Outback Ecology

Spinifex Ridge Molybdenum Project

Baseline Soil Survey – Proposed Creek Diversion Pathway

November 2006

Moly Mines Limited

Spinifex Ridge Molybdenum Project
Moly Mines Limited

Author: MB

Outback Ecology Services

1/71 Troy Terrace

Jolimont WA 6014

Ph: +61 (08) 9388 8799

Fax: +61 (08) 9388 8633

admin@outbackecology.com

Distribution:

Receiver(s):	Copies	Contact Name
Moly Mines Limited	1	Trevor Naughton

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EXECUTIVE SUMMARY

The baseline soil survey of the proposed Coppin Creek diversion path has indicated that the majority of soils within the minor drainage lines sampled are similar in terms of physical and chemical characteristics, to the soils within the existing creek.

The surface characteristics of the six sampling sites varied according to their position either within, or adjacent to, the minor drainage lines of the study area, with the structure and texture at the soil surface ranging from single-grained loamy sands to aggregated sandy loams. The abundance of coarse fragment cover at the six sites ranged from moderate (approximately 25%) in the broader flat areas, to abundant (50-90%) and very abundant (>90%), in the minor drainage channels sampled.

The soil textures within the soil profiles examined, ranged from loamy sands (approximately 5% clay), to clay loams (30-35% clay). All samples were within the wide range of soil textures exhibited in the survey of the section of Coppin Creek proposed to be diverted. No dispersive soils were identified at the six sampling sites.

As was the case with the soils examined within Coppin Creek, the soils within the diversion path were classed as highly alkaline and predominantly non-saline. The amount of plant-available nutrients (N, P, K and S) within the soils was low, but at comparable levels to that of the Coppin Creek soils. Similar water soluble concentrations of Al, As, Cu and Mn, were found within the soils of the creek bed and banks of the section of Coppin Creek proposed to be diverted.

Of particular importance to the construction of a creek diversion channel will be the creation of a suitable creek bed and creek bank surfaces with low potential erodibility. This will be particularly important in the early stages following construction, prior to the establishment of vegetation. Vegetation cover plays a key role in the stabilisation of the existing bank, and some creek bed surfaces of Coppin Creek. At the same time it will be important to construct soil profiles capable of supporting the diverse range of vegetation communities found within the proposed diversion area.

It must be recognised that the soils / regolith materials underlying areas within the diversion path which may be excavated for the diversion, were not sampled during this investigation. The morphology of the minor drainage lines sampled, and their capacity to accommodate the flow volumes and velocities experienced in Coppin Creek, have not been considered in this investigation.

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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 the proposed creek diversion path at Spinifex Ridge, located approximately 50km north east of Marble Bar, Western Australia. The survey was one component of a broader baseline assessment undertaken concurrently by Outback Ecology, that also considered vegetation and flora, vertebrate and invertebrate fauna, aquatic ecology and stygofauna within the broader Project Area.

1.2 Scope and Objectives of the Study

The proposed mining operation is to include a diversion of Coppin Creek, prior to entry into Coppin Gap. The objectives of the study were to provide baseline data on the soils of the proposed diversion path, thus identifying any potentially problematic materials, and to compare the surface soils of the diversion pathway with those of the existing creek line (OES 2006b). Sample sites were chosen where the existing elevation of the land surface equated to that of the proposed diversion. The soil / regolith material that underlie areas within the diversion path which may be excavated for the diversion, were not sampled during this investigation.

2.0 MATERIALS AND METHODS

2.1 Sampling Regime

The investigation into soil properties consisted of assessment and sampling at six sites (Figure 1). The sites selected encompassed a series of existing minor drainage and lower-lying areas where the ground level is similar to that of the proposed elevation of the diversion path. Soil pits were excavated to a depth of approximately 1m at each site.

The soil profile was described (soil profile morphology, soil structure, root distribution) according to the classification terminology described in 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 six 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). 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 AND DISCUSSION

3.1 Site Descriptions

The soil profile morphology, physical and chemical characteristics of each profile are summarised for each site (Sections 3.1.1 to 3.1.6). The vegetation classifications given for each site are based on those described in the concurrent Outback Ecology Vegetation and Flora Survey Report for project area (OES 2006a).

3.1.1 Creek Diversion Site D1

Site Details: Broad, flat drainage area.

GPS Coordinates: 0198701 mE
7686297 mN

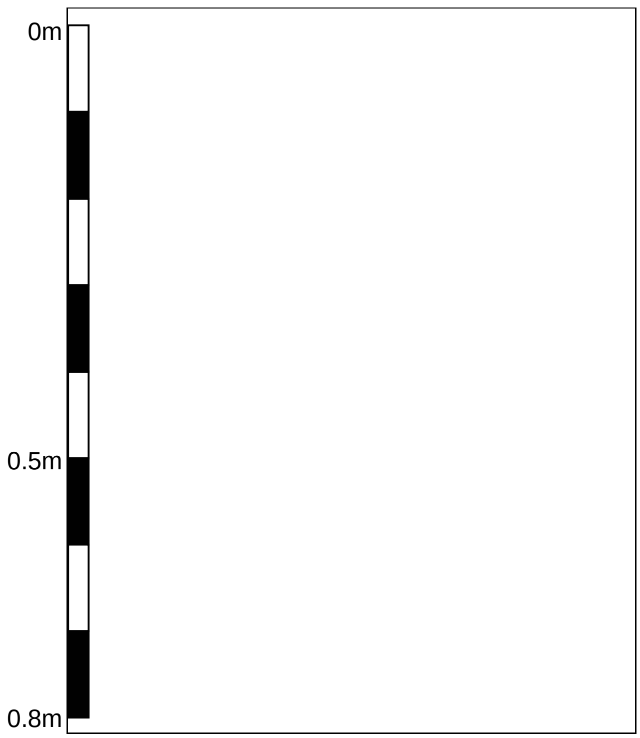

Plate 1 Soil Profile at Site D1

0-10cm: moderate polyhedral aggregates, 5-100mm in size, approximately 25% sub-angular and sub-rounded coarse fragments, 2-20mm in size, common root abundance.

10-40cm: predominantly single grained structure, approximately 40% sub-rounded and sub-angular coarse fragments, 2-50mm in size, few roots present.

40-80cm: moderate polyhedral aggregates, 5-75mm in size, approximately 50% sub-angular coarse fragments, 2-50mm in size, few roots present.

Soil surface: weak platy crust at surface, approximately 25% sub-rounded coarse fragment and 5% litter cover.

Vegetation: D1 – *Triodia longiceps* hummock grassland.

Plate 2 Sample Site D1

Table 1 Soil physical and chemical characteristics for Site D1

Depth Interval (cm)	Soil Structure	Soil Texture	% Coarse (>2mm)	Soil pH (H_2O)	EC (dS/m)	Root Score[1.]	Emerson Test Class[2.]	MOR (kPa)	Available Nutrients					Organic C (%)
									Nitrate N (mg/kg)	Amm. N (mg/kg)	Avail. P (mg/kg)	Avail. K (mg/kg)	Avail. S (mg/kg)	
0-5	Moderate polyhedral aggregates	Sandy loam	25	9.7	0.17	2	5 or 6	29.0	1.0	1.0	3.0	22.30	11.8	0.33
10-20	Predominantly single grained	Clayey sand	40	9.7	0.09	1	-	11.5	1.0	1.0	4.0	77.0	3.8	0.16
40-50	Moderate polyhedral aggregates	Sandy clay loam	50	10.2	0.61	1	5 or 6	24.2	1.0	1.0	2.0	76.0	39.1	0.12

1. See Appendix B for root abundance classes
2. See Appendix D for Emerson Test Classes

3.1.2 Creek Diversion Site D2

Site Details: Flat adjacent to minor drainage line.

GPS Coordinates: 0199152 mE 7686574 mN

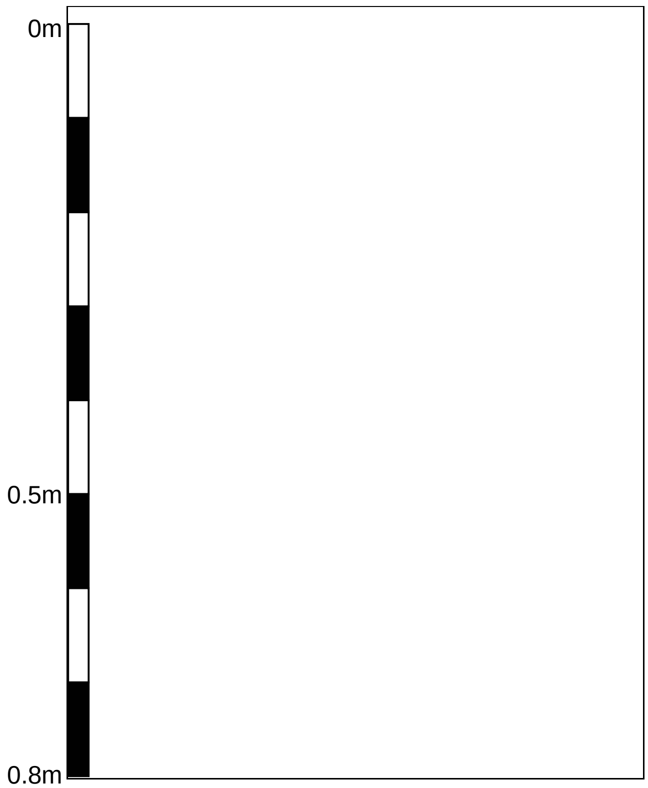

Plate 3 Soil Profile at Site D2

0-30cm: moderate polyhedral aggregates, 5-50mm in size, approximately 75% sub-angular and sub-rounded coarse fragments, 2-75mm in size, common root abundance.

30-80cm: moderate polyhedral aggregates, approximately 90% platy and angular coarse fragments, 5-50mm in size, few roots present.

Soil surface: weak platy crust where soil surface exposed, approximately 60% sub-rounded and sub-angular coarse fragment and 10% litter cover.

Vegetation: 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 4 Sample Site D2

Table 2 Soil physical and chemical characteristics for Site D2

Depth Interval (cm)	Soil Structure	Soil Texture	% Coarse (>2mm)	Soil pH (H_2O)	EC (dS/m)	Root Score[1.]	Emerson Test Class[2.]	MOR (kPa)	Available Nutrients					Organic C (%)
									Nitrate N (mg/kg)	Ammonium N (mg/kg)	Avail. P (mg/kg)	Avail. K (mg/kg)	Avail. S (mg/kg)	
0-5	Moderate polyhedral aggregates	Sandy loam	75	8.6	0.11	2	5 or 6	23.2	1.0	1.0	5.0	272.0	4.6	0.79
10-20	Moderate polyhedral aggregates	Sandy loam	75	8.8	0.10	1	5 or 6	38.4	1.0	2.0	2.0	201.0	3.1	0.69
40-50	Moderate polyhedral aggregates	Sandy clay loam	90	9.9	0.25	1	5 or 6	136.2	3.0	1.0	2.0	80.0	3.9	0.27

1. See Appendix B for root abundance classes
2. See Appendix D for Emerson Test Classes

3.1.3 Creek Diversion Site D3

Site Details: Within minor drainage line

GPS Coordinates: 0199592 mE
7687110 mN

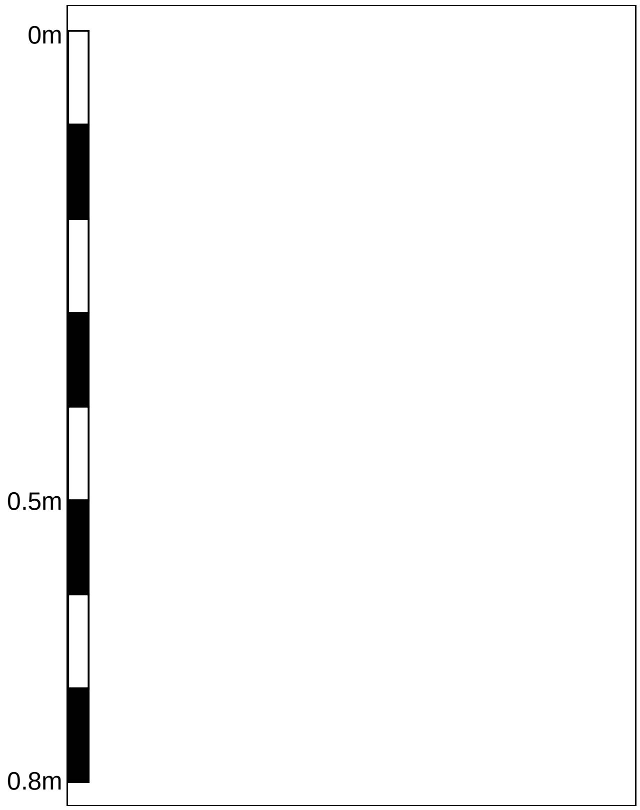

Plate 5 Soil Profile at Site D3

0-20cm: weak polyhedral aggregates, 5-20mm in size, approximately 75% angular and platy coarse fragments, 2-75mm in size, many roots present.

30-50cm: moderate polyhedral aggregates, approximately 75% platy and angular coarse fragments, 5-150mm in size, common root abundance.

50-80cm: moderate polyhedral aggregates between rock fragments, approximately 90% platy and angular coarse fragments, 5-50mm in size, few roots present.

Soil surface: loose surface between coarse fragments, approximately 75% angular (platy) and sub-angular coarse fragment and 5% litter cover.

Vegetation: 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 pungens* hummock grassland.

Plate 6 Sample Site D3

Table 3 Soil physical and chemical characteristics for Site D3

Depth Interval (cm)	Soil Structure	Soil Texture	% Coarse (>2mm)	Soil pH (H_2O)	EC (dS/m)	Root Score[1]	Emerson Test Class[2]	MOR (kPa)	Available Nutrients					Organic C (%)
									Nitrate N (mg/kg)	Ammonium N (mg/kg)	Avail. P (mg/kg)	Avail. K (mg/kg)	Avail. S (mg/kg)	
0-5	Weak polyhedral aggregates	Clayey sand	75	8.1	0.09	3	5 or 6	3.7	1.0	2.0	5.0	204.0	2.6	0.3
10-20	Moderate polyhedral aggregates	Sandy loam	75	8.7	0.09	2	5 or 6	9.2	1.0	1.0	2.0	74.0	2.5	0.4
40-50	Moderate polyhedral aggregates	Clay loam, sandy	90	8.9	0.10	1	5 or 6	18.0	1.0	1.0	3.0	93.0	2.4	0.3

1. See Appendix B for root abundance classes
2. See Appendix D for Emerson Test Classes

3.1.4 Creek Diversion Site D4a

Site Details: Broad flat adjacent to minor drainage line

GPS Coordinates: 0199824 mE
7687304 mN

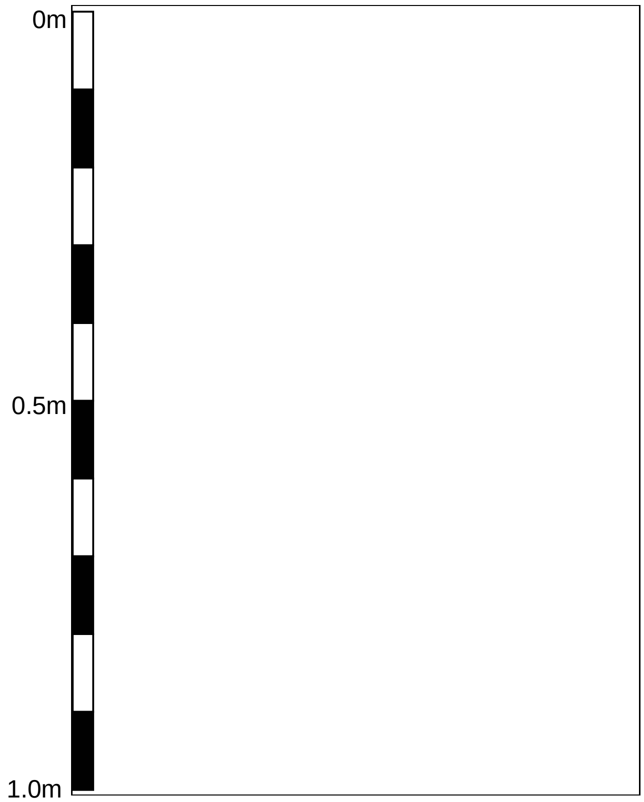

Plate 7 Soil Profile at Site D4a

0-5cm: Predominantly single grained with some very weak polyhedral aggregates, 5-20mm in size, approximately 75% sub-angular and sub-rounded coarse fragments, 2-50mm in size, many roots present.

5-100cm: single grained soil between rock fragments, approximately 90% sub-angular and sub-rounded coarse fragments, 2-100mm in size, common root abundance decreasing to few at 50cm depth

Soil surface: platy crust between coarse fragments, approximately 75% sub-angular and sub-rounded coarse fragment and 5% litter cover.

Vegetation: 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 pungens* hummock grassland.

Plate 8 Sample Site D4a

Table 4 Soil physical and chemical characteristics for Site D4a

Depth Interval (cm)	Soil Structure	Soil Texture	% Coarse (>2mm)	Soil pH (H_2O)	EC (dS/m)	Root Score[1.]	Emerson Test Class[2.]	MOR (kPa)	Available Nutrients					Organic C (%)
									Nitrate N (mg/kg)	Amm N (mg/kg)	Avail. P (mg/kg)	Avail. K (mg/kg)	Avail. S (mg/kg)	
0-5	Predominantly single grained – some weak aggregates	Clayey sand	75	8.9	0.08	3	-	49.3	1.0	1.0	11.0	322.0	3.1	0.5
10-20	Single grained	Clayey sand	75	9.0	0.08	2	-	25.5	1.0	1.0	3.0	306.0	4.8	0.4
40-50	Single grained	Loamy sand	90	9.0	0.09	1	-	23.0	1.0	1.0	2.0	282.0	2.8	0.2
90-100	Single grained	Loamy sand	90	9.1	0.08	1	-	43.6	1.0	1.0	2.0	277.0	2.5	0.2

1. See Appendix B for root abundance classes
2. See Appendix D for Emerson Test Classes

3.1.5 Creek Diversion Site D4b

Site Details: Base of minor drainage line

GPS Coordinates: 0199806 mE
7687301 mN

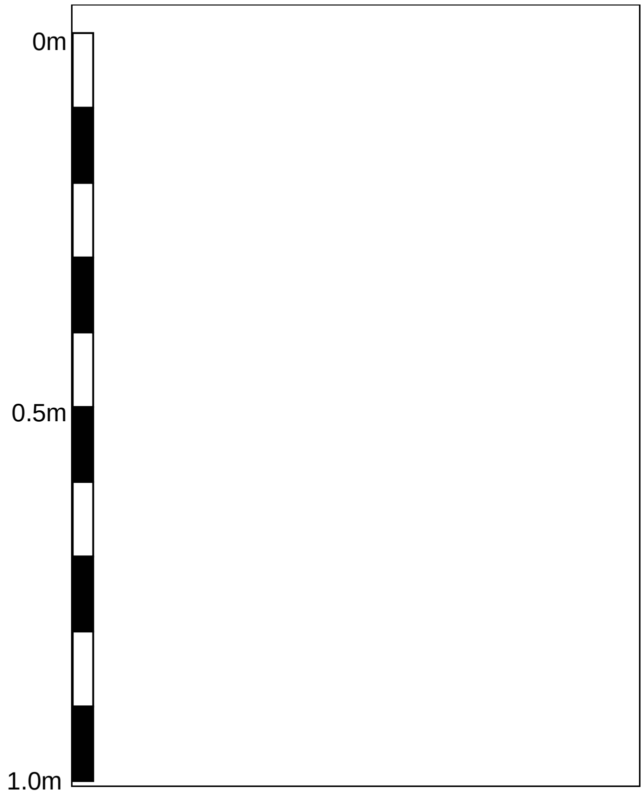

Plate 9 Soil Profile at Site D4b

0-80cm: Single grained soil between rock fragments, approximately 90% sub-angular and sub-rounded coarse fragments, 2-100mm in size, few roots present.

80-100cm: Predominantly single grained with some very weak polyhedral aggregates, approximately 90% sub-angular and sub-rounded coarse fragments, 2-150mm in size, few roots present.

Soil surface: loose surface between coarse fragments, >90% sub-angular and sub-rounded coarse fragment and <5% litter cover.

Vegetation: 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 pungens* hummock grassland.

Plate 10 Sample Site D4b

Table 5 Soil physical and chemical characteristics for Site D4b

Depth Interval (cm)	Soil Structure	Soil Texture	% Coarse (>2mm)	Soil pH (H_2O)	EC (dS/m)	Root Score[1.]	Emerson Test Class[2.]	MOR (kPa)	Available Nutrients					Organic C (%)
									Nitrate N (mg/kg)	Ammonium N (mg/kg)	Avail. P (mg/kg)	Avail. K (mg/kg)	Avail. S (mg/kg)	
0-5	Single grained	Loamy sand	90	9.1	0.07	1	-	0.5	8.0	1.0	5.0	178.0	2.8	0.1
10-20	Single grained	Loamy sand	90	9.1	0.06	1	-	0.4	2.0	1.0	5.0	181.0	2.0	0.2
40-50	Single grained	Loamy sand	90	9.0	0.07	1	-	0.2	1.0	1.0	4.0	163.0	1.9	0.1
90-100	Predominantly single grained – some weak aggregates	Clayey sand	90	8.8	0.07	1	-	1.9	1.0	1.0	5.0	188.0	2.0	0.2

1. See Appendix B for root abundance classes
2. See Appendix D for Emerson Test Classes

3.1.6 Creek Diversion Site D5

Site Details: Base of minor drainage line

GPS Coordinates: 0199905 mE
7687398 mN

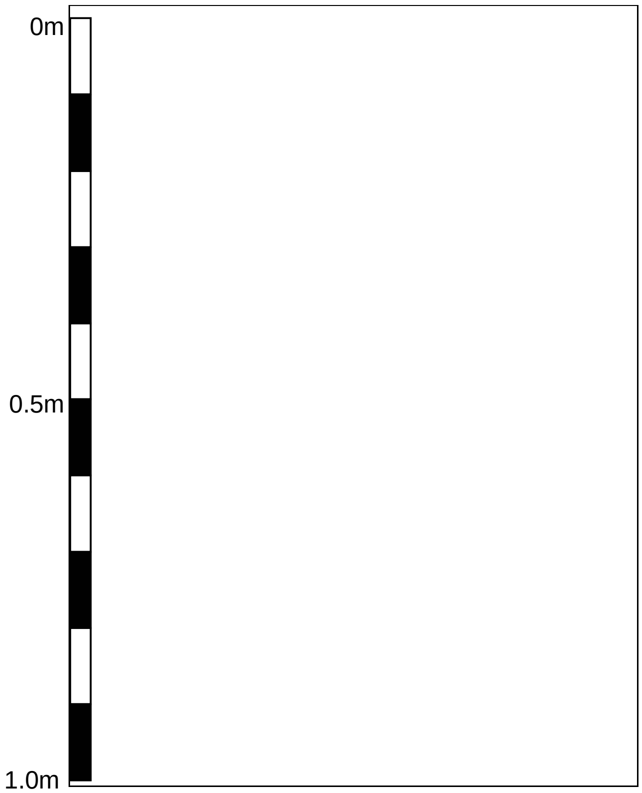

Plate 11 Soil Profile at Site D5

0-5cm: weak platy aggregates, 5-20mm in size, approximately 25% sub-angular and sub-rounded coarse fragments, 2-75mm in size, common root abundance.

5-50cm: single grained structure, approximately 90% sub-angular and sub-rounded coarse fragments, 2-100mm in size, many roots present.

50-100cm: weak polyhedral aggregates between rock fragments, approximately 90% sub-angular and sub-rounded coarse fragments, 2-150mm in size, common root abundance.

Soil surface: platy crust and loose surface between coarse fragments, 90% sub-angular and sub-rounded coarse fragment and <5% litter cover.

Vegetation: 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 pungens* hummock grassland.

Plate 12 Sample Site D5

Table 6 Soil physical and chemical characteristics for Site D5

Depth Interval (cm)	Soil Structure	Soil Texture	% Coarse (>2mm)	Soil pH (H_2O)	EC (dS/m)	Root Score[1.]	Emerson Test Class[2.]	MOR (kPa)	Available Nutrients					Organic C (%)
									Nitrate N (mg/kg)	Ammonium N (mg/kg)	Avail. P (mg/kg)	Avail. K (mg/kg)	Avail. S (mg/kg)	
0-5	Weak platy aggregates	Sandy loam	25	8.7	0.10	2	5 or 6	2.8	5.0	2.0	6.0	206.0	4.4	0.6
10-20	Single grained	Loamy sand	90	8.9	0.07	3	-	0.4	2.0	1.0	5.0	191.0	3.2	0.2
40-50	Single grained	Loamy sand	90	8.9	0.07	3	-	0.3	1.0	1.0	4.0	151.0	4.7	0.2
90-100	Weak polyhedral aggregates	Clayey sand	90	8.7	0.11	2	-	2.3	2.0	1.0	3.0	132.0	6.9	0.2

1. See Appendix B for root abundance classes
2. See Appendix D for Emerson Test Classes

3.2 Soil Surface Characteristics

The characteristics of the soil surface will be an important feature of the creek diversion, with the soil texture, amount of coarse material and surface roughness likely to have a large influence on the potential erodibility of the diversion channel and the downstream sediment load.

The surface of the soil profiles examined within the proposed diversion path exhibited characteristics similar to those of the major drainage channel of Coppin Creek (OES 2006b). While the range of soil textures, coarse fragment and vegetative cover at each site was not as diverse as those found across the creek transects within the section of Coppin Creek proposed to be diverted, the surface characteristics of the diversion path-way sites were encompassed within the range of characteristics present within Coppin Creek.

The surface characteristics of the six sites varied according to position within the minor drainage lines and adjacent areas sampled, with the structure and texture of the surface soils ranging from single grained loamy sands to aggregated sandy loams. The abundance of coarse fragment cover at the six sites ranged from moderate (25%) in the broader flat areas, to abundant (50-90%) and very abundant (>90%), in the minor drainage channels sampled.

3.3 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. All soil materials sampled were hand textured, with the soil textures ranging from loamy sands (approximately 5% clay), to clay loams (30-35% clay). All samples were within the wide range of soil textures exhibited in the survey of the section of Coppin Creek proposed to be diverted (OES 2006b).

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. It is often affected by root growth, stock and vehicle compaction, and with respect to reconstructed soil profiles, the methods of soil handling and deposition. When a soil material is disturbed, the breakdown of aggregates into primary particles can lead to structural decline, potentially increasing the erodibility of a soil material.

The soils of the six sites examined within the proposed diversion path were comparable in structure to those found within Coppin Creek (OES 2006b), ranging from single grained soil, dominated by coarse material, to soil with a higher percentage clay fraction exhibiting a moderate structure.

3.5 Structural Stability

The structural stability of a soil and its susceptibility to structural decline is complex and depends on the net effect of a number of properties such as the amount and type of clay present, organic matter content, soil chemistry and the nature of disturbance. Soil aggregates that slake and particularly those which disperse, indicate a weak soil structure that is easily degraded. Dispersive soils should be seen as potentially problematic when exposed via excavation or when used for the reconstruction of soil profiles, particularly if left exposed at the surface.

As was the case for the soils within the section of Coppin Creek proposed to be diverted (OES 2006b), all soil aggregates collected from sites within the proposed diversion path slaked upon wetting. No dispersive soils were identified within the samples collected from the six sites in the diversion path.

3.6 Soil Strength

A modified modulus of rupture (MOR) test was conducted on all samples collected. This test is a measure of the soil strength of disturbed soil material following a wetting / drying cycle, identifying the tendency of a soil to hardset as a direct result of soil slaking and dispersion of clay particles. A modulus of rupture of over 60 kPa has been described as the critical value for distinguishing potentially problematic soils in agricultural scenarios (Cochrane and Aylmore, 1997). Modulus of rupture values of Australian soils can range from 0 to 800 kPa, although values in excess of 500 kPa are rare (Cochrane and Aylmore, 1997). Restricted root penetration into the soil matrix and reduced seedling emergence are likely consequences of a high MOR. In reconstructed soil profiles following mining operations, materials normally deep within the profile that may have a high MOR may often be exposed or re-deposited closer to the surface leading to germination / emergence and root penetration problems.

As the MOR test is conducted on re-constructed soil blocks composed of the <2mm soil fraction, it does not take into account the effect of coarse material content or soil structure on soil strength, nor any degree of compaction that may be present in the field. It does however provide insight into the potential for layers to hardset and compact with repeated wetting and drying cycles, and the ability of roots to fracture the soil matrix and penetrate crack faces.

The soil materials (<2mm) of the six sites within the diversion path study area exhibited soil strength values that were typically less than the level considered to be potentially problematic (60 kPa) (Figure 2). One sample (Site D2, 40-50cm) recorded a comparatively high average MOR of 136.2 kPa. This material was classed as a sandy clay loam, having a higher clay content than the majority of the other materials sampled, and was also well structured, with no observable physical impedance to root proliferation.

The range of soil strength values measured for the six diversion path sites was within the range identified for the soils within the section of Coppin Creek proposed to be diverted (OES 2006b).

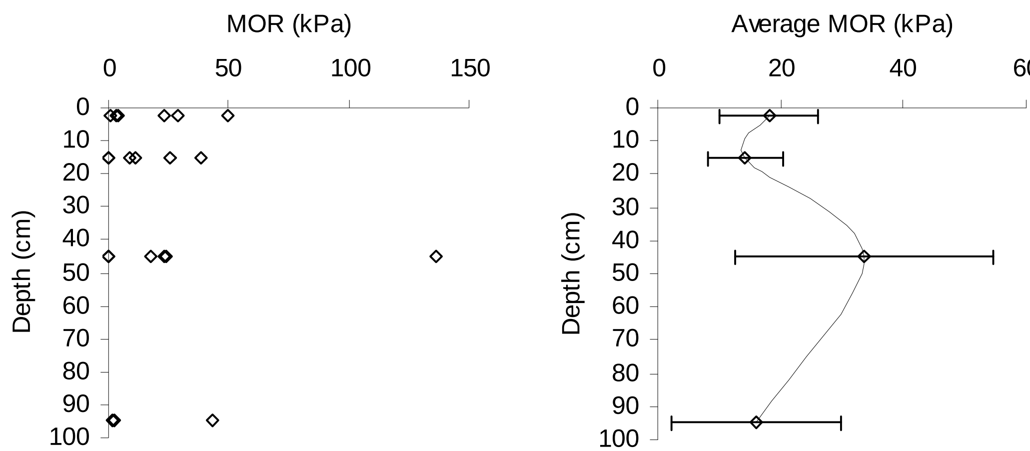

Figure 2 Individual and average soil pH (H_2O) levels with corresponding sample depth (error bars represent standard error).

3.7 Soil pH

The soil pH provides 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. Many Australian soils however, exhibit a soil pH out of this range, with many native plants adapting to more extremely acidic or alkaline conditions.

The soils within the proposed creek diversion pathway were classed as highly alkaline and remained relatively homogenous throughout the depth of soil profile measured (Figure 3). The pH values measured within the minor drainage lines of the diversion path were comparatively similar to the values measured within Coppin Creek (OES 2006b).

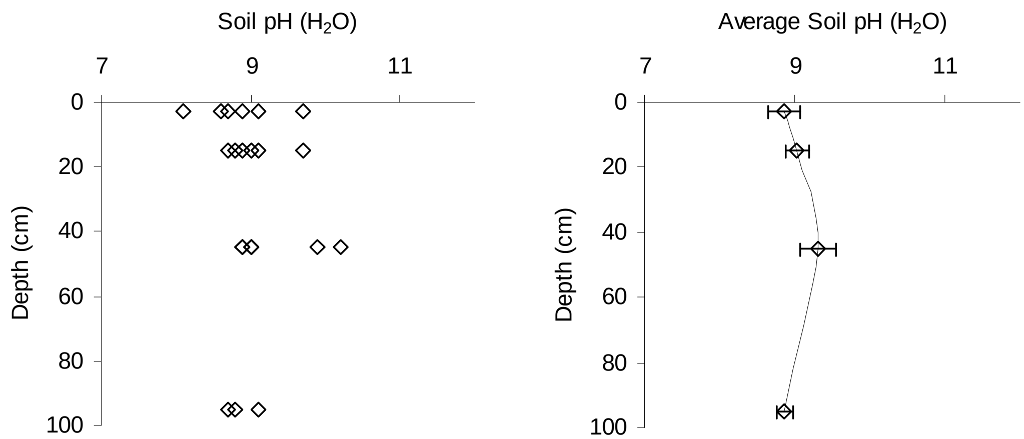

Figure 3 Individual and average soil pH (H_2O) levels with corresponding sample depth (error bars represent standard error).

3.8 Electrical Conductivity

Electrical conductivity (EC) is a measure of a soil's salinity, defined as the presence of soluble salts. Salinity can have major impacts on the productivity and survival of vegetation, although many Australian native plants have adapted to extremely saline conditions.

The majority of soil materials sampled were classed as non-saline based on standard CSIRO categories (Appendix C) (Figure 4). One sample from Site D1, 40-50 cm, exhibited an electrical conductivity value classed as 'moderately saline'.

The EC values measured within the minor drainage lines of the diversion path were comparatively similar to the values measured within Coppin Creek (OES 2006b).

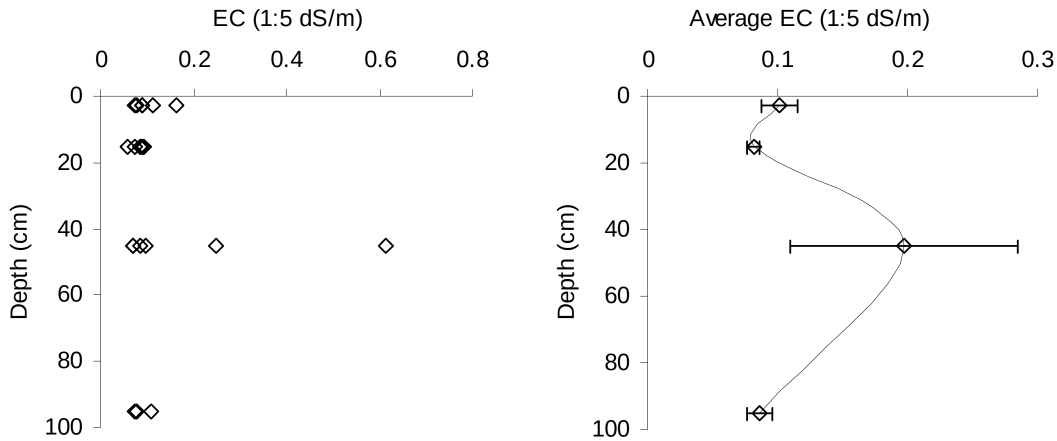

Figure 4 Individual and average electrical conductivity (1:5 dS/m) levels with corresponding sample depth (error bars represent standard error).

3.9 Soil Nutrient Status

The levels of plant-available nutrients held within the soils sampled in the diversion path was generally low, as is typical of native soils in this region (Figures 5 to 9). The levels of N, P, K and S generally dropped slightly with depth. All available nutrient levels were comparable to those found in the soil survey of Coppin Creek (OES 2006b).

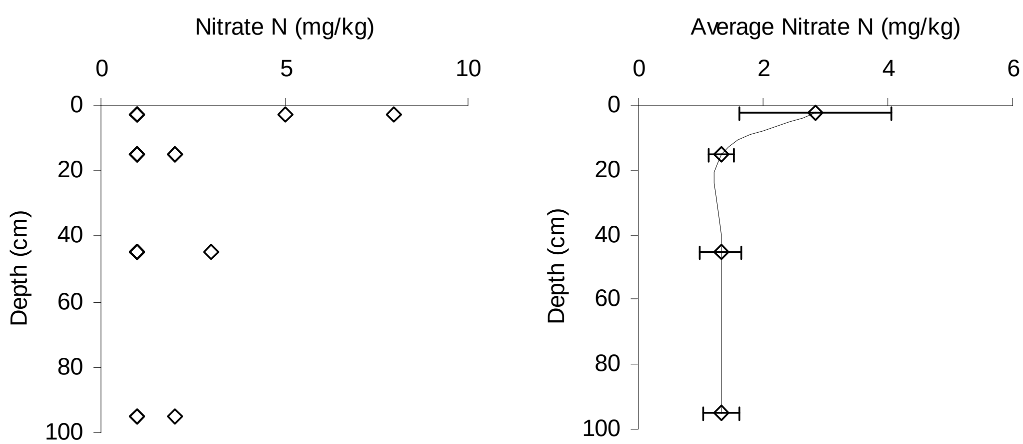

Figure 5 Individual and average nitrate (mg/kg) levels with corresponding sample depth (error bars represent standard error).

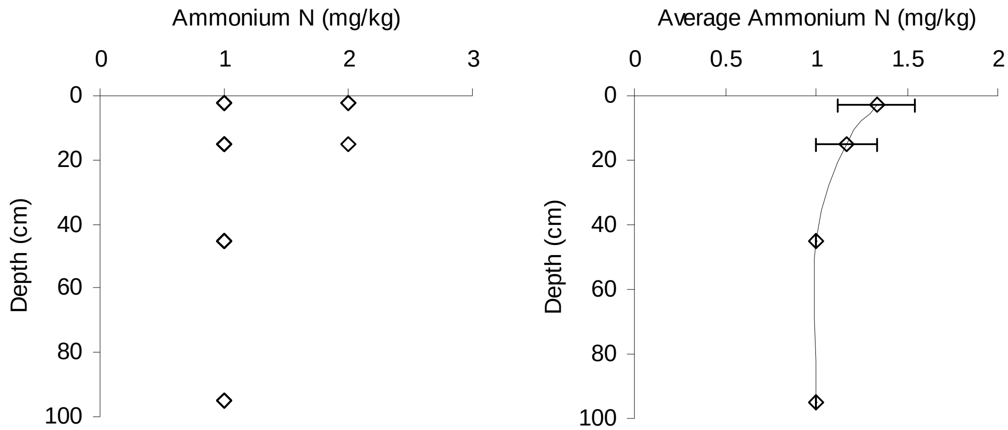

Figure 6 Individual and average ammonium (mg/kg) levels with corresponding sample depth (error bars represent standard error).

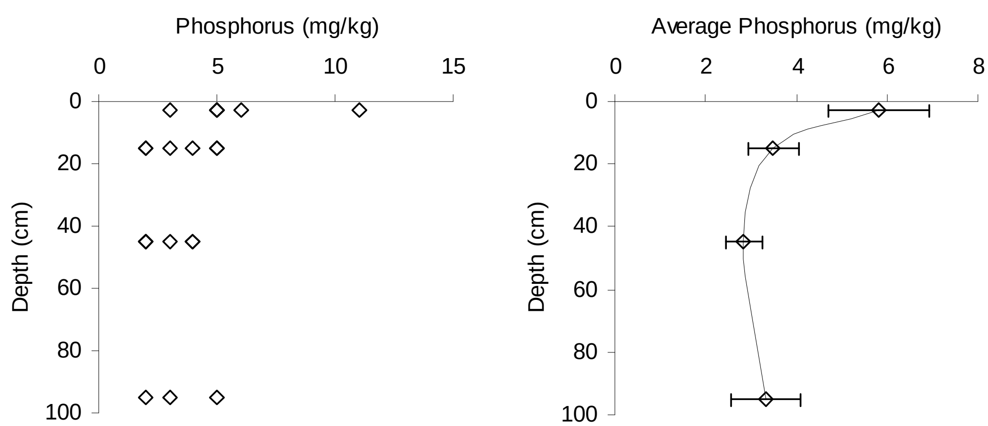

Figure 7 Individual and average available phosphorus (mg/kg) levels with corresponding sample depth (error bars represent standard error).

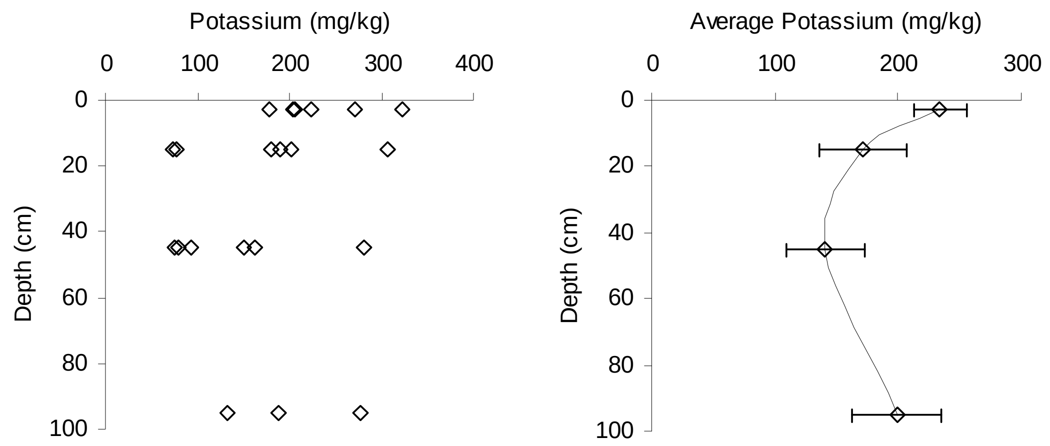

Figure 8 **Individual and average available potassium (mg/kg) levels with corresponding sample depth (error bars represent standard error).**

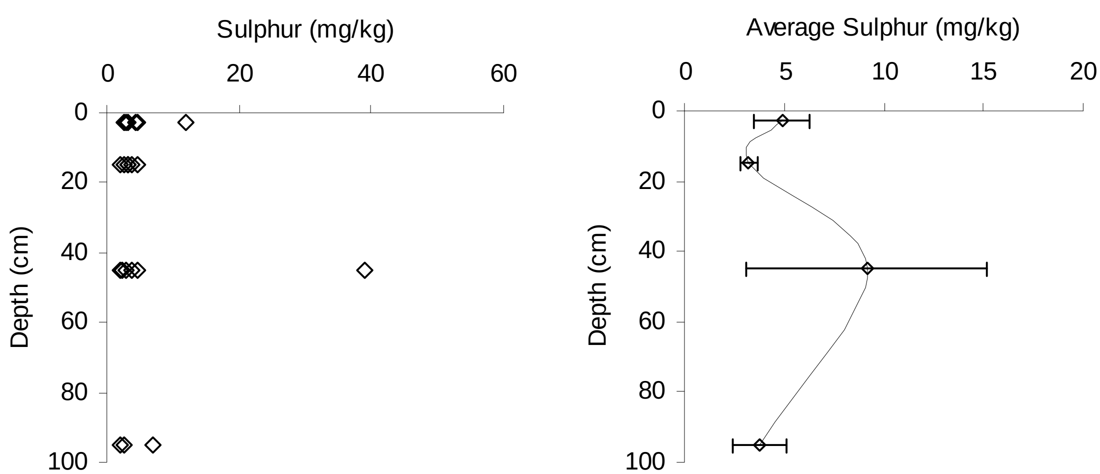

Figure 9 **Individual and average available sulphur (mg/kg) levels with corresponding sample depth (error bars represent standard error).**

As would be expected, organic carbon levels were low, as is typical of native soils in this region (Figure 10). Average organic carbon levels decreased slightly with depth. The levels of organic carbon measured for the diversion path soils were comparable to those found in the soil survey of Coppin Creek (OES 2006b).

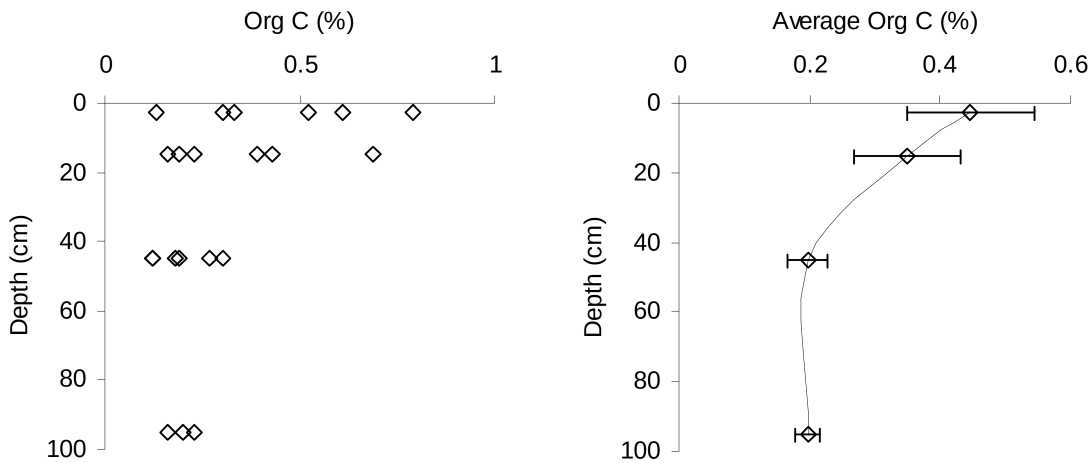

Figure 10 Individual and average organic carbon (%) levels with corresponding sample depth (error bars represent standard error).

3.10 Soil Metal Concentrations

Measurements of water-soluble metal concentrations of the samples collected indicated that only very low levels of Al, As, Cd, Cu, Pb, Mn, Mo and Zn were present (Table 7). Most materials sampled were below the detectable limit for the bulk of the elements measured, with only Al, As, Cu and Mn detected at a reportable level within some samples (yellow highlight). For the metals detected, there was no apparent correlation with the depth of sample or other physical or chemical parameters.

The same metals, at similar water soluble concentrations, were found within the soils of the creek bed and banks of the section of Coppin Creek proposed to be diverted (OES 2006b).

Table 7 Water soluble metal concentrations of soils from diversion area sample sites (yellow highlight indicates concentrations at a 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
Sample	**dl**	**1.0**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**
	Depth (cm)								
D1	0 TO 5	7	<0.1	<0.1	0.3	<0.1	0.2	<0.1	<0.1
D1	10 TO 20	14	<0.1	<0.1	<0.1	<0.1	0.1	<0.1	<0.1
D1	40 TO 50	<1	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
D2	0 TO 5	<1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
D2	10 TO 20	<1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
D2	40 TO 50	3	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
D3	O TO 5	<1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
D3	10 TO 20	<1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
D3	40 TO 50	<1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
D4	0 TO 5	<1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
D4	10 TO 20	<1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
D4	40 TO 50	<1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
D4	90 TO 100	<1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
D4b	0 TO 5	<1	<0.1	<0.1	<0.1	<0.1	0.1	<0.1	<0.1
D4b	10 TO 20	<1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
D4b	40 TO 50	<1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
D4b	90 TO 100	2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
D5	0 TO 5	<1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
D5	10 TO 20	<1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
D5	40 TO 50	1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
D5	90 TO 100	<1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1

3.11 Root Growth

While the abundance of root penetration generally dropped rapidly with depth, root penetration extended beyond the base of all soil pits, with no apparent chemical or physical restrictions to root penetration observed in any of the profiles. The abundance of roots throughout the soil profiles examined was also influenced by the proximity of the soil pit to existing vegetation. The full extent of root penetration into the existing regolith, beyond the depth of the soil pits, is unknown.

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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%.

Modulus of Rupture (MOR)

This test is a measure of soil strength and identifies the tendency of a soil to hardset as a direct result of soil slaking and dispersion.

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-horizons'.

Appendix B

Root Abundance 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

Appendix D

Emerson Aggregate Test Classes

Emerson Aggregate Test Classes (Moore, 1998)

Class	Description
Class 1	Dry aggregate slakes and completely disperses
Class 2	Dry aggregate slakes and partly disperses
Class 3a	Dry aggregate slakes but does not disperse; remolded soil disperses completely
Class 3b	Dry aggregate slakes but does not disperse; remolded soil partly disperses
Class 4	Dry aggregate slakes but does not disperse; remolded soil does not disperse; carbonates and gypsum are present
Class 5	Dry aggregate slakes but does not disperse; remolded soil does not disperse; carbonates and gypsum are absent; 1:5 suspension remains dispersed
Class 6	Dry aggregate slakes but does not disperse; remolded soil does not disperse; carbonates and gypsum are absent; 1:5 suspension remains flocculated
Class 7	Dry aggregate does not slake; aggregate swells
Class 8	Dry aggregate does not slake; aggregate does not swell