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THE LAND SYSTEMS OF THE DARWIN REGION

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Most of the field work for this survey was carried out prior to Cyclone 'Tracy' in 1974. Due to subsequent staff turnover, the report did not progress past an early draft stage for many years. However, due to continuing demand for the information contained in the report, it has been compiled with contributions by a number of authors other than those involved in the original survey. The report has been compiled and edited by P. Fogarty, K. Day and B. Wood, and included are individual papers by J.E. Lau, P. Fogarty and D. Sivertsen. Data gathering and mapping of land systems was carried out by D. Howe, B. Forster, K. Day, B. Wood and D. Sivertsen.

1.0 INTRODUCTION

This report documents a broadscale land resource inventory of the Darwin Region, and an evaluation of the capability of the land to support a number of forms of land use. The study serves as a basis for regional planning decisions and aims to promote land uses which accord with the continuing ability of the land to support them.

The foundation of the report is a classification of the survey area into Land systems. The utility of this system of classification follows from two premises (Austin and Basinski, 1978):

(i) that many land and soil attributes are interdependent and occur in closely associated sets. This means that attributes which can be identified on air photos can be used to predict the distribution of those attributes which can only be determined by field inspection. It also means that multi-attribute land classification provides a meaningful generalisation of land properties;

(ii) that land uses are strongly influenced by the interacting effects of many land attributes. Thus, to determine whether a parcel of land is suited to a particular use, it is important to have information on a range of land attributes.

A land system is defined as an area of land which has a distinctive and recurring pattern of landform, soils and vegetation. A land system is composed of a sequence of land units, the latter being relatively homogeneous in land attributes. While the land units within a land system may be markedly different (say, hillcrest and lower slopes), they are related geomorphically; that is, the formation of one is closely related to the formation of the other. The association of land units within the land system thus forms a predictable pattern, in terms of biophysical composition, distribution and relative proportion.

1.1 The Survey Area

The Darwin Region covered by this report has a total area of approximately 6 000 sq.km (see Figure 1). In general terms it includes the land east to the Adelaide River, west to include part of Finniss River Station, and south to latitude 13°S.

1.2 Previous Surveys

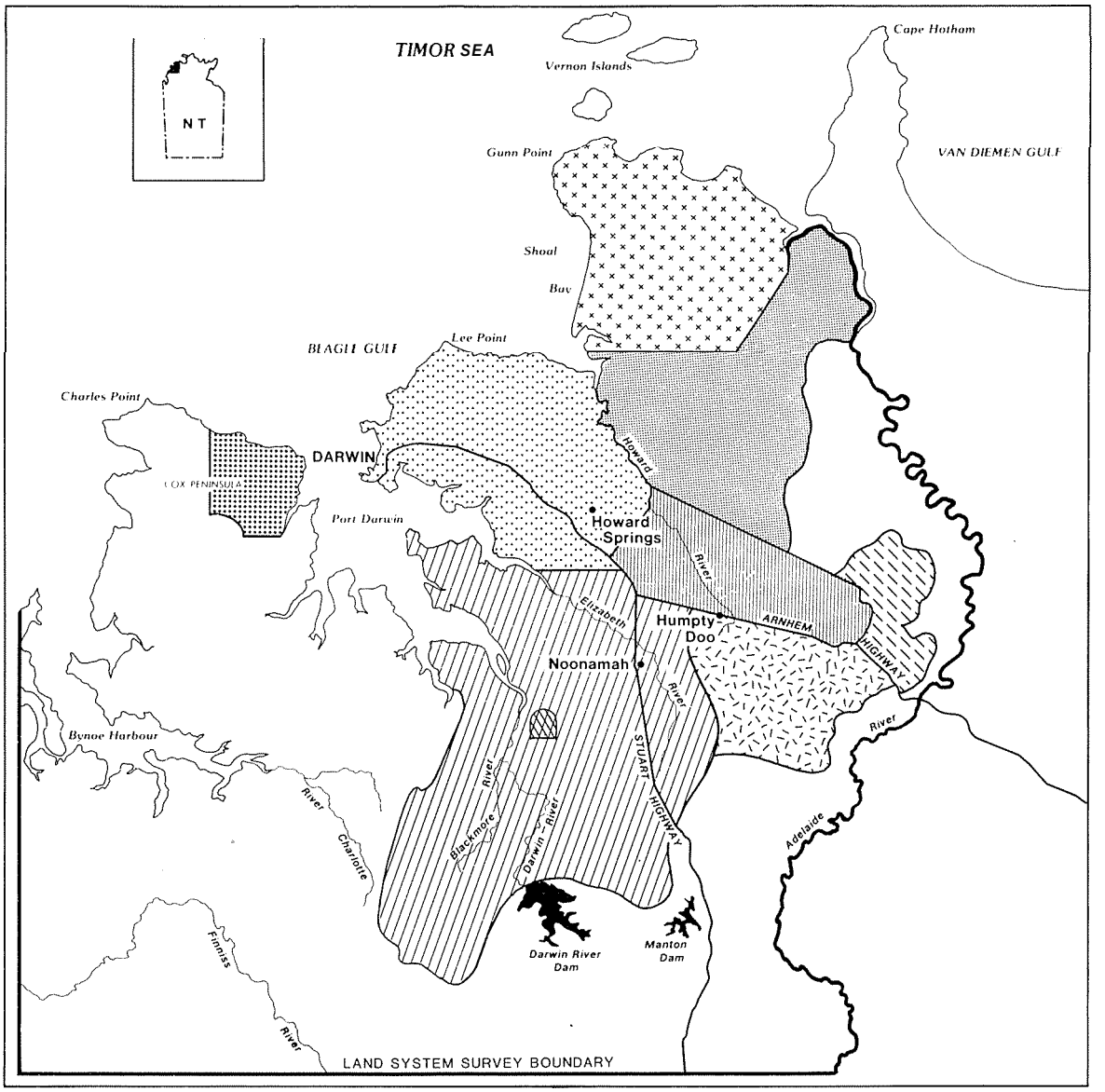
The survey area adjoins in the east the Adelaide-Alligator survey (Story et *al.*, 1969), of which the land system classification forms the basis for this survey.

Within the Darwin Region survey area a number of more detailed *land* unit surveys have been carried out, covering much of the area affected by the spreading rural-urban fringe. They cover a total of approximately 1 900 sq.km (see also Figure 1).

1.3 Survey Procedure

Following the acquisition of any available biophysical information relevant to the survey area (for instance, geological maps, adjacent land system surveys), a preliminary interpretation of 1:80 000 scale, black and white aerial photos was carried out. This entailed a tentative delineation of land systems. Sample sites were then selected for field investigation. Sampling aimed to check the reliability of the preliminary land system boundaries marked on the air photos and to determine the exact nature of a range of

FIG. 1: The area covered by this land systems survey, and more detailed land resource surveys in the Darwin region.



LEGEND

GUNN POINT LAND **UNIT** MAPPING

LAND UNITS OF AN AREA ON **KOOLPINYAH** STATION

LAND UNITS OF THE HOWARD SPRINGS - **HUMPTY-DOO** AREA

LAND UNITS OF THE **LAMBELLS** LAGOON-MIDDLE POINT AREA

LAND RESOURCES OF THE ELIZABETH, DARWIN AND BLACKMORE RIVER CATCHMENTS

LAND UNITS OF MANDORAH-COX PENINSULA

LAND RESOURCES OF THE DARWIN AREA

LANDRESOURCES OFTHEHUMPTY-DOOAREA

LAND RESOURCES OF BERRY SPRINGS NATURE RESERVE AND PROPOSED DEVELOPMENT AREA

N

Scale

0 5 10 15 20

kilometres

Table 1: Definition and physical requirements of land uses considered in the report.

Land Use	Definition	Optimum Physical Requirements
Urban Subdivision	Intensive subdivision into small blocks; provision of secondary roads, underground utilities, stormwater drainage	Flat to gently sloping land; good drainage and no flooding, moderately deep to deep and readily excavated soil, no extensive outcrop
Rural Living	Subdivision into 2.5–20ha blocks, for rural living (as opposed to cultivation)., selective clearing.	Flat to gently sloping land; good to moderately good drainage; no extensive rock outcrop (N.B. whole block need not satisfy these requirements, but a significant proportion should comply).
Cultivation	Intensive horticultural and agricultural development on blocks between 5 and 50 ha; extensive clearing.	Flat to gently sloping land; no flooding; deep to moderately deep freely drained soils, gravel free; no outcrop (N.B. whole block need not satisfy these requirements, but a significant proportion should comply).
Improved Pasture	Pasture improvement on blocks over 20 ha, for hay production and/or intensive grazing; extensive or selective clearing.	Flat to gently sloping land; no flooding; moderately deep to deep soils with no or low gravel content; minor or no outcrop.

biophysical attributes in each land system. Sampling continued until it was possible to account for the variation in land, soil and vegetation attributes in the survey area.

Following the field work, land system boundaries were adjusted where necessary, and the site data sorted to formalise land system descriptions.

1.4 Data Presentation

In land system surveys, information is presented at two levels of resolution: mapped information at the broader land systems level and descriptive information at the land unit level. Information is presented for each unit on landform, soils, vegetation structure and composition, and the proportion of each unit in the land system. An assessment has also been made of the capability of each unit for urban subdivision, rural living, intensive agriculture and pasture improvement. However, as the aim of the survey was to provide broad-scale land resource information over a large area, it is land systems which have actually been mapped, at a scale of 1:100 000.

1.5 Land Evaluation

Land evaluation is the process of analysing and expressing the effect which natural land characteristics have on the ability of land to support usage (Howe *et al.* 1979). This is achieved by rating the component land units of each land system in terms of their capability for a number of land uses.

The derivation of capability ratings is based on identification of the soil and land properties which have a bearing on the particular land use. These include for example, soil depth, stone and gravel content of the soil, site drainage, and slope gradient. Rating tables have been devised in which these physical properties are subdivided into classes which correspond to three levels of capability: high (C_1), moderate (C_2 and low or no capability (N). They are derived from similar studies by Howe *et al.* (1979), Woodward and Neilson (eds, 1981) and Fogarty et *al.* (1984). The capability for each land unit is determined by the most limiting physical property.

Land evaluation here is derived only from land resource data, and therefore does not provide an absolute measure of land suitability as factors other than physical ones may also influence decisions on land use allocation. Further, limitations may be overcome by capital inputs, although this is not necessarily practical or feasible.

Summaries of the land evaluation assessments are presented in the land system descriptions in Chapter 2. They show the capability rating for urban subdivision, cultivation, intensive pasture improvement and also identify the limitations to each land use. Table 1 indicates briefly the features of each land use which have been considered in this analysis. It will be noted that most land uses have similar requirements, with the implication that the same land units will have a similar capability for a range of uses. This reflects the climate - soil inter-relationships of the seasonal tropics, whereby heavy seasonal rainfall results in only very shallow and gravelly soils occurring on slopes of greather

than 3–5%. This contrasts sharply with temperate regions.

Land resource information can also be used to determine capability for other forms of land use. To do this, it is necessary first to define the physical requirements of the particular form of land use, then to compare with the land unit descriptions in Chapter 2, which pertain to the area of concern.

2.0 LAND SYSTEM DESCRIPTION

This section presents a tabular description of each land system, documenting in summary form, geology, landform, soils, vegetation and land capability as they occur in each land unit. A general summary of land capability for the land system as a whole is presented at the base of each description. Schematic block diagrams illustrate the landform and geology, and show the relationship between the land units which comprise each land system. The land systems have been arranged in alphabetical order, which to some extent, reflect their geomorphic relationships. For instance, the land systems whose names start with 'K' are all related to the Koolpinyah surface (see Section 4.2), while the coastal plains start with the letter 'C'.

The terminology used is that of McDonald *et al.* (1984).

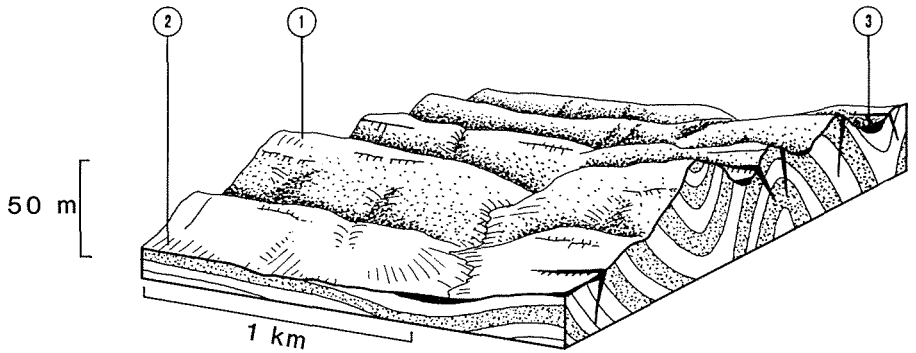
Areas of land systems outlined in this Section are included as Table 2.

Table 2: Areas of land systems of the Darwin Region.

Land System		Sheet:	1	2	3	4	Total Area
			Square Kilometres				
Dissected Foothills							
Baker	(B)			427.0		82.8	509.8
Bend	(Be)			234.3		52.9	287.2
Bustard	(Bs)		6.7	642.8			649.5
Rumwaggon	(Rw)			220.6		24.1	244.7
Granite and Dolomite Lowlands							
Gully	(Gu)			109.0			109.0
Grappa	(Gr)			313.4			313.4
Gecko	(Gc)			164.5			164.5
Woodcutter	(Wc)			58.6			58.6
Koolpinyah Surface							
Kay	(K)		401.3	285.1	84.6	10.8	781.8
Keating	(Ke)		92.0	50.7	35.4	95.1	273.2
Krans	(Kr)		90.8	145.0		18.9	254.7
Keefers Hut	(Kf)		92.0	221.0	12.6		325.6
Knifehandle	(Kn)		28.0	45.2	25.7	16.9	115.8
Kosher	(Kh)		61.3	9.4	38.9	90.3	199.9
Krokane	(Kk)		60.9	24.6	4.5	20.0	110.0
Kapping	(Kp)			47.0			47.0
Alluvial Plains							
Effington	(Ef)		12.3	34.8		7.3	54.4
Fabian	(Fb)		1.6	74.3			75.9
Flatwood	(Fw)			35.4		55.4	90.8
Coastal Plains							
Cyperus	(Cp)		9.7		135.5	190.6	335.8
Copeman	(Cm)			27.5		12.5	40.0
Littoral	(L)		269.0	326.7	95.3	12.9	703.9
Paludal	(Pa)			35.8			35.8
Pinwinkle	(Pw)		9.0	67.7	16.7	13.3	106.7
						Total	5,888.0

BAKER LAND SYSTEM (B)

Rugged dissected uplands with generally strike aligned ridges, intervening narrow valleys and short lower slopes; developed on siltstone, quartz greywacke, quartzite and minor conglomerates of Lower Proterozioc formations; shallow lithosols and outcrop; eucalypt woodland.



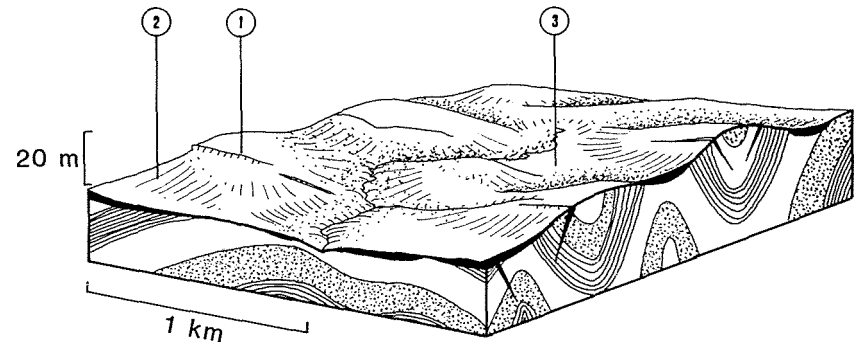
☐ LOWER PROTEROZOIC SEDIMENTS ALLUVIUM & COLLUVIUM

Unit	%	Landform	Soils	Vegetation	Capability Urban	Arable	Pasture
					N	N	N
B1	70	Steep hillslopes and ridges, isolated lower hills, usually strike-aligned; commonly 10-30 m high, less freqently over 50 m; slopes to 40%; rocky frequent outcrop; very rapid drainage.	Shallow lithosols (L1) and outcrop.	Woodland (*E.* dicromophloia, *E.bleeseri*, E. miniata, E. tetrodonta, E. tectifica, E. foelscheana) with a low tree understory (*Terminalia ferdinandiana*, Xanthostemon, Owenia vernicosa) and shrub layer (*Grevillea* decurrens, Livistona *humilis, Cochlospermum* fraseri, Cycas *armstrongii*).	Steep slopes, shallow soils, outcrop.		
B2	15	Gentle lower slopes below ridges; gently concave; relief to 10 m; slopes less than 8%; minor outcrop of rock and of laterite (lower in unit); moderately rapid drainage.	kloderately deep lithosols (L1) and moderately deep yellow massive earths (M2).				
					N	N	N
B3	15	Narrow linear alluvial flats between ridges; slopes generally less than 2%; slow drainage.	Moderately deep hard mottled yellow duplex soils.	Open woodland (E. bigalerita, E. alba var. australasica, E. polycarpa, *Lophostemon*) or perennial grassland (*Themeda australis*, *Eriachne* burkittii, Germania grandiflora); scattered to dense suckers (Lophostemon, Welaleuca *viridiflora*).	Site drainage.		

Low capability for urban, arable or pasture development due to extent of steep terrain and very shallow stony soils.

BEND LAND SYSTEM (Be)

Low ridges and hills of Lower Proterozoic siltstone, sandstone and quartz, with minor alluvial flats and stream lines; lithosols and shallow mottled yellow duplex soils; eucalypt woodland, with grassland on drainage lines.



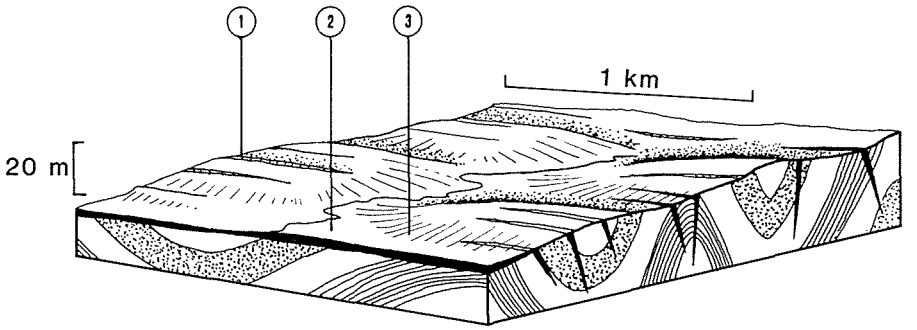
ALLUVIUM & COLLUVIUM LOWER PROTEROZOIC SEDIMENTS

Unit	%	Landform	Soils	Vegetation	Capability Urban	Arable	Pasture
					N	N	N
Be1	60	Upper slopes and crests of low, strike-aligned hills; commonly less than 15 m high; slopes to 10 m; scattered outcrop; rapid drainage.	Shallow lithosols (L1), minor moderately deep lithosols (L2), shallow yellow massive earths (M2).	Woodland (*E.* bleeseri, E. *miniata*, *E.* tectifica, E. tetrodonta, E. *clavigera*, Erythrophleum) with scattered low trees (*Terminalia* ferdinandiana, Xanthostemon, Gardenia megasperma, Acacia sp.) and shrubs (Cycas, Grevillea decurrens, Livistona *humilis*, Cochlospermum fraseri); sparse to mod. dense perennial grasses (Eriachne *avenacea*, Heteropogon triticeus, *Plectrachne pungens*, Sorghum *plumosum*).	Very gravelly shallow soils.		
					C_2	N	C_2
Be2	25	Gentle lower slopes below Bel; up to 400 m wide; relief to 5 m; slopes to 5%; infrequent laterite benches and pavements low in unit; rare rock outcrop; moderately rapid drainage.	Nod. deep (L2) lithosols, gravelly yellow massive earths (M2).	Woodland (Erythrophleum chlorostachys, E. miniata, E. tetrodonta, E. *clavigera*) with scattered low trees (*Terminalia* ferdinandiana, Gardenia *megasperma*, Acacia sp.) and shrubs (Cycas, Livistona *humilis*, *Pandanus* sp.); perenial grasses (Sorghum *plumosum*, Heteropogon triticeus, *Plectrachne pungens*).	Shallow gravelly soils		
					N	N	N
Be3	15	Alluvial flats, rarely channelled, to 500 m wide; slopes generally less than 2%; slow drainage.	Hard mottled yellow duplex soils (D3a, D3b).	Perennial grassland (Eriachne *burkittii*, Themeda australis, *Allotheropsis semialata*) with scattered trees (*E.* polycarpa, E. papuana, Nelaleuca viridiflora) and shrubs (*Grevillea* pteridiifolia, *Pandanus* sp.).	Site drainage		

Mostly low capability for urban, arable and pasture development due to very gravelly, shallow soils.

BUSTARD LAND SYSTEM (Bs)

Very low ridges and hills on Lower Proterozoic sediment and intervening alluvial flats; shallow and moderately deep lithosols with minor shallow yellow massive earths and earthy sands; eucalypt woodland, open woodland and low open woodland, shrubland to grassland on alluvial flats.



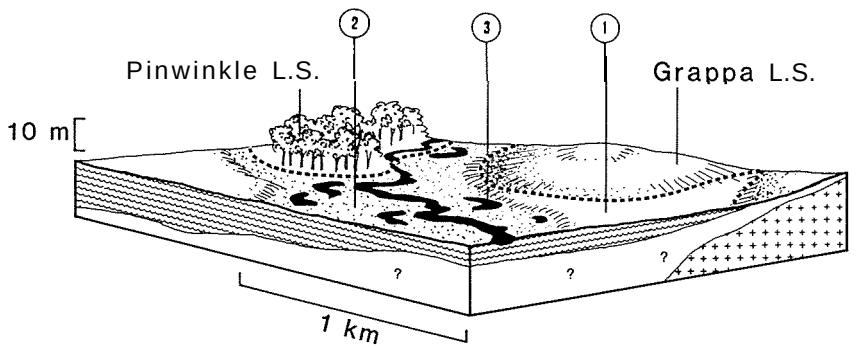
ALLUVIUM & COLLUVIUM ☐ LOWER PROTEROZOIC SEDIMENTS

Unit	%	Landform	Soils	Vegetation	Capability Urban	Arable	Pasture
					C_2	N	C_2
Bs1	70	Gently undulating upland plains interspersed with low linear stoney (quartz) and gravelly ridges; laterite and quartz outcrop common on ridges; relief to 8 m; slopes to 6%; rapid drainage.	Moderately deep lithosols (L2); less common shallow yellow massive earths (M2).	Extremely variable; woodland or open woodland (E. tetrodonta, E. miniata, E. bleeseri, E. confertiflora) with scattered shrubs (Livistona *humilis*, *Grevillea* decurrens, Acacia sp.) and suckers (Eucalyptus spp., *Erythrophleum*, Petalostigma) with scattered shrubs and suckers as above; or low shrubland (Eucalyptus spp., *Xanthostemon paradoxus*, Buchanania and Erythrophleum suckers, Petalostigma).	Very gravelly soils, outcrop.		
					N	N	N
Bs2	25	Alluvial flats to 200 m wide generally non-incised; very slow drainage.	Hard mottled yellow duplex soils (D3a), earthy sands (S1a) co-dominant.	Perennial grassland (*Eriachne* burkittii, Themeda australis, *Alloteropsis semialata*) with scattered shrubs (Lophostemon lactifluus, *Melalecua* viridiflora, Grevillea pteridiifolia).	Site drainage.		
					N	N	C_2
Bs3	5	Gentle lower slopes, occasionally between Bsl and Bs2; relief less than 5 m; slopes to 3%; slow drainage.	Hard mottled yellow duplex soils (D2), niinor gravelly yellow massive earths (M2).	Woodland (*E.* polycarpa, Lophostemon) with low tree understory (*Petalostigma*, *Banksia* dentata, Owenia *vernicosa*) and scattered shrubs (Melaleuca dealbata, M. viridiflora, Grevillea pteridiifolia); perennial grasses (Themeda australis, Sorghum plumosum, Eriachne avenacea).	Site drainage.		

Moderate capability for urban and pastoral development on upland areas; remainder subject to wet season waterlogging.

COPEMAN LAND SYSTEM (Cm)

Low swampy coastal plains, freshwater over estuarine clays, black cracking clays over saline muds; grassland

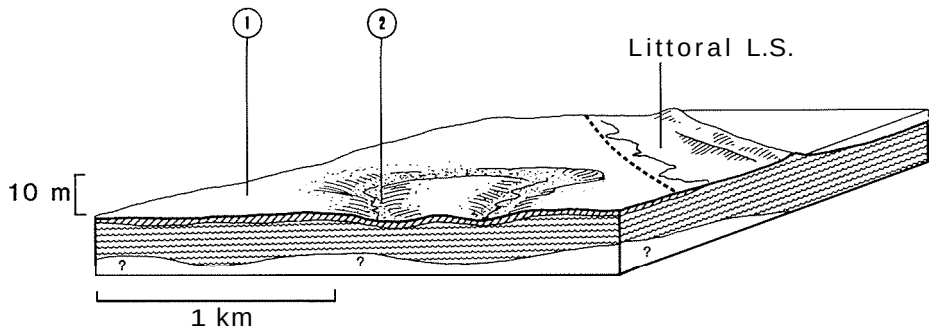


Unit	%	Landform	Soils	Vegetation	Capability Urban	Arable	Pasture
					N	$N(C_2)$*	$N(C_2)$*
Cm1	70	Slightly elevated clay plains to 1 km wide; slopes less than 0.4%; flooded most of wet season and subsequent months.	Massive cracking clays, usually carbonate rich.	Perennial grassland (Imperata, Coelorhachis, Germania, Ectrosia leporina, *Fimbristylis*, Cyperus, Phyla); scattered clumps of *Melaleuca* viridiflora.	Site drainage (except for rice).		
					N	N	$N(C_2)$*
Cm2	20	Lower plains, to 0.75 km wide; slopes less than 0.3%, with scattered depressions; very slow drainage, flooded well into dry season.	Black massive cracking clays.	Short perennial grassland as for Pal and Pa2.	Site drainage.		
					N	N	N
Cm3	10	Waterfilled billabongs and channels.	-	Vegetation as for Pal, clumps of Relaleuca spp. and *Pandanus* spp.	Site drainage.		

Low capability for development due to wet season inundation "(except for specific agricultural or pastoral uses, e.g. rice).

CYPERUS LAND SYSTEM (Cp)

Seasonally flooded coastal plains, estuarine clays overlain by freshwater clays; black massive cracking clays over predominantly saline muds; sedgeland, reedland and grassland; extensive bare areas.



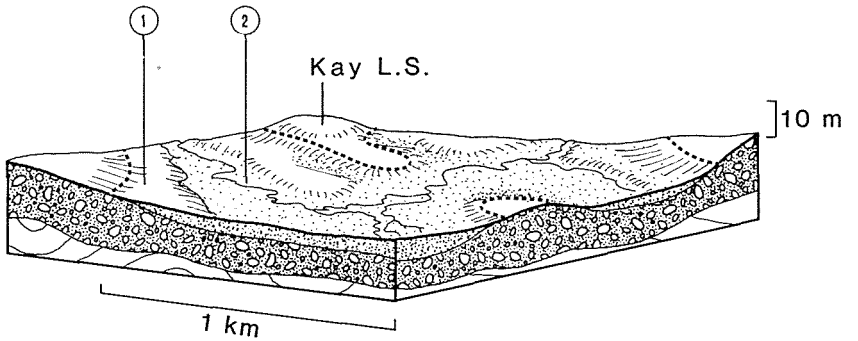
MODERN SOLUM MARINE ALLUVIUM

Unit	%	Landform	Soils	Vegetation	Capability Urban	Arable	Pasture
					N	$N(C_2)$*	$N(C_2)$*
Cpl	70	Slightly elevated, seasonally dry plains; slopes commonly 0-1%; relief usually less than 1 m; infrequent ancient dune lines subparallel to coastline.	Black massive cracking clays, usually carbonate-rich, more alkaline at depth (C_2).	Sedgeland and reedland (Eleocharis, Scleria poaeformis, Typha *domingensis*); scattered herbs (Phyla *nodiflora*, *Monochoria* vaginata); minor areas of grassland (*Diplachne parviflora*, Xerochloa *imberbis*); bare areas over small proportion.	Site drainage		
					N	N	N
Cp2	30	Low poorly drained plains; commonly channelled; scattered muddy depressions.	Black massive cracking clays (C_1, C_2).	Bare; minor patches of vegetation as for Cpl.	Site drainage		

Low capability for development due to wet season and permanent inundation, *(except for specific agricultural or pastoral uses, e.g. rice)

EFFINGTON LAND SYSTEM (Ef)

Flood plains of dominantly sandy alluvium immediately adjacent to upland surface; earthy sands and siliceous sands; tall shrubland



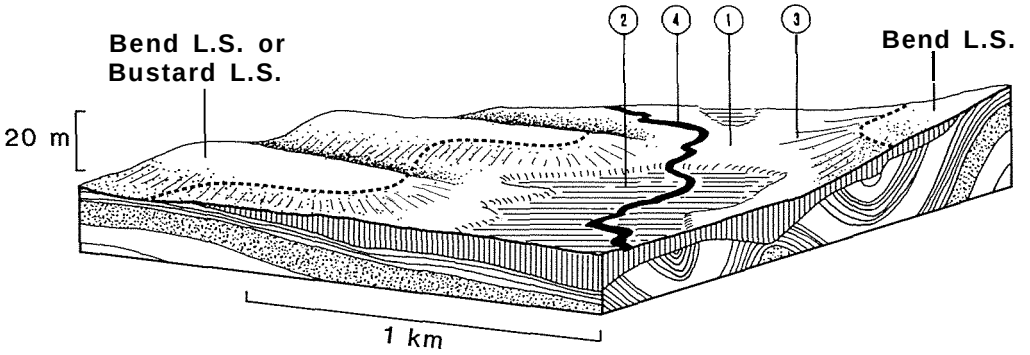
SANDY ALLUVIUM — TERTIARY SANDS & GRAVELS

Unit	%	Landform	Soils	Vegetation	Capability Urban	Arable	Pasture
					N	N	N
Ef1	60	Flood plains and gentle lower sandy slopes below Kay and Keating land systems; relief to 3 m; slopes commonly less than 2.5%; minor areas of laterite pavement; slow drainage.	Siliceous sands (S2a, S2b) and earthy sands (S1a, S1b) co-dominant.	Tall shrubland (*Grevillea* pteridii-folia, Verticordia cunninqhamii, *Melaleuca* sp., *Banksia*, Pandanus); tall shrubland (*Jacksonia dilatata, Calytrix* exstipulata, Acacia sp.) on lower slopes; annual grasses (*Sorghum* sp., Eriachne *triseta*) and perennial grasses (Pseudopoqonatherum *contortum*, *Eriachne* schultziana, *Paspalum orbiculare*).	Site drainage.		
					N	N	N
Ef2	40	Lower active flood plains up to 1.5 km wide, but commonly 0.5 km; relief to 2 m; slopes commonly less than 2% but locally to 4%; stream courses to 5 m wide, usually meandering; associated low levees.	Siliceous sands (S2a) and earthy sands (S1a) co-dominant; less frequent hard mottled yellow duplex soils.	Tall shrubland as for flood plains of Ef1 with scattered E. polycarpa, *Lophostemon*, *E.* papuana; grasses as for Ef1.	Site drainage.		

Low capability for development due to wet season inundation.

FABIAN LANE SYSTEM (Fb)

Broad alluvial flood plains; hard mottled yellow duplex soils; few erosional rises developed on Lower Proterozoic rocks; perennial grassland

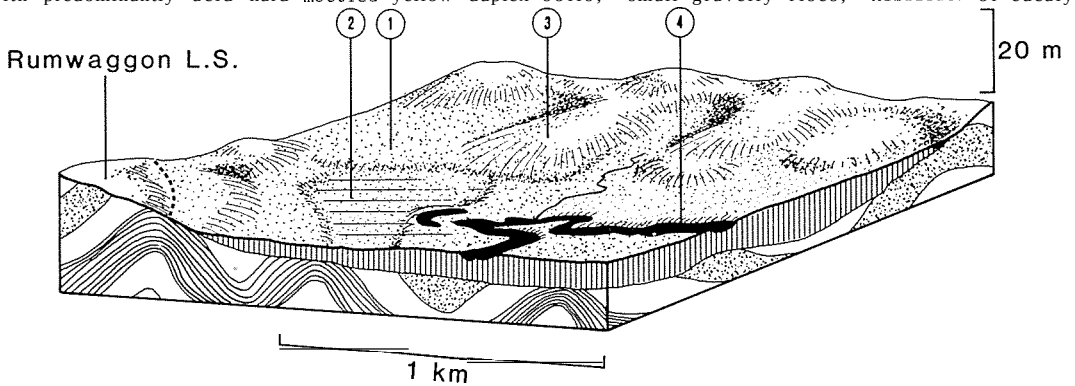


Unit	%	Landform	Soils	Vegetation	Capability Urban	Arable	Pasture
					N	$N(C_2)$*	$N(C_2)$*
Fhl	30	Broad, slightly elevated flood plains to 800 m wide; slopes commonly below 1%, relief to 3 m.	Acid hard mottled yellow duplex soils (D3), minor alkaline duplex soils (D4).	Perennial grassland (Chyrosopogon setifolius, Eriachne burkittii, *Themeda australis*, Alloteropsis *semi*-alata, Eragrostis sp.); minor sedges (Fimbristylis sp., Haemodorum sp.); widely scattered E. polycarpa and low *Terminalia fitzgeraldii* and *Melaleuca viridiflora*; minor areas of woodland or open woodland as for Fwl.	Site drainage.		
					N	$N(C_2)$*	$N(C_2)$*
Fb2	50	Poorly drained, almost level depressions within Fbl; slopes less than 0.5%; scattered billabongs.	Alkaline hard mottled yellow duplex soils (D4).	Perennial grassland as for Fbl, with more sedges and less Themeda; trees absent.	Site drainage		
					C_2	N	C_2
Fb3	10	Low gravelly rises; relief to 8 m; slopes less than 4%; moderately rapid drainage.	Noderately deep lithosols (L2); gravelly yellow massive earths (M2).	Woodland or low woodland as for Rwl.	Shallow gravelly soils.		
					N	N	N
Fb4	10	Stream courses and minor channels; weakly developed levees and infrequent billabongs.		Variable, as for Fw4			

Generally low capability for development due to wet season inundation "(except for some specific agricultural or pastoral uses, e.g. rice)

FLATWOOD LAND SYSTEM (Fw)

Broad alluvial flood plains with predominantly acid hard mottled yellow duplex soils; small gravelly rises; Melaleuca or eucalypt woodland or open wood-land.



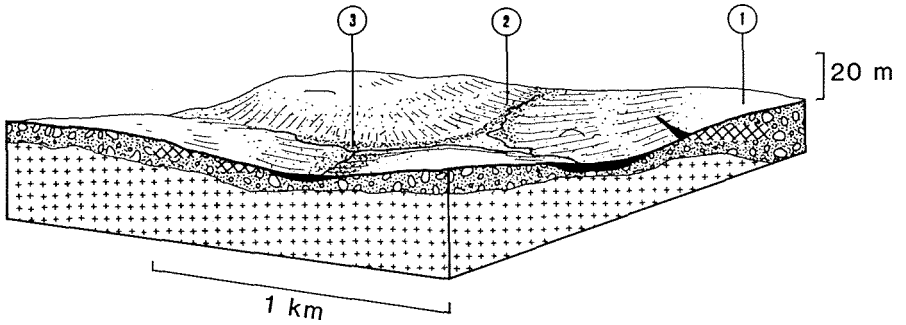
ALLUVIUM LOWER PROTEROZOIC SEDIMENTS

Unit	%	Landform	Soils	Vegetation	Capability Urban	Arable	Pasture
					N	$N(C_2)$*	$N(C_2)$*
Fwl	50	Slightly elevated alluvial plains, up to 500 m wide; slopes less than 2%; relief to 3 m; slow drainage.	Acid hard apedal mottled yellow duplex soils (D3).	Woodland or open woodland (E. polycarpa, E. papuana, E. foelscheana, lactiflua, Erythrophleum) with *Pandanus* and many suckers (Lophostemon sp., Eucalyptus sp., Erythrophleum, Eugenia *bleeseri*); perennial grasses (Themeda *australis*, Sorghum *plumosum*, Coelorhachis, Imperata).	Site drainage.		
					N	$N(C_2)$*	$N(C_2)$*
Fw2	25	Poorly drained lower plains, adjacent to Fwl; up to 250 m wide; slope less than 0.5%.	Acid hard mottled yellow duplex soils (D3), minor alkaline hard mottled yellow duplex soils (D4).	Grassland as for Fbl and Fb2	Site drainage.		
					C_2	N	C_2
Fw3	20	Low gravelly rises; relief to 8 m; slopes below 4%; moderately rapid drainage.	Moderately deep lithosols (L2) and gravelly yellow massive earths (M2).	Woodland or low woodland as for Rwl.	Gravelly soils.		
					N	N	N
Fw4	5	Stream courses and scattered billabongs.	Deep alluvial yellow massive earths	Very variable, from grassland through tall shrubland (*Bambusaarnhemica*, *Pandanus* sp.) to woodland (Lophostemon, E. papuana, *Erythro*-phleum, E. polycarpa, *Pandanus* sp.); dense perennial grasses (*Coelorhachis*, Imperata, *Panicum*).	Flooding.		

Generally low capability for development due to wet season inundation "(except for specific agricultural or pastoral uses, e.g. rice).

GECKO LAND SYSTEM (Gc)

Gently undulating low hills, probably formed on granite, also minor sandstone and siltstone, and alluvium derived from these rocks, eucalypt woodland



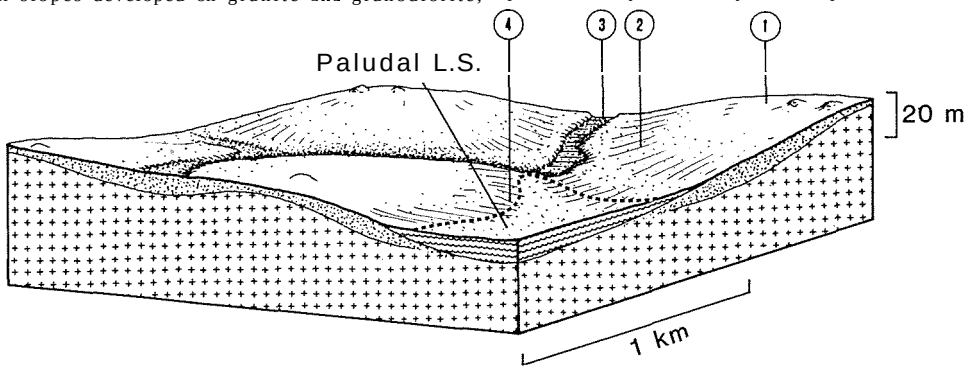
GRANITE LATERITE OUTCROP ALLUVIUM SANDS & GRAVELS

Unit	%	Landform	Soils	Vegetation	Capability Urban	Arable	Pasture
Gc1	60	Level to gently undulating surface; relief 8 m; slopes Lo 2.5%; minor laterite outcrop; rapid drainage.	Gravelly red massive earths (M1), sometimes shallow; minor lithosols (L2).	Woodland, minor open forest (E. tetrodonta, E. miniata, E. *bleeseri*) with a low tree understory (Xanthostemon, *Terminalia ferdinandiana*, Planchonia, Buchanania) and shrubs (*Livistona* humilis, Cycas, Persoonia, *Pachynema* dilatatum).	C_2 Shallow gravelly soils.	N	C_2
Gc2	25	Lower slopes; often gravelly; relief up to 10 m; slopes commonly 4% and locally to 7%; minor low laterite scarps at upper margin, occasional granite and sandstone outcrop; moderately rapid drainage.	Shallow and moderately deep lithosols (L1 and L4).	Woodland to open woodland (E. *confertiflora, Erythrophleum*) with low trees (Petalostigma, Planchonia) with shrubs; or low open shrubland (*Livistona humilis,* Petalostigma, Acacia gonocarpa, Pachynema dilatatum, *Persoonia*, Calytrix sp.); perennial grasses (Heteropogon triticeus, *Eriachne* avenacea, Plectrachne pungens).	C_2 Shallow gravelly soils.	N	C_2
Gc3	15	Sandy drainage floors to 200 m wide; channels frequently incised; poor drainage.	Fellow earthy sands (S1) and siliceous sands (S2); minor areas of friable apedal mottled yellow duplex soils (D5).	Grassland with Leptocarpus *spathaceus* or low woodland (Pandanus, Lophostemon, *Grevillea pteridiifolia*).	N Site drainage.	N	N

Moderate capability for urban and pastoral development; small areas waterlogged or inundated in wet season.

GRAPPA LAND SYSTEM (Gr)

Gently rolling hills, usually convex slopes developed on granite and granodiorite; predominantly mottled yellow duplex soils; tall shrubland (Livistona).



ALLUVIUM LITCHFIELD COMPLEX

Unit	%	Landform	Soils	Vegetation	Capability Urban	Arable	Pasture
Grl	60	Low rounded hill crests and upper slopes; relief 15 to 20 m; slopes to 3.5%; scattered massive granite outcrop; rapid drainage.	Shallow lithosols (L4) and shallow gravelly yellow duplex soils (D1).	Tall shrubland (Livistona humilis, Grevillea pteridiifolia) with scattered low trees (Xanthostemon, Petalostigma) and common low shrubs (Calytrix spp., Grevillea *angulata*); minor areas of low woodland (E. grandifolia, E. foelscheana, E. confertiflora) associated with granite outcrops.	C_2	N	C_2
					Gravelly shallow soils.		
Gr2	20	Sandy, convex wash slopes merging with Grl; relief to 10 m; slopes to 5%; moderately rapid drainage.	Gravelly, sandy mottled yellow duplex soils (D1) and shallow earthy sands (S1b) directly onto weathered granite.	Tall shrubland (Livistona *humilis*, Grevillea pteridiifolia) with widely scattered low trees (Xanthostemon, Nelaleuca viridiflora, Owenia *Vernicosa*) and common low shrubs (*Grevillea angulata*, G. dryandrii, Acacia gonocarpa) and suckers (*Syzygium* bleeseri, *Pandanus* sp.); rare *Pandanus* tall shrubland on lowest slopes.	C_2	A	C_2
					Eloderate slope gradients, gravelly soils.		

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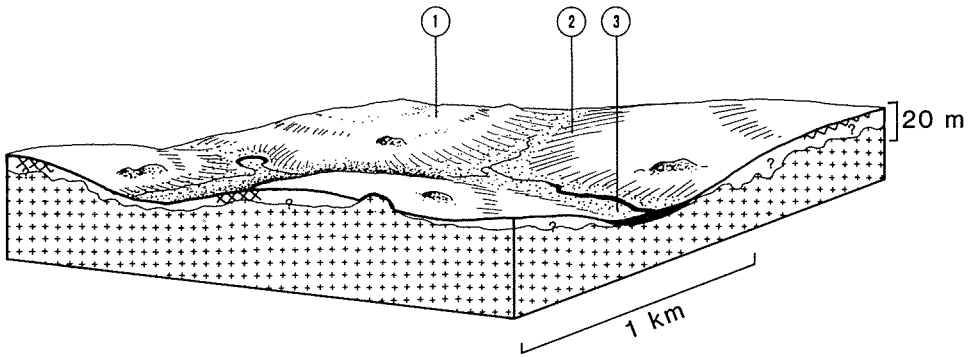
Unit	%	Landform	Soils	Vegetation	Capability		
					Urban	Arable	Pasture
					N	N	N
Gr3	10	Drainage floors commonly to 100 m wide, less frequently wider; axial slopes to 2%, essentially level cross section; rarely incised channels; slow drainage.	Predominantly hard mottled yellow duplex soils (D3a).	Low woodland or tall shrubland (Pandanus sp., Lophostemon, Grevillea pteridiifolia, *Metrosideros, Melaleuca viridiflora*); dense perennial grasses (Themeda australis, Germania *grandiflora*, Eriachne burkittii); or perennial grassland (Eriachne avenacea, E. burkittii, Chrysopogon setifolius, *Eragrostis* sp., *Fimbristylis* sp.).	Site drainage		
					N	N	N
Gr4	10	Concave fringing slope between Gr2 and Paludal land system. Relief to 4 m; slopes 3.5%; slow drainage.	Shallow friable mottled yellow duplex soils overlying granite (D5).	Grassland (Ectrosia leporina, *Pseudoraphis, Paspalum* sp., Brachiara sp.).	Site drainage		

Moderate capability for urban and pastoral development; minor areas subject to wet season flooding and inundation

GULLY LAND SYSTEM (Gu)

Undulating terrain developed on granite, schist, and gneiss; predominantly red massive earths and mottled yellow duplex soils; woodland (eucalypt and mixed).



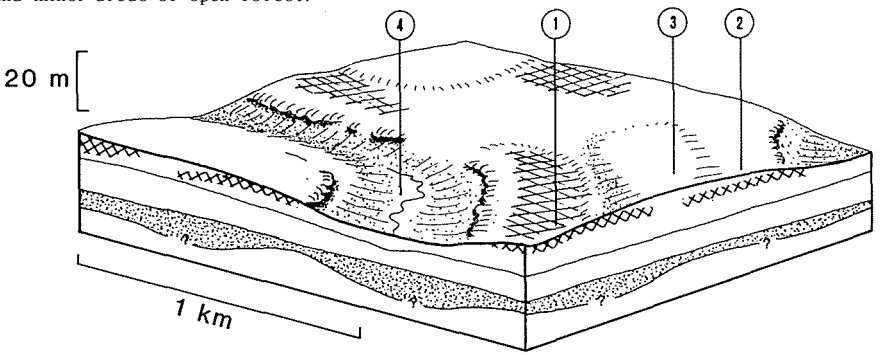
LATERITE OUTCROP RUM JUNGLE COMPLEX

Unit	%	Landform	Soils	Vegetation	Capability Urban	Arable	Pasture
Gu1	60	Broad low rises with usually level crests and convex margins; relief to 20 m; slopes to 5%; rare small depressions; laterite outcrop common across crests; minor granite outcrop; rapid drainage.	Gravelly red massive earths (M4); minor moderately deep lithosols (L3).	Woodland (E. confertiflora, E. foelscheana, Erythrophleum, Terminalia canescens) with low trees (*Petalostigma*, *Terminalia* ferdinandiana, Planchonia, Hakea *arborescens*) and widely scattered shrubs (*Livistona*, Acacia gonocarpa); perennial grasses (Heteropogon *triticeus*, Themeda *australis*, Sorghum *plumosum*).	C_2	N	C_2
					Outcrop, gravelly soils.		
Gu2	20	Colluvial foot slopes to Gu1; gently convex; relief to 15 m; slopes to 6%; occasional outcrop of massive rounded granite; slow drainage.	Hard, mottled yellow duplex soils, often gravelly and sometimes shallow (D1); minor red massive earths (M4).	Woodland as for Gu1.	C_2	N	C_2
					Drainage, gravelly soils.		
Gu3	20	Alluvial flats to 350 m wide; occasionally channeled; slopes less than 2%; very slow drainage.	Predominantly friable mottled yellow duplex soils (D3).	Grassland (*Eriachne* burkittii, Themeda australis, Panicum trachyrachis) with scattered trees (*E.* polycarpa, E. *papuana*, E. alba var. *australasica*, Lophostemon, *Melaleuca viridiflora*) and shrubs (Pandanus sp., *Grevillea pteridifolia*).	N	N	N
					Site drainage		

Moderate capability for urban and pasture development; minor areas subject to wet season waterlogging.

KAPPING LAND SYSTEM (Kp)

Broad, gently undulating upland surface; extensive laterite pavement and gravel veneer; shallow lithosols, minor gravelly yellow massive earths; low open shrubland to low open woodland and minor areas of open forest.



LATERITE PAVEMENT MESOZOIC SEDIMENTS

Unit	%	Landform	Soils	Vegetation	Capability Urban	Arable	Pasture
					N	N	N
Kpl	40	Almost level, extensive laterite pavement; relief less than 3 m; slopes less than 2%; rapid drainage.	Shallow - moderately deep lithosols (L3).	Low open shrubland to low shrubland (*Calytrix* exstipulata, Acacia spp., Verticordia cunninghamii, Grevillea pteridiifolia, G. *heliosperma, Melaleuca* viridiflora); scattered low trees (Acacia spp.).	Outcrop, shallow gravelly soil.		
					C_2	N	C_2
Kp2	30	Almost level to gently undulating plains; relief to 5 m; slopes to 3%; scattered laterite pavement and outcrop; rapid drainage.	Noderately deep lithosols (L3) and gravelly yellow massive earths (M5b).	Low open woodland (Acacia spp. Owenia vernicosa, *Terminalia* ferdinandiana, Petalostigma *quadriloculare, Planchonia*) with widely scattered emergent trees (E. confertiflora, Alstonia actinophylla), dense shrubs (*Livistona* humilis, Cycas armstrongii, *Grevillea* pteridiifolia) and suckers (Acacia sp., *Alphitonia*); sparse annual (Sorghum sp.) and perennial grasses (Heteropogon *triticeus*).	Gravelly soils.		
					C_1	C_2	C_1
Kp3	25	Almost level to gently undulating plains; relief to 5 m; slopes to 3%; occurs in association with Kp2; rare laterite outcrop; moderately rapid drainage.	Yellow massive earths, commonly moderately deep and gravelly (M5a).	Open forest (*E.* tetrodonta, E. *miniata*) with a second story tree layer (*Terminalia* ferdinandiana, *Syzygium subor*bicularis, Planchonia) and shrubs (*Grevillea* decurrens, Cycas armstrongii, *Pandanus* sp.) and suckers (Eucalyptus spp., Acacia spp.); annual grasses (Sorghum sp., Schizachyrium).	Gravelly soils, outcrop.		

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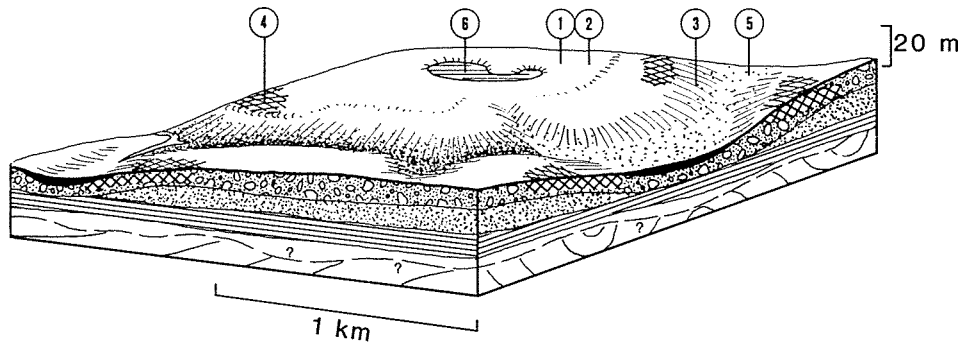
Unit	%	Landform	Soils	Vegetation	Capability Urban	Arable	Pasture
					N	N	N
Kp4	5	Alluvial flats and drainage floors to 200 m wide; rarely incised; marginal slopes less than 2%; slow drainage.	Siliceous sands and earthy sands co-dominant (S1, S2).	Grassland, tall open shrubland with Grevillea pteridiifolia, *Pandanus* sp., Nelaleuca viridiflora, Lophostemon lactifluus.	Site drainage.		

Moderate capability for urban, pastoral development; small areas have moderate capability for arable agriculture.

KAY LAND SYSTEM (K)

Level to very gently undulating upland terrain; red massive earths, often deep, and gravelly yellow massive earths; eucalypt tall open forest or Open forest.



LATERITE ALLUVIUM TERTIARY SANDS & GRAVELS MESOZOIC BEDS

Unit	%	Landform	Soils	Vegetation	Capability Urban	Arable	Pasture
					C_1	C_1	C_1
K1	40	Very gently undulating surface; width to 5 km; relief to 10 m; slopes to 2%; moderately rapid drainage.	Deep red massive earths (M3a); less common gravelly red massive earths (M4) and gravelly yellow massive earths (M5); well drained.	Tall open forest grading into open forest (E. tetrodonta, *E.* rniniata, Erythrophleum chlorostachys) with scattered low trees (Terminalia ferdinandiana, Xanthosternon, *Plan*-chonia, Buchanania) and shrubs (Cycas, *Pandanus* sp., Acacia spp.); perennial grasses (Heteropogon triticeus, Sorghum plumosum, Themeda australis, Chrysopogon latifolius, Imperata *cyl*-indricus) and annual grasses (Sorghum sp., *Schizachrium* fragile).			
					C_1	C_2	C_1
K2	30	Very gently undulating surface; gravelly surface; usually in association with K1 but sometimes occurring as lower wash slopes; relief to 15 m; slopes to 3%; commonly with pavement of rounded ironstone gravels; common laterite outcrop; rapid drainage.	Shallow gravelly yellow massive earths (M5); minor lithosols (L2).	Woodland with scattered low trees and open shrub layer (species as per K1); perennial grasses (*Eriachne* avenacea, Heteropoqon triticeus, Chrysopoqon latifolius, Sorghum *plumosum*) and annual grasses (Sorghum sp.).	Gravelly soils		

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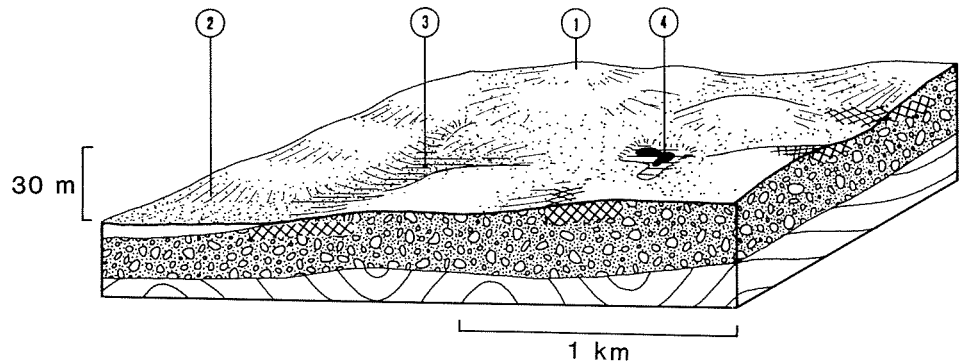
Unit	%	Landform	Soils	Vegetation	Capability Urban	Capability Arable	Capability Pasture
					C_1	C_2	C_1
K3	15	Gentle slopes to 200 m wide; relief to 25 m; slopes to 4.5%; moderately rapid drainage.	Deep red massive earths (M3a).	Tall open forest (*E.* tetrodonta) with subordinate trees (*E. miniata*) and scattered shrubs (Cycas armstrongii, Livistona *humilis, Pandanus* sp.); dense perennial grasses as for K1.		Slopes	
					C_2	N	C_2
K4	5	Laterite outcrop and gravelly slopes; slopes to 5%; moderately rapid drainage.	Shallow to moderately deep lithosols (L3).	Low open shrubland, low shrubland or low open woodland as for Kpl and Kp2.	Outcrop.	Gravelly shallow soils.	
					N	N	N
K5	5	Alluvial flats to 200 m wide; slopes to 2% at margins, axial slopes less than 1%; channels usually absent; slow drainage.	Siliceous sands (S2a, S2b) on margins; acid mottled yellow duplex soils (03) on plains; poorly drained.	Grassland as for Kn2		Site drainage.	
					N	N	N
K6	5	Isolated internal drainage depressions; wet season inundation.	Acid mottled yellow duplex soils; poorly drained (D3).	Grassland, *Melaleuca* open shrubland, or Melaleuca closed forest. As for Kk1.		Site drainage.	

High capability for urban, arable and pastoral development.

KEATING LAND SYSTEM (Ke)

Gently undulating, slightly dissected terrain with frequent remnants of Kay plateau surface; gravelly yellow and red massive earths; eucalypt open forest or woodland.



Unit	%	Landform	Soils	Vegetation	Capability Urban	Capability Arable	Capability Pasture
Ke1	55	Remnants of Kay plateau surface; gently undulating surface, relief to 20 m; slopes commonly less than 2.5%, locally to 5%. Occasional laterite outcrop, moderately rapid drainage.	Gravelly red massive earths (Mc) and gravelly yellow massive earths (MB) co-dominant; minor mottled red lithosols (L3).	Open forest, minor woodland (*E. tetrodonta, E. miniata, Erythrophleum chlorostachys, E. bleeseri, E. confertiflora*) with scattered lower trees (*Terminalia ferdinandiana, T. grandiflora, Syzygium suborbicularis, Acacia* sp., *Planchonia, Xanthostemon, Buchanania, Petalostigma*) and shrubs (*Cycas armstrongii, Livistona humilis, Acacia dimidiata, Persoonia, Pandanus, Petalostigma*). Dense perennial grasses (*Heteropogon triticeus, Chrysopogon latifolius, Sorghum plumosum, Eriachne avenacea*) and annual grasses (*Aristida* sp. and *Sorghum* sp.).	C_1 Gravelly soils.	C_2	C_1
Ke2	20	Shady and gravelly slopes to 250 m wide; relief to 15 m; slopes to 3 5%; infrequent laterite outcrop at lower margins; moderately rapid drainage.	As above.	Tall open forest (*E. tetrodonta, Erythrophleum chlorostachys, E. miniata*) with scattered low trees and shrubs as in Ke1; grasses as in Ke1.	C_1 Gravelly soils.	C_2	C_1

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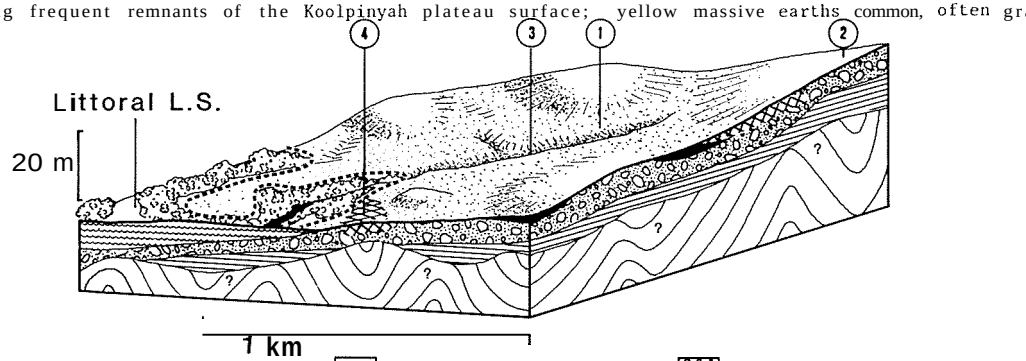
Unit	%	Landform	Soils	Vegetation	Capability Urban	Arable	Pasture
					N	N	C_2
Ke3	15	Alluvial flats with incised channels, up to 300 m wide; marginal slopes to 2%, axial slopes commonly less than 1%; slow drainage.	Silieous sands (S2), earthy sands (S1), mottled grey massive earths (M6) and minor mottled yellow duplex soils (D3).	Grassland as for Kn2; rare patches of evergreen tall closed forest.	Site drainage.		
					N	N	N
Ke4	10	Internal drainage depressions.	Friable mottled duplex soils (D5).	Grassland, *Melaleuca* open shrubland or *Melaleuca* closed forest as for Kkl.	Site drainage.		

Large areas have high capability for pastoral and urban development, and moderate capability for arable agriculture.

KEEFER'S HUT LAND SYSTEM (Kf)

Dissected, rolling terrain including frequent remnants of the Koolpinyah plateau surface; yellow massive earths common, often gravelly and shallow; eucalypt woodland or open forest.



Unit	%	Landform	Soils	Vegetation	Capability: Urban	Arable	Pasture
					C_2	N	C_2
Kf1	60	Gentle gravelly sideslopes, often to 300 m wide; relief to 20 m, slopes to 3.5%; scattered laterite outcrops, more common on lower slopes; rapid drainage.	Shallow gravelly yellow massive earths (M5) and mod. deep lithosols (L2).	Woodland (E. bleeseri, E. confertiflora, E. tetrodonta) with widely scattered low trees (Planchonia, Buchanania) and shrubs (Cycas, *Grevillea* decurrens) grading to low woodland (Melaleuca *viridiflora*) with scattered shrubs (Lophostemon lactifluus, Pandanus).	Shallow gravelly soils.		
					C_2	N	C_2
Kf2	20	Level margins and convex remnants of Kay plateau surface; relief to 10 m; slopes to 3%, locally up to 7%; scattered laterite outcrop, moderately rapid drainage.	Gravelly red massive earths, gravelly massive yellow earths (M4, M5b) and mod. deep lithosols (L2).	Tall open forest or open forest as for K1.	Very gravelly soils.		
					N	N	N
Kf3	10	Narrow drainage lines to 80 m wide; often incised channel; axial slopes to 2.5%; slow drainage.	Yellow earthy and siliceous sands, often gravelly (S1, S2); mottled grey massive earths (M6); minor yellow massive earths and mottled yellow duplex soils.	Open forest (*Melaleuca* cajuputi, *M.* dealbata, *Erythrophleum chlorostachys*, E. papuana) with *Pandanus* sp. understory along shallow creek lines, merging to woodland or open woodland (*E.* polycarpa, E. papuana, Planchonia, Lophostemon) away from creek lines; perennial grasses (*Coelorhachis*, Heteropogon, Imperata, Themeda).	Site drainage		

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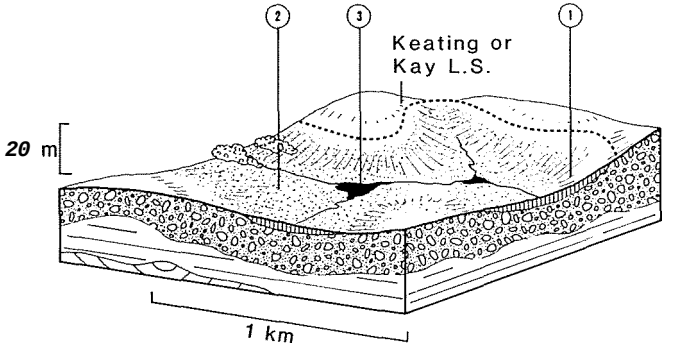
Unit	%	Landform	Soils	Vegetation	Capability Urban	Arable	Pasture
					C_2	N	C_2
Kf4	10	Outcropping laterite pavement and low benches with extensive ferruginous gravels; relief to 10 m; slopes about 3%; moderately rapid drainage.	Shallow to mod. deep lithosols (L1 and L2); minor shallow gravelly red massive earths and shallow gravelly yellow massive earths (M5).	Hid-High Woodland (*Erythrophleum* chlorostachys, E. confertiflora) with a second story tree layer (*Xanthostemon*, Buchanania, *Petalostigma*) and numerous shrubs (Cycas, *Xanthostemon*, Pandanus, *Melaleuca*); annual grasses (Sorghum sp.) and perennial grasses (Heteropogon triticeus, Chrysopogon *latifolius*).	Outcrop, shallow soils.		

Moderate capability for urban development and pastoral development; gravelly soils common.

KNIFEHANDLE LAND SYSTEM (Kn)

Broad shallow valleys with side slopes and drainage floors usually adjacent to or within Kay and Keating land systems; earthy sands and siliceous sands common; minor gravelly massive earths; eucalypt open forest, grassland, tall open shrubland and paperbark closed forest.



SANDY ALLUVIUM & COLLUVIUM

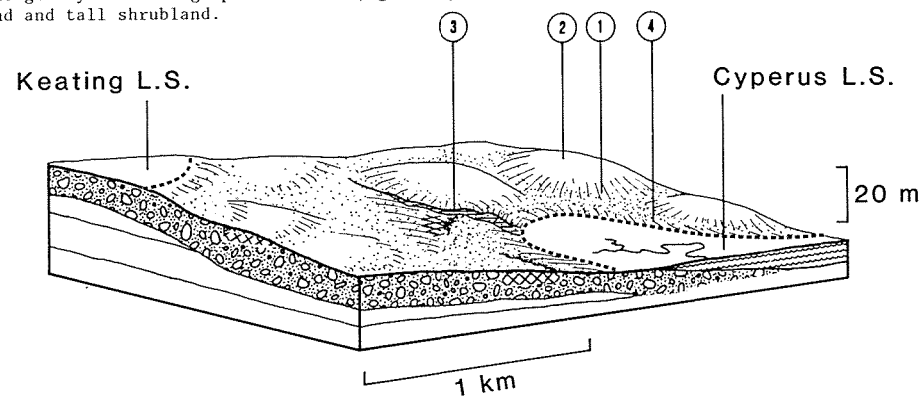
TERTIARY SEDIMENTS

Unit	%	Landform	Soils	Vegetation	Capability Urban	Arable	Pasture
					C_2	N	C_2
Kn1	45	Footslopes below Kay or Keating land systems; occasionally gravelly surface; relief to 15 m; slopes less than 4%; scattered laterite pavement and rubble low in unit; moderately rapid drainage.	Shallow gravelly red massive earths (M4); minor gravelly yellow massive earths (M5).	Open forest, rarely tall open forest; as for K3, K4 and Ke2.	Shallow gravelly soils.		
					N	N	C_2
Kn2	35	Alluvial floors to 300 m wide; axial slopes less than 1%, up to 2.5% on margins; infrequently incised channels.	Hard mottled yellow duplex soils (D3), minor earthy sands (S1a), sometimes shallow (S1b).	Grassland with annual grasses (*Sorghum* sp., Ectrosia *leporina*) and perennial grasses (Eriachne *burkittii*, Panicum, Coelorachis, *Pseudoraphis*, Themeda); minor sedges; often merging to tall open shrubland (Pandanus sp., Grevillea *pteridiifolia*, *Banksia* dentata, Lophostemon lactif*luus*, Verticordia *cunninghamii*).	Site drainage.		
					N	N	N
Kn3	20	Channelled drainage floors with widely scattered internally-draining depressions, sometimes with permanent water; sandy bed loads, small levee areas; very slow to ponded drainage.	Siliceous sands (S2a), earthy sands (S1a) and friable mottled yellow duplex soils (D5).	Paperbark closed forest (*Melaleuca* cajuputi, *M. viridiflora*); scattered evergreen tall closed forest (Acacia auriculiformis, Nelaleuca cajuputi, Carpentaria acuminata, Hydriastele) with dense lower trees (Nauclea *orientalis*) and dense ferns (*Blechnum* sp., Stenochleana *palustris*) and vines.	Site drainage		

Moderate capability for urban and pastoral development; limitations include wet season inundation, shallow and gravelly soils.

KOSHER LAND SYSTEM (Kh)

Sloping coastward margins of the gently undulating upland terrain; gravelly red massive earths, commonly shallow; earthy and siliceous sands; mixed closed forest and open forest, woodland and tall shrubland.



MARINE ALLUVIUM LATERITE OUTCROP TERTIARY SANDS & GRAVELS

Unit	%	Landform	Soils	Vegetation	Capability Urban	Arable	Pasture
Kh1	55	Lower sandy wash slopes; relief to 15 m; slope commonly less than 2.5% but locally to 5%; laterite pavement common in unit with scattered laterite rubble; slow drainage.	Red massive earths, sandy, usually gravelly and sometimes shallow (M3); less common earthy sands (S1b); minor mod. deep lithosols (L2, L3).	Semi-deciduous closed forest (*Melaleuca cajuputi, M. viridiflora, E. tetrodonta, Acacia auriculiformis, Bombax ceiba*) with dense low tree understory (*Lophostemon lactifluus, Alphitonia excelsa, Alstonia actinophylla, Planchonia, Strichnos lucida, Sterculia quadrifida*) and shrubs (*Acacia* sp., *Pandanus* sp.); rare minor grasses (*Aristida* sp.).	C_2	C_2	C_2
					Site drainage.		
Kh2	25	Low hills and gentle crests; usually gravelly; relief to 10 m; slopes less than 4%; common laterite outcrop and pavement; similar to Kel; well drained.	Shallow to moderately deep lithosols, minor shallow gravelly red massive earths (M4) and shallow siliceous sands.	Open forest to woodland with moderately dense low trees and shrubs as in Kel.	C_2	N	C_2
					Shallow gravelly soils, outcrop.		
Kh3	10	Drainage lines and floors to 80 m wide, occasionally channelled slopes to 2.3%; poor drainage	Earthy sands (S1a), some times with siliceous carbonate subsoil; friable mottled yellow duplex soils (D5).	Open forest (*Melalueca cajuputi*) with dense low tree understory (*Barringtonia acutangula, Timonius timon*).	N	N	
					Site drainage.		

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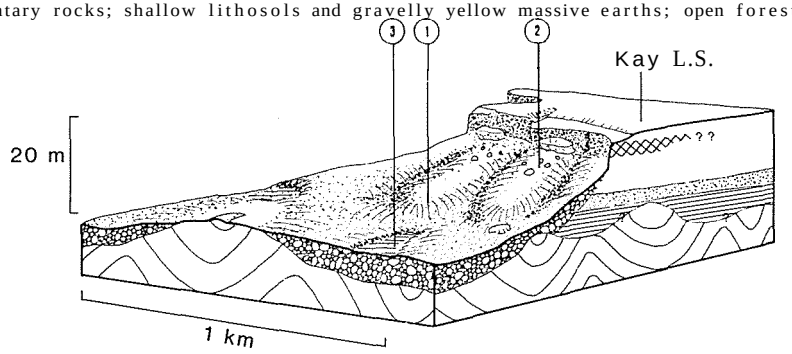
Unit	%	Landform	Soils	Vegetation	Capability Urban	Arable	Pasture
					N	N	C_2
Kh4	10	Sandy lower slopes, usually adjacent to Cyperus or Littoral land systems; up to 400 m wide; relief to 2 m; slopes less than 3%; laterite benches and pavement common; slow drainage.	Friable mottled yellow duplex soils (D5), earthy sands (S1) co-dominant.	*Pandanus* tall shrubland with widely scattered *Melaleuca viridiflora*; scattered grasses (*Eriachne burkittii*) and sedges (*Frimbristylis* sp.).	Site drainage.		

Large areas have moderate capability for urban, arable and pastoral development; wet season waterlogging the major limitation.

KRANS LAND SYSTEM (Kr)

Steep, dissected terrain, forming the edge of the Kay plateau, in places, developed on Lower Cretaceous sandstone and shale, and occasionally on underlying Lower Proterozoic sedimentary rocks; shallow lithosols and gravelly yellow massive earths; open forest or tall open forest.



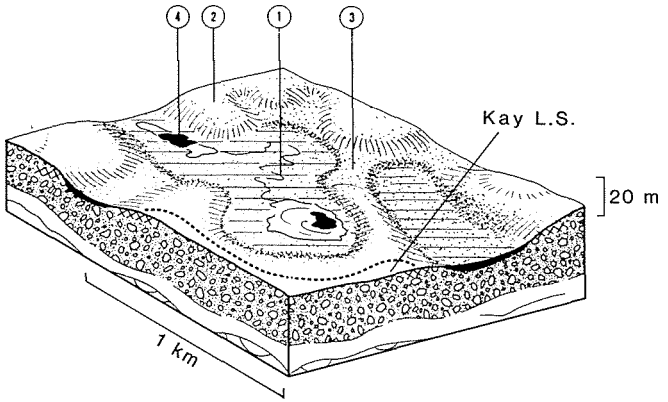
LATERITE OUTCROP MESOZOIC BEDS COLLUVIAL WASH LOWER PROTEROZOIC SEDIMENTS

Unit	%	Landform	Soils	Vegetation	Capability Urban	Arable	Pasture
Kr1	60	Gentle gravelly sideslopes and low rises; relief to 15 m; slopes to 5%; rapid drainage.	Gravelly yellow massive earths (M5); minor shallow lithosols (L1, L3).	Woodland to open woodland, (E. tetrodonta, E. miniata, E. *bleeseri*) with scattered low trees (Planchonia, Xanthostemon, *Terminalia ferdinandiana*) and common shrubs (*Cycas*, Livistona humilis, Grevillea *ducrrens*).	C_2 Very gravelly soils.	N	C_2
Kr2	30	Upper scree slopes; stony, strewn with laterite boulders and outcrop; often bounded upslope by laterite scarps to 5 m high. Relief to 25 m; slopes commonly 10% but locally to 40%; commonly gullied; infrequent rock outcrop.	Shallow lithosols (L1).	Woodland or open forest (E. tetrodonta, E. *miniata*, Erythrophleum, E. bleeseri) with scattered low trees (*Planchonia*, *Exocarpos* latifolius, *Xanthostemon*, Acacia sp.) and shrubs (*Livistona humilis*, *Cycas*).	N Rock outcrop, shallow gravelly soils.	N	N
Kr3	10	Gullies and alluvial drainage floors to 60 m wide; axial slopes to 4%, almost level cross sections; indistinctly channelled; slow drainage.	Noderately deep mottled yellow duplex soils (D3).	Woodland to open woodland (Lophostemon lactifluus, E. clavigera, *Erythrophleum*) with shrub understory (Pandanus sp., *Cycas*); perennial grasses (Heteropogon triticeus).	N Site drainage.	N	N

Large areas with moderate capability for urban and pastoral development; major limitations: shallow, gravelly soils and poor site drainage.

KROKANE LAND SYSTEM (Kk)

Internal drainage depressions and broad, shallow valleys, usually within Kay land system; mottled yeliow duplex soils common; grassland, open shrubland and minor paperbark closed forest.

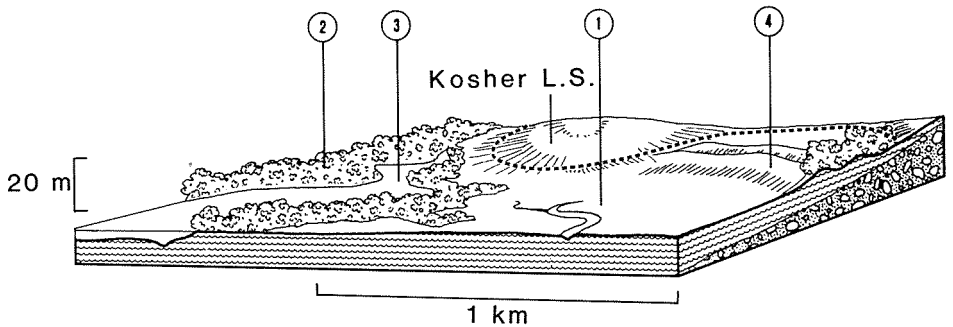


ALLUVIUM LATERITE OUTCROP TERTIARY SANDS & GRAVELS

Unit	%	Landform	Soils	Vegetation	Capability Urban	Arable	Pasture
Kkl	50	Seasonally flooded depressions to 300 m wide; marginal slopes to 2.5%; usually level floors.	Clottled yellow duplex soils (D3).	Variable; short grassland (*Eriachne* sp., Ectrosia leporina, Panicum sp., *Paspalum* sp.); low open heathland to open shrubland (*Melaleuca* viridiflora, *Pandanus* sp.); *Melaleuca* closed forest.	N	N	N
					Site drainage.		
Kk2	25	Upland surface; gently undulating; relief to 10 m; slopes to 3.5%; scattered laterite outcrop and pavement on lower margins of unit.	Moderately deep gravelly red and yellow massive earths (M4, M5).	Open forest to tall open forest as for K1 and K3.	N	N	C_2
					Outcrop, gravelly soils		
Kk3	15	Broad sandy drainage ways linking areas of Kkl.	Siliceous sands dominant; also minor yellow earthy sands (S1, S2) and mottled grey massive earths (M6).	Grassland or open woodland (*E. polycarpa,* Lophostemon lactifluus) with *Pandanus* sp. understory; annual (Sorghum sp.) and perennial (*Eriachne* burkittii, Coelorhachis *rottboellioides*, Imperata cylindricus).	N	N	C_2
					Site drainage.		
KK4	10	Perennial billabongs to 400 m wide and 2 km long, but commonly smaller.	-	Open water or herbaceous swamp vegetation.	N	N	N
					As above.		

Generally low capability for development; small areas have moderate potential for pdstoral development.

Level tidal flats and .ns; active and stable coastal sand dunes; saline muds and massive cracking clays; samphire, sedgeland mangrove low closed forest.



MARINE ALLUVIUM SANDS & GRAVELS

Unit	%	Landform	Soils	Vegetation	Capability Urban	Arable	Pasture
					N	N	N
L1	60	Tidal flats; up to 1 km wide; slopes less than 0.4%; recent estuarine and marine clays, in places over buried mangroves; seasonal drying and surface cracking; intermittent tidal flooding.	Uniform saline muds and clays (CS1); cracking grey clays (C2).	Samphire (*Arthrocnemum*) sedgeland or bare of vegetation.	Tidal flooding		
					N	N	N
L2	25	Coastal and riverine mangrove fringe; up to 100 m wide; slopes up to 0.9%; riverine mangroves on low clay levees up to 100 m wide and 1 m elevation; daily tidal flooding; also common laterite outcrop.	Saline muds (CS1), often interspersed between laterite outcrop.	Mangrove low closed forest.	Tidal flooding.		
					N	N	N
L3	10	Channels up to 10 m deep and 200 m wide with outlets up to 5 km wide; minor channels up to 5 m deep and 15 m wide.	-	-		-	

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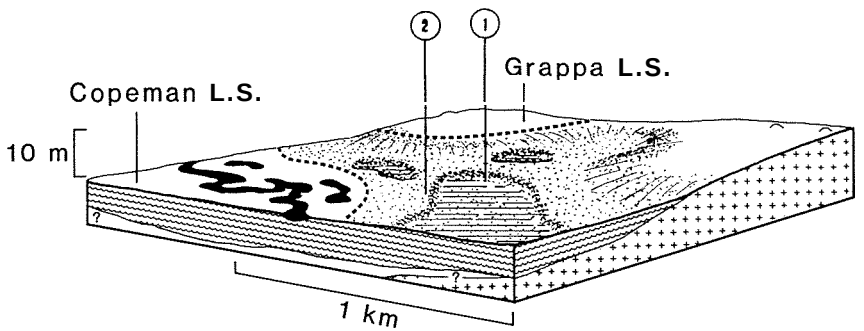
Unit	%	Landform	Soils	Vegetation	Capability Urban	Arable	Pasture
					N	N	N
L4	5	Coastal dune complex; active and stable beach ridges, up to 1 km wide; active outer dune shelving seawards up to gradients of 40%; deep; calcareous sands; up to 5 fixed dunes, each up to 200 m wide, 5 m high, with slopes up to 6%; deep siliceous sands and earthy sands; inter-dune swales up to 100 m wide; slopes up to 0.8%; coastal outcrops of laterite, or of calcareous beach rock, up to 50 m wide on 1% slopes, overlain by sandy beach to landward; tidal flooding over lower areas of unit; lateral seepage and run-off concentrated along swales.	Calcareous sands (S3) and weakly cracking clays over sand in inter-dune swales; uniform saline clays (CS1) over sands in swales where tidal flooding occurs.	Woodland, mainly non-eucalypts (*Acacia, Pandanus, Abrus, Eugenia, Canarium*) with lianes or semi-deciduous closed forest as for Kh1.	Tidal flooding, seasonal wave erosion.		

Low capability for development due to tidal inundation.

PALUDAL LAND SYSTEM (Pa)

Low swampy plains; fresh water clays over marine sediment; no distinct channels; friable duplex soils and massive clays; short perennial grassland.

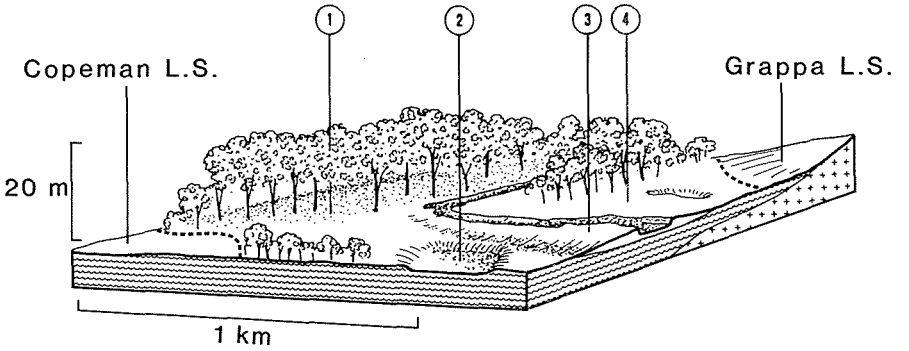


Unit	%	Landform	Soils	Vegetation	Capability Urban	Arable	Pasture
					N	N	N
Pal	50	Depressed plains 150 m to 1 km wide which are permanently inundated up to 1 m deep; almost level.	Friable mottled yellow duplex soils, alkaline subsoil (D5).	Short perennial grassland (Hymenachne, *Oryza* dominant also *Eleocharis*, *Nelumbo*, *Phragmites*).	Site drainage.		
					N	N	C_2
Pa2	50	Slightly elevated plain up to 1 km wide usually in association with Pal; seasonally inundated; slopes less than 0.3%, relief less than 2 m.	Massive cracking grey clays, friable mottled yellow duplex soils co-dominant (C1, D5).	Short perennial grassland (*Oryza australiensis* dominant, also *Scleria*, Pseudoraphis, Eleocharis, Hymenachne.	Site drainage		

Generally low capability for developnient due to wet season drainage, some areas with moderate capability for pasture improvement.

PINWINKLE LAND SYSTEM (Pw)

Large swampy depressions on clay plains, and broad back plains along river courses; soils predominantly black massive cracking clays overlying marine alluvium; paperbark tall closed forest to open forest.



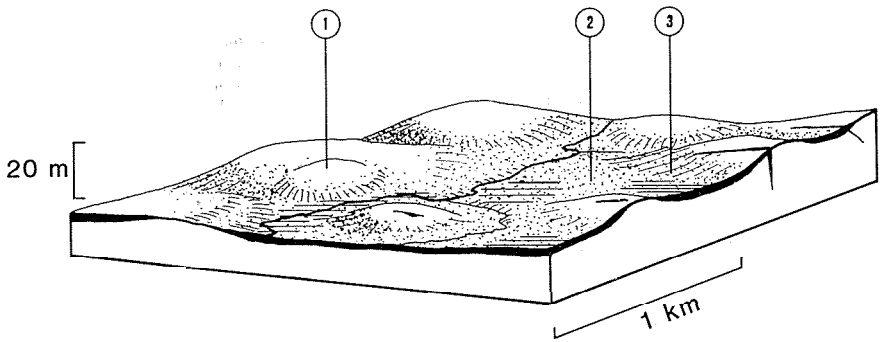
ALLUVIUM GRANITE/TERTIARY SEDIMENTS

Unit	%	Landform	Soils	Vegetation	Capability Urban	Arable	Pasture
Pwl	70	Wooded swamps to 3 km wide; almost level; seasonally inundated to a depth of 2 m.	Black massive cracking clays; organic surface horizons; usually over alkaline subsoils (C2).	Tall closed forest to open forest (*Melaleuca* cajuputi, *M. viridiflora*); rare grasses (Pseudoraphis, *Eleocharis*); minor areas of evergreen tall closed forest (*Terminalia sericocarpa*, Vavaea australiana, Acacia auriculiformis, Melaleuca cajuputi, *Livistona* benthamii, Barringtonia).	N Site drainage.	N	N
Pw2	15	Lower very slowly drained depressions; seasonally inundated and rarely dry; similar to Pal.	Friable mottled yellow duplex soils; organic surface horizons, usually over alkline subsoil (D5).	Short perennial grassland as for Pal.	N Site drainage.	N	N
Pw3	10	Levees; up to 250 m wide; back slopes to 3%; includes river channels and water filled billabongs.	Alluvial soils with silty bed loads. Deep, loamy alluvial massive earths and black massive cracking clays (C2).	Short perennial grassland (Pseudo*raphis*) with low shrubs (Grewia *retusifolia*); often bare; scattered trees (Melaleuca viridiflora, *Alstonia actinophglla*).	N Site drainage.	N	C_2
Pw4	5	Alluvial plains to 0.5 km wide, moderately well drained; seasonally inundated to 1 m depth.	Black massive cracking clays, usually carbonate-rich, over saline muds (C2).	Bare	N Site drainage.	N	N

Low capability for development due to wet season or permanent inundation.

BUMWAGGON LAND SYSTEM (Rw)

Low rounded hills and low gravelly ridges with intervening broad alluvial flats; developed on highly weathered rocks of Lowrr Proterozoic age; lithosols on upland units; hard mottled duplex soils on alluvial areas; eucalypt woodland or low woodland on hills; perennial grassland, woodland or open woodland on flats.



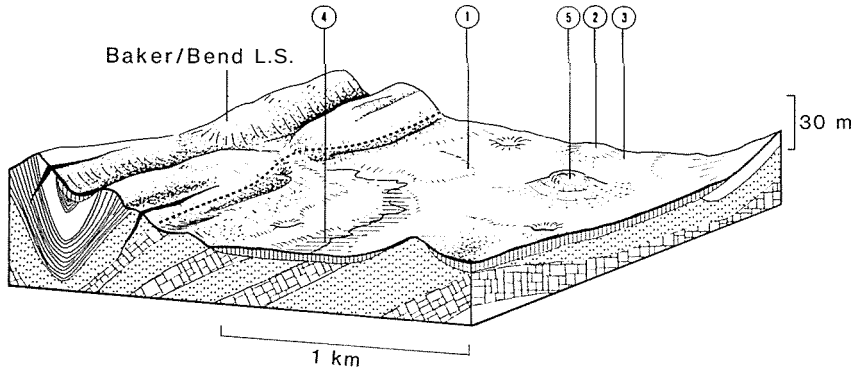
COLLUVIUM

Unit	%	Landform	Soils	Vegetation	Capability Urban	Arable	Pasture
					C_2	N	C_2
Rwl	45	Low rounded rises and less common low strike ridges; relief less than 10 m; slopes to 5%, occasionally to 10%; rapid drainage.	Commonly shallow lithosols (L1) with minor mod. deep lithosols (L2).	Woodland (E. tectifica, E. miniata, E. dicromophloia, E. clavigera, Erythrophleum) to low woodland (*Xanthostemon* paradoxus, E. foelscheana, Owenia *vernicosa*, and eucalypts as above); scattered shrubs (Acacia sp., Grevillea *decurrens*, *Livistona* humilis, Cochlospermum *fraseri*); and annual grasses (Sorghum sp.).	Gravelly shallow soils, slope gradients.		
					N	N	N
Rw2	30	Alluvial flats to 250 m wrde, infrequently channelled; slopes less than 1 5%; very slow drainage	Predominant hard mottled yellow duplex sorls (D3a); less frequent alkaline hard mottled duplex soils (04)	Perennial grassland as for Fb1 or *Melaleuca* woodland to open woodland as for Fwl	Site drainage		
					N	N	C_2
Rw3	25	Gentle lower slopes and less common low gravelly and stony slopes, relief less than 10 m, slopes less than 5%; laterite benches and pavement common at foot of unit; slow drainage	Nod deep lithosols (L2), gravelly hard mottled yellow duplex soils (D3)	Woodland (*E* polycarpa, Lophostemon, E *grandifolia*) or tall shrubland (*Grevillea pteridiifolia*, *Pandanus* sp) with scattered low trees (*Syzygium eucalyptoides*, *Petalostigma*, *Melaleuca viridiflora*); moderately dense to dense perennial grasses (Sorghum *plumosum*, *Eriachne* avenacea, Themeda *australis*, Heteropogon *triticeus*)	Site drainage		

Modrrate capability for urban and pastoral development on upland areas; remainder subject Lo wet season waterlogging or flooding

WOODCUTTER LAND SYSTEM (Wc)

Very gently upland surface, below Bakrr, Bend land systems; probably developed on Tertiary sedimerits overlying carbonate-rich rocks of Lower Proterozoic age; deep red massive earths and yellow massive earths; woodland (eucalypts and mixed).



Unit	%	Landform	Soils	Vegetation	Capability Urban	Arable	Pasture
Wc1	60	Undulating upland plain; relief to 10 m; slopes commonly 1.5%; rare sink holes across unit; indistinctly incised channels cross unit; moderately rapid drainage.	Deep red massive earths (M3).	Woodland, minor open forest (*Erythrophleum*, E. miniata, E. *confertiflora*, E. papuana) with low tree understory; sometimes dense (*Petalostigma*, *Terminalia grandiflora*, Acacia sp., Ficus opposita) and scattered shrubs (*Livistona humilis*, Cycas, *Pandanus* sp.); perennial grasses Heteropogon *triticeus*, Chrysopogon latifolius, *Imperata cylindricus*.	C_1	C_1	C_1
Wc2	15	Low gravelly rises; relief to 10 m; slopes to 5%; infrequent laterite outcrop on crests; rapid drainage.	Moderately deep lithosols (L2) and shallow gravelly yellow massive earths (M5).	Woodland (*E.* bleeseri, E. miniata, Erythrophleum) with scattered shrubs (Livistona humilis, Cycas).	C_2	N	C_2 Very gravelly shallow soils.
Wc3	10	Gravelly slopes and scattered low gravelly ridges; relief to 8 m; slopes to 3.5%; laterite benches and outcrop common in unit; moderately rapid drainage.	Shallow gravelly yellow massive earths (M5).	Woodland (Erythrophleum, E. clavigera, E. *bleeseri*) with scattered shrubs (*Cycas*, Eucalyptus suckers); perennial grasses (*Chrysopogon latifolius*, *Heteropogon* triticeus).	C_3	N	C_3 Shallow gravelly soils

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Unit	%	Landform	Soils	Vegetation	Capability Urban	Arable	Pasture
					N	N	N
Wc5	5	Minor ironstone knobs to 5 m high; slopes up Lo 10%; common massive laterite outcrops.	Shallow lithosols (L1).	Semi-deciduous closed forest (Eryth-*rophleum*, Canarium *australianum*, Sterculia quadrifida, Drypetes *lasiogyna*, Alstonia actinophylla, *Denhamia* obscura, Acacia *auriculiformis*, Ficus platypoda, Exocarpus *latifolius*, *Syzygium suborbicularis*); dense shrubs (*Bambusa* arnhemica) and vines (Diascorea *transversa*); rare grasses; minor areas of open forest (*E.* miniata, *Erythrophleum*).	Outcrop, very shallow soils		
					N	N	N
Wc4	10	Alluvial drainage floors to 150 m wide; axial slopes to less than 1.5%; marginal slopes Lo 1%; indistinctly channelled; minor sandy bed loads lower in unit.	Hard mottled yellow duplex soils (D3), minor siliceous sands (S2).	Low open forest Lo open woodland (*Lophostemon*, E. polycarpa, E. *papuana*, *Banksia* dentata, Nelaleuca cajuputi, *M. viridiflora*) with scattered shrubs (Pandanus sp.).	Site drainage		

High capability for urban, arable arid pastoral development; small areas of rock outcrop, and wet season waterlogging

3.0 GEOLOGY

This section summarises the geology of the survey area (as understood at the time of survey in 1973) and elaborates on relationships between geology and land systems. For the purposes of this discussion the survey area has been broken up into five broad geologic regions, each characterised by distinctive lithology and structure.

3.1 Granite Complexes

Two granitic complexes exist in the area; the Rum Jungle Complex in the southeast and the Litchfield Complex in the west. They are of economic importance because the major metalliferous mineralisation in the area (uranium-copper-lead in the Rum Jungle area and tin-tantalum in the West Arm-Mt Finniss area) is associated with them.

The Rum Jungle Complex consists of schist, gneiss, and granite contained in six major rock units of varying ages. Veins and dykes of pegmatite and amphibolite, and quartz-tourmaline veins are also present (Rhodes, 1969). The Litchfield Complex in this area includes tonalite, granodiorite, granite, and metamorphosed basic rocks (Walpole *et al.*, 1968). Pegmatite veins intrude the Noltenius Formation in a 10 km wide belt extending south for 55 km from Kings Table; they contain tin, tantalum and niobium minerals (Summers, 1957) and are probable offshoots of the nearby Litchfield Complex.

The Litchfield Complex may extend further north than mapped beneath the Bathurst Island Formation on Cox Peninsula. Sand and clay leases in the Raft Point - Rankin Point area are pegged on weathered granite and similar weathered granitic material has been logged beneath typical Bathurst Island Formation rocks in water bores to the north.

The Rum Jungle Complex is regarded as ranging from Archaean to Proterozoic in age (Walpole *et al.*, 1968) and generally to have been basement on which the younger rocks of the Pine Creek Geosyncline were deposited and around which they were domed during a later period of folding. The Litchfield Complex is considered to be of similar age although no definite Archaean age has been found from isotopic dating.

Gully land system on the Rum Jungle Complex and Grappa land system on the Litchfield Complex are both topographically higher, contain more outcrop, and have drainage more indicative of homogeneous underlying material than Gecko land system. Gecko land system appears to have formed mostly on a mantle of granite derived colluvium and, in the west, isolated outcrops of the Noltenius Formation which were seen at two sites on the survey. Distinct laterite cappings, exposed in breakaways, were observed occasionally in Gecko land system and in Gully land system, both on major drainage divides.

3.2 Pine Creek Geosyncline

During Lower Proterozoic time the survey area was part of the north trending Pine Creek Geosyncline.

The oldest rocks belong to the Batchelor Group, deposited on the north-western flank of the geosyncline. The Batchelor Group consists of coarse clastic sediments rich in feldspathic material (Beestons and Crater Formations respectively) alternating with reef dolomites

(Celia and Coomalie Dolomites respectively). The Batchelor Group crops out in a dome around the Rum Jungle Complex and in the core of a north - plunging anticline between the Arnhem Highway and Rum Jungle; both structures were caused by post-depositional folding. Beestons Formation and Crater Formation, containing some beds resistant to erosion, are generally characterised by Bend and sometimes by Rumwaggon land systems. The Celia Dolomite and the Coomalie Dolomite crop out very poorly. They have numerous closed surface depressions and are generally associated with Woodcutter land system.

The Goodparla Group is regarded as having been deposited from the east. Its three laterally-equivalent formations have differing lithologies thought to depend mainly on distance from sediment source. The Mt Partridge Formation which crops out only to the east of and outside the survey area contains feldspathic rocks typical of a near-source sedimentary environment. The Masson Formation, represented in the survey area only by the Acacia Gap Tongue, contains sandstone. The Golden Dyke Formation, regarded as having been deposited in a trough environment, for the most part beyond the limit of coarse clastic sedimentation, is characterized by pyritic carbonaceous siltstone and dolomite.

Baker land system in the eastern half of the survey area is nearly always formed on the resistant quartzites of the Acacia Gap Tongue. Both Manton and Darwin River Dams span ridges of the Acacia Gap Tongue in Baker land system. Quartzite of the Acacia Gap Tongue provides most of the crushed rock for the Darwin area both from Baker land system already mentioned and from low outcrop protruding through the rocks of the Bathurst Island Formation, between Howard Springs and Darwin. The Golden Dyke Formation crops out in the Rum Jungle dome, in the anticline between Rum Jungle and the Arnhem Highway, and in a belt from Tumbling Waters to the junction of the Stuart Highway and the Howard Springs Road. Cavernous dolomitic rocks which yield large supplies of groundwater from beneath Cretaceous rocks in the McMinns Lagoon area may also belong to the Golden Dyke Formation as may the dolomite drilled at Shoal Bay (Lau, 1973). The land systems most commonly formed on areas of mapped Golden Dyke Formation are Bend and Rumwaggon. Smaller areas of Woodcutter (to the north of Darwin River Dam) and Bustard (Elizabeth River area) have also formed on mapped Golden Dyke Formation.

The Finniss River Group, which succeeds the Goodparla Group, is regarded as another lateral facies assemblage, this time deposited from the west. The Noltenius Formation, containing pebble and boulder conglomerate as well as greywacke and siltstone is considered to grade basinward to the Burrell Creek Formation which consists mainly of medium to fine grained greywacke and siltstone. Three previously unmapped outcrops of the Noltenius Formation were located during the survey; in wavecut platforms on Channel Island, in the peninsula adjacent to it, and in an isolated ridge of Baker land system between East and Middle Arms. The wavecut platforms were observed at low tide from the air only; strongly folded beds are visible in the Channel Island outcrop, and in

the adjacent area northerly trending steeply dipping beds are evident. The outcrop in Baker land system consists of parallel ridges trending 255°. Rocks observed were poorly-indurated slightly micaceous fawn mudstones with jointing in one direction and no visible bedding.

Bustard land system is commonly associated with the Noltenius and Burrell Creek Formations. The characteristic photopattern of stripes parallel to expected strike of beds is due not only to differing lithologies interbedded in the Noltenius and Burrell Creek Formations but also to quartz veins and pegmatites which commonly occur parallel to strike and which, with laterite, make up most rock outcrop in this deeply weathered land system. Between the mouths of the Charlotte and the Annie Rivers, Bustard land system appears to emerge from beneath the adjoining Keefers Hut land system which have formed on the overlying Lower Cretaceous Formation. Baker land system consists of long strike ridges formed on relatively resistant greywacke and valleys formed on less resistant mudstone interbeds.

3.3 Depot Creek Sandstone

The Depot Creek Sandstone Member of the Buldiva Sandstone is the only representative in the area of widespread Upper Proterozoic sedimentation to the south. At Rum Jungle it is represented by lenses of siliceous quartz breccia in a hematite-rich sandy matrix (Malone 1962). Further north, along the lower reaches of the Darwin River, quartz hematite breccia and silicified sandstone with small lenses of sandstone breccia are thought to belong to this Member (Maggs and Barclay, 1966). Well-sorted ripple-marked white sandstone dipping 30° to the south-east which crops out poorly on a low sandy rise 7 km north north-west of Berry Springs is considered to belong to this Member; the outcrop occurs within a wavy northerly-trending light coloured photo pattern in the surrounding thinly striped pattern characteristic of Bustard land system and can be seen to overlie nearby Lower Proterozoic rocks.

3.4 Bathurst Island Formation (originally the 'Mullaman Beds')

The Bathurst Island Formation of Lower Cretaceous age underlies most of the northern portion of the area and crops out mainly in coastal cliffs at Darwin, on Cox Peninsula, and at Shoal Bay. Outcrop has been mapped in the area only as far south as the lower reaches of Darwin River.

Skwarko in Walpole *et al.*, (1968) has described the formation at Darwin as follows:

> *'The beds at Darwin are nearly horizontal and overlie Precambrian rocks. In several sections a basal gravel or conglomerate overlies the steeply undulating contact. It is succeeded by up to 8 m of deeply weathered quartz sandstone, and this by 11 m of silicified fossiliferous claystone. Bedding planes are not readily discernible, but several persistent bands with belemnite casts made it possible to determine the gentle northerly dip. All outcrops are strongly coloured by lateritisation.'*

On Cox Peninsula, water bore logs from the Delissaville to West Point area indicate a thick

section of granite-derived, generally coarse- grained sand and gravel underlying 15–20 m of claystone, mudstone, and sandstone typical of the Bathurst Island Formation and overlying basement of granite and schist. At Shoal Bay diamond drilling to basement has shown the Bathurst Island Formation to consist entirely of claystone, mudstone and siltstone (Lau, 1973). Poorly lithified medium to coarse-grained clayey sandstone found beneath laterite in the Howard River and Howard Springs area is also regarded as the former formation, possibly a coarse basal section.

3.5 Laterite

Williams (in Story et *al.* 1969) notes that laterites and lateritic fabrics are major constituents of the regolith on the Koolpinyah surface. In the survey area, laterites are also common on the extensive Bustard land system.

The main compositional feature noted on the survey was the abundance of angular gravel-sized fragments, mainly vein quartz but also quartzite and sandstone, in laterites (Williams' '*detrital laterites*') of Baker, Bustard, Bend, Gecko, and Gully land systems. In contrast, detritus in laterites on the Koolpinyah surface-derived land systems (for example Kay and Keating) is mostly sand-size or finer, probably because it consists of reworked material from the Bathurst Island Formation. Minor exceptions occur where ridges of Baker land system abut the Koolpinyah surface-derived land systems and provide a source of coarse material as scree. Large fragments of quartz and quartzite seen in a laterite capping on the present-day watershed of Acacia Creek and Berry Creek (Keating land system) must originally have come as scree from the high ridges of Baker land system to the east before being separated from it by a tributary of Acacia Creek. Acacia Creek may therefore have migrated relatively recently, probably westward and probably by breaching the high ridges.

Massive red limonitic rock (Williams' 'gossanous *laterite*') was seen at one site in an area of mapped Coomalie Dolomite. Mottled-zone laterite (Williams, 1969) is soft and crops out only when it is capped by the hard laterites already mentioned and when the erosion products from it and the overlying capping are being rapidly removed from the base of the profile e.g. in sea cliffs. The mottled zone was observed only at two sites during the survey; both sites were scarps at the edge of major drainage divides. Preferential erosion of the soft mottled zone by water seeping through the hard permeable laterite capping has apparently removed support for the capping; blocks of laterite, some up to two metres long, have broken from the scarp and fallen to the talus slope where they have remained close to the scarp trapped by dense vegetative cover until they have weathered to smaller lumps. On many laterite scarps observed during the survey, the mottled zone beneath the capping was entirely scree covered and the slope appeared stable.

Laterite crops out in three distinct topographic situations:

(1) In scarps and breakaways already mentioned. These are frequently on the boundary between Kay and Krans land systems and on remnants of the Koolpinyah surface in Keating and

Keefers Hut land systems. Some at least, appear nearly inactive. Relatively small lateritic plateaux with apparently active scarps at their margins were also seen at two sites on Gecko land system.

(2) As patchy outcrop on low gravelly domes. These domes are a common landform on all land systems except those with high relief and those with low relief, i.e. alluvial and coastal plains. Generally these domes slope gently down to, and merge with creek lines.

Ironstone outcrops frequently occur beside creeks. These outcrops are generally small and low. However low laterite scarps observed beside creeks at three sites including a strike valley in Baker land system appear to result from incision of the creeks.

In Bustard land system the most common outcrops on the low domes are northerly striking quartz - feldspar - mica pegmatites and quartz veins. Quartz fragments are therefore common in the adjoining laterites. Thicknesses of 2-3 m of laterite capping on pegmatites were observed in a mine shaft at one site in this system.

(3) As extensive pavements, particularly in Kapping land system, but also in Kay, Keating and Keefers Hut land systems.

3.6 Unconsolidated Sediments

The unconsolidated sediments are mainly Quaternary in age with sandy (Effington) and silty (Flatwood and Fabian) alluvium and clayey littoral and estuarine sediments (Cyperus, Copeman, Littoral, Paludal, Pinwinkle). Little systematic geological investigation has been done on the unconsolidated sediments except for some shallow investigations for construction materials, particularly sand.

3.7 Structure

The Lower Proterozoic sedimentary rocks have been moderately to tightly folded. The regional trend of the fold axes varies from north and northeast in the west to northwest in the east of the area. These axes have been strongly modified around the margin of the Rum Jungle Complex. All structural axes are strongly reflected in the trend of ridges in Baker land system and of photolineations in Bustard land system. In both of the latter, quartz veins parallel to regional trends are extremely common. These veins together with vegetation variations with lithology probably contribute to the striped dark and light photo pattern which characterises Bustard land system.

Walpole and others (1968) consider that the north-trending Mt. Fitch Fault Zone was active during and after the deposition of the Finniss River Group and that it marks the eastern edge of the Finniss River Group. A corresponding change from the northerly trends of Bustard land system to the concentric trends of Woodcutter and Bend land systems around the Rum Jungle Complex can be seen across the fault.

The Giants Reef Fault is a horizontal tear fault with a displacement of 4.8 km, west block moving north. A corresponding displacement of Gully, Baker, and Woodcutter land systems is evident on the map. Infilling of the fault zone by resistant quartz has produced a narrow northeast-trending band of Baker land system.

The unnamed northwest-trending fault is not well exposed. It probably involves both vertical and horizontal movement, the eastern block moving north and down. It has apparently been displaced by the Giants Reef Fault. The fault closely parallels the breakaway from Kay land system in the east to Krans land system in the west over its northern half.

4.0 PHYSIOGRAPHY

Land system mapping is strongly based on identification of characteristic landform patterns. Such patterns are closely associated with geology, and the superimposed drainage pattern. Aspects such as the degree and nature of dissection of the land surface and associated depositional pattern are a function of the former. They, in turn, have a strong control on attributes of relevance to land use such as slope gradient, rock outcrop, surface drainage and soil depth. The following section aims to draw these aspects together for the survey area as a whole, and to outline the rationale behind the land system classification.

Due to similarities with the adjacent Adelaide-Alligator survey area, the work of Williams (Story *et al.*) in outlining landform development has been drawn upon for this section.

4.1 Rugged Ridge and Hilly Terrain

This terrain is associated with the metasedimentary rocks of the Lower Proterozoic formations. It includes rugged strike ridges, lower undulating terrain with low quartz ridges, and narrow drainage lines. The designation of land systems is based on relief, and the extent of the intervening alluvials, and allied closely with these factors are slopes gradients, surface stone and gravel cover, and types of soil. High ridges with steep, rock-strewn slopes, and narrow footslopes and drainage lines are designated as Baker land system. It is extensive in the centre and south-west of the survey area, with isolated ridges situated in the east. Ridges have relief to 60 metres and slope gradients in excess of 20%. As such, there is little soil material on the slopes. The lower less dissected terrain in which hills are somewhat more rounded and slope gradients gentler is termed Bend land system. Extensive surface stone and shallow soils are, however, characteristic. The low subdued terrain developed on the Lower Proterozoic rocks has been designated Rumwaggon land system, and has associated large tracts of alluvial terrain.

4.2 Granite Hills

The granite terrain is characterised by rolling, domed hills with distinctly convex sideslopes. The associated drainage lines are narrow and mostly incised. The granite has been deeply weathered, and is blanketed by a deep mantle of coarse siliceous material. Outcrop is thus not common. Relief over the granite land systems (Grappa, Gecko and Gully) is usually less than 30 metres, with slope gradients less than 5%.

4.3 Gently Undulating Upland Surface

This surface has previously been termed the Koolpinyah surface (Story et *al.*, 1969). It is formed of sediments deposited in the late Tertiary period and also their more recent derivatives. The sediments are highly variable and range from clays to sands, often with a high content of ferruginous gravels. They have been derived from erosion of the Lower Cretaceous, Lower and Upper Proterozoic rocks and deposited as alluvial and colluvial aprons. Following deposition, these sediments have undergone intense weathering to produce a lateritic mantle, and also to some extent further erosion and resorting.

The Koolpinyah surface interfingers with the terrain of the Lower Proterozoic rocks to the south of the survey area, and is extensive in the middle and northern survey area. It forms the Darwin, Gunn Point and Cox Peninsula salients, where the Tertiary sediments overlie lower Cretaceous rocks. The terrain is a very gently undulating surface, with long slopes and low domed crests. It has an extensive cover of lateritic gravels, and laterite outcrop is quite common. The characteristic vegetation of this surface is the *E. miniata - E. tetrodonta* association. The above properties vary somewhat according to the degree of dissection of the surface, and this attribute forms the basis for classification into land systems.

Kay land system represents the virtually undissected surface, on which slope gradients are very low, there is little outcrop and soils are generally deep and gravel-free. Keating land system defines the slightly dissected and more rolling terrain. The flat surfaces with deep soils are less extensive than in Kay, while sloping, gravelly terrain is more extensive. Laterite outcrop and areas of very gravelly soils are likewise moderately extensive land system. Small, residual areas of the flat to gently sloping surface on which outcrop and shallow soils are extensive, have been designated Kapping land system. Krans land system defines those areas where dissection of the Koolpinyah surface has created a low scarpline with associated steep lower slopes. Broad sandy drainage lines and their adjacent slopes have been designated as Knifehandle land system, with Krokane land system accounting for the internally drainage billabong and spillway areas.

Terrain which grades between that clearly formed on the lateritic surface, and that formed on the Lower Proterozoic rocks is grouped into Bustard land system. It is comprised of low gravelly quartz ridges and intervening gentle slopes, formed of what appears to be predominantly lateritic sediments.

4.4 Alluvial Terrain

Tracts of mature alluvial plain are. not extensive in the survey area. They are associated with the mid reaches of the Adelaide, Finniss and Blackmore Rivers where they rarely excede 2 kilometres in width. Low ridges and hills of Bend and Rumwaggon land systems commonly bound the plains. While the plains are inundated or flooded during the wet season, they are not actively aggrading as the channels are incised and peak floods rarely break their banks. Much of the

flooding is the result of the accumulation of runoff from adjacent slopes onto the back plains, from which drainage is very slow.

The plains are designated as Flatwood, Fabian and Effington land systems. The former two land systems are associated predominantly with terrain developed on Lower Proterozoic rocks and have mostly poorly drained texture contrast soils. They are differentiated on the basis of vegetation cover, with Flatwood predominantly wooded and Fabian supporting grassland. Effington is associated with the Tertiary Sedimentary surface and has more obvious, although gentle slope gradients and sandy soils.

4.5 Estuarine Plains

This terrain has formed in geologically recent times, postdating the above alluvial deposits. It consists of very flat, poorly drained clay plains, extensive on the lower reaches of the major rivers, and also forming a fringe around much of the coastline. Williams (1969) accounts for the development of the plains in terms of '...estuarine sediments laid down in drowned river valleys. Throughout the plains, several feet of freshwater clays have been deposited over gleyed estuarine or coastal muds and clays, and each year the plains are flooded by fresh water to depths up to 2 metres for up to 6 or 8 months. Certain low-lying portions of the plains form perennial sedge or paperbark swamps.. .'.

The land systems of the coastal plains have been classified according to whether they seasonally dry out (Cyperus), flood for much of the year (Copeman, Paludal, Pinwinkle), or are subject to tidal flooding (Littoral).

5.0 SOILS

A considerable amount of data has been collected on soil types in the Darwin Region, both during field work for this land system survey and also in subsequent more detailed surveys (Wells and Harrison, 1978; Fogarty *et al.*, 1979, 1984; Sivertsen *et al.*, 1980; Lucas, 1981; Van Cuylenberg, 1984). To organise this data, it has been necessary to classify the soils into groups which have broadly similar morphological properties. This allows for more ready comprehension and also communication about these soils. Essential to this classification is the adoption of a relatively simple terminology which is capable of automatically conveying a considerable amount of information. This chapter outlines this terminology and the information which it conveys.

5.1 Classification

The classification scheme (Table 3) is primarily that of Northcote *et al.* (1975), although modified in places to include some of the Great Soil Groups of Stace *et al.* (1968). This system gives descriptive terms to soils which are classified in the field using a taxonomic key and a numerical designation (Northcote, 1979). The former descriptive groupings are broad, and have therefore been divided into more specific groups to account for any internal variation. These subgroups are designated by an alpha-numeric symbol for the sake of this discussion. In some cases they have also been designated with family names, as per Hooper (1969), Forster (1976), and Olsen (1982).

A summary of some of the soil groups' basic properties is

Table 3: Scheme of soil classification for the land systems of the Darwin Region.

					Subgroup	Usual P. P.F	Alternative Family Name
		Shallow, stony on Lower Proterozoic rocks			L1	Uc	Skeletal Soils (Burrell)
		Shallow–mod. deep, gravelly, Lower Proterozoic rocks			L2	Uc	Skeletal Soils (Burrell)
	Lithosols						
		Shallow–mod. deep, Fe gravels, uniform texture			L3	Um	Hotham
		Shallow, on granite, uniform, sandy texture			L4	Uc	(Masson)
			Deep		S1a	Uc5.11,4.2	Boroalba (Kapalga)
		Earthy sands	Shallow–mod. deep		S1b	Uc5.11,4.2	Boroalba (Kapalga)
	Uniform sands		Deep		S2a	Uc1.21	Kapalga (Boroalba)
		Siliceous sands	Shallow–mod. deep		S2b	Uc1.21,.11	Kapalga (Boroalba)
		Calcareous sands			S3	Uc5.12	Dune Sands
		Granite			M1	Gn2.84	Masson
all soils of the survey area		Lower Proterozoic rocks, gravelly, sandy surface, loamy subsoil			M2	Gn2.61,.64	Batten
	Massive earths		Deep massive earths, sandy loam grading to light clay	red	M3a	Gn2.11	Berrimah
				yellow	M3b	Gn2.64	Ramil, Walgait
			Mod. deep gravelly red		M4	Gn2.14, .24	Stuart, Hotham
		Tertiary lateritic sediments	Shallow–mod. deep, gravelly yellow		M5	Gn2.24	Koolpinyah
			Mottled grey subsoil, sandy surface, mod. deep		M6	Gn2.94	-
		Granite, lower slopes			D1	Dy5.51	Masson
	Yellow duplex soils	Lower Proterozoic rocks, lower slopes			D2	Dy3.81	Stapleton
		Alluvial, acid, hardsetting, apedal			D3	Dv3.53	-
		Alluvial, alkaline, hardsetting			D4	Dy3.13,.53, .63	Keppler, Bundey
		Alluvial, friable			D5	Dy, Dg	Dashwood, Murribibby Burton
	Massive cracking clays	Acid cracking clays			C1	Ug5.16,. 28	Wildman
		Alkaline cracking clays			C2	Ug5.16,. 28	Wildman, Carmour
	Non–cracking saline clays				CS1	Ug5.5	Carpentaria

Table 4: Estimated proportion of soil groups in each land system.

Land System Code		Be	B	Rw	Bs	Wc	K	Ke	Kp	Kr	Kf	Kn	Kh	Kk	Gr	Gu	Gc	Fw	Fb	Cm	Cp	Ef	Pw	Pa	L
Lithosols	L1	60	70																						
	L2	20	10	45	60													10	10						
	L3					15	10	5	60	30	50		25												
	L4														30	10	30								
Massive earths	M1															50	60								
	M2	5	5	10	10													10	10						
	M3a					60	30							50											
	M3b						5																		
	M4							35			10	30	50	10											
	M5					15	40	35	35	60	30	15		15											
	M6							5																	
Yellow duplex soils	D1														40	20									
	D2			25																					
	D3a				5		10			10								40	10			5			
	D3b	15	15	15	10	10						20			10			20	20						
	D4			5														20	50						
	D5							10			5		10		10	20							20	70	
Uniform sands	S1a				15			5			5	15	10				5					30			
	S1b											10			10							10			
	S2a						5	5	5			10		15								40			
	S2b												5									15			
	S3																								5
Massive cracking clays	C1																			30	30		10	30	
	C2																			70	70		70		
Non-cracking saline clays	CS1																								80

presented in Table 3. Table 4 presents the extimated proportion of soil groups in each land system.

Lithosols (L)

This group of soils shows little or no profile development apart from some accumulation of organic material to form a darker surface horizon. The lithosols are consistently shallower than 80 cm and frequently less than 50 cm, and contain over 40% (by volume) stone or gravel through most of the profile. They are associated with the undulating to rugged terrain, where the finer soil material has been removed by surface wash and throughflow. Four sub-groups of lithosols have been defined, and are closely associated with different parent lithology.

5.2.1 *Shallow Stony ZithosoZs (L1)* are characteristic of the steeply sloping hills and ridges developed on Lower Proterozoic lithologies (mapped as Bend and Baker land systems). This terrain has extensive rock outcrop and surface stone, and the soils are less than 40 cm deep. Textures are coarse, ranging from a loamy sand to a sandy loam, and colours are yellow to yellowish brown.

5.2.2 *Gravelly ZithosoZs (L2)* have developed on the more undulating terrain of the above lithologies (mapped as Rumwaggon land system, and unit 3 of Flatwood and Fabian land system). They contain 40-60% angular siltstone and quartz gravels and depth varies between 40 and 60 cm. Surface textures are sandy loams, increasing to sandy clay loams or clay loams at depth, and colours similar to the above sub-groups.

5.2.3 *Lateritic ZithosoZs (L3)* are extensive on the Tertiary sedimentary surface mapped as the 'K' group of land systems. They differ from the above group in that the gravels are generally subrounded and ferruginous in nature, and textures are coarser, often uniformly sandy loams. Depth rarely excedes 50 cm. Colours are more reddish than the above subgroups, with subsoils often yellowish red.

5.2.4 *Granite ZithosoZs (L4)* are characteristic of low rises and upper slopes on the granite terrain, mapped as Gecko and Grappa land systems. They are consistently shallow with uniform sandy profiles rarely heavier than a loamy sand. Red and yellow colours are common. Stone fragments are common throughout, and overlying a dense layer of siliceous gravels at 20-30 cm. This is often underlain by friable deeply weathered granite.

5.3 Uniform Sands (S)

This group of soils has developed on broad depositional aprons on lower lying areas within the gently undulating upland surface, and on lower slopes associated with this surface. Uniform sands have also developed on the broad ridges which are found in littoral areas. This subgroup consist of uniform structureless loamy sands, or occasionally sandy loams. Profile development is weak, with only a thin surface

soil horizon overlying a uniformly pale coloured B horizon. Mottling is a common feature, indicative of periodic wet season saturation.

The uniform sands can be split into two major subgroups on the basis of the fabric of the soil material (i.e. the arrangement of the sand grains when viewed closely). Essentially, the *earthy sands (S1)* are porous, with a large proportion of sand grains given some coherence by finer particles. The *siliceous sands (S2)* lack this binding material, being loose and single grained.

Due to their high content of sand and large pores, internal drainage is rapid. However, these soils are situated on lower slope and outwash areas and are therefore saturated by runon and lateral seepage for much of the wet season.

Two series have been recognised within each subgroup of uniform sands, although they are not easily distinguished in the field. Sla and S2a designate the sands which are over 100 cm deep, and which are commonly found on the broad depositional aprons (Effington land system, Knifehandle land system unit **3).** Slb and S2b designate those sands of less than 100 cm depth and which commonly overlie hardened ferruginous material, or occasionally a dense clay layer. These soils are common along lower slopes to the gently undulating upland surface.

A minor subgroup, *the calcareous sands (S3)* are uniformly coarse soils formed from marine and windblown calcareous sand. They are defined by unit 4 of Littoral land system and often carry a monsoon forest or vine thicket. They have weakly developed organic surface horizons which have loose consistences and overlying yellowish subsoils in which cemented shell fragments are a common feature.

5.4 Massive Earths (M)

The general features of the massive earths are gradational texture profiles with a light textured surface grading to a medium . or heavy textured subsoil. They are always massive, i.e. structureless with an earthy or porous fabric.

The massive earths occur on all parent rock types found within the survey area, and this fact is useful in distinguising broad groups within the massive earths.

Some chemical data from massive earths of the Elizabeth–Blackmore catchments have been presented by Fogarty *et al.* (1984) and they are shown to have consistently very low levels of plant nutrients, low levels of exchangeable cations and acid to strongly acid soil reaction trends.

5.4.1 *Massive earths of the granite terrain (M1)* have only restricted extent and occur on the upper slopes mapped within Gecko land system. They are moderately deep red earths in which textures range from loamy sand in the surface to sandy clay loam in the subsoil. Siliceous gravels are commonly present, accounting for up to 20% of the soil volume. Subsoil colours are yellowish red to reddish brown, with only a weakly differentiated surface horizon.

5.4.2 *Massive earths of the Lower Proterozoic lithologies (M2)* are closely associated with the gravelly lithosols (L2) and occur on the mid and upper slopes of Rumwaggon land system. They are freely drained soils with a coarse textured surface grading to a medium textured subsoil. Angular siltsone and quartz gravels are present and occupy 10–30% of the soil volume. They are termed yellow massive earths and have yellowish brown or brownish yellow subsoils.

5.4.3 *Massive earths of the Tertiary sediments* includes a variety of soils developed over a range of topographic situations and a diversity of sediments.

The deep red massive earths (M3a) are moderately extensive, and occur on the broad, flat to very gently sloping parts of the gently undulating surface (mapped as Kay unit 1) and are indicated by a tall well formed open forest of E. *tetrodonta* and *E. miniata*. The profiles are deep (>150 cm) with surface textures commonly a sandy loam or a light sandy clay loam grading to a light clay at 60–80 cm. A small amount of ferruginous gravel (<10%) may be present in the deep subsoil, otherwise they are gravel-free.

The soil has a relatively deep surface horizon and subsoil colours are generally red or brownish red.

The red massive earths are friable when moist, but harden considerably as the dry season progresses. They have medium to rapid drainage due to their porous fabric. Owing to their depth and absence (in most cases) of gravel, the deep red earths have a relatively high moisture storage capacity when compared to the other groups of massive earths.

The deep yellow massive earths (M3b) occur as minor soils associated with the red massive earths described above. They differ in that their subsoil colours are generally yellowish brown to brownish yellow, and frequently have subsoil mottling, indicating periodic wet season saturation. Textural trend is similar to the above subgroup.

Lateritic red massive earths (M4) are extensive on the gently undulating surface of the survey area. They have moderately deep to deep profiles, similar in texture trend to the previous groups but with 10–30% ferruginous gravel in the surface soil, and up to 50% in the subsoil. They overlie hard mottled lateritic material at depths between 80 and 120 *cm.* Subsoil colours range from reddish brown to yellowish red, often becoming more reddish with depth.

Lateritic yellow massive earths (M5) are extensive soils on the gently undulating surface. They are generally between 40

and 80 cm deep, with a coarse textured surface soil grading to textures no heavier than a light clay in the subsoil. Gravel percentage varies between 30 and 50% throughout the profile. Due to their high content of gravel and coarse surface textures, and also their lack of depth, this group of soils has a relatively low moisture storage capacity, and a droughtly surface horizon.

Mottled grey massive earths *(M6)* are a variable subgroup, developed on gentle lower slope situations. They are poorly drained and are subject to both runon from upslope and fluctuating wet season water tables. Characteristically, these soils have a light grey to yellowish grey loamy sand surface, which has only weak coherence. The subsoil is a mottled grey or yellowish grey sandy clay loam which extends to 50–80 cm, and overlie a dense layer of ferruginous gravel. This latter layer is often cemented and impenetrable, although quite porous.

5.5 Yellow Duplex Soils (D)

The distinguishing attribute of this group is the clear contrast between the sandy or loamy surface soil and the clay subsoil. The light textured surface is generally less than 50 cm thick while the overall profile depth is consistently greater than 120 cm. This group occurs on gentle lower slopes and plains, and as such is subject to wet season saturation and, in many cases, inundation.

There is considerable morphological variation in the group of yellow duplex soils, and five subgroups have been designated.

5.5.1 ***Hard apedal yellow duplex soils associated with granite*** *(D1)* have developed on the mid and lower slopes of undulating terrain, mapped as Grappa and Gully land systems. They have a loamy sand or sandy loam surface, often with 5–20% angular siliceous gravels, overlying a light gravelly clay. A weakly developed A_2 horizon is usually present between 10 and 40 cm depth. Subsoil colours are strong brown or yellowish brown, often weakly mottled.

5.5.2 ***Hard*** *apedal* ***mottled yellow duplex soils associated*** *with* ***Lower Proterozoic rocks*** *(D2)* are characteristic of the lower slopes mapped as Rumwaggon land system (unit **3).** The surface is a sandy loam to light sandy clay loam with unbleached A_2 horizons clearly evident. The subsoil is a light to medium clay, yellowish brown to brownish yellow and predominantly mottled.

Chemical analyses presented by Fogarty ***et al.*** (1984) show these soils to be extremely depleted of all nutrient elements, and also to have an acid soil reaction trend.

5.5.3 ***Hard apedal mottled yellow duplex soils*** *(D3)* occur on plains units in a number of land systems, although most extensively in Flatwood and Fabian land systems. They exhibit a

medium textured surface abruptly overlying a medium to heavy clay subsoil which is prominently mottled. They have a brown surface A_1 horizon and a clear A_2 horizon which is weakly bleached.

This subgroup has acid soil reaction trends, with surface pH between 6.0 and 6.5 and subsoil pH between 6.0 and 5.0.

5.5.4 ***Alkaline hard mottled yellow duplex soils*** *(D4)* are also characteristic of the broad alluvial plains mapped as Flatwood and Fabian land system. Morphologically these soils are similar to the D3 soils described above, and with which they occur in association. However, they differ in that the soil reaction trend shows a marked rise in pH in the subsoil, to between 8 and 9 at 60–80 cm.

5.5.5 ***Friable mottled yellow duplex soils*** *(D5)* are extensive in situations which are perennially moist and where organic matter build up has been considerable. The surface is therefore very dark and friable, and is usually around 30 cm deep. It overlies a mottled light clay subsoil in which ferruginous gravels (<10%) are a common feature. This group has a strongly acid soil reaction trend.

5.6 Massive Surfaced Cracking Clays (C)

This group of soils has deep, uniform, medium to heavy clay profiles which have pronounced shrink–swell properties. They occur extensively on the estuarine plains (Cyperus, Copeman, Pinwinkle land systems) and as such are subject to long periods of inundation. Two subgroups have been defined although both are closely associated on the plains.

5.6.1 ***Acid massive cracking clays*** *(C1)* have a very dark grey to black surface and a heavy clay texture. In situations which dry out during the dry season, the surface cracks extensively. They are also very hard when dry. The subsoil is dark grey, often becoming lighter coloured at about 100 cm, with strong yellow mottling a common feature.

The soil recation trend is strongly acid, with surface pH ranging from 5.5 to 6.5, and subsoil pH falling to around 4 by 100 cm.

5.6.2 *Alkaline* ***massive cracking clays*** *(C2)* have a similar morphology to the above subgroup of soils but have an alkaline soil reaction trend. Surface pH is generally neutral to slightly acid, increasing to around 8.5 at 60–100 cm. Rare calcium carbonate nodules are also found in the subsoil of most profiles in this subgroup.

5.7 Non Cracking Saline Clays (CS1)

This group of soils occurs in Littoral land system (Unit 1). They are deep uniform clays, which are subject to seasonal marine inundation. Salt encrustation and a highly flocculated surface layer is common in these soils. Soil pH is high throughout the profile. The surface crust may be regularly cracked. Vegetation is absent.

6.0 VEGETATION

6.1 Introduction

The descriptions appearing in this chapter have been compiled largely from field data obtained by B. Forster in 1972 and 1973 and from the land system descriptions he compiled using this data and other sources available to him. The following should be noted; where the names of species have changed since 1972/73 the most recent name has been used, apart from this Forster's species identification and nomenclature has not been revised or changed.

6.2 Previous Descriptions

The vegetation of the Darwin Region has been described by various workers in the past. Christian and Stewart (1953) provide the earliest published, broad systematic descriptions whilst Perry (1960) describes the Region in terms of pasture types.

More detailed vegetation descriptions also exist for discrete areas within the Darwin Region. Such descriptions are usually associated with more intensive land unit mapping and are contained in the reports by Fogarty *et al.* (1975), Fogarty *et al.* (1984), Lucas (1980a), Lucas (1980b), Sivertsen *et al.* (1980) and Wells and Harrison (1978).

6.3 Classification

The stuctural classification in this report (Table 5) follows that of Specht (1970) with several alterations, some of which were adopted during a meeting of the Biological Resources Interim Council in 1975*.

The height classes of the tree strata have been changed to: >20 m; 10–20 m; and <10 m from those originally designated by Specht, i.e. >30 m; 10–30 m; and 5–10 m. The 20 m cutoff point was adopted because no trees in the region attain a height of 30 or more metres. There does seem to be some ecological justification for separating trees over 20 m tall from those which are shorter; for example, *Eucalyptus tetrodonta* forms a characteristic community of pure stands over 20 m tall on certain soil types.

Shrubs are defined as woody plants branching at or near the base, for which three height classes were adopted by Forster, these are: >2 m; 1–2 m; and <1 m. These too, differ from Specht's original classes of 2–8 m, and 0–2 m.

6.4 Community Descriptions

As stated previously a number of detailed vegetation descriptions exist for particular areas within the Darwin Regional Area. In this report, therefore, a broad community description is given including the most common and/or distinguishing species, which can then be used to characterise the various land systems. These land systems fall into six broad geomorphic groups:

(i) those formed on the rugged terrain and associated alluvials of the Lower Proterozoic sediments – Baker, Bend and Rumwaggon;

(ii) those associated with the Lower Cretaceous sediments of the Koolpinyah surface – Kay, Keating, Krans, Keefer's Hut, Knifehandle, Kosher, Krokane and Kapping:

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* This system is now superceded by Walker and Hopkins in 'The Australian Soil and Land Survey Field Handbook[1] (McDonald *et al.* 1984).

Table 5: Structural Forms of Vegetation (adapted from Specht, 1970)

Life Form & Height of Tallest Stratum	Projective Foliage Cover of Tallest Stratum			
	Dense 70 - 100%	Mid-Dense 30 - 70%	Sparse 10 - 30%	Very Sparse 10%
Trees 20 m	Tall closed forest	Tall open forest	Tall woodland	Tall open woodland
Trees 10 - 20 m	Closed forest	Open forest	Woodland	Open woodland
Trees 3 - 10 m	Low closed forest	Low open forest	Low woodland	Low open woodland
Shrubs 8 m	Closed scrub	Open scrub	Tall shrubland	Open shrubland
Shrubs 1 - 2 m	Closed heath	Open heath	Low shrubland	Low open shrubland
Shrubs 1 - 1 m	Closed heath	Open heath	Low shrubland	Low open shrubland
Herbs	Closed herbland	Herbland	Open Herbland	
	Closed tussock grassland	Tussock grassland	Open tussock grassland	-
	Closed grassland	Grassland	Open grassland	-
	Closed sedgeland	Sedgeland	Open sedgeland	-
	Closed reedland	Reedland	Open reedland	-

(iii) those derived from formations intermediate between the above groups - Bustard and Woodcutter;

(iv) those formed on granite, schist, gneiss and granodiorite - Gully, Gecko and Grappa;

(v) those associated with major river flood plains and alluvial sediments - Effington, Fabian and Flatwood; and

(vi) those associated with the coastal plains and the littoral margins - Cyperus, Copeman, Paludal, Pinwinkle and Littoral.

The following descriptions are presented in a more or less geomorphic sequence. However, where a community occurs in more than one land system it will be described only once and its distribution over the various land systems given.

The ridges, crests and gravelly slopes of Baker and Bend land systems support a woodland, infrequently a low woodland, dominated by *Eucalyptus (E.) dichromophloia, E. bleeseri,* or *E. tectifica* usually occuring with *E. miniata, E. tetrodonta, Erythrophleum chlorostachys* (Ironwood) and/or *E. foelscheana.* These woodlands often contain scattered low trees and shrubs - *Terminalia ferdinandiana, Xanthostemon yaradoxus, Gardenia megasperma, Livistona humilis, Cycas armstrongii, Grevillea decurrens* and *Cochlospermwn fraseri.* Grasses are usually sparse, the most characteristic being *Cymbopogon bombycinus, Plectrachne pungens, Heteropogon triticeus* and annual *Sorghwn* sp. The soils most commonly associated with this community are lithosols and skeletal soils. These woodlands are also found on low, gravelly erosional rises in Rumwaggon, Bustard, Woodcutter, Fabian and Flatwood land systems in all of which they are a minor component.

The gently undulating denudational plains, the lower colluvial wash slopes and Koolpinyah surface remnants occurring in many land systems support an Open Forest (rarely a tall Open Forest or Woodland) dominated by *E. miniata, E. tetrodonta* and Ironwood. A secondary tree layer is common and often quite well developed. The main species are *E. clavigera, Terminalia ferdinandiana, T. grandiflora, Planchonia careya, Buchanania obovata* and *Petalostigma pubescens.* The shrub layer, again often well developed, consists mainly of *Cycas armstrongii, Livistona humilis* and scattered *Pandanus spiralis.* The grass layer is often very dense and usually dominated by perennials, the main species being *Sorghwn plumosum, Themeda australis, Eriachne avenacea, Chrysopogon latifolius* and *Heteropogon triticeus.*

The above community dominates in Kay, Keating, Krans, Keefers Hut, Gecko and Woodcutter land systems, is an important component of Bend and Baker and also occurs as a minor component of Kosher, Krokane, Kapping and Knifehandle. The associated soils are variable, they are predominantly lithosols and gravelly red massive earths. These growing conditions are the optimum, in this region at least, for such species as *E. miniata,* Ironwood, *Terminalia ferdinandiana* and *Planchonia careya,* all of which are at their best in terms of size and shape in these areas, particularly in the land units which have gravelly red earths.

Where these soils change to deep sandy and loamy red earths the vegetation community changes from that described above to Tall Open Forest dominated by *E. tetrodonta.* The secondary tree layer is usually characterised by *E. miniata,* Ironwood and *Terminalia grandiflora* whilst the shrub layer, sometimes well developed though often scattered, consists mainly of *Cycas armstrongii, Pandanus spiralis* and *Acacia* spp. The grass layer is usually very dense and varies in composition with soil type. On sandy soils annual species, particularly *Sorghum* sp., achieve dominance, whilst on the loamy soils perennials such as *Sorghum plumosum, Heteropogon triticeus, Themeda australis* and *Chrysopogon latifolius* dominate. This community is an important component of Kay land system and a minor component of Keating and Keefer's Hut land systems.

Species such as *E. tetrodonta* and *Terminalia grandiflora* find their optimum growing conditions in these sandy soils.

The laterite pavements and outcrops occurring within and along the breakaways of the Koolpinyah surface, support a low shrubland to low open shrubland of *Calytrix extipulata, C. brachychaeta, Verticordia cunninghamii* and several *Acacia* spp.; grasses tend to be sparse, the most commonly occurring and characteristic species being *Schizachyrium fragile.* This community forms an important part of Kapping and also has minor occurrence in Kay.

The colluvial wash slopes occurring below the Koolpinyah surface in Kosher support a semi-deciduous closed forest of *Melaleuca cajuputi, M. viridiflora, Bombax ceiba* and *Acacia auriculiformis.* The community is also characterised by a dense low tree layer of *Lophostemon lactifluus, Alphitonia excelsa, Alstonia actinophylla, Strychnos Zucida* and *Sterculia quadrifida.* Such a community also forms a minor component of Littoral land system. The soils most commonly associated with this community are sandy and gravelly red earths and earthy sands in Kosher and siliceous sands in the dune complex of Littoral.

The broad domed rises and colluvial footslopes of Gully, support a Woodland of *E. clavigera, E. foelscheana,* Ironwood and *Terminalia canescens* with an understory of *Livistona humilis, Petalostigma pubescens, Terminalia ferdinandiana* and *Hakea arborescens.* The major grasses encountered are *Heteropogon triticeus, Themeda australia* and *Sorghum plumosum.* The low domed hill and wash slopes of Grappa support a similar community except that the taller trees mentioned above, are absent. The latter community, a low woodland, usually contains a more pronounced shrub layer than that encountered in Gully. The dominant species are *Grevillea dryandri, G. pteridiifolia, G. dryandri* and *Acacia gonoclada.* The Woodland of Gully occurs on either red earths or gravelly red duplex soils whilst the Low Woodland of Grappa occurs on lithosols, yellow duplex soils and earthy sands.

The alluvial flats of many of those land systems occurring higher in the landscape support a grassland dominated by *Eriachne burkittii, Themeda australis, Allotergosis semialata* and *Chrysopogon setifolius,* usually with emergent trees and shrubs including *E. polycarpa, E. papuana, Lophostemon lactifluus, Grevillea pteridiifolia* and *Pan-*

danus sp. This community is of major importance in Rumwaggon and Fabian and also has minor occurrence in Bend, Bustard, Gully, Flatwood and Grappa. The dominant soil types associated with this community are yellow duplex soils, irrespective of the land system in which they occur.

Other communities of the alluvial floors and floodplains, include Woodlands and Open Woodlands dominated by E. *polycarpa*, E. *papuana* and Ironwood. These woodlands often contain secondary strata tree species occurring in distinct, almost monospecific bands, the positioning of which seems to be governed by height above the dry season water table. Upslope such species as *Petalostigma pubescens* and *Planchonia careya* were found giving way to species such as *Owenia vernicosa* and *Banksia dentata* further downslope which in turn give way to *Pandanus* sp., *MeZaZeuca viridiflora*, *Grevillea pteriidiifolia* and/or *Lophostemon lactifluus* in seepage areas. This latter community complex forms the major component of Flatwood but is also found in such diverse land systems as Bustard, Keefer's Hut, Krokane, Knifehandle, Kapping, Woodcutter, Rumwaggon and Fabian.

In Effington where the main soil type of the flood plains becomes either earthy or siliceous sand yet another variant of the above two communities occurs. The tall tree species again appear as emergents this time above a Low Woodland or Tall Shrubland dominated by *Grevillea pteridiifolia*, *Verticordia cunninghamii*, *MeZaZeuca* spp., *Banksia dentata* and *Pandanus* sp. Grasses such as *Eriachne triseta*, *Pseudopogonatherum contortum*, *Eriachne burkittii* and *E. schultzeana* provide a dense ground cover.

There are many other minor communities occurring in the upland and alluvial land systems; these have been outlined in Table 6.

The vegetation communities of the coastal plains and littoral zone are quite distinctive and tend to have little overlap with the communities described above.

The higher seasonally dry, cracking clay plains of Cyperus support a sedgeland/reedland dominated by *Eleocharis* spp., *Scleria poaeformis* and *Typha domingensis*, whilst the more poorly drained plains of Copeman support a grassland of *Imperata cylindrica*, *Coelorahchis rottboelioides*, *Ischaemum* sp. as well as many sedges. The latter community is characterised by emergent stands of *MeZaZeuca viridiflora*.

Pinwinkle LS, occupying depressions in the cracking clay plains, is characterised by a Tall Closed Forest of *MeZaZeuca viridiflora* and *M. cajuputi* often with *Terminalia sericocarpa* and *Livistona benthami* occurring adjacent to open bodies of open water.

The low swampy plains of Paludal, where the dominant soils are humic gleys, support a Low Grassland of either *Oryza australiensis* in the slightly better drained situations-, or *Hymenachne acutiglumis* in more poorly drained areas. These communities also have minor occurrence in Pinwinkle and Paludal.

The littoral zones are characterised by mangroves forming Closed Forests or Low Closed Forests on the seaward edge and samphire sedgelands on the landward side.

Table 6: Less frequently occurring communities of the upland and alluvial land systems.

Structural Form(s)	Dominant Tree and Shrub Species	Dominant Grasses	Landform and Soils	Occurrence - Land Systems
Low Woodland	Grevillea pteridiifolia, Pandanus spiralis, Syzygium bleeseri and Petalostigma pubescens.	Sorghum plumosum, Eriachne avenacea, Themeda australia, Heteropogon triticeus.	Gravelly wash slopes and spurs. Lithosols, gravelly red and yellow massive soils.	Rumwaggon Keefer's Hut
Low Open Woodland	E. clavigera, Ironwood, Petalostigma pubescens/Buchania obovata and Xanthostemon paradoxus.	Eriachne avenacea, Heteropogon triticeus, Sorghum plumosum, Themeda australis.	Gravelly rises, wash slopes and low laterite scarps. Lithosols and shallow yellow massive earths.	Bustard Gecko
Low Open Woodland	Acacia spp., Owenia vernicosa, Terminalia ferdinandiana/Livistona humilis and Cycas armstrongii.	Annual Sorghum sp. and Heteropogon triticeus.	Laterite outcrop and pavement, skeletal soils and lithosols.	Kay Kapping
Open Forest	Ironwood, E. clavigera, Lophostemon lactifluus/Pandanus sp. and Cycas armstrongii.	Heteropogon triticeus.	Gullies and drainage floors. Gleyed podzolics.	Krans
Open Woodland	E. bigalerita, E. alba, E. polycarpa and Lophostemon lactifluus.	Themeda australis, Eriachne burkittii, Ischaemum arundinaceum.	Narrow alluvial flats. Lithosols and yellow duplex soils.	Baker
Closed Forest	Ironwood, Canarium australianum, Sterculia quadrifida, Drypetes australasica, Alstonia actinophylla and Exocarpus latifolius.		Laterite outcrops, skeletal soils and lithosols.	Woodcutter Keating
Open Forest (Closed Forest)	Melaleuca cajuputi, M. dealbata, Ironwood and E. papuana/Barringtonia acutangula and Timonius timon.		Narrow drainage floors and internally drained depressions. Earthy and siliceous sands - minor yellow duplex soils.	Keefer's Hut Keating Knifehandle Kosher Krokane
Grassland		Sorghum sp. (annual), Ectrosia leporina, Eriachne burkittii, Panicum sp., Coelorhchis rottboelioides and Themeda australis.	Narrow alluvial flats and drainage floors. Yellow duplex soils, earthy and siliceous sands.	Knifehandle Kay Keating Krokane Kapping Grappa Gecko
Low Woodland	Grevillea pteridiifolia, Lophostemon lactifluus, Melaleuca viridiflora and Pandanus sp.	Eriachne hurkittii and sedges.	Sandy wash slopes, drainage floors and internally drained depressions. Yellow duplex soils.	Kay Kosher Krokane Grappa

7.0 LAND EVALUATION

7.1 Introduction

As described in Section 1.5, land evaluation provides a guide to the ability of the land to support a variety of land uses. It is based on a comparison of the physical requirements of the land use to the actual physical properties of the land. This is achieved by way of rating tables which combine the land and soil attributes which have a bearing on the particular land use, and subdivides each into classes which correspond to low, moderate and high capability.

The land evaluation is carried out at the level of land units. In order to determine the overall capability of a land system it is therefore necessary to take into account the proportion of the unit within the land system, as presented in Chapter 2. A general statement on overall capability of each land system accompanies each description in Chapter 2.

7.2 Rating Tables

The tables presented here (Tables 7, 8 and 9) serve as a guide to permit consistency in determining evaluation ratings, and to allow analysis of ratings from first principles. While the actual classes are somewhat arbitary, they are based on similar studies, both in the Northern Territory and in southern states [Fogarty *et al.*, 1979; Howe *et al.*, 1979; Woodward and Neilson (eds), 1981; Houghton and Emery (eds), 1981; Anon, 19741. Table 10 summarises the findings of the evaluation for each of the land units in all land systems.

7.3 Cultivation

Cultivation includes horticulture and row crops, which require annual cultivation. Their general requirements are for deep, medium textured and gravel-free soils with free drainage on flat to very gently sloping terrain. Rock outcrop and surface stone should be absent. This evaluation does not consider soil fertility as all soils are inherently very low in nutrient elements and would require fertiliser application if developed for horticulture. It also takes no account of groundwater availability which would require consideration in the event of development.

7.4 Urban Development and Rural Living

Both these land uses require flat to gently sloping land which is not subject to wet season flooding or long periods of waterlogging. It is desirable for soils to be readily excavated so rock outcrop and stone should be minor or absent and soils moderately deep to deep.

In the case of urban development, this evaluation applies only to subdivisions and not to individual house construction, in which case it may be considered that additional capital inputs are justified; for instance, high, steep hills have low capability for urban subdivision, but in particular cases may be considered desirable in order to take advantage of relief above surrounding terrain.

In the case of rural living, it is not necessary that the whole area of a block conform to the requirements stated here; however, there should be sufficient land to permit house construction, a substantial year-round living area, satisfactory effluent disposal, together with year-round access.

Table 7: Capability Ratings for Arable Farming.

Factors Affecting Land Use	C1	C_2	N
Site drainage	Mod.rapid	Rapid, slow	Very slow, very rapid
Soil drainage	Well-mod.well	Rapid, slow	Imperfect, very poor
Slope gradient	0–1.5%	1.5–3%	>3%
Soil depth	>120 cm	80–120 cm	<80 cm
Gravel content (A horizon)	<2%	2–10%	>10%
Stone content (A horizon)	0	0–5%	>5%
Rock outcrop	0	0–2%	>2%

C_1 = high capability; C_2 = moderate capability; N = low or no capability

Table 8: Capability Ratings for Urban Subdivision.

Factors Affecting Land Use	C_1	C_2	N
Site drainage	Mod.rapid - very rapid	Slow	Very slow.
Soil drainage	Mod.well - very rapid	Imperfect	Poor, very poor.
Slope gradient	0–4%	4–6%	>6%
Soil depth	>100 cm	50–100 cm	<50 cm
Gravel and stone content	<20%	20–50%	>50%
Rock outcrop	<5%	5–10%	>10%

7.5 Intensive Pasture Improvement

This land use includes intensive pasture improvement for hay production and for holding high stock numbers. The primary requirements are for land which is not subject to inundation, or land which does not have excessively gravelly and stony soils. The latter requirement excludes land with moderately steep to steep slopes. As pasture species are available for most physical situations, this analysis is necessarily very broad. It would be necessary to consider the physical properties of any land on which pasture improvement is proposed to plan selection of pasture species which are most appropriate.

Table 9: Capability Ratings for Intensive Pasture Improvement.

Factors Affecting Land Use	C_1	C_2	N
Site drainage	Mod.rapid, rapid	Slow	Very slow, very rapid.
Soil drainage	Mod.well, well	Imperfect	Poor, very poor, rapid
Slope gradient	0–1%	1–4%	>4%
Soil depth	>80 cm	50–80 cm	<50 cm
Gravel content	<10%	10–30%	>30%
Stone content	0	0–5%	>5%
Rock outcrop	0	0–5% .	>5%

Table 10: Summary of land capability ratings for the land systems of Darwin Region.

Land Systems and Land Units		Cultivation	Intensive Pasture Development	Urban Subdivision and Rural Living
Baker	1	N	N	N
	2	N	N	N
	3	N	N	N
Bend	1	N	N	N
	2	N	C_2	C_2
	3	N	N	N
Bustard	1	N	C_2	C_2
	2	N	N	N
	3	N	C_2	N
Copeman	1	N(C_2)	N(C_2)	N
	2	N	N(C_2)	N
	3	N	N	N
Cyperus	1	N(C_2)	N(C_2)	N
	2	N	N	N
Effington	1	N	N	N
	2	N	N	N
Fabian	1	N(C_2)	N(C_2)	N
	2	N(C_2)	N(C_2)	N
	3	N	C_2	C_2
	4	N	N	N
Flatwood	1	N(C_2)	N(C_2)	N
	2	N(C_2)	N(C_2)	N
	3	N	C_2	C_2
	4	N	N	N
Gecko	1	N	C_2	C_2
	2	N	C_2	C_2
	3	N	N	N
Grappa	1	N	C_2	C_2
	2	N	C_2	C_2
	3	N	N	N
	4	N	N	N
Gully	1	N	C_2	C_2
	2	N	C_2	C_2
	3	N	N	N

Table 10: Continued

Land Systems and Land Units		Culti-vation	Intensive Pasture Development	Urban Subdivision and Rural Living
Kapping	1	N	N	N
	2	N	C_2	C_2
	3	C_2	C_1	C_1
	4	N	N	N
Kay	1	C_1	C_1	C_1
	2	C_2	C_1	C_1
	3	C_2	C_1	C_1
	4	N	C_2	C
	5	N	N	N
	6	N	N	N
Keating	1	C	C_1	C_1
	2	C_2	C_1	C_1
	3	N	C_2	N
	4	N	N	N
Keefer Hut	1	N	C_2	C_2
	2	N	C_2	C_2
	3	N	N	N
	4	N	C_2	C_2
Knifehandle	1	N	C_2	C_2
	2	N	C_2	N
	3	N	N	N
Kosher	1	C_2	C_2	C_2
	2	N	C_2	C_2
	3	N	N	N
	4	N	C_2	N
Krans	1	N	C_2	C_2
	2	N	N	N
	3	N	N	N
Krokane	1	N	N	N
	2	N	C_2	N
	3	N	C_2	N
	4	N	N	N
Littoral	1	N	N	N
	2	N	N	N
	3	N	N	N
	4	N	N	N

Table 10: Continued

Land Systems and Land Units		Culti-vation	Intensive Pasture Development	Urban Subdivision and Rural Living
Paludal	1	N	N	N
	2	N	N	N
Pinwinkle	1	N	N	N
	2	N	N	N
	3	N	C_2	N
	4	N	N	N
Rumwaggon	1	N	C_2	C_2
	2	N	N	N
	3	N	C_2	N
Woodcutter	1	C_1	C_1	C_1
	2	N	C_2	C_2
	3	N	C_2	C_2
	4	N	N	N
	5	N	N	N

C_1 : High capability
C_2 : Moderate capability; few limitations present
N : Low or no capability; severe limitations present.

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