WESTERN AUSTRALIAN DEPARTMENT OF AGRICULTURE

technical bulletin

No. 55

ISSN 0083—8675

AGDEX 524

PACKSADDLE PLAINS SOIL SURVEY

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Report prepared 1972

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Manuscript received August, 1980

INTRODUCTION

A semi-detailed soil survey of the Packsaddle Plains area near Kununurra was carried out in late June, 1972. The survey was conducted at the request of the Ord Project Co-ordinating Committee in order to delineate the nature and extent of irrigable soils and to provide a basis for farm and irrigation channel layouts.

Locality

The Packsaddle Plains area is situated on the west bank of the Ord River just upstream from the Diversion Dam, i.e. about five kilometres south-west of the townsite of Kununurra. The area mapped was some four thousand hectares in extent. (See Locality Map, Figure 1).

Environment

(a) *Vegetation:* The vegetation of the Packsaddle Plains area can readily be divided into two units; one which is predominantly open grassland with a scattered covering of Bauhinia trees on clay plains, and the other carrying Eucalypt woodland with a grass understorey on medium textured soils.

(b) *Climate:* The area, at a latitude of 15°S, receives its rainfall in summer. When monsoonal fronts reach the area, rainfall can be as high as 1 000–1 500 mm. In these years rainfall is frequent during January, February and March and falls of very high intensity are recorded. In approximately 50 per cent of years however, monsoonal fronts do not reach the area and rain is from thunderstorms only. Rainfall in those years average from 430 mm to 610 mm and can be very patchy with extended dry periods. Climatic data for Kimberley Research Station (34 year records) are summarised in Table 1.

(c) *Physiography:* The area is one of gentle relief with a slight fall from south to north and from the levee soils near the Ord River back towards Packsaddle Creek and the Dunham River. (See cross-sections presented in Figure 2 on page 4.)

Figure 1.—Location map for Kununurra and Ord River area. Distance from Kununurra to Wyndham = 50 km

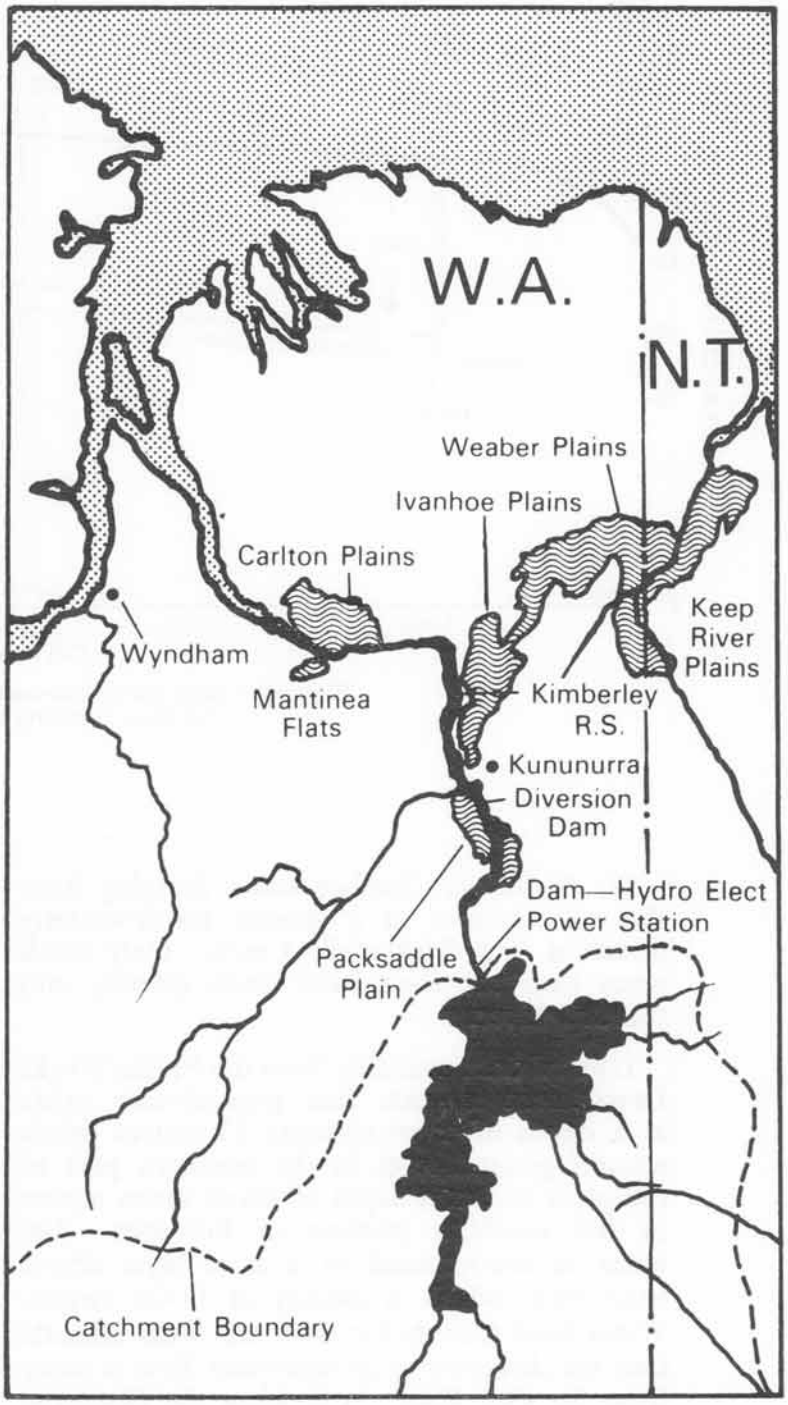

TABLE 1—CLIMATIC DATA FOR KIMBERLEY RESEARCH STATION
(January 1946–June 1980 inclusive)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec	Year
Rainfall (mm)	190·5	201·9	114·8	44·1	12·0	3·2	6·5	0·6	3·6	23·3	63·1	123·8	787·4
Number of rain days	14·0	14·1	9·7	2·9	1·1	0·3	0·4	0·1	0·7	3·3	6·9	10·5	64·0
Mean max. temp. °C	36·0	35·0	35·5	35·1	32·7	30·5	30·5	32·9	35·8	38·5	38·9	37·8	....
Mean temperature °C	30·2	29·6	29·5	27·9	25·3	22·9	22·3	24·2	27·4	30·7	31·7	31·3	....
Mean min. temp. °C	24·4	24·2	23·4	20·7	17·9	15·3	14·1	15·5	19·0	22·8	24·5	24·8	....
Relative Humidity (%)	65·0	68·5	60·6	44·3	36·2	35·7	31·9	32·5	34·2	39·0	47·7	55·8	....
Evaporation (mm)	230·1	175·8	195·1	216·8	212·4	202·6	209·4	240·6	294·0	329·9	287·0	274·9	2 869

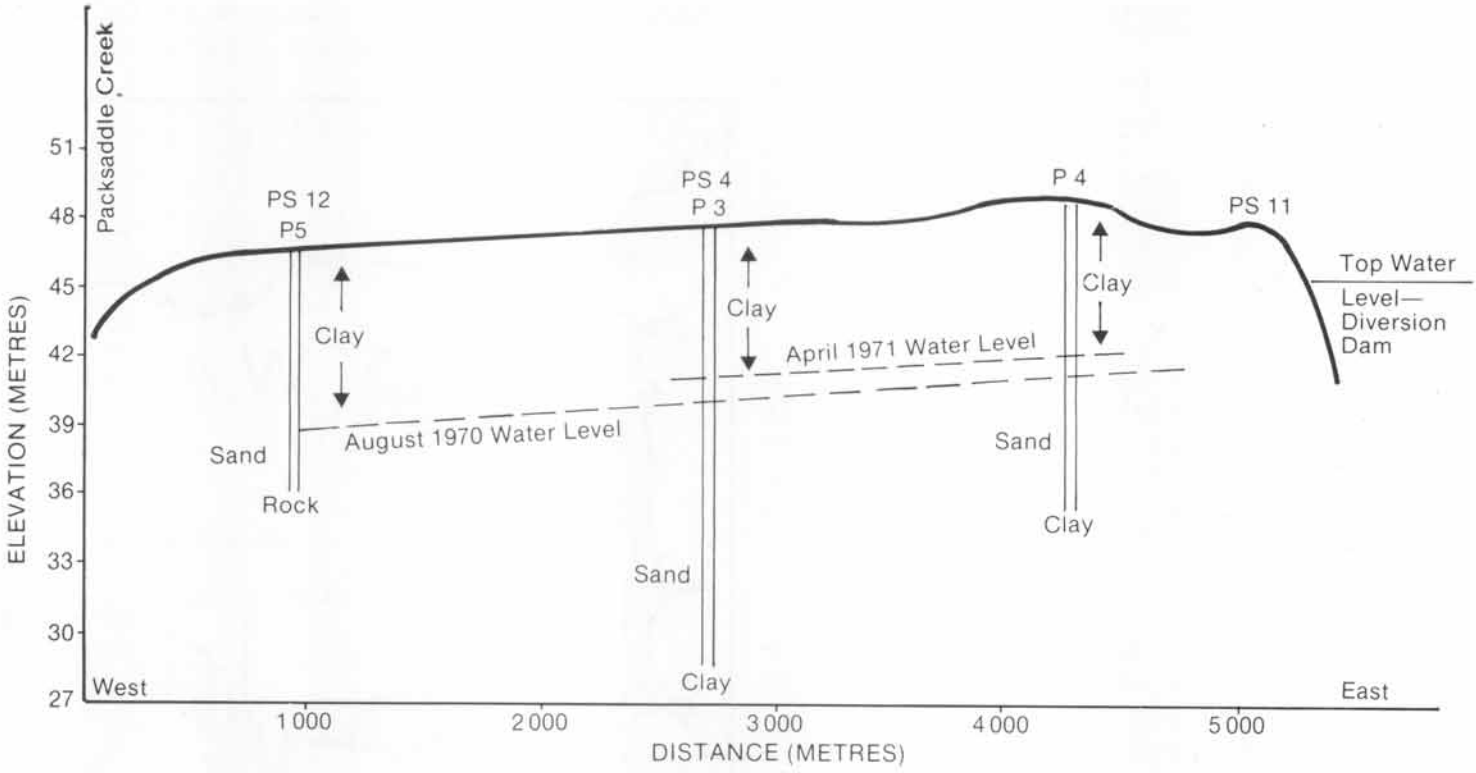

Figure 2.—West-east cross-section from Packsaddle Creek to Ord River Showing Water Table Levels.

(d) *Hydrology:* Surface water draining from the area escapes in a general north-westerly direction into Packsaddle Creek. Only small areas near the river bank drain directly into the Ord River.

Limited data available from the Public Works Department indicate that groundwater exists at a depth of approximately 13 metres below natural ground level in the northern part of the plain and at a depth of about seven metres in the southern portion of the area. The water is encountered in a sand layer above hard rock, which is usually at 17–20 metres. Water level records for these test wells indicate that the direction of groundwater flow is away from the Ord River, both when the Diversion Dam is full and when it is three metres below top level.

As the Diversion Dam will be full at all times in future, it can be expected that the sand aquifer below Packsaddle Plain will remain fully charged with water moving away from the River.

The presence of the apparently continuous sand layer below the Plain indicates that any excess irrigation water moving down through the overlying soils should be able to escape, and not build up a shallow watertable with attendant salinity hazards.

No information is available on the quality of the groundwater, but it would be expected to be of low salinity, and similar to the quality of the water in the Diversion Dam. Figure 2 presents a cross section of Packsaddle Plains, showing ground elevations, depths to water and the sand aquifer.

(e) *Geology:* The soil survey area lies immediately below the point where the Ord River emerges from the Carr Boyd Ranges and begins its course through the alluvial plains. The Packsaddle Plains are bounded by the Ord River on the east, and on the south and west by the Carr Boyd Ranges, these being mainly quartz sandstones of middle Proterozoic Age.

However, most of the soils are developed on alluvial deposits of the Ord River, the catchment of which is some 45 million hectares in extent, and contains a wide variety of very old rocks e.g. Archaean greywacke, mica schist and dolomite, Lower Proterozoic basalt, granite and granodiorites, and Cambrian basalts, etc. (Dow and Gemuts, 1969).

Figure 3 PACKSADDLE PLAIN SOIL SURVEY

SOIL SURVEYOR: T.C. STONEMAN
JULY 1972

LEGEND

Cununurra clay (normal phase)	Cc	Unnamed soil "A"	A
Cununurra clay (acid phase)	Cc (acid)	Unnamed soil "B"	B
Cununurra clay (alkaline phase)	Cc (alk)	Unnamed soil "C"	C
Cununurra clay (gilgaed phase)	Cc (g)	Unnamed soil "D"	D
Packsaddle sandy loam	Psl	Recent alluvial soils, frequently eroded, mainly Ord loamy sand	R
Packsaddle sandy loam (shallow phase)	Psl (s)		
Ord loamy sand	Ols	Eroded soils near Packsaddle Creek	E
		Swamps & flooded areas	W
		Profile sampling site	▲

0 1 2 3
kilometres

SOIL MAPPING PROCEDURE

The soil map accompanying this report was compiled by means of air photo-interpretation and limited ground traversing; distinctive patterns were delineated on air photographs and ground checks made to establish the relationship between photo-appearance, vegetation and soils. As a result of this "free survey" procedure, 13 soil units have been identified and mapped (see Fig. 3 on page 5).

SOIL TYPE DESCRIPTIONS

Cununurra clay

Four phases of Cununurra clay have been mapped:—

(i) Normal phase (1 241 hectares)—soil surface slightly gilgaied, moderate cracking hidden by surface crust. Typical profile is:—

0–0·5 cm—Grey brown light clay, surface crust.

0·5–1 cm—grey brown light clay, fine aggregates, "self mulching".

1–120 cm—light brownish grey (10 YR 6/2) to brown (7·5 YR 4/2) clay with few nodules of $CaCO_3$ and fine manganese nodules from 25 cm. Few small pockets of brown sand from 75 cm.

120–150 cm—dark reddish brown (5 YR 3/4) clay with coarser and more frequent $CaCO_3$ nodules.

150–180 cm—reddish brown (5 YR 4/4) with some sand, mica and coarse $CaCO_3$.

180 cm + —brown sandy clay loam.

Vegetation is typically an open stand of *Lysiphyllum cunninghamii* ("Bauhinia") with a grass cover of *Chrysopogon fallax* ("Ribbon Grass") and *Aristida* sp., and with some *Astrebla squarrosa* ("Bull Mitchell grass").

(ii) Alkaline phase (542 hectares)—soil surface cracked, surface crust present, slightly gilgaied surface. Typical profile is:—

0–0·5 cm—brownish grey clay, surface crust, with a few fine $CaCO_3$ nodules present.

0·5–1 cm—grey brown clay, fine aggregates, "self mulching".

1–15 cm—dark reddish brown (5 YR 3/2) clay, with $CaCO_3$ nodules.

15–50 cm—dark brown (7·5 YR clay, with fine $CaCO_3$ nodules,

50–120 cm—dark brown (7·5 YR 3/2) clay, with fine $CaCO_3$, and manganese nodules.

120–150 cm—yellowish red faintly mottled (5 YR 4/6) clay, slightly micaceous, and with some larger $CaCO_3$ nodules.

150–180 cm—reddish brown (5 YR 4/3) silty clay, crumbly, slightly micaceous and with some $CaCO_3$ nodules.

Areas of the alkaline phase of Cununurra clay are indicated by the presence of *Terminalia volucris* ("Rosewood") and scattered *Carissa lanceolata* ("Konkerberry"). *Lysiphyllum cunninghamii* ("Bauhinia") is also commonly present, with the grass *Aristida latifolia* dominant, with some *Astrebla squarrosa* ("Bull Mitchell Grass") and *Brachyachne* sp. ("Native Couch") also present.

(iii) Acid phase (214 hectares),—Ground surface slightly gilgaied, soil surface massive with some fine cracks. Typical profile is:—

0–1 cm—grey and orange mottled light clay, thick platy structure.

1–10 cm—grey and orange mottled light clay, small blocky structure.

10–25 cm—yellowish brown, finely mottled (10 YR 5/4) light clay.

25–60 cm—yellowish brown (10 YR 5/4) light clay, with a few fine manganese concretions.

60–150 cm—yellowish brown (10 YR 5/4) light clay, with a few $CaCO_3$ nodules, very crumbly below 120 cm.

150–180 cm—reddish yellow (7·5 YR 6/6) light clay, with a few $CaCO_3$ nodules, very crumbly.

Vegetation is an open grassland, with a few scattered *Lysiphyllum cunninghamii* ("Bauhinia"). Dominant grasses are *Sorghum* sp. and *Eriachne glauca*. *Rynchospora tenuifolia* is also present.

(iv) Gilgai phase (172 hectares)—The ground surface is distinctly gilgaied with scattered small depressions (two metres diameter) and relatively larger shelf areas.

(a) Shelf profile:—

0–0·5 cm—light greyish brown clay, thin crust, with a few $CaCO_3$ nodules.

0·5–2 cm—grey brown clay, fine aggregates "self mulching".

2–15 cm—dark reddish brown (5 YR 3/3) clay, with fine $CaCO_3$ nodules, blocky structure.

15–30 cm—dark reddish brown (5 YR 3/3) tough clay with fine $CaCO_3$ nodules.

30–90 cm—dark brown (7·5 YR 3/2) clay with fine $CaCO_3$ nodules.

90–135 cm—reddish brown, clay loam, mottled (5 YR 4/4), with many $CaCO_3$ nodules.

(b) Depression profile:—

0–1 cm—grey clay, surface crust, massive and cracked, sometimes with thin curled skin on top of crust.

1–15 cm—grey clay, with few fine manganese nodules, large blocky structure.

15–90 cm—greyish brown (2·5 YR 5/2) clay, with few fine manganese nodules and fine sand pockets.

90–135 cm—brown (7·5 YR 5/4) light clay, with coarse $CaCO_3$ concretions.

Vegetation is mainly open grassland with scattered *Lysiphyllum cunninghamii* ("Bauhinia") and *Carissa lanceolata* ("Konkerberry"). Common grasses are *Iseilema vaginiflorum* ("Flinders Grass"), *Eragrostis japonica* and *Fimbristylis* (?) *quinquangularis*.

Packsaddle sandy loam (541 hectares)

A typical profile of Packsaddle sandy loam is:—

0–10 cm—dusky red (10 R 3/4) loamy sand to sandy loam surface firm coherent, slightly cracked, powders to "bulldust".

10–45 cm—dark red (10 R 3/6) sandy loam.

45–60 cm—dark red (10 R 3/6) sandy clay loam.

60–145 cm—dark red (10 R 3/6) light clay, slightly micaceous.

145–180 cm—reddish brown (2·5 YR 4/4) light clay, slightly micaceous, and with a few $CaCO_3$ nodules.

Vegetation is typically a Eucalypt forest, mainly *E. pruinosa* ("Silver Leaf Box"), with *E. clavigera* ("Cabbage Gum"), *E. dichromophloia* ("Bloodwood") and occasional *Carissa lanceolata* ("Konkerberry") shrubs. Grasses are *Heteropogon contortus*, ("Spear Grass") and *Eriachne obtusa*.

A small area (18 hectares) of a *shallow phase* of Packsaddle sandy loam also exists, in which dark red sandy clay loam is encountered by 25 cm and the dark red clay by 37 cm depth. The shallow phase seems to be distinguished by quite a dense stand of *Melaleuca minutifolia* with some *Terminalia platyptera* ("Nutwood") and a few *Eucalyptus pruinosa* "Silver Leafed Box".

Ord loamy sand (28 hectares)

A typical profile of Ord loamy sand is:—

0–48 cm—dark reddish brown (2·5 YR 3/4) loamy sand.

48–55 cm—dark red (2·5 YR 3/6) sandy loam.

55–165 cm—yellowish red (5 YR 4/6) sandy loam.

165–180 cm—red (2·5 YR 4/6) sandy loam.

The soil profile is slightly micaceous throughout.

Vegetation is an open Eucalypt forest of *E. dichromophloia* ("Bloodwood") and some *E. clavigera* ("Cabbage Gum"), with a grass understorey dominated by *Aristida hygrometrica* and some *Heteropogon contortus* ("Spear Grass").

Minor soil "A" (206 hectares)

A typical profile of Minor Soil "A" is:—

0–10 cm—yellow grey loamy sand, firm surface powders to "bulldust".

10–30 cm—strong brown (7·5 YR 5/6) sandy loam.

30–90 cm—yellowish brown (10 YR 5/6) with red (2·5 YR 4/8) mottles, sandy clay loam, with soft black manganese patches.

90–105 cm—light brownish grey (2·5 Y 6/2) with red (2·5 YR 4/6) mottles, sandy clay loam, with soft black manganese patches.

105–180 cm—light olive grey (5 Y 6/2) and red (10 R 4/6) mottles, clay, with soft manganese patches.

Vegetation is mainly *Eucalyptus pruinosa* ("Silver-leafed Box") forest, with a few *Terminalia platyptera* ("Nutwood") and *E. clavigera* ("Cabbage Gum").

Minor Soil "B" (area limits not defined)

A typical profile of Minor Soil "B" is:—

0–30 cm—brown (10 YR 5/3) sand, with a firm crusted surface, powders to "bulldust".

30–60 cm—pale yellow (2·5 Y 7/4) loamy sand.

60–90 cm—reddish yellow, mottled (7·5 Y 6/6) loamy sand to sandy loam, with soft ferruginous gravel.

90–150 cm—pale yellow (5 Y 7/4) with red (2·5 YR 4/8) mottles, sandy loam.

150–180 cm—light grey (5 Y 7/1) with brownish yellow (10 YR 6/8) mottles, sandy clay.

Vegetation is mainly open forest of *Eucalyptus clavigera* ("Cabbage Gum"), *Eucalyptus grandifolia* and occassional *Adansonia gregorii* ("Baobab") with the grass *Eriachne obtusa*. Small areas of deep sand (e.g. 0–120 cm +, yellow grey sand) occur within the areas of this soil "type" as mapped. The sand patches are bare of tree cover and frequently have *A. gregorii* around the fringe.

Minor Soil "C" (5 hectares)

Only a small area of this soil was mapped in the south-west of the survey area. A typical profile is:—

0–30 cm—Grey with faint orange mottles sandy loam, firm surface, but powders to light grey "bulldust".

30 cm + —Brown with grey mottles sandy clay.

The soil carries a thin grass cover with no trees or shrubs present.

Minor Soil "D" (area limits not defined)

This soil type occurs along the southern boundary of the survey area, against the foothills of the Carr Boyd Ranges. The soil descriptions bear some similarities to the Rainyerri series described by Burvill (1945) for the Mantinea area. A typical profile is:—

0–60 cm—greyish yellow loamy sand, light sandy loam, crusted surface, powders to "bulldust", slight surface gravel and some flat stones (shale).

60–75 cm—yellow grey with red mottles light clay with shale fragments.

In addition to the soils described above, three other units have been identified on the soil map. These are (a) recent alluvial soils, frequently eroded, mainly Ord loamy sand, (b) eroded soils near Packsaddle Creek, and (c) swamps and flooded areas. None of the units has been studied, and boundaries drawn are by photo-interpretation.

SOIL ANALYSIS

Soil samples from representative profiles were collected and tested for soluble salts and pH. All samples were low in soluble salts (less than 0·1% or 3 milliseimens/cm at 25°C) to a depth of 180 cm. The values for pH are set out below in Table 2.

Soil samples from the same profiles were submitted to the Government Chemical Laboratories for analysis. The data derived appears in Appendix I.

TABLE 2—pH VALUES (1:5)

Depth (cm.)	Soil Type								
	Cununurra Clay					Packsaddle Sandy Loam	Ord Loamy Sand	"A"	"B"
	Normal	Alkaline	Acid	Gilgaied Shelf	Gilgaied Depression				
Surface	7·0	8·1	5·8	8·5	6·5	n.a.*	n.a.	n.a.	n.a.
0–30	7·1	8·4	7·2	8·7	7·2	5·8	6·8	6·4	6·5
30–60	8·2	8·8	7·4	8·9	8·1	6·0	6·6	6·1	6·3
60–90	8·7	8·6	8·4	9·0	9·1	6·6	7·0	6·6	5·9
90–120	8·8	8·7	8·5	9·4	9·5	7·0	7·3	6·8	5·9
120–150	9·1	8·5	8·6	9·5	9·6	7·9	7·4	7·1	5·9
150–180	9·2	8·5	8·5	....	....	8·3	7·5	7·5	5·8

* n.a. = not available

SUITABILITY OF THE SOILS FOR IRRIGATED AGRICULTURE

Based on soil texture profiles, limited analytical data, and experience with irrigated agriculture on the nearby Ivanhoe Plain, the following assessment can be made of each mapped soil in terms of its suitability for irrigated agriculture:—

Cununurra clay (*normal phase*)—This soil is expected to be comparable to the Cununurra clay on Ivanhoe Plain. Texture and pH profiles are very similar and soluble salts are even lower than on Ivanhoe Plain. Land grades are generally adequate, although limited areas have a grade of less than 0·045 per cent.

Cununurra clay (*alkaline phase*)—The pH values in the top 60 cm of the profile are somewhat higher than in the normal phase of Cununurra clay. On Kimberley Research Station experience has shown that clay soils with pH's much higher than normal Cununurra clay (i.e. Walyara clay with pH $>$ 8·5 in the top 30 cm) are associated with poor growth of maize, rice, young sudax, (Gunn, 1969). Whether the pH of the top 30–60 cm of Cununurra clay, (Alkaline phase) is sufficiently high to cause nutritional imbalances, etc., cannot be stated with certainty. Certainly, the possibility exists for potential crop yields being reduced due to higher than normal pH values. Land grades appear to be adequate for irrigation on most areas of this phase.

Cununurra clay (*acid phase*)—The only discernible differences between the acid and the normal phase are that the pH of the top few centimetres of soil (ph 5·8) is more acid and the profile is yellower in colour throughout. It is likely that the acid phase will behave agriculturally much the same as the normal phase. Land grades appear to be generally satisfactory, although a relatively flat area exists near the southern end of the Plain.

Cununurra clay (*gilgai phase*)—The same possible restrictions as for the alkaline phase apply to the gilgai phase; pH values in the shelf areas are much higher ($>$8·5) than normal and may adversely affect crop yields.

Packsaddle sandy loam—The powdery ("bull-dust") nature of the soil surface may cause difficulties in the initial land preparation for irrigation. Suijdendorp (personal communication) has reported that soils with powdery surfaces at the Dunham River irrigation project were very difficult to handle mechanically when dry i.e. grading and land planing.

As Packsaddle sandy loam is the major area of levee soil (560 hectares) on Packsaddle Plain, it is appropriate to refer to certain changes in irrigation practices which may prove necessary on this lighter soil, as compared to Cununurra clay on the Ivanhoe Plain. These suggestions are largely based on recent experience with irrigated peanuts on Ord sandy loam at Kimberley Research Station:—

1. The length of irrigation runs will probably need to be shorter than is normally the case on Cununurra clay (perhaps 200 m rather than 400 m in length) due to the levee soils being lighter in texture and more permeable.

2. Channel stops will probably need to be larger than the size used on Cununurra clay, in order to avoid leakage around the edges of the stops.
3. Packsaddle sandy loam areas generally have a good grade of about 0·2 per cent. Care will be needed to avoid erosion of drains by keeping drain grades down to paddock slope and avoiding a drop greater than about five cm from the end of the irrigation furrows into the tail drains.

Ord loamy sand—This soil is light textured to depth (i.e. sandy loam at 180 cm) and may require special watering techniques to avoid wastage of water, or difficulty in distributing water over a relatively permeable soil. The Ord sandy loam soils mapped by Burvill for the Ivanhoe Plain appear to be a little finer textured at the surface and at depth (e.g. fine sandy loam at the surface and fine sandy clay loam at about 120 cm).

Minor Soil "A"—The texture profile of this soil is quite similar to Packsaddle sandy loam, although the sand fraction is generally coarser. The powdery soil surface may pose problems for grading etc. when dry. There are no other known limitations on this soil at present.

Minor Soil "B"—As the profile of this soil is usually sandy to at least 90 cm and there are patches of deep sands in the unit as mapped, this area is not regarded as being suitable for normal furrow irrigation.

COMMENTS

Of the 4 000 hectares soil surveyed, minor soil "B" is regarded as being unsuitable for furrow irrigation because of high permeability, 714 hectares of Cununurra clay, alkaline and gilgai phases, may possibly suffer yield reductions due to high surface soil pH values, 28 hectares of Ord loamy sand may have a high water requirement due to high permeability, while the remaining area of 2 014 hectares of Cununurra clay, normal and acid phases, and Packsaddle sandy loam is expected to be generally well suited to irrigated agriculture.

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APPENDIX 1

CHEMICAL ANALYSIS OF TYPICAL PROFILES

CUNUNURRA CLAY—NORMAL PHASE

Depth (cm)	0–30	30–60	60–90	90–120	120–150	150–180
pH (1:5)	7·2	8·9	9·0	9·2	9·5	9·6
Mechanical analysis:			Less than 2 mm (per cent)			
Coarse sand	7·8	3·1	3·4	4·5	2·9	4·1
Fine sand	30·3	31·3	30·1	28·3	29·2	50·6
Silt	17·2	17·7	17·1	15·0	21·6	21·5
Clay	42·9	49·0	49·4	53·9	45·3	24·2
Organic carbon, C	0·59	0·42	0·43	0·41	0·33	0·15
Nitrogen, N	0·039	0·025	0·024	0·026	0·015	0·011
C/N Ratio	15·1	16·8	17·9	15·8	22·0	13·6
Calcium carbonate $CaCO_3$	<0·1	0·4	0·6	0·5	1·1	1·9
Hydrochloric acid soluble:						
Phosphorus, P	0·007	0·006	0·006	0·006	0·009	0·018
Potassium, K	0·43	0·45	0·47	0·49	0·50	0·44
			milliequivalents per 100g			
Cation Exchange Capacity	38·0	39·5	40·3	37·8	42·9	22·7
Exchangeable cations:						
Calcium, Ca	36·8*	37·6*	36·2*	32·7*	38·0*	19·9*
Magnesium, Mg						
Potassium, K	0·80	0·80	0·85	0·80	0·85	0·50
Sodium, Na	0·40	1·1	3·3	4·2	4·1	2·3
Hydrogen, H (ph 7)	....	....	....	....	....	....
			parts per million			
Zinc, Zn (extractable)†	0·89	1·1	0·78	1·2	0·66	0·64

CUNUNURRA CLAY—ALKALINE PHASE

Depth (cm)	0–30	30–60	60–90	90–120	120–150	150–180
pH (1:5)	8·8	9·3	9·4	9·2	9·0	9·1
Mechanical analysis:			Less than 2 mm (per cent)			
Coarse sand	2·9	4·2	4·6	3·5	1·8	2·8
Fine sand	26·3	25·8	24·2	25·2	25·3	30·8
Silt	19·0	16·2	17·4	13·1	18·4	23·5
Clay	49·8	51·9	55·7	56·6	56·2	44·8
Organic carbon, C	0·41	0·39	0·46	0·38	0·25	0·21
Nitrogen, N	0·023	0·029	0·029	0·024	0·016	0·018
C/N Ratio	17·8	13·4	15·9	15·8	15·6	11·7
Calcium carbonate $CaCO_3$	0·4	1·0	1·1	1·0	0·9	1·3
Hyrdochloric acid soluble:						
Phosphorus, P	0·008	0·008	0·008	0·008	0·011	0·01
Potassium, K	0·55	0·56	0·59	0·64	0·66	0·64
			milliequivalents per 100g			
Cation Exchange Capacity	43·3	43·7	38·6	44·5	29·0	17·3
Exchangeable cations:						
Calcium, Ca	42·2*	40·3*	33·0*	37·8*	22·8*	13·0*
Magnesium, Mg						
Potassium, K	0·80	0·90	0·95	1·0	0·95	0·65
Sodium, Na	0·35	2·5	4·7	5·7	5·3	3·6
Hydrogen, H (pH 7)	....	....	....	....	....	....
			parts per million			
Zinc, Zn (extractable)†	0·48	0·91	0·52	0·72	0·63	0·56

CUNUNURRA CLAY—ACID PHASE

Depth (cm)	0–30	30–60	60–90	90–120	120–150	150–180
pH (1:5)	6·5	6·9	8·7	8·6	8·4	8·4
Mechanical analysis:			Less than 2 mm (per cent)			
Coarse sand	20·4	19·8	2·7	18·6	16·8	16·5
Fine sand	24·5	27·4	44·9	25·7	30·1	30·8
Silt	17·1	17·7	17·8	18·9	21·0	21·1
Clay	36·5	34·4	35·5	36·8	33·5	32·6
Organic carbon, C	0·36	0·26	0·16	0·17	0·13	0·13
Nitrogen, N	0·031	0·020	0·014	0·014	0·010	0·012
C/N Ratio	11·6	13·0	11·4	12·1	13·0	10·8
Calcium carbonate $CaCO_3$	<0·1	<0·1	0·2	0·6	0·4	0·1
Hydrochloric acid soluble:						
Phosphorus, P	0·009	0·007	0·006	0·008	0·009	0·012
Potassium, K	0·25	0·24	0·28	0·31	0·30	0·33
			milliequivalents per 100g			
Cation Exchange Capacity	17·0	17·8	19·5	21·4	21·5	22·2
Exchangeable cations:						
Calcium, Ca	9·3	9·7	18·6*	20·4*	20·6*	21·3*
Magnesium, Mg	6·6	7·1				
Potassium, K	0·30	0·25	0·35	0·40	0·40	0·40
Sodium, Na	0·40	0·65	0·50	0·60	0·55	0·50
Hydrogen, H (pH 7)	0·4	0·1	....	....	....	....
			parts per million			
Zinc, Zn (extractable)†	0·38	0·62	0·34	0·60	0·48	0·88

CUNUNURRA CLAY—GILGAI PHASE

	Shelf Profile				
Depth (cm)	0–30	30–60	60–90	90–120	120–135
pH (1:5)	9·2	9·4	9·4	9·6	9·8
Mechanical analysis:			Less than 2 mm (per cent)		
Coarse sand	7·3	4·2	5·1	10·8	15·5
Fine sand	21·8	26·4	25·9	33·9	37·7
Silt	20·9	19·3	20·3	18·0	16·8
Clay	49·4	51·4	50·4	36·9	31·5
Organic carbon, C	0·36	0·34	0·33	0·21	0·15
Nitrogen, N	0·026	0·024	0·020	0·014	0·010
C/N Ratio	13·8	14·2	16·5	15·0	15·0
Calcium carbonate $CaCO_3$	0·5	0·9	0·9	7·0	8·2
Hydrochloric acid soluble:					
Phosphorus, P	0·006	0·006	0·006	0·010	0·014
Potassium, K	0·40	0·39	0·41	0·42	0·47
			milliequivalents per 100g		
Cation Exchange Capacity	39·7	40·6	40·0	27·1	21·8
Exchangeable cations:					
Calcium, Ca	34·8*	31·4*	29·4*	18·8*	14·3*
Magnesium, Mg					
Potassium, K	0·65	0·65	0·65	0·45	0·40
Sodium, Na	4·2	8·5	10·0	7·8	7·1
Hydrogen, H (pH 7)	....	....	....	....	....
			parts per million		
Zinc, Zn (extractable)†	0·71	0·47	0·55	0·71	0·61

CUNUNURRA CLAY—GILGAI PHASE

Depression profile

	0–30	30–60	60–90	90–120	120–135
Depth (cm)					
pH (1:5)	7·4	8·0	9·7	9·6	10·0
Mechanical analysis:			Less than 2 mm (per cent)		
Coarse sand	8·3	8·2	10·1	7·6	7·5
Fine sand	34·1	36·5	32·6	41·3	39·9
Silt	19·0	14·8	15·9	16·4	17·8
Clay	40·1	40·5	42·4	36·8	36·8
Organic carbon, C	0·41	0·31	0·21	0·15	0·12
Nitrogen, N	0·030	0·029	0·014	0·011	0·008
C/N Ratio	13·7	10·7	15·0	13·6	15·0
Calcium carbonate $CaCO_3$	0·1	0·1	1·7	5·5	3·5
Hydrochloric acid soluble:					
Phosphorus, P	0·007	0·006	0·006	0·014	0·015
Potassium, K	0·38	0·33	0·38	0·46	0·51
			milliequivalents per 100g		
Cation Exchange Capacity	28·3	28·6	30·1	24·1	23·8
Exchangeable cations:					
Calcium, Ca	25·0*	23·6*	23·4*	17·0*	15·6*
Magnesium, Mg					
Potassium, K	0·65	0·60	0·55	0·45	0·45
Sodium, Na	2·6	4·4	6·1	6·7	7·8
Hydrogen, H (ph 7)	....	....	....	....	....
			parts per million		
Zinc, Zn (extractable)†	0·75	0·62	0·46	0·59	0·67

PACKSADDLE SANDY LOAM

	0–30	30–60	60–90	90–120	120–150	150–180
Depth (cm)						
pH (1:5)	5·7	5·6	6·1	7·0	8·6	9·0
Mechanical analysis:			Less than 2 mm (per cent)			
Coarse sand	21·3	19·3	19·2	14·5	13·6	19·6
Fine sand	31·5	29·1	30·6	36·1	41·2	37·6
Silt	18·6	14·6	16·1	16·6	14·5	15·6
Clay	27·3	36·3	33·8	34·2	31·1	29·2
Organic carbon, C	0·79	0·44	0·52	0·34	0·22	0·19
Nitrogen, N	0·060	0·035	0·032	0·027	0·019	0·014
C/N Ratio	13·2	12·6	16·3	12·6	11·6	13·6
Calcium carbonate $CaCO_3$		less than 0·1			0·3	0·3
Hydrochloric acid soluble:						
Phosphorus, P	0·014	0·010	0·009	0·009	0·010	0·012
Potassium, K	0·36	0·40	0·37	0·41	0·42	0·45
			milliequivalents per 100g			
Cation Exchange Capacity	13·6	14·1	14·7	15·7	16·2	18·4
Exchangeable cations:						
Calcium, Ca	5·8	5·5	5·8	6·2	14·6*	16·3*
Magnesium, Mg	4·4	5·7	6·4	7·7	....	....
Potassium, K	0·45	0·30	0·50	0·65	0·70	0·70
Sodium, Na	0·05	0·15	0·35	0·60	0·90	1·4
Hydrogen, H (pH 7)	2·9	2·5	1·7	0·5	....	....
			parts per million			
Zinc, Zn (extractable)†	0·77	0·69	0·43	0·77	1·4	1·1

PACKSADDLE SANDY LOAM

Depth (cm)	0–30	30–60	60–90	90–120	120–150	150–180
pH (1:5)	5·6	6·3	6·6	6·8	7·4	7·5
Mechanical analysis:			Less than 2 mm (per cent)			
Coarse sand	22·8	12·7	13·9	12·5	11·6	8·7
Fine sand	31·6	34·3	35·1	36·1	37·2	40·6
Silt	11·3	11·4	13·4	17·6	13·5	17·7
Clay	33·9	41·4	38·3	35·3	36·4	32·3
Organic carbon, C	0·56	0·41	0·27	0·22	0·19	0·19
Nitrogen, N	0·047	0·039	0·025	0·020	0·016	0·017
C/N Ratio	11·9	10·5	10·8	11·0	11·9	11·2
Calcium Carbonate $CaCO_3$	<0·1	<0·1	<0·1	<0·1	<0·1	<0·1
Hydrochloric acid soluble						
Phosphorus, P	0·013	0·012	0·010	0·010	0·009	0·012
Potassium, K	0·40	0·43	0·44	0·46	0·48	0·49
			milliequivalents per 100g			
Cation Exchange Capacity	10·7	11·4	11·6	11·8	31·8	16·7
Exchangeable cations:						
Calcium, Ca	5·2	5·8	5·4	5·5	12·8*	15·7*
Magnesium, Mg	3·2	3·6	4·1	5·0		
Potassium, K	0·55	0·50	0·55	0·70	0·80	0·85
Sodium, Na	0·10	0·10	0·05	0·10	0·15	0·15
Hydrogen, H (pH 7)	1·7	1·4	1·5	0·5	....	....
			parts per million			
Zinc, Zn (extractable)†	0·44	0·55	0·39	2·4	0·53	0·92

ORD LOAMY SAND

Depth (cm)	0–30	30–60	60–90	90–120	120–150	150–180
pH (1:5)	6·6	6·9	7·3	7·2	7·5	7·8
Mechanical analysis:			Less than 2 mm (per cent)			
Coarse sand	43·1	45·7	29·7	16·2	8·4	11·5
Fine sand	38·1	29·5	52·6	59·7	64·8	59·7
Silt	7·1	9·2	6·7	10·2	12·3	12·4
Clay	10·1	15·4	10·8	14·4	15·5	17·5
Organic carbon, C	0·32	0·21	0·19	0·14	0·17	0·13
Nitrogen, N	0·024	0·020	0·013	0·012	0·010	0·009
C/N Ratio	13·3	10·5	14·6	11·7	17·0	14·4
Calcium carbonate $CaCO_3$	<0·1	<0·1	<0·1	<0·1	<0·1	<0·1
Hydrochloric acid soluble:						
Phosphorus, P	0·010	0·011	0·009	0·011	0·012	0·011
Potassium, K	0·30	0·31	0·29	0·32	0·35	0·32
			milliequivalents per 100g			
Cation Exchange Capacity	8·3	11·6	10·5	13·8	15·3	15·3
Exchangeable cations:						
Calcium, Ca	4·2	5·6	10·2*	13·4	14·9*	14·8*
Magnesium, Mg	3·1	5·1				
Potassium, K	0·40	0·30	0·25	0·30	0·25	0·30
Sodium, Na	0·05	0·10	0·10	0·15	0·15	0·20
Hydrogen, H (pH 7)	0·5	0·5	....	....	....	....
			parts per million			
Zinc, Zn (extractable)†	0·91	0·38	0·51	0·82	0·86	1·6

MINOR SOIL "A"

Depth (cm)	0–30	30–60	60–90	90–120	120–150	150–180
pH (1:5)	6·8	6·4	6·3	6·8	6·6	7·2
Mechanical analysis:			Less than 2 mm (per cent)			
Coarse sand	28·1	27·2	26·4	24·4	20·6	17·7
Fine sand	35·6	32·2	33·2	33·6	30·3	35·7
Silt	13·7	11·3	11·3	12·4	13·4	13·5
Clay	22·5	30·7	28·9	31·0	36·3	33·8
Organic carbon, C	0·28	0·21	0·18	0·13	0·14	0·12
Nitrogen, N	0·036	0·026	0·021	0·016	0·016	0·014
C/N Ratio	7·7	8·1	8·6	8·1	8·8	8·6
Calcium carbonate $CaCO_3$	<0·1	<0·1	<0·1	<0·1	<0·1	<0·1
Hydrochloric acid soluble:						
Phosphorus, P	0·009	0·008	0·007	0·006	0·006	0·007
Potassium, K	0·29	0·31	0·32	0·34	0·35	0·39
			millequivalents per 100g			
Cation Exchange Capacity	7·6	8·2	9·9	12·1	14·3	16·2
Exchangeable cations:						
Calcium, Ca	3·7	4·3	4·1	5·0	6·0	7·0
Magnesium, Mg	3·4	2·6	4·3	5·4	6·4	7·1
Potassium, K	0·45	0·25	0·25	0·40	0·45	0·40
Sodium, Na	0·05	0·05	0·10	0·20	0·35	0·45
Hydrogen, H (ph 7)	....	1·0	1·1	1·1	1·1	1·2
			parts per million			
Zinc, Zn (extractable)†	0·28	0·54	0·47	0·91	0·46	0·99

MINOR SOIL "B"

Depth (cm)	0–30	30–60	60–90	90–120	120–150	150–180
pH (1:5)	6·4	6·4	5·4	5·4	5·4	5·2
Mechanical analysis:			Less than 2 mm (per cent)			
Coarse sand	58·0	53·7	41·0	49·1	53·4	43·9
Fine sand	34·2	32·7	41·6	29·2	29·1	22·0
Silt	7·5	8·0	4·0	6·1	6·0	10·1
Clay	1·0	6·0	12·1	14·1	10·1	24·4
Organic carbon, C	0·09	0·08	NSS	0·07	0·07	0·08
Nitrogen, N	0·008	0·010	0·013	0·014	0·010	0·015
C/N Ratio	11·3	8·0	....	5·0	7·0	5·3
Calcium carbonate $CaCO_3$	<0·1	<0·1	NSS	<0·1	<0·1	<0·1
Hydrochloric acid soluble:						
Phosphorus, P	0·003	0·004	NSS	0·009	0·009	0·006
Potassium, K	0·04	0·08	NSS	0·24	0·14	0·28
			milliequivalents per 100g			
Cation Exchange Capacity	1·4	1·4	2·4	3·7	3·0	7·9
Exchangeable cations:						
Calcium, Ca	0·45	0·55	0·55	0·70	0·70	1·60
Magnesium, Mg	0·30	0·50	1·10	1·70	1·30	3·70
Potassium, K	0·05	0·10	0·20	0·20	0·15	0·10
Sodium, Na	<0·05	<0·05	0·05	0·05	0·05	0·75
Hydrogen, H (pH 7)	0·6	0·2	0·5	1·1	0·8	1·7
			parts per million			
Zinc, Zn (extractable)†	0·36	0·39	NSS	0·64	0·92	1·0

* Calcium + Magnesium reported by calculation—(Ca + Mg) = C.E.C. — (K + Na).

† Extractable Zinc was determined following the procedure of Trierweiler and Lindsay. Soil. Si. Soc. Amer. Proc. 33, 49–56 (1969)

There was no stone fraction in any of the samples.

N.S.S. = not sufficient sample.

10445/2/81—500

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