 182)

Low fertility and low nutrient holding capacity. Very low total nitrogen at the surface (0.02-0.03%). Very low organic carbon (OC 0.4%) at the surface, decreasing with depth. Clay content was 8-14% at the surface, increasing with depth to 29% in the subsoil. Neutral pH at the surface to moderately alkaline at depth. Negligible salinity levels (EC 0.01-0.11 dS/m) throughout. Low CEC levels (7-11 cmol/kg). Available soil water holding capacity was low. Subsoil laboratory dispersion (R1) was very high.

General Land Capability Class: **Class 2 – Moderate**

Comments

Land unit 8P9	Plains	Sites: 3	Area: 229 ha

Summary: Level plain, with termitaria microrelief; a deep, yellowish red to red, loamy sand grading to massive, clay loam, with low open woodland.

Geology: Czs: unconsolidated colluvial and aeolian sand.

Landform: Level plain with termitaria microrelief.

Soil Classification: Haplic, Eutrophic, Red Kandosol; thin, non-gravelly, sandy A1, clay loamy B, moderate depth.

Vegetation: *Triodia schinzii, Paraneurachne muelleri* tall hummock grassland.

Landscape

Slope: 0-1%

Surface gravels: 0-5%

Rock outcrop: 0%

Drainage: Well drained

Runoff: Very slow

Permeability: Slow

General Soil Profile Description

Deep, well drained, yellowish red loamy sand grading to red, massive, sandy clay loam or clay loam (Red Kandosols), overlying weathered sediments of clay and ferruginous fragments.

Surface Soil: A1: Yellowish red; loamy sand; weak subangular bloacky structure; 0% gravels; field pH 5.5-6.5. Lower depth 0.05-0.10 m with a gradual horizon change.

Sub-surface layer: A3 (if present): Yellowish red; loamy sand or sandy loam; single grain structure; 0% gravels; field pH 6.0-6.5. Lower depth 0.2-0.4 m.

Subsoil layer: B2: Red; sandy clay loam or clay loam; massive structure; earthy fabric; 0% gravels; 0-20% ferruginous nodules; field pH 6.0-7.0. Lower depth 0.6-1.3 m.

Substrate layer: Cr: Strong; weathered sediments of clay and ferruginous segregations.

Soil Analytical Properties (representative site number FRE15: 115, no laboratory analysis available)

Sites in this land unit were not sampled for laboratory analysis.

General Land Capability Class: **Class 2 – Moderate**

Comments

Land unit 10A1 | Drainage Systems | Sites: 1 | Area: 789 ha

Summary: Shallow broad alluvial plain, with gilgai microrelief; a very deep, cracking, grey, clay, with mid tussock grassland.

Geology: Czb; grey-black clay rich soil.

Landform: Level plain, broad alluvial plain, with gilgai microrelief.

Soil Classification: Haplic, Epipedal, Grey Vertosol; Non-gravelly, medium fine surface layers, medium fine B, deep depth.

Vegetation: *Astrebla elymoides*, *Iseilema vaginiflorum*, *Polymeria longifolia* mid tussock grassland.

Landscape

Slope: 0-1%

Surface gravels: 0-10%

Rock outcrop: 0%

Drainage: Imperfectly drained

Runoff: Very slow runoff

Permeability: Slow

General Soil Profile Description

Very deep, imperfectly drained, cracking, grey clay (Grey Vertosols), overlying mottled clay sediments.

Surface Soil: A1: Dark grey; medium clay; strong subangular blocky structure; no mottles; 0-2% gravels; non-calcareous; no segregations; field pH 6.5-7.5. Lower depth variation 0.05-0.20 m with a gradual horizon change.

Sub-surface layer: B1 (if present): Grey; medium clay; strong angular blocky structure; 0% gravels; no mottles; non-calcareous; no segregations; field pH 7.0-8.0.

Subsoil layer: B2: Grey; medium clay; massive structure; 0% gravels; no mottles; non-calcareous; 0-3% gypsum crystals; field pH 7.5-9.0. Lower depth 1.3-1.6 m.

Substrate layer: BC (not encountered, assume): Grey; medium clay; massive.

Soil Analytical Properties (representative profile number FRE15: 188)

Low fertility and high nutrient holding capacity. Very low total nitrogen at the surface (0.02%). Extremely low organic carbon (OC 0.32%) at the surface, decreasing with depth. Clay content was 49% at the surface, increasing with depth to 57% in the subsoil. Mildly alkaline pH at the surface and at depth. Negligible salinity levels at the surface (EC 0.03-0.06 dS/m) with increases to highly/extremely saline at depth (EC 1.9-4.3 dS/m), supported by a high chloride concentration. Gypsum was identified in the subsoil layers (1-4%) and this may also contribute to the EC levels. High CEC levels (26-28 cmol/kg) in the surface soil and very high ECEC levels (43-63 cmol/kg) in the subsoil. Available soil water holding capacity was moderate. Subsoil laboratory dispersion (R1) was high.

General Land Capability Class: Class 3 – Marginal

Comments

Land unit 10D1 Drainage Systems Sites: 3 Area: 40 ha

Summary: Open drainage channel subject to periodic water flow; a moderately deep, brown, massive sandy soil, with low open woodland.

Geology: Qa: alluvium of sand, minor gravel, silt and clay.

Landform: Open depression drainage channel in a level plain.

Soil Classification: Basic, Paralithic, Brown-Orthic Tenosol; medium thickness, non-gravelly, sandy A1, sandy B, moderately deep depth.

Vegetation: *Eucalyptus victrix*, *Atalaya hemiglauca*, *Acacia elachantha* low open woodland.

Landscape

Slope: 0-2%

Surface gravels: 0-5%

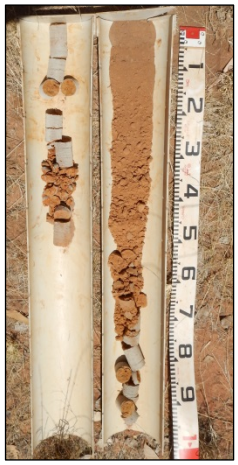
Rock outcrop: 0-5%

Drainage: Well drained

Runoff: Very slow

Permeability: Moderate

General Soil Profile Description



Moderately deep, well drained, brown, sandy, single grain grading to massive (Brown-Orthic Tenosols), overlying mottled alluvium

Surface Soil: A1: Brown; sand; single grain structure; 0% gravels; field pH 6.0-7.0. Lower depth 0.05-0.30 m with a gradual horizon change.

Sub-surface layer: A2: Brown; sand or loamy sand; single grain structure; 0% mottles; 0% gravels; field pH 6.0-7.0. Lower depth 0.5-0.9 m.

Subsoil layer: Not present.

Substrate layer: C: Yellowish brown or light olive brown; sandy clay loam or clay; massive; 30-50% distinct red mottles; 0-5% gravels; field pH 6.5-7.5.

Soil Analytical Properties (representative site number FRE15: 116, no laboratory analysis available)

Sites in this land unit were not sampled for laboratory analysis.

General Land Capability Class: Class 3 – Marginal

Comments

Land unit is similiar to Alroy Map Unit 1.3 (Edgoose and Lehman, 1996). Subject to periodic water flow, in places there is scouring on sides exposing underlying calcrete rock and alluvium.

Land unit 13S1	Inland Wetlands	Sites: 4	Area: 276 ha

Summary: Closed drainage depression subject to temporary inundation, with gilgai microrelief; a very deep, cracking, grey, clay, with tall tussock grassland.

Geology: Qp: claypans, sheetwash; silts and clays.

Landform: Closed depression in a level plain, subject to temporary inundation during wet season.

Soil Classification: Mottled, Epipedal, Grey Vertosols; slightly gravelly, fine A1, medium fine B, deep depth.

Vegetation: *Eulalia aurea* tall tussock grassland.

Landscape

Slope: 0-1%

Surface gravels: 0-10%

Rock outcrop: 0%

Drainage: Imperfectly drained

Runoff: Very slow

Permeability: Very slow

General Soil Profile Description

Very deep, imperfectly drained, grey, cracking, clay soil, with mottled upper layers (Mottled, Grey Vertosols), overlying calcareous substrate.

Surface Soil: A1: Greyish brown; light clay; strong blocky structure; 0-2% quartz gravels; field pH 5.5-6.0. Lower depth 0.05-0.15 m with a gradual horizon change.

Sub-surface layer: B1: Grey; medium or light clay; strong angular blocky structure; 0% gravels; field pH 5.5-6.5. Lower depth 0.2-0.3 m.

Subsoil layer: B2: Light brownish grey; medium clay; massive structure; 0% gravels; field pH 6.0-7.0. Lower depth 1.0-1.6 m.

Substrate layer: Cr: White; massive; highly calcareous; field pH 8.5-9.0.

Soil Analytical Properties (representative site number FRE15: 103)

Low fertility and low nutrient holding capacity. Low total nitrogen at the surface (0.046%). Low organic carbon (0.72%) at the surface, decreasing with depth. Clay content was 35% at the surface and remains about the same content throughout the profile. Slightly acidic pH at the surface and subsoil and moderately alkaline in the substrate. Negligible salinity levels (0.01 dS/m) with a slight increase at the substrate boundary (0.13 dS/m). Low ECEC levels (11-13 cmol/kg) throughout the profile. Available soil water holding capacity was moderately low. Subsoil laboratory dispersion (R1) was moderate.

General Land Capability Class: **Class 4 – Not Suitable**

Comments

Land unit is similar to Alroy Map Unit 5.3 (Edgoose and Lehman, 1996).

Land unit 13S2 | Inland Wetlands | Sites: 4 | Area: 558 ha

Summary: Margin areas of drainage depression, with gilgai microrelief; a moderately deep, cracking, grey, clay, with mid tussock grassland.

Geology: Qp: claypans, sheetwash; silts and clays.

Landform: Margin areas of closed depression (inland wetlands 13S1), where there is less inundation.

Soil Classification: Endocalcareous (or Endohypersodic), Epipedal, Grey Vertosol; slightly gravelly, fine surface, medium fine B, moderate depth.

Vegetation: *Aristida latifolia*, *Eulalia aurea*, *Iseilema vaginiflorum* mid tussock grassland.

Landscape

Slope: 0-2%

Surface gravels: 0-10%

Rock outcrop: 0%

Drainage: Imperfectly drained

Runoff: Very slow

Permeability: Slow

General Soil Profile Description

Moderately deep, imperfectly drained, cracking, grey, clay, with no mottles in upper layers (Grey Vertosols), overlying calcareous substrate.

Surface Soil: A1: Grey; light clay; strong blocky structure; 0-2% quartz gravels; 0-2% red mottles; 0-2% soft calcareous segregations; non or slightly calcareous; field pH 7.0-9.5. Lower depth 0.05-0.15 m with a gradual horizon change.

Sub-surface layer: Generally not present.

Subsoil layer: B2k: Grey; medium clay; massive structure; 0% gravels; 0-5% red mottles; 5-10% soft calcareous segregations; moderately calcareous; field pH 8.0-9.0. Lower depth 0.5-0.9 m.

Substrate layer: Cr: White; limestone/calcrete weathered rock; very highly calcareous; field pH 8.5-9.0.

Soil Analytical Properties (representative site number FRE15: 122, no laboratory analysis available)

Sites in this land unit were not sampled for laboratory analysis.

General Land Capability Class: Class 3 – Marginal

Comments

Land unit 13S3	Inland Wetlands	Sites: 3	Area: 16 ha

Summary: Level plain, with many surface gravels; a very shallow, grey, clay loam, with low tussock grassland.

Geology: Qp: claypans, sheetwash; silts and clays and Czs/Czk: Unconsolidated colluvial and aeolian sand over calcrete.

Landform: Flat in a level plain adjacent to closed depression, would be inundated during wet season.

Soil Classification: Basic, Paralithic, Leptic Tenosol; Medium thickness, slightly gravelly, clay loamy A1, clay loamy B, very shallow depth.

Vegetation: *Aristida contorta, Aristida holathera, Fimbristylis dichotoma* low tussock grassland.

Landscape

Slope: 0-1%

Surface gravels: 10-60% quartz and ironstone

Rock outcrop: 0%

Drainage: Imperfectly drained

Runoff: Very slow

Permeability: Slow

General Soil Profile Description

Very shallow, imperfectly drained, clay loam (Leptic Tenosols), overlying weathered mottled clay substrate.

Surface Soil: A1: Grey; clay loam; 0% mottles; single grain structure; 0% gravels; 0% segregations; field pH 6.0-6.5. Lower depth 0.15-0.50 m with a clear horizon change.

Sub-surface layer: Not present.

Subsoil layer: Not present.

Substrate layer: Cr: light brownish grey; light clay; 10-50% distinct red mottles; non-calcareous; field pH 6.0-7.0.

Soil Analytical Properties (representative site number FRE15: 175, no laboratory analysis available)

Sites in this land unit were not sampled for laboratory analysis.

General Land Capability Class: **Class 4 – Not Suitable**

Comments

Land unit 14G1 | Downs plains | Sites: 15 | Area: 10,399 ha

Summary: Level plain, with gilgai micorelief; a very deep, cracking, grey, clay, gypsum and sodic at depth, with mid open tussock grassland.

Geology: Czb; grey-black clay rich soil.

Landform: Level plain, with gilgai microrelief.

Soil Classification: Endohypersodic, Epipedal, Grey Vertosol; non-gravelly, medium fine surface layers, medium fine B, deep depth.

Vegetation: *Astrebla pectinata*, *Aristida latifolia* mid open tussock grassland.

Landscape

Slope: 0-1%

Surface gravels: 0-10% subrounded quartz

Rock outcrop: 0%

Drainage: Moderately well drained

Runoff: No runoff

Permeability: Slow

General Soil Profile Description

Very deep, moderately well drained, cracking, grey, medium clay soil (Grey Vertosols), gypsum crystals and sodic in the subsoil, overlying clay sediments.

Surface Soil: A1: Grey; light clay; strong subangular blocky structure; 0-5% gravels; field pH 6.5-7.5. Lower depth 0.05-0.15 m with a gradual horizon change.

Sub-surface layer: B1 (or A3): Grey; medium clay; strong blocky structure; rough-ped fabric; 0% gravels; field pH 7.0-8.0. Lower depth 0.2-0.5 m.

Subsoil layer: B2 or B2y: Grey; medium clay; massive structure; 0% gravels; 0-5% gypseous crystals; non-calcareous; field pH 8.0-8.5.Lower depth >1.5 m.

Substrate layer: BCy or Cy: Greyish brown; medium-heavy clay, 2-5% faint red mottles; very firm; 2-5% gypseous crystals; non-calcareous; weathered clay sediments.

Soil Analytical Properties (representative profile number FRE15: 129, 147)

Low fertility and high nutrient holding capacity. Low total nitrogen at the surface (0.030-0.40%). Extremely low organic carbon (0.31-0.49%) at the surface, decreasing with depth. Clay content was 40% at the surface and remains about the same content throughout the profile. Mildly alkaline pH throughout the profile and in some areas the surface was slightly acidic to neutral. Generally very low salinity levels in the surface layers but in some areas up to high, and extreme for all subsoil layers, this is supported by a high chloride concentration. Gypsum was identified in the soil layers (2-6%) below the surface and this may also contribute to the EC levels. High CEC levels in the surface layers (29 cmol/kg) and moderate to very high in the subsoil layers (23-52 cmol/kg). ESP indicates the soils are non-sodic in the upper layers, and strongly sodic in the subsoil. Available soil water holding capacity was moderate. Subsoil laboratory dispersion (R1) was moderate.

General Land Capability Class: **Class 3 – Marginal**

Comments

Unit corresponds with the conceptual “Mitchell Grass Downs” bioregion (Commonwealth of Australia, 2012).

Land unit is similar to Alroy map unit 2.1 (Edgoose and Lehman, 1996).

Land unit 14G2 | Downs plains | Sites: 4 | Area: 1,158 ha

Summary: Level plain, with no gilgai microrelief; very deep, imperfectly drained, cracking, grey, clay; with low open tussock grassland.

Geology: Czb; grey-black clay rich soil.

Landform: Level plain, with no gilgai microrelief.

Soil Classification: Endohypersodic, Epipedal, Grey Vertosol; non-gravelly, medium fine surface layers, medium fine B, moderate or deep depth.

Vegetation: *Iseilema vaginiflorum*, *Fimbristylis dichotoma*, *Chloris pectinata* low open tussock grassland.

Landscape

Slope: 0-0.5%

Surface gravels: 0-5%

Rock outcrop: 0%

Drainage: Imperfectly drained

Runoff: No runoff

Permeability: Slow

General Soil Profile Description

Very deep, imperfectly drained, cracking, grey, clay (Grey Vertosols), sodic in the subsoil but no gypsum present, overlying clay sediments.

Surface Soil: A1: Grey; light medium clay; strong rough-ped angular blocky structure; 0% mottles; 0-2% gravels; 0% segregations; non-calcareous; field pH 6.5-8.0. Lower depth 0.05-0.15 m.

Sub-surface layer: B1 (if present): Grey; medium clay; strong rough-ped angular blocky structure; 0% mottles; 0% gravels; 0% segregations; non-calcareous; field pH 7.0-8.0. Lower depth 0.2-0.5 m.

Subsoil layer: B2: Grey; medium clay; massive structure; 0% mottles, 0% gravels; 0% segregations; non-calcareous; field pH 7.0-9.0. Lower depth >1.5 m.

Substrate layer: BCy (or Cy): Grey; medium clay; massive; 3% faint orange mottles; 0% gravels; 0-3% gypseous soft segregations; non-calcareous; field pH 8.0-9.0.

Soil Analytical Properties (representative site numbers FRE15: 140, 189)

Low fertility and high nutrient holding capacity. Low total nitrogen at the surface (0.023%). Extremely low organic carbon (0.21%) at the surface, decreasing with depth. Clay content was 42% at the surface, increasing slightly with depth to 50%. Mildly alkaline pH throughout the profile. Very low salinity levels in the surface layers, and subsoil layers are all extremely saline, this was supported by a high chloride concentration. Gypsum was identified in the soil layers (0.1-1.4%) below the surface and this may also contribute to the EC levels. High CEC levels in the surface layers (25 cmol/kg) and high in the subsoil layers (32 Cmol/kg). ESP indicates soils were non-sodic in the upper layers and strongly sodic in the subsoil. Available soil water holding capacity was moderate. Subsoil laboratory dispersion (R1) was moderate.

General Land Capability Class: Class 3 - Marginal

Comments

Occurs in association with Land Unit G1, differs in that there was no gilgai microrelief, gypsum not present in the subsoil (but may be present in the substrate), and vegetation indicating an occasionally wetter soil surface.

6. Soil

6.1 Soil distribution

The general distribution of the main soil classes is presented in Figure 6.1 and discussed in the following sections. This map was generated by using the Land Unit polygon boundaries and assigning to each land unit the dominant soil class. Other soil classes do occur in the land units but cannot be represented at this scale of mapping.

6.2 Soil classes

All soils were classified to the family level of the Australian Soil Classification (Isbell, 2002). At the highest level of the classification four soils orders were identified: Vertosols, Calcarosols, Kandosols, and Tenosols and at a lower level there were 10 soil Great Groups identified during this survey (Table 6.1).

A further 11 Great Groups (marked by * in the table) where recognised by the previous survey of Lennartz (2004) but no soils where classified similarly in this survey, e.g. Massive, Red Vertosols, or Regolithic, Red-Orthic Tenosols. There was not sufficient data available from the Lennartz work to revaluate these site classes or correlate with the current study soil classes, and therefore the classifications have been carried as is.

It should be noted that the number of sites per soil class does not indicate the proportional area of soil classes within the overall study area, as for large relatively homogenous areas fewer sites per area were required.

There was one dominant Great Group soil class for each Soil Order: Epipedal, Grey for the Vertosols; Paralithic, Calcic (or Supracalcic) for the Calcarosols; Eutrophic, Red for the Kandosols; and Paralithic, Leptic (or Red-Orthic or Brown-Orthic) for the Tenosols.

For each land unit, the representative soil profile descriptions are provided in Appendix 1, along with analytical data and photographs.

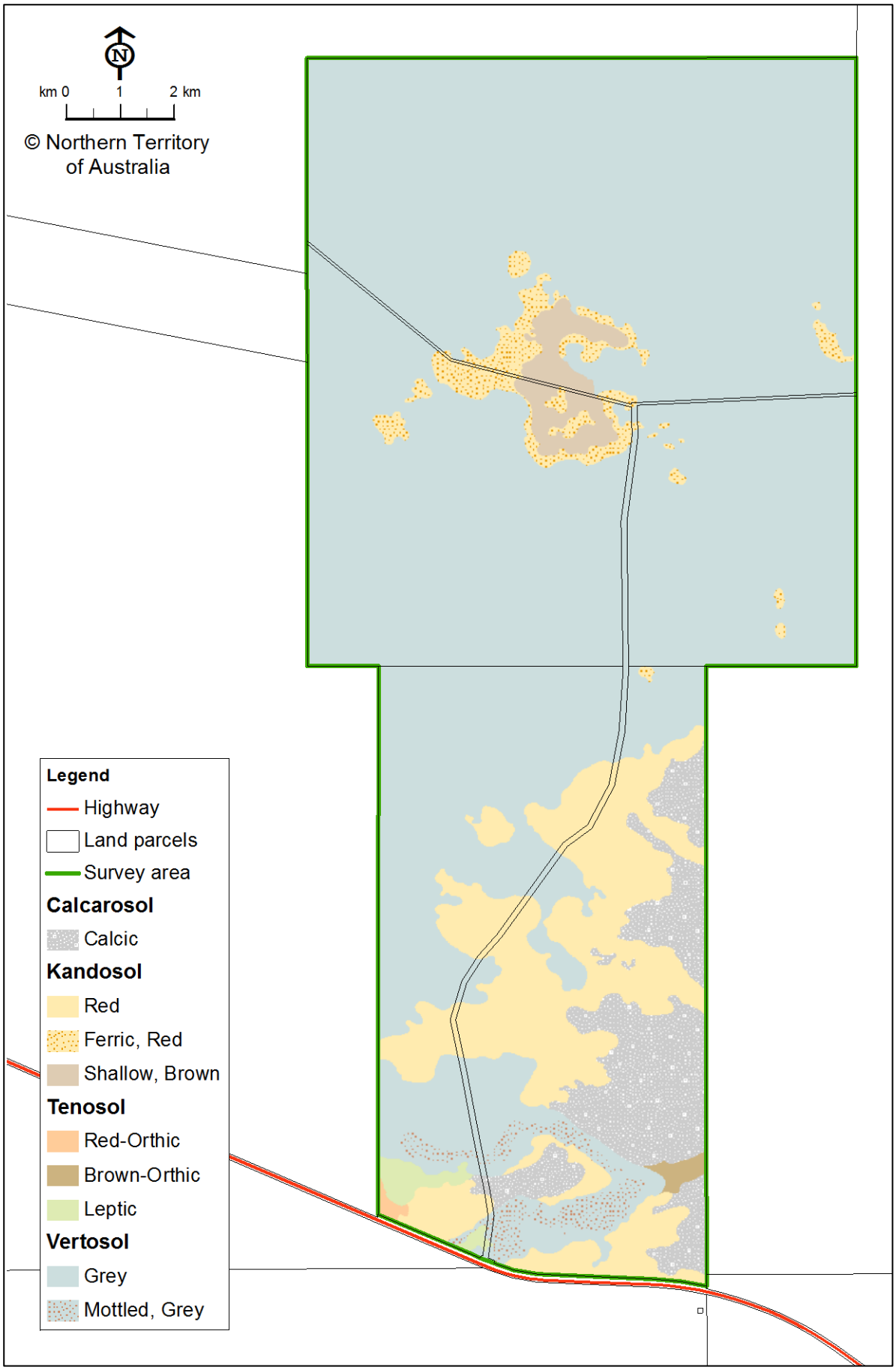


Figure 6.1. The major soil classes and their distribution for the study area.

Table 6.1. Soil classes identified, the number of sites described per class, and the land units that they occurred in.

Orders	Suborders	Great Groups	Count of sites	Land Units occurred in
Calcarosols (CA)	Calcic (BD)	Paralithic (DU)	3	8P6, 8P7
		Regolithic (GF)*	1	8P6
	Hypercalcic (CQ)	Paralithic (DU)	1	8P6
	Supracalcic (FB)	Paralithic (DU)	3	8P6
		Petrocalcic (DZ)*	2	8P6
		Regolithic (GF)*	1	8P6
		Unknown (YY)*	1	8P6
Kandosols (KA)	Red (AA)	Eutrophic (AH)	27	8P1, 8P4, 8P7, 8P8, 8P9
		Dystrophic (AF)*	3	8P1, 8P7
		Mesotrophic (AG)*	1	8P7
	Brown (AB)	Eutrophic (AH)	5	8P2, 8P8
Tenosols (TE)	Leptic (CY)	Paralithic (DU)	15	8P4, 8P5, 8P6, 8P7, 13S3
	Red-Orthic (IN)	Paralithic (DU)	11	8P3, 8P4, 8P6
		Regolithic (GF)*	1	8P6
	Brown-Orthic (IO)	Paralithic (DU)	6	8P4, 8P5, 10D1
	Grey-Orhtic (IQ)	Paralithic (DU)	1	13S3
Vertosols (VE)	Grey (AD)	Epipedal (GS)	22	10A1, 13S1, 13S2, 14G1, 14G2
		Self-mulching (EI)*	2	14G1
	Red (AA)	Massive (DF)*	1	8P7
	Brown (AB)	Crusty (BH)*	2	13S2, 14G1
		Self-mulching (EI)*	3	14G1, 14G2

Note: * identifies soil classes characterised only from historical data of Lennartz 2004

6.2.1 *Vertosols*

Vertosols are clay soils with shrink-swell properties that exhibit strong cracking when dry, and have slickensides and/or lenticular structural aggregates at depth. Many soils exhibit gilgai microrelief, but this feature is not used in their definition (Isbell, 2002).

The Grey Vertosols are widespread. In the northern area they are associated with the grey-black clay surface geology unit (Czb), with well-structured subsoils that were sodic and may contain some gypsum (e.g. Representative Site Nos. 129, 140). In the southern areas they are associated with inland depressions of clay pans and sheet wash surface geology unit (Qp); usualy these soils had mottling in the upper 0.5 m (e.g. Representative Site No. 103).

Laboratory data indicates:

- Low fertility and high nutrient holding capacity.
- Low total nitrogen at the surface (0.023-0.40%).
- Extremely low organic carbon (0.21-0.49%) at the surface, and decreases with depth.
- Clay content was 40-42% at the surface and remains about the same or increases in content (about 50%) down the profile.

- Mildly alkaline pH throughout the profile and in some areas the surface was slightly acidic to neutral.
- Generally very low salinity levels in the surface layers but in some areas up to high, and extreme for all subsoil layers, this is supported by a high chloride concentration.
- Gypsum was identified in the soil layers (1-6%) below the surface.
- High CEC levels in the surface layers (25-29 Cmol/kg) and moderate to very high in the subsoil layers (23-52 Cmol/kg).
- ESP indicates the soils are non-sodic in the upper layers, and strongly sodic in the subsoil.
- Laboratory dispersion (R1=0.62-0.89) was moderate to high.
- Available soil water holding capacity was low to moderate.

6.2.2 *Calcarosols*

Calcarosols are usually calcareous throughout the profile, often highly (Isbell, 2002).

The Calcarosols occur on the upper pedoplain surface associated with the calcrete geology unit (Czk). Generally for this survey these soils were shallow, well drained, red, sandy loam with many quartz and limestone fragments, and moderately or highly calcareous with an alkaline pH through most of the soil profile.

Laboratory data indicates:

- Low fertility and nutrient holding capacity.
- Very low total nitrogen at the surface (0.03%).
- Very low organic carbon (OC 0.4%) at the surface, decreasing with depth
- Clay content was 10% at the surface, slightly increasing with depth to 12% in the subsoil.
- Strongly alkaline pH at the surface and at depth.
- Salinity levels were negligible (EC 0.06-0.08 dS/m) throughout.
- Low CEC levels (6-7 Cmol/kg).
- Laboratory dispersion (R1=0.94) was high.
- Available soil water holding capacity was very low.

6.2.3 *Kandosols*

Kandosols lack strong texture contrast with massive or weakly structured B horizons and are not calcareous throughout (Isbell, 2002).

Kandosols were widespread in the southern area associated with the unconsolidated colluvial and aeolian sand geology unit (Czs). In the northern area there were small areas associated with the ferricrete and dolomudstone geology units (Czf and Cmy).

The Kandosols were dominantly shallow or moderately deep, well drained, with loamy sand or sandy loam surface layers and sandy loam or sandy clay loam or light clay subsoils, red in colour throughout, massive in structure, neutral pH (Red Kandosols, e.g. Representative Site Nos. 127, 163). In the north areas there were many ferruginous fragments on the surface and/or in the profile (Ferric, Red Kandosols) or shallow and brown coloured (Brown Kandosols).

Laboratory data indicates:

- Low fertility and nutrient holding capacity.
- Low total nitrogen at the surface (0.063% Brown Kandosol, 0.020-0.038% Red Kandosol).

- Low organic carbon (OC 0.77% Brown Kandosol, 0.19% Red Kandosol) at the surface, and decreases with depth.
- Clay content was 5-7% at the surface and increases with depth to 26-30% in the subsoil Red Kandosol, and the Brown Kandosol was 17.5% at the surface and increases with depth to 55% in the substrate.
- Neutral to mildly alkaline pH at the surface and grades to slightly acid to neutral at depth.
- Salinity levels were negligible (EC 0.01-0.04 dS/m) throughout.
- Low ECEC levels (3-11 Cmol/kg).
- Laboratory dispersion (R1=0.64-0.68) was moderate.
- Available soil water holding capacity was low.

6.2.4 ***Tenosols***

Tenosols have weak pedological development apart from the A horizon (Isbell, 2002).

The Tenosols occurred in the southern area, associated with colluvial and Aeolian sand geology unit (Czs) or alluvium (Qa).

The Tenosols were either shallow, imperfectly drained, brown, loamy sand grading to sandy loam (Leptic Tenosols) that often occurred adjacent to the inland wetland Land Units. Or they were moderately deep or deep, well drained loam sand grading to yellowish red sandy loam (Red-Orthic e.g. Representative Site Nos. 107 or Brown-Orthic Tenosols).

Laboratory data indicates:

- Low fertility and nutrient holding capacity.
- Low total nitrogen at the surface (0.020%).
- Extremely low organic carbon (OC 0.22%) at the surface, and decreases with depth.
- Clay content was 6% at the surface and increases with depth to 35% in the substrate.
- Mildly alkaline pH at the surface grading to neutral at depth.
- Salinity levels were negligible (EC 0.01-0.03 dS/m) throughout.
- Low ECEC levels (4-7 Cmol/kg).
- Laboratory dispersion (R1=0.63) was moderate.
- Available soil water holding capacity was low.

7. Vegetation

7.1 Vegetation communities

Seventy-four sites were assessed during early October 2015 and sixteen sites assessed during early March 2016. All sites except one were unburnt (99.5%). Ground strata vegetation was generally in poor condition in October 2015 due to dry season desiccation. Conversely, ground strata vegetation was in very good condition in March 2016 following monsoon-associated rainfall during December 2015. Twenty vegetation communities were described, with structural classification in accordance with the NVIS classification (ESCAVI 2003). Vegetation communities including count of sites, approximate extent, and Land Unit occurrence are summarised in Table 7.1.

Vegetation community descriptions are provided in Appendix 2. Species by growth form for taxa identified during the field survey are listed in Appendix 3.

7.2 Vegetation community distribution

Major vegetation communities were generally distributed in association with underlying geology. Vegetation occurring on the vast area of grey-black clay-rich soil (Czb) in the north of the study area was typically Mitchell Grass (*Astrebla* spp.) open tussock grassland. On unconsolidated sand (Czs), vegetation included generally Bloodwood (*Corymbia terminalis*) low open woodland, Kerosene Grass (*Aristida* spp.) mid tussock grassland and Feathertop Spinifex (*Triodia schinzii*) tall hummock grassland. Vegetation on calcrete (Czk) was generally Northern Wanderrie Grass (*Eriachne obtusa*) mid tussock grassland. Communities in low-lying areas generally consisted of Smooth-barked Coolibah (*Eucalyptus victrix*) low open woodland and Brown Silkytop (*Eulalia aurea*) tall tussock grassland. Figure 7.1 shows the general distribution of the major vegetation communities within each land unit.

Table 7.1. Vegetation communities including count of sites, extent and occurrence.

Community		Count of sites	Area (ha)	Area %	Land Unit occurence
Woodland: 9.2%					
8P4 – Com2	*Corymbia terminalis*, *Eucalyptus victrix*, *Ventilago viminalis* low open woodland	5	34.1	0.2%	8P4
8P5 – Com1	*Eucalyptus victrix* low open woodland	10	56.6	0.3%	8P5
8P7 – Com1	*Corymbia terminalis, ± Hakea arborescens, ± Ventilago viminalis* low open woodland	7	1,100.4	6.4%	8P7
8P8 – Com1	*Corymbia terminalis*, ± *Eucalyptus victrix*, ± *Hakea arborescens* low open woodland	5	297.4	1.7%	8P8
10D1 – Com1	*Eucalyptus victrix*, *Atalaya hemiglauca*, *Acacia elachantha* low open woodland	2	27.9	0.2%	10D1
14G1 – Com2	*Vachellia sutherlandii* low open woodland	1	72.8	0.4%	14G1
Tussock grassland: 89.7%					
13S3 – Com1	*Aristida contorta*, *A. holathera* low tussock grassland	3	15.7	0.1%	13S3
8P1 – Com1	*Aristida contorta*, *Dactyloctenium radulans*, *Sporobolus australasicus* low open tussock grassland	2	435.7	2.5%	8P1
8P2 – Com1	*Aristida inaequiglumis, Eriachne obtusa* tall open tussock grassland with *Corymbia aparrerinja* isolated clumps of trees	2	273.7	1.6%	8P2
8P3 – Com1	*Aristida holathera*, *Aristida inaequiglumis*, *Chrysopogon fallax* mid tussock grassland	10	53.0	0.3%	8P3, 8P4, 8P5
8P4 – Com1	*Aristida hygrometrica*, *Chrysopogon fallax*, *Aristida holathera* mid open tussock grassland	8	123.1	0.7%	8P4, 8P9
8P6 – Com1	*Eriachne obtusa*, *Aristida holathera*, *Enneapogon purpurescens* mid tussock grassland	5	827.0	4.8%	8P6
8P7 – Com2	*Chrysopogon fallax*, *Aristida holathera*, ± *Eragrostis xerophila* mid tussock grassland	5	618.0	3.6%	8P7
10A1 – Com1	*Astrebla elymoides*, *Iseilema vaginiflorum*, *Polymeria longifolia* mid tussock grassland	1	788.9	4.6%	10A1
13S1 – Com1	*Eulalia aurea* tall tussock grassland	5	281.9	1.6%	13S1
13S2 – Com1	*Aristida latifolia*, *Eulalia aurea*, *Iseilema vaginiflorum* mid tussock grassland	2	549.8	3.2%	13S2
14G1 – Com1	*Astrebla pectinata*, *Aristida latifolia* mid open tussock grassland	9	10,066.6	58.5%	14G1, 14G2
14G2 – Com1	*Iseilema vaginiflorum*, *Fimbristylis dichotoma*, *Chloris pectinata* low open tussock grassland	2	1,417.7	8.2%	14G2, 14G1
Hummock grassland: 1.0%					
8P9 – Com1	*Triodia schinzii*, *Paraneurachne muelleri* tall hummock grassland	5	170.9	1.0%	8P9, 8P4, 8P3
Forbland: 0.05%					
13S2 – Com2	*Elacholoma prostratus*, *Ammannia multiflora* annual low open forbland	1	8.4	0.05%	13S2

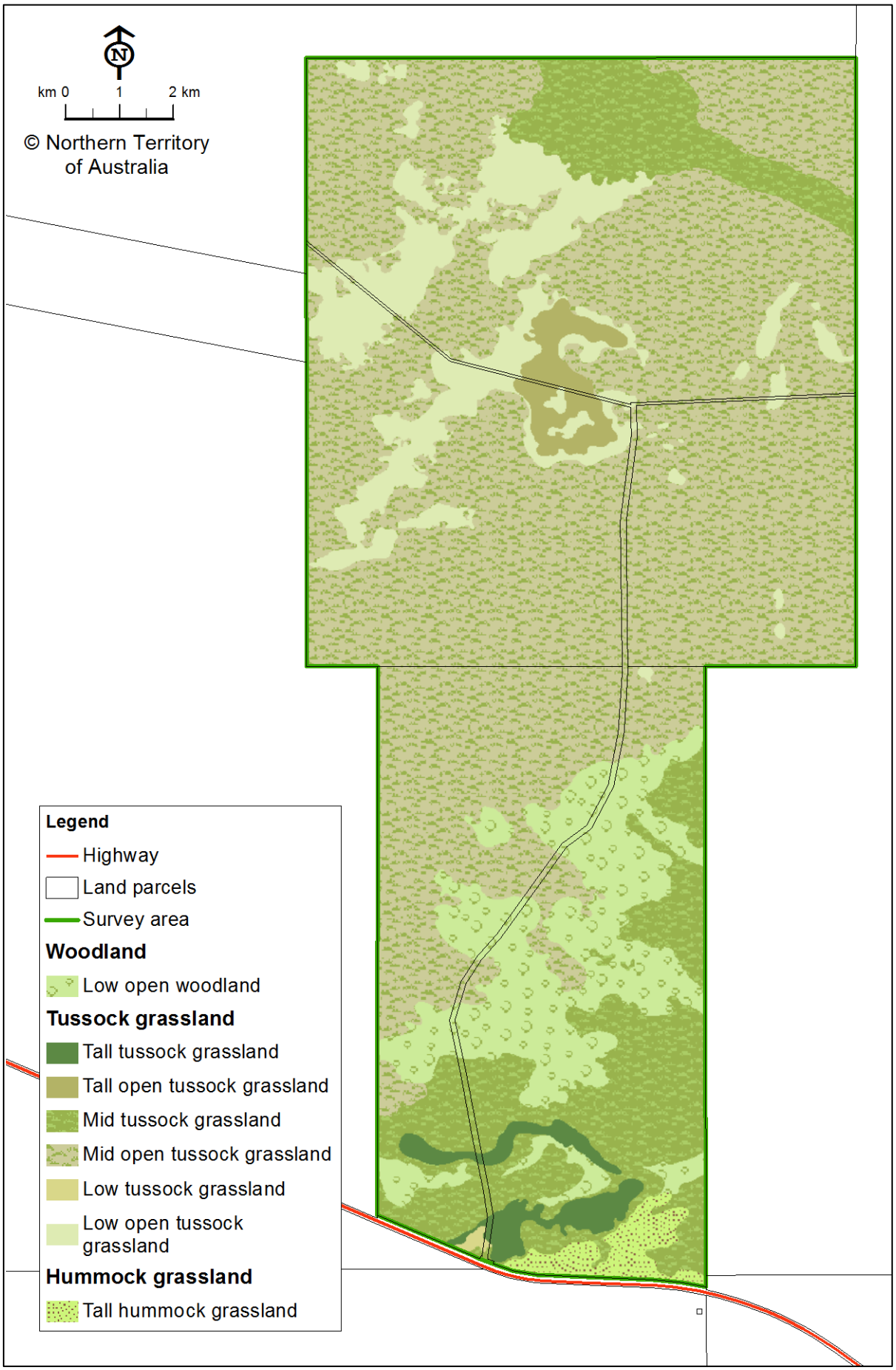


Figure 7.1. General distribution of the major vegetation communities.

8. Land Evaluation

For this study a General Land Capability assessment was conducted that identified good versatile country that could also be considered for irrigated agriculture. The land evaluation is not specific for growing a particular crop, land use or land management practice. While other assessment reports in this series contain an Agricultural Suitability framework that determines suitability for specific crops, it was not considered appropriate in this study due to no examples or experience of crop production in this part of the Barkly region.

8.1 General land capability assessment

Land capability assessment involves an evaluation of land unit characteristics that could influence the general use of the land (Napier & Hill, 2012).

The five key soil and land characteristics considered important for General Land Capability assessment in the survey area were:

- Slope;
- Rock outcrop;
- Soil depth;
- Soil drainage; and
- Microrelief.

For each of these five characteristics, each land unit was then assigned a limitation class. Limitation classes are numbered one to four. Class four has the highest degree of limitation. The lower the limitation the more capable the land is to support a range of land uses.

The overall General Land Capability Class for the land unit was determined by the highest number assigned from the five characteristics, and therefore determined by the most limiting characteristic.

8.1.1 *Slope*

Slope is a critical element that influences runoff and soil erosion. The risk of soil loss from water erosion increases with slope, particularly in the survey area where rainfall intensities are high. Use of any land with a slope greater than 1% in the survey area could pose a threat to long term productivity of the land. Table 8.1 provides the classification of slope into limitation classes and lists the land units assigned to each limitation class, their distribution is presented in Figure 8.1.

Table 8.1. Limitation classes according to slope.

Limitation Class	Slope (%)	Slope Class	Land Units
1	0-1	Level	8P1, 8P3, 8P4, 8P5, 8P8, 8P9, 10A1, 13S1, 13S3, 14G1, 14G2
2	1-3	Gentle	8P2, 8P6, 8P7, 10D1, 13S2
3	3-10	Substantial	Not in survey area
4	>10	Excessive	Not in survey area

8.1.2 *Rock outcrop*

The presence of rock outcrop reduces the area and volume of soil and creates unfavourable conditions for agricultural practices and other land uses. Table 8.2 provides the classification of rock outcrop into limitation classes and lists the land units assigned to each limitation class, their distribution is presented in Figure 8.1.

Table 8.2. Limitation classes according to rock outcrop.

Limitation Class	Rock Outcrop (%)	Rock Outcrop Class	Land Units
1	0	None	8P1, 8P2, 8P3, 8P4, 8P5, 8P7, 8P8, 8P9, 10A1, 13S1, 13S2, 13S3, 14G1, 14G2
2	0-2	Negligible	Not in survey area
3	2-10	Rock	8P6, 10D1
4	>10	Abundant	Not in survey area

8.1.3 *Soil depth*

Soil depth can restrict root penetration and the effective volume of soil that can be utilised by plants. Soil depth is a crucial element in most agricultural activities. Table 8.3 provides the classification of soil depth into limitation classes and lists the land units assigned to each limitation class, their distribution is presented in Figure 8.1.

Table 8.3. Limitation classes according to soil depth

Limitation Class	Soil Depth (m)	Soil Depth Class	Land Units
1	>1.5	Very Deep	10A1, 13S1, 14G1, 14G2
1	1.0-1.5	Deep	Not in survey area
2	0.5-1.0	Moderate	8P1, 8P3, 8P4, 8P7, 8P8, 8P9, 10D1, 13S2
3	0.25-0.5	Shallow	8P2, 8P5, 8P6
4	<0.25	Very Shallow	13S3

8.1.4 *Soil drainage*

Drainage is used to summarise local soil wetness conditions using the six classes defined by NCST (2009). The subsoil horizons within the survey area contained more clay than the topsoil horizons and hence were intrinsically less permeable than the topsoil. When rainfall rates exceed the permeability of the subsoil, water will perch in the soil. Table 8.4 provides the classification of soil drainage into limitation classes and lists the land units assigned to each limitation class, their distribution is presented in Figure 8.1.

Table 8.4. Limitation classes according to soil drainage

Limitation Class	Soil Drainage	Drainage Class	Land Units
1	Water is removed from the soil rapidly in relation to supply. No horizon is normally wet for more than several hours after water addition.	Rapid	Not in survey area
1	Water is removed from the soil readily but not rapidly, and some horizons may remain wet for several days after water addition.	Well	8P1, 8P2, 8P3, 8P4, 8P7, 8P8, 8P9, 10D1
2	Water is removed from the soil somewhat slowly in relation to supply, and horizons remain wet for up to one week.	Moderate	8P6, 14G1
3	Water is removed from the soil slowly in relation to supply, and horizons remain wet for several weeks.	Imperfect	8P5, 10A1, 13S2, 13S3, 14G2
4	Water is removed from the soil very slowly in relation to supply. Seasonal ponding occurs, perched water table may be present, and all soil horizons remain wet for several months.	Poor	13S1
4	Water is removed from the soil so slowly that the water table remains at or near the surface for most of the year.	Very Poor	Not in survey area

8.1.5 *Microrelief*

Microrelief refers to local relief of up to a few metres about the plane of the land surface, caused by deformation and “buckling” of the upper regolith, in landscapes dominated by reactive, shrink-swell clay soils (NCST, 2009). Gilgai vertical intervals of up to approximately 0.3 m or less present a negligible limitation to agricultural development, greater than 0.3 m can significantly impede trafficability, tillage and crop success because of problems with uneven cultivation, reduced trafficability, seasonal ponding and detrimental conditions for crop growth. The degree of limitation depends on the spatial extent (%) of the land surface, the amplitude (vertical interval), and the relative proportion of mounds, depressions and flat shelf areas. Table 8.5 provides the classification of microrelief into limitation classes and lists the land units assigned to each limitation class, their distribution is presented in Figure 8.1.

Table 8.5. Limitation classes according to microrelief

Limitation Class	Vertical interval (m)	Proportion of land surface (%)	Microrelief Class	Land Units
1	No gilgai microrelief	No gilgai microrelief	None	8P1, 8P2, 8P3, 8P4, 8P5, 8P6, 8P7, 8P8, 8P9, 10D1, 13S3, 14G2
2	<0.3	<20	Negligible	13S2
3	<0.3	>20	Moderate	13S1
3	>0.3	<20	Moderate	10A1, 14G1
4	>0.3	>20	Severe	Not in survey area

8.2 General land capability classes

A final limitation class was assigned to each land unit by selecting the highest limitation class that had been assigned to it in any of the five land characteristics considered above; these are listed in Table 8.6. This translates into an overall General Land Capability Class where Class 1 has the highest degree of capability (i.e. least limitations) and Class 4 has the lowest capability for a range of land uses.

Table 8.7 provides a description of the General Land Capability Classes, the land units in each class, and provides the total area of land in each class. Their distribution is presented in Figure 8.2.

Based on the criteria used, approximately 2,492 ha were considered to have moderate capability, consisting of land units possessing well or moderately well drained and deep soils, with sandy or loamy texture. An extensive area, approximately 14,448 ha, was considered to have marginal capability; to develop these areas would require management to overcome shallow soils, imperfect drainage or gilgai microrelief. Approximately 292 ha, were considered not suitable due to very shallow soils or poor drainage.

It is important to note that the land resource information has been collected according to national soil and land resource assessment guidelines at a cartographic scale of 1:50,000. The mapping is a guide, and for site specific uses those areas should be inspected by a suitably qualified professional. Soil depth, drainage, underlying substrate and the soil variability should be some of the characteristics considered, and other characteristics to evaluate will depend on the potential land use, e.g. if irrigation is to be conducted, then deeper (>1.5 m) profile conditions and drainage would be needed.

8.3 Area of interest for irrigated agricultural development

The stakeholder identified a section of land that they were interested in developing that was adjacent to the Barkly Highway, on the western side of the north-south access road, covering approximately 2 x 2 km (400 ha). For this area, additional soil sites were placed on a somewhat grid layout. The agricultural land capability map (Figure 8.2) shows that this area of interest falls into three classes.

- Class 4 land was considered not suitable due to shallow soils and poor drainage; the area was mapped as Land Unit 13S1, and 13S3.
- Class 3 land was considered marginally suitable, requiring major management to overcome the shallow soils and imperfect drainage; the area was mapped as Land Unit 8P5, 8P6 and 13S2.
- Class 2 land was considered moderately suitable, requiring minor management to overcome the moderately deep soils (the significance of this limitation will depend on the crops to be grown and their plant rooting depth needs); the area was mapped as Land Unit 8P3, and 8P4.

This study identified Class 2 land that would be potentially suitable. But as discussed above a suitably qualified professional should conduct investigations of the proposed areas prior to development to verify the finer scale soil distribution and soil characteristics. The site and soil data collected during this survey would assist.

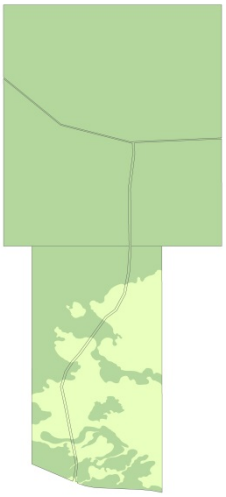
Table 8.6. General Land Capability Classes for each land unit and characteristic.

Land Unit	Slope	Rock Outcrop	Soil Depth	Soil Drainage	Microrelief	General Land Capability Class*	Area (ha)
8P1	1	1	2	1	1	2	436
8P2	2	1	3	1	1	3	274
8P3	1	1	2	1	1	2	19
8P4	1	1	2	1	1	2	122
8P5	1	1	3	3	1	3	73
8P6	2	3	3	2	1	3	1,157
8P7	2	1	2	1	1	2	1,389
8P8	1	1	2	1	1	2	297
8P9	1	1	2	1	1	2	229
10A1	1	1	1	3	3	3	789
10D1	2	3	2	1	1	3	40
13S1	1	1	1	4	3	4	276
13S2	2	1	2	3	2	3	558
13S3	1	1	4	3	1	4	16
14G1	1	1	1	2	3	3	10,399
14G2	1	1	1	3	1	3	1,158

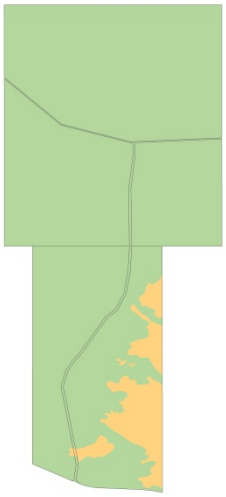
* Numbers 1 to 4 indicates the degree of limitation, with 4 being the most limited and therefore least capable to support a range of land uses, as described in Table 8.7.

Table 8.7. General Agricultural Land Capability class description

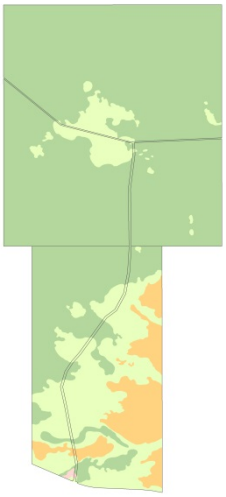
Class	General Land Capability	Description	Land Units	Area (ha)
1	High	Land with minimal limitations. Highly productive requiring only minimal management practices. (Slope 0-1%; and rock outcrop - nil; and soil depth >1.0 m; and soil drainage - rapid or well; and no gilgai microrelief)	Not in survey area	0
2	Moderate	Land with moderate limitations. Will require minor management practices. (Slope 1-3%; and/or rock outcrop - 0-2%; and/or soil depth 0.5 - 1.0 m; and/or soil drainage – moderate; and/or gilgai microrelief <0.3 m vertical interval and <20% of land surface)	8P1, 8P3, 8P4, 8P7, 8P8, 8P9	2492
3	Marginal	Land with severe limitations. Will require major management practices. (Slope 3-10%; and/or rock outcrop - 2-10%; and/or soil depth 0.25-0.5 m; and/or soil drainage – imperfect; and/or gilgai microrelief <0.3 m vertical interval and >20% of land surface)	8P2, 8P5, 8P6, 10A1, 10D1, 13S2, 14G1, 14G2	14,448
4	Not suitable	Land not suitable for agriculture. Limitations cannot be overcome with practical and cost effective management practices. (Slope >10%; and/or rock outcrop - >10%; and/or soil depth <0.25 m; and/or soil drainage – poor or very poor; and/or gilgai microrelief >0.3 m vertical interval and >20% of land surface)	13S1, 13S3	292



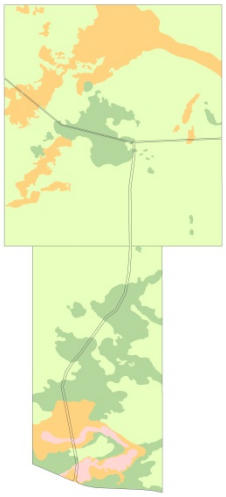
Slope



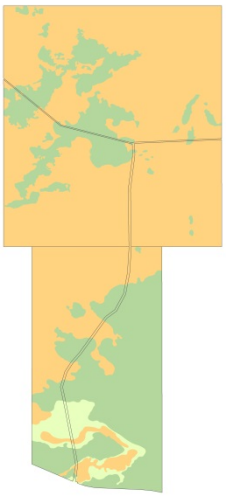
Rock outcrop



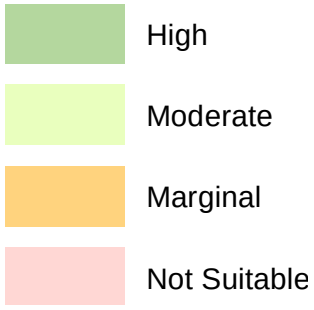
Soil depth



Soil Drainage



Microrelief



Legend for suitability classes

Figure 8.1. Distribution of the land characteristics suitability classes used in the General Land Capability evaluation.

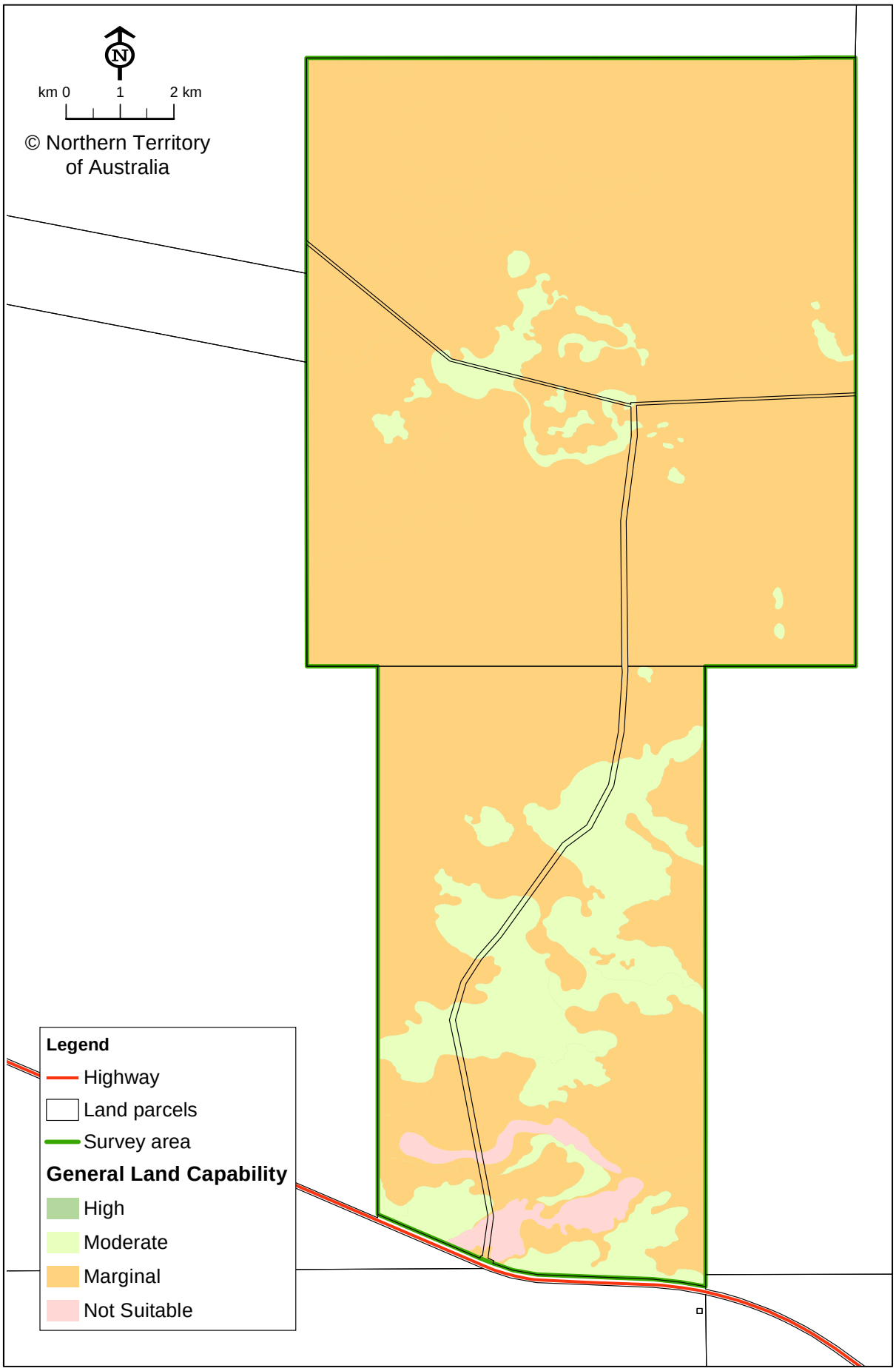


Figure 8.2. Distribution of the General Land Capability Classes. (description of the classes are provided in Table 8.7).

9. Crop Suitability

The Department of Primary Industry and Fisheries (DPIF) has provided crop suitability information presented in Table 9.1. The commercial success of plant industries in the Northern Territory is dependent on several factors, including available markets, prevailing prices, input costs, logistics, difficulty of management and the skills and tenacity of the grower. For the study area, based on land capability alone, there are a number of limiting factors. There are 2,492 ha of land with moderate limitations, with a further 14,448 ha of land with severe limitations such as slope 3-10% and / or rock outcrop 2-10%; and / or soil depth 0.25 – 0.5 metres; and / or soil drainage – imperfect; and / or gilgai microrelief < 0.3 m vertical interval and > 20% of the land surface. The land with moderate soil limitations will require only minor management practices to overcome slope, soil depth, rocks, soil drainage and gilgai microrelief. Based on existing successful plant industries in the Northern Territory, enterprises would need input of grower motivation and expertise, and water and nutrients to be successful within the current study area.

Most agricultural, horticultural or forestry crops that are adapted to a tropical climate would not grow and yield commercial quantities without relatively high levels of inputs such as fertiliser. In a climate such as the Barkly, sustainable development requires soil conservation measures to mitigate potential soil erosion risk. Any enterprise that included cultivation of trees or crops over the dry season would need to manage fire risk.

If these requirements are fulfilled, the following crops may have potential in the Barkly region.

Table 9.1. Description of potential crops (DPIF).

Crop group	Potential	Comments
Sub-tropical to semi-arid tropical fruit	Some examples of fruit with a wider climatic tolerance include banana, mango, citrus, papaya and papaw, passionfruit, pitahaya or dragonfruit and pineapple.	High water requirements, however, some crops including mango, pitahaya and citrus can tolerate a dry season.
Ornamentals	Some examples include heliconias and ornamental gingers.	High input of water and fertiliser required. Highly perishable and require post-harvest logistic systems to accompany cultivation.
Vegetables, herbs, annual fruits	Examples of temperate “summer” crops: Vegetables include pumpkin, cucumber, bitter melon, snake gourd, hairy melon, winter melon, long melon, sin qua, luffa, snake bean, chili, taro, yam bean and okra. Herbs include basil, kankong, coriander and parsley. Annual fruit crops include watermelon,	Erosion from wet season rainfall, pressure from insects and diseases restricts production to dry season. Wind and high temperatures may limit Barkly production in the Summer / Wet Season. All require high inputs of water and fertiliser to produce commercial yields. Melon crops are grown approximately 200 km South of Frewena at Ali Curung, with

Crop group	Potential	Comments
	rockmelon, honeydew melon and hami melon.	production focussed on shoulder seasons of Autumn and Spring, in between production in Southern States (summer) and the Top End of the NT (winter).
Hay and fodder crops	Tropical introduced grasses Rhodes Grass or Sabi Grass, Aerobic (non-paddy) rice; tropical legumes such as cavalcade or fodder peanuts produce their own nitrogen.	Irrigated dry season crops. These are high volume, low value crops. The cost of transport can consume revenue generated by the crop, but crops have been successful in this region when cattle prices are high enough to justify strong fodder prices.
Grains and pulses	Previous crops grown in the Northern Territory include; rice, grain sorghum, corn, soybeans, barley, oats, navy bean and peanuts, however need appropriate inputs of water and fertiliser.	The Top End has long history with limited success; some higher yields from irrigated dry season cropping. Would need to overcome market and transport logistics for commercial success. May be successful as stock feed if cattle prices are strong.
Fibre and industrial crops	Fibre: Kenaf Ethanol: Cassava Biodiesel: Oil palm Industrial gels/gums: Guar Medicinal essential oils: Poppies	Currently not in commercial production in the Northern Territory. Poppies are grown as a commercial trial but have extensive security requirements.
Native fruit	There are several species of native plant foods under investigation in Central Australia.	Local species could be adapted to low fertility soil; however current markets are small but growing.

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10.2 Spatial data sources

Land Parcels, Road Centrelines, Railways, Town locations - Digital Cadastral Database of the NT. Department of Lands, Planning and the Environment, NT. Metadata. Data extracted October 2014

Appendix 1 Soil profile descriptions and analytical data for representative sites

The following pages provide soil descriptions and analytical data (when available) for sites representative of each land unit. All soil sites that were sampled during this study are included.

The pages are organised in numerical order of the site number.

The cross reference table shows land units and sites that occur in each land unit that are presented in this appendix.

Land unit code	Site number presented in this appendix	Laboratory data available
Plains		
8P1	187	Yes
8P2	143	Yes
8P3	107	Yes
8P4	163	Yes
8P5	192	Yes
8P6	177 181	Yes Yes
8P7	127 191 131	Yes Yes Yes
8P8	180 182	Yes Yes
8P9	115	No
Drainage channel		
10A1	188	Yes
10D1	116	No
Inland wetlands		
13S1	103	Yes
13S2	122	No
13S3	175	No
Downs plains		
14G1	129 147	Yes Yes
14G2	140 189	Yes Yes

Site: 103 **Land Unit: 13S1** Australian Soil Classification: Mottled, Epipedal, Grey Vertosol VEADGSDQFQRW

Soil Profile Description

Depth m	Horizon	Description
Surface	-	Firm; dry; 5% 25 mm subrounded quartz gravels; normal gilgai; runoff very slow; slowly permeable; imperfectly drained; no rock outcropping.
0-0.10	A1	Greyish brown (10YR 5/2 dry, 10YR 4/1 moist); light clay; strong subangular blocky; dry; firm; 15% distinct orange mottles; 2% 20 mm quartz gravels; 0% segregations; field pH 5.5; field EC 0.05 dS/m.
0.10-0.30	B1	Grey (10YR 5/1 dry, 10YR 4/1 moist); medium clay; strong angular blocky; dry; strong; 15% distinct orange mottles; 0% coarse fragments; 0% segregations; field pH 5.5; field EC 0.04 dS/m.
0.30-0.80	B21	Grey (10YR 6/1 dry, 2.5Y 5/2 moist); medium clay; strong smooth-ped angular blocky; dry; strong; 10% distinct dark mottles; 0% coarse fragments; 0% segregations; field pH 6.0; field EC 0.04 dS/m.
0.80-1.10	B22	Light brownish grey (10YR 6/2 dry, 2.5Y 5/2 moist); medium clay; massive; dry; strong; 0% mottles; 0% coarse fragments; 0% segregations; slightly calcareous; field pH 6.5; field EC 0.09 dS/m.
1.10-1.50	Cr	White (10YR 8/1 dry); massive; dry; highly calcareous; field pH 8.5; field EC 0.14 dS/m. Stopped by reaching the depth limit of the coring equipment.

Analytical Data

Depth m	Total N %	Available P mg/kg		Ext. K mg/kg	Sulfate S mg/kg	Extr. Micronutrients mg/kg			
		Bicarb	Acid			Cu	Zn	Mn	Fe
0-0.10	0.046	10	8	0.73	2	1.5	0.4	14.1	80.4

Depth m	Coarse Sand %	Fine Sand %	Silt %	Clay %	ECEC/clay ratio	OC %
0-0.10	23.5	40.3	5.5	34.5	0.3	0.72
0.10-0.20	22.4	36.9	3.8	38.4	0.3	0.49
0.20-0.30	23.8	38.7	3.6	35.0	0.3	0.29
0.50-0.60	26.6	39.3	3.6	31.4	0.4	0.28
0.80-0.90	30.0	37.2	1.9	29.8	0.4	0.19
1.10-1.20	-	-	-	-	-	0.23
1.40-1.50	-	-	-	-	-	0.10

Site Summary: Closed depression within a level plain subject to temporary inundation. The soil was deep, imperfectly drained, grey, clay with cracks from the surface into the subsoil, strongly developed blocky structure, and distinct orange mottles in the upper layers; overlying calcareous weathered substrate. The vegetation was *Eulalia aurea* tall tussock grassland.

Site Location: MGA94 Zone 53 541087mE 7853092mN

Depth m	$pH_{1:5}$ H_2O	$EC_{1:5}$ H_2O dS/m	$Cl_{1:5}$ mg/kg	NO_3-N mg/kg	ADMC %	Exchangeable Cations Cmol/kg				ECEC Cmol/kg	ESP %	Ca/Mg Ratio	15 Bar %	$^1/_3$ Bar %	R1 Disp. Ratio
						Ca	Mg	Na	K						
0-0.10	6.1	0.01	<20	<1	2.5	7.28	3.56	<0.080	0.822	12	0.7	2.04	8.1	13.5	0.53
0.10-0.20	6.0	0.01	<20	<1	3.6	8.54	3.32	<0.080	0.780	13	0.6	2.57	9.2	13.9	0.58
0.20-0.30	6.1	0.01	<20	<1	3.2	8.64	2.39	<0.080	0.622	12	0.7	3.62	9.1	14.4	0.66
0.50-0.60	6.2	0.01	<20	<1	2.7	8.63	2.08	<0.080	0.603	11	0.7	4.15	9.2	14.5	0.78
0.80-0.90	6.3	0.01	<20	<1	3.0	8.65	1.96	<0.080	0.593	11	0.7	4.41	8.5	13.7	0.94
1.10-1.20	7.6	0.13	<20	<1	-	11.5	2.13	<0.090	0.923	13 (CEC)	0.7	5.42	-	-	-
1.40-1.50	8.5	0.10	<20	<1	-	10.6	2.62	<0.090	0.960	14 (CEC)	0.7	4.05	-	-	-

Site: 107 **Land Unit: 8P3** Australian Soil Classification: Basic, Paralithic, Red-Orthic Tenosol TEIODUARAEKLV

Soil Profile Description

Depth m	**Horizon**	**Description**
Surface	-	Firm; no visible microrelief; dry; very slow runoff; slowly permeable; well drained; no rock outcropping.
0-0.05	A1	Brown (7.5YR 4/4 dry, 5YR 3/3 moist); sand; massive; dry; firm; 0% mottles; 0% coarse fragments; 0% segregations; field pH 6.0; field EC 0.03 dS/m.
0.05-0.25	B1	Strong brown (7.5YR 5/4 dry, 5YR 3/4 moist); loamy sand; massive; dry; firm; 0% mottles; 0% coarse fragments; 0% segregations; field pH 6.0; field EC 0.03 dS/m.
0.25-0.70	B2	Yellowish red (5YR 5/8 dry, 5YR 4/6 moist); fine sandy loam; massive; dry; very firm; 0% mottles; 0% coarse fragments; 0% segregations; field pH 6.0; field EC 0.03 dS/m.
0.70-1.10	BC	Yellowish brown (10YR 5/6 dry, 7.5YR 4/4 moist); clay loam sandy; massive; dry; strong; 20% distinct grey mottles, 10% distinct red mottles; 5% ferruginous nodules; field pH 6.0; field EC 0.03 dS/m.
1.10-1.40	Cr	Dark yellowish brown (10YR 4/6 dry, 7.5YR 4/3 moist); medium clay; massive; dry; very strong; field pH 7.0; field EC 0.05 dS/m. Stopped by reaching the depth limit of the coring equipment.

Analytical Data

Depth	**Total**	**Available P** mg/kg		**Ext. K**	**Sulfate S**	**Extr. Micronutrients** mg/kg			
m	**N** %	**Bicarb**	**Acid**	mg/kg	mg/kg	**Cu**	**Zn**	**Mn**	**Fe**
0-0.10	0.020	5	4	0.27	<1	0.3	<0.1	2.5	8.1

Depth m	**Coarse Sand** %	**Fine Sand** %	**Silt** %	**Clay** %	**ECEC/clay** ratio	**OC** %
0-0.10	36.4	55.7	1.8	5.6	0.7	0.22
0.10-0.20	39.7	52.2	1.8	9.0	0.5	0.13
0.20-0.30	33.7	49.3	1.8	14.1	0.3	0.09
0.50-0.60	32.9	49.5	1.8	15.8	0.3	0.11
0.80-0.90	28.5	39.5	1.6	29.7	0.3	0.11
1.10-1.20	32.2	30.5	1.6	35.3	0.4	0.15
1.40-1.50	-	-	-	-	-	0.14

Site Summary: Level plain. The soil was moderately deep, well drained, brown, loamy sand grading to yellowish red, sandy loam, massive structure (Tenosols), occasionally grading to sandy clay loam (Kandosols); overlying weathered clay substrate. The vegetation was *Aristida holathera*, *Chrysopogon fallax*, *Aristida hygrometrica* mid tussock grassland.

Site Location: MGA94 Zone 53 540778mE 7852131mN

Depth m	**pH$_{1:5}$ H$_2$O**	**EC$_{1:5}$ H$_2$O** dS/m	**Cl$_{1:5}$** mg/kg	**NO$_3$-N** mg/kg	**ADMC** %	**Exchangeable Cations** Cmol/kg				**ECEC** Cmol/kg	**ESP** %	**Ca/Mg** Ratio	**15 Bar** %	**$^1/_3$ Bar** %	**R1 Disp.** Ratio
						Ca	**Mg**	**Na**	**K**						
0-0.10	7.8	0.03	<20	<1	<1.5	1.93	0.47	<0.090	0.33	4 (CEC)	2.4	4.12	<1.5	3.0	0.65
0.10-0.20	7.6	0.01	<20	<1	<1.5	1.56	0.63	<0.090	0.56	4 (CEC)	2.1	2.47	2.0	3.5	0.65
0.20-0.30	7.4	0.01	<20	<1	<1.5	2.82	0.91	<0.080	0.35	4	1.9	3.09	3.1	5.2	0.63
0.50-0.60	7.1	0.01	<20	<1	1.6	3.18	0.93	<0.080	0.34	5	1.8	3.43	4.0	6.2	0.63
0.80-0.90	6.8	0.01	<20	<1	2.8	5.32	1.58	<0.080	0.47	7	1.1	3.37	8.1	11.0	0.61
1.10-1.20	7.4	0.14	<20	<1	4.9	11.5	2.97	<0.090	0.96	15 (CEC)	0.6	3.87	11.2	15.8	0.86
1.40-1.50	8.2	0.12	<20	<1	-	12.8	3.23	<0.090	0.82	16 (CEC)	0.6	3.96	-	-	-

Site: 115 **Land Unit: 8P9** Australian Soil Classification: Haplic, Eutrophic, Red Kandosol KAAAAHCDAEKOW

Soil Profile Description

Depth m	**Horizon**	**Description**
Surface	-	Firm; dry; light grazing disturbance; termitaria; very slow runoff; slowly permeable; well drained; no rock outcropping.
0-0.08	A1	Strong brown (7.5YR 4/6 dry, 7.5YR 3/6 moist); loamy sand; weak subangular blocky structure; dry; firm; 0% mottles; 0% coarse fragments; 0% segregations; field pH 6.5.
0.08-0.25	B2	Red (2.5YR 5/6 dry, 2.5YR 3/6 moist); sandy clay loam; massive; earthy fabric; dry; very firm; 0% mottles; 0% coarse fragments; 0% segregations; field pH 6.5.
0.25-0.50	B31	Red (2.5YR 5/6 dry, 2.5YR 4/6 moist); loam; massive; dry; very firm; 5% faint grey mottles; 0% coarse fragments; 0% segregations; field pH 6.5.
0.50-1.20	B32	Red (2.5YR 5/6 dry, 2.5YR 4/6 moist); light clay; massive; dry; very firm; 35% faint grey mottles; 3% ferruginous nodules; field pH 7.0.
1.20-1.50	Cr	Light brownish grey (10YR 6/2 dry); dry; strong; 0% mottles; field pH 67.5. Stopped by reaching the depth limit of the coring equipment.

Analytical Data

Depth	**Total**	**Available P** mg/kg		**Ext. K**	**Sulfate S**	**Extr. Micronutrients** mg/kg			
m	**N** %	**Bicarb**	**Acid**	mg/kg	mg/kg	**Cu**	**Zn**	**Mn**	**Fe**
0-0.10	-	-	-	-	-	-	-	-	-

Depth m	**Coarse Sand** %	**Fine Sand** %	**Silt** %	**Clay** %	**CEC/clay** ratio	**OC** %
0-0.10	-	-	-	-	-	-
0.10-0.20	-	-	-	-	-	-
0.20-0.30	-	-	-	-	-	-
0.50-0.60	-	-	-	-	-	-
0.80-0.90	-	-	-	-	-	-
1.10-1.20	-	-	-	-	-	-
1.40-1.50	-	-	-	-	-	-

Site Summary: Level plain with termitaria. The soil was deep, well drained, brown loamy sand grading to red, massive loam and clay with ferruginous nodules; overlying weathered sediments of clay and ferruginous fragments. The vegetation was *Aristida hygrometrica*, *Aristida holathera Aristida inaequiglumis* mid tussock grassland.

Site Location: MGA94 Zone 53 544944mE 7851452mN

This site was **not sampled for laboratory analysis**.

Depth m	**pH$_{1:5}$ H$_2$O**	**EC$_{1:5}$ H$_2$O** dS/m	**Cl$_{1:5}$** mg/kg	**NO$_3$-N** mg/kg	**ADMC** %	**Exchangeable Cations** Cmol/kg				**ECEC** Cmol/kg	**ESP** %	**Ca/Mg** Ratio	**15 Bar** %	**$^1/_3$ Bar** %	**R1 Disp.** Ratio
						Ca	**Mg**	**Na**	**K**						
0-0.10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.10-0.20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.20-0.30	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.50-0.60	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.80-0.90	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.10-1.20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.40-1.50	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Site: 116 **Land Unit: 10D1** Australian Soil Classification: Basic, Paralithic, Brown-Orthic Tenosol TEIODUARBEKKV

Soil Profile Description

Depth m	**Horizon**	**Description**
Surface	-	Loose; dry; light grazing disturbance; no microrelief; very slow runoff; moderate permeable; well drained; no rock outcropping.
0-0.20	A1	Brown (7.5YR 4/4 dry, 7.5YR 4/4 moist); sand; single grain; dry; firm; 0% mottles; 0% coarse fragments; 0% segregations; field pH 6.5.
0.20-0.40	A21	Brown (7.5YR 4/4 dry, 7.5YR 4/4 moist); sand; single grain; dry; firm; 0% mottles; 0% coarse fragments; 0% segregations; field pH 6.5.
0.40-0.70	A22	Strong brown (7.5YR 4/6 dry, 7.5YR 4/6 moist); loamy sand; single grain; dry; very firm; 0% mottles; 0% coarse fragments; 0% segregations; field pH 6.5.
0.70-1.00	C1	Yellowish brown (10YR 5/4 dry); light clay; massive; dry; strong; 50% distinct orange mottles; 0% coarse fragments; 0% segregations field pH 6.5.
1.00-1.50	C2	Light olive brown (2.5Y 5/3 dry); light clay; massive; dry; strong; 50% prominent red mottles; 0% coarse fragments; 0% segregations field pH 7.0. Stopped by reaching the depth limit of the coring equipment.

Analytical Data

Depth	**Total**	**Available P** mg/kg		**Ext. K**	**Sulfate S**	**Extr. Micronutrients** mg/kg			
m	**N** %	**Bicarb**	**Acid**	mg/kg	mg/kg	**Cu**	**Zn**	**Mn**	**Fe**
0-0.10	-	-	-	-	-	-	-	-	-

Depth m	**Coarse Sand** %	**Fine Sand** %	**Silt** %	**Clay** %	**CEC/clay** ratio	**OC** %
0-0.10	-	-	-	-	-	-
0.10-0.20	-	-	-	-	-	-
0.20-0.30	-	-	-	-	-	-
0.50-0.60	-	-	-	-	-	-
0.80-0.90	-	-	-	-	-	-
1.10-1.20	-	-	-	-	-	-
1.40-1.50	-	-	-	-	-	-

Site Summary: Open depression, drainage channel subject to periodic water flow in a level plain. The soil was moderately deep, well drained, brown sand or loamy sand, single grain grading to massive; overlying alluvium. The vegetation was *Aristida hygrometrica*, *Aristida inaequiglumis* mid open tussock grassland.

Site Location: MGA94 Zone 53 546034mE 7853073mN

This site was **not sampled for laboratory analysis**.

Depth	**pH$_{1:5}$ H$_2$O**	**EC$_{1:5}$ H$_2$O**	**Cl$_{1:5}$**	**NO$_3$-N**	**ADMC**	**Exchangeable Cations** Cmol/kg				**ECEC**	**ESP**	**Ca/Mg**	**15 Bar**	**$^1/_3$ Bar**	**R1 Disp.**
m		dS/m	mg/kg	mg/kg	%	**Ca**	**Mg**	**Na**	**K**	Cmol/kg	%	Ratio	%	%	Ratio
0-0.10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.10-0.20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.20-0.30	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.50-0.60	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.80-0.90	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.10-1.20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.40-1.50	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Site: 122 **Land Unit: 13S2** Australian Soil Classification: Endocalcareous, Epipedal, Grey Vertosol VEADGSFZEQRV

Soil Profile Description

Depth m	**Horizon**	**Description**
Surface	-	Firm; dry; 5% 5-25 mm subrounded quartz gravels; normal gilgai; no runoff; very slow permeability; imperfectly drained; no rock outcropping.
0-0.15	A1	Grey (10YR 5/1 dry, 7.5YR 5/1 moist); light clay; strong angular blocky; dry; very firm; 0% mottles; 1% 5 mm quartz gravels; 2% soft calcareous segregations; slightly calcareous; field pH 8.0.
0.15-0.40	B21	Grey (10YR 5/1 dry, 7.5YR 5/1 moist); medium clay; massive; dry; very firm; 0% mottles; 0% coarse fragments; 2% soft calcareous segregations; slightly calcareous; field pH 8.0;
0.40-0.80	B22k	Grey (10YR 5/1 dry, 7.5YR 5/1 moist); light medium clay; massive; dry; strong; 0% mottles; 0% coarse fragments; 10% soft calcareous segregations; moderately calcareous; field pH 8.0.
0.80-0.90	Cr	White (10YR 8/0 dry); dry; very highly calcareous; field pH 8.0. Stopped by an unidentified layer too hard to penetrate.

Analytical Data

Depth m	**Total N** %	**Available P** mg/kg		**Ext. K** mg/kg	**Sulfate S** mg/kg	**Extr. Micronutrients** mg/kg			
		Bicarb	**Acid**			**Cu**	**Zn**	**Mn**	**Fe**
0-0.10	-	-	-	-	-	-	-	-	-

Depth m	**Coarse Sand** %	**Fine Sand** %	**Silt** %	**Clay** %	**CEC/clay** ratio	**OC** %
0-0.10	-	-	-	-	-	-
0.10-0.20	-	-	-	-	-	-
0.20-0.30	-	-	-	-	-	-
0.50-0.60	-	-	-	-	-	-
0.80-0.90	-	-	-	-	-	-
1.10-1.20	-	-	-	-	-	-
1.40-1.50	-	-	-	-	-	-

Site Summary: Margin areas of closed depression within a level plain subject to temporary inundation. The soil was moderately deep, imperfectly drained, grey, cracking, clay, no mottles, grading from slight to moderately calcareous with depth; overlying calcareous weathered rock substrate. The vegetation was *Aristida latifolia*, *Eulalia aurea*, *Chrysopogon fallax* mid tussock grassland.

Site Location: MGA94 Zone 53 541826mE 7854660mN

This site was **not sampled for laboratory analysis**.

Depth m	**$pH_{1:5}$ H_2O**	**$EC_{1:5}$ H_2O** dS/m	**$Cl_{1:5}$** mg/kg	**NO_3-N** mg/kg	**ADMC** %	**Exchangeable Cations** Cmol/kg				**ECEC** Cmol/kg	**ESP** %	**Ca/Mg** Ratio	**15 Bar** %	**$^1/_3$ Bar** %	**R1 Disp.** Ratio
						Ca	**Mg**	**Na**	**K**						
0-0.10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.10-0.20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.20-0.30	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.50-0.60	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.80-0.90	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.10-1.20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.40-1.50	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Site: 127 **Land Unit: 8P7** Australian Soil Classification: Haplic, Eutrophic, Red Kandosol KAAAAHCDAEKMV

Soil Profile Description

Depth m	Horizon	Description
Surface	-	Firm; dry; 10% 5-25 mm subrounded quartz gravels; medium grazing disturbance; termitaria; very slow runoff; slowly permeable; well drained; no rock outcropping.
0-0.05	A1	Yellowish red (5YR 4/6 dry, 5YR 4/3 moist); loamy fine sand; weak; platy; dry; very firm; 0% mottles; 0% coarse fragments; 0% segregations; field pH 6.2; field EC 0.07 dS/m.
0.05-0.20	A2	Red (10YR 4/6 dry, 5YR 4/3 moist); loamy fine sand; weak; subangular blocky; dry; strong; 0% mottles; 0% coarse fragments; 0% segregations; field pH 5.9; field EC 0.04 dS/m.
0.20-0.50	B21	Red (2.5YR 4/8 dry, 2.5YR 3/4 moist); clay loam; massive; earthy; dry; strong; 0% mottles; 0% coarse fragments; 0% segregations; field pH 6.0; field EC 0.05 dS/m.
0.50-0.80	B22	Red (2.5YR 4/8 dry, 2.5YR 3/4 moist); light clay; massive; earthy; dry; strong; 0% mottles; 0% coarse fragments; 0% segregations field pH 6.4; field EC 0.09 dS/m.
0.80-1.00	Cr	White (5YR 8/0); dry; very strong; 0% mottles; field pH 7.3; field EC 0.22 dS/m. Stopped by an unidentified layer too hard to penetrate.

Analytical Data

Depth m	Total N %	Available P mg/kg		Ext. K mg/kg	Sulfate S mg/kg	Extr. Micronutrients mg/kg			
		Bicarb	Acid			Cu	Zn	Mn	Fe
0-0.05	0.038	8	11	0.37	<1	0.3	0.5	10.7	6

Depth m	Coarse Sand %	Fine Sand %	Silt %	Clay %	ECEC/clay ratio	OC %
0-0.05	32.2	58.0	1.6	5.4	0.9	0.37
0.10-0.20	32.9	48.1	3.4	15.6	0.4	0.33
0.20-0.30	30.0	46.5	1.6	20.9	0.4	0.23
0.50-0.60	27.8	38.2	1.5	29.8	0.4	0.23
0.80-0.90	-	-	-	-	-	0.27
1.10-1.20	-	-	-	-	-	-
1.40-1.50	-	-	-	-	-	-

Site Summary: Level to gently undulating plain with termitaria microrelief. The soil was moderately deep, well drained, yellowish red loamy fine sand grading to red clay loam or light clay; overlying calcareous weathered sediments. The vegetation was *Corymbia terminalis* low open woodland over *Aristida holathera*, *Chrysopogon fallax*, *Eulalia aurea* mid tussock grassland.

Site Location: MGA94 Zone 53 544412mE 7859364mN

Depth m	$pH_{1:5}$ H_2O	$EC_{1:5}$ H_2O dS/m	$Cl_{1:5}$ mg/kg	NO_3-N mg/kg	ADMC %	Exchangeable Cations Cmol/kg				ECEC Cmol/kg	ESP %	Ca/Mg Ratio	15 Bar %	$^1/_3$ Bar %	R1 Disp. Ratio
						Ca	Mg	Na	K						
0-0.05	7.6	0.02	<20	<1	<1.5	2.31	0.677	<0.090	0.393	5 (CEC)	1.8	3.41	1.8	3.6	1.00
0.10-0.20	7.3	0.03	<20	<1	<1.5	5.40	0.855	<0.080	0.45	7	1.2	6.32	3.1	5.9	0.71
0.20-0.30	7.3	0.02	<20	<1	2.1	6.36	0.944	<0.080	0.52	8	1.0	6.74	4.8	8.4	0.68
0.50-0.60	7.2	0.01	<20	<1	3.2	9.68	0.986	<0.080	0.52	11	0.7	9.82	8.3	13.0	0.66
0.80-0.90	8.3	0.08	<20	<1	-	-	0.502	<0.090	0.572	11 (CEC)	0.8	22.51	-	-	-
1.10-1.20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.40-1.50	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Site: 129 **Land Unit: 14G1** Australian Soil Classification: Endohypersodic, Epipedal, Grey Vertosol VEADGSBPERRX

Soil Profile Description

Depth m	**Horizon**	**Description**
Surface	-	Surface crust; dry; normal gilgai; 10% 5-30 mm subrounded quartz gravels; no runoff; slowly permeable; moderately well drained; no rock outcropping.
0-0.05	A1	Dark grey (10YR 4/1 dry, 10YR 4/1 moist); medium clay; strong subangular blocky; rough-ped fabric; dry; weak; 0% mottles; 1% 5 mm quartz gravels; 0% segregations; field pH 7.5; field EC 0.36 dS/m.
0.05-0.25	A2	Dark grey (10YR 4/1 dry, 10YR 4/1 moist); medium clay; strong subangular blocky; rough-ped fabric; dry; weak; 0% mottles; 0% coarse fragments; 0% segregations; field pH 8.0; field EC 0.28 dS/m.
0.25-0.60	B21y	Grey (10YR 5/1 dry, 10YR 5/1 moist); medium clay; massive; dry; firm; 0% mottles; 0% coarse fragments; 1% gypseous crystals; field pH 8.0; field EC 2.27 dS/m.
0.60-1.00	B22y	Grey (10YR 5/1 dry; 10YR 5/1 moist); medium clay; massive; dry; firm; 3% faint white mottles; 0% coarse fragments; 1% gypseous crystals; field pH 8.0.
1.00-1.50	BCy	Greyish brown (10YR 5/2 dry, 10YR 5/2 moist); medium clay; massive; dry; very firm; 5% faint white mottles; 0% coarse fragments; 1% gypseous crystals; field pH 8.0; field EC 4.39 dS/m. Stopped by reaching the depth limit of the coring equipment.

Analytical Data

Depth	**Total**	**Available P** mg/kg		**Ext. K**	**Sulfate S**	**Extr. Micronutrients** mg/kg			
m	**N** %	**Bicarb**	**Acid**	mg/kg	mg/kg	**Cu**	**Zn**	**Mn**	**Fe**
0-0.05	0.030	5	8	1.0	4	0.5	0.1	3.2	8.5

Depth m	**Coarse Sand** %	**Fine Sand** %	**Silt** %	**Clay** %	**CEC/clay** ratio	**OC** %
0-0.05	12.3	38.7	8.3	40.2	0.7	0.31
0.10-0.20	11.7	38.3	6.9	44.4	0.7	0.27
0.20-0.30	13.4	41.7	7.1	35.4	0.8	0.20
0.50-0.60	13.3	37.5	-	-	-	0.27
0.80-0.90	13.4	38.1	-	-	-	0.24
1.10-1.20	14.4	34.0	-	-	-	0.21
1.40-1.50	11.7	34.9	-	-	-	0.16

Site Summary: Level plain, with gilgai microrelief. The soil was deep, moderately well drained, dark grey, cracking, medium clay, strongly structured, over grey, medium clay, with gypsum crystals; overlying weathered clay sediments; The vegetation was *Aristida latifolia*, *Astrebla pectinata mid open tussock grassland.*

Site Location: MGA94 Zone 53 540963mE 7860226mN

Gypsum concentration from laboratory estimate: 0.2-0.3 m 2.2%; 0.5-0.6 m 6.9%; 0.8-0.9 m 6.3%; 1.1-1.2 m 8.0%; 1.4-1.5 m 6.1%

Depth	**pH$_{1:5}$ H$_2$O**	**EC$_{1:5}$ H$_2$O**	**Cl$_{1:5}$**	**NO$_3$-N**	**ADMC**	**Exchangeable Cations** Cmol/kg				**CEC**	**ESP**	**Ca/Mg**	**15 Bar**	**$^1/_3$ Bar**	**R1 Disp.**
m		dS/m	mg/kg	mg/kg	%	**Ca**	**Mg**	**Na**	**K**	Cmol/kg	%	Ratio	%	%	Ratio
0-0.05	7.8	0.06	<20	1	3.3	25.8	1.52	<0.090	1.16	29	0.3	16.9	12.0	18.3	0.53
0.10-0.20	7.6	1.02	<20	<1	5.2	29.2	0.847	<0.090	0.592	29	0.3	34.5	13.2	18.8	0.41
0.20-0.30	7.6	1.86	<20	<1	4.4	26.1	1.33	0.239	0.381	24	1.0	19.6	12.5	16.6	0.59
0.50-0.60	7.6	2.56	32	<1	5.1	24.9	3.21	1.97	0.422	25	7.9	7.77	14.6	19.4	0.66
0.80-0.90	7.5	3.20	377	<1	5.4	19.5	5.58	5.27	0.602	23	23	3.49	15.2	20.7	0.79
1.10-1.20	7.6	3.73	948	<1	6.5	17.7	6.69	7.23	0.645	23	31	2.64	16.2	22.4	0.87
1.40-1.50	7.6	4.00	1320	<1	6.9	17.3	7.19	7.77	0.716	25	31	2.41	17.3	24.2	0.86

Site: 131	Land Unit: Not Used occurs in 8P7	Australian Soil Classification: Ceteric, Paralithic, Calcic Calcarosol	CABDDUICBEOOW

Soil Profile Description

Depth m	Horizon	Description
Surface	-	Surface crust; cryptogam surface; dry; 5% 10 mm subrounded quartz gravels; very slow runoff; slowly permeable; moderately well drained; no rock outcrop.
0-0.10	A1	Brown (10YR 5/3 dry, 10YR 5/2 moist); light clay; strong angular blocky; dry; very firm; 0% mottles; 0% coarse fragments; 2% calcareous soft segregations; moderately calcareous; field pH 8.0.
0.10-0.25	A2k	Brown (10YR 5/3 dry, 10YR 5/2 moist); medium clay; medium subangular block; dry; strong; 0% mottles; 0% coarse fragments; 2% calcareous soft segregations; moderately calcareous; field pH 8.0.
0.25-0.40	B1k	Greyish brown (10YR 5/2 dry, 10YR 4/2 moist); medium clay; massive; dry; strong; 0% mottles; 0% coarse fragments; 5% calcareous soft segregations; highly calcareous; field pH 8.0.
0.40-1.20	B2k	Grey (10YR 5/1 dry, 10YR 4/2 moist); medium clay; massive; dry; strong; 0% mottles; 0% coarse fragments; 5% calcareous soft segregations; highly calcareous; field pH 8.0.
1.20-1.30	Ckr	White (10YR 8/0 dry); medium clay; mix of soil and calcrete fragments; dry; very strong; very highly calcareous; field pH 8.0; field EC 0.42 dS/m. Stopped by an unidentified layer too hard to penetrate.

Analytical Data

Depth m	Total N %	Available P mg/kg		Ext. K mg/kg	Sulfate S mg/kg	Extr. Micronutrients mg/kg			
		Bicarb	Acid			Cu	Zn	Mn	Fe
0-0.05	0.048	6	9	0.91	6	0.6	0.1	5.3	6.2

Depth m	Coarse Sand %	Fine Sand %	Silt %	Clay %	CEC/clay ratio	OC %
0-0.05	22.0	47.7	1.4	24.3	0.6	0.49
0.10-0.20	21.9	41.7	6.5	27.8	0.7	0.37
0.20-0.30	12.0	51.0	4.9	27.8	0.7	0.22
0.50-0.60	21.9	42.2	4.9	27.9	0.7	0.18
0.80-0.90	22.3	40.1	4.8	28.1	0.7	0.19
1.10-1.20	22.9	39.6	4.9	30.0	0.7	0.18
1.40-1.50	-	-	-	-	-	-

Site Summary: Level plain. The soil was deep, moderately well drained, brownish grey, light clay, grading to grey, medium clay, calcareous throughout; overlying calcareous weathered substrate. The vegetation was *Aristida latifolia*, *Eulalia aurea*, *Chrysopogon fallax* mid tussock grassland.

Site Location: MGA94 Zone 53 543033mE 7857382mN

Depth m	$pH_{1:5}$ H_2O	$EC_{1:5}$ H_2O dS/m	$Cl_{1:5}$ mg/kg	NO_3-N mg/kg	ADMC %	Exchangeable Cations Cmol/kg				CEC Cmol/kg	ESP %	Ca/Mg Ratio	15 Bar %	$^1/_3$ Bar %	R1 Disp. Ratio
						Ca	Mg	Na	K						
0-0.05	7.8	0.05	<20	1	2.5	12.2	3.18	<0.090	0.987	15	0.6	3.84	8.6	12.3	0.71
0.10-0.20	7.7	0.04	<20	<1	3.0	16.3	2.44	<0.090	0.716	18	0.5	6.67	9.0	13.5	0.53
0.20-0.30	8.4	0.08	<20	<1	3.3	18.7	2.19	<0.090	0.694	20	0.5	8.52	9.3	13.8	0.59
0.50-0.60	8.5	0.11	<20	<1	3.6	18.6	3.17	0.177	0.265	20	0.9	5.86	9.6	14.3	0.59
0.80-0.90	8.8	0.13	<20	<1	4.0	17.8	3.72	0.717	0.310	21	3.4	4.77	10.1	15.3	0.63
1.10-1.20	8.9	0.17	34	<1	4.6	17.2	3.92	1.19	0.317	20	6.0	4.38	11.8	16.6	0.68
1.40-1.50	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Site: 140 **Land Unit: 14G2** Australian Soil Classification: Endohypersodic, Epipedal, Grey Vertosol VEADGSBPERRX

Soil Profile Description

Depth m	Horizon	Description
Surface	-	Cracking; surface crust; dry; 5% 5-25 mm subrounded quartz gravels; medium grazing disturbance; no runoff; slowly permeable; imperfectly drained; no rock outcropping.
0-0.05	A1	Grey (10YR 5/1 dry, 10YR 5/1 moist); light medium clay; strong rough-ped angular blocky; dry; very firm; 0% mottles; 2% 5-10 mm quartz gravels; 0% segregations; non-calcareous; field pH 7.5; field EC 0.12 dS/m.
0.10-0.25	B1	Grey (10YR 6/1 dry, 10YR 6/1 moist); medium clay; strong rough-ped angular blocky; dry; strong; 0% mottles; 0% coarse fragments; 0% segregations; non-calcareous; field pH 7.5; field EC 0.10 dS/m.
0.25-0.80	B2	Grey (10YR 5/1 dry, 10YR 5/1 moist); medium clay; massive; dry; strong; 0% mottles; 0% coarse fragments; 0% segregations; non-calcareous; field pH 8.0; field EC 2.6 dS/m.
0.80-1.50	BC	Grey (10YR 5/1 dry, 10YR 5/1 moist); medium clay; massive; dry; strong; 3% faint orange mottles; 0% coarse fragments; 3% gypseous soft segregations; non-calcareous; field pH 8.0; field EC 3.0 dS/m. Stopped by reaching the depth limit of the coring equipment.

Analytical Data

Depth m	Total N %	Available P mg/kg		Ext. K mg/kg	Sulfate S mg/kg	Extr. Micronutrients mg/kg			
		Bicarb	Acid			Cu	Zn	Mn	Fe
0-0.10	0.023	4	6	1.1	2	0.7	0.1	13.2	16.3

Depth m	Coarse Sand %	Fine Sand %	Silt %	Clay %	CEC/clay ratio	OC %
0-0.10	11.5	39.1	8.3	41.8	0.6	0.21
0.10-0.20	11.6	39.5	6.6	42.2	0.6	0.21
0.20-0.30	10.1	32.5	4.9	49.8	0.6	0.17
0.50-0.60	11.0	32.7	8.5	48.7	0.6	0.13
0.80-0.90	9.7	32.7	6.8	50.7	0.6	0.12
1.10-1.20	10.1	34.6	3.0	49.0	1.0	0.10
1.40-1.50	8.4	30.1	8.4	51.2	1.3	0.11

Site Summary: Level plain with no gilgai microrelief, a localised area that becomes inundated. The soil was moderately deep, imperfectly drained, cracking, grey, medium clay, strongly structured, with gypsum crystals in the subsoil; overlying weathered clay sediments. The vegetation was *Chloris pectinata Fimbristylis dichotoma*, *Iseilema vaginiflorum* low open tussock grassland.

Site Location: MGA94 Zone 53 547361mE 7867221mN

Gypsum concentration from laboratory estimate: 0.2-0.3 m <0.1%; 0.5-0.6 m <0.1%; 0.8-0.9 m 0.3%; 1.1-1.2 m 0.7%; 1.4-1.5 m 1.4%

Depth m	$pH_{1:5}$ H_2O	$EC_{1:5}$ H_2O dS/m	$Cl_{1:5}$ mg/kg	NO_3-N mg/kg	ADMC %	Exchangeable Cations Cmol/kg				CEC Cmol/kg	ESP %	Ca/Mg Ratio	15 Bar %	$^1/_3$ Bar %	R1 Disp. Ratio
						Ca	Mg	Na	K						
0-0.10	7.6	0.04	<20	3	3.6	13.1	9.65	0.577	1.46	25	2.3	1.4	14.4	24.5	0.70
0.10-0.20	7.7	0.05	29	1	4.7	13.4	8.40	1.21	1.18	24	5.1	1.6	14.9	25.8	0.81
0.20-0.30	7.9	0.31	333	7	6.0	15.7	9.84	3.24	1.10	30	10.8	1.6	15.8	26.5	0.77
0.50-0.60	7.8	1.37	864	14	6.8	15.6	10.4	5.18	1.02	28	18.5	1.5	13.4	25.7	0.59
0.80-0.90	7.6	2.34	1090	15	7.4	15.7	11.5	6.34	1.09	32	19.9	1.4	15.4	27.7	0.70
1.10-1.20	6.8	2.74	1120	15	7.1	27.9	12.2	5.58	0.973	46 ECEC	12.0	2.3	15.7	27.4	0.78
1.40-1.50	7.3	3.20	1230	16	7.9	42.6	14.1	6.61	1.08	64 ECEC	10.3	3.0	18.2	30.2	0.70

Site: 143 **Land Unit: 8P2** Australian Soil Classification: Haplic, Eutrophic, Brown Kandosol KAAABHCDAELOU

Soil Profile Description

Depth m	Horizon	Description
Surface	-	Firm; dry; 3% 5 mm subrounded ironstone gravels; medium grazing disturbance; termitaria microrelief; very slow runoff; slowly permeable; well drained; no rock outcropping.
0-0.10	A1	Strong brown (7.5YR 5/6 dry, 7.5YR 4/3 moist); loam; massive; dry; strong; no mottles; 5% ferruginous fragments; non-calcareous; field pH 6.5.
0.10-0.25	B2	Strong brown (7.5YR 4/6 dry, 5YR 4/6 moist); clay loam; massive; dry; strong; no mottles; 3% ferruginous fragments; non-calcareous; field pH 6.5.
0.25-0.90	Cr	Yellowish red (5YR 5/6 dry, 5YR 4/6 moist); light clay; massive; dry; strong; 0% mottles; 60% ferruginous fragments; non-calcareous; field pH 7.0. Stopped by an unidentified layer too hard to penetrate.

Analytical Data

Depth m	Total N %	Available P mg/kg		Ext. K mg/kg	Sulfate S mg/kg	Extr. Micronutrients mg/kg			
		Bicarb	Acid			Cu	Zn	Mn	Fe
0-0.05	0.063	11	13	0.81	4	0.9	0.5	18.9	38.4

Depth m	Coarse Sand %	Fine Sand %	Silt %	Clay %	CEC/clay ratio	OC %
0-0.05	12.7	58.3	13.2	17.5	0.3	0.77
0.10-0.20	9.8	53.0	7.9	27.8	0.2	0.25
0.20-0.30	8.7	46.8	8.1	40.4	0.2	0.28
0.50-0.60	10.2	28.7	6.6	55.6	0.2	0.21
0.80-0.90	-	-	-	-	-	0.15
1.10-1.20	-	-	-	-	-	-
1.40-1.50	-	-	-	-	-	-

Site Summary: Level to gently undulating residual plain with termitaria microrelief. The soil was shallow, well drained, strong brown, loam, with common ferruginous fragments; grading to clay loam; overlying weathered sediments of clay with more than 50% ferruginous fragments. The vegetation was low open woodland over *Aristida inaequiglumis* mid open tussock grassland with *Corymbia aparrerinja* isolated clumps of trees.

Site Location: MGA94 Zone 53 543806mE 7867279mN

Depth m	$pH_{1:5}$ H_2O	$EC_{1:5}$ H_2O dS/m	$Cl_{1:5}$ mg/kg	NO_3-N mg/kg	ADMC %	Exchangeable Cations Cmol/kg				ECEC Cmol/kg	ESP %	Ca/Mg Ratio	15 Bar %	$^1/_3$ Bar %	R1 Disp. Ratio
						Ca	Mg	Na	K						
0-0.05	6.7	0.04	<20	4	<1.5	3.30	1.75	<0.080	0.834	6	1.3	1.89	6.5	12.6	0.73
0.10-0.20	6.5	0.02	<20	<1	2.2	3.65	1.46	<0.080	0.772	6	1.3	2.50	7.0	11.0	0.57
0.20-0.30	6.3	0.02	<20	<1	3.9	4.51	1.85	<0.080	0.844	7	1.1	2.44	9.5	13.3	0.64
0.50-0.60	6.2	0.02	<20	<1	6.6	6.44	2.67	<0.080	1.11	10	0.8	2.41	15.2	20.5	0.53
0.80-0.90	6.2	0.02	<20	<1	--	6.56	2.64	<0.080	0.979	10	0.8	2.48	-	-	-
1.10-1.20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.40-1.50	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Site: 147 **Land Unit: 14G1** Australian Soil Classification: Gypsic, Epipedal, Grey Vertosol VEADGSBZERRX

Soil Profile Description

Depth m	**Horizon**	**Description**
Surface	-	Firm; cracking; normal gilgai; dry; 5% 5-35 mm subrounded quartz gravels; light grazing disturbance; no runoff; slow permeable; moderately well drained.
0-0.05	A1	Grey (10YR 5/1 dry, 10YR 5/1 moist); light clay; strong blocky; dry; very firm; 0% mottles; 0% coarse fragments; 0% segregations; non-calcareous; field pH 6.5.
0.05-0.25	B1	Grey (10YR 5/1 dry, 10YR 5/1 moist); medium clay; strong rough-ped blocky; dry; very firm; 0% mottles; 0% coarse fragments; 0% segregations; non-calcareous; field pH 7.0.
0.25-1.10	B2y	Grey (10YR 5/1 dry, 10YR 5/1 moist); medium clay; massive; dry; strong; 0% mottles; 0% coarse fragments; 3% gypseous crystals; non-calcareous; field pH 8.0.
1.10-1.50	BCy	Greyish brown (10YR 5/2 dry, 10YR 5/2 moist); medium heavy clay; massive; dry; strong; 5% faint red mottles; 3% 5 mm quartz gravels; 3% gypseous crystals; non-calcareous; field pH 8.0. Stopped by reaching the depth limit of the coring equipment.

Analytical Data

Depth	**Total**	**Available P** mg/kg		**Ext. K**	**Sulfate S**	**Extr. Micronutrients** mg/kg			
m	**N** %	**Bicarb**	**Acid**	mg/kg	mg/kg	**Cu**	**Zn**	**Mn**	**Fe**
0-0.10	0.040	5	9	1.4	8	0.6	0.2	11.1	11.6

Depth m	**Coarse Sand** %	**Fine Sand** %	**Silt** %	**Clay** %	**CEC/clay** ratio	**OC** %
0-0.10	18.1	37.1	4.6	42.3	0.6	0.49
0.10-0.20	16.6	31.4	2.8	48.3	0.6	0.23
0.20-0.30	15.2	31.6	2.8	48.4	0.6	0.21
0.50-0.60	14.6	31.1	6.7	48.3	0.9	0.20
0.80-0.90	15.3	32.3	2.9	48.3	1.1	0.18
1.10-1.20	15.8	31.4	6.5	48.8	1.5	0.17
1.40-1.50	13.0	29.2	6.6	49.2	1.7	0.13

Site Summary: Level plain with gilgai microrelief. The soil was deep, moderately well drained, grey, cracking, medium clay, with gypsum crystals in the subsoil; overlying weathered clay sediments. The vegetation was *Astrebla pectinata* mid open tussock grassland.

Site Location: MGA94 Zone 53 548577mE 7867219mN

Gypsum concentration from laboratory estimate: 0.2-0.3 m <0.1%; 0.5-0.6 m 0.9%; 0.8-0.9 m 1.2%; 1.1-1.2 m 1.6%; 1.4-1.5 m 2.8%

Depth	**$pH_{1:5}$**	**$EC_{1:5}$ H_2O**	**$Cl_{1:5}$**	**NO_3-N**	**ADMC**	**Exchangeable Cations** Cmol/kg				**CEC**	**ESP**	**Ca/Mg**	**15 Bar**	**$^1/_3$ Bar**	**R1 Disp.**
m	**H_2O**	dS/m	mg/kg	mg/kg	%	**Ca**	**Mg**	**Na**	**K**	Cmol/kg	%	Ratio	%	%	Ratio
0-0.10	6.3	0.06	25	3	4.3	19.8	5.47	<0.080	1.50	27	0.3	3.62	16.2	20.8	0.51
0.10-0.20	6.7	0.03	<20	1	6.0	24.7	4.02	<0.080	0.962	30	0.3	6.14	16.9	20.1	0.49
0.20-0.30	6.9	0.09	<20	<1	6.2	25.8	4.12	0.178	0.908	31	0.6	6.26	18.3	21.0	0.45
0.50-0.60	6.9	1.51	<20	<1	6.1	35.9	5.94	1.00	0.96	44	2.3	6.04	20.9	23.2	0.44
0.80-0.90	7.2	2.39	190	<1	6.0	37.0	9.85	4.40	1.05	52	8.4	3.76	22.0	23.1	0.66
1.10-1.20	7.4	3.31	1040	<1	7.0	53.1	12.3	7.85	1.12	74	10.6	4.32	22.9	26.0	0.89
1.40-1.50	7.3	4.20	1680	<1	8.0	57.8	13.6	8.93	1.19	82	11.0	4.25	21.3	26.6	0.89

Site: 163 **Land Unit: 8P4** Australian Soil Classification: Haplic, Eutrophic, Red, Kandosol KAAAAHCDAEKMV

Soil Profile Description

Depth m	**Horizon**	**Description**
Surface	-	Firm; dry; light grazing disturbance; termitaria; very slow runoff; slowly permeable; well drained.
0-0.10	A1	Yellowish red (5YR 4/6 dry, 2.5YR 3/6 moist); loamy sand; massive; dry; weak; 0% mottles; 0% coarse fragments; 0% segregations; field pH 6.0.
0.10-0.30	A3	Yellowish red (5YR 4/6 dry, 2.5YR 3/6 moist); loamy sand; single grain; dry; weak; 0% mottles; 0% coarse fragments; 0% segregations; field pH 6.5.
0.30-0.50	B21	Red (2.5YR 4/8 dry, 2.5YR 4/4 moist); sandy loam; massive; dry; firm; 0% mottles; 0% coarse fragments; 0% segregations; non-calcareous; field pH 6.5.
0.50-0.70	B22	Red (2.5YR 4/8 dry, 2.5YR 4/4 moist); clay loam; massive; earthy; dry; very firm; 0% mottles; 15% ferruginous nodules; non-calcareous; field pH 6.0.
0.70-0.90	Cr	Yellowish brown (10YR 5/6 dry, 2.5YR 3/6 moist); clay loam; massive; dry; strong; 0% mottles; 55% ferruginous fragments; non-calcareous; field pH 6.0. Stopped by an unidentified layer too hard to penetrate.

Analytical Data

Depth m	**Total N** %	**Available P** mg/kg		**Ext. K** mg/kg	**Sulfate S** mg/kg	**Extr. Micronutrients** mg/kg			
		Bicarb	**Acid**			**Cu**	**Zn**	**Mn**	**Fe**
0-0.10	0.019	6	9	0.24	<1	0.4	0.2	5.3	6.3

Depth m	**Coarse Sand** %	**Fine Sand** %	**Silt** %	**Clay** %	**CEC/clay** ratio	**OC** %
0-0.10	35.8	52.8	2.9	7.2	0.5	0.19
0.10-0.20	35.9	51.3	2.8	8.9	0.3	0.14
0.20-0.30	33.9	51.6	2.7	10.6	0.3	0.08
0.50-0.60	29.0	41.7	<1.0	26.0	0.2	0.10
0.80-0.90	29.2	37.0	6.1	29.8	0.2	0.11
1.10-1.20	-	-	-	-	-	-
1.40-1.50	-	-	-	-	-	-

Site Summary: Level to gently undulating plain with termitaria. The soil was moderately deep, well drained, yellowish red loamy sand grading to red, massive clay loam with ferruginous nodules; overlying weathered sediments of clay and ferruginous fragments. The vegetation was *Corymbia terminalis* low open woodland over *Chrysopogon fallax*, *Aristida holathera*, *Aristida hygrometrica* mid tussock grassland.

Site Location: MGA94 Zone 53 541164mE 7852112mN

Depth m	**$pH_{1:5}$ H_2O**	**$EC_{1:5}$ H_2O** dS/m	**$Cl_{1:5}$** mg/kg	**NO_3-N** mg/kg	**ADMC** %	**Exchangeable Cations** Cmol/kg				**ECEC** Cmol/kg	**ESP** %	**Ca/Mg** Ratio	**15 Bar** %	**$^1/_3$ Bar** %	**R1 Disp.** Ratio
						Ca	**Mg**	**Na**	**K**						
0-0.10	7.7	0.01	<20	1	<1.5	1.78	0.66	<0.09	0.39	4 CEC	2.3	2.71	3.1	3.4	0.92
0.10-0.20	7.4	0.01	<20	<1	<1.5	2.06	0.69	<0.08	0.27	3	2.6	2.98	3.1	3.2	0.88
0.20-0.30	7.1	0.01	<20	<1	<1.5	2.10	0.72	<0.08	0.30	3	2.5	2.94	3.7	3.3	0.76
0.50-0.60	6.5	0.02	<20	<1	2.2	3.72	1.45	<0.08	0.39	6	1.4	2.57	7.4	7.9	0.56
0.80-0.90	6.4	0.01	<20	<1	3.6	4.51	1.87	<0.08	0.43	7	1.2	2.41	9.9	11.1	0.66
1.10-1.20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.40-1.50	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Site: 175 **Land Unit: 13S3** Australian Soil Classification: Basic, Paralithic, Grey-Orthic Tenosol TEIQDUARBFMMT

Soil Profile Description

Depth m	Horizon	Description
Surface	-	Dry; light grazing disturbance; no microrelief; 10% 5-30 mm subrounded quartz gravels and 10% 5 mm ferruginous fragments; very slow runoff; slow permeability; imperfectly drained.
0-0.20	A1	Pinkish grey (7.5YR 6/2 dry); clay loam; single grain; dry; weak; 0% mottles; 0% coarse fragments; 0% segregations; non-calcareous; field pH 6.0.
0.20-1.00	Cr	Light brownish grey (10YR 6/2 dry); light clay; massive; dry; strong; 40% distinct red mottles; 0% coarse fragments; 0% segregations; non-calcareous; field pH 6.5. Stopped by an unidentified layer too hard to penetrate.

Analytical Data

Depth	Total	Available P mg/kg		Ext. K	Sulfate S	Extr. Micronutrients mg/kg			
m	N %	Bicarb	Acid	mg/kg	mg/kg	Cu	Zn	Mn	Fe
0-0.10	-	-	-	-	-	-	-	-	-

Depth m	Coarse Sand %	Fine Sand %	Silt %	Clay %	CEC/clay ratio	OC %
0-0.10	-	-	-	-	-	-
0.10-0.20	-	-	-	-	-	-
0.20-0.30	-	-	-	-	-	-
0.50-0.60	-	-	-	-	-	-
0.80-0.90	-	-	-	-	-	-
1.10-1.20	-	-	-	-	-	-
1.40-1.50	-	-	-	-	-	-

Site Summary: Level plain, 10-60% quartz and ironstone gravels on the surface. The soil was very shallow, imperfectly drained, clay loam; overlying a mottled clay substrate. The vegetation was *Aristida contorta*, *Aristida holathera* low tussock grassland.

Site Location: MGA94 Zone 53 542010mE 7851754mN

This site was **not sampled for laboratory analysis**.

Depth	$pH_{1:5}$ H_2O	$EC_{1:5}$ H_2O	$Cl_{1:5}$	NO_3-N	ADMC	Exchangeable Cations Cmol/kg				ECEC	ESP	Ca/Mg	15 Bar	$^1/_3$ Bar	R1 Disp.
m		dS/m	mg/kg	mg/kg	%	Ca	Mg	Na	K	Cmol/kg	%	Ratio	%	%	Ratio
0-0.10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.10-0.20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.20-0.30	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.50-0.60	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.80-0.90	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.10-1.20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.40-1.50	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Site: 177 **Land Unit: 8P6** Australian Soil Classification: Ceteric, Paralithic, Calcic, Calcarosol CABDDUICAFKLU

Soil Profile Description

Depth m	**Horizon**	**Description**
Surface	-	Weak; moist; light grazing disturbance; no microrelief; 20% 2-20 mm subangular calcrete fragments; no runoff; very slow permeability; moderately well drained, no rock outcropping.
0-0.08	A1	Dark reddish brown (5YR 3/4 dry, 5YR 4/4 moist); loamy sand; weak subangular blocky structure; 0% mottles; 0% coarse fragments; 0% segregations; moderately calcareous; field pH 8.0.
0.08-0.30	B1	Dark reddish brown (5YR 3/4 dry, 5YR 4/4 moist); sandy loam; weak subangular blocky structure; 0% mottles; 30% 2-10mm calcrete coarse fragments; 0% segregations; highly calcareous; field pH 8.0.
0.30-0.55	C	White (10YR 8/1) weathered calcrete; highly calcareous; field pH 8.5. Stopped at this depth by rock.

Analytical Data

Depth	**Total**	**Available P** mg/kg		**Ext. K**	**Sulfate S**	**Extr. Micronutrients** mg/kg			
m	**N** %	**Bicarb**	**Acid**	mg/kg	mg/kg	**Cu**	**Zn**	**Mn**	**Fe**
0-0.10	0.03	2	9	0.54	<1	0.2	0.1	2.6	<2.0

Depth m	**Coarse Sand** %	**Fine Sand** %	**Silt** %	**Clay** %	**CEC/clay** ratio	**OC** %
0-0.10	30.9	58.2	4.5	10.4	0.7	0.41
0.10-0.20	31	56.4	4.5	10.4	0.6	0.26
0.20-0.30	33.8	51.6	2.9	12.1	0.5	0.26
0.50-0.60	-	-	-	-	-	-
0.80-0.90	-	-	-	-	-	-
1.10-1.20	-	-	-	-	-	-
1.40-1.50	-	-	-	-	-	-

Site Summary: Level plain, 20% calcrete fragments on the surface. The soil was shallow, moderately well drained, reddish, loamy sand grading to red, gravelly sandy loam, overlying a weathered calcrete substrate. The vegetation was *Aristida holathera*, *Eriachne obtusa* low tussock grassland.

Site Location: MGA94 Zone 53 545915mE 7859053mN

Depth	**$pH_{1:5}$**	**$EC_{1:5}$ H_2O**	**$Cl_{1:5}$**	**NO_3-N**	**ADMC**	**Exchangeable Cations** Cmol/kg				**CEC**	**ESP**	**Ca/Mg**	**15 Bar**	**$^1/_3$ Bar**	**R1 Disp.**
m	**H_2O**	dS/m	mg/kg	mg/kg	%	**Ca**	**Mg**	**Na**	**K**	Cmol/kg	%	Ratio	%	%	Ratio
0-0.10	8.90	0.06	<20	3	<1.5	7.57	0.677	<0.090	0.434	7	1.3	11.2	4.9	5.2	0.67
0.10-0.20	9.00	0.06	<20	1	<1.5	7.59	0.562	<0.090	0.356	7	1.4	13.5	5.1	5.4	0.81
0.20-0.30	9.07	0.07	<20	<1	<1.5	7.73	0.547	<0.090	0.385	6	1.5	14.1	6.0	6.5	0.94
0.50-0.60	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.80-0.90	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.10-1.20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.40-1.50	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Site: 180 **Land Unit: 8P8** Australian Soil Classification: Haplic, Eutrophic, Red Kandosol KAAAAHCDAELMV

Soil Profile Description

Depth m	Horizon	Description
Surface	-	Dry; light grazing disturbance; termitaria microrelief; 0% coarse fragments; very slow runoff; moderate permeability; well drained, no rock outcropping.
0-0.10	A1	Yellowish red (5YR 4/6 dry, 5YR 3/3 moist); sandy loam; weak subangular blocky structure; 0% mottles; 0% coarse fragments; 0% segregations; non-calcareous; field pH 6.5.
0.10-0.60	B21	Red (2.5YR 4/6 dry, 5YR 4/3 moist); sandy clay loam; massive; 0% mottles; 0% coarse fragments; 0% segregations; non-calcareous; field pH 7.0.
0.60-1.00	B22	Red (2.5YR 4/6 dry, 5YR 4/3 moist); clay loam; 0% mottles; massive; 0% coarse fragments; 0% segregations; non-calcareous; field pH 7.5.
1.00-1.10	C1	White (10YR 8/1); 80% chert and quartz fragments; non calcareous.
1.10-1.50	C2	Weathered calcrete; horizon is a mix of colours: white (10YR 8/1), red (2.5YR 4/6) and reddish yellow (7.5YR 7/6). Stopped by reaching the depth limit of the coring equipment.

Analytical Data

Depth	Total	Available P mg/kg		Ext. K	Sulfate S	Extr. Micronutrients mg/kg			
m	N %	Bicarb	Acid	mg/kg	mg/kg	Cu	Zn	Mn	Fe
0-0.10	0.03	4	11	0.44	2	0.6	0.3	11.5	11.1

Depth m	Coarse Sand %	Fine Sand %	Silt %	Clay %	CEC/clay ratio	OC %
0-0.10	38.2	46.5	3.3	13.8	0.4	0.40
0.10-0.20	35.3	44.5	3.3	18.9	0.4	0.25
0.20-0.30	32.1	44	3.5	22.2	0.4	0.23
0.50-0.60	29.6	39.6	3.4	29.1	0.3	0.29
0.80-0.90	33.7	37.9	2.7	25.8	0.4	0.26
1.10-1.20	31.0	34.2	13	20.7	0.5	0.14
1.40-1.50	-	-	-	-	-	-

Site Summary: Level plain, with termitaria microrelief. The soil was moderately deep, well drained, red, sandy loam grading to red, clay loam, overlying a weathered calcrete substrate, with quartz and chert fragments. The vegetation was *Corymbia terminalis* low open woodland.

Site Location: MGA94 Zone 53 545987mE 7856105mN

Depth m	$pH_{1:5}$ H_2O	$EC_{1:5}$ H_2O dS/m	$Cl_{1:5}$ mg/kg	NO_3-N mg/kg	ADMC %	Exchangeable Cations Cmol/kg				CEC Cmol/kg	ESP %	Ca/Mg Ratio	15 Bar %	$^1/_3$ Bar %	R1 Disp. Ratio
						Ca	Mg	Na	K						
0-0.10	7.10	0.04	<20	6	<1.5	4.08	0.865	<0.080	0.362	5 ECEC	1.5	4.72	4.5	5.3	0.95
0.10-0.20	7.56	0.03	<20	<1	<1.5	5.26	0.747	<0.090	0.373	7	1.3	7.04	5.4	6.0	0.73
0.20-0.30	7.43	0.02	<20	<1	<1.5	5.85	0.787	<0.090	0.424	8	1.1	7.43	6.6	7.4	0.79
0.50-0.60	7.48	0.03	<20	<1	1.7	8.04	0.859	<0.090	0.49	10	0.9	9.36	9.7	11.3	0.75
0.80-0.90	8.22	0.11	<20	<1	1.6	7.88	0.722	<0.090	0.437	9	1.0	10.9	9.6	11.4	0.84
1.10-1.20	8.89	0.08	<20	<1	1.7	10.8	0.676	<0.090	0.339	10	0.9	15.9	8.7	10.6	0.98
1.40-1.50	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Site: 181 **Land Unit: 8P6** Australian Soil Classification: Ceteric, Paralithic, Supracalcic Calcarosol CAFBDUICAHLMU

Soil Profile Description

Depth m	**Horizon**	**Description**
Surface	-	Dry; light grazing disturbance; hard setting; no microrelief; 40% 15 mm subrounded quartz fragments; moderately rapid runoff; moderate permeability; well drained; no rock outcropping.
0-0.08	A1	Yellowish red (5YR 5/7 dry); sandy loam; weak subangular blocky; 0% mottles; 30% calcrete coarse fragments; 0% segregations; slightly calcareous; field pH 7.5.
0.08-0.20	Bk	Red (2.5YR 4/8 dry); sandy clay loam; single grain structure; 0% mottles; 60% quartz and calcrete coarse fragments; 0% segregations; moderately calcareous; field pH 8.0. Stopped at this depth by a gravel layer.

Analytical Data

Depth	**Total**	**Available P** mg/kg		**Ext. K**	**Sulfate S**	**Extr. Micronutrients** mg/kg			
m	**N** %	**Bicarb**	**Acid**	mg/kg	mg/kg	**Cu**	**Zn**	**Mn**	**Fe**
0-0.10	0.03	3	9	0.64	1	0.3	0.1	5.1	2.9

Depth m	**Coarse Sand** %	**Fine Sand** %	**Silt** %	**Clay** %	**CEC/clay** ratio	**OC** %
0-0.10	27.3	59.5	2.6	10.6	0.7	0.41
0.10-0.20	22.8	61.9	2.5	12.5	0.6	0.22
0.20-0.30	-	-	-	-	-	-
0.50-0.60	-	-	-	-	-	-
0.80-0.90	-	-	-	-	-	-
1.10-1.20	-	-	-	-	-	-
1.40-1.50	-	-	-	-	-	-

Site Summary: Level plain, many calcrete and quartz fragments on the surface. The soil was shallow, well drained, red, gravelly sandy loam over a subsoil of red, sandy clay loam with many gravels, and moderately calcareous effervescence. The vegetation was *Eriachne obtusa*, *Enneapogon purpurescens* low tussock grassland.

Site Location: MGA94 Zone 53 543025E 7852771mN

Depth	**$pH_{1:5}$**	**$EC_{1:5}$ H_2O**	**$Cl_{1:5}$**	**NO_3-N**	**ADMC**	**Exchangeable Cations** Cmol/kg				**CEC**	**ESP**	**Ca/Mg**	**15 Bar**	**$^1/_3$ Bar**	**R1 Disp.**
m	**H_2O**	dS/m	mg/kg	mg/kg	%	**Ca**	**Mg**	**Na**	**K**	Cmol/kg	%	Ratio	%	%	Ratio
0-0.10	8.39	0.08	<20	2	<1.5	5.98	1.41	<0.090	0.532	7	1.2	4.23	5.3	5.9	0.93
0.10-0.20	8.70	0.06	<20	<1	<1.5	6.5	1.08	<0.090	0.451	7	1.3	6.02	4.8	5.6	0.80
0.20-0.30	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.50-0.60	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.80-0.90	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.10-1.20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.40-1.50	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Site: 182 **Land Unit: 8P8** Australian Soil Classification: Mottled, Eutrophic, Brown Kandosol KAABAHDQAEKOW

Soil Profile Description

Depth m	Horizon	Description
Surface	-	Firm; dry; light grazing disturbance; no microrelief; 0% coarse fragments; slow runoff; moderate permeability; imperfectly drained; no rock outcropping.
0-0.10	A1	Brown (7.5YR 4/4 dry, 7.5YR 4/3 moist); loamy sand; weak subangular blocky structure; 0% mottles; 0% coarse fragments; 0% segregations; non-calcareous; field pH 6.5.
0.10-0.30	B1	Strong brown (7.5YR 5/6 dry, 7.5YR 4/3 moist); loamy sand; massive structure; 0% mottles; 0% coarse fragments; 0% segregations; non-calcareous; field pH 6.5.
0.30-0.80	B2	Strong brown (7.5YR 5/6 dry, 7.5YR 4/3 moist); sandy clay loam; massive structure; 10% distinct red mottles; 3% quartz and calcrete fragments; 0% segregations; non-calcareous; field pH 6.5.
0.80-1.50	BCg	Light yellowish brown (10YR 6/4 dry) mixed with 20% light greenish grey (5GY 7/1); medium clay; massive structure; 20% distinct red mottles; 0% coarse fragments; 0% segregations; non-calcareous; field pH 7.0.
1.50-	C	White (10YR 8/1); massive; 0% mottles; 0% coarse fragments; 30% soft calcareous segregations; very highly calcareous. Stopped by reaching the depth limit of the coring equipment.

Analytical Data

Depth	Total	Available P mg/kg		Ext. K	Sulfate S	Extr. Micronutrients mg/kg			
m	N %	Bicarb	Acid	mg/kg	mg/kg	Cu	Zn	Mn	Fe
0-0.10	0.02	3	6	0.18	<1	0.4	1.1	3.2	15.2

Depth m	Coarse Sand %	Fine Sand %	Silt %	Clay %	CEC/clay ratio	OC %
0-0.10	33.3	60.6	2.3	7.6	0.3	0.22
0.10-0.20	33.2	58.8	2.4	9.4	0.3	0.17
0.20-0.30	37.5	52.1	2.3	9.6	0.4	0.12
0.50-0.60	34.1	52.7	3.6	11.5	0.4	0.14
0.80-0.90	31.1	39.9	1.8	29	0.4	0.17
1.10-1.20	28.1	41.6	1.8	29	0.4	0.13
1.40-1.50	24.7	41.3	3.7	30.6	0.5	0.13

Site Summary: Gently undulating plain, no surface coarse fragments or microrelief. The soil was deep, imperfectly drained, brown, loamy sand grading to strong brown, sandy clay loam, with distinct red mottles, overlying a massive, gleyed, clay and calcrete substrate. The vegetation was Eucalyptus victrix low open woodland.

Site Location: MGA94 Zone 53 544031mE 78529222mN

Depth m	$pH_{1:5}$ H_2O	$EC_{1:5}$ H_2O dS/m	$Cl_{1:5}$ mg/kg	NO_3-N mg/kg	ADMC %	Exchangeable Cations Cmol/kg				ECEC Cmol/kg	ESP %	Ca/Mg Ratio	15 Bar %	$^1/_3$ Bar %	R1 Disp. Ratio
						Ca	Mg	Na	K						
0-0.10	6.56	0.01	<20	1	<1.5	1.76	0.513	<0.080	0.144	2	3.2	3.43	1.9	2.1	0.81
0.10-0.20	6.62	0.01	<20	<1	<1.5	1.95	0.796	<0.080	0.203	3	2.6	2.45	2.3	2.4	0.84
0.20-0.30	6.88	0.01	<20	<1	<1.5	2.70	0.751	<0.080	0.256	4	2.1	3.60	3.0	3.6	0.77
0.50-0.60	7.17	0.01	<20	<1	<1.5	3.56	0.674	<0.080	0.290	5	1.7	5.28	4.0	4.6	0.96
0.80-0.90	7.50	0.01	<20	<1	1.7	8.48	1.54	<0.090	0.450	11 CEC	0.8	5.52	10.4	12.4	0.96
1.10-1.20	7.73	0.02	<20	<1	1.8	8.97	1.61	<0.090	0.391	12 CEC	0.8	5.58	10.4	12.4	0.99
1.40-1.50	8.13	0.04	<20	<1	2.4	12.8	2.31	<0.090	0.500	16 CEC	0.6	5.56	14.5	20.3	0.98

Site: 187 **Land Unit: 8P1** Australian Soil Classification: Ferric, Eutrophic, Red Kandosol KAAAAHBUAGLLV

Soil Profile Description

Depth m	Horizon	Description
Surface	-	Firm; dry; light grazing disturbance; no microrelief; 30% 5 mm subrounded ironstone fragments; slow runoff; slow permeability; well drained no rock outcropping.
0-0.10	A1	Reddish brown (5YR 4/4 dry); clay loam; moderate subangular blocky structure; 0% mottles; 20% 5 mm ironstone fragments; 0% segregations; non-calcareous; field pH 7.0.
0.10-0.60	B2	Yellowish red (5YR 4/6 dry); clay loam; massive; 0% mottles; 0% coarse fragments; 5% ferruginous segregation fragments; non-calcareous; field pH 8.0. Stopped at this depth by a gravel layer.

Analytical Data

Depth m	Total N %	Available P mg/kg		Ext. K mg/kg	Sulfate S mg/kg	Extr. Micronutrients mg/kg			
		Bicarb	Acid			Cu	Zn	Mn	Fe
0-0.10	0.03	4	7	0.7	<1	0.6	0.1	9.3	9.6

Depth m	Coarse Sand %	Fine Sand %	Silt %	Clay %	CEC/clay ratio	OC %
0-0.10	16.4	48.4	7.3	30.5	0.5	0.33
0.10-0.20	13.2	41.2	5.6	41	0.5	0.24
0.20-0.30	12.1	41.4	10.4	39.7	0.6	0.24
0.50-0.60	11.1	43.1	7.3	41.1	0.5	0.25
0.80-0.90	-	-	-	-	-	-
1.10-1.20	-	-	-	-	-	-
1.40-1.50	-	-	-	-	-	-

Site Summary: Gently undulating plain, with many ironstone fragments on the surface. The soil was moderately deep, well drained, reddish brown, gravelly clay loam grading to red gravelly clay loam. The vegetation was *Aristida contorta*, *Dactyloctenium radulans*, *Sporobolus australasicus* low open tussock grassland.

Site Location: MGA94 Zone 53 542581mE 7867599mN

Depth m	$pH_{1:5}$ H_2O	$EC_{1:5}$ H_2O dS/m	$Cl_{1:5}$ mg/kg	NO_3-N mg/kg	ADMC %	Exchangeable Cations Cmol/kg				CEC Cmol/kg	ESP %	Ca/Mg Ratio	15 Bar %	$^1/_3$ Bar %	R1 Disp. Ratio
						Ca	Mg	Na	K						
0-0.10	7.13	0.02	<20	3	2.4	9.79	4.20	<0.080	0.666	15 ECEC	0.5	2.33	11.1	16.8	0.76
0.10-0.20	7.64	0.03	<20	4	3.0	16.2	4.64	<0.090	0.510	22	0.4	3.50	14.4	18.9	0.57
0.20-0.30	8.51	0.07	<20	5	3.1	18.6	3.95	0.312	0.188	23	1.3	4.71	14.8	19.8	0.53
0.50-0.60	8.72	0.09	<20	5	3.2	18.2	4.06	0.819	0.209	23	3.6	4.49	15.6	20.9	0.63
0.80-0.90	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.10-1.20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.40-1.50	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Site: 188 **Land Unit: 10A1** Australian Soil Classification: Endohypersodic, Epipedal, Grey Vertosol VEGSADBPERRX

Soil Profile Description

Depth m	**Horizon**	**Description**
Surface	-	Hard setting; cracking; dry; light grazing disturbance; normal gilgai mounds; 2% 5 mm subrounded quartz fragments; slow runoff; slow permeability; imperfectly drained; no rock outcropping.
0-0.10	A1	Dark grey (2.5Y 4/1 moist); medium clay; weak subangular blocky structure; 0% mottles; 0% coarse fragments; 0% segregations; non-calcareous; field pH 7.0.
0.10-0.40	B21	Dark grey (2.5Y 4/1 moist); medium clay; strong subangular blocky structure; 0% mottles; 0% coarse fragments; 0% segregations; non-calcareous; field pH 7.0.
0.40-1.30	B22	Grey (2.5Y 5/1 moist); medium clay; massive; 0% mottles; 0% coarse fragments; 3% soft gypseous segregations; non-calcareous; field pH 7.5.
1.30-1.50	B23y	Greyish brown (2.5Y 5/2 moist); medium clay; massive; 0% mottles; 0% coarse fragments; 3% soft gypseous segregations; non-calcareous; field pH 8.5. Stopped by reaching the depth limit of the coring equipment.

Analytical Data

Depth	**Total**	**Available P** mg/kg		**Ext. K**	**Sulfate S**	**Extr. Micronutrients** mg/kg			
m	**N** %	**Bicarb**	**Acid**	mg/kg	mg/kg	**Cu**	**Zn**	**Mn**	**Fe**
0-0.10	0.02	<2	6	1.04	7	0.5	0.2	7.7	9.8

Depth m	**Coarse Sand** %	**Fine Sand** %	**Silt** %	**Clay** %	**CEC/clay** ratio	**OC** %
0-0.10	10.9	34.3	9.1	48.5	0.6	0.32
0.10-0.20	12.8	35.6	8.9	46.7	0.6	0.25
0.20-0.30	11.9	34.4	9.0	48.3	0.6	0.22
0.50-0.60	9.6	30.7	8.7	54.0	0.5	0.22
0.80-0.90	9.4	31.6	8.7	53.8	0.5	0.23
1.10-1.20	9.1	30.1	8.2	54.3	0.5	0.19
1.40-1.50	7.3	27.3	11.8	56.8	0.5	0.15

Site Summary: Level plain, with gilgai microrelief, and cracking surface. The soil was very deep, imperfectly drained, dark grey, subangular blocky clay over a subsoil of grey massive clay with common gypsum crystals. The vegetation was *Astrebla elymoides*, *Iseilema vaginiflorum* mid tussock grassland.

Site Location: MGA94 Zone 53 543430mE 7871937mN

Gypsum concentration from laboratory estimate: 0.8-0.9 m 0.8%; 1.1-1.2 m 1.0%; 1.4-1.5 m 2.3%; 1.4-1.5 m 4.1%

Depth	**pH$_{1:5}$**	**EC$_{1:5}$ H$_2$O**	**Cl$_{1:5}$**	**NO$_3$-N**	**ADMC**	**Exchangeable Cations** Cmol/kg				**CEC**	**ESP**	**Ca/Mg**	**15 Bar**	**$^1/_3$ Bar**	**R1 Disp.**
m	**H$_2$O**	dS/m	mg/kg	mg/kg	%	**Ca**	**Mg**	**Na**	**K**	Cmol/kg	%	Ratio	%	%	Ratio
0-0.10	7.50	0.06	<20	<1	4.3	21.1	5.12	0.126	1.02	28	0.4	4.11	19.6	27.2	0.57
0.10-0.20	7.74	0.03	<20	<1	3.9	21.6	4.35	0.163	0.732	26	0.6	4.98	17.5	24.2	0.58
0.20-0.30	7.70	0.05	<20	<1	4.0	22.7	4.48	0.206	0.737	28	0.7	5.07	21.5	24.6	0.59
0.50-0.60	7.02	1.93	43	<1	4.6	24.5	8.18	1.96	1.02	29	6.8	2.99	21.6	31.3	0.65
0.80-0.90	7.17	2.54	293	<1	4.5	17.3	11.3	4.18	1.03	27	15.6	1.53	22.3	30.8	0.75
1.10-1.20	7.66	3.72	889	<1	4.8	16.3	15.6	6.79	1.04	29	23.2	1.04	23.6	24.1	0.87
1.40-1.50	7.83	4.33	1310	<1	6.1	13.6	14.9	8.49	1.15	27	30.9	0.91	24.9	33.8	0.83

Site: 189 **Land Unit: 14G2** Australian Soil Classification: Endohypersodic, Epipedal, Grey Vertosol VEGSADBPERRX

Soil Profile Description

Depth m	Horizon	Description
Surface	-	Trampled; dry; light grazing disturbance; no microrelief; 5% 10 mm subrounded quartz fragments; very slow runoff; slow permeability; imperfectly drained, no rock outcropping.
0-0.10	A1	Dark grey (2.5Y 4/1 dry); medium clay; strong subangular blocky structure; 0% mottles; 0% coarse fragments; 0% segregations; non-calcareous; field pH 6.5.
0.10-0.30	B21	Grey (2.5Y 5/1 dry); medium clay; strong subangular blocky structure; 0% mottles; 0% coarse fragments; 0% segregations; non-calcareous; field pH 7.0.
0.30-0.90	B22	Grey (2.5Y 5/1 dry); light clay; 0% mottles; 0% coarse fragments; 2% gypseous crystals; non-calcareous; field pH 8.0. Stopped by an unidentified layer too hard to penetrate.

Analytical Data

Depth	Total	Available P mg/kg		Ext. K	Sulfate S	Extr. Micronutrients mg/kg			
m	N %	Bicarb	Acid	mg/kg	mg/kg	Cu	Zn	Mn	Fe
0-0.10	0.03	<2	<2	0.88	5	1.1	3.2	20.5	14.3

Depth m	Coarse Sand %	Fine Sand %	Silt %	Clay %	CEC/clay ratio	OC %
0-0.10	11.7	40.6	8.1	43.1	0.5	0.40
0.10-0.20	10.9	39.3	7.9	45.2	0.6	0.28
0.20-0.30	10.6	38.8	7.8	45.3	0.6	0.29
0.50-0.60	9.8	36.9	9.4	47.8	0.6	0.19
0.80-0.90	11.0	35.6	7.5	47.8	0.6	0.16
1.10-1.20	-	-	-	-	-	-
1.40-1.50	-	-	-	-	-	-

Site Summary: Level plain, few quartz fragments on the surface, notable by no gilgai microrelief compared with nearby areas. The soil was very deep, imperfectly drained, dark grey, suabgular blocky clay over a subsoil of grey clay that may have gypsum crystals at depth. The vegetation was *Iseilema vaginiflorum*, *Fimbristylis dichotoma*, *Chloris pectinata* low tussock grassland.

Site Location: MGA94 Zone 53 543359mE 7871192mN

Gypsum concentration from laboratory estimate: 0.5-0.6 m <0.1%; 0.8-0.9 m 0.2%

Depth	$pH_{1:5}$	$EC_{1:5}$	$Cl_{1:5}$	NO_3-N	ADMC	Exchangeable Cations Cmol/kg				CEC	ESP	Ca/Mg	15 Bar	$^1I_3$ Bar	R1 Disp.
m	H_2O	H_2O dS/m	mg/kg	mg/kg	%	Ca	Mg	Na	K	Cmol/kg	%	Ratio	%	%	Ratio
0-0.10	7.07	0.07	23	2	3.0	10.7	9.00	0.753	0.957	21 ECEC	3.5	1.19	17.0	22.1	0.76
0.10-0.20	7.86	0.05	26	<1	3.5	13.9	8.33	1.27	0.673	25	5.0	1.66	18.0	25.2	0.77
0.20-0.30	7.76	0.48	639	1	3.7	15.6	8.09	2.33	0.507	26	9.1	1.93	18.0	24.2	0.73
0.50-0.60	7.94	1.20	1340	19	4.6	16.5	8.04	4.11	0.423	28	14.5	2.05	17.1	27.8	0.69
0.80-0.90	8.17	1.60	1360	23	4.5	17.4	8.15	4.11	0.462	28	14.8	2.13	19.6	25.9	0.62
1.10-1.20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.40-1.50	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Site: 191 **Land Unit: 8P7** Australian Soil Classification: Ceteric, Paralithic, Calcic Calcarosol CABDDUICAELMW

Soil Profile Description

Depth m	**Horizon**	**Description**
Surface	-	Firm; moist; light grazing disturbance; no microrelief; 2% 5 mm subrounded quartz fragments; slow runoff; slow permeability; well drained; no rock outcropping.
0-0.10	A1	Dark reddish brown (5YR 3/4 moist); sandy loam; moderate subangular blocky structure; 0% coarse fragments; 0% mottles; 0% segregations; non-calcareous; field pH 8.5.
0.10-0.30	B1	Dark reddish brown (5YR 3/4 moist); sandy clay loam; moderate subangular blocky structure; 0% mottles; 0% coarse fragments; 0% segregations; slightly calcareous; field pH 8.5.
0.30-0.60	B21	Reddish brown (5YR 4/4 moist); clay loam; massive; 0% mottles; 0% coarse fragments; 1% soft calcareous segregations; slightly calcareous; field pH 8.0.
0.60-0.90	B22	Reddish brown (5YR 4/4 moist); clay loam; massive; 0% mottles; 0% coarse fragments; 1% soft calcareous segregations; moderately calcareous; field pH 8.0. Stopped by an unidentified layer too hard to penetrate.

Analytical Data

Depth m	**Total N** %	**Available P** mg/kg		**Ext. K** mg/kg	**Sulfate S** mg/kg	**Extr. Micronutrients** mg/kg			
		Bicarb	**Acid**			**Cu**	**Zn**	**Mn**	**Fe**
0-0.10	0.05	2	7	1.05	1	0.7	0.1	4.8	4.4

Depth m	**Coarse Sand** %	**Fine Sand** %	**Silt** %	**Clay** %	**CEC/clay** ratio	**OC** %
0-0.10	21.6	43.6	4.0	31.7	0.6	0.45
0.10-0.20	23.8	41.6	3.8	31.8	0.6	0.32
0.20-0.30	21.6	43.3	6.7	30.8	0.7	0.33
0.50-0.60	22.2	41.9	6.7	30.8	0.7	0.24
0.80-0.90	20.9	43.2	5.2	32.5	0.6	0.23
1.10-1.20	-	-	-	-	-	-
1.40-1.50	-	-	-	-	-	-

Site Summary: Level plain, with a few quartz fragments on the surface. The soil was deep, well drained, dark reddish brown sandy loam over reddish brown, clay loam with few soft calcareous segregations and moderately calcareous effervescence. The vegetation was *Corymbia terminalis* low open woodland.

Site Location: MGA94 Zone 53 542450mE 7857169mN

Depth m	**$pH_{1:5}$ H_2O**	**$EC_{1:5}$ H_2O** dS/m	**$Cl_{1:5}$** mg/kg	**NO_3-N** mg/kg	**ADMC** %	**Exchangeable Cations** Cmol/kg				**CEC** Cmol/kg	**ESP** %	**Ca/Mg** Ratio	**15 Bar** %	**$^1/_3$ Bar** %	**R1 Disp.** Ratio
						Ca	**Mg**	**Na**	**K**						
0-0.10	8.29	0.14	<20	21	3.0	15.8	3.72	<0.090	0.976	20	0.5	4.25	12.4	18.2	0.75
0.10-0.20	8.66	0.10	<20	3	3.1	18.3	3.50	<0.090	0.609	20	0.4	5.24	11.5	15.4	0.63
0.20-0.30	8.62	0.11	<20	1	3.2	18.3	3.88	<0.090	0.502	21	0.4	4.71	11.5	16.2	0.62
0.50-0.60	8.67	0.13	<20	<1	3.2	16.6	5.35	0.188	0.682	20	0.9	3.11	12.5	17.1	0.64
0.80-0.90	8.80	0.14	<20	<1	3.1	14.8	6.19	0.574	0.316	21	2.7	2.39	12.8	18.5	0.75
1.10-1.20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.40-1.50	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Site: 192 **Land Unit: 8P5** Australian Soil Classification: Basic, Paralithic, Leptic Tenosol TECYDUARAEKKU

Soil Profile Description

Depth m	Horizon	Description
Surface	-	Loose; moist; light grazing disturbance; no microrelief; 0% coarse fragments; very slow runoff; slow permeability; moderately well drained.
0-0.10	A1	Brown (7.5YR 5/3 moist); loamy sand; weak subangular blocky structure; 0% mottles; 0% coarse fragments; 0% segregations; non-calcareous; field pH 5.5.
0.10-0.25	B2	Brown (7.5YR 5/4 moist); loamy sand; moderate subangular blocky structure; 0% mottles; 0% coarse fragments; 0% segregations; non-calcareous; field pH 6.0.
0.25-1.20	BC	A mix of brown (7.5YR 4/4 moist) yellowish brown (10YR 5/6) and grey (2.5Y 5/1); clay loam sandy; massive structure; 5% prominent red mottles; 0% coarse fragments; 0% segregations; non-calcareous; field pH 6.5.
1.20-1.50	C	Brown (7.5YR 5/4 moist); massive structure; 20% prominent red mottles; 0% coarse fragments; 20% calcareous segregation fragments; non-calcareous matrix with slightly calcareous segregations; field pH 8.0. Stopped by reaching the depth limit of the coring equipment.

Analytical Data

Depth m	Total N %	Available P mg/kg		Ext. K mg/kg	Sulfate S mg/kg	Extr. Micronutrients mg/kg			
		Bicarb	Acid			Cu	Zn	Mn	Fe
0-0.10	0.02	8	12	0.25	3	0.6	<0.1	3.8	58.5

Depth m	Coarse Sand %	Fine Sand %	Silt %	Clay %	CEC/clay ratio	OC %
0-0.10	41.1	49.9	3.5	8.3	0.3	0.31
0.10-0.20	42.2	49.3	3.6	8.3	0.3	0.22
0.20-0.30	30.8	38.1	5.3	30.3	0.3	0.26
0.50-0.60	39.2	37.6	3.6	21.8	0.3	0.19
0.80-0.90	38.1	38.8	3.5	21.8	0.3	0.14
1.10-1.20	31.9	38.4	3.4	28.7	0.4	0.17
1.40-1.50	29.3	36.4	5.7	30.5	0.4	0.15

Site Summary: Level plain, with a loose surface. The soil was very shallow, moderately well drained, brown loamy sand, overlying a weathered clay and calcrete substrate. The vegetation was *Chrysopogon fallax*, *Fimbristylis dichotoma* low tussock grassland.

Site Location: MGA94 Zone 53 541770mE 7852719mN

Depth m	$pH_{1:5}$ H_2O	$EC_{1:5}$ H_2O dS/m	$Cl_{1:5}$ mg/kg	NO_3-N mg/kg	ADMC %	Exchangeable Cations Cmol/kg				ECEC Cmol/kg	ESP %	Ca/Mg Ratio	15 Bar %	$^1/_3$ Bar %	R1 Disp. Ratio
						Ca	Mg	Na	K						
0-0.10	5.96	0.01	<20	2	<1.5	1.49	0.497	<0.080	0.231	2	3.5	3.00	2.5	3.4	0.80
0.10-0.20	5.85	0.01	<20	5	<1.5	1.54	0.546	<0.080	0.216	2	3.4	2.82	2.1	2.6	0.78
0.20-0.30	6.44	0.01	<20	1	1.8	6.31	2.19	<0.080	0.497	9	0.9	2.88	8.8	12.1	0.63
0.50-0.60	6.63	0.01	<20	<1	<1.5	4.83	1.40	<0.080	0.344	7	1.2	3.45	6.8	9.5	0.89
0.80-0.90	6.63	0.01	<20	<1	<1.5	5.58	1.46	<0.080	0.310	7	1.1	3.82	7.7	8.7	0.94
1.10-1.20	7.05	0.03	<20	<1	1.9	8.42	2.07	<0.080	0.406	11	0.7	4.07	10.6	15.0	0.90
1.40-1.50	8.77	0.1	<20	3	2.8	11.5	2.49	<0.090	0.451	14 (CEC)	0.7	4.61	13.7	19.0	0.84

Appendix 2 Vegetation communities

The following provides information on the vegetation communities identified in the study area during the field survey.

Land Unit 8P1 – Community 1

Aristida contorta, *Dactyloctenium radulans*, *Sporobolus australasicus* low open tussock grassland on level ferricrete plains.

This is the only community within unit 8P1.

Upper and mid strata are absent.

The ground stratum consists of *Aristida contorta*, *Dactyloctenium radulans*, *Sporobolus australasicus* low open tussock grassland. Occasional forbs include *Portulaca oleracea*, *Corchorus sidoides* and *Neptunia dimorphantha*. Vegetation desiccation occurs during prolonged dry periods.

Structural and floristic summary				
Number of sites: 2	Approximate coverage across total land unit area: 100%			Area: 435.7 ha
Strata	**Growth Form**	**Cover % (Range)**	**Mean Height m (Range)**	**Basal Area m^2/ha**
Ground	Tussock Grass	20	0.1 (0.05-0.5)	
	Frequency of Dominant Species			
Ground	**100%:** *Aristida contorta, Dactyloctenium radulans*, *Sporobolus australasicus*, *Chloris pectinata*, *Aristida inaequiglumis*, *Portulaca oleracea*			

Other communities present	**Approximate coverage across total land unit extent**
None	-

Land Unit 8P2 – Community 1

Aristida inaequiglumis, Eriachne obtusa tall open tussock grassland with *Corymbia aparrerinja* isolated clumps of trees on level to gently undulating plains with termitaria microrelief.

This is the only community within unit 8P2. Only 30% of the land unit area contains isolated clumps of trees.

When present, the upper stratum occurs as *Corymbia aparrerinja* isolated clumps of trees. Maximum height is 7 metres.

The mid stratum is very sparse and dominated by *Gossypium australe*.

The ground stratum is *Aristida inaequiglumis*, *Eriachne obtusa* tall open tussock grassland. Other species include *Dichanthium fecundum*, *Heliotropium* sp., *Tephrosia* sp. and *Bonamia media.*

Structural and floristic summary				
Number of sites: 2	Approximate coverage across total land unit area: 100%			Area: 273.7 ha
Strata	**Growth Form**	**Cover % (Range)**	**Mean Height m (Range)**	**Basal Area m^2/ha**
Upper	Tree	3 (0-20)	6 (5-7)	0.25
Mid	Shrub	0.8 (0.5-1)	(0.5-1.5)	
Ground	Tussock Grass	11 (10-12)	1 (0.1-1.2)	
	Frequency of Dominant Species		**Frequency of Other Species**	
Mid	**50%:** *Gossypium australe*			
Ground	**100%:** *Aristida inaequiglumis*, *Eriachne obtusa*		**50%:** *Dichanthium fecundum*, *Heliotropium* sp., *Bonamia media*	
Other communities present				**Approximate coverage across total land unit extent**
None				-

Land Unit 8P3 – Community 1

Aristida holathera, *Aristida inaequiglumis*, *Chrysopogon fallax* mid tussock grassland on level plains.

This is the dominant community within unit 8P3. Also occurs in units 8P4 and 8P5.

The tallest stratum occurs as *Eucalyptus victrix, Corymbia terminalis* isolated clumps of trees. Patches of *Acacia elachantha* occur with up to 6% cover. *Atalaya hemiglauca* and *Acacia sericophylla* occur less often. Maximum height is 6 metres.

The mid stratum is *Gossypium australe* mid sparse shrubland. Occasional patches of *Melaleuca lasiandra* occur with up to 10% cover.

The ground stratum is *Aristida holathera* var. *holathera*, *Aristida inaequiglumis, Chrysopogon fallax* mid tussock grassland. Other species include *Fimbristylis dichotoma*, *Bergia henshallii* and introduced *Cenchrus ciliaris*.

Structural and floristic summary				
Number of sites: 10	Approximate coverage across total land unit area: 80%			Area: 53.0 ha
Strata	**Growth Form**	**Cover % (Range)**	**Mean Height m (Range)**	**Basal Area m^2/ha**
Upper	Tree	3.2 (0-5)	4.6 (2.5-6)	0.43
Mid	Shrub	2.5 (0-10)	1.4 (1-2.5)	
Ground	Tussock Grass	41.7 (26-69)	0.7 (0.1-1.5)	
	Frequency of Dominant Species		**Frequency of Other Species**	
Upper	**100%:** *Eucalyptus victrix* **70%:** *Corymbia terminalis*		**40%:** *Acacia elachantha* **30%:** *Atalaya hemiglauca*, *Acacia sericophylla*	
Mid	**40%:** *Gossypium australe*		**20%:** *Carissa lanceolata*, *Eremophila longifolia* **10%:** *Melaleuca lasiandra*	
Ground	**100%:** *Aristida holathera* var. *holathera* **70%:** *Aristida inaequiglumis*, *Chrysopogon fallax*		**50%:** *Fimbristylis dichotoma* **40%:** *Cenchrus ciliaris*, *Bergia henshallii* **30%:** *Eriachne obtusa*	

Other communities present	**Approximate coverage across total land unit extent**
8P9 – Com1 *Triodia schinzii*, *Paraneurachne muelleri* tall hummock grassland	20%

Land Unit 8P4 – Community 1

Mixed unit with two main communities:

Community 1: *Aristida hygrometrica*, *Chrysopogon fallax*, *Aristida holathera* mid tussock grassland on level plains with termitaria microrelief.

This is the dominant community within unit 8P4 and is associated with *Corymbia terminalis*, *Eucalyptus victrix*, *Ventilago viminalis* low open woodland.

The tallest stratum occurs as *Eucalyptus victrix*, *Corymbia terminalis* and *Acacia sericophylla* isolated trees. Maximum height is 6 metres.

The mid stratum is *Gossypium australe* mid sparse shrubland.

The ground stratum is *Aristida hygrometrica*, *Chrysopogon fallax*, *Aristida holathera* var. *holathera* mid tussock grassland. Other species include *Aristida inaequiglumis* and *Eriachne obtusa*.

Structural and floristic summary				
Number of sites: 8	Approximate coverage across total land unit area: 40%			Area: 123.1 ha
Strata	**Growth Form**	**Cover % (Range)**	**Mean Height m (Range)**	**Basal Area m^2/ha**
Upper	Tree	4.6 (2-7)	4.2 (3-7)	0.50
Mid	Shrub	3.1 (2-6)	1.6 (0.8-2.5)	
Ground	Tussock Grass	36.8 (16-48)	0.6 (0.1-1.2)	
	Frequency of Dominant Species		**Frequency of Other Species**	
Upper	**75%:** *Eucalyptus victrix*, *Corymbia terminalis*		**63%:** *Acacia sericophylla* **38%:** *Atalaya hemiglauca*	
Mid	**100%:** *Gossypium australe*		**25%:** *Carissa lanceolata*	
Ground	**100%:** *Aristida hygrometrica*, *Chrysopogon fallax* **88%:** *Aristida holathera* var. *holathera* **75%:** *Aristida inaequiglumis*		**63%:** *Eriachne obtusa* **50%:** *Sida platycalyx* **38%:** *Fimbristylis dichotoma*, *Cenchrus ciliaris*, *Eragrostis eriopoda*	

Other communities present	**Approximate coverage across total land unit extent**
8P4 Com2 *Corymbia terminalis*, *Eucalyptus victrix*, *Ventilago viminalis* low open woodland	30%
8P3 Com1 *Aristida holathera*, *Aristida inaequiglumis*, *Chrysopogon fallax* mid tussock grassland	15%
8P9 – Com1 *Triodia schinzii*, *Paraneurachne muelleri* tall hummock grassland	10%

Land Unit 8P4 – Community 2

Mixed unit with two main communities:

Community 2: *Corymbia terminalis*, *Eucalyptus victrix*, *Ventilago viminalis* low open woodland on level plains with termitaria microrelief.

This community is associated with *Aristida hygrometrica*, *Chrysopogon fallax*, *Aristida holathera* mid tussock grassland within unit 8P4.

The tallest stratum occurs as *Corymbia terminalis*, *Eucalyptus victrix*, *Ventilago viminalis* low open woodland. Other species include *Atalaya hemiglauca*, *Acacia sericophylla* and *Hakea arborescens*. Maximum height is 7 metres.

The mid stratum is *Gossypium australe* mid sparse shrubland.

The ground stratum is *Chrysopogon fallax*, *Aristida holathera* var. *holathera*, *Aristida hygrometrica* mid tussock grassland. Other species include *Triodia schinzii*, *Fimbristylis dichotoma* and *Aristida inaequiglumis*.

Structural and floristic summary				
Number of sites: 5	Approximate coverage across total land unit area: 30%			Area: 34.1 ha
Strata	**Growth Form**	**Cover % (Range)**	**Mean Height m (Range)**	**Basal Area (m^2/ha)**
Upper	Tree	9.4 (8-10)	5.3 (3-6.5)	0.95
Mid	Shrub	3.4 (2-6)	1.5 (0.8-3)	
Ground	Tussock Grass	54 (42-62)	0.7 (0.1-1.5)	

	Frequency of Dominant Species	**Frequency of Other Species**
Upper	**100%:** *Corymbia terminalis* **60%:** *Eucalyptus victrix*, *Ventilago viminalis*	**40%:** *Atalaya hemiglauca*, *Acacia sericophylla*, *Hakea arborescens*
Mid	**100%:** *Gossypium australe*	**20%:** *Carissa lanceolata*, *Eremophila longifolia*
Ground	**100%:** *Chrysopogon fallax*, *Aristida holathera* var. *holathera* **80%:** *Aristida hygrometrica*, *Triodia schinzii*	**60%:** *Fimbristylis dichotoma*, *Aristida inaequiglumis* **40%:** *Eragrostis eriopoda*, *Perotis rara*

Other communities present	**Approximate coverage across total land unit extent**
8P4 Com1 *Aristida hygrometrica*, *Chrysopogon fallax*, *Aristida holathera* mid tussock grassland	40%
8P3 Com1 *Aristida holathera*, *Aristida inaequiglumis*, *Chrysopogon fallax* mid tussock grassland	15%
8P9 – Com1 *Triodia schinzii*, *Paraneurachne muelleri* tall hummock grassland	10%

Land Unit 8P5 – Community 1

Eucalyptus victrix low open woodland on level plains.

This is the dominant community within unit 8P5.

The tallest stratum occurs as *Eucalyptus victrix*[1] low open woodland. Other species include *Atalaya hemiglauca*, *Acacia sericophylla* and *Corymbia terminalis*, Maximum height is 8 metres.

The mid stratum is *Gossypium australe* mid sparse shrubland.

The ground stratum is *Aristida holathera* var. *holathera*, *Chrysopogon fallax*, *Fimbristylis dichotoma* mid tussock grassland. Other species include *Eriachne obtusa* and *Bergia henshallii.*

Structural and floristic summary				
Number of sites: 10	Approximate coverage across total land unit area: 70%			Area: 56.6 ha
Strata	**Growth Form**	**Cover % (Range)**	**Mean Height m (Range)**	**Basal Area m^2/ha**
Upper	Tree	8.4 (5-15)	4.8 (2.5-8)	0.65
Mid	Shrub	1.4 (0-4)	1.5 (0.8-3)	
Ground	Tussock Grass	58.8 (38-78)	0.6 (0.1-1.5)	
	Frequency of Dominant Species		**Frequency of Other Species**	
Upper	**100%:** *Eucalyptus victrix*		**40%:** *Atalaya hemiglauca*, *Acacia sericophylla* **30%:** *Corymbia terminalis*	
Mid	**50%:** *Gossypium australe*		**20%:** *Carissa lanceolata*	
Ground	**100%:** *Aristida holathera* var. *holathera, Chrysopogon fallax* **90%:** *Fimbristylis dichotoma*		**70%:** *Eriachne obtusa* **40%:** *Bergia henshallii* **30%:** *Aristida inaequiglumis* **20%:** *Sida platycalyx*, *Perotis rara*	

Other communities present	**Approximate coverage across total land unit extent**
8P3 Com1 *Aristida holathera*, *Aristida inaequiglumis*, *Chrysopogon fallax* mid tussock grassland	25%
13S1 – Com1 *Eulalia aurea* tall tussock grassland	5%

[1] In this report, Smooth-barked Coolibah is recorded as *Eucalyptus victrix*. Note that due to taxonomic uncertainty of the Coolibah group in this region, future name changes may occur.

Land Unit 8P6 – Community 1

Eriachne obtusa, *Aristida holathera*, *Enneapogon purpurescens* mid tussock grassland on level plains and low rises of quartz and limestone outcrops.

This is the dominant community within unit 8P6.

The tallest stratum occurs as *Corymbia terminalis*, ± *Atalaya hemiglauca*, ± *Hakea chordophylla* isolated trees. Maximum height is 4.5 metres.

The mid stratum is *Gossypium australe*, *Eremophila latrobei*, *Carissa lanceolata*, *Acacia lysiphloia* mid sparse shrubland.

The ground stratum is *Eriachne obtusa*, *Aristida holathera* var. *holathera*, *Enneapogon purpurescens* mid tussock grassland. Other grasses include *Eragrostis eriopoda* and *Aristida inaequiglumis*. Forbs include *Spermacoce auriculata*, *Bonamia media* and *Heliotropium* sp.

Structural and floristic summary				
Number of sites: 5	Approximate coverage across total land unit area: 70%			Area: 827.2 ha
Strata	**Growth Form**	**Cover % (Range)**	**Mean Height m (Range)**	**Basal Area m^2/ha**
Upper	Tree	1.7 (0-4)	3.8 (3-4.5)	0.35
Mid	Shrub	3.6 (0-10)	1.4 (0.8-2.5)	
Ground	Tussock Grass	38.8 (32-48)	0.5 (0.05-1.2)	
	Frequency of Dominant Species		**Frequency of Other Species**	
Upper	**100%:** *Corymbia terminalis*		**40%:** *Atalaya hemiglauca*, *Hakea chordophylla*	
Mid	**80%:** *Gossypium australe* **60%:** *Eremophila latrobei*, *Carissa lanceolata*		**50%:** *Acacia lysiphloia*	
Ground	**100%:** *Eriachne obtusa*, *Aristida holathera* var. *holathera*, *Enneapogon purpurescens*		**80%:** *Eragrostis eriopoda*, *Spermacoce auriculata* **60%:** *Aristida inaequiglumis*, *Bonamia media*, *Heliotropium* sp.	
Other communities present				**Approximate coverage across total land unit extent**
8P7 – Com1 *Corymbia terminalis, ± Hakea arborescens, ± Ventilago viminalis* low open woodland				30%

Land Unit 8P7 – Community 1

Corymbia terminalis, ± *Hakea arborescens,* ± *Ventilago viminalis* low open woodland on level to gently undulating plains.

This community forms a mosaic with *Chrysopogon fallax*, *Aristida holathera* var. *holathera*, ± *Eragrostis xerophila* mid tussock grassland within unit 8P7.

The tallest stratum occurs as *Corymbia terminalis*, ± *Hakea arborescens,* ± *Ventilago viminalis* low open woodland. Maximum height is 8.5 metres.

The mid stratum is *Gossypium australe*, ± *Carissa lanceolata* mid sparse shrubland.

The ground stratum is *Aristida holathera* var. *holathera*, *Eriachne obtusa*, *Aristida inaequiglumis* mid tussock grassland. Other common grasses include *Eulalia aurea* and *Chrysopogon fallax*.

Structural and floristic summary				
Number of sites: 7	Approximate coverage across total land unit area: 55%			Area: 1,100.4 ha
Strata	**Growth Form**	**Cover % (Range)**	**Mean Height m (Range)**	**Basal Area m^2/ha**
Upper	Tree	9 (4-12)	6.6 (3.5-8.5)	0.71
Mid	Shrub	3.1 (1-6)	1.4 (0.7-2.5)	
Ground	Tussock Grass	30 (14-40)	0.6 (0.1-1.2)	
	Frequency of Dominant Species		**Frequency of Other Species**	
Upper	**100%:** *Corymbia terminalis*		**29%:** *Hakea arborescens*, *Ventilago viminalis*	
Mid	**86%:** *Gossypium australe*		**57%:** *Carissa lanceolata*	
Ground	**86%:** *Eriachne obtusa*, *Aristida holathera* var. *holathera*, *Aristida inaequiglumis* **71%:** *Eulalia aurea*		**57%:** *Chrysopogon fallax* **43%:** *Corchorus sidoides*, *Enneapogon purpurescens* **29%:** *Dichanthium fecundum*, *Eragrostis eriopoda*, *Eragrostis xerophila*	
Other communities present				**Approximate coverage across total land unit extent**
8P7 – Com2 *Chrysopogon fallax*, *Aristida holathera*, ± *Eragrostis xerophila* mid tussock grassland				45%

Land Unit 8P7 – Community 2

Chrysopogon fallax, *Aristida holathera*, ± *Eragrostis xerophila* mid tussock grassland on level to gently undulating plains.

This community forms a mosaic with *Corymbia terminalis,* ± *Hakea arborescens,* ± *Ventilago viminalis* low open woodland within unit 8P7.

The tallest stratum occurs as *Corymbia terminalis*, ± *Hakea chordophylla* isolated trees. Maximum height is 7 metres.

The mid stratum is *Carissa lanceolata* mid sparse shrubland.

The ground stratum is *Chrysopogon fallax*, *Aristida holathera* var. *holathera*, ± *Eragrostis xerophila* mid tussock grassland. Other species include *Aristida latifolia*, *Eriachne obtusa*, *Eulalia aurea*, *Fimbristylis dichotoma* and *Aristida inaequiglumis*.

Structural and floristic summary				
Number of sites: 5	Approximate coverage across total land unit area: 45%			Area: 618.0 ha
Strata	**Growth Form**	**Cover % (Range)**	**Mean Height m (Range)**	**Basal Area (m^2/ha)**
Upper	Tree	1.4 (0-3)	5.3 (4.5-7)	0.5
Mid	Shrub	4.4 (1-15)	1.5 (0.8-2.5)	
Ground	Tussock Grass	44 (30-60)	0.6 (0.1-1.2)	
	Frequency of Dominant Species		**Frequency of Other Species**	
Upper	**60%:** *Corymbia terminalis*		**40%:** *Hakea chordophylla* **20%:** *Acacia sericophylla*, *Ventilago viminalis*	
Mid	**60%:** *Carissa lanceolata*		**20%:** *Acacia lysiphloia*, *Gossypium australe*, *Eremophila latrobei*	
Ground	**100%:** *Chrysopogon fallax* **80%:** *Aristida holathera* var. *holathera* **60%:** *Eragrostis xerophila*		**40%:** *Aristida latifolia*, *Eriachne obtusa*, *Eulalia aurea*, *Fimbristylis dichotoma*, *Aristida inaequiglumis* **20%:** *Cenchrus ciliaris*, *Dichanthium fecundum*, *Aristida hygrometrica*	
Other communities present				**Approximate coverage across total land unit extent**
8P7 – Com1 *Corymbia terminalis,* ± *Hakea arborescens,* ± *Ventilago viminalis* low open woodland				55%

Land Unit 8P8 – Community 1

Corymbia terminalis, ± *Eucalyptus victrix* low open woodland on lower-lying level plains with termitaria microrelief.

This is the only community within unit 8P8 and occurs in lower-lying flood-out areas that likely receive and convey surface water during high rainfall events. Woody species basal area is relatively high within the survey area at approximately 1.6 m^2/ha.

The tallest stratum occurs as *Corymbia terminalis*, ± *Eucalyptus victrix* low open woodland. Maximum height is 9 metres.

The mid stratum when present is *Gossypium australe*, *Carissa lanceolata* mid sparse shrubland.

The ground stratum is *Chrysopogon fallax*, *Eriachne obtusa* mid tussock grassland. Other species include *Aristida holathera* var. *holathera*, *Fimbristylis dichotoma*, *Eulalia aurea* and *Bonamia media*.

Structural and floristic summary				
Number of sites: 5	Approximate coverage across total land unit area: 100%			Area: 297.3 ha
Strata	**Growth Form**	**Cover % (Range)**	**Mean Height m (Range)**	**Basal Area m^2/ha**
Upper	Tree	15 (5-25)	5.6 (2.5-9)	1.55
Mid	Shrub	1.4 (0-3)	1.4 (0.8-2)	
Ground	Tussock Grass	38.4 (34-50)	0.6 (0.1-1.5)	
	Frequency of Dominant Species		**Frequency of Other Species**	
Upper	**100%:** *Corymbia terminalis* **60%:** *Eucalyptus victrix*		**40%:** *Atalaya hemiglauca* **20%:** *Hakea arborescens*	
Mid	**60%:** *Gossypium australe*, *Carissa lanceolata*		**40%:** *Acacia lysiphloia* **20%:** *Senna artemisioides* subsp. *oligophylla*	
Ground	**100%:** *Chrysopogon fallax* **80%:** *Eriachne obtusa* **60%:** *Aristida holathera* var. *holathera*, *Fimbristylis dichotoma*, *Eulalia aurea*, *Bonamia media*		**40%:** *Eragrostis eriopoda*, *Perotis rara* **20%:** *Aristida latifolia*, *Enneapogon purpurescens*, *Aristida inaequiglumis*	
Other communities present				**Approximate coverage across total land unit extent**
None				-

Land Unit 8P9 – Community 1

Triodia schinzii, *Paraneurachne muelleri* tall hummock grassland on level plains with termitaria microrelief.

This community occurs mainly within unit 8P9 and to a limited extent within units 8P3 and 8P4. It is found toward the southern boundary of the survey area and is likely to extend over a vast area to the south of the Barkly Highway.

The tallest stratum occurs as *Corymbia terminalis*, ± *Acacia sericophylla*, ± *Hakea macrocarpa* isolated trees. Other species include *Hakea chordophylla*, *Acacia hemignosta* and *Acacia elachantha.* Maximum height is 9.5 metres.

The mid stratum is *Gossypium australe, ± Petalostylis cassioides* mid sparse shrubland.

The ground stratum is *Triodia schinzii*, *Paraneurachne muelleri* tall hummock grassland. Other common grass species include *Aristida holathera* var. *holathera* and *Aristida inaequiglumis*.

Structural and floristic summary				
Number of sites: 5	Approximate coverage across total land unit area: 67%			Area: 170.9 ha
Strata	**Growth Form**	**Cover % (Range)**	**Mean Height m (Range)**	**Basal Area m^2/ha**
Upper	Tree	3.4 (0-5)	6.9 (3.5-9.5)	0.35
Mid	Shrub	8.2 (2-15)	1.7 (1-3)	
Ground	Hummock Grass	31.2 (20-44)	1 (0.1-1.6)	
	Frequency of Dominant Species		**Frequency of Other Species**	
Upper	**80%:** *Corymbia terminalis* **60%:** *Acacia sericophylla*, *Hakea macrocarpa*		**40%:** *Hakea chordophylla*, *Acacia hemignosta*, *Acacia elachantha*	
Mid	**80%:** *Gossypium australe*		**40%:** *Petalostylis cassioides*	
Ground	**100%:** *Triodia schinzii*, *Paraneurachne muelleri* **80%:** *Aristida holathera* var. *holathera*, *Aristida inaequiglumis*		**60%:** *Aristida hygrometrica*, *Dichanthium fecundum*, *Fimbristylis dichotoma* **40%:** *Corchorus sidoides*	

Other communities present	**Approximate coverage across total land unit extent**
8P4 – Com2 *Aristida hygrometrica, Chrysopogon fallax, Aristida holathera mid open tussock grassland*	33%

Land Unit 10A1 – Community 1

Astrebla elymoides, *Iseilema vaginiflorum*, *Polymeria longifolia* mid tussock grassland on broad alluvial level plains with gilgai microrelief.

The upper stratum is absent.

The mid stratum consists of sparse and isolated *Sesbania brachycarpa* to 1.5 m high.

The ground stratum is *Astrebla elymoides*, *Iseilema vaginiflorum*, *Chenopodium auricomum* mid tussock grassland. Other species include *Cyperus bifax*, *Aristida latifolia*, *Eulalia aurea* and *Panicum* sp.

Structural and floristic summary				
Number of sites: 1	Approximate coverage across total land unit area: 100%			Area: 788.9 ha
Strata	**Growth Form**	**Cover % (Range)**	**Mean Height m (Range)**	**Basal Area m^2/ha**
Mid	Shrub	2	1.2 (0.8-1.5)	
Ground	Tussock Grass	70	0.5 (0.2-0.7)	
	Frequency of Dominant Species			
Mid	**100%:** *Sesbania brachycarpa*			
Ground	**100%:** *Astrebla elymoides*, *Iseilema vaginiflorum*, *Polymeria longifolia*, *Cyperus bifax*, *Aristida latifolia*, *Eulalia aurea*, *Panicum* sp.			

Other communities present	**Approximate coverage across total land unit extent**
None	-

Land Unit 10D1 – Community 1

Eucalyptus victrix, *Atalaya hemiglauca*, *Acacia elachantha* low open woodland within open depression in a level plain.

This is the only community within unit 10D1.

The tallest stratum occurs as *Eucalyptus victrix*, *Atalaya hemiglauca*, *Acacia elachantha* low open woodland. Maximum height is 6 metres.

The mid stratum is absent or sparse, mainly consisting of regenerating *Eucalyptus victrix* and *Atalaya hemiglauca*.

The ground stratum is *Aristida holathera* var. *holathera*, *Aristida hygrometrica*, *Aristida inaequiglumis* mid open tussock grassland.

Structural and floristic summary				
Number of sites: 2	Approximate coverage across total land unit area: 100%			Area: 27.9 ha
Strata	**Growth Form**	**Cover % (Range)**	**Mean Height m (Range)**	**Basal Area m^2/ha**
Upper	Tree	9 (3-15)	4.3 (3-6)	1.13
Mid	Shrub	2	1.25 (0.8-2)	
Ground	Tussock Grass	21 (14-28)	0.5 (0.1-1.2)	
	Frequency of Dominant Species		**Frequency of Other Species**	
Upper	**100%:** *Eucalyptus victrix*, *Atalaya hemiglauca*, *Acacia elachantha*		**50%:** *Acacia colei*	
Mid	**100%:** *Eucalyptus victrix*, *Atalaya hemiglauca*			
Ground	**100%:** *Aristida holathera* var. *holathera*, *Aristida hygrometrica*, *Aristida inaequiglumis*		**50%:** *Eragrostis eriopoda*, *Fimbristylis dichotoma*, *Sida platycalyx*, *Triodia schinzii*	

Other communities present	**Approximate coverage across total land unit extent**
None	-

Land Unit 13S1 – Community 1

Eulalia aurea tall tussock grassland within closed drainage depression subject to temporary inundation.

This is the only community within unit 13S1.

The tallest stratum is *Eucalyptus victrix* isolated trees. Maximum height is 6.5 metres.

The mid stratum is typically absent, consisting of regenerating *Eucalyptus victrix* when present.

The ground stratum is *Eulalia aurea* tall tussock grassland. Other species include *Fimbristylis dichotoma* and *Marsilea drummondii.*

Annual sedges such as *Schoenoplectus lateriflorus* and *Eleocharis atropurpurea* occur after summer rainfall events.

Structural and floristic summary				
Number of sites: 5	Approximate coverage across total land unit area: 100%			Area: 282.0 ha
Strata	**Growth Form**	**Cover % (Range)**	**Mean Height m (Range)**	**Basal Area m^2/ha**
Upper	Tree	4.4 (3-8)	4 (1.5-6.5)	0.35
Ground	Tussock Grass	42.8 (24-64)	1 (0.1-1.2)	
	Frequency of Dominant Species		**Frequency of Other Species**	
Upper	**100%:** *Eucalyptus victrix*			
Ground	**100%:** *Eulalia aurea*		**80%:** *Marsilea drummondii*. **60%:** *Fimbristylis dichotoma*	

Other communities present	**Approximate coverage across total land unit extent**
None	-

Land Unit 13S2 – Community 1

Aristida latifolia, *Eulalia aurea*, *Iseilema vaginiflorum* mid tussock grassland on margin areas of closed drainage depression with less inundation.

This is the dominant community within unit 13S2.

The tallest stratum occurs as *Eucalyptus victrix* low open woodland. Maximum height is 4 metres.

The mid stratum consists of regenerating *Eucalyptus victrix*.

The ground stratum is *Aristida latifolia*, *Eulalia aurea*, *Iseilema vaginiflorum* mid tussock grassland. Other species include *Chrysopogon fallax* and *Fimbristylis dichotoma*.

Annual sedges such as *Schoenoplectus lateriflorus* and *Eleocharis atropurpurea* occur after summer rainfall events.

Structural and floristic summary				
Number of sites: 2	Approximate coverage across total land unit area: 98.5%			Area: 549.8 ha
Strata	**Growth Form**	**Cover % (Range)**	**Mean Height m (Range)**	**Basal Area m^2/ha**
Upper	Tree	2.5 (2-3)	3 (2-4)	0.25
Mid	Shrub	2.5 (2-3)	1.8 (1.5-2)	
Ground	Tussock Grass	48 (46-50)	0.9 (0.1-1.2)	
	Frequency of Dominant Species		**Frequency of Other Species**	
Upper	**100%:** *Eucalyptus victrix*		-	
Mid	**100%:** *Eucalyptus victrix*		-	
Ground	**100%:** *Aristida latifolia*, *Eulalia aurea*, *Iseilema vaginiflorum*		**50%:** *Chrysopogon fallax*, *Fimbristylis dichotoma*	

Other communities present	**Approximate coverage across total land unit extent**
13S2 – Com2 *Elacholoma prostratus*, *Ammannia multiflora* annual low open forbland	1.5%

Land Unit 13S2 – Community 2

Elacholoma prostratus, *Ammannia multiflora* low open forbland on margin areas of closed drainage depression with less inundation.

This is a minor community within unit 13S2.

The upper and mid strata are both absent.

The ground stratum is *Elacholoma prostratus*, *Ammannia multiflora* low open annual forbland. Other species include *Stemodia* sp. Manners Creek, *Marsilea drummondii*, *Fimbristylis dichotoma*, *Nesaea repens* and *Schoenoplectus lateriflorus*. *Eucalyptus victrix* seedlings also occur.

Structural and floristic summary				
Number of sites: 1	Approximate coverage across total land unit area: 1.5%			Area: 8.4 ha
Strata	**Growth Form**	**Cover % (Range)**	**Mean Height m (Range)**	**Basal Area m^2/ha**
Ground	Tussock Grass	22	0.1 (0.05-0.3)	
	Frequency of Dominant Species		**Frequency of Other Species**	
Ground	**100%:** *Elacholoma prostratus*, *Ammannia multiflora*		**100%:** *Stemodia* sp. Manners Creek, *Marsilea drummondii*, *Fimbristylis dichotoma, Nesaea repens, Eucalyptus victrix*, *Schoenoplectus lateriflorus*	

Other communities present	**Approximate coverage across total land unit extent**
13S2 – Com1 *Aristida latifolia*, *Eulalia aurea*, *Iseilema vaginiflorum* mid tussock grassland	98.5%

Land Unit 13S3 – Community 1

Aristida contorta, *Aristida holathera* low tussock grassland on very shallow flat on level plain adjacent to closed drainage depression.

This is the only community within unit 13S3.

The tallest stratum usually absent with occasional *Eucalyptus victrix* isolated trees.

The mid stratum is absent.

The ground stratum is *Aristida contorta*, *Aristida holathera* var. *holathera* low tussock grassland. Other common species include *Fimbristylis dichotoma* and *Bergia henshallii*.

Annual sedges such as *Schoenoplectus lateriflorus* and *Eleocharis atropurpurea* occur after summer rainfall events.

Structural and floristic summary				
Number of sites: 3	Approximate coverage across total land unit area: 100%			Area: 15.7 ha
Strata	**Growth Form**	**Cover % (Range)**	**Mean Height m (Range)**	**Basal Area m^2/ha**
Upper	Tree	<1 (0-2)	3	0
Ground	Tussock Grass	55 (40-68)	0.3 (0.05-1)	
	Frequency of Dominant Species		**Frequency of Other Species**	
Upper	**33%:** *Eucalyptus victrix*			
Ground	**100%:** *Aristida contorta*, *Aristida holathera* var. *holathera*, *Fimbristylis dichotoma*		**67%:** *Bergia henshallii* **33%:** *Eriachne obtusa*, *Chloris pectinata*, *Dactyloctenium radulans*, *Eulalia aurea*, *Iseilema* sp.	

Other communities present	**Approximate coverage across total land unit extent**
None	-

Land Unit 14G1 – Community 1

Astrebla pectinata, *Aristida latifolia* mid open tussock grassland on level plains with gilgai microrelief.

This is the dominant community within unit 14G1 and covers approximately 58% of the entire study area.

The upper and mid strata are both absent.

The ground stratum is *Astrebla pectinata*, *Aristida latifolia* mid open tussock grassland. Other grasses include *Chrysopogon fallax* and *Iseilema vaginiflorum*. *Astrebla squarrosa* and *Cyperus bifax* occur within gilgai depressions.

Structural and floristic summary				
Number of sites: 9	Approximate coverage across total land unit area: 97%			Area: 10,066.6 ha
Strata	**Growth Form**	**Cover % (Range)**	**Mean Height m (Range)**	**Basal Area m^2/ha**
Ground	Tussock Grass	26.7 (12-40)	0.6 (0.1-1)	
	Frequency of Dominant Species		**Frequency of Other Species**	
Ground	**100%:** *Astrebla pectinata*, *Aristida latifolia*		**67%:** *Iseilema vaginiflorum* **33%:** *Chrysopogon fallax*, *Astrebla squarrosa* **22%:** *Streptoglossa* sp., *Cyperus bifax*	

Other communities present	**Approximate coverage across total land unit extent**
14G2 – Com1 *Iseilema vaginiflorum*, *Fimbristylis dichotoma*, *Chloris pectinata* low open tussock grassland	2.5%
14G1 – Com2 *Vachellia sutherlandii* low open woodland	0.5%

Land Unit 14G1 – Community 2

Vachellia sutherlandii low open woodland on level plains with gilgai microrelief.

This minor community is found in a single 72.8 ha patch within unit 14G1, surrounded by *Astrebla pectinata*, *Aristida latifolia* mid open tussock grassland.

The upper stratum occurs as *Vachellia sutherlandii* low open woodland.

The mid stratum is absent.

The ground stratum is *Dactyloctenium radulans*, *Astrebla pectinata*, *Cyperus bifax* low open tussock grassland. Forb species include *Portulaca oleracea*, *Neptunia dimorphantha* and *Gomphrena breviflora*.

Structural and floristic summary				
Number of sites: 1	Approximate coverage across total land unit area: 0.5%			Area: 72.8 ha
Strata	**Growth Form**	**Cover % (Range)**	**Mean Height m (Range)**	**Basal Area m^2/ha**
Upper	Tree	8	7 (2-9)	2.5
Ground	Tussock Grass	28	0.4 (0.05-0.6)	
	Frequency of Dominant Species		**Frequency of Other Species**	
Upper	**100%:** *Vachellia sutherlandii*			
Ground	**100%:** *Dactyloctenium radulans*, *Astrebla pectinata*, *Cyperus bifax*		**100%:** *Portulaca oleracea*, *Neptunia dimorphantha, Gomphrena breviflora*	

Other communities present	**Approximate coverage across total land unit extent**
14G1 – Com1 *Astrebla pectinata*, *Aristida latifolia* mid open tussock grassland	97%
14G2 – Com1 *Iseilema vaginiflorum*, *Fimbristylis dichotoma*, *Chloris pectinata* low open tussock grassland	2.5%

Land Unit 14G2 – Community 1

Iseilema vaginiflorum, *Fimbristylis dichotoma*, *Chloris pectinata* low open tussock grassland on level plain without gilgai microrelief.

This is the only community within unit 14G2.

The upper and mid strata are both absent.

The ground stratum is *Iseilema vaginiflorum*, *Fimbristylis dichotoma*, *Chloris pectinata* low open tussock grassland. Other species include *Panicum* sp., *Dactyloctenium radulans* and *Aristida contorta*.

Structural and floristic summary				
Number of sites: 2	Approximate coverage across total land unit area: 100%			Area: 1,417.7 ha
Strata	**Growth Form**	**Cover % (Range)**	**Mean Height m (Range)**	**Basal Area m^2/ha**
Ground	Tussock Grass	40 (14-66)	0.2 (0.05-0.4)	
	Frequency of Dominant Species		**Frequency of Other Species**	
Ground	**100%:** *Iseilema vaginiflorum*, *Fimbristylis dichotoma*, *Chloris pectinata*, *Panicum* sp.		**50%:** *Dactyloctenium radulans*, *Aristida contorta*	

Other communities present	**Approximate coverage across total land unit extent**
None	-

Appendix 3 Plant species list

The following species were recorded in the study area during the field survey.

Scientific name			Common name
Trees			
Acacia	*hemignosta*	FABACEAE	Club-leaf Wattle
Acacia	*sericophylla*	FABACEAE	Dogwood
Atalaya	*hemiglauca*	SAPINDACEAE	Whitewood
Corymbia	*aparrerinja*	MYRTACEAE	Ghost Gum
Corymbia	*terminalis*	MYRTACEAE	Bloodwood
Eucalyptus	*victrix*[2]	MYRTACEAE	Smooth-barked Coolibah
Hakea	*arborescens*	PROTEACEAE	Yellow Hakea
Hakea	*chordophylla*	PROTEACEAE	Northern Corkwood
Vachellia	*sutherlandii*	FABACEAE	Barklys Wattle
Ventilago	*viminalis*	RHAMNACEAE	Supplejack
Shrubs			
Acacia	*ancistrocarpa*	FABACEAE	Fitzroy Wattle
Acacia	*colei*	FABACEAE	Wattle
Acacia	*elachantha*	FABACEAE	Halls Creek Wattle
Acacia	*lysiphloia*	FABACEAE	Turpentine
Acacia	*stipuligera*	FABACEAE	Scrub Wattle
Capparis	*umbonata*	CAPPARACEAE	Wild Orange, Northern Wild Orange, Bush Orange, Native Pomegranate
Carissa	*lanceolata*	APOCYNACEAE	Conkerberry
Eremophila	*goodwinii*	SCROPHULARIACEAE	Purple Fuchsia Bush
Eremophila	*latrobei*	SCROPHULARIACEAE	Native Fuschia
Eremophila	*longifolia*	SCROPHULARIACEAE	Emu Bush
Gossypium	*australe*	MALVACEAE	Native Cotton
Hakea	*macrocarpa*	PROTEACEAE	Flat-leaved Hakea
Indigofera	*georgei*	FABACEAE	Georges Indigo
Melaleuca	*lasiandra*	MYRTACEAE	Sandhill Tea Tree
Petalostylis	*cassioides*	FABACEAE	Butterfly Bush
Scaevola	*glabrata*	GOODENIACEAE	Scaevola
Senna	*artemisioides* subsp. *oligophylla*	FABACEAE	Oval-leaf Cassia
Senna	*glutinosa* subsp. *glutinosa*	FABACEAE	Senna
Senna	*sturtii*	FABACEAE	Grey Cassia
Sesbania	*brachycarpa*	FABACEAE	Purple Sesbania Pea

[2] In this report, Smooth-barked Coolibah is recorded as *Eucalyptus victrix*. Note that due to taxonomic uncertainty of the Coolibah group in this region, future name changes may occur.

Scientific name			Common name
Solanum	*lithophilum*	SOLANACEAE	Solanum
Swainsona	*burkei*	FABACEAE	Hairy Darling Pea
Trianthema	*pilosa*	AIZOACEAE	Trianthema
Grasses			
Aristida	*contorta*	POACEAE	Bunched Kerosene Grass
Aristida	*holathera* var. *holathera*	POACEAE	Erect Kerosene Grass
Aristida	*hygrometrica*	POACEAE	Northern Kerosene Grass
Aristida	*inaequiglumis*	POACEAE	Curly Wiregrass
Aristida	*latifolia*	POACEAE	Feathertop Wiregrass
Astrebla	*elymoides*	POACEAE	Hoop Mitchell Grass, Weeping Mitchell Grass, Slender Mitchell Grass
Astrebla	*pectinata*	POACEAE	Barley Mitchell Grass
Astrebla	*squarrosa*	POACEAE	Bull Mitchell Grass
**Cenchrus*	*ciliaris*	POACEAE	Buffel Grass
Chloris	*pectinata*	POACEAE	Comb Chloris
Chrysopogon	*fallax*	POACEAE	Golden Beard Grass
Dactyloctenium	*radulans*	POACEAE	Button Grass
Dichanthium	*fecundum*	POACEAE	Curly Bluegrass
Dichanthium	*sericeum*	POACEAE	Silky Bluegrass
Enneapogon	*purpurescens*	POACEAE	Purple Nine-awn
Eragrostis	*eriopoda*	POACEAE	Woollybutt Grass
Eragrostis	*xerophila*	POACEAE	Knottybutt Neverfail
Eriachne	*ciliata*	POACEAE	Slender Wanderrie
Eriachne	*obtusa*	POACEAE	Northern Wanderrie
Eulalia	*aurea*	POACEAE	Silky Browntop
Iseilema	*fragile*	POACEAE	Slender Flinders Grass
Iseilema	*vaginiflorum*	POACEAE	Red Flinders Grass
Panicum	*laevinode*	POACEAE	Pepper Grass
Paraneurachne	*muelleri*	POACEAE	Northern Mulga Grass
Perotis	*rara*	POACEAE	Comet Grass
Sporobolus	*australasicus*	POACEAE	Australian Dropseed, Fairy Grass
Triodia	*schinzii*	POACEAE	Feathertop Spinifex
Yakirra	*australiensis*	POACEAE	Desert Flinders Grass
Sedges			
Cyperus	sp.	CYPERACEAE	Nutgrass
Cyperus	*bifax*	CYPERACEAE	Downs Nutgrass
Eleocharis	*atropurpurea*	CYPERACEAE	Eleocharis
Fimbristylis	*dichotoma*	CYPERACEAE	Eight Day Grass, Common Fringe-rush
Schoenoplectus	*lateriflorus*	CYPERACEAE	Schoenoplectus
Forbs			
Ammannia	*multiflora*	LYTHRACEAE	Jerry Jerry

Scientific name			Common name
Bergia	*henshallii*	ELATINACEAE	Bergia
Bonamia	*media*	CONVOLVULACEAE	Common Bonamia
Cleome	*viscosa*	CLEOMACEAE	Tickweed, Mustard Bush
Corchorus	*sidoides*	MALVACEAE	Flannel Weed
Crotalaria	*medicanigea*	FABACEAE	Clover-leaf Rattlepod, Trefoil Rattlepod
Crotalaria	*novae-hollandiae*	FABACEAE	New Holland Rattlepod
Elacholoma	*prostrata*	PHRYMACEAE	Mimulus, Monkey Face
Evolvulus	*alsinoides*	CONVOLVULACEAE	Blue Periwinkle, Tropical Speedwell
Gomphrena	*breviflora*	AMARANTHACEAE	Gomphrena
Goodenia	*armitana*	GOODENIACEAE	Narrow-leaved Goodenia
Heliotropium	sp.	BORAGINACEAE	Heliotropium
Hibiscus	*sturtii* var. *campylochlamys*	MALVACEAE	Sturt's Hibiscus, Hill Hibiscus
Hybanthus	*aurantiacus*	VIOLACEAE	Orange Spade Flower
Neptunia	*dimorphantha*	FABACEAE	Sensitive Plant, Nervous Plant
Nesaea	*repens*	LYTHRACEAE	Nesaea
Polymeria	*longifolia*	CONVOLVULACEAE	Erect Bindweed
Portulaca	*oleracea*	PORTULACACEAE	Pigweed, Common Purslane, Munyeroo
Pterocaulon	*serrulatum*	ASTERACEAE	Fruit-salad Bush, Apple Bush
Ptilotus	*calostachyus*	AMARANTHACEAE	Weeping Mulla Mulla
Ptilotus	*macrocephalus*	AMARANTHACEAE	Large Green Pussy-tails
Ptilotus	*obovatus*	AMARANTHACEAE	Smoke Bush
Scaevola	*ovalifolia*	GOODENIACEAE	Bushy Fanflower
Scaevola	*parvifolia*	GOODENIACEAE	Fanflower
Sida	*platycalyx*	MALVACEAE	Lifesaver Burr
Spermacoce	*auriculata*	RUBIACEAE	Spermacoce
Stemodia	sp. Manners Creek	PLANTAGINACEAE	Stemodia
Streptoglossa	sp.	ASTERACEAE	Mintbush
Tephrosia	sp.	FABACEAE	Tephrosia
Tribulus	*eichlerianus*	ZYGOPHYLLACEAE	Bindieye
Trichodesma	*zeylanicum*	BORAGINACEAE	Cattle Bush
Ferns			
Marsilea	*drummondii*	MARSILEACEAE	Common Nardoo

*Introduced species