Spinifex Ridge
Molybdenum Project

Baseline Soil Survey

November 2006

MOLY MINES LIMITED

Outback Ecology

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Moly Mines Limited

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EXECUTIVE SUMMARY

The baseline soil survey for the Spinifex Ridge Molybdenum Project Area areas has indicated that the majority of the soil profiles show little pedological organization or structure, with only slight textural differences present through the majority of soil profiles examined. Most profiles consisted of a shallow loamy, or clayey sand to sandy loam A-horizon, overlying a B-horizon dominated by a high coarse fraction (>2mm), generally increasing in size and abundance with increasing depth.

The soil materials sampled exhibited a wide range of pH values, with little consistency between soil pH and position within the landscape, or vegetation community. Similarly, landscape position offered little explanation for the electrical conductivity (EC) of materials sampled, the majority of which were considered to be non-saline.

Soil nutrient analyses indicated low nutrient levels (total N, available P, K and S) that were typical for the region, again with little consistent trend in nutrient level in relation to position within the landscape or to vegetation community. As expected, the level of all measured nutrients generally decreased slightly with depth in the soil profile.

Analysis of water-soluble metal concentrations in surface soils indicated very low baseline levels. Most materials sampled were below the detectable limit for the bulk of the elements measured, with only Al regularly occurring at a detectable level. For the metals detected, there was no apparent correlation with landform or vegetation unit.

There was little apparent difference in the physical or chemical soil properties of surface soils between the sample sites to the north, and those to the south of Talga Range.

Issues requiring consideration during project development, include topsoil management, the potential erodibility of the materials, and possible heavy metal content of deeper regolith materials. Direct return of topsoils is preferred where possible, alternatively, ‘paddock-dumped’ soil stockpiles are recommended. Stockpiles and landforms should be designed and constructed to minimize the potential for erosion. Finally, further definition of heavy metal content of deeper regolith materials is recommended as the project develops, to ensure appropriate management of these materials.

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1.0 INTRODUCTION

1.1 Project Background

Outback Ecology Services (OES) was commissioned by Moly Mines Limited (Moly Mines) to conduct a baseline soil survey of Exploration Licence E45/2226 and the proposed project footprint area to the north (a component of Licence EA45/2825) at Spinifex Ridge, located approximately 50km north-east of Marble Bar, Western Australia. The survey was one component of a broader assessment undertaken concurrently by Outback Ecology that also considered vegetation and flora, vertebrate fauna, aquatic ecology and stygofauna. This report combines an initial survey of the area immediately south of the Talga Range (completed in 2005), with a survey of surface soils from north of the Talga Range completed in 2006.

1.2 Scope and Objectives of the Study

The proposed mining operation is to include a single open-cut mine and associated infrastructure, including waste and tailings storage facilities. At the time of survey, no exact locations for infrastructure had been identified. Soil sample sites were chosen to encompass the range of landform and vegetation communities present within the project area, comprising E45/2226 as well as the proposed footprint area to the north of the Talga Range. Soil sampling and profile descriptions were restricted to surface soils, apart from areas where costeaning from historic exploration activities facilitated deeper examination. This report documents the results of this survey and includes:

- Description of soil profile morphology, to the maximum depth possible, based on Australian Soil Classification Standards,
- Evaluation of soil physical parameters (soil structure and texture),
- Measurement of soil chemical parameters (soil pH, electrical conductivity, total N, ammonium and nitrate N, extractable P, K and S, and organic C),
- Examination of possible correlations between measured soil properties, landform and vegetation communities.

2.0 MATERIALS AND METHODS

2.1 Sampling Regime

The investigation into soil properties consisted of assessment and sampling at 24 sites to the south of the Talga Range, and 17 sites to the north (Figure 1). The sites selected encompassed a range of landform and vegetation units within the area of the ore body, proposed waste dumps / infrastructure footprints and surrounding areas. Sampling was generally restricted to surface soils (0-5cm and 10-

20cm sampling intervals), however deeper samples were collected from some sites within the ore body area (southern sites) where costeaning had exposed the soil profile.

Where possible, the soil profile was described (soil profile morphology, soil structure, root distribution) based on the Australian Soil and Land Survey Handbook (McDonald *et al.* 1998). Samples were collected from consistent depth intervals at each site for analyses of chemical and physical parameters.

2.2 Test Work and Procedures

CSBP Soil and Plant Laboratory conducted analyses on the soils from the 41 sites for ammonium and nitrate N (Scarle, 1984), extractable phosphorus and potassium (Colwell, 1965; Rayment and Higginson, 1992), extractable sulphur (Blair *et al.,* 1991) and organic carbon (Walkley and Black, 1934). Analysis of total nitrogen was conducted by combustion at 950℃ in oxygen using a Leco FP-428 Nitrogen Analyser. Measurements of electrical conductivity (1:5 H_2O) and pH (1:5 H_2O), were conducted using the methods described in Rayment and Higginson (1992).

Analysis of the water soluble metal concentrations of surface soils from each site was conducted by ALS Environmental on a 1:5 soil / water leachate using ICPAES.

All chemical characteristics reported have been measured on the <2mm fraction of soil material collected.

Soil texture was assessed by OES staff using the procedure described in McDonald *et al.* (1998). The approximate percentage of coarse material (>2mm) was estimated visually for each sample.

Figure 1 Soil sample sites

3.0 RESULTS & DISCUSSION

A description of the soil profile morphology to the maximum depth possible at each site has been documented, with a summary of measured parameters tabulated for each of the southern sites (Sections 3.1.1 – 3.1.24), and the northern sites (3.2.1 – 3.2.17). Individual soil characteristics are then discussed in further detail (Sections 3.3 – 3.10). For comparative purposes, sites have been grouped based on their location, with landform units of valley floor, drainage lines, lower / mid slope and upper slope / crest.

3.1 Southern Site Descriptions

Terminology for the descriptions of soil parameters are based on those described in McDonald *et al*., (1998). The vegetation classifications given for each site are based on those described in the concurrent Outback Ecology Vegetation and Flora Baseline Report for the Project Area (OES 2006a).

3.1.1 Site S1

Site Details: Valley Floor

GPS Coordinates: 20°54.551S 120°05.284E

Plate 1 Soil sample Site S1

Texture: Loamy sand throughout top 20cm of profile dominated by coarse fragments. Sub angular and angular coarse fragments 5-50mm in size.

Structure: Apedal, single grained throughout profile surface. Sandy fabric and very weak consistence throughout top 20cm of profile.

Root growth: Penetration throughout soil matrix, decreasing slightly with depth.

Vegetation Classification:
P1 *Acacia inaequilatera* high shrubland to open shrubland over *Corchorus parviflorus* low scattered shrubs to open shrubland over *Triodia epactia* hummock grassland.

Table 1 Soil sample characteristics - Site S1

Sample Depth (cm)	Soil texture	% Coarse (>2mm)	pH (H_2O)	EC (dS/m)	Root Score*	Org C (%)	Total N (%)	Nitrate N (mg/kg)	Amm. N (mg/kg)	Avail. P (mg/kg)	Avail. K (mg/kg	Avail. S (mg/kg
0-5	Loamy sand	40	6.6	0.017	2	0.24	0.02	3	1	10	200	1.6
10-20	Loamy sand	40	7.0	0.032	1	0.22	0.02	1	3	4	104	1.7

* See Appendix B for Root Abundance Scoring details

3.1.2 Site S2

Site Details: Valley floor

GPS Coordinates: 20°54.390
120°05.519

Plate 2 Soil sample Site S2

Texture: Loamy sand throughout top 20cm of profile dominated by coarse fragments. Sub angular and angular coarse fragments 5-75mm in size.

Structure: Apedal, single grained throughout profile surface. Sandy fabric and very weak consistence throughout top 20cm of profile.

Root growth: Penetration throughout soil matrix, decreasing slightly with depth.

Vegetation Classification:
P1 *Acacia inaequilatera* high shrubland to open shrubland over *Corchorus parviflorus* low scattered shrubs to open shrubland over *Triodia epactia* hummock grassland.

Table 2 Soil sample characteristics - Site S2

Sample Depth (cm)	Soil texture	% Coarse (>2mm)	pH (H_2O)	EC (dS/m)	Root Score*	Org C (%)	Total N (%)	Nitrate N (mg/kg)	Amm. N (mg/kg)	Avail. P (mg/kg)	Avail. K (mg/kg	Avail. S (mg/kg
0-5	Loamy sand	10	6.9	0.018	2	0.25	0.02	3	2	8	132	1.4
10-20	Loamy sand	40	6.8	0.015	1	0.23	0.02	1	2	4	89	1.5

* See Appendix B for Root Abundance Scoring details

3.1.3 Site S3

Site Details: Lower slope

GPS Coordinates: 20°54.083
120°05.748

Plate 3 Soil sample Site S3

Texture: Clayey sand throughout top 20cm of profile dominated by coarse fragments. Sub angular and angular coarse fragments 5-100mm in size.

Structure: Apedal, single grained throughout profile surface. Sandy fabric and weak consistence throughout top 20cm of profile.

Root growth: Penetration throughout soil matrix, decreasing slightly with depth.

Vegetation Classification:
H1 *Acacia inaequilatera* scattered tall shrubs to high open shrubland over mixed *Corchorus parviflorus* / *Indigofera monophylla* / *Tephrosia* spp. / *Ptilotus calostachyus* low scattered shrubs to low open shrubland over *Triodia epactia* hummock grassland.

Table 3 Soil sample characteristics - Site S3

Sample Depth (cm)	Soil texture	% Coarse (>2mm)	pH (H_2O)	EC (dS/m)	Root Score*	Org C (%)	Total N (%)	Nitrate N (mg/kg)	Amm. N (mg/kg)	Avail. P (mg/kg)	Avail. K (mg/kg	Avail. S (mg/kg
0-5	Clayey sand	40	6.7	0.013	2	0.22	0.02	1	1	13	154	1.7
10-20	Clayey sand	25	6.7	0.018	1	0.25	0.03	2	3	6	125	1.9

* See Appendix B for Root Abundance Scoring details

3.1.4 Site S4

Site Details: Drainage line – Creek bed **GPS Coordinates:** 20°54.215 120°06.019

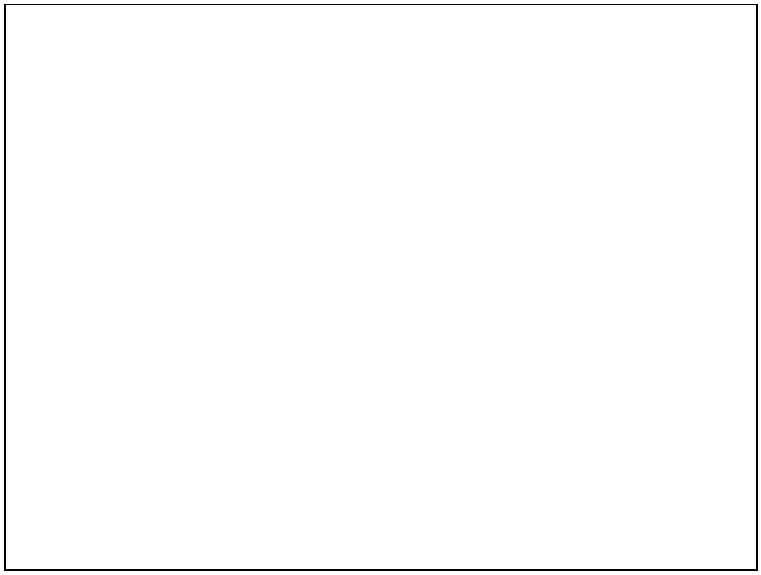


Plate 4 Soil sample Site S4

Texture: Sand to loamy sand throughout top 20cm of profile. Sub rounded, rounded and sub angular coarse fragments 5-20mm in size.

Structure: Apedal, single grained throughout profile surface. Sandy fabric and very weak consistence throughout top 20cm of profile.

Root growth: Patchy penetration throughout soil matrix, some areas with zero root growth corresponding to bare patches.

Vegetation Classification:
D3 *Eucalyptus camaldulensis* var. *obtusa / E. vitrix* open woodland to woodland over *Melaleuca glomerata / Acacia ampliceps / Acacia coriacea* ssp. *pendens* and *Acacia tumida* var. *pilbarensis* low open woodland to woodland over *Cyperus vaginatus* very open sedges over *Triodia longiceps* hummock grassland.

Table 4 Soil sample characteristics - Site S4

Sample Depth (cm)	Soil texture	% Coarse (>2mm)	pH (H_2O)	EC (dS/m)	Root Score*	Org C (%)	Total N (%)	Nitrate N (mg/kg)	Amm. N (mg/kg)	Avail. P (mg/kg)	Avail. K (mg/kg	Avail. S (mg/kg
0-5	Sand	5	7.4	0.080	0	0.62	0.04	8	2	8	121	7.8
10-20	Loamy sand	10	8.1	0.091	0	0.78	0.07	2	1	7	170	5.4

* See Appendix B for Root Abundance Scoring details

3.1.5 Site S5

Site Details: Lower mid slope **GPS Coordinates:** 20°53' 49.3
120°05' 52.1

Plate 5 Soil sample Site S5

Texture: Clayey sand throughout top 20cm of profile dominated by coarse fragments. Sub angular and angular coarse fragments 5-150mm in size.

Structure: Apedal, single grained throughout profile surface. Sandy fabric and weak consistence throughout top 20cm of profile.

Root growth: Penetration throughout soil matrix, decreasing slightly with depth.

Vegetation Classification:
H1 *Acacia inaequilatera* scattered tall shrubs to high open shrubland over mixed *Corchorus parviflorus* / *Indigofera monophylla* / *Tephrosia* spp. / *Ptilotus calostachyus* low scattered shrubs to low open shrubland over *Triodia epactia* hummock grassland.

Table 5 Soil sample characteristics - Site S5

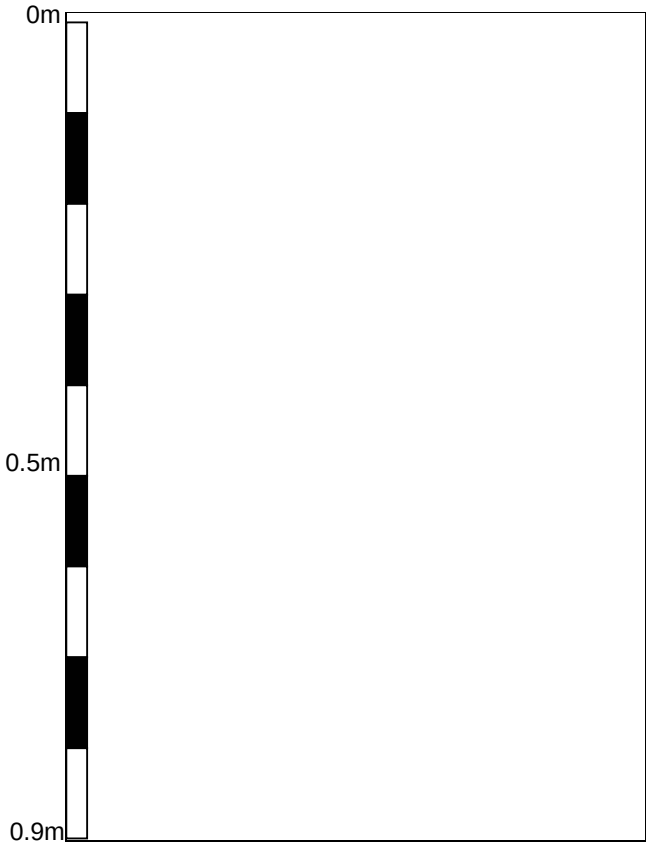
Sample Depth (cm)	Soil texture	% Coarse (>2mm)	pH (H_2O)	EC (dS/m)	Root Score*	Org C (%)	Total N (%)	Nitrate N (mg/kg)	Amm. N (mg/kg)	Avail. P (mg/kg)	Avail. K (mg/kg	Avail. S (mg/kg
0-5	Clayey sand	50	7.8	0.074	2	0.63	0.06	5	1	12	182	3.7
10-20	Clayey sand	40	7.9	0.110	1	0.38	0.04	3	2	6	84	21.6

* See Appendix B for Root Abundance Scoring details

3.1.6 Site S6

Site Details: Lower slope

GPS Coordinates: 20°53' 27.6
120°06' 02.4



Texture: Clayey sand throughout top 20cm of profile, increasing in clay content to sandy clay loam at around 40cm. Profile dominated by coarse fragments, sub angular and angular coarse fragments 5-150mm in size, increasing in volume with depth to approximately 90% at around 40cm.

Structure: Apedal, single grained throughout profile surface. Sandy fabric and weak consistence throughout top 20cm of profile. Some weak aggregates between coarse fragments at depth.

Root growth: Penetration throughout soil matrix, decreasing with depth to few roots penetrating beyond 40cm.

Plate 6 Soil profile at Site S6

Vegetation Classification:
H1 *Acacia inaequilatera* scattered tall shrubs to high open shrubland over mixed *Corchorus parviflorus* / *Indigofera monophylla / Tephrosia* spp. */ Ptilotus calostachyus* low scattered shrubs to low open shrubland over *Triodia epactia* hummock grassland.

Plate 7 Soil sample Site S6

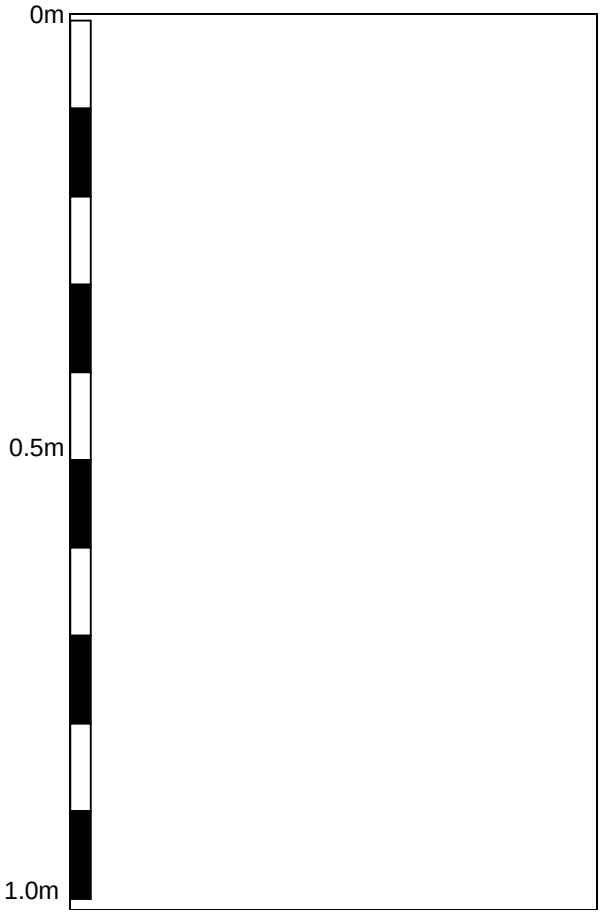
Table 6 Soil sample characteristics - Site S6

Sample Depth (cm)	Soil texture	% Coarse (>2mm)	pH (H_2O)	EC (dS/m)	Root Score*	Org C (%)	Total N (%)	Nitrate N (mg/kg)	Amm. N (mg/kg)	Avail. P (mg/kg)	Avail. K (mg/kg	Avail. S (mg/kg
0-5	Clayey sand	50	6.9	0.019	2	0.19	0.02	2	1	12	219	2.8
10-20	Clayey sand	75	7.5	0.028	1	0.21	0.03	3	2	4	129	1.8
40-50	Sandy clay loam	90	8.3	0.080	1	0.34	0.04	3	4	3	69	3.1

* See Appendix B for Root Abundance Scoring details

3.1.7 Site S7

Site Details: Lower mid slope **GPS Coordinates:** 20°53' 23.6
120°06' 00.4



Texture: Clayey sand throughout top of profile, increasing in clay content to sandy clay loam at around 40cm, and clay loam at 70cm. Profile dominated by coarse fragments beyond 50cm, sub angular and angular coarse fragments 5-100mm in size.

Structure: Apedal, single grained throughout profile surface. Sandy fabric and weak consistence throughout top 20cm of profile. Some weak aggregates between coarse fragments increasing from around 30cm.

Root growth: Penetration throughout soil matrix, decreasing with depth to few roots penetrating beyond 70cm.

Plate 8 Soil profile at Site S7

Vegetation Classification:
H1 *Acacia inaequilatera* scattered tall shrubs to high open shrubland over mixed *Corchorus parviflorus* / *Indigofera monophylla* / *Tephrosia* spp. / *Ptilotus calostachyus* low scattered shrubs to low open shrubland over *Triodia epactia* hummock grassland.

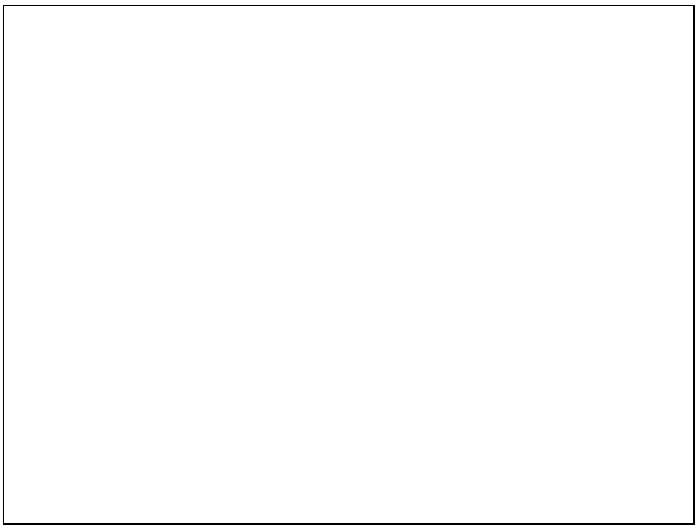


Plate 9 Soil sample Site S7

Table 7 Soil sample characteristics - Site S7

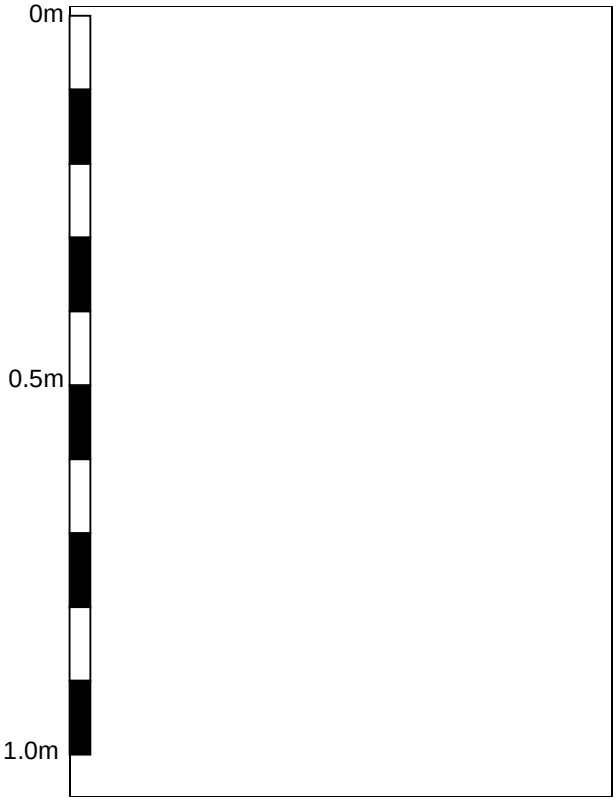
Sample Depth (cm)	Soil texture	% Coarse (>2mm)	pH (H_2O)	EC (dS/m)	Root Score*	Org C (%)	Total N (%)	Nitrate N (mg/kg)	Amm. N (mg/kg)	Avail. P (mg/kg)	Avail. K (mg/kg	Avail. S (mg/kg
0-5	Clayey sand	25	8.3	0.085	2	0.28	0.03	4	1	8	213	2.8
10-20	Clayey sand	25	8.3	0.092	1	0.28	0.03	3	3	4	124	2.9
40-50	Sandy clay loam	50	8.1	0.127	1	0.21	0.02	2	4	3	100	11.6
80-90	Clay loam	50	9.3	0.974	1	0.24	0.02	3	1	3	79	512

* See Appendix B for Root Abundance Scoring details

3.1.8 Site S8

Site Details: Upper slope

GPS Coordinates: 20°53' 11.9
120°06' 06.5



Texture: Clayey sand throughout top of profile, increasing in clay content to clay loam at around 40cm. Profile dominated by coarse fragments, sub angular and angular coarse fragments 5-100mm in size, increasing in volume with depth to approximately 90% at around 30cm.

Structure: Apedal, single grained throughout profile surface. Sandy fabric and weak consistence throughout top 20cm of profile. Some weak aggregates between coarse fragments at depth.

Root growth: Penetration throughout soil matrix, decreasing with depth to few roots penetrating beyond 30cm.

Plate 10 Soil profile at Site S8

Vegetation Classification:
H1 *Acacia inaequilatera* scattered tall shrubs to high open shrubland over mixed *Corchorus parviflorus* / *Indigofera monophylla / Tephrosia* spp. */ Ptilotus calostachyus* low scattered shrubs to low open shrubland over *Triodia epactia* hummock grassland.

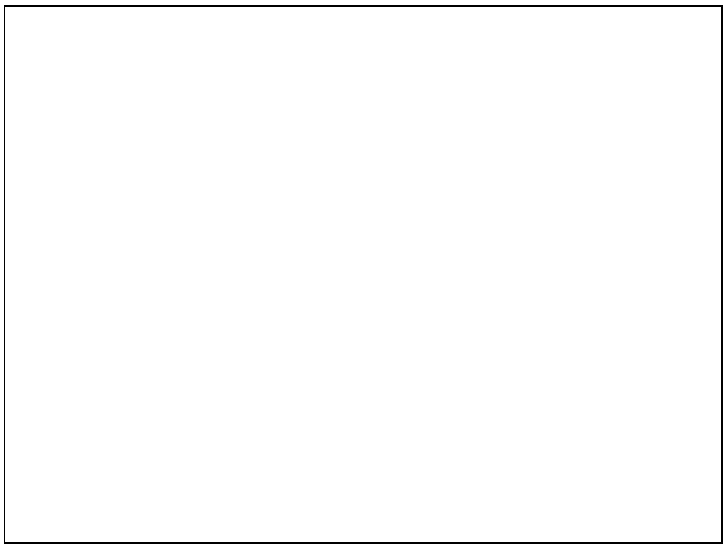


Plate 11 Soil sample Site S8

Table 8 Soil sample characteristics - Site S8

Sample Depth (cm)	Soil texture	% Coarse (>2mm)	pH (H_2O)	EC (dS/m)	Root Score*	Org C (%)	Total N (%)	Nitrate N (mg/kg)	Amm. N (mg/kg)	Avail. P (mg/kg)	Avail. K (mg/kg	Avail. S (mg/kg
0-5	Clayey sand	20	8.4	0.087	3	0.67	0.06	3	1	9	165	2.7
10-20	Clayey sand	75	8.4	0.094	1	0.52	0.05	3	2	3	248	5.1
40-50	Clay loam	90	8.4	0.110	1	0.42	0.04	5	1	3	378	3.2

* See Appendix B for Root Abundance Scoring details

3.1.9 Site S9

Site Details: Drainage line **GPS Coordinates:** 20°53' 14.5
120°06' 02.8

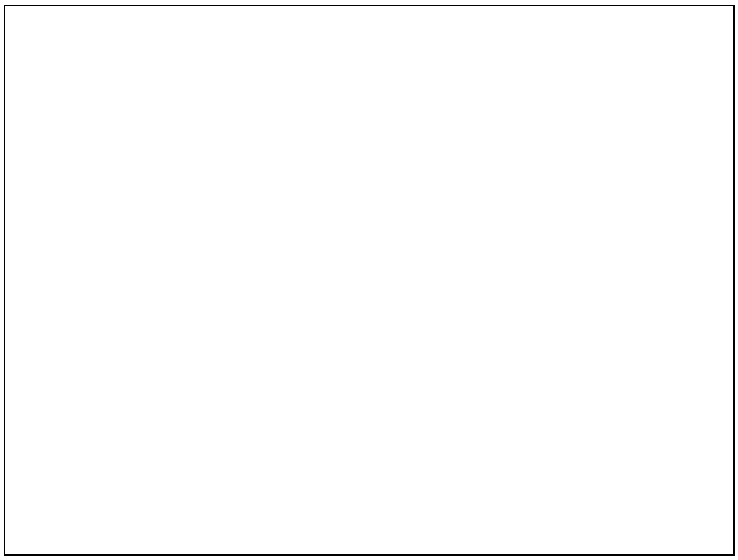


Plate 12 Soil sample Site S9

Texture: Clayey sand throughout top 20cm of profile dominated by coarse fragments. Sub angular coarse fragments 5-100mm in size.

Structure: Apedal, single grained throughout profile surface. Sandy fabric and weak consistence throughout top 20cm of profile.

Root growth: Penetration throughout soil matrix, decreasing slightly with depth.

Vegetation Classification:
D5 *Corymbia hamersleyana* low open woodland over *Acacia tumida* var. *pilbarensis* / *A. pyrifolia* open scrub to high open shrubland over *Triodia epactia* hummock grassland.

Table 9 Soil sample characteristics - Site S9

Sample Depth (cm)	Soil texture	% Coarse (>2mm)	pH (H_2O)	EC (dS/m)	Root Score*	Org C (%)	Total N (%)	Nitrate N (mg/kg)	Amm. N (mg/kg)	Avail. P (mg/kg)	Avail. K (mg/kg	Avail. S (mg/kg
0-5	Clayey sand	40	7.6	0.078	2	1.48	0.15	15	21	10	458	3.1
10-20	Clayey sand	40	7.7	0.068	2	0.69	0.08	8	2	5	317	2.8

* See Appendix B for Root Abundance Scoring details

3.1.10 Site S10

Site Details: Lower slope

GPS Coordinates: 20°53' 30.4
120°06' 11.7

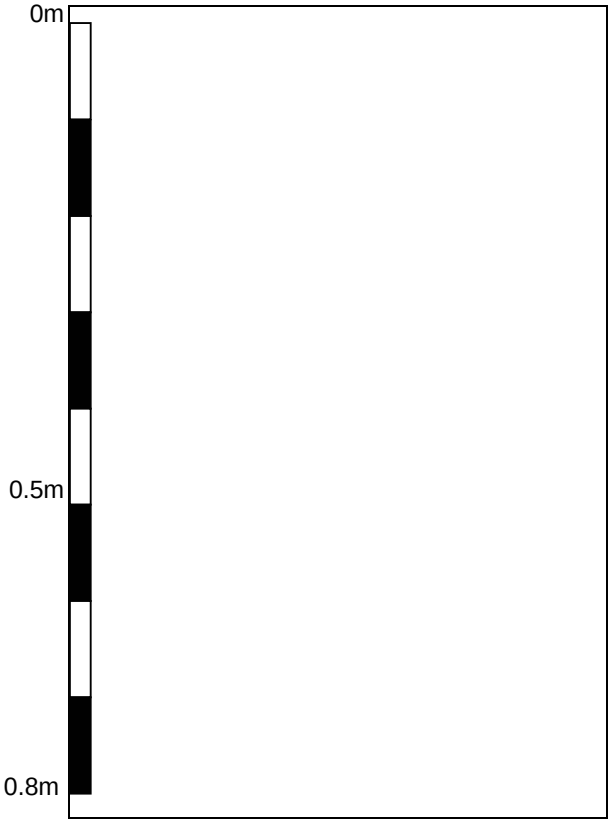


Plate 13 Soil profile at Site S10

Texture: Clayey sand throughout top of profile, increasing in clay content to clay loam at around 30cm. Profile dominated by coarse fragments, sub angular and angular coarse fragments 5-100mm in size, increasing in volume with depth to approximately 75% at around 40cm.

Structure: Apedal, single grained throughout profile surface. Sandy fabric and weak consistence throughout top 20cm of profile. Some weak aggregates between coarse fragments at depth.

Root growth: Penetration throughout soil matrix, decreasing with depth to few roots penetrating beyond 40cm.

Vegetation Classification:
(prior to being burnt)
P1 *Acacia inaequilatera* high shrubland to scattered shrubs over *Triodia epactia* hummock grassland.

Plate 14 Soil sample Site S10

Table 10 Soil sample characteristics - Site S10

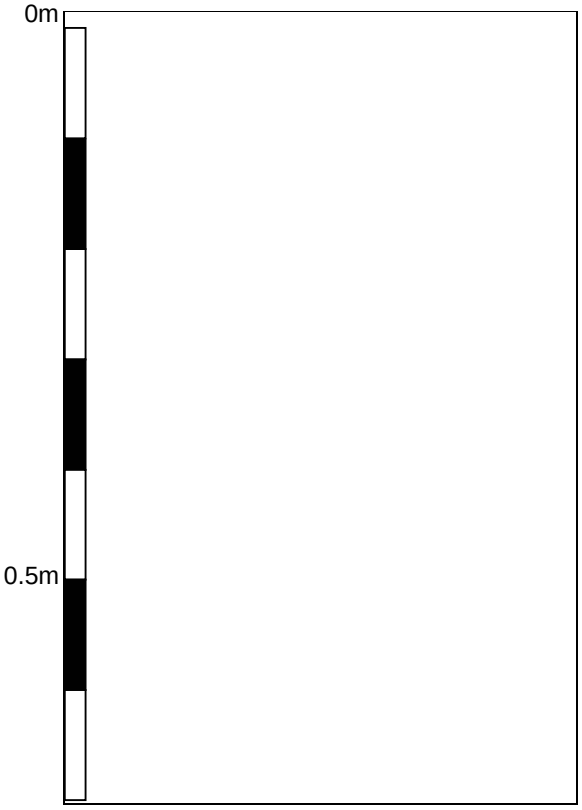
Sample Depth (cm)	Soil texture	% Coarse (>2mm)	pH (H_2O)	EC (dS/m)	Root Score*	Org C (%)	Total N (%)	Nitrate N (mg/kg)	Amm. N (mg/kg)	Avail. P (mg/kg)	Avail. K (mg/kg	Avail. S (mg/kg
0-5	Clayey sand	25	8.2	0.097	2	0.47	0.04	2	1	10	182	8.3
10-20	Clayey sand	40	8.5	0.095	1	0.53	0.05	2	1	6	138	29.5
40-50	Clay loam	75	8.5	0.106	1	0.27	0.03	1	4	2	128	28.3

* See Appendix B for Root Abundance Scoring details

3.1.11 Site S11

Site Details: Mid slope

GPS Coordinates: 20°53' 33.2
120°06' 21.8



Texture: Clayey sand throughout top of profile, increasing in clay content to clay loam at around 40cm. Profile dominated by coarse fragments, sub angular and angular coarse fragments 5-75mm in size, increasing in volume with depth to approximately 75% at around 40cm.

Structure: Apedal, single grained throughout profile surface. Sandy fabric and weak consistence throughout top 20cm of profile. Some weak aggregates between coarse fragments at depth.

Root growth: Penetration throughout soil matrix, decreasing with depth to few roots penetrating beyond 50cm.

Plate 15 Soil profile at Site S11

Vegetation Classification:
(prior to being burnt)
H1 *Acacia inaequilatera* scattered tall shrubs to high open shrubland over mixed *Corchorus parviflorus* / *Indigofera monophylla / Tephrosia* spp. */ Ptilotus calostachyus* low scattered shrubs to low open shrubland over *Triodia epactia* hummock grassland.

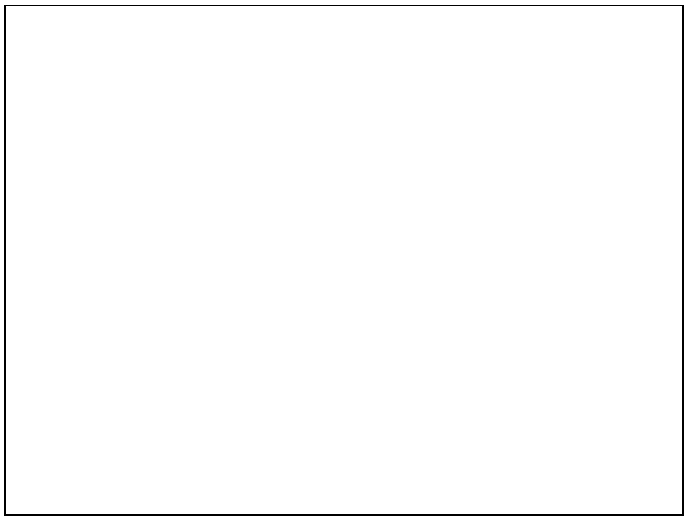


Plate 16 Soil sample Site S11

Table 11 Soil sample characteristics - Site S11

Sample Depth (cm)	Soil texture	% Coarse (>2mm)	pH (H_2O)	EC (dS/m)	Root Score*	Org C (%)	Total N (%)	Nitrate N (mg/kg)	Amm. N (mg/kg)	Avail. P (mg/kg)	Avail. K (mg/kg	Avail. S (mg/kg
0-5	Clayey sand	50	8.3	0.151	2	1.10	0.09	8	4	10	174	25.2
10-20	Clayey sand	25	8.3	0.133	2	0.92	0.09	8	3	7	158	18.2
40-50	Clay loam	75	8.5	0.129	1	0.56	0.06	2	3	3	236	16.9

* See Appendix B for Root Abundance Scoring details

3.1.12 Site S12

Site Details: Drainage line – creek bed **GPS Coordinates:** 20°53' 31.9
120°06' 19.0

Plate 17 Soil sample Site S12

Texture: Clay loam to clayey sand throughout top 20cm of profile. Less than 5% coarse material in profile surface.

Structure: Apedal, single grained throughout profile surface. Sandy fabric and very weak consistence throughout top 20cm of profile.

Root growth: Patchy penetration throughout soil matrix, some areas with zero root growth corresponding to bare patches.

Vegetation Classification:
(prior to being burnt)
D3 *Eucalyptus camaldulensis* var. *obtusa* / *E. vitrix* open woodland to woodland over *Melaleuca glomerata* / *Acacia ampliceps* / *Acacia coriacea* ssp. *pendens* and *Acacia tumida* var. *pilbarensis* low open woodland to woodland over *Cyperus vaginatus* very open sedges over *Triodia longiceps* hummock grassland.

Table 12 Soil sample characteristics - Site S12

Sample Depth (cm)	Soil texture	% Coarse (>2mm)	pH (H_2O)	EC (dS/m)	Root Score*	Org C (%)	Total N (%)	Nitrate N (mg/kg)	Amm. N (mg/kg)	Avail. P (mg/kg)	Avail. K (mg/kg	Avail. S (mg/kg
0-5	Clay loam	5	9.6	1.664	1	1.1	0.08	14	2	14	242	28.3
10-20	Clayey sand	10	9.3	0.593	1	0.52	0.04	9	2	5	112	13.3

* See Appendix B for Root Abundance Scoring details

3.1.13 Site S13

Site Details: Lower slope

GPS Coordinates: 20°53' 23.6
120°06' 10.0

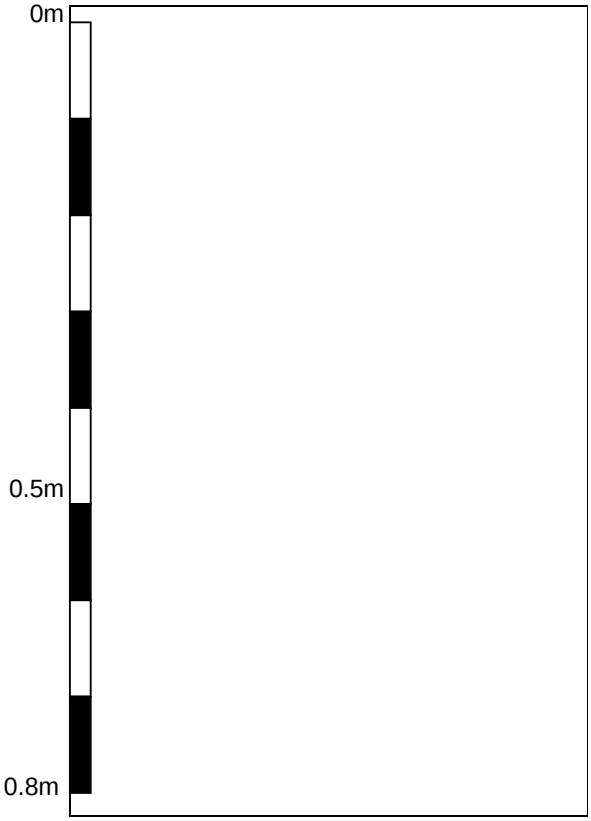


Plate 18 Soil profile at Site S13

Texture: Clayey sand throughout top 10cm of profile, increasing in clay content to sandy clay loam and clay loam, sandy, at around 40cm. Profile dominated by coarse fragments, sub angular and angular coarse fragments 5-100mm in size, increasing in volume with depth to approximately 90% at around 40cm.

Structure: Apedal, single grained throughout profile surface. Sandy fabric and weak consistence throughout top 20cm of profile. Some weak aggregates between coarse fragments at depth.

Root growth: Penetration throughout soil matrix, decreasing with depth to few roots penetrating beyond 40cm.

Vegetation Classification:
H1 *Acacia inaequilatera* scattered tall shrubs to high open shrubland over mixed *Corchorus parviflorus* / *Indigofera monophylla / Tephrosia* spp. */ Ptilotus calostachyus* low scattered shrubs to low open shrubland over *Triodia epactia* hummock grassland.

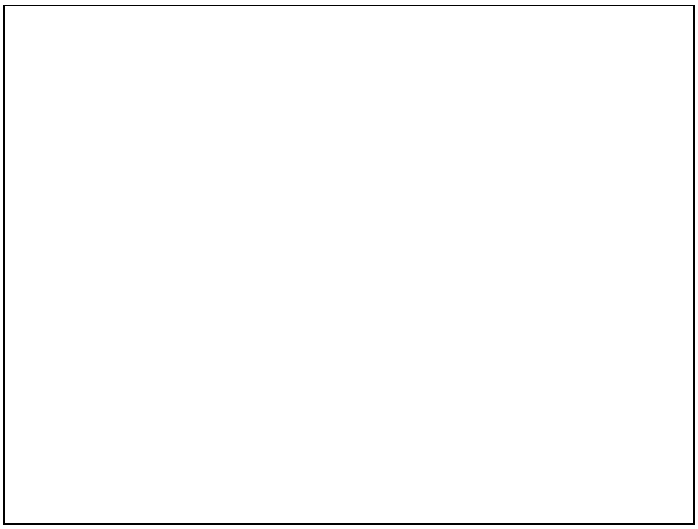


Plate 19 Soil sample Site S13

Table 13 Soil sample characteristics - Site S13

Sample Depth (cm)	Soil texture	% Coarse (>2mm)	pH (H_2O)	EC (dS/m)	Root Score*	Org C (%)	Total N (%)	Nitrate N (mg/kg)	Amm. N (mg/kg)	Avail. P (mg/kg)	Avail. K (mg/kg	Avail. S (mg/kg
0-5	Clayey sand	25	7.6	0.037	2	0.47	0.04	4	2	9	206	10.8
10-20	Sandy clay loam	40	8.1	0.050	1	0.41	0.04	4	4	3	160	7.5
40-50	Clay loam, sandy	90	8.1	0.060	1	0.37	0.04	2	4	2	77	6.3

* See Appendix B for Root Abundance Scoring details

3.1.14 Site S14

Site Details: Drainage line **GPS Coordinates:** 20°53' 25.5
120°05' 08.6

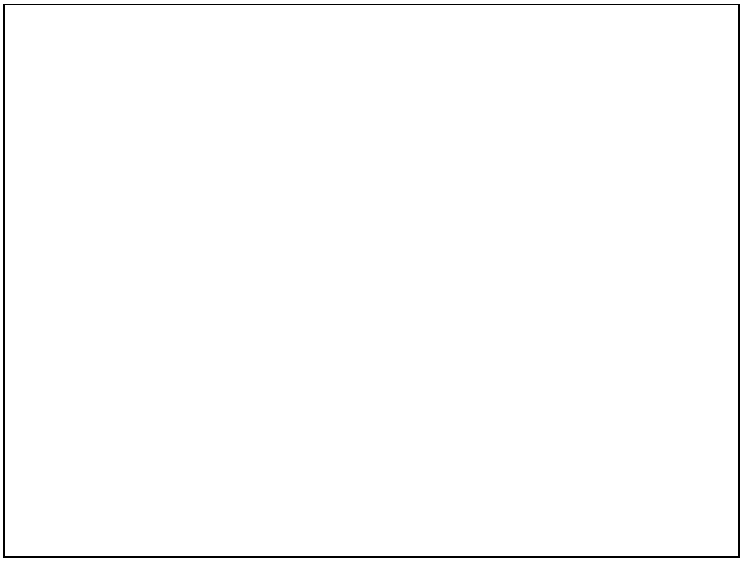


Plate 20 Soil sample Site S14

Texture: Loamy sand increasing to clayey sand throughout top 20cm of profile. Sub angular and angular coarse fragments 5-50mm in size.

Structure: Apedal, single grained throughout profile surface. Sandy fabric and weak consistence throughout top 20cm of profile.

Root growth: Penetration throughout soil matrix, decreasing slightly with depth.

Vegetation Classification:
D5 *Corymbia hamersleyana* low open woodland over *Acacia tumida* var. *pilbarensis* / *A. pyrifolia* open scrub to high open shrubland over *Triodia epactia* hummock grassland.

Table 14 Soil sample characteristics - Site S14

Sample Depth (cm)	Soil texture	% Coarse (>2mm)	pH (H_2O)	EC (dS/m)	Root Score*	Org C (%)	Total N (%)	Nitrate N (mg/kg)	Amm. N (mg/kg)	Avail. P (mg/kg)	Avail. K (mg/kg	Avail. S (mg/kg
0-5	Loamy sand	10	8.0	0.045	2	0.83	0.07	5	1	5	354	2.0
10-20	Clayey sand	20	7.9	0.044	2	0.57	0.05	2	2	3	254	1.8

* See Appendix B for Root Abundance Scoring details

3.1.15 Site S15

Site Details: Lower slope

GPS Coordinates: 20°53' 25.2
120°05' 16.8

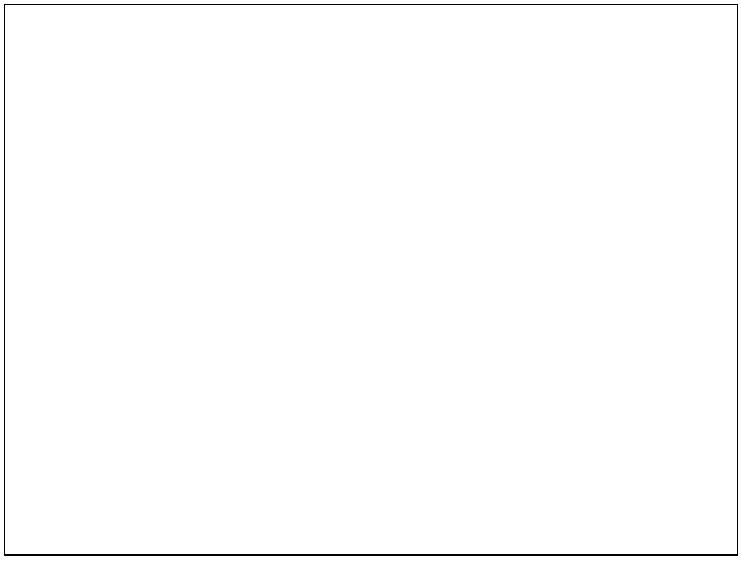


Plate 21 Soil sample Site S15

Texture: Clayey sand throughout top 20cm of profile. Sub angular and angular coarse fragments 5-150mm in size.

Structure: Apedal, single grained throughout profile surface. Sandy fabric and weak consistence throughout top 20cm of profile.

Root growth: Penetration throughout soil matrix, decreasing slightly with depth.

Vegetation Classification:
H1 *Acacia inaequilatera* scattered tall shrubs to high open shrubland over mixed *Corchorus parviflorus* / *Indigofera monophylla* / *Tephrosia* spp. / *Ptilotus calostachyus* low scattered shrubs to low open shrubland over *Triodia epactia* hummock grassland.

Table 15 Soil sample characteristics - Site S15

Sample Depth (cm)	Soil texture	% Coarse (>2mm)	pH (H_2O)	EC (dS/m)	Root Score*	Org C (%)	Total N (%)	Nitrate N (mg/kg)	Amm. N (mg/kg)	Avail. P (mg/kg)	Avail. K (mg/kg	Avail. S (mg/kg
0-5	Clayey sand	40	8.4	0.107	2	0.47	0.04	2	1	10	107	23.7
10-20	Clayey sand	25	8.4	0.142	1	0.41	0.03	1	1	4	94	34.9

* See Appendix B for Root Abundance Scoring details

3.1.16 Site S16

Site Details: Lower slope

GPS Coordinates: 20°53' 28.7
120°05' 23.7

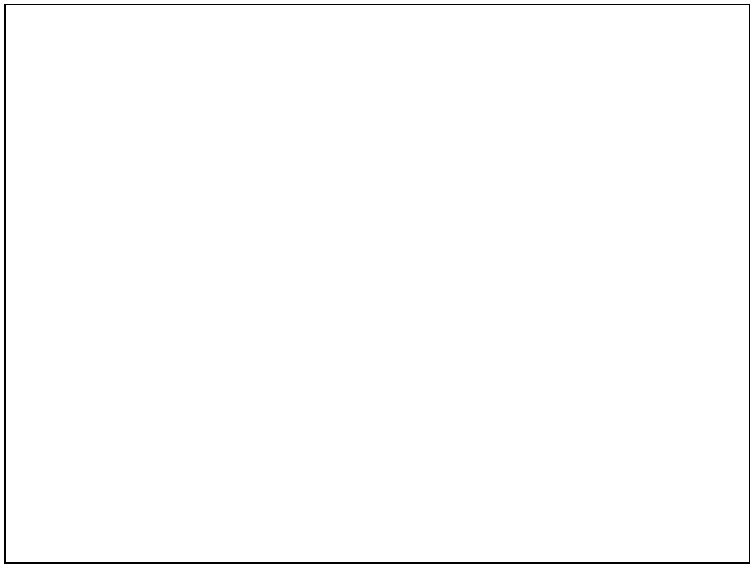


Plate 22 Soil sample Site S16

Texture: Clayey sand increasing to sandy clay loam in top 20cm of profile. Profile dominated by coarse fragments, sub angular and angular coarse fragments 5-75mm in size.

Structure: Apedal, single grained throughout profile surface. Sandy fabric and weak consistence throughout top 20cm of profile.

Root growth: Penetration throughout soil matrix, decreasing slightly with depth.

Vegetation Classification:
H1 *Acacia inaequilatera* scattered tall shrubs to high open shrubland over mixed *Corchorus parviflorus* / *Indigofera monophylla* / *Tephrosia* spp. / *Ptilotus calostachyus* low scattered shrubs to low open shrubland over *Triodia epactia* hummock grassland.

Table 16 Soil sample characteristics - Site S16

Sample Depth (cm)	Soil texture	% Coarse (>2mm)	pH (H_2O)	EC (dS/m)	Root Score*	Org C (%)	Total N (%)	Nitrate N (mg/kg)	Amm. N (mg/kg)	Avail. P (mg/kg)	Avail. K (mg/kg	Avail. S (mg/kg
0-5	Clayey sand	40	7.0	0.016	2	0.22	0.02	1	2	19	329	3.4
10-20	Sandy clay loam	50	8.0	0.025	1	0.32	0.03	2	2	11	307	2.2

* See Appendix B for Root Abundance Scoring details

3.1.17 Site S17

Site Details: Lower slope

GPS Coordinates: 20°53' 24.7
120°05' 28.8

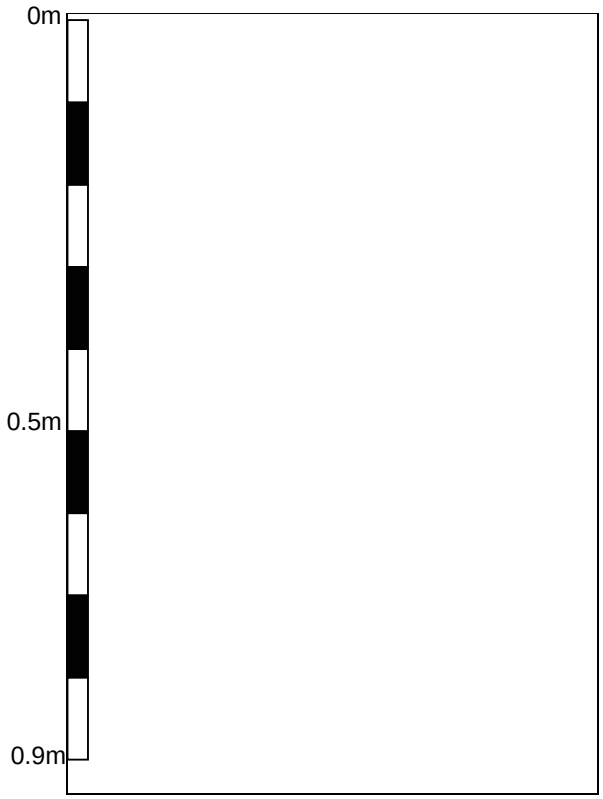


Plate 23 Soil profile at Site S17

Texture: Clayey sand throughout top 10cm of profile, increasing in clay content to sandy clay loam at around 10cm. Profile dominated by coarse fragments, sub angular and angular coarse fragments 5-75mm in size, increasing in volume with depth to approximately 90% at around 30cm.

Structure: Apedal, single grained throughout profile surface. Sandy fabric and weak consistence throughout top 20cm of profile. Some weak aggregates between coarse fragments at depth.

Root growth: Penetration throughout soil matrix, decreasing with depth to few roots penetrating beyond 60cm.

Vegetation Classification:
H1 *Acacia inaequilatera* scattered tall shrubs to high open shrubland over mixed *Corchorus parviflorus* / *Indigofera monophylla* / *Tephrosia* spp. / *Ptilotus calostachyus* low scattered shrubs to low open shrubland over *Triodia epactia* hummock grassland.

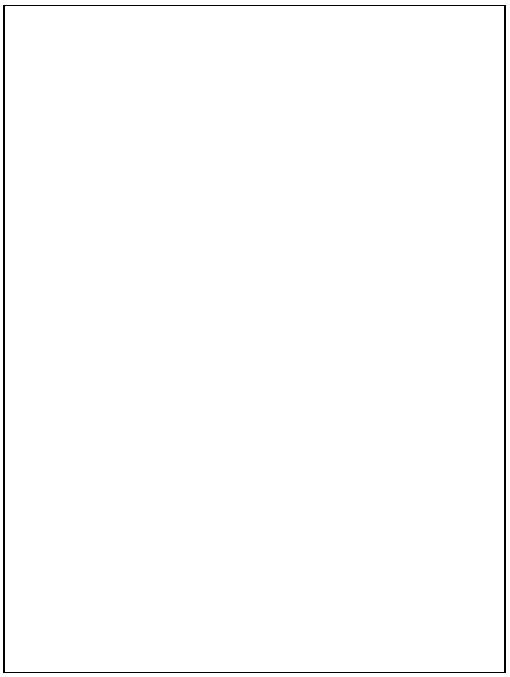


Plate 24 Soil sample Site S17

Table 17 Soil sample characteristics - Site S17

Sample Depth (cm)	Soil texture	% Coarse (>2mm)	pH (H_2O)	EC (dS/m)	Root Score*	Org C (%)	Total N (%)	Nitrate N (mg/kg)	Amm. N (mg/kg)	Avail. P (mg/kg)	Avail. K (mg/kg	Avail. S (mg/kg
0-5	Clayey sand	40	8.2	0.093	2	0.83	0.07	3	2	9	221	3.2
10-20	Sandy clay loam	75	8.5	0.083	2	0.46	0.05	3	3	4	174	2.4
40-50	Sandy clay loam	90	8.4	0.095	1	0.28	0.03	2	3	3	103	2.8

* See Appendix B for Root Abundance Scoring details

3.1.18 Site S18

Site Details: Valley floor

GPS Coordinates: 20°53' 25.9
120°05' 32.6

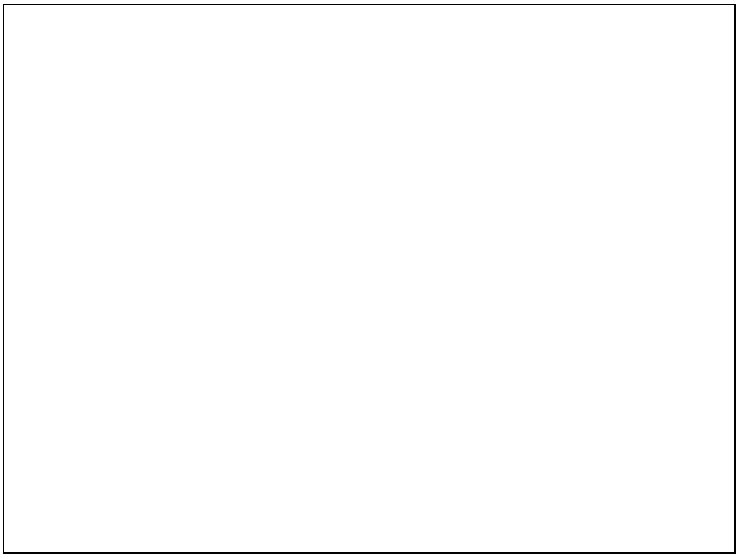


Plate 25 Soil sample Site S18

Texture: Clayey sand through top 20cm of profile. Profile dominated by coarse fragments, sub angular and angular coarse fragments 5-75mm in size.

Structure: Apedal, single grained throughout profile surface. Sandy fabric and weak consistence throughout top 20cm of profile.

Root growth: Penetration throughout soil matrix, decreasing slightly with depth.

Vegetation Classification:
H1 *Acacia inaequilatera* scattered tall shrubs to high open shrubland over mixed *Corchorus parviflorus* / *Indigofera monophylla* / *Tephrosia* spp*.* / *Ptilotus calostachyus* low scattered shrubs to low open shrubland over *Triodia epactia* hummock grassland.

Table 18 Soil sample characteristics - Site S18

Sample Depth (cm)	Soil texture	% Coarse (>2mm)	pH (H_2O)	EC (dS/m)	Root Score*	Org C (%)	Total N (%)	Nitrate N (mg/kg)	Amm. N (mg/kg)	Avail. P (mg/kg)	Avail. K (mg/kg	Avail. S (mg/kg
0-5	Clayey sand	40	7.4	0.075	2	0.78	0.07	6	2	9	259	2.7
10-20	Clayey sand	50	7.4	0.052	1	0.89	0.06	4	1	5	272	3.4

* See Appendix B for Root Abundance Scoring details

3.1.19 Site S19

Site Details: Lower slope

GPS Coordinates: 20°53' 26.3
120°05' 39.5

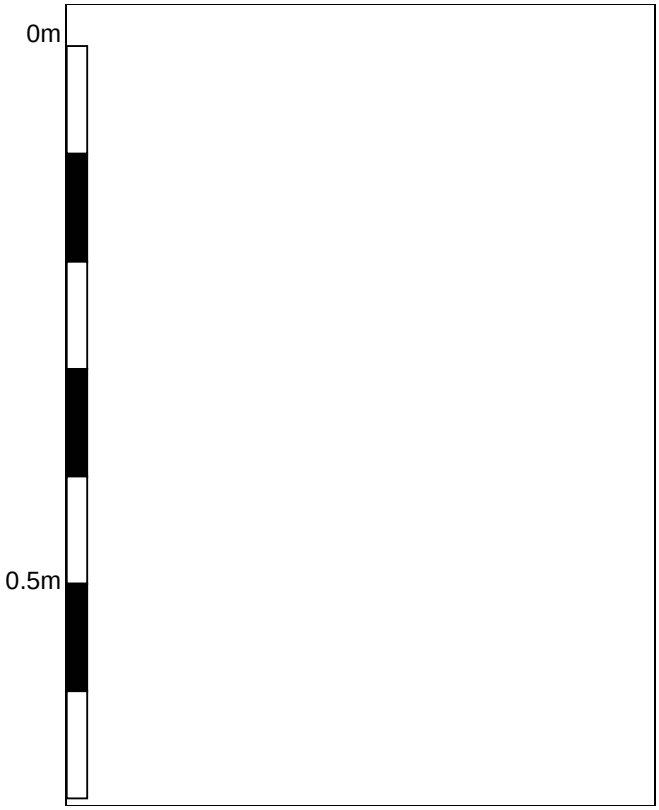


Plate 26 Soil profile at Site S19

Texture: Clayey sand throughout top 20cm of profile, increasing in clay content to sandy clay loam at around 30cm. Profile dominated by coarse fragments, sub angular and angular coarse fragments 5-75mm in size, increasing in volume with depth to approximately 75% at around 40cm.

Structure: Apedal, single grained throughout profile surface. Sandy fabric and weak consistence throughout top 20cm of profile. Some weak aggregates between coarse fragments at depth.

Root growth: Penetration throughout soil matrix, decreasing with depth to few roots penetrating beyond 60cm.

Vegetation Classification:
H1 *Acacia inaequilatera* scattered tall shrubs to high open shrubland over mixed *Corchorus parviflorus* / *Indigofera monophylla* / *Tephrosia* spp. / *Ptilotus calostachyus* low scattered shrubs to low open shrubland over *Triodia epactia* hummock grassland.

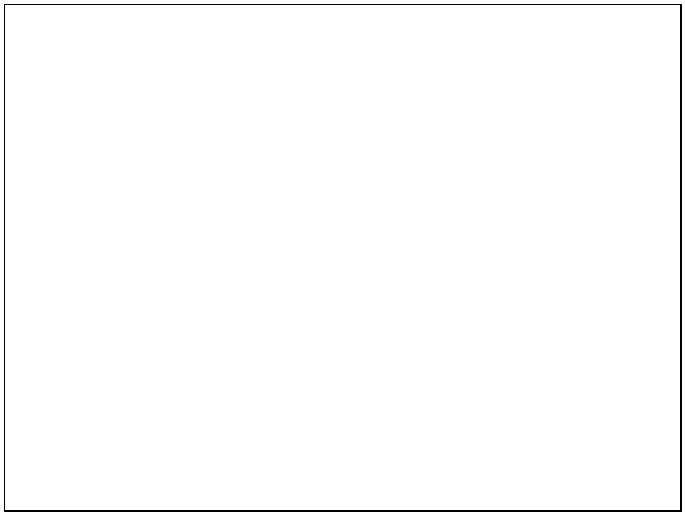


Plate 27 Soil sample Site S19

Table 19 Soil sample characteristics - Site S19

Sample Depth (cm)	Soil texture	% Coarse (>2mm)	pH (H_2O)	EC (dS/m)	Root Score*	Org C (%)	Total N (%)	Nitrate N (mg/kg)	Amm. N (mg/kg)	Avail. P (mg/kg)	Avail. K (mg/kg	Avail. S (mg/kg
0-5	Clayey sand	25	7.3	0.040	2	1.02	0.08	6	4	12	339	3.2
10-20	Clayey sand	40	7.8	0.095	2	0.50	0.04	3	3	6	190	4.7
40-50	Sandy clay loam	75	8.0	0.102	1	0.42	0.04	4	4	5	107	5.6

* See Appendix B for Root Abundance Scoring details

3.1.20 Site S20

Site Details: Hill crest **GPS Coordinates:** 20°53' 41.8
120°06' 08.5

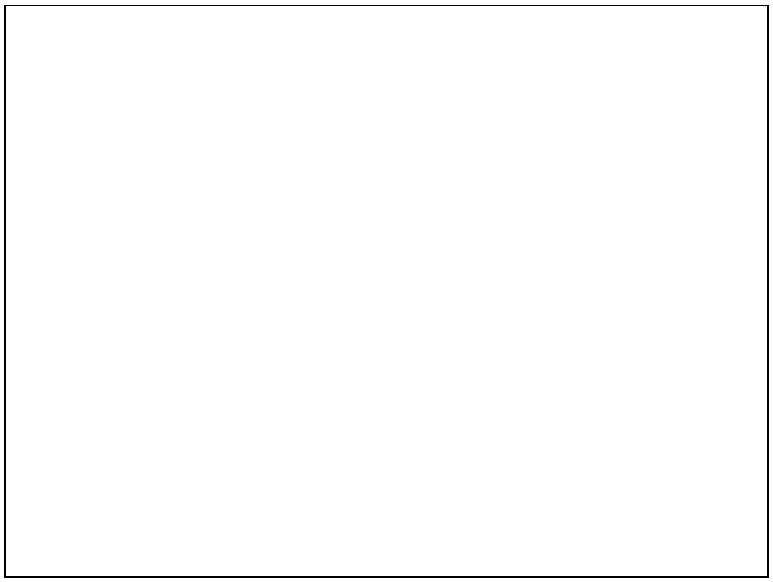


Plate 28 Soil sample Site S20

Texture: Loamy sand increasing to clayey sand in top 20cm of profile. Profile dominated by coarse fragments, sub angular and angular coarse fragments 5-150mm in size.

Structure: Apedal, single grained throughout profile surface. Sandy fabric and weak consistence throughout top 20cm of profile.

Root growth: Penetration throughout soil matrix, decreasing slightly with depth.

Vegetation Classification:
(prior to being burnt)
H1 *Acacia inaequilatera* scattered tall shrubs to high open shrubland over mixed *Corchorus parviflorus* / *Indigofera monophylla* / *Tephrosia* spp. / *Ptilotus calostachyus* low scattered shrubs to low open shrubland over *Triodia epactia* hummock grassland.

Table 20 Soil sample characteristics - Site S20

Sample Depth (cm)	Soil texture	% Coarse (>2mm)	pH (H_2O)	EC (dS/m)	Root Score*	Org C (%)	Total N (%)	Nitrate N (mg/kg)	Amm. N (mg/kg)	Avail. P (mg/kg)	Avail. K (mg/kg	Avail. S (mg/kg
0-5	Loamy sand	75	8.0	0.070	1	1.01	0.09	7	8	11	232	13.1
10-20	Clayey sand	90	8.0	0.130	1	0.56	0.05	4	4	6	127	4.6

* See Appendix B for Root Abundance Scoring details

3.1.21 Site S21

Site Details: Lower slope

GPS Coordinates: 20°53' 50.3
120°06' 18.9

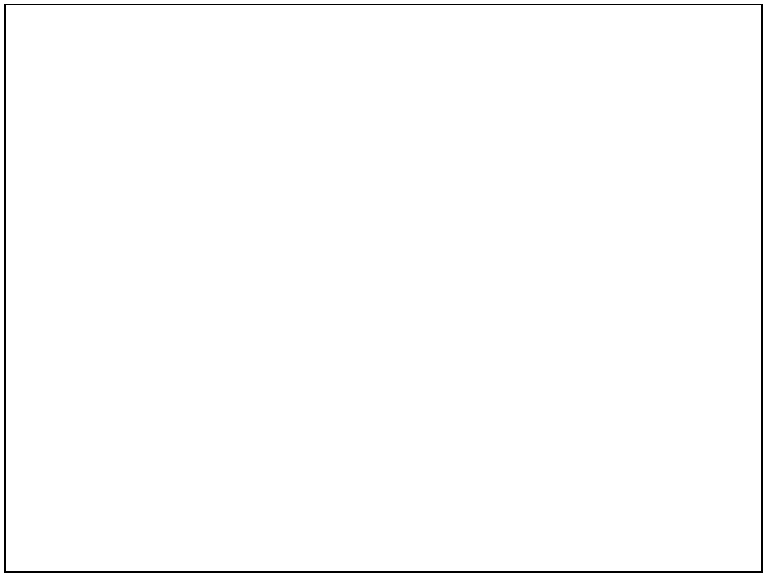


Plate 29 Soil sample Site S21

Texture: Clayey sand in top 20cm of profile. Profile dominated by coarse fragments, sub angular and angular coarse fragments 5-100mm in size.

Structure: Apedal, single grained throughout profile surface. Sandy fabric and weak consistence throughout top 20cm of profile.

Root growth: Penetration throughout soil matrix, decreasing slightly with depth.

Vegetation Classification:
(prior to being burnt)
H1 *Acacia inaequilatera* scattered tall shrubs to high open shrubland over mixed *Corchorus parviflorus* / *Indigofera monophylla* / *Tephrosia* spp. / *Ptilotus calostachyus* low scattered shrubs to low open shrubland over *Triodia epactia* hummock grassland.

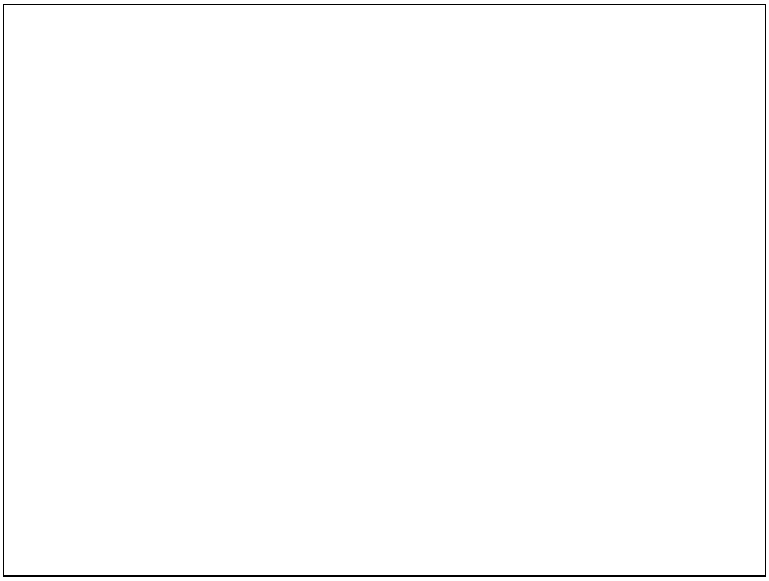
Table 21 Soil sample characteristics - Site S21

Sample Depth (cm)	Soil texture	% Coarse (>2mm)	pH (H_2O)	EC (dS/m)	Root Score*	Org C (%)	Total N (%)	Nitrate N (mg/kg)	Amm. N (mg/kg)	Avail. P (mg/kg)	Avail. K (mg/kg	Avail. S (mg/kg
0-5	Clayey sand	75	7.4	0.021	1	0.31	0.03	1	2	13	161	3.7
10-20	Clayey sand	75	8.0	0.034	1	0.37	0.04	1	3	8	85	25.6

* See Appendix B for Root Abundance Scoring details

3.1.22 Site S22

Site Details: Drainage line **GPS Coordinates:** 20°54' 07.8
120°06' 16.9



Texture: Sand to loamy sand in top 20cm of profile. Less than 5% sub angular and sub rounded coarse fragments 5-25mm in size.

Structure: Apedal, single grained throughout profile surface. Sandy fabric and weak consistence throughout top 20cm of profile.

Root growth: Few roots, although penetration throughout soil matrix, abundance decreasing slightly with depth.

Vegetation Classification:
(prior to being burnt)
P1 *Acacia inaequilatera* high shrubland to scattered shrubs over *Triodia epactia* hummock grassland.

Plate 30 Soil sample Site S22

Table 22 Soil sample characteristics - Site S22

Sample Depth (cm)	Soil texture	% Coarse (>2mm)	pH (H_2O)	EC (dS/m)	Root Score*	Org C (%)	Total N (%)	Nitrate N (mg/kg)	Amm. N (mg/kg)	Avail. P (mg/kg)	Avail. K (mg/kg	Avail. S (mg/kg
0-5	Sand	5	7.9	0.087	1	0.2	0.02	3	1	4	183	12.8
10-20	Loamy sand	5	8.7	0.199	1	0.19	0.02	1	1	3	34	27.1

* See Appendix B for Root Abundance Scoring details

3.1.23 Site S23

Site Details: Lower slope

GPS Coordinates: 20°54' 17.0
120°06' 17.0

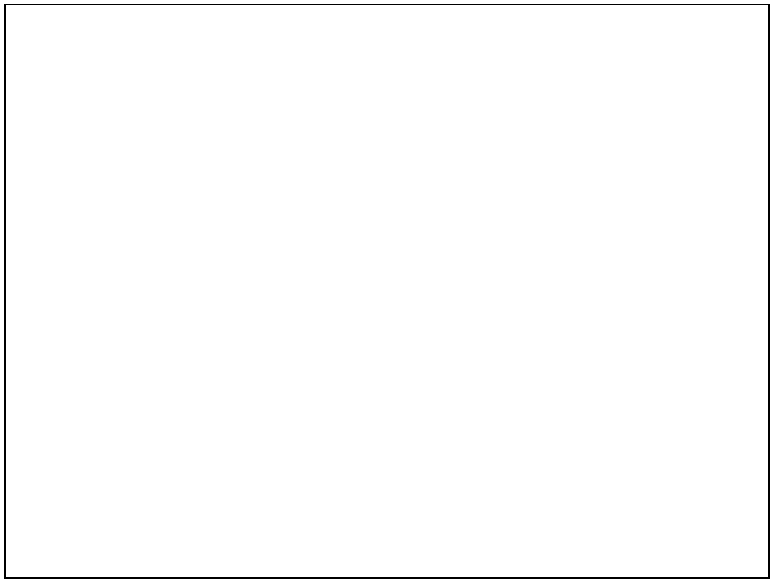


Plate 31 Soil sample Site S23

Texture: Clayey sand through top 20cm of profile. Profile dominated by sub angular coarse fragments 5-75mm in size.

Structure: Apedal, single grained throughout profile surface. Sandy fabric and weak consistence throughout top 20cm of profile.

Root growth: Penetration throughout soil matrix, decreasing slightly with depth.

Vegetation Classification:
H1 *Acacia inaequilatera* scattered tall shrubs to high open shrubland over mixed *Corchorus parviflorus* / *Indigofera monophylla* / *Tephrosia* spp. / *Ptilotus calostachyus* low scattered shrubs to low open shrubland over *Triodia epactia* hummock grassland.

Table 23 Soil sample characteristics - Site S23

Sample Depth (cm)	Soil texture	% Coarse (>2mm)	pH (H_2O)	EC (dS/m)	Root Score*	Org C (%)	Total N (%)	Nitrate N (mg/kg)	Amm. N (mg/kg)	Avail. P (mg/kg)	Avail. K (mg/kg	Avail. S (mg/kg
0-5	Clayey sand	40	7.7	0.017	2	0.43	0.02	3	3	8	171	2.5
10-20	Clayey sand	40	7.5	0.021	1	0.50	0.03	2	2	4	166	3.7

* See Appendix B for Root Abundance Scoring details

3.1.24 Site S24

Site Details: Lower slope

GPS Coordinates: 20°53' 35.1
120°05' 56.1

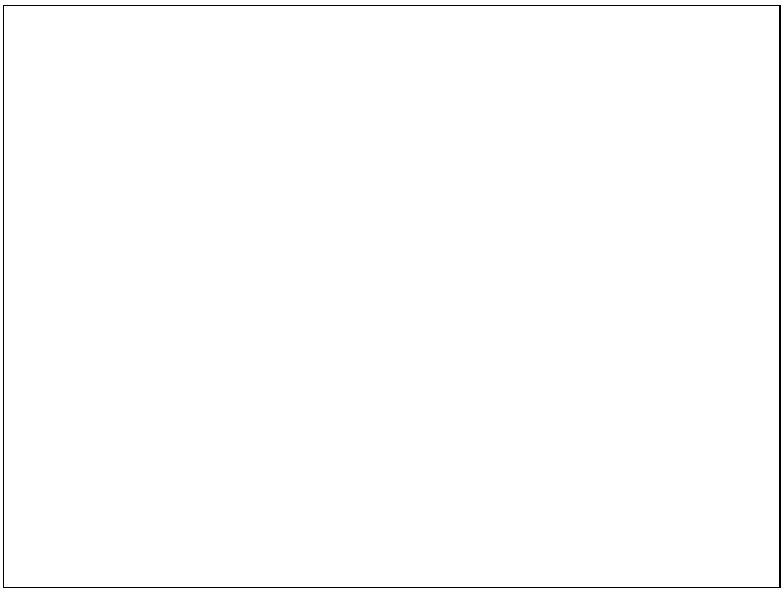


Plate 32 Soil sample Site S24

Texture: Clayey sand through top 20cm of profile. Profile dominated by sub-angular coarse fragments 5-100mm in size.

Structure: Apedal, single grained throughout profile surface. Sandy fabric and weak consistence throughout top 20cm of profile.

Root growth: Penetration throughout soil matrix, decreasing slightly with depth.

Vegetation Classification:
H1 *Acacia inaequilatera* scattered tall shrubs to high open shrubland over mixed *Corchorus parviflorus* / *Indigofera monophylla* / *Tephrosia* spp. / *Ptilotus calostachyus* low scattered shrubs to low open shrubland over *Triodia epactia* hummock grassland.

Table 24 Soil sample characteristics - Site S24

Sample Depth (cm)	Soil texture	% Coarse (>2mm)	pH (H_2O)	EC (dS/m)	Root Score*	Org C (%)	Total N (%)	Nitrate N (mg/kg)	Amm. N (mg/kg)	Avail. P (mg/kg)	Avail. K (mg/kg	Avail. S (mg/kg
0-5	Clayey sand	40	6.3	0.233	2	0.22	0.02	1	1	11	244	145.0
10-20	Clayey sand	50	6.9	0.018	1	0.21	0.02	1	2	7	187	4.2

* See Appendix B for Root Abundance Scoring details

3.2 Northern Site Descriptions

The soil profile morphology, soil physical and chemical characteristics of each sample site north of the Talga Range are summarised for each site (Sections 3.2.1 to 3.2.16). The vegetation classifications given for each site are based on those described in the concurrent OES Vegetation and Flora Survey Report for the Project Area (OES 2006a).

3.2.1 Site N1

Site Details: Valley floor / flat, adjacent to major drainage line

GPS Coordinates: 0199681 mN 7689199 mE

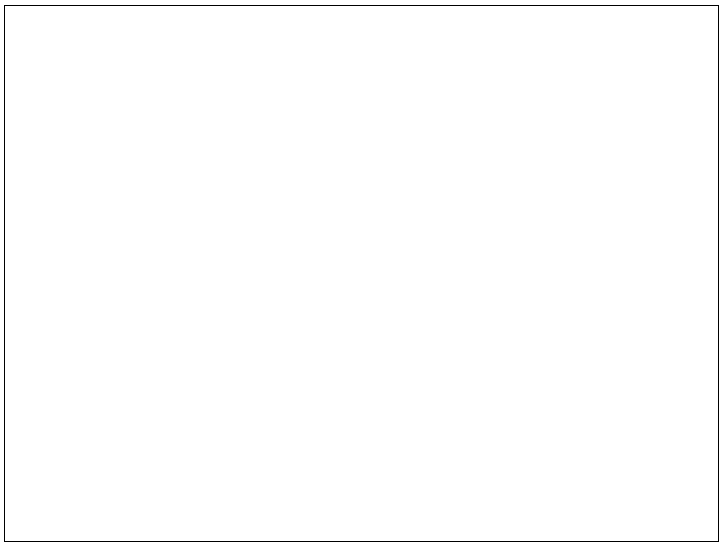


Plate 33 Soil sample Site N1

Texture: Clayey sand through top 20cm of profile. Profile dominated by sub-angular and sub-rounded coarse fragments 5-200mm in size.

Structure: Apedal, single grained throughout profile surface. Sandy fabric and weak consistence throughout top 20cm of profile.

Root growth: Few roots, penetration throughout soil matrix.

Vegetation Classification:
P9 Mixed *Grevillea* and *Acacia* scattered tall shrubs over *Triodia epactia* hummock grassland.

Table 25 Soil sample characteristics - Site N1

Sample Depth (cm)	Soil texture	% Coarse (>2mm)	pH (H_2O)	EC (dS/m)	Root Score*	Org C (%)	Nitrate N (mg/kg)	Amm. N (mg/kg)	Avail. P (mg/kg)	Avail. K (mg/kg	Avail. S (mg/kg
0-5	Clayey sand	40	7.6	0.039	1	0.25	1	1	5	280	2.1
10-20	Clayey sand	40	7.4	0.094	1	0.16	1	1	6	219	2.3

* See Appendix B for Root Abundance Scoring details

3.2.2 Site N2

Site Details: Minor drainage line

GPS Coordinates: 0199291 mN
7692400 mE

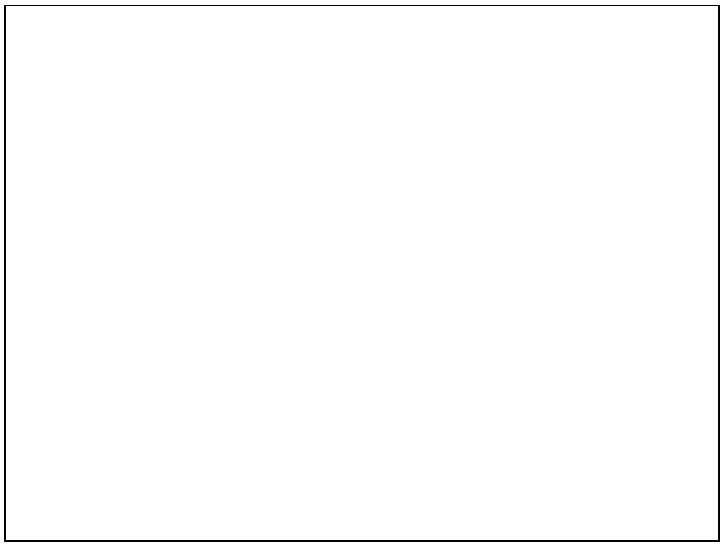


Plate 34 Soil sample Site N2

Texture: Clayey sand through top 20cm of profile. Profile dominated by sub-angular and sub-rounded coarse fragments 5-100mm in size.

Structure: Apedal, single grained throughout profile surface. Sandy fabric and weak consistence throughout top 20cm of profile.

Root growth: Few roots, penetration throughout soil matrix.

Vegetation Classification:
P9 Mixed *Grevillea* and *Acacia* scattered tall shrubs over *Triodia epactia* hummock grassland.

Table 26 Soil sample characteristics - Site N2

Sample Depth (cm)	Soil texture	% Coarse (>2mm)	pH (H_2O)	EC (dS/m)	Root Score*	Org C (%)	Nitrate N (mg/kg)	Amm. N (mg/kg)	Avail. P (mg/kg)	Avail. K (mg/kg	Avail. S (mg/kg
0-5	Clayey sand	50	7.0	0.014	1	0.27	1	1	8	185	1.9
10-20	Clayey sand	50	6.9	0.014	1	0.24	1	1	4	205	1.5

* See Appendix B for Root Abundance Scoring details

3.2.3 Site N3

Site Details: Minor drainage line

GPS Coordinates: 0199092 mN
7689230 mE

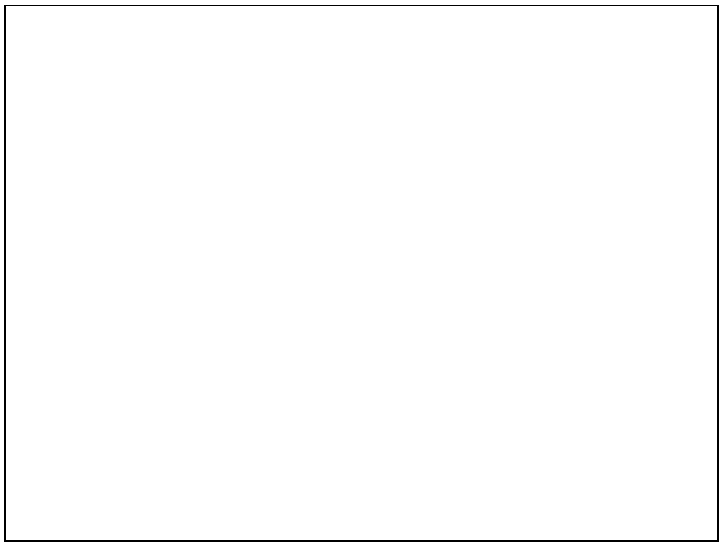


Plate 35 Soil sample Site N3

Texture: Sandy loam through top 20cm of profile. Approximately 5-20% sub-angular and sub-rounded coarse fragments 5-50mm in size.

Structure: Thin surface crust present, overlying apedal, single grained soil to 20cm. Sandy fabric and weak consistence throughout top 20cm of profile.

Root growth: Few roots, penetration throughout soil matrix.

Vegetation Classification:
D7 *Acacia tumida* var. *pilbarensis* open scrub to high shrubland over *Triodia epactia* open hummock grassland along drainage lines.

Table 27 Soil sample characteristics - Site N3

Sample Depth (cm)	Soil texture	% Coarse (>2mm)	pH (H_2O)	EC (dS/m)	Root Score*	Org C (%)	Nitrate N (mg/kg)	Amm. N (mg/kg)	Avail. P (mg/kg)	Avail. K (mg/kg	Avail. S (mg/kg
0-5	Sandy loam	5	6.9	0.014	2	0.11	1	1	6	151	1.6
10-20	Sandy loam	20	6.9	0.015	1	0.17	1	1	4	164	1.6

* See Appendix B for Root Abundance Scoring details

3.2.4 Site N4

Site Details: Minor drainage line

GPS Coordinates: 0197866 mN
7689803 mE

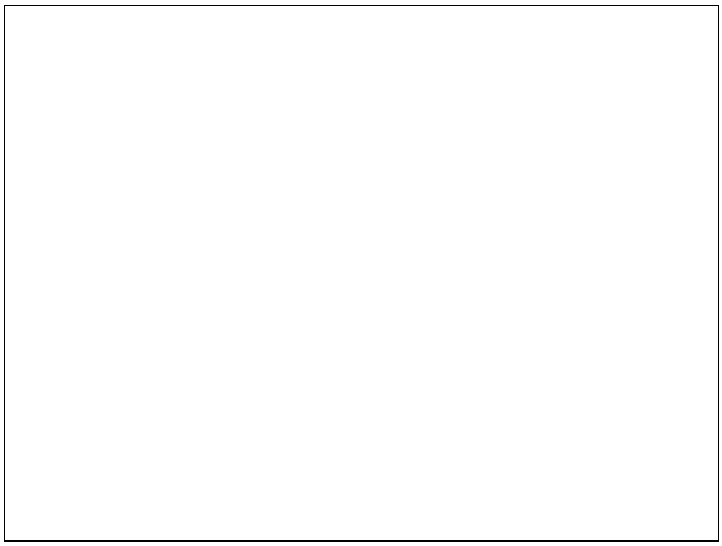


Plate 36 Soil sample Site N4

Texture: Sandy loam through top 20cm of profile. Approximately 10-25% sub-angular coarse fragments 5-50mm in size.

Structure: Thin surface crust present, overlying apedal, single grained soil to 20cm. Sandy fabric and weak consistence throughout top 20cm of profile.

Root growth: Few roots, penetration throughout soil matrix.

Vegetation Classification:
P2 *Acacia inaequilatera* high open shrubland to scattered shrubs over *Triodia wiseana* hummock grassland with some *Triodia epactia.*

Table 28 Soil sample characteristics - Site N4

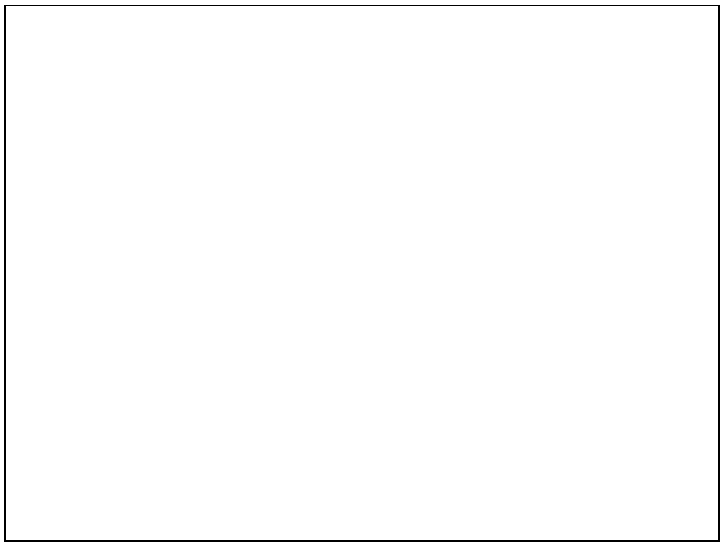
Sample Depth (cm)	Soil texture	% Coarse (>2mm)	pH (H_2O)	EC (dS/m)	Root Score*	Org C (%)	Nitrate N (mg/kg)	Amm. N (mg/kg)	Avail. P (mg/kg)	Avail. K (mg/kg	Avail. S (mg/kg
0-5	Sandy loam	10	6.9	0.018	1	0.55	2	1	9	130	3.4
10-20	Sandy loam	25	6.8	0.021	1	0.62	2	1	8	118	3.6

* See Appendix B for Root Abundance Scoring details

3.2.5 Site N5

Site Details: Valley floor / flat

GPS Coordinates: 0197403 mN
7690820 mE



Texture: Loamy sand through top 20cm of profile. Profile dominated by sub-angular coarse fragments 5-100mm in size.

Structure: Apedal, single grained throughout profile surface. Sandy fabric and weak consistence throughout top 20cm of profile.

Root growth: Few roots, penetration throughout soil matrix.

Vegetation Classification:
P9 Mixed *Grevillea* and *Acacia* scattered tall shrubs over *Triodia epactia* hummock grassland.

Plate 37 Soil sample Site N5

Table 29 Soil sample characteristics - Site N5

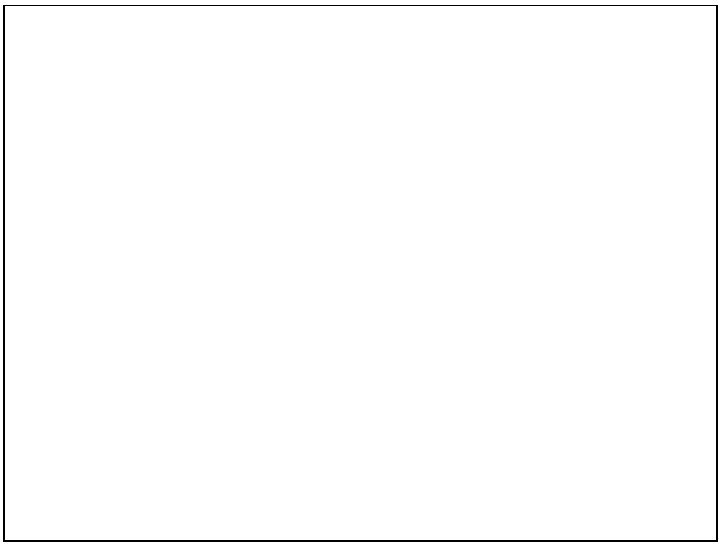
Sample Depth (cm)	Soil texture	% Coarse (>2mm)	pH (H_2O)	EC (dS/m)	Root Score*	Org C (%)	Nitrate N (mg/kg)	Amm. N (mg/kg)	Avail. P (mg/kg)	Avail. K (mg/kg	Avail. S (mg/kg
0-5	Loamy sand	40	6.9	0.015	1	0.30	1	1	4	122	2.4
10-20	Loamy sand	75	6.9	0.015	1	0.25	1	1	3	106	2.4

* See Appendix B for Root Abundance Scoring details

3.2.6 Site N6

Site Details: Valley floor / flat

GPS Coordinates: 0196465 mN
7689197 mE



Texture: Loamy sand through top 20cm of profile. Profile dominated by sub-angular coarse fragments 5-75mm in size.

Structure: Apedal, single grained throughout profile surface. Sandy fabric and weak consistence throughout top 20cm of profile.

Root growth: Few roots, penetration throughout soil matrix.

Vegetation Classification:
P1 *Acacia inaequilatera* high shrubland to scattered shrubs over *Triodia epactia* hummock grassland.

Plate 38 Soil sample Site N6

Table 30 Soil sample characteristics - Site N6

Sample Depth (cm)	Soil texture	% Coarse (>2mm)	pH (H_2O)	EC (dS/m)	Root Score*	Org C (%)	Nitrate N (mg/kg)	Amm. N (mg/kg)	Avail. P (mg/kg)	Avail. K (mg/kg	Avail. S (mg/kg
0-5	Loamy sand	25	6.7	0.016	1	0.31	1	1	23	263	2.2
10-20	Loamy sand	50	6.6	0.024	1	0.28	1	1	19	237	1.7

* See Appendix B for Root Abundance Scoring details

3.2.7 Site N7

Site Details: Valley floor / flat

GPS Coordinates: 0196057 mN
7689898 mE

Plate 39 Soil sample Site N7

Texture: Clayey sand through top 20cm of profile. Approximately 5-20% sub-angular coarse fragments 5-50mm in size.

Structure: Thin surface crust present, overlying apedal, single grained soil to 20cm. Sandy fabric and weak consistence throughout top 20cm of profile.

Root growth: Few roots, penetration throughout soil matrix.

Vegetation Classification:
P1 *Acacia inaequilatera* high shrubland to scattered shrubs over *Triodia epactia* hummock grassland.

Table 31 Soil sample characteristics - Site N7

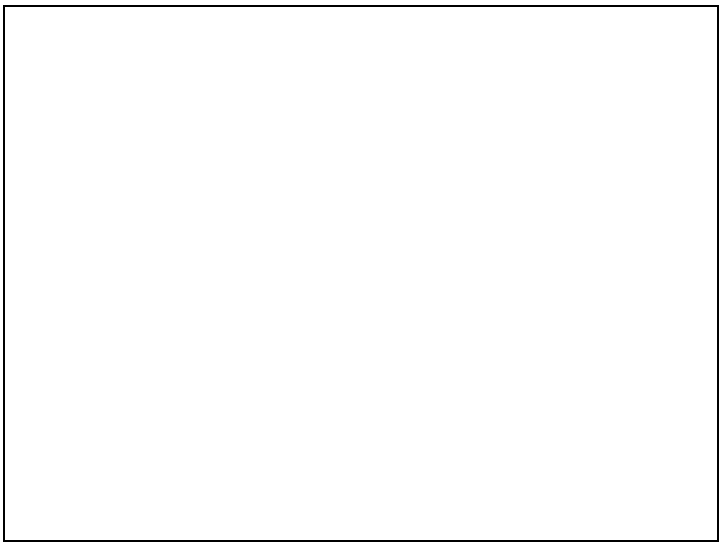
Sample Depth (cm)	Soil texture	% Coarse (>2mm)	pH (H_2O)	EC (dS/m)	Root Score*	Org C (%)	Nitrate N (mg/kg)	Amm. N (mg/kg)	Avail. P (mg/kg)	Avail. K (mg/kg	Avail. S (mg/kg
0-5	Clayey sand	5	6.5	0.026	1	0.27	1	1	11	174	2.2
10-20	Clayey sand	20	6.8	0.014	1	0.29	1	1	8	161	1.8

* See Appendix B for Root Abundance Scoring details

3.2.8 Site N8

Site Details: Valley floor / flat, adjacent to minor drainage line

GPS Coordinates: 0196802 mN 7691100 mE



Texture: Loamy sand through top 20cm of profile. Profile dominated by sub-angular coarse fragments 5-100mm in size.

Structure: Apedal, single grained throughout profile surface. Sandy fabric and weak consistence throughout top 20cm of profile.

Root growth: Few roots, penetration throughout soil matrix.

Vegetation Classification:
P9 Mixed *Grevillea* and *Acacia* scattered tall shrubs over *Triodia epactia* hummock grassland.

Plate 40 Soil sample Site N8

Table 32 Soil sample characteristics - Site N8

Sample Depth (cm)	Soil texture	% Coarse (>2mm)	pH (H_2O)	EC (dS/m)	Root Score*	Org C (%)	Nitrate N (mg/kg)	Amm. N (mg/kg)	Avail. P (mg/kg)	Avail. K (mg/kg	Avail. S (mg/kg
0-5	Loamy sand	50	6.6	0.016	1	0.31	1	1	137	137	2.1
10-20	Loamy sand	75	6.6	0.025	1	0.38	1	1	119	119	2.5

* See Appendix B for Root Abundance Scoring details

3.2.9 Site N9

Site Details: Minor drainage line

GPS Coordinates: 0196123 mN
7692250 mE

Plate 41 Soil sample Site N9

Texture: Clayey sand to sandy loam through top 20cm of profile. Approximately 25-40% sub-angular and sub-rounded coarse fragments 5-75mm in size.

Structure: Predominantly apedal, with some weak aggregates from 5-20cm. Sandy fabric and weak consistence throughout top 20cm of profile.

Root growth: Common roots, penetration throughout soil matrix.

Vegetation Classification:
D7 *Acacia tumida* var. *pilbarensis* open scrub to high shrubland over *Triodia epactia* open hummock grassland along drainage lines.

Table 33 Soil sample characteristics - Site N9

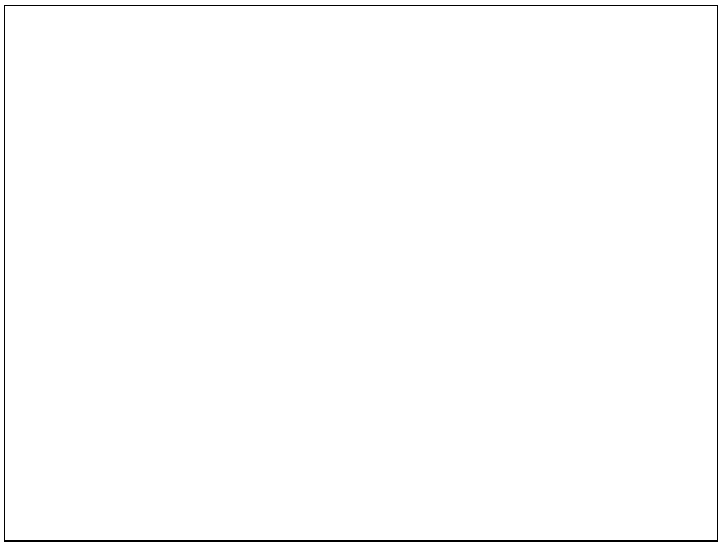
Sample Depth (cm)	Soil texture	% Coarse (>2mm)	pH (H_2O)	EC (dS/m)	Root Score*	Org C (%)	Nitrate N (mg/kg)	Amm. N (mg/kg)	Avail. P (mg/kg)	Avail. K (mg/kg	Avail. S (mg/kg
0-5	Clayey sand	25	6.5	0.017	2	0.57	1	1	6	167	2.2
10-20	Sandy loam	40	6.4	0.014	2	0.43	1	1	5	153	2.0

* See Appendix B for Root Abundance Scoring details

3.2.10 Site N10

Site Details: Valley floor / flat

GPS Coordinates: 0197252 mN
7691790 mE



Texture: Loamy sand through top 20cm of profile. Profile dominated by sub-angular coarse fragments 5-75mm in size.

Structure: Apedal, single grained throughout profile surface. Sandy fabric and weak consistence throughout top 20cm of profile.

Root growth: Few roots, penetration throughout soil matrix.

Vegetation Classification:
P9 Mixed *Grevillea* and *Acacia* scattered tall shrubs over *Triodia epactia* hummock grassland.

Plate 42 Soil sample Site N10

Table 34 Soil sample characteristics - Site N10

Sample Depth (cm)	Soil texture	% Coarse (>2mm)	pH (H_2O)	EC (dS/m)	Root Score*	Org C (%)	Nitrate N (mg/kg)	Amm. N (mg/kg)	Avail. P (mg/kg)	Avail. K (mg/kg	Avail. S (mg/kg
0-5	Loamy sand	30	6.6	0.014	1	0.23	1	1	7	107	2.1
10-20	Loamy sand	50	6.8	0.015	1	0.21	1	1	4	97	2.0

* See Appendix B for Root Abundance Scoring details

3.2.11 Site N11

Site Details: Bank of drainage line

GPS Coordinates: 0197510 mN 7689014 mE

Plate 43 Soil sample Site N11

Texture: Sandy loam to sandy clay loam through top 20cm of profile. Approximately 25-40% sub-angular and sub-rounded coarse fragments 5-75mm in size.

Structure: Predominantly apedal, with some weak aggregates from 5-20cm. Sandy fabric and weak consistence throughout top 20cm of profile.

Root growth: Common roots, penetration throughout soil matrix.

Vegetation Classification:
D7 *Acacia tumida* var. *pilbarensis* open scrub to high shrubland over *Triodia epactia* open hummock grassland.

Table 35 Soil sample characteristics - Site N11

Sample Depth (cm)	Soil texture	% Coarse (>2mm)	pH (H_2O)	EC (dS/m)	Root Score*	Org C (%)	Nitrate N (mg/kg)	Amm. N (mg/kg)	Avail. P (mg/kg)	Avail. K (mg/kg	Avail. S (mg/kg
0-5	Sandy loam	25	6.9	0.019	2	0.19	1	1	6	142	2.1
10-20	Sandy clay loam	25	7.0	0.02	2	0.33	1	1	6	150	2.0

* See Appendix B for Root Abundance Scoring details

3.2.12 Site N12

Site Details: Valley floor / flat

GPS Coordinates: 0199276 mN
7690860 mE

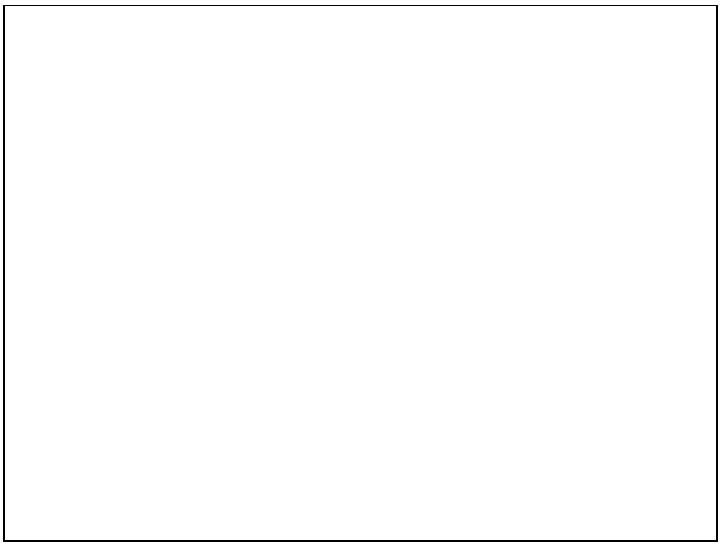


Plate 44 Soil sample Site N12

Texture: Sandy loam through top 20cm of profile. Approximately 10% sub-angular coarse fragments 5-50mm in size.

Structure: Thin surface crust present, overlying apedal, single grained soil to 20cm. Sandy fabric and weak consistence throughout top 20cm of profile.

Root growth: Few roots, penetration throughout soil matrix.

Vegetation Classification:
P9 Mixed *Grevillea* and *Acacia* scattered tall shrubs over *Triodia epactia* hummock grassland.

Table 36 Soil sample characteristics - Site N12

Sample Depth (cm)	Soil texture	% Coarse (>2mm)	pH (H_2O)	EC (dS/m)	Root Score*	Org C (%)	Nitrate N (mg/kg)	Amm. N (mg/kg)	Avail. P (mg/kg)	Avail. K (mg/kg	Avail. S (mg/kg
0-5	Sandy loam	10	6.7	0.014	1	0.22	1	1	6	152	2.1
10-20	Sandy loam	10	6.7	0.015	1	0.24	1	1	4	163	2.0

* See Appendix B for Root Abundance Scoring details

3.2.13 Site N13

Site Details: Valley floor / flat

GPS Coordinates: 0197994 mN
7693005 mE

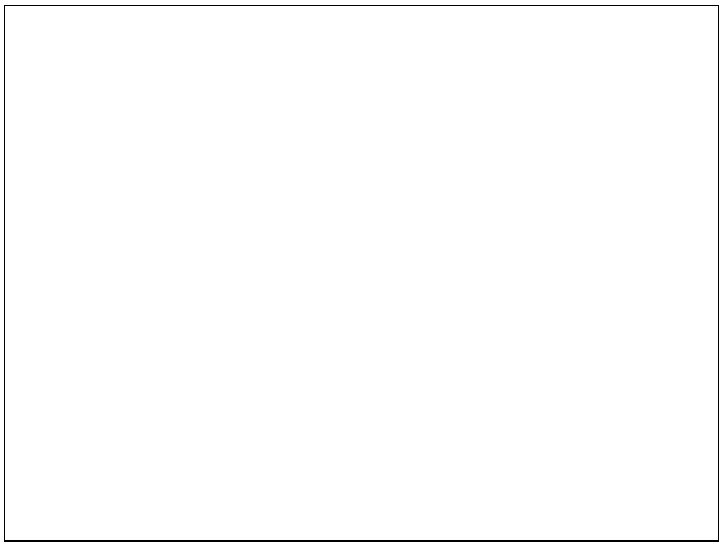


Plate 45 Soil sample Site N13

Texture: Sandy loam through top 20cm of profile. Approximately 10% sub-angular coarse fragments 5-50mm in size.

Structure: Thin surface crust present, overlying apedal, single grained soil to 20cm. Sandy fabric and weak consistence throughout top 20cm of profile.

Root growth: Few roots, penetration throughout soil matrix.

Vegetation Classification:
P2 *Acacia inaequilatera* high open shrubland to scattered shrubs over *Triodia wiseana* hummock grassland with some *Triodia epactia.*

Table 37 Soil sample characteristics - Site N13

Sample Depth (cm)	Soil texture	% Coarse (>2mm)	pH (H_2O)	EC (dS/m)	Root Score*	Org C (%)	Nitrate N (mg/kg)	Amm. N (mg/kg)	Avail. P (mg/kg)	Avail. K (mg/kg	Avail. S (mg/kg
0-5	Sandy loam	10	6.8	0.016	1	0.33	1	1	10	164	2.0
10-20	Sandy loam	10	6.8	0.016	1	0.30	1	1	9	148	2.3

* See Appendix B for Root Abundance Scoring details

3.2.14 Site N14

Site Details: Minor drainage line

GPS Coordinates: 0197932 mN
7692160 mE

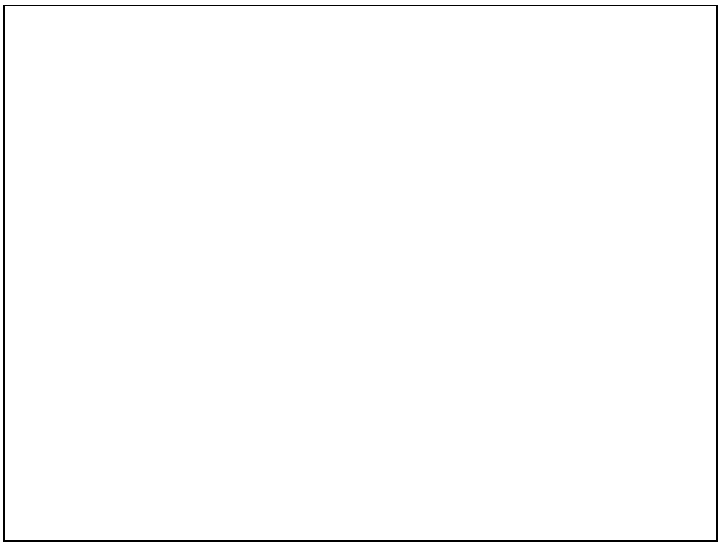


Plate 46 Soil sample Site N14

Texture: Sandy clay loam through top 20cm of profile. Approximately 10-20% sub-angular and sub-rounded coarse fragments 5-50mm in size.

Structure: Thin surface crust present, overlying predominantly apedal, single grained soil, with some weak aggregates to 20cm. Sandy fabric and weak consistence throughout top 20cm of profile.

Root growth: Few roots, penetration throughout soil matrix.

Vegetation Classification:
P9 Mixed *Grevillea* and *Acacia* scattered tall shrubs over *Triodia epactia* hummock grassland.

Table 38 Soil sample characteristics - Site N14

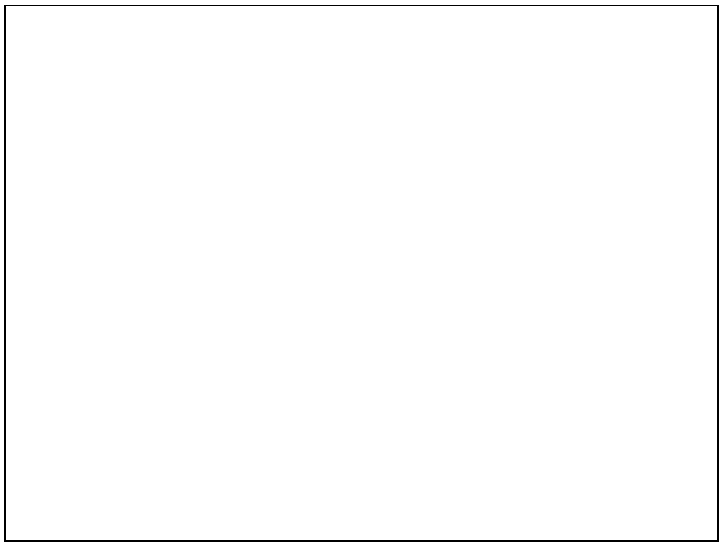
Sample Depth (cm)	Soil texture	% Coarse (>2mm)	pH (H_2O)	EC (dS/m)	Root Score*	Org C (%)	Nitrate N (mg/kg)	Amm. N (mg/kg)	Avail. P (mg/kg)	Avail. K (mg/kg	Avail. S (mg/kg
0-5	Sandy clay loam	10	6.8	0.017	2	0.36	1	1	12	235	3.1
10-20	Sandy clay loam	20	6.9	0.015	1	0.27	1	1	5	231	1.8

* See Appendix B for Root Abundance Scoring details

3.2.15 Site N15

Site Details: Valley floor / flat

GPS Coordinates: 0198910 mN 7689791 mE



Texture: Loamy sand through top 20cm of profile. Approximately 20-40% sub-angular coarse fragments 5-50mm insize.

Structure: Apedal, single grained throughout profile surface. Sandy fabric and weak consistence throughout top 20cm of profile.

Root growth: Few roots, penetration throughout soil matrix.

Vegetation Classification:
P1 *Acacia inaequilatera* high open shrubland to scattered shrubs *Triodia epactia* hummock grassland.

Plate 47 Soil sample Site N15

Table 39 Soil sample characteristics - Site N15

Sample Depth (cm)	Soil texture	% Coarse (>2mm)	pH (H_2O)	EC (dS/m)	Root Score*	Org C (%)	Nitrate N (mg/kg)	Amm. N (mg/kg)	Avail. P (mg/kg)	Avail. K (mg/kg	Avail. S (mg/kg
0-5	Loamy sand	20	6.6	0.125	1	0.17	1	1	6	140	4.0
10-20	Loamy sand	40	6.7	0.108	1	0.35	1	1	6	146	2.8

* See Appendix B for Root Abundance Scoring details

3.2.16 Site N16

Site Details: Minor drainage line

GPS Coordinates: 0198541 mN
7689119 mE

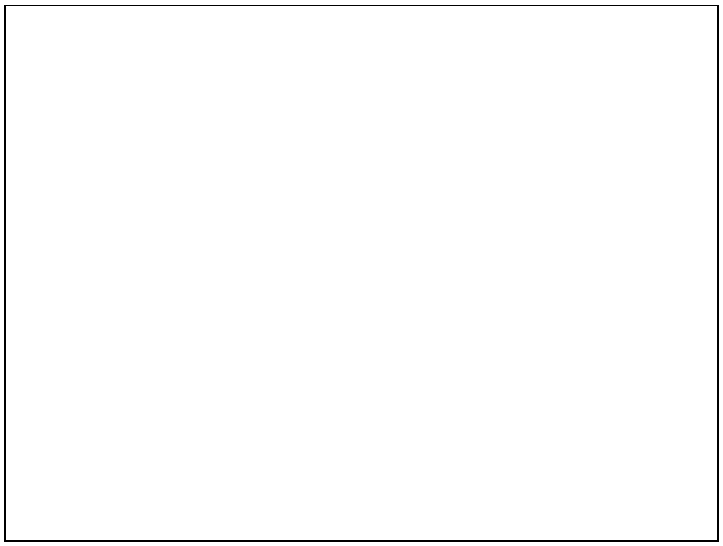


Plate 48 Soil sample Site N16

Texture: Clayey sand through top 20cm of profile. Profile dominated by sub-angular and sub-rounded coarse fragments 5-150mm in size.

Structure: Apedal, single grained throughout profile surface. Sandy fabric and weak consistence throughout top 20cm of profile.

Root growth: Few roots, penetration throughout soil matrix.

Vegetation Classification:
D7 *Acacia tumida* var. *pilbarensis* open scrub to high shrubland over *Triodia epactia* open hummock grassland.

Table 40 Soil sample characteristics - Site N16

Sample Depth (cm)	Soil texture	% Coarse (>2mm)	pH (H_2O)	EC (dS/m)	Root Score*	Org C (%)	Nitrate N (mg/kg)	Amm. N (mg/kg)	Avail. P (mg/kg)	Avail. K (mg/kg	Avail. S (mg/kg
0-5	Clayey sand	75	6.7	0.015	1	0.37	1	1	5	114	2.2
10-20	Clayey sand	75	6.7	0.016	1	0.57	1	1	5	145	2.0

* See Appendix B for Root Abundance Scoring details

3.2.17 Site N17

Site Details: Valley floor / flat

GPS Coordinates: 0198502 mN
7691007 mE

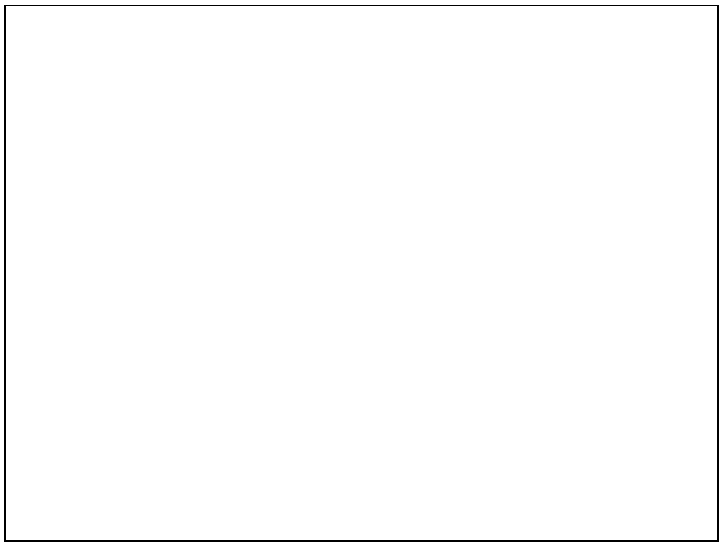


Plate 49 Soil sample Site N17

Texture: Clayey sand through top 20cm of profile. Approximately 10% sub-angular and sub-rounded coarse fragments 5-50mm in size.

Structure: Thin surface crust present, overlying apedal, single grained soil to 20cm. Sandy fabric and weak consistence throughout top 20cm of profile.

Root growth: Few roots, penetration throughout soil matrix.

Vegetation Classification:
P9 Mixed *Grevillea* and *Acacia* scattered tall shrubs over *Triodia epactia* hummock grassland.

Table 41 Soil sample characteristics - Site N17

Sample Depth (cm)	Soil texture	% Coarse (>2mm)	pH (H_2O)	EC (dS/m)	Root Score*	Org C (%)	Nitrate N (mg/kg)	Amm. N (mg/kg)	Avail. P (mg/kg)	Avail. K (mg/kg	Avail. S (mg/kg
0-5	Clayey sand	10	6.8	0.014	1	0.35	1	1	4	151	2.1
10-20	Clayey sand	10	6.8	0.016	1	0.29	1	1	5	158	2.1

* See Appendix B for Root Abundance Scoring details

3.3 Soil Profile Morphology

The majority of the surface soils and soil profiles examined within the area south of the Talga Range were similar in morphology, with most soil profiles showing little pedological organisation or structure, or only very weak aggregation and slight textural differences. Most profiles consisted of a shallow loamy or clayey sand to sandy loam A-horizon, overlying a B-horizon dominated by a high coarse fraction (>2mm) percentage. The coarse fraction was most often dominated by sub-angular and sub-rounded material, usually increasing in size and abundance with increasing depth.

The greatest variation in profile morphology amongst the southern sites, was the depth to fractured or solid rock. Shallow, skeletal soils were identified on the upper ridge slopes and ridge crests of the study area where there was a minimal cover of soil over fractured or solid rock, which was often exposed at the surface. The depth of 'soil' generally increased slightly lower in the landscape.

The soils within the drainage lines were more variable (see OES 2006b for greater detail), with areas of relatively deep sandy material, concentrated coarse fragments (>2mm), and areas of concentrated silt and clay present within creek beds.

The surface soils (0-20cm) of the northern Project Area also showed little pedological organisation or structure, with weak aggregation only present in some of the soils within the drainage lines sampled.

3.4 Soil Structure

Soil structure describes the arrangement of solid particles and void space in a soil. It is an important factor influencing the ability of soil to support plant growth, store and transmit water and resist erosional processes. A well-structured soil is one with a range of different sized aggregates, with component particles bound together to give a range of pore sizes facilitating root growth and the transfer of air and water. Soil structure can be influenced by the particle size distribution, chemical composition and organic matter content of a soil, and is often affected by root growth, stock and vehicle compaction.

The structure of the surface soil materials within the northern and southern survey areas is generally classed as single grained, meaning that there is very little aggregation of soil particles. This is typical of the coarse surface soil materials throughout the Pilbara region of Western Australia. There was a weak, thin surface crust present at some sites, and some aggregation of soil particles within the finer textured soils along the drainage lines sampled. There was also some degree of weak aggregation within some of the deeper materials sampled within the southern area, corresponding to the higher clay fraction of these materials. No physical soil impedances to root penetration were observed.

3.5 Soil Texture

The particle size distribution and resulting textural class of soil materials is an important factor influencing most physical and many chemical and biological properties. Soil structure, water holding capacity, hydraulic conductivity, soil strength, fertility, erodibility and susceptibility to compaction are some of the factors closely linked to soil texture.

Generally, as would be expected, the soils from lower positions in the landscape within the study area generally exhibited finer textures, with higher percentages of clay materials being distributed through these soil profiles, although the major drainage lines in the area were also inter-dispersed by areas of sandy material. Topsoil materials were generally slightly coarser in texture than underlying soil materials, with the percentage of clay material increasing with depth at most sites. The percentage of coarse material (>2mm) also generally increased with depth.

3.6 Soil pH

The soil pH gives a measure of the soil acidity or alkalinity. The ideal pH range for plant growth of most agricultural species is considered to be between 5.0 and 7.5 (Moore 1998), with the availability of some nutrients being affected outside of this range, and various metal toxicities (e.g. Al and Mn) becoming important at low pH. Obviously, many native plant species have adapted to, and are able to tolerate, soil pH values outside of the 'ideal' range.

The soil materials sampled indicated a wide range of pH values (Figure 2), ranging from 6.3 to 9.6. There was little consistency between soil pH and position within the landscape, with all landform units exhibiting a relatively large range of pH values. While the average pH values were lowest for the lower lying areas of 'valley floor' and 'drainage lines', these sites also exhibited the widest range of soil pH values, with the highest pH (most alkaline) soil also sampled from within a drainage line (Site 12).

There was generally a slight increase in soil pH with increasing depth.

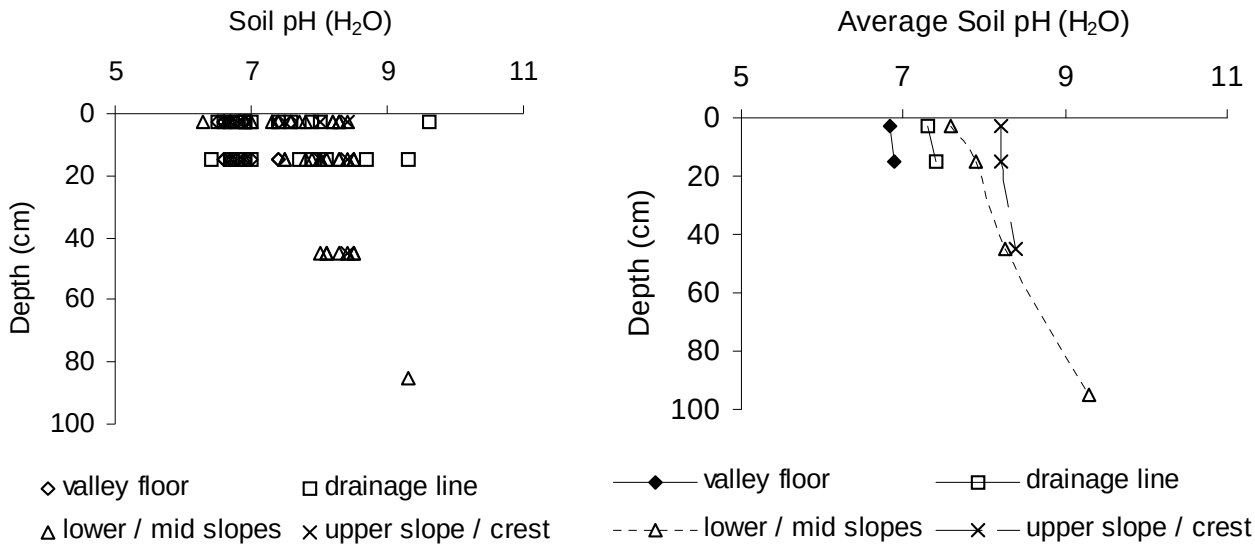


Figure 2 Individual and average soil pH (H_2O) of samples with corresponding sample depth, grouped into landscape units.

3.7 Electrical Conductivity

The electrical conductivity (EC) of the majority of materials sampled was considered to be non-saline (0 – 0.2 dS/m) based on the standard USDA and CSIRO categories (Appendix C). There was little consistent correlation between electrical conductivity and position within the landscape, or with depth within the soil profile (Figure 3), with a high amount of variation present within each landform unit. As would be expected, the highest value for electrical conductivity was measured in a low-lying drainage area (Site S12, 0-5cm, EC = 1.6 dS/m), although this was not consistent for all drainage lines sampled.

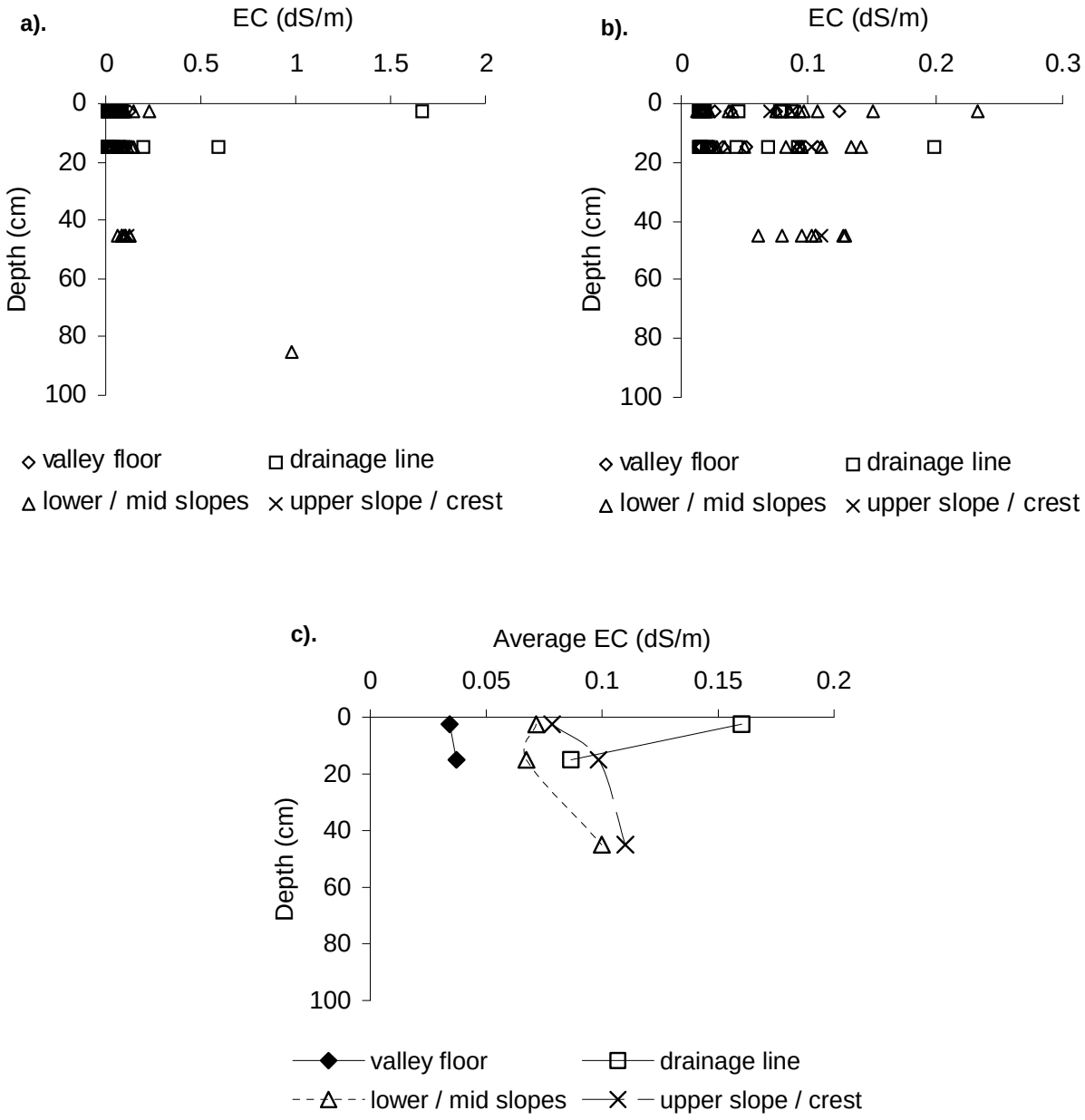


Figure 3 Electrical Conductivity (EC) values with corresponding sample depth, grouped into landform: a) Complete range of EC values measured, b) greater detail of values within 0 – 0.3 dS/m range, and c) Average values for each landscape unit.

3.8 Soil Nutrient Status

Soil nutrient analyses were conducted on the <2mm fraction of sampled material. The amount of nutrients held within the soil materials sampled was generally low, as is typical of native soils in a low nutrient-cycling environment.

There appears to be little consistent trend in nutrient level (total N, available P, K and S) corresponding to position within the landscape (Figures 4 to 7), or to particular vegetation community. As with other soil chemical parameters, nutrient levels were inconsistent, with a high amount of variation present within each landscape unit. As would be expected, the level of all measured nutrients generally decreased slightly with depth through the soil profile.

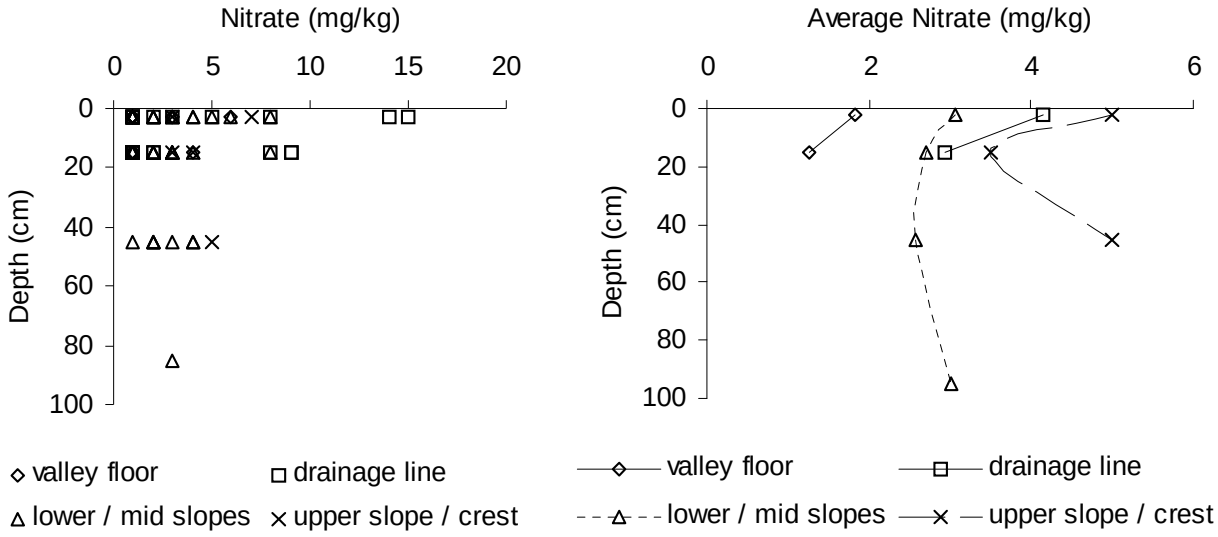


Figure 4 Individual and average nitrate N (mg/kg) levels with corresponding sample depth, grouped into landscape unit.

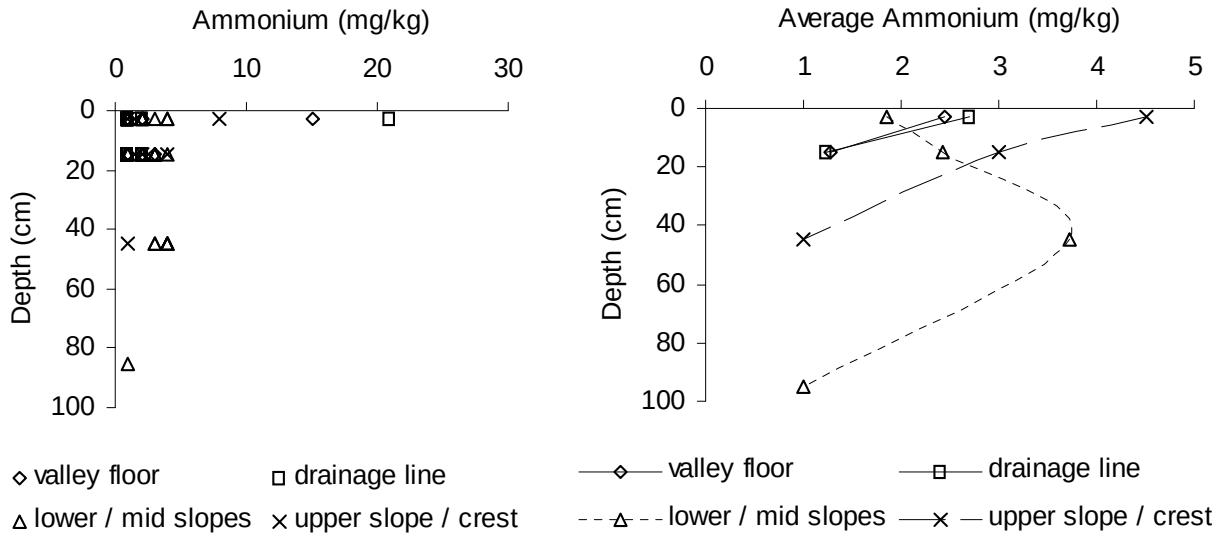


Figure 5 Individual and average ammonium N (mg/kg) levels with corresponding sample depth, grouped into landscape unit.

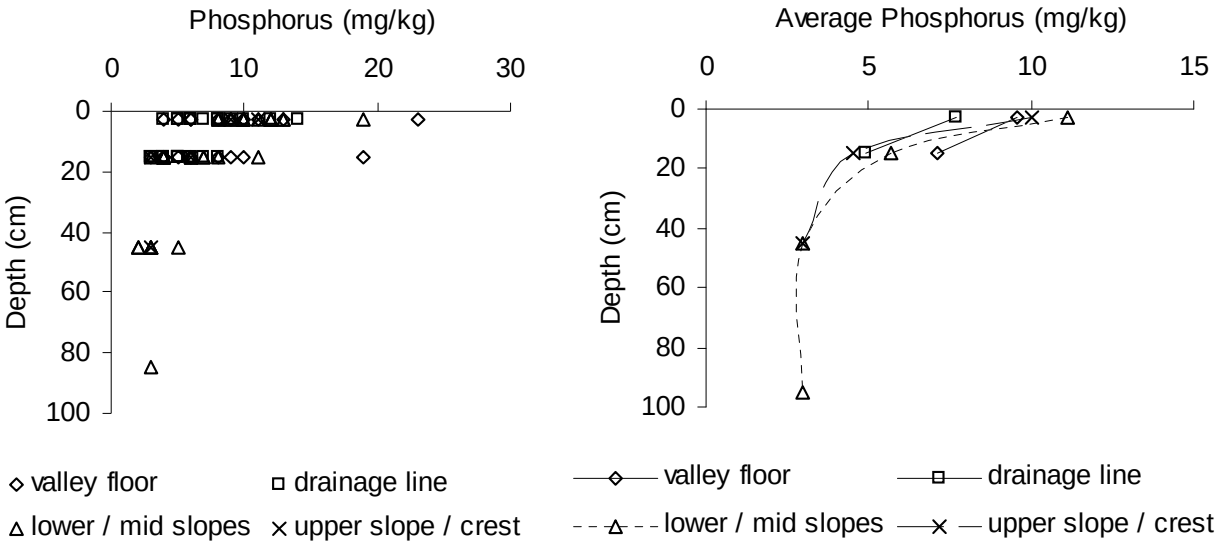


Figure 6 Available phosphorus (mg/kg) of individual samples and average values with corresponding sample depth, grouped into landscape unit.

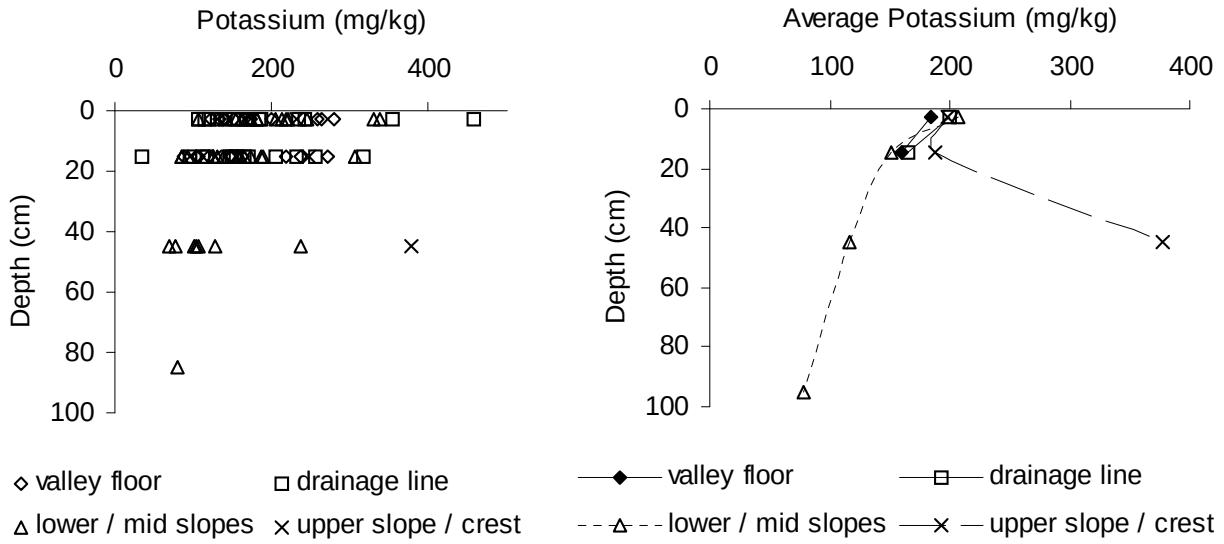


Figure 7 Available potassium (mg/kg) of individual samples and average values with corresponding sample depth, grouped into landscape unit.

Although the levels of plant-available sulphur measured on collected samples were variable, the average values for each landform unit indicated a slightly higher average for the lower / mid slopes on the southern side of the Talga Range (Figure 8). Two of the collected samples recorded relatively high levels of available sulphur (both on southern lower slope sites). Site S24 registered an available S level of 145 mg/kg at the surface (0-5cm), and Site S7 measured 512 mg/kg at a depth of 80-90cm (both excluded from mean value calculation in Figure 8.

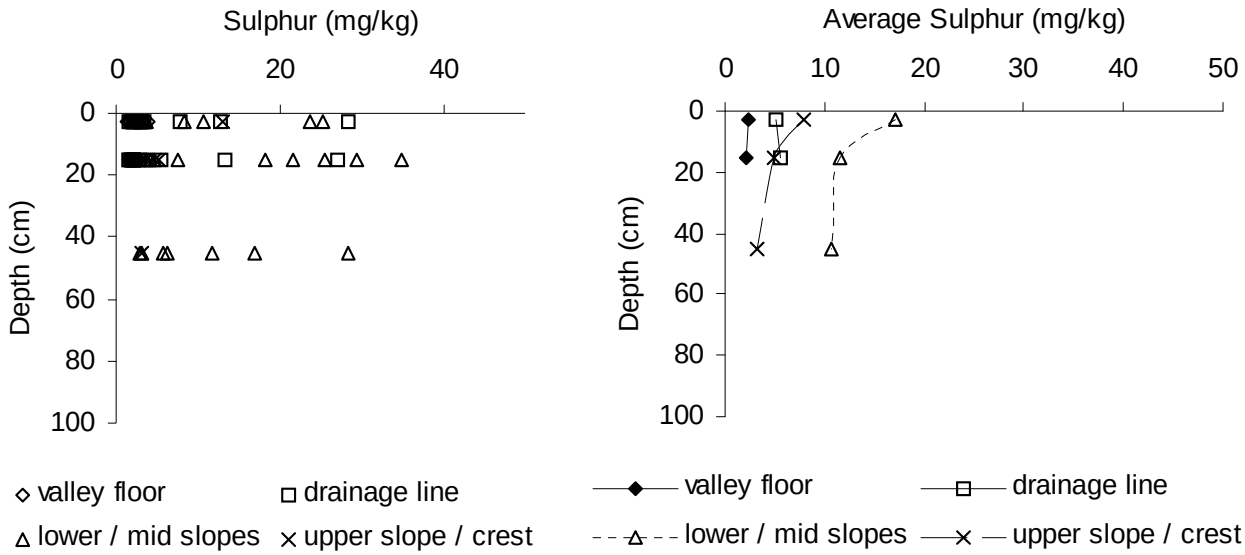


Figure 8 Available sulphur (mg/kg) of individual samples and average values with corresponding sample depth, grouped into landscape unit. (Two samples registered higher than indicated on figure: Site S24, 0-5cm = 145 mg/kg, Site S7, 80-90cm = 512 mg/kg)

3.9 Root Growth

Root penetration, although relatively sparse in some areas, extended beyond the depth of all investigations, with no apparent chemical or physical restrictions to root penetration observed in any of the profiles. Whilst the abundance of roots generally dropped rapidly with depth, there were roots penetrating the base of each profile where deeper examination was possible.

3.10 Baseline Soil Metal Concentrations

Measurements of water soluble metal concentrations of the surface samples collected indicated that only very low levels of Al, As, Cd, Cu, Pb, Mn, Mo and Zn were present in the southern (Table 42) and northern soils (Table 43). Most materials sampled were below the detectable limit for the bulk of the elements measured, with only Al regularly occurring at a detectable level (yellow highlight). For the metals detected, there was no apparent correlation with landform or vegetation unit. Low levels of Mn were detected at some sites, both north and south of the Talga Range, with Cu and Mo recorded at a detectable level at two of the southern sites.

Table 42 Water soluble metal concentrations of soil materials from southern sites (yellow highlight indicates detectable level).

		Al	As	Cd	Cu	Pb	Mn	Mo	Zn
		mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
	Detection Limit	1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Site #	Sample Depth (cm)								
S1	0-5	6	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
S1	10-20	13	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
S2	0-5	5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
S2	10-20	18	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
S3	0-5	22	<0.1	<0.1	<0.1	<0.1	0.1	<0.1	<0.1
S4	0-5	2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
S5	0-5	<1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
S6	0-5	6	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
S6	10-20	28	<0.1	<0.1	0.2	<0.1	0.2	<0.1	<0.1
S6	40-50	<1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
S7	0-5	2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
S7	10-20	3	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
S7	80-90	<1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
S8	0-5	1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
S8	40-50	1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
S9	0-5	2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
S10	0-5	2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
S10	10-20	<1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
S10	40-50	<1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
S11	0-5	<1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
S11	40-50	<1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
S12	0-5	<1	<0.1	<0.1	0.3	<0.1	0.7	0.5	<0.1
S13	0-5	2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
S14	0-5	4	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
S15	0-5	2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
S16	0-5	3	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
S17	0-5	2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
S18	0-5	3	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
S19	0-5	2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
S19	10-20	<1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
S19	40-50	<1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
S20	0-5	1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
S21	0-5	4	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
S22	0-5	6	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
S23	0-5	3	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
S24	0-5	3	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1

Table 43 Water soluble metal concentrations of soil materials from northern sites (yellow highlight indicates detectable level).

		Al	As	Cd	Cu	Pb	Mn	Mo	Zn
		mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
	Detection Limit	1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Site	Sample Depth (cm)								
N1	0-5	3	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
N1	10-20	3	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
N2	0-5	4	<0.1	<0.1	<0.1	<0.1	0.2	<0.1	<0.1
N2	10-20	5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
N3	0-5	3	<0.1	<0.1	<0.1	<0.1	0.1	<0.1	<0.1
N3	10-20	4	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
N4	0-5	4	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
N4	10-20	3	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
N5	0-5	3	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
N5	10-20	3	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
N6	0-5	4	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
N6	10-20	4	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
N7	0-5	4	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
N7	10-20	6	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
N8	0-5	5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
N8	10-20	7	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
N9	0-5	6	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
N9	10-20	6	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
N10	0-5	3	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
N10	10-20	3	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
N11	0-5	2	<0.1	<0.1	<0.1	<0.1	0.2	<0.1	<0.1
N11	10-20	5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
N12	0-5	6	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
N12	10-20	6	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
N13	0-5	6	<0.1	<0.1	<0.1	<0.1	0.1	<0.1	<0.1
N13	10-20	6	<0.1	<0.1	<0.1	<0.1	0.1	<0.1	<0.1
N14	0-5	11	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
N14	10-20	11	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
N15	0-5	6	<0.1	<0.1	<0.1	<0.1	0.3	<0.1	<0.1
N15	10-20	8	<0.1	<0.1	<0.1	<0.1	0.2	<0.1	<0.1
N16	0-5	2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
N16	10-20	5	<0.1	<0.1	<0.1	<0.1	0.1	<0.1	<0.1

4.0 CONCLUSIONS AND RECOMMENDATIONS

The soil materials sampled within the Project Area at Spinifex Ridge are relatively homogenous. Whilst some slight differences in texture and soil chemical characteristics were identified, there is little consistent trend with any of the measured parameters and position within the landscape, or with vegetation community. Based on soil chemical properties, no potentially problematic soils have been consistently identified.

Many regolith and waste rock materials, once disturbed and brought to the surface during mining operations, will behave differently to how they would in their natural setting. Such materials often have intrinsic properties that make their management and incorporation into rehabilitation designs difficult. The difficulties faced in restoring functioning ecosystems on such landforms, often under extreme ranges of temperature and rainfall, is often exacerbated by the properties of the waste material. The way in which these materials are likely to weather and develop over time should be taken into account when planning final landform designs.

The general increase in clay content with depth through most of the deeper profiles examined, indicates that the soil materials from depth may potentially be prone to erosion if exposed and placed on relatively steep slopes. It is recommended that, during project development, such materials be stockpiled / rehabilitated in such a way as to mitigate their potential erodibility. It is also recommended that topsoil material (approximately 0-15cm), be collected and stockpiled separately to preserve the seed store and the generally-higher nutrient levels that are present. Wherever possible, these topsoils should be re-spread immediately after stripping. If this is not possible, then shallow stockpiles (<2m) that are promptly revegetated are recommended. Paddock dumping is an effective method to meet this recommendation.

The baseline levels of water soluble metals in surface soils are low. It is recommended however, that the heavy metal content of deeper, untested, regolith material be measured as the project develops. This will allow any potential impact on the surrounding environment to be predicted and monitored over time.

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Appendix A
Glossary of Terms

Glossary of Terms

Aggregate (or ped)
A cluster of primary particles separated from adjoining peds by natural planes of weakness, voids (cracks) or cutans.

Bulk density
Mass per unit volume of undisturbed soil, dried to a constant weight at 105°C.

Cation exchange capacity (CEC)
The total potential of soils for adsorbing cations, expressed in millimoles of charge per kg (mmolc/kg) of soil.

Clay
The fraction of mineral soil finer than 0.002mm (2µm).

Coarse fragments
Particles greater than 2mm in size.

Consistence
The strength of cohesion and adhesion in soil.

Cutan
Coatings or deposits of clay material on the surface of peds, stones, etc.

Dispersion
The process whereby the structure or aggregation of the soil is destroyed, breaking down into primary particles.

Electrical conductivity
How well a soil conducts an electrical charge, related closely to the salinity of a soil.

Exchangeable Sodium Percentage (ESP)
Is calculated as the proportion of the cation exchange capacity occupied by the sodium ions and is expressed as a percentage. Sodic soils are categorised as soils with an ESP of 6-14%, and strongly sodic soils have an ESP of greater than 15%.

Organic Carbon
Carbon residue retained by the soil in humus form. Can influence many physical, chemical and biological soil properties.

Plant available water

The ability of a soil to hold that part of the water that can be absorbed by plant roots. Available water is the difference between field capacity and permanent wilting point.

Slaking

The partial breakdown of soil aggregates in water due to the swelling of clay and the expulsion of air from pore spaces.

Soil horizon

Relatively uniform materials that extend laterally, continuously or discontinuously throughout the profile, running approximately parallel to the surface of the ground and differs from the related horizons in chemical, physical or biological properties.

Soil pH

The negative logarithm of the hydrogen ion concentration of a soil solution. The degree of acidity or alkalinity of a soil expressed in terms of the pH scale, from 2 to 10.

Soil structure

The distinctness, size, shape and arrangement of soil aggregates (or peds) and voids within a soil profile. Can be classed as *'apedal'*, having no observable peds, or *'pedal'*, having observable peds.

Soil strength

The resistance of a soil to breaking or deformation. '*Hardsetting'* refers to a high soil strength upon drying.

Soil texture

The size distribution of individual particles of a soil.

Subsoil

The layer of soil below the topsoil or A horizons, often of finer texture (i.e. more clayey), denser and stronger in colour. Generally considered to be the 'B-horizons' above partially weathered or un-weathered material.

Topsoil

Soil consisting of various mixtures of sand, silt, clay and organic matter; considered to be the nutrient-rich top layer of soil – The 'A-horizon'.

Appendix B

Root Scoring Categories

Scoring of root abundance.

Root abundance is scored on a visual basis within the categories defined by McDonald *et al*., 1998:

Score	Roots per 10 cm^2	
	Very fine and fine roots	*Medium and coarse roots*
0 – No roots	0	0
1 – Few	1 - 10	1 or 2
2 – Common	10 - 25	2 – 5
3 – Many	25 - 200	>5
4 - Abundant	>200	>5

Appendix C

Soil Electrical Conductivity Classes

Soil Electrical Conductivity Classes (based on standard USDA and CSIRO categories) adapted from Moore (1998).

EC (1:5) (dS/m)						
Salinity Class	**Sand**	**Sandy loam**	**Loam**	**Clay loam**	**L/Med Clay**	**Heavy Clay**
Non-saline	<0.13	<0.17	<0.20	<0.22	<0.25	<0.33
Slightly Saline	0.13-0.26	0.17-0.33	0.20-0.40	0.22-0.44	0.25-0.50	0.33-0.67
Moderately Saline	0.26-0.52	0.33-0.67	0.40-0.80	0.44-0.89	0.50-1.00	0.67-1.33
Very Saline	0.52-1.06	0.67-1.33	0.80-1.60	0.89-1.78	1.00-2.00	1.33-2.67
Extremely Saline	>1.06	>1.33	>1.60	>1.78	>2.00	>2.67