THE PASTORAL LAND RESOURCES

OF

ORANGE CREEK STATION

N.T.

SEPTEMBER, 1983
CHAPTER I

INTRODUCTION

In the latter half of the 1970's concern was expressed about the severity of soil erosion which was occurring south of Alice Springs. It was proposed that an assessment of the erosion status of the middle sections of the Finke catchment be undertaken. This was to encompass portions of the Finke, Palmer and Hugh River systems thought to be suffering severe degradation at that time. However, subsequent reconnaissance traverses of the area revealed that accelerated erosion had been exaggerated to a large degree and, in many cases, confused with geomorphic processes which have been occurring for several millennia. It was, therefore, concluded that a large scale erosion assessment would not serve a very useful purpose with regard to land management on specific pastoral enterprises.

It was perceived, however, that there was a requirement for a land resource appraisal study to provide relevant information on lands that could be recognised as pastorally different for the land manager and for government personnel working in the range management, soil conservation and animal production disciplines.

In the early 1960's Perry et al. (1962) produced a report and map on the land systems of the Alice Springs area. The map was published at a scale of 1:1 000 000, and delineated 88 broad land types over most of the region. Whilst providing a regional overview and some general correlation between areas these land systems have not proved to be a practical base for management at a pastoral property level and less so at a part property or on an individual watering point basis.

Beckett and Bie (1976), in a review of land resource assessment studies in Australia, stated that 'No instances can be found where a second and more detailed land system survey satisfactorily answered questions raised by an earlier and less detailed one. Decisions on management within a property relate to areas which are not more complex than land
units. In as much as they attempt to bring together soil and vegetation, land units have provided a useful guide to decisions on management, whereas land systems are too broad and varied. It seems agreed that the subdivision of properties for management must be based on maps at scales from 1:250,000 upwards, and of mapping units more uniform than land systems'.

Given these very pertinent statements it was felt that land management would be aided by mapping and describing what have been loosely described as 'pastorally different map units'.

The objectives of this study are:

1) To document briefly the climatic, geologic and physiographic environment of the land.

2) To provide a description of lands which can be recognised as pastorally different and which should be considered in conjunction with the map.

3) To provide means for the landholder to use relevant information contained in the report and on the map in various problem solving and decision making activities, so enabling land management to be based on quantified information.

4) To provide additional information for use by extension workers in the fields of rangeland agronomy, soil conservation, animal production and bushfire control. Information of this type should also provide a more detailed basis for range condition assessment since the map sheet is suited to all user groups.
CHAPTER 2

PHYSICAL ENVIRONMENT

Orange Creek Station occupies 2738 km² of land, the homestead being 95 km from Alice Springs on the Stuart Highway. The Tarcoola to Alice Springs rail line passes through the property and the Hugh River trucking yards are located in the south-east corner. The Hugh River Stock Route traverses the lease in an east-west direction.

1) Climate

Information contained here was extracted from 'Climate of Australia', 1981 edition, published by the Bureau of Meteorology.

The climate of Central Australia can be described as a modified continental type. Extreme minimum temperatures are not as low as those recorded in other continents because of the latitude and absence of extensive mountain masses. However, extreme maxima are comparatively high mainly due to the great east-west extent of the continent. Climatic discomfort is largely associated with high temperatures in the summer, although short periods of discomfort due to cold conditions may occur.

The approximate 10, 50 and 90 percentile rainfall figures (or 1st, 5th and 9th deciles) for the area are 100 mm, 175 mm and 400 mm respectively. The 50 percentile is usually called the median. The 10, 50 and 90 percentiles (1st, 5th and 9th deciles) are the annual rainfall totals that are not exceeded by 10, 50 and 90 percent of all recordings.

The dominance of rainfall over other climatic elements has led to a climatic classification based on two main parameters, median annual rainfall (5th decile) and seasonal rainfall incidence. Under this system the area falls into the arid zone summer maximum (AZ [S]) classification. Median rainfall is less than 350 mm and the ratio
of summer rainfall (November to April) to winter rainfall is equal to or less than 3.0.

A major factor relating to rainfall in the area is the erratic nature of the annual totals. The occurrence of irregular annual totals which cannot be forecast with any accuracy is best described in terms of variability. One index for assessing variability is given by the 90 - 10 percentile range to the 50 percentile value.

\[ \text{Variability Index} = \frac{(90 - 10)}{50} \text{ percentiles} \]

The index figure for Orange Creek is 1.7 which places it in the very high variability category.

Rain days (falls of 0.2 mm or more) are ± 25 per year. No figures are available for local rainfall intensities. The figures given below are from records taken at Alice Springs based on an expected 50 year return cycle.

<table>
<thead>
<tr>
<th>Period in Hours</th>
<th>1</th>
<th>3</th>
<th>6</th>
<th>12</th>
<th>24</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total Rainfall (mm)</strong></td>
<td>54</td>
<td>55</td>
<td>74</td>
<td>103</td>
<td>138</td>
</tr>
<tr>
<td><strong>Intensity per hour (mm)</strong></td>
<td>54</td>
<td>18.3</td>
<td>12.3</td>
<td>8.6</td>
<td>5.75</td>
</tr>
</tbody>
</table>

In some years the property may receive falls of rain in the winter period resulting in a significant growth of herbage.

Between 15 and 20 thunder days may be experienced each year. Hail occurs infrequently in association with summer storms.

SLCN1 A 5
Average daily maximum temperatures may range from 20°C in July to 36°C in January. Heat waves, when temperatures exceed 40°C for a number of days may occur. The average minimum ranges from 4°C in July to 20°C in January. Between June and August ground frosts may occur.

The 3 p.m. figures for relative humidity are less than 20% in January and 30% in July. Evaporation rates are high with figures of 450-500 mm in January and 160 mm in July.

The dominant wind direction is from the south-east with wind speeds up to 39 km/h being common. In January conditions at 3 p.m. are calm for 7% of the time and in July for 11% of the time.

Drought, in general terms, refers to an acute water shortage. The best single measure of water availability is rainfall, although parameters such as evaporation and soil moisture content are significant, or even dominant, in some situations.

Gibbs and Maher (1967) defined a drought as one with the years rainfall in the first decile range. One method of assessing the incidence of rainfall deficiency is an analysis of the distribution of annual rainfalls less than the median. The ratio of this range to the 30 percentile value may be used as an index of rainfall deficiency or drought incidence.

\[
\text{Index of Drought Incident} = \frac{(50 - 10)}{(30)} \text{ percentile.}
\]

The index of drought incidence for Orange Creek lies in the 0.7 - 0.8 range, classed as high to severe.

**Management Implications of Climate**

a) **Rainfall**

(i) **Annual total - Median (50 percentile) rainfall (approx. 175 mm)** provides a better guide to expected rainfall than does the average rainfall figure (240 mm). It is better
to base management concepts on an expected 50/50 chance, rather than on an average which is distorted too much by unusually wet years which are a feature of the erratic rainfall pattern experienced.

(ii) **Intensity** - The beneficial effect of intense rainfall is that sufficient run off is produced to fill surface water storages. The detrimental effects are soil loss by sheet, rill and gully erosion in grazed areas, and damage to, and soil loss from, roads and dam walls etc. During intense rainfall most soils (except for deep sands) are not able to absorb the large amount of water in a short period. Hence storage of soil moisture is low and run off is high. General depression type rainfall of low to moderate intensity allows for a build up of soil moisture and consequent forage production. Very infrequent hail storms may pulverise standing dry forage.

(iii) **Rainfall effectiveness** - A moderate to high rainfall for the year does not mean that it is always effective in producing forage growth response. If storms are followed by periods of very high temperatures new growth is 'burnt off' and soil moisture lost by evaporation. The most effective rain for forage production is that which should fall between mid January and the end of March or early April. Such rains usually provide more soil moisture storage and less run off. Winter rainfall will produce a growth of palatable herbage. Too much winter rainfall may be detrimental to standing dry forage.

b) **Temperature**

The effects of periods of high temperatures on new growth is noted above. Severe frosts in winter may be detrimental to herbage produced by winter rainfall.
c) **Thunder days**

Ground strikes by lightning may occur. A major consideration is the potential for the initiation of wildfires.

d) **Evaporation**

High rates of evaporation result in significant loss of water from dams. If summer rains are delayed or deficient evaporation may cause forage conditions to deteriorate rapidly.

e) **Drought**

Drought may be categorised as unpredictable and unavoidable. Drought management should be discussed with Department of Primary Production (D.P.P.) extension officers. Advantage should be taken of exceptionally good rainfall years to allow for pasture regeneration.

f) **Wind**

The frequency of wind is of relevance to operation of windmills. Destructive winds of up to 100 knots may be associated with summer storms. Wind direction at any particular time may have a significant effect on cattle movement. It should be noted and discussed with Department of Primary Production extension staff.

**Summary**

Climatic factors should have a major influence on short, medium and long term management decisions. Lack of rapid flexibility in a pastoral enterprise means that forward planning is essential.

2. **GEOLOGY**

This information has been extracted from Bureau of Mineral Resources reports by P. J. Cook, 1968, 1969 and A. T. Wells et al. 1970.
The main east west trending block is known as the James Ranges. The dominant outcrop formations include Pacoota Sandstone, Stairway Sandstone, Mereenie Sandstone and Hermannsburg Sandstone.

The Pacoota Sandstone commonly forms prominent strike ridges or high escarpments. It consists predominantly of quartzose sandstone with thin interbeds of siltstone. The sandstone is coarse grained and is commonly ferruginized. Clay minerals found are predominantly kaolinitic and illitic, with minor chlorite and montmorillonite.

The Stairway Sandstone expresses itself topographically as prominent strike ridges. In this area the sandstone has a sand to shale ratio of 2:1. It is comprised of four main rock types - arenites, lutites, carbonates and phosphorites. Clay minerals are predominantly illitic, with minor kaolin and chlorite. The limestone and dolomite contain appreciable amounts of quartz in places. Phosphate can occur in one of a number of pellet forms, as a cement, as phosphatized fossils, and as secondary minerals.

The Mereenie Sandstone exhibits itself as prominent ridges and ranges and consists of white or pale brown fine grained sandstone, which weathers dark brown in places.

The Hermannsburg Sandstone is a sequence of red/brown and grey/brown kaolinitic and silt sandstone with minor conglomerate and conglomeratic sandstone. This formation is expressed topographically as prominent ridges and ranges.

Minor formations in these ranges include -

a) Jay Creek Limestone. Generally expressed as low rises with ridges of more resistant carbonate beds. It consists of algal and oolitic limestone and dolomite, siltstone and shale with a few thin interbeds of calcareous sandstone. The limestone is yellow or grey and the shale brown and green.
b) Goyder Formation. Generally exposed in a dissected pediment below the Pacoota Sandstone. It consists of sandstone, siltstone, dolomite and limestone.

c) Horn Valley Siltstone. Outcrops in the deep alluvium filled strike valleys. The formation contains siltstone, calcareous siltstone, claystone, limestone and minor sandstone. The ratio of non-carbonate to carbonate rocks here is approximately 5:1. The claystone is composed mainly of illite and kaolinite with minor chlorite.

d) Stokes Siltstone. Rarely exposed, and generally forms wide alluvium covered valleys. It is composed mainly of siltstone and claystone with minor limestone and sandstone. The ratio of non-calcareous to calcareous sediments is approximately 25:1. The dominant clay mineral is illite, with minor chlorite.

Minor areas mapped as Quarternary conglomerate occur in a few valleys. These are topographically expressed as scree slopes and gibber plains; may also be described as terrace gravel. The gravels cover bevelled surfaces of older rocks and occur in strike valleys, with the material being derived from valley walls.

Tertiary sandstone occurs in isolated locations and is consequently of minor significance.

South of the James Ranges different geological formations occur. The main types to be found are the Pertatataka Formation, Jay Creek Limestone, Tertiary Silcrete, and Tertiary Conglomerate. Additionally smaller areas of Inindia Beds, Chandler Limestone, Pacoota Sandstone, Chalcedonic Limestone and Quaternary Conglomerate occur.

The Pertatataka formation consists of siltstone and shale with minor dolomite, limestone, sandstone and conglomerate. It is topographically expressed as strike ridges. In this area the siltstone -shale facies predominate.
Tertiary siltstone and sandstone are topographically expressed as mesa cappings and low outcrops.

Silcrete ('billy') is best developed on clastic formations with a high percentage of clay in the matrix and generally forms sub-horizontal or gently dipping sheets.

Tertiary conglomerate is expressed as low rubbly outcrops. Much of the conglomerate is locally derived and occurs as piedmont gravels adjacent to prominent ranges. Some is fluviatile in origin and is preserved in low rises along the margins of the Hugh River. The disposition of the conglomerates indicates that there has been very little change in position of the major drainage channels in post-Tertiary time.

Of minor importance are -

a) Inindia Beds - comprised mainly of siltstone and shale with limestone, dolomite, chert and sandstone interbeds.

b) Chandler Limestone outcrops consist of limestone, dolomite and interlaminated chert. The formation is exposed in low ridges and hills; the outcrops are generally discontinuous, and the sediments are usually strongly contorted and, in places, brecciated.

c) T1 - Chalcedonic limestone, siltstone and calcareous sandstone is limited in extent. It is expressed as mesa cappings and low ridges.

North of the James Ranges the only expressed outcrops are very small patches of T1 and one small area of Travertine.

Quaternary aeolian, colluvial and fluvial sands cover a large portion of the lease.
Management Implications

A geological outline gives general background information on the parent material of soil types found on the property. Factors such as grain size, presence of carbonate etc. all have a direct influence.

Major concentrations of rabbits appear to be associated with outcrops or subcrops of Jay Creek Limestone. In other areas rabbit numbers are very low.

Halites present in the geological formations are the dominant factor influencing soil salinity.

3. Physiography and Drainage

The major physiographic units are:

(a) Mountain ranges and hills. These rise 60 to 300 metres above the general land surface level in the area and are composed of gently dipping sediments. Drainage lines generally follow strike valleys and joint and fault patterns. In a few instances a dendritic drainage pattern can be observed, as in the Hermannsburg Sandstone. Steep marginal escarpments may occur.

The Hugh River cuts through the ranges on the western side of the lease and swings easterly to run along the base of the southern escarpment of the ranges. Drainage from the ranges into the Hugh is via Tidenvale, Log Hole and Stuart Hole creeks.

(b) Gibber or alluvial plains with mesas or low hills. These plains are gently undulating and have a surface with varying degrees of stoniness. A few discontinuous strike ridges rise 15 to 30 metres above the surrounding plain as well as a few low mesas. The drainage pattern is irregular and, except for
the waterway which enters the Hugh south of No. 2 Stock Route bore, is not highly developed. Drainage is locally controlled by hills and is directed to either the Finke or the Hugh Rivers.

(c) **Strike ridges.** A few prominent strike ridges occur to the south of the Hugh River in the central part of the property.

(d) **Mesas.** An area of mesas rising 70 - 90 metres above the surrounding areas occurs in the south east corner. The tops may be remnants of an old peneplaned surface. Here there is a closely spaced network of steep drainage lines.

(e) **Sandplain and sandplain with dunes.** These occur mainly to the north of James Ranges. The dunes take the form of the reticulate type rather than the long parallel type associated with the Simpson Desert. The area is underlain by gently dipping and undifferentiated sandstone, conglomerate and siltstone which are often exposed at the surface. Minor areas of Tertiary sediment also outcrop.

To the south of the James Ranges sand plains and sand plains with scattered dunes occur. These sand plains have been modified by water activity.

Small dune fields bound much of the length of the Hugh River south of the James Ranges and quite large areas of dune field are to be found north of Walkabout Bore.

A weakly developed irregular drainage pattern occurs in many of these sand mantled areas.

(f) **Alluvial flood plains and claypans.** Minor floodplains occur along the Hugh River and some of its tributaries. Claypans occur in a discontinuous belt along the northern edge of the James Range and dune mantled areas bordering the Hugh River. Larger claypans such as the one north of Rainbow Valley act as temporary water sources for cattle.
The Hugh River is gently winding and has a high width to depth ratio. Local braiding may also occur. The bed of the river is a mixture of stone and sand, though the banks are generally sandy which reflects the abundance of sandy sediment supplied under conditions of partial weathering, effective slope wash and flash flooding. The braiding pattern reflects a fairly poorly sorted bed load. The sand and stone/gravel tend to develop patterns due to selective scour and fill and a system of alternating gravel bars and sandy reaches may be seen. Water may be retained in deeper scour pools for varying periods after the river runs. These pools often occur on river bends.

Drainage lines in sand mantled terrain are ill defined and express themselves by the presence of dense stands of mulga. In other areas drainage lines take the form of incised channels. Broad shallow drainage floors have proven to be suitable for the location of dams.
Management Implications

Rugged mountain terrain

- restricts grazing to long, relatively narrow valleys.
- provides a natural barrier to cattle movement.
- may cause problems with control of feral horses and cattle.
- access problems make wildfire control difficult.

Mesa and strike ridge systems

- terrain slope produces high degree of run off during intense rainfall. Will fill dams if present.
- such land forms produce the soil catenary effect of increasing soil salinity down slope. Footslopes and drainage ways may be markedly saline. e.g. between stockroute and One Tree Hill Dam. This is a feature of arid landscapes.

Gently sloping or undulating plains

- less rapid removal of soil by erosion has produced deeper and more productive soils.

Dune fields

- restrict ready access.
- may influence the progression of controlled or uncontrolled fires.

Watercourse areas and claypans

- may provide temporary surface waters, e.g. claypans and waterholes along the Hugh River.
broad mulga waterway areas are suitable for dam locations.

General landform

- south of the James Ranges much of the soil material removed by natural or accelerated erosion is lost into the drainage network.

- aeolian sand deposits bounding the ranges and Hugh River have resulted in less productive pastoral land than might otherwise have been the case. The sand material has, however, provided a good physical growing medium for irrigated crops in an area with a good supply of bore water.
Map units were delineated on 1971 black and white air photography at a scale of approximately 1:84,000. Consequently the degree of purity in terms of specific vegetation and soils described is not very high. This topic is discussed more fully in the following section on Management Guidelines.

The landscape has been divided into eleven major types based on readily identifiable landform. Each of these types has been subdivided into more homogeneous units which are recognisable as pastorally different lands. The map units, however, are not intended to represent discrete land units as land system components, as the scale of air photography and mapping has not allowed for their separation, i.e. some map units are composed of a number of land units.

Map units are associated with a particular land form more so than than their position in the overall landscape. The governing reason for this is the continuum to be observed within a particular landform. Such a grouping is of relevance in arid lands as it facilitates correlation of factors such as run off, run through and run on, increasing soil salinity down slope etc.

This section provides a simplified guide to the map units. Full descriptions are given in the Chapter V.
Map Unit 1. Deeply dissected hill terrain

Field Criteria: Deeply dissected hilly to mountainous terrain with lithosols. (James Ranges).

Land Use: Unsuitable for grazing.
LAND TYPE 2

Lands associated with strike valleys found within the James Ranges and the outer margins of the range. These areas are comprised of three map units as shown below:

2.a Upper stony terraces
2.b Colluvial slopes
2.c Footslopes and drainage ways

Map Unit 2.a: Upper stony terraces

Field Criteria: Two distinct forms of this unit occur. These are:

(i) Gently sloping, pronounced terrace formations such as those north of Tidenvale creek with relief up to 20 m; carry sparse oat grass cover with scattered mulga and cassias; surface covered by rounded gravel and cobble sized material; stony clay soils.

(ii) Sloping mulga (weakly grooved) covered terraces, the more extensive areas of which have been dissected such as those near Valley Dam and areas bordering the Hugh River; surfaces and margins of terraces covered by angular cobble to stone sized material; mulga shrublands with a ground cover of spear grass, mulga grass and minor oat grass; stony red earths. Minor areas of this type found above Tidenvale Creek and the creek line north west of Stuart Bore.

Land Use: Stable lands of low productivity. Forage production limited by stony nature of surface and, in the case of the mulga terraces, the low water holding capacity of the soils.
Gently sloping lands lying below steep margins of the ranges or below the 2.a. terraces; found in the main strike valleys and also flanking the edges of the main range.

**Field Criteria:** Three forms of this unit are to be observed. These are:

(i) Uniform to concave slopes such as along Tidenvale Creek; support a dense oat grass and umbrella grass ground cover with an upper story of open mulga, whitewood and witchetty bush; texture contrast moderately calcareous (clay loam) soils; some scalding occurs immediately below the 2.a. terraces.

(ii) South of Valley Dam this unit occurs as slightly concave slopes below the stony mulga terraces. Stony clay soils support oat grass and some Mitchell grass and umbrella grass with scattered mulga. Copper burrs and tomato bush also occur.

(iii) North of Valley Dam and in areas flanking the main range more convex forms are noted; these are generally gravel surfaced, have steeper slopes than other forms and have soils which are moderate to very gravelly throughout; carry a sparse to moderate ground cover which is oat grass dominant and may have patches of bluebush associated with it; the very open to scattered shrub cover consists mainly of mulga or witchetty bush.

**Land Use:** These notes relate to the three areas referred to above.

(i) This area is capable of producing a dense stand of palatable fodder; not prone to serious water erosion though some movement of surface material during prolonged drought may occur.
(ii) The area can produce a moderate stand of fodder including perennial grasses (e.g. Mitchell grass); long moderate slopes, though water movement retarded in places by gravelly surface; subject to some sheet erosion and where runoff is concentrated, gully erosion may occur e.g. old highway locations. Active gully heads can be seen upslope from the present highway. The gravelly surface is probably the main feature limiting the density of the pasture.

(iii) Produce a sparse to moderate cover of palatable plants. The more convex areas north of Eagles Nest Bore carry a sparse ground cover including a high proportion of copper burr as well as minor blue bush. More gently sloping areas, e.g. north of Valley Dam produce a moderately dense pasture. Plant density is most influenced by the gravelly nature of the surface and soil profile. Sheet erosion may be significant on steeper slopes and gullying has been initiated by concentration of run off along roads.

Map Unit 2.c. - Footslopes and drainage ways

Field Criteria:

(i) Flat to gently sloping lands bounding a generally braided water course system e.g. Tidenvale Creek; footslopes dominated by open woodland of ironwood, whitewood and witchetty bush; dense ground cover of palatable species including oat grass and umbrella grass. Areas at the bases of some terraces are moderately saline, carry a sparse cover of copper burrs and samphires; may be scalped. Coarse textured alluvial areas and braided channels carry a woodland of ironwood, mulga and red gum.

SLCNI B 5
The ground cover consists of a variety of rank perennial grasses. Red texture contrast soils (some calcareous) occur on footslopes; course textured alluvial soils are found in braided areas.

(ii) The area around Valley Dam consists of mulga shrubland growing on a deep massive red earth. Ground cover is moderate to sparse and dominated by woollybutt, spear grass and mulga grass.

**Land Use:**

(i) The run on areas have the capacity to produce a good dense stand of palatable grasses; rilling and scalping are a minor concern and generally fairly restricted; soil salinity is a limiting factor in discrete areas.

(ii) Essentially stable and moderately productive; productivity is limited by chemical fertility.

It should be noted that in a number of instances mapping scale has not allowed for the separation of discrete units. In these situations the dominant unit is shown above the minor one on the map e.g. 2.b or 2.b.

\[
\begin{array}{c}
2.a \\
2.b \\
2.c
\end{array}
\]
LAND TYPE 3

Land associated with high mesa terrain occurring in the south-eastern part of the property. Two map units are described. These are:

3.a. Mesa surfaces and surrounding scarps
3.b. Colluvial slopes, footslopes and drainage ways

Map Unit 3.a - Mesa surfaces and surrounding scarps

Field Criteria: High mesa tops and scarps lying 90-100 m above surrounding terrain sparse grass and shrub cover; lithosols or rock outcrops.

Land Use: Undisturbed areas of no grazing value.

Map Unit 3.b - Colluvial slopes, footslopes and drainage ways

Field Criteria:

Moderately to steeply sloping land below scarps; surface covered by angular stone up to 10 cm in diameter; closely dissected by channels up to 5 m deep; mulga is dominant shrub especially along waterways; sparse oat grass and umbrella grass, some copper burrs and samphires, occasional witchetty bush and minor patches of blue bush (associated with calcareous outcrop); shallow to moderately deep stony red texture contrast soils; may be scalded and saline in lower areas.
Land Use: Capable of producing sparse cover of forage species; degree of slope and stoniness limit density of forage plants; moderately saline soils in places; marginal grazing value.
LAND TYPE 4

Lands associated with low inclined Tertiary Sandstone mesa terrain.

Three distinct sub-types are identified:

4.a. Mesa surfaces and low scarps
4.b. Colluvial slopes
4.c. Footslopes and drainage ways

Map Unit 4.a. - Mesa surfaces and low scarps

Field Criteria: Low inclined mesa tops and scarps; generally no scarp on downslope side; sparse cover of shrubs and grass; lithosols and rock outcrop.

Land Use: Very limited grazing value due to stoniness and soil depth.

Map Unit 4.b. - Colluvial slopes

Field Criteria: Gently sloping stony surface below 4.a. with a residual sandy loam soil mantle covering more than 50% of the area; surface stone and surface soil have darker colour than 5.b and the area is more eroded; supports sparse to moderate cover of oat grass, umbrella grass, and copper burrs; saltbush and samphires are common in some of the lower areas.

Stony areas are devoid of vegetation or carry sparse copper burrs and samphires; Red texture contrast soils (sandy loam overlying medium to heavy clay).
Land Use: Productive areas with moderate to dense palatable forage growth on the residual soil mantles; total productivity is governed by the proportion of residual soil cover; stoniness, soil salinity and erosion also limit productivity on the remainder; gradual erosion of residual soil mantle will further reduce productivity in the long term; when run off water is concentrated (roads, cattle pads) rilling and minor gulling are initiated due to high erodibility of sub soil clay and care is needed in road construction in these areas.

Map Unit 4.c. - Footslopes and drainage ways

A fair proportion of this unit occurs in the 4.b. map unit when separating was not possible.

Field Criteria: Flats and minor drainage ways occupying lower sites; patches of stone free scalding, significant rilling in places; moderately dense oat grass and umbrella grass with scattered Mitchell grass in rills and along channels; scattered mulga, cassia and turkey bush associated with drainage ways; deposition of soil material from units above provides a more uniform soil mantle; samphires and copper burrs occur in discrete areas; red texture contrast soils with uniform clays on scalded areas.

Land Use: Degree of soil cover, soil depth and run-on make this quite a productive unit; relatively small in extent; Intense storms produce a high degree of water movement through the unit resulting in fairly extensive rilling and scalding; wind movement may play some part in the development of scalds; care needed in road construction.
LAND TYPE 5

Lands associated with low inclined Tertiary Silcrete (grey 'billy') mesa terrain and remnants. Three distinct units are identified:

a) Mesa surfaces, low scarps and remnants
b) Colluvial slopes
c) Footslopes and drainage ways.

Map Unit 5.a. - Mesa surfaces, low scarps and remnants

Field Criteria: Inclined mesa tops, scarps and remnants; outcrops of grey billy; scattered mulga and turkey bush; lithosols and rock outcrops.

Land Use: Small but visually prominent units with little grazing value.

Map Unit 5.b. - Colluvial slopes

Field Criteria: Gently to moderately sloping land; stony surface with variable proportions of residual soil mantle; vegetation is variable; on residual soil mantles oat grass, umbrella grass, mulga grass and sidas are most common; blue bush may occur; on stony surfaces, have sparse cover of copper burrs and samphieres; rarely saltbush; red texture contrast soils; sandy loam surface overlying medium to heavy clay; surface soil and stone colour is paler than that associated with 6.b and 4.b units.
Land Use: Moderately productive land growing a range of palatable forage species on the residual soil mantles; salinity levels appear higher than those associated with 4.b and 4.c but are probably less than in 6.c; stone mantled areas have a low productivity; it is thought that the soil material of the residual mantles is probably being moved downslope and a long term increase in stony surface will result; because of the erodible nature of underlying clays, care may be required with road construction.

Map Unit 5.c. - Feetlopes and drainage ways

Field Criteria: Mapped as a pure unit and as a minor part of 5.b, shown on map as 5.b, 5.c; gently sloping to level areas with minor drainage ways; surface may be uneven due to wind mounding around shrubs; oat grass, umbrella grass, sparse Mitchell grass, cotton bush, samphires, copper burrs, cassias and saltbush may be present; scattered mulga on some drainage lines; red texture contrast soils and recent alluvial wash; minor surface gravel, moderately saline; moderate to severe erosion.

Land Use: Non eroded areas are quite productive; unit can be regarded as fragile and may be subject to both wind and water damage; roadlines should avoid these units.
LAND TYPE 6

Lands associated with prominent strike ridges south of the James Ranges. The three map units recognised here are

1) Prominent strike ridges
2) Colluvial slopes
3) Footslopes and drainage ways.

Map Unit 6.a. - Prominent strike ridges

Field Criteria: Steeply dipping prominent strike ridges and associated scree slopes; differ in form depending on geology; rock outcrop and stony skeletal soils; sparse ground cover and scattered shrubs.

Land Use: Of little use for grazing. Prominent forms of relief for orientation purposes.

Map Unit 6.b - Colluvial slopes

Field Criteria: Moderately sloping land below prominent ridges; sixty per cent of area carries residual soil mantle; remainder has stony surface which supports little more than sparse copper burrs; residual soil mantles support a moderate density of oat grass, umbrella grass and some sidas; patches of bluebush may be found; moderately deep red texture contrast soils (sandy loam over medium to heavy clay); soil salinity increases down slope; in S-W corner of the property have rubble covered slopes with moderate shrub cover perennial speargrass and minor spinifex; little grazing value.

SLCN1 B 13
Land Use: Moderate to good fodder production for grazing especially on the lower colluvial slopes; salinity and degree of stone cover are limiting features; residual soil mantle subject to sheet erosion and the percentage of productive land is possibly declining; rills occur where water flow is allowed to concentrate and care required in road construction, due to the high erodibility of the clay subsoils.

Map Unit 6.c - Footslopes and drainage ways

Field Criteria: Flat to very gently sloping lands and drainage ways; salt tolerant plants much in evidence; generally treeless though more developed water ways have mulga, whitewood and corkwood trees; ground cover is variable; less saline residual surface soils have oat grass, umbrella grass and sidas; more saline areas are dominated by copper burrs and samphires; Mitchell grass is evident on disturbed sites; deep red texture contrast soils (sandy loam over medium to heavy clay); clay subsoil has moderate to high salinity; some salt efflorescence visible (white surface patches); rills, minor gullies and scalds are common.

Land Use: Run-on areas which receive a considerable volume of water following intense storms; as a consequence, considerable quantities of soil have been deposited here from higher areas; fresh surface material is relatively salt free and can produce a dense stand of grass; the large flows of water also tend to induce erosion; there is also evidence of wind movement of soil during dry times; because of its run-on situation, growth response in these areas should be better than on run-off/run-through sites above following moderate rainfalls; preferred grazing land should be avoided for road construction because of potential erosion problems.
A number of tracts of lands have been classified as plains of some sort. This group consists of residual plains not associated with major relief types such as the strike ridges or mesa terrain, or alluvial plains which are included under other types.

Map Unit 7.1 - Undulating or irregular plains

Field Criteria: Occur as gently rounded rises with moderate side slopes; have distinct pattern of minor drainage ways; land surface often cobbly to stony; may carry reasonable cover of Acacia shrubs or have very little shrub cover except in lower watercourses; ground cover is variable in composition with oat grass, umbrella grass, sidas and copper burrs occurring; shallow lithosols and uniform or gradational (clay loam) soils.

Land Use; Generally not a highly productive unit; lower margins and flats (minor in extent) capable of producing a reasonable stand of fodder; limiting features to productivity are stone cover, soil depth and degree of run-off; essentially stable land.

Map Unit 7.2 - Plains of low relief

Field Criteria: Gently rolling plains with a fair degree of rounded (sandstone and quartzite) surface gravel up to 5 cm in diameter; supports a very open woodland/shrubland association of whitewood and witchetty bush with mulga occurring near minor drainage lines; ground cover in the less gravelly or non-gravelly areas is dominated by oat
grass and umbrella grass; copper burrs are present in variable proportions, the proportion increasing as the degree of surface gravel increases; red texture contrast soils and uniform non-cracking clays; minor scalding.

**Land Use:** Productive country though fodder growth is limited in some areas by gravelly surface; run-off is not rapid and good moisture penetration occurs; stable country and presents no major hazard to road construction.

**Map Unit 7.3  -  Highly calcareous plains of low relief**

**Field Criteria:** Generally treeless, bulldusty gently rolling plains; stands of witchetty bush occur on higher ground where limestone bedding crops out, e.g., vicinity of Hugh River trucking yard; rabbits are generally prevalent in these areas; little if any drainage pattern; ground cover is dominated by oat grass with few copper burrs; perennial grasses such as umbrella grass do not appear to inhabit these areas; surface is generally free of gravel and where found, only forms a slight cover; much of the gravel found is limestone; red calcareous earths (sandy loam to light to medium clay subsoil).

**Land Use:** Forage production is good; the uniform gentle slopes may carry considerable sheet water flow after intense storms but there is no evidence of accelerated soil loss; minor rilling and gullying may be found at the bases of long slopes; the soils are soft and highly calcareous and are prone to wind erosion especially when physically disturbed; no deflation occurs, however soil mounding around low shrubs is a common feature in some areas; some of this trapped material may have originated outside this unit; road

SLCN1 B 16
construction can result in the soil material becoming pulverized and bull dusty; the poor load bearing capacity of the soils means that major roads such as the access road to the trucking yards should be sheeted with a suitable road base and be regularly maintained.

Map Unit 7.4 - Undulating gravelly calcareous plains

Field Criteria: Varying amounts of limestone gravel up to 4 cm diameter covers the surface; slopes are generally steeper than those of 7.3 and soils may be shallower; carried witchetty bush shrubland previously, however due to shrub death, is now seen as grassland with very open shrubland or scattered shrubs; much fallen shrub material remains around which wind blown soil has accumulated; blue bush may be present; ground cover is dominated by oat grass, umbrella grass may grow on or around mounded trapped soil material and a small proportion of copper burrs may be present; moderately deep to deep gradational calcareous sandy clay loams over clays; rabbits will be much in evidence.

Land Use: Productive grazing lands capable of growing a moderate to dense stand of forage; subject to slight sheet water erosion and wind movement of soil across the landscape may occur in dry times; the gravelly surface retards water and wind erosion to some degree and increases quantity of water entering soil after a rainfall event; there appears to be a good deal of resiliency in the land as far as ground cover goes; shrub regeneration appears to be low; compared with the areas on units 7.2, 6.b, 5.b, etc., the percentage surface gravel here is much lower and does not appear to affect forage density; road construction through these areas does not pose any major problems.
Map Unit 7.5 - Cobbly plains of low relief

Field Criteria: Gently to moderately sloping land, a large proportion of which is covered by dark-reddish cobble and gravel and devoid of vegetation or only supports copper burrs and a few low shrubs; a minor proportion of the area has scattered surface gravel or a residual soil mantle; minor depressions and drainage lines carry scattered mulga and occasional whitewoods; residual soil mantle carries oat grass and mulga grass; where surface stone disturbed near minor drainage lines, scattered Mitchell grass plants have established; red texture contrast soils (sandy loam over heavy clay) or uniform non cracking heavy clays.

Land Use: Small in extent and not very productive; essentially stable land; small area on western boundary has incised drainage and is virtually rubble land.

Map Unit 7.6 - Gravelly plains of low relief

Field Criteria: Gently sloping plains having a gravelly surface; gravel is dominated by dark ironstone material up to 5 cm in diameter and may cover 25 to 30% of surface; small ridges may occur in the plains; vegetation is generally grassland with scattered low chenopod and cassia shrubs; ground cover consists of oat grass, umbrella grass, Mitchell grass, copper burrs, sidas and samphires; moderate plant density; in lower waterway areas, scattered mulga grows along drainage lines; sheet erosion, rills and minor gullies are common; scalding is moderately severe on lower sites and surface may be gravelly or gravel free; red texture contrast soils and uniform non-cracking clays occur; clay sub soils have moderate to high salinity levels; small alluvial fans may be observed, e.g. on road between Soakage Dam and railway air strip.
**Map Unit 7.7 - Plains of low relief: 30% sand mantled**

**Field Criteria:** Gently undulating plains with a mosaic of sand mantled areas covering 30% or less of the unit; open mulga woodland with cassias and scattered whitewood; ground cover of oat grass and mulga grass; on sand areas mulga cover is more dense and ground cover consists of mulga grass and woollybutt; soils consist of red texture contrast types with a sandy loam surface soil overlying sandy clay; sand mantled areas have coarse, uniform textured loamy sand soils; slight erosion by water and wind.

**Land Use:** Moderate forage production; mosaic pattern produces uneven grazing pressure over the unit, less utilization being made of the sand mantled areas.

**Map Unit 7.8 - Gravelly plains of moderate relief (slightly dissected)**

**Field Criteria:** Gravel surfaced lands dissected by a moderately developed reticulate drainage network; moderate woodland cover consists of mulga, whitewood, witchetty bush and scattered ironwood; dense mulga in waterways; ground cover mainly oat grass and mulga grass with minor areas of umbrella grass and blue bush;
soils consist of deep red texture contrast soils and gradational calcareous types.

Land Use: Capable of producing moderate to good stands of palatable forage; numerous drainage lines mean that extreme care would be needed for road construction.
LAND TYPE 8

Lands associated with sand dune formations which occur mainly north of the James Ranges. The dominant dune pattern is reticulate. Two forms are noted, the first with a weakly developed drainage pattern, the second with no evident surface drainage network.

Map Unit 8.1 - Dunefields with a weak drainage pattern

Field Criteria: Scattered dunes with ill defined drainage ways; spinifex, desert oak, desert poplar and occasional mulga cover much of the area; swales and drainage floors carry mulga and colony wattle over woollybutt and wire grasses, some spinifex and minor oat grass; soils on dunes consist of uniform deep sands whilst drainage areas have deep uniform and gradational loamy sands and sandy loams.

Land Use: Overall has moderately low forage production; the drainage ways provide some grazing potential; stable land subject to little pressure; tree and shrub cover may suffer in the event of hot fires.

Map Unit 8.2 - Dunefields with no surface drainage pattern

Field Criteria: Reticulate or parallel (minor) dunes and swales; vegetation dominated by desert oak, minor mulga in some swales; spinifex and a minor component of woollybutt and kerosene grass in the swales; deep uniform sands on dunes; deep uniform loamy sands in swales.

SLCN1 B 21
Land Use: Low productivity of suitable forage species; may get herbage following winter rainfall; stable country; trees and shrubs susceptible to hot summer fires.
LAND TYPE 9

Sand plains with exposures of calcareous soils. Two units are differentiated based on the degree of exposure of calcareous soils.

Map Unit 9.1 - Sand plain with a small proportion of calcareous soils

Field Criteria: Level to gently undulating sand plains supporting spinifex, minor palatable species, desert oak, colony wattle, scattered mallee and mulga; less than 30% of the area consists of exposures of calcareous soils which carry mulga, whitewood, witchetty bush and a ground cover dominated by a moderately dense stand of oatgrass; deep uniform loamy sands and calcareous earths; minor deep, massive red earths.

Land Use: Low to moderate forage productivity; areas north of the James Ranges are generally better than those to the south. Stable land.

Map Unit 9.2 - Sand plain with a moderate to large proportion of calcareous Soils

Field Criteria: Similar to 9.1 but calcareous soil areas occupy 30 to 50% of the land and the surface drainage pattern is more developed.

Land Use: Moderate to good forage production. Areas north of the James Ranges better than those to the south.
LAND TYPE 10

Sand plain lands free of calcareous soils with minor variations which influence their productivity. The three types separated out are:

a) Sand plains without dunes
b) Sand plains with scattered dunes
c) Sand plain watercourse areas

Map Unit 10.1 - Sand plains without dunes

Field Criteria: Flat to gently undulating sand plains; upper storey dominated by a moderately dense mulga especially south of the James Ranges; to the north, some desert oak and colony wattle may be found; ground cover consists of woollybutt, mulga grass, spear grass and wire grass, and a varying proportion of spinifex. A greater proportion of spinifex is found in the north; deep uniform sands and loamy sands.

Land Use: Low to moderate productivity; generally better south of the ranges; essentially stable land; shrub cover is susceptible to hot wildfires.

Map Unit 10.2 - Sand plains with scattered dunes

Field Criteria: Similar in appearance to 10.1 except for the occurrence of well spaced irregular dunes; spinifex is more dominant in the ground cover and desert oaks may be found; colony wattle and mallee may occur north of the ranges; deep uniform sands and loamy sands.

SLCN1 B 24
Land Use: Low forage productivity. Stable land though upper storey vegetation may be susceptible to fire.

**Map Unit 10.3 - Sand plain watercourse areas**

Field Criteria: Broad sandy plains bounding weakly defined drainage floors north of the ranges; soils are mainly aeolian sands which have been re-deposited as alluvial material; low sand rises may be seen; ground cover consists of a variable mixture of spinifex, woollybutt, mulga grass, wire grass and spear grass and some oat grass; mulga and colony wattle dominate the top storey; scattered whitewood and eucalypts found near more incised drainage lines on northern edge of ranges; deep uniform loamy sands and massive red earths.

Land Use: Moderate forage production especially on areas along the foot of the ranges; receive some run-off and are hence better watered than surrounding areas.
LAND TYPE 11

Alluvial plains and claypans: These units are associated with the Hugh River, major drainage lines south of the ranges and claypan areas bounding the northern edge of the ranges and the lower sections of the Hugh. Three units are delineated:

a) Sandy plains associated with the Hugh River
b) Mulga waterway areas
c) Claypan areas

Map Unit 11.1 - Sandy plains associated with the Hugh River

Field Criteria: Level to slightly uneven or hummocky, sandy and gravelly plains bounding the Hugh River south of the ranges; gravelly areas are minor and may have braided channels and carry stands of red gums; sandy plains are more extensive; the colour of these sands is much less red than that of the sand plains and sand dunes; dominant shrub cover consists of prickly wattle and colony wattle, with lignums and small cassia shrubs; ground cover consists of mulga grass, kerosene grass, wire grass and minor oat grass; alluvial soils which range from coarse sands and gravel through loamy sands, loams and sandy clay loams.

Land Use: Not highly productive forage areas even though a large bulk of material may be produced. Sands are often mobile and soil movement may occur when denuded of vegetation.
Map Unit 11.2  Mulga waterway areas

Field Criteria: Found south of the ranges in association with drainage lines flowing into the Hugh or to the Finke; moderate to dense stands of mulga occur with a sparse to dense grass ground cover depending on density of mulga; grass species include kerosene grass, mulga grass, white spear grass and oat grass; main drainage floor generally sparsely grassed; deep red earth soils.

Land Use: Fairly stable areas of moderate to low productivity; areas with annual grasses are more productive. Have provided stable dam sites.

Map Unit 11.3  Claypan areas

Field Criteria: Generally associated with sand plains or sand dune areas; may have eucalypts e.g. bloodwoods and small shrubby tea trees on surrounding areas; surfaces are free of gravel or only slightly gravelly; deep uniform non-cracking medium to heavy sandy clays; saline.

Land Use: Whilst devoid of vegetation, claypans may store surface water for considerable periods after rain; the surrounding sand plain or dune areas often have more suitable forage material available than do the 8 and 10 units; major claypans are shown on the map.
CHAPTER IV

MANAGEMENT GUIDELINES

In providing general guidelines, a great deal of reliance is placed on the use of the map and information in the report (in particular Chapter 3). It should be noted that the document only provides a basic framework on which to build a system of management techniques and options. It is emphasised that, when specific problems arise or decisions have to be made relating to changes in land management, additional advice should be sought from rangeland, soil conservation or animal production extension officers.

The map units are types of land which are readily recognisable. Whilst distinctions between map units are based on landform, soils and vegetation, these factors in combination determine the productivity or capability of each unit. Homogeneity of a particular mapping unit will vary across the survey area with minor changes in geology, soils and vegetation, but the map units will be physically consistent within localised areas.

As the main use of the map units is at the localised (e.g. bore area) level it was considered that further splitting up of land would provide an unmanageable number of units.

Good land management is essentially the art of problem solving and decision making.

Problems may be solved and decisions made at:

(i) whole property level;
(ii) part property level;
(iii) paddock level;
(iv) watering point level.
In relation to time they are:

(i) short term (annual or seasonal);
(ii) medium term (within five years);
(iii) long term (more than five years).

The types of problems and decisions relate to:

(i) maintenance or conservation of existing resources based on established watering and fencing facilities
(ii) development of new facilities leading to greater utilisation of unused or little used resources.

Most problem solving and decision making probably centres on the existing watering point or paddock level on a short to medium term basis, and is based on the maintenance of existing resources. Medium term problems and decisions relate to maintenance and development, while long term thinking mainly concerns developments.

The application of the Map and Report to Management

It should be noted that the author is aware of a range of factors which restrict the management options available and the rapidity with which change can be brought about, for example seasonal weather patterns, market situation, transport, disease control, availability of water, and other economic and social factors. Various combinations of these may produce a low degree of flexibility in the overall enterprise.

The property should be viewed as consisting of a number of sub-enterprises, each comprised of some 50 to 80 km$^2$ of pastoral land. Of importance at this level are:

(i) the quantity and quality of water available and whether it is permanent or temporary;
(ii) the types of land which occur and their productivity;
(iii) the area of each land type at increasing distances from water.
Tables giving a breakdown of pastoral resources by showing the area of each land type available in relation to distance from water are provided in Appendix 3. Within and to the south of, the James Ranges grazing areas have been calculated to a maximum radius of 8 km while to the north of the ranges a radius of 10 km has been used. Quite often the presence of fences or inaccessible terrain reduces the potential grazing distances below these chosen radii. Where two permanent watering facilities are in fairly close proximity (for example 8 km) available areas have been calculated for the full grazing radius from each watering point. In addition the area available off each watering point to a line midway (bisector) between the two waters is provided. The different calculations are required to cater for use of both waters simultaneously or only one of them.

A device for calculating area of each land type in relation to distance from a known point accompanies this report. Its use is described in Appendix 4.

Management of areas around established watering points

Chapter 3 provides a general description of the map units, the map shows the disposition of these units in relation to the watering point and Appendix 3 provides the area of each unit available in relation to distance from water.

Reference to the map illustrates that the grazing lands around each watering point consists of a mosaic of pastorally different lands. The grazing capacity of an area will depend upon the quality and quantity of palatable forage available on the component units of that area. No attempt has been made to define grazing capacities for any one watering point. Forage production in any one year will depend on a number of factors of which the most important is the effectiveness of summer rainfall for plant growth. There is no accurate method for assessing an annual grazing capacity and reliance has to be placed on a subjective judgement at the end of the growing season. A grazing preference rating has not been assigned to the units. The managers knowledge of cattle...
habits around each watering point will be much more precise under contemporary conditions and it is assumed that he will be able to relate the grazing preference of cattle to the map units.

Whilst definite stocking rates cannot be given an attempt should be made to relate stock numbers to forage availability and the state of the land resource. Land available for grazing should not be taken to include all land within a paddock or within a distance of 8 km from water. In the case of Indera Bore for example (a completely fenced area) it might be considered that map units 4.a, 6.a, 6.b, 9.1, 10.2 and 10.3 may have very limited grazing potential (a total area of 48 km²). Pastoral resource available in the paddock can thus be put at 66 km² and not 114 km², the full area. When considering a safe stocking rate for the prevailing conditions, base it on the 66 km² figure. The light use areas provide a relief back up should forage availability have been over estimated or seasonal conditions not reach up to expectations. Management (and relevant advisers) should derive a similar concept for each water.

An assessment of forage conditions around each water should be made in late March or early April; then, after considering forage availability with cattle numbers, make practical adjustments if necessary i.e. forward plan. When exceptionally good seasons prevail, stock numbers should not be adjusted up too much to allow for regeneration or thickening up of the forage resources. At the end of a severe drought, the option of leaving one or two more productive and previously well utilised areas destocked until two successive growing seasons have occurred should be considered. This will allow for natural rehabilitation of land which has gone through a high degree of drought induced stress.

As a basis for annual planning approximate rainfall at each major watering point and stock numbers on, or planned for, each area could be noted on a copy of the land resource map. After assessing forage availability at the end of the growing season the map could be shaded to
denote growth response as good, moderate or poor. In good years, response may be uniform, while in others it may vary from one part of the property to another. Such a map would provide broad overview of how the enterprise is set up for the year, given the contemporary conditions. Finer assessments might prove valuable at the watering point level. If desired, changes in forage reserves can be noted as the year progresses. If there is a poor initial response in some areas or the initial estimate of forage reserves proves to be over optimistic, the available options to reduce grazing pressure on these areas before they are completely denuded should be evaluated. It may also be beneficial to indicate on the map the general grazing patterns of cattle during the year. This could be done at two monthly or three monthly intervals. Especially note when cattle start to move into less productive country as this may indicate that forage resources are becoming limited.

The compiling of such distributions year by year combined with the evaluations of growth response early in the year may allow for more soundly based annual planning in future years. This would be achieved by checking these past records to find a similar set of seasonal conditions, stock numbers etc. to see whether any major problems were encountered in that year in relations to forage supply, over utilisation, stock mortality etc. Compare these facts with the current conditions. The observations required need not be time consuming. They could be made during bore inspections, maintenance operations or mustering activities.

In Summary—

(i) Include an evaluation of the quantity and status of available land resources in all management decisions.

(ii) Where stress to the land resource has occurred or is likely to occur, consider what options are available to alleviate actual or potential problems. Discuss with extension advisers potential early warning guidelines which could be used for different pastoral land units or at a watering point level.
Planning Guides for New Facilities

(i) Watering Points

The establishment of a watering point and associated facilities involves a large capital and operating investment and must, therefore, be able to support an adequate number of stock to provide an economic return on that investment without over-utilising the land resource. The map and report should be consulted so that final decision making is based on documented land resource information.

When a new bore is being considered it is suggested that-

(a) the location of a few potential bore sites be marked on the map;
(b) use is made of the measuring device to derive the area of suitable grazing lands available up to a radius of 8 km (or the preferred radius) from each alternate site. If the availability of water is not limiting, choose the site which will give best overall productivity;
(c) check to ensure that the proposed grazing area does not overlap another to too great a degree (refer to the table and discussion at the end of this section for full details);
(d) where possible, locate bores away from rugged terrain, areas of low productivity and property bounderies. For example, the grazing area available around Jinx or Desert Bores is about half that available of a bore such as Indera Bore. In such cases it would take much longer to obtain a return on investment or the stocking rate required to achieve a quicker return may exceed the safe capacity of the land available;
(e) if the site chosen appears to be, or could become, susceptible to increased erosion, use the measuring device to offset the bore to a safe distance so that the
sensitive area lies outside the zone of excessive grazing and trampling associated with a watering point. If a sensitive area is the only site where water is available, consideration should be given to locating troughs outside the erosion prone area. As a general guide, depositional areas such as minor floodouts or places where the stream gradient becomes more gentle are less susceptible to erosion than others. Sand plains and sand dunes may also be fairly resistant. With bores located in sensitive areas, additional fencing may help in reducing potential erosion problems. Advisory assistance should be sought from soil conservation officers. For example Indera Bore is located in a stable position while the area around Whitewood Bore has foreseeable erosion problems when it is developed.

If a major dam is to be built, again select a few potential sites, calculate the areas of different pastoral lands available and, with an advisor, make an assessment of their safe grazing capacity. The selected site should give the greatest potential grazing capacity, best mix of country, or should best fulfill whatever other objectives management may require. Points (c) to (e) above should also be taken into account. Look for relatively stable areas in which to site a dam (e.g. mulga waterway areas such as that where Indera Dam is located). Advice on the suitability of the soils for dam construction purposes should be sought.

The construction of small dams (temporary storages) within the grazing area of a bore is recommended to allow for grazing pressure to be spread more evenly over the area. More importantly, they may provide the means whereby the heavily utilised areas around the bore can be spelled for a period to allow a degree of regeneration to occur. This would involve shutting the bore down until
the temporary storages dry up and the bore is needed or until animal management requirements necessitate the use of stock handling facilities located at the bore.

When dams (both large and small) are being considered, there is some potential for cost saving and/or prevention of over-utilisation of grazing land. It is generally considered that a beast will consume some 70 litres (15 gallons) of water per day. If an allowance of 25 litres (5 gallons) is made for seepage and evaporation it may be seen that 95 litres (20 gallons) storage is required per beast day. On this basis 0.8 cubic metres or 1 cubic yard of water is sufficient to cater for one beast for eight days. In each case, therefore, an assessment of the potential grazing area should be undertaken. If the dam is to be a permanent water source discuss with advisors a safe stocking rate for a full year. If it is to be used as a temporary watering point, for example 6 months use, derive a stocking rate to match that time span with available forage resources. Convert the stocking rate to the total number of beast grazing days to be carried. Dividing this number by eight will provide the approximate dam capacity required in cubic yards. Four fifths of the capacity in cubic yards provides the capacity in cubic metres. The above concept may be regarded as a rule of thumb guide and modifications may be necessary for particular situations. Following on from the above considerations it may be seen that there is little value in having a dam with a capacity of 50% more water than one which is sufficient to meet the demands of stock numbers based on the availability of forage resources. Cost savings could be achieved. In addition, if a dam is over-designed in comparison with available forage, it may result in stock being held in the area too long to the detriment of the land resource.
Calculation of grazing areas available from two watering points

The desired grazing radius for cattle and the distance between watering points are topics to be discussed by management and advisory personnel. In all combinations of the above two figures, where the spacing of watering points is less than twice the grazing radius, there is a degree of overlap in the grazing areas, the size of which depends on the distance between the waters. If only one bore is in use the potential grazing area can be considered as that enclosed by a full circle based on the accepted grazing radius. If the two bores are used simultaneously the total grazing area available may be significantly less than the sum of the areas of two full circles.

In Figure 1 an example is given where two bores are located 10 km apart and a grazing radius of 8 km has been selected. Where only Bore A is in use the available area is that of a full circle based on that bore. When Bores A and B are used simultaneously, the total area which should be used for assessing a stocking rate is the sum of the two full circles less the area of overlap (hatched area Figure 1). Alternatively the area available from each bore can be calculated by measuring the area of the part circle to the bisector (a line midway between the two bores).

Figure 1  Diagram showing overlap area (hatched) and bisector line when two bores are used simultaneously.
In the example shown above the overlap has an area of 50 km² which may have a significant influence on the total number of stock grazed. If only one bore is in use the grazing area is 200 km². When both are in use the total area is only 350 km² (or 175 km for each bore). Stock numbers should be reduced to reflect this difference in forage resources available in this instance. Table 1 below is based on a supposed grazing radius of 8 km and provides the areas of overlap which occur for a range of bore spacings.

Table 1. Details relating to grazing areas available when two bores at varying distances are used simultaneously.

<table>
<thead>
<tr>
<th>Bore spacing (km)</th>
<th>Grazing area (km²) available if both bores in use.</th>
<th>Area of overlap (km²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>275</td>
<td>125</td>
</tr>
<tr>
<td>6</td>
<td>290</td>
<td>110</td>
</tr>
<tr>
<td>7</td>
<td>305</td>
<td>95</td>
</tr>
<tr>
<td>8</td>
<td>320</td>
<td>80</td>
</tr>
<tr>
<td>9</td>
<td>335</td>
<td>65</td>
</tr>
<tr>
<td>10</td>
<td>350</td>
<td>50</td>
</tr>
<tr>
<td>11</td>
<td>361</td>
<td>39</td>
</tr>
<tr>
<td>12</td>
<td>374</td>
<td>26</td>
</tr>
<tr>
<td>13</td>
<td>380</td>
<td>20</td>
</tr>
<tr>
<td>14</td>
<td>391</td>
<td>9</td>
</tr>
<tr>
<td>15</td>
<td>397</td>
<td>3</td>
</tr>
<tr>
<td>16</td>
<td>400</td>
<td>0</td>
</tr>
</tbody>
</table>

If management operates on different grazing radii similar sets of figures can be derived.
Due consideration should be given to the above principles when stocking existing facilities and in the selection of new watering points.

(ii) Fences

Fencing may be carried out for a number of purposes such as disease control or the separation of different stock types. It also has an effect on the land resource. Again because of the high cost of fencing value for money is required. When a new fence is planned a proposed alignment should be marked on the map. The measuring device can then be used to calculate the areas of pastorally different lands which would be left on each side of the fence. Should it appear that too little forage reserves would remain on one side a couple of alternate locations can be tested to achieve the desired mix of country and available area on both sides. This may avoid undue stress being applied on one side of the fence. Fence lines require access tracks for construction and maintenance. These may also be used as firebreaks. The proposed fence location in relation to areas which may be prone to erosion should be checked and, if needed, advice is available from soil conservation officers.

Summary

The discussion above considers some of the ways in which the map and report information may be used in decision making. No doubt there are other uses for it which will apply to specific problems. The acquisition of a set of aerial photographs covering the property will also aid the understanding of the composition of the land resources. Total coverage is available at a scale of 1: 84 000 (black and white) whilst partial coverage is available at 1: 50 000 (colour and black and white) and 1: 15 000 (black and white). Full use should be made of advisory services available from D.P.P. advisors, soil conservation officers and pastoral inspectors.
### CHAPTER V

DETAILED DESCRIPTION OF MAP UNITS

**LAND TYPE 1**

Extremely rugged terrain of the James Ranges

<table>
<thead>
<tr>
<th>MAP UNIT 1</th>
<th>Deeply dissected hill terrain</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Field criteria</strong></td>
<td>Dissected hilly to mountainous terrain; lithosols.</td>
</tr>
<tr>
<td><strong>Lithology</strong></td>
<td>Gently dipping sandstones (Mereenie, Hermannsburg, Pacoota and Stairway).</td>
</tr>
<tr>
<td><strong>Terrain</strong></td>
<td>Gillen, Krichauff and Sonder Land Systems. Hill slopes and crests; 10-45% slope.</td>
</tr>
<tr>
<td><strong>Soil</strong></td>
<td>Lithosols; very shallow; gravelly or stony. Uc1.23; Uc1.13.</td>
</tr>
<tr>
<td><strong>Vegetation</strong></td>
<td>Low Acacia shrubland; scattered ghost gums, Eucalyptus papuana, Fremiphila spp. Triodia basedowii, minor Enneapogon spp.</td>
</tr>
<tr>
<td><strong>Erosion</strong></td>
<td>No accelerated erosion.</td>
</tr>
<tr>
<td><strong>Land use</strong></td>
<td>Generally unsuitable for grazing. Limited shrub browsing capability in extreme drought situation.</td>
</tr>
</tbody>
</table>

SLCN2 H 1
LAND TYPE 2

MAP - UNITS ASSOCIATED WITH STRIKE VALLEYS

Strike valleys are longitudinal valleys eroded in, and developed parallel to, the strike of underlying weak strata. Here they are confined to areas within and bounding Map Unit 1 (The James Ranges). Whilst the units which occur on the margins of the ranges are not located in valleys they are similar to the valley units in most respects.

The lands within strike valleys may be subdivided into three units. Unit 2.a. which is comprised of stony terraces is a discontinuous unit consisting of remnants of a previous valley fill surface. Colluvial slopes and footslopes, and drainage way units, 2.b and 2.c are found in all cases.
MAP UNIT 2.a. - Upper stony terraces

Field criteria: Sloping mulga covered stony terraces or nearly level stony terraces with little shrub cover; mulga terraces have angular stone cover; shrubless terraces have a surface cover of rounded gravel and cobble.

Lithology: Mulga terraces - Quarternary Conglomerate. Shrub free terraces - Stokes Siltstone (includes fossiliferous limestone and sandstone interbeds).

Terrain: Stokes terraces - level to gently sloping with prominent terrace faces 10-15 m high. Gillen, Krichauff, Sonder Land System.

Position on slope: Upper mid slopes. Conglomerate terraces - gently sloping with well developed drainage pattern; low edge scarps 3-6 m high.

Soil: Stony desert loams (Dr 1.12, Dr 1.13) of the Orange Creek family occur on the Stokes terraces; stony red earths (Gm 2.12) of the Hermannsburg family are found on the conglomerate terraces.
The conglomerate terraces have a high concentration of surface stone and may be stony throughout the profile. Slightly acid to neutral in reaction. The Stokes terraces have stony red texture contrast soils. Surface texture - sandy loam; subsoil texture - light to medium clay. May be alkaline at depth with a moderate degree of carbonate.

Profiles are deep on Stokes terraces but may be shallow on the conglomerate ones.

**Vegetation**

Conglomerate terraces - Open shrubland of groved *Acacia aneura*. Ground cover dominated by varying proportions of *Enneapogon* spp., *Digitaria coenicola* and minor *Aristida* spp.

Stokes terraces found north of Tideneale Creek carry open grassland dominated by *Enneapogon* spp. and *Digitaria* spp. with minor *Aristida* spp. Scattered shrubs include low *A. aneura*, *Cassia* spp. and *Eremophila* spp.

**Erosion**

The main terraces and their margins are well protected by surface stone and no accelerated wind or water erosion is occurring.

**Land use**

Conglomerate terraces have limited grazing potential. Mulga component may be relevant. The Stokes terraces have a moderate grazing potential.

Limiting factors are stoniness and low water holding capacity in mulga areas.
MAP UNIT 2.b - Colluvial slopes

Field criteria: Gently to moderately sloping land in strike valleys. Soils and vegetation are variable; slightly convex slopes with very gravelly surfaces are calcareous and carry oat grass and scattered low shrubs; uniform to slightly concave slopes have red duplex soils with a heavy clay subsoil and support open woodland and perennial grasses including mitchell grass. These duplex soils are prone to sheet rill and gully erosion. They differ from the 6.b (strike ridge) unit in that the soil surface is more uniform and salt tolerant plants are few indicating lower soil salinity. Terraces of 2.a protrude into this unit.

Lithology: Colluvial material derived from Mereenie, Pacoota and Stairway Sandstones, Stokes Siltstone and Conglomerate.

Terrain: Gillen, Krichauff and Sonder Land Systems. Gently to moderately sloping lands; gently undulating along the valley.

Position on slope: Midslopes between valley walls (or 2.a) and valley fill areas (2.c) below; slope range 1-5% with steeper slopes occurring in undulations along the valleys.

Soil: Desert loams (Dr 1.33, Dr 1.52) of the Orange Creek, D2, and D3 families, solonized brown soils (Gc 2.22) of the SkCa
group and minor red earths (Gn 2.12) of the Hermannsburg family.

The soils are variable, depending on the parent material. North of Valley Dam gradational calcareous and red texture contrast soils are found. Slopes may be convex and the light coloured gravelly soil surface, dominance of oat grass and presence of scattered blue bush and occasional dead witchetty bush distinguish this area from that to the south of Valley Dam. 15% ± cover of rounded (3-4 cm Ø) surface gravel. Moderately developed algal crust. Aeolian sand has been deposited on part of this unit (too small in extent to map separately).

Red texture contrast soils occur south of Valley Dam. These are less gravelly, darker red, have a less well developed algal crust, occur on more uniform to slightly concave slopes and are more erodible than those to the north. Parent material changes cause the difference. Soils are moderately deep to deep, have 5-10% gravel cover, a higher sand fraction, neutral surface and slightly to moderately alkaline subsurface sections, small to moderate amounts of carbonate at depth.

In the valley of Tidenvale Creek two distinct variations are found. Land below the Stokes terraces have texture contrast soils with medium to heavy clay subsoils.
Surface material when present is sandy loam. Moderately saline as indicated by presence of bassia and samphires and mitchell grass occurs on disturbed, e.g. rilled, sites. Scalding and rilling are common. Scalds may be stony.

Lands not associated with Stokes Terraces have red texture contrast soils (light red to yellowish red surface). Surface is often gravel free and in no case does gravel exceed 10% cover. Surface textures are loamy sands/sandy loams; light textured clay subsoils. Profiles are alkaline throughout and moderate amounts of carbonate occur at depth. The soils associated with the southern arm of Tidenvale Creek are similar in most respects to those south of Valley Dam.

Vegetation

Open shrubland dominates; woodland species such as *Atalaya hemiglauc*a occur in restricted areas. *Acacia aneura* is the dominant shrub component except on calcareous soils where *Acacia kempeana* is more common. On saline areas below the Stokes terraces halophytic plants such as *Halosarcia* spp. and *Sclerolaena* spp. may predominate and *Astrebla pectinata* may occur in association with *Enneapogon* spp. and *Digitaria coenica*.

South of Valley Dam on the heavier clay soils a considerable component of *Astrebla pectinata* may be found. Dominant ground cover throughout the unit is comprised of
Enneapogon spp., Digitaria coenicola and small Aristida spp., e.g. Aristida contorta. Solanum spp. are found in the Valley Dam area and small Cassia shrubs occur as a minor component. Sand mantled areas carry A. aneura shrubland and a ground cover of large Aristida spp. e.g. Aristida inequiglumis.

**Erosion**

Water erosion is affecting parts of the unit. The saline areas below the Stokes terraces are prone to rilling and scalding. South of Valley Dam areas below the stony mulga terraces appear highly erodible and active gullying is occurring. In addition road works associated with the Stuart Highway have altered overland flow patterns and caused increased erosion.

Much of the unit is not greatly affected by contemporary water erosion. Little aeolian movement occurs in the Valley Dam area. Slight mounding of soil on the calcareous areas above Tidenvale Creek indicates some recent movement.

**Land use**

Productive areas suitable for extensive grazing. Forage density varies from sparse on gravelly slopes to thick on sandy surfaced calcareous soils where infiltration is rapid. Stoniness, soil depth or salinity may limit productivity in the upper positions. Rapid runoff especially at the commencement of the summer rainfall period may result in little
moisture being made available for plant growth.

Erosion constitutes a moderate limitation south of Valley Dam.
Field criteria: Valley flats and drainage ways associated with strike valleys. Flat to very gently sloping lands with single or braided drainage lines. Tall woodland vegetation dominates the coarse textured alluvial areas. Along Tidenevale Creek areas of open woodland (whitewood) with a dense ground cover of oat grass are found. Stone mantled flats with moderate to severe scalding and a halophytic plant cover occurs below the Stokes terraces. In the Valley Dam area deep sandy red earths with mulga shrubland typify the unit.

Lithology: Quarternary alluvium and colluvium.

Terrain: Gillen, Krichauff and Sonder Land Systems. Flat to very gently sloping areas and central drainage lines.

Position on Slope: Lower slopes and valley flats. Slope range 0-1%.

Soil: Desert loams (Dr 1.13) of the Orange Creek and Rodinga soil families and red earths of the Bond Springs soil family.

Predominantly red texture contrast soils having loamy sand/sandy loam surface soils and light clay subsoils. Surface may have scattered surface gravel more so where
there are signs of soft scalding. pH is neutral at surface becoming alkaline with depth. Small to moderate quantities of carbonate below 50 cm. Crusting is non algal and soft. Trampling produces a dry loose surface.

Below the Stokes terraces stone mantled clays occur. Moderately saline and have a moderate carbonate content.

Braided stream channel areas have coarse textured alluvial soils.

Deep massive sandy red earths occur near Valley Dam. These have a soft crust (non algal) or are dry and loose. Textures are in the sandy loam/sandy clay loam range; surface pH is slightly acid becoming neutral at depth.

Vegetation

Woodland communities - common in Tidenvale Creek. Mainly *Atalaya hemiglauca* with scattered *Acacia estrophiolata* and *Eucalyptus camaldulensis* close to drainage channels. *Acacia aneura* occurs in association with the *A. hemiglauca* spp. minor amounts of *Digitaria coenica* and *Aristida contorta* constitute the ground cover.

Saline areas are devoid of tree and shrub cover and the sparse ground cover consists mainly of *Sclerolaena* spp., *Halosarea* spp. sparse *Astrebla pectinata* and minor *Enneapogon* spp.
Shrubland - *A. aneura* dominated shrubland occurs in the vicinity of Valley Dam. Ground cover consists of *Eragrostis eriopoda*, *Aristida* spp. and some *Sclerolaena* spp.

**Erosion**  
These areas are subject to a moderate to high degree of rilling, slight gullying and scalding. Sensitive areas as erosion processes occur even where little or no grazing has occurred. Red earth areas near Valley Dam are stable.

**Land use**  
Productive run on areas are capable of producing a dense stand of grass. Small in extent. Major limitations are the erodibility of soils and in certain cases the degree of soil salinity.
LAND TYPE 3

MAP UNITS ASSOCIATED WITH HIGH MESA TERRAIN

MAP UNIT 3.a - Mesa surfaces and surrounding scarps

Field criteria: Prominent mesas with relief of 100 m. Pale
coloured deep weathering zone visible below
mesa top. Very steep scarps and upper
scree slopes.

Lithology: Tertiary sandstone, siltstone and
conglomerate.

Terrain: Chandler land system.
Mesa surfaces which are level to gently
inclined. Much rock outcrop. Steep scarps
and scree slopes.

Position on Slope: Gently sloping mesa tops, steep scarps and
upper scree slopes. Slopes 25% on scree
and scarps, 1/2% on tops.

Soil: Shallow lithosols and rock outcrop. Soil
family S k.

Vegetation: Mixed sparse grass and shrub cover.

Erosion: Nil

Land use: Unsuited to grazing.

SLCN2 H 13
MAP UNIT 3.b - Colluvial slopes, footslopes and drainage ways

Field criteria: Mid slopes below high scarps; well developed closely spaced drainage network with channels incised up to 6 m. Surface covered by angular stone material up to 10 cm in diameter. Moderate areas of stony scalds.

Because of their small extent it has not been possible to map the lower slope and drainage areas as a separate unit and their description is included here.

Lithology: Colluvial material derived from Tertiary sediments.

Terrain: Chandlers land system. Dissected sloping terrain with minor areas of level land bounding main drainage channels in lower positions.

Position on Slope: Mid slopes: ±-6%, lower areas 1%.

Soil: Desert loams (Dr 1.33) of the Rodinga family with minor areas of the Orange Creek family and solonized brown soils (Gc 1.12) of the SkCa or Santa Teresa families.

On midslope areas cobble mantled red texture contrast soils are found. Generally stony throughout the profile and moderately saline. In lower positions moderately deep red texture contrast soils
Vegetation

Midslopes - Open *Acacia aneura* shrubland with *Enneapogon* spp. and *Digitaria* spp. Scattered *Acacia kempeana* and *Maireana astrotricha* which are probably associated with soils derived from minor exposure of Jay Creek limestone. *Halosarcia* spp. and *Sclerolaena* spp. are to be found indicating the somewhat saline condition of the soils. *A. aneura* is quite dense on drainage lines.

Erosion

Nil

Land use

Fairly low productivity of forage. Limitations include stoniness, soil depth, salinity, scalding and high rates of runoff.
MAP UNIT 4.a - Mesa surfaces and low scarps

Field criteria : Tertiary sandstone mesas less than 30 m. high. Tops may be gently inclined resulting in no observable scarp on backslope.

Lithology : Tertiary sandstone, siltstone and conglomerate.

Terrain : Chandlers land system. Low gently inclined mesa tops with small scarps.

Position on Slope : Crests (1-3% slope) and small scarps (20% slope).

Soil : Lithosols or outcrop.

Vegetation : Scattered low *Acacia aneura* and *Eremophila* spp. and sparse short grasses.

Erosion : Nil

Land use : Small units with limited grazing potential.
MAP UNIT 4.b - Colluvial slopes, footslopes and drainage ways.

Field criteria: Slopes and drainage areas lying below low sandstone mesas; surface gravel and soils are darker than on 5.b; significant sapphire component in vegetation; more eroded than 5.b; approx. 50% of surface has gravel mantle, 50% has a residual sandy loam mantle.

Lithology: Mixed tertiary sediments, mainly sandstone, siltstone and conglomerate.

Terrain: Chandlers land system. Pediment terrain below low mesas; concave profile with few minor convexities.

Position on Slope: Mid and lower slopes (slope 1-3%); drainage floors (slope 1%).

Soil: Desert loams (Dr 1.33) of the Rodinga family and minor areas of medium to fine textured alluvial soils.

Sites having a residual soil mantle have red texture contrast soils (Dr. 1.33). The residual layer consists of loamy sand/sandy loam, ranges from 1-10 cm in depth and is thinner than those associated with unit 6.b. Soft surface crust. Profiles moderately deep to deep. The heavy clay subsoil has a well developed medium to coarse blocky structure and is dark red.
Kaolinite dominates clay minerals and there is little evidence of marked swelling and shrinking. Moderate carbonate occurs below 30 cm. Salinity content is higher than in 6.b soils and surface whitening is evident in places. pH is neutral at the surface to moderately alkaline at depth.

Cobble and gravel cover areas where the residual soil mantle has been lost. Fragments may be completely exposed or partly embedded in the underlying clay. A firm slightly algal crust occurs on the surface of the clay which, in other respects is similar to that found underlying residual soil mantles.

These soils may be classed as uniform fine textured clay soils. (uf 6.12).

On lower sites the depth of the residual soil mantle may exceed 20 cm or there may be a complete absence of stone. Subsoil salinity is high.

Vegetation: Open Chenopod shrubland (shrub steppe) and grassland. Residual soil areas carry moderately dense Enneapogon spp., Digitaria coenicola, and some Sida spp. Atriplex nummularia and Halosarcia spp. would indicate these lands to be more saline than those of the 5.b and 6.b units. Sparse low shrubs including Acacia aneura, Eremophila and Cassia spp. are found associated with minor drainage ways and Astrebla pectinata is found on disturbed sites.
Erosion

Subject to sheet erosion. Margins of residual soil mantles are vulnerable to soil loss resulting in a reduction in the extent of these areas. The underlying clay is highly erodible and if the protective stone cover is disturbed rills and gullies may develop where concentration of flow occurs. Gullies seldom exceed 50 cm in depth.

On lower sites scalding and rilling is prevalent. No evidence of major wind erosion was noted.

Land use

Currently quite productive lands. Should a high rate of loss of the residual soil mantle occur the grazing capacity of these lands will be reduced considerably. The major limitations to land use are erosion (severe), stone cover (severe) and salinity (moderate).
LAND TYPE 5

Map Units Associated with Low Mesa Terrain comprised of Tertiary Silcrete - (Grey billy).

MAP UNIT 5.a - Mesa surfaces, low scarps and remnants

Field Criteria: Low mesas, gently sloping surfaces or rounded remnants; small scarps on upslope edges, lacking on backslopes; outcrops of grey billy on surface and scarp.

Lithology: Tertiary Silcrete cappings and scree.

Terrain: Chandlers land system. Uneven mesa tops and low scarps.

Position On Slope: Level to gently sloping mesa tops (0-1%). Steep scree slopes (25%).

Soils: Lithosols and outcrop.

Vegetation: Scattered Acacia aneura with Eremophila spp. over sparse Enneapogon spp. and Aristida contorta.

Erosion: Nil.

Land Use: Limited grazing potential; small units of negligible grazing value.
**Field Criteria**

- Surface is stony (cobble) or has a residual soil mantle—proportions vary from 30:70 to 50:50. Bluebush more common than on 4.b or 6.b and surface colour is paler. The silcrete material is of lighter colour than the ferruginised material on surface of 4.b and 6.b.

**Lithology**

- Colluvial material derived from silcrete. Minor intrusions of Jay Creek Limestone and calcareous shaley material.

**Terrain**


**Position On Slope**

- Middle and lower slopes (½ to 3%)

**Soils**

- Desert loams of the Rodinga and D4 (Dr 1.33) and Orange Creek (Dr 1.13) soil families. Red texture contrast soils (Dr 1.33, Dr 1.13) dominate the unit. The surface has up to 70% residual soil mantle, the balance having a stony (gravel and cobble) cover. The proportion of cobble increases up slope and stone material is in a rounded form. The unit 6.5 km SW of Nombra Bore has platey shale material on the surface (cobble and stone grades). The stony calcareous nature of this unit may be the cause of greater quantities of blue bush.
Dr 1.33 soils occur where residual soil mantles are found. South of Whitewood Bore the surface layer comprises a gravelly sandy loam with few small stones. Subsoil consists of medium to heavy, well structured clay with shale gravel encountered below 120 cm. Carbonate is absent from surface layer but present in all subsurface horizons and increases with depth.

South of the Hugh rail bridge soft surfaced (somewhat puffy) Dr 1.13 soils are found. Residual soil covers more than 50% of the area. Gravel surfaces are quite soft, 95% of gravel is 1-2 cm dia. In this area, bluebush, saltbush and samphires form a considerable part of the vegetative cover with a few dead witchetty bushes. Surface loamy sand has soft highly algal crust with pH 7.8. Subsurface layers are fine sandy clay loam, sandy clay and gravelly clay. pH increases to 9.0 below 25 cm. Carbonate (trace) occurs in surface layers (to 25 cm) and becomes moderate to large at depth. Soft patches of gypsum are also observed at depth. Salinity would be quite high though no surface efflorescence seen.

The soils where residual mantle is absent can be classed as stone mantled uniform non-cracking clays (Uf 6.12).

Vegetation: Variable depending on stoniness, salinity, calcareous nature of soil and depth. Stone mantled areas are practically devoid of vegetation or carry Sclerolaena spp, and in
some places Halosarcia spp. and Atriplex spp.. Residual soil mantles support a grass dominant community consisting of Aristida contorta, Sporobolus actinocladus, Enneapogon spp, Sida spp, Digitaria coenicola and Sclerolaena spp. On more calcareous sites, Enneapogon spp, Sporobolus actinocladus and Digitaria coenicola are the major spp. Sclerolaena spp and Maireana astrotricha are also found and in some instances minor halosarcia spp.

Erosion

Appears to be moderate to severe. Residual soil mantles appear to be the remnants of what was previously a uniform cover. It is not possible to determine to what degree accelerated erosion has induced this pattern. It could be that the residual mantle is slowly working down slope. When the stony surface is disturbed rills and minor gullies may develop even on very gentle slopes. On more calcareous sites such as S.S.E. of the Hugh rail bridge some past wind movement has occurred.

Land Use

Capable of producing a good range of palatable plants. Productivity is limited to a large extent by the stony and scalded nature of much of the surface. Productivity will be further reduced as soil from the residual mantles is eroded away. The soils have good moisture holding characteristics; soil salinity reduces productivity as palatable plants, especially perennial grasses cannot cope with this factor. Salinity increases downslope.
Care is required with the construction of roads as the soils are susceptible to gully erosion when surface water is allowed to concentrate.

MAP UNIT 5.c  -  Footslopes and drainage ways

Field Criteria : Mapped as a separate unit south of Soakage Dam; other small unmapped areas are found associated with 5b. Soil surface generally stone free and uneven due to rilling, gullying, scalding and past wind movement. Oat grass, umbrella grass, scattered mitchell grass, cotton bush, samphires, copper burrs and small Cassias may be seen. Scattered mulga on some drainage lines.

Lithology : Colluvial and alluvial material derived from Tertiary silcrete and shale.

Terrain : Chandler land system. Level or very gently sloping ground. May be hummocky. Rills and small drainage channels.

Position On Slope : Lower slope and drainage way areas. Slopes 0-15%.

Soils : Desert loams (Dr 1.33) of the Rodinga soil family. Red texture contrast (Dr 1.33) soils with 20-30 cm of slightly acid to neutral sandy loam overlying moderately to strongly alkaline clays which are yellowish.
Vegetation

Fresh surface deposits appear to support species which are not tolerant of high salinity levels. On such surfaces Enneapogon spp are dominant with scattered Digitaria coenicaola and Cassia spp. On eroded areas or surfaces lacking fresh deposits vegetation reflects the saline nature of the soil. Maireana aphylla, Halosarcia spp, Sclerolaena spp and scattered Maireana astrotricha are dominant. Some Astrebla pectinata colonises disturbed sites such as rills and small gullies.

Erosion

Highly disturbed areas which receive a high degree of run on; and rills, small gullies and scalds are common. Some scalds have fine gravel on surface. Sandy surficial material is also subject to wind erosion.

Land Use

Not suitable for road locations, dams etc. Hummocky sandy loam surface soils produce a moderately dense stand of good forage. Overall productivity is limited by proportion of these found in the unit (50-70%). The remainder of the area carries little forage but does support salt tolerant species.
LAND TYPE 6

Prominent Strike Ridge Terrain

MAP UNIT 6.a - Ridge crests and scree slopes

Field Criteria: Prominent strike ridge crests and steep upper slopes occurring south of the Hugh River. Rubble surfaces with very sparse ground cover.

Lithology: Pertatataka formation, Chandler and Jay Creek Limestones. Steeply dipping strata.

Terrain: Gillen land system. Prominent ridges and hills.

Position On Slope: Crests and steep upper slopes; 5-30%.

Soils: Lithosols on crests; stony shallow red texture contrast (Drl.13) on steep slopes.

Vegetation: Very sparse. Low Eremophila and Cassia shrubs, Enneapogon spp, Sclerolaena spp and scattered Triodia spp which are found on pockets of trapped sand.

Erosion: Nil.

Land Use: Little grazing capability.
MAP UNIT 6.b  -  Colluvial slopes

Field Criteria : Mid slope areas below prominent strike ridges. 35% of the surface is stone mantled and very sparsely vegetated; 65% carries a residual soil mantle with dense grass cover. Dominant colour of stone is dark red. Scalding may occur in lower areas or bordering drainage lines.

Lithology : Mixed colluvial sediments of shale, sandstone and limestone.

Terrain : Gillen land system. Uniform concave slopes with some irregularities along slope due to drainage lines.

Position On Slope : Mid to lower slope areas; 1% to 4%.

Soils : Desert loams (Dr 1.33) of the Rodinga soil family. Red texture contrast soils (Dr 1.33) are found where a residual soil mantle occurs. The surface soil consists of 10-20 cm of loamy sand/sandy loam which has a very soft crust .5 to 1 cm thick. A stone layer 5 cm thick occurs between this layer and the clay subsoil layers. Upper part of top clay layer has faint sporadic bleach in most cases. Where residual mantle has been removed a stony (cobble and gravel) surface is normal. Much of this material is partly embedded into the soil surface. Exposed soil material has a firm crust 1 cm thick. Given the absence of the

Erosion: Moderate to severe. Sheet erosion is dominant. If water is concentrated by road lines, cattle pads, etc, rills and small gullies may develop.

Land Use: Areas of residual soils produce dense stands of forage. Stone mantled areas carry little suitable feed and reduce the overall productivity of the unit. Stony surface, erosion and salinity are the main limiting factors. Care required with road line locations.
### Field Criteria

Foot slopes and drainage floors below 6.b. Salt tolerant plants are much in evidence; yellowish red sandy surface soils; rills and small gullies are common; scalding and a few stone mantled areas; evidence of past disturbance giving a hummocky surface. Salt efflorescence may be visible.

### Lithology

Colluvium and alluvium derived from shales, sandstone and limestone

### Terrain

Gillen land system. Flat to very gently sloping. Uneven surface due to soil movement.

### Position On Slope

Footslopes and broad drainage floors. Slopes less than 1%.

### Soils

Desert loams (Dr 1.33, Dr 1.13) of the Rodinga family. Deep red texture contrast soils (Dr 1.33, Dr 1.13). These soils differ from those of 6.b in the following respects.

- a) Soil profiles are deep
- b) Stone mantle is only sporadic and material is in the gravel size range.
- c) Carbonates occur in large quantities in upper clay layers.
- d) A greater profusion of samphires indicates a higher level of soil salinity and larger patches of salt
efflorescence may be seen. Well watered due to run on, and infiltration rates are high except on scalded areas.

**Vegetation**

Grassland and open Chenopod shrubland (shrub steppe) communities. Major species include Halosarcia spp, Enneapogon spp, Digitaria coenica, Sporobolus actinoclados, Sclerolaena spp, Sida spp, and scattered Cassia spp. Main drainage channels may have Acacia aneura, Atalaya hemiglaucu and Hakea spp along their margins.

**Erosion**

Subject to water and wind activity as evidenced by the rills, small gullies, scalds and hummocky surface.

**Land Use**

A favoured site due to its run on situation. Less disturbed sites are capable of producing a dense cover of forage species. Disturbed sites are bare or support a sparse cover of salt tolerant species.

Not ideal units for access road location.
LAND TYPE 7

Plains

A variety of land forms throughout the lease are classified as plains. Significant variations occur in the types and, on a pastoral basis, ten maps are defined.

MAP UNIT 7.1 - Undulating or irregular plains

Field Criteria: Low rises occurring south of the ranges. Gently rounded in form with slopes generally less than 9%. Distinct pattern of minor drainage lines. Surface generally cobbly to stony and vegetation cover is variable.

Lithology: Remnants of Tertiary Conglomerate.

Terrain: Angas and Gillen land systems. Convex rounded rises with moderate density of minor drainage lines.

Position On Slope: Upper, mid and lower slope positions. Slopes range up to 10-15%.

Soils: Somewhat difficult to classify and are best classed as stony desert loams of the Orange Creek family. Lithosols - with minor areas of shallow red texture contrast (Dr 1.13) soils. Uniform or gradational texture profiles may occur. Surface stone may be rounded or angular. Surface may be slightly
Vegetation: Grassland or very open shrubland. Acacia aneura, Acacia kempeana and Cassia spp. form the dominant shrub types. Atalaya hemiglaucac may occur. Ground cover is dominated by Enneapogon spp. and Sclerolaena spp. usually very sparse. Minor pockets of Triodia spp.

Erosion: Slight sheet erosion due to slope. Surface generally well protected by stone cover.

Land Use: Produce a sparse stand of palatable forage. Productivity limited by stoniness, run off and shallow soil depth.

MAP UNIT 7.2 - Plains of Low Relief

Field Criteria: Gently rolling plains which may have little surface stone or a 15% cover of rounded quartzite and sandstone gravel up to 5 cm dia. Carries an open woodland/shrubland association.

Lithology: Sedentary soils developed on weathered Tertiary conglomerate and calcareous sediments.
Terrain: Angas, Chandlers and Renners land systems. Gently undulating plains. Minor drainage lines which are not incised.

Position On Slope: Upper, mid and lower sites. Slopes are less than 3%.

Soils: Desert loams of the Orange Creek (Dr 1.13) and Rodinga (Dr 1.33) families. Red texture contrast (Dr 1.13, Dr 1.33) soils and uniform non-cracking clays (Uf 6.12) soils which may be free of surface gravel are found. Surface crusts are moderately soft, and profiles may be calcareous throughout, increasing to large at depth. A hardpan occurred at 100 cm in one profile. Some soils may be slightly to moderately saline, especially west of the Stuart Highway. Infiltration and permeability are good.

Vegetation: Open woodland/shrubland and occasionally grassland associations. *Acacia aneura*, *Acacia kempeana*, *Atalaya hemiglauca*, and *Cassia* spp. occur over a ground cover of *Enneapogon* spp, *Sporobolus actinocladus*, *Digitaria coenigcola*, and *Sclerolanea* spp. Occasional *Maireana astrotricha* and *Astrebla pectinata* species may be observed.

Erosion: Slight sheet erosion will occur on these lands though no deleterious effects are evident.
Land Use: Capable of producing a moderate to dense stand of forage over the greater part of the area.

Stable land and presents no hazard to road construction.
M A P  U N I T  7.3  -  Highly Calcareous Plains of Low Relief

Field Criteria: Rolling plains, with banded grey limestone outcrops more pronounced on the low crests and near lower drainage ways. Very little channelised surface drainage except at the base of slopes. Yellowish red surface soils with no surface gravel or only a trace of fine gravel; banded outcrop areas carry a cover of witchetty bush and some blue bush; non outcrop areas with little or no tree and shrub cover; marked tendency to become bull dusty when mechanically disturbed.

Lithology: Banded algal limestone of Jay Creek formation.

Terrain: Chandlers, Gillen and Renners land systems. Level to gently undulating; banded limestone outcrop in some areas giving a terrace like effect to the terrain (terrace height 50 cm.). No channelised drainage in upper and middle slopes. Banded limestone produces an onion ring type pattern on air photographs.

Position On Slope: Upper, middle and lower slopes; slopes generally between 1% and 3%.

Soils: Solonized brown soils (Gc 1.12) of the Santa Teresa family. Away from the bands of outcrop these soils are moderately deep to deep. The surface has a soft to slightly hard, partly algal crust up to 1 cm. thick. There may be a scattering of...
surface gravel including non calcareous material. The surface allows for the ready infiltration of water into the soil. When disturbed, the surface becomes pulverulent making it susceptible to wind erosion. The soils range from sandy clay loam on the surface to light to medium clays at depth. The high proportion of free carbonate in these soils may result in the field texturing being somewhat finer than it should be. Traces of decomposed parent material are to be found throughout. The surface is yellowish red and with depth light or pale red or red brown colours may develop. They are highly calcareous throughout and moderately to strongly alkaline soil reactions are recorded.

**Vegetation**

a) Banded outcrop areas - (open shrubland) *Acacia kempeana* shrublands with 50-100% mortality. Ground cover of *Enneapogon* spp. and some *Sclerolaena* spp.

b) Open short grass plains - (Open grassland) shrubs absent or very sparse in which case they may reflect the presence of limestone sub crop. Ground cover of *Enneapogon* spp and a trace of *Sclerolaena* spp. Perennial grasses would not appear to colonise these highly calcareous areas.

**Erosion**

Very little evidence of water erosion though some sheet loss must occur on long gentle slopes.
Slight soft scalding bounding some drainage ways. Wind movement is evident in the open shrubland areas due to mounding round shrub bases and fallen dead shrubs. It is probably significant on the open grassland areas as well but no obvious signs are present. The pulverulent nature of the soil makes it susceptible to wind action especially if the surface is disturbed by animal or vehicle.

The soil surface remains friable.

Land Use

In the outcrop areas rabbit infestation is high and imposes a severe restriction on forage availability for cattle. Wind erosion is a slight limitation. Though infiltration of water into the soil is good, the water holding capacity is not high and fairly rapid drying out may occur. Grassland areas capable of growing a moderate to good stand of oat grass.
MAP UNIT 7.4 - Undulating gravelly calcareous plains

Field Criteria: Gently rolling plains with a varying cover of calcareous surface gravel. Vegetation consists of open shrubland dominated by witchetty bush, with mulga which is moderately dense in water ways and where surface gravel is much reduced. Ground cover dominated by oat grasses. Limestone gravel is spheroidal and pale reddish brown in colour. Areas having scattered surface gravel have a yellowish red/reddish yellow loose to soft surface. Blue bush is a common feature in vegetative cover and scattered witchetty bush and mulga occur, the mortality of these being greater than 50%. Mounding suggests wind movement of some of the surface soils. The tops of gentle rises in these areas have up to 50% stone cover (gravel).

Lithology: Oolitic limestone of Jay Creek formation west of Stuart Highway. Calcareous sandstone and conglomerate in central areas.

Terrain: Chandlers, Gillen and Renners land systems. Gently sloping plains with low rounded rises. Slight terracing in the central areas. Weakly developed drainage patterns.

Position On Slope: Rounded rises to lower small flats. Slopes may exceed 5% for short distance on rises. Generally 2½%.
Gradational textured soils either highly calcareous throughout (Gc 1.12) or becoming highly calcareous with depth (Gc 1.22). Those soils with a stony surface cover often have a small to moderate amount of gravel throughout the profile. They form a firmer surface crust than those soils which have only a slight quantity of surface gravel. Soils with oolitic limestone to the west are calcareous throughout. Shallow soils with sandstone and conglomerate on the surface only become highly calcareous in the subsoil. These soils have a surface pH of 7-7.5 and a range of 8.5-9.0 in subsoil. Those which are calcareous throughout range from 8.5-9.0 throughout the profile.

Surface soils are generally sandy loams and sandy clay loams with a trace to large quantities of gravel. Sub soils are generally in the light to light medium clay range and varying amounts of gravel occurs, generally increasing with depth. Most of the gravel occurring throughout the profile is rounded. In some instances marly material may be encountered at depth.

Low rounded rises may have shallow red texture contrast soils with a gravelly sandy loam overlying a gravelly light clay. These may also occur at base of rises and loss of the sandy loam layer has resulted in the formation of scattered small scalded areas.
Vegetation: Open shrubland generally dominated by species which reflect the calcareous nature of the soils. Those areas with oolitic limestone carry a moderate cover of *Acacia kempeana* and moderately dense *Acacia aneura* in drainage floors. *Enneapogon* spp, *Sida* spp, and *Solanum* spp occur as ground cover. Other areas have *Acacia kempeana*, *Maireana astrotricha* and scattered *A. aneura* up to 5 metres high. The mortality rates in the witchetty and mulga is high (50%). The ground cover includes predominantly *Enneapogon* spp, a trace of *Digitaria coenicola* in places, *Sida* spp and *Sclerolaena* spp.

Erosion: Minor on stony surfaced areas. Some soft scalding may occur on interzones between stony and non-stony areas. Soils not protected by surface gravel have been subject to wind action in the past and soil material has been mounded round fallen shrubs.

Land Use: Productive areas for extensive grazing. Erosion is a slight to moderate limitation in the relatively stone free surface areas. Shrub mortalities have added to the potential instability of this landscape. Shallow soil depth and consequent lower capacity to store moisture is a slight limitation on the low rises.

SLCN2 H 40
The soil surface is quite receptive to rainfall and signs of excessive sheeting across the surface are not evident. Capable of producing dense stands of palatable forage. More suited for road lines than 7.3.
Field Criteria: Gently rolling plains of low relief (15 m) with a gibber surface of gravel and cobble sized fractions. Surface may be gibber, have residual soil mantles or have an incomplete cover of surface gravel and cobble. Surface gravel is dark and ferruginous. Red texture contrast soils predominate. Vegetation ranges from absent through copper burr dominated shrub steppe to open grassland with associated open mulga or open woodland communities. Variations are too small to map out. Mulga and woodland communities are associated with less stony phases and perhaps better watered sites.

Lithology: Mixed tertiary sediments with some conglomerate and quartzite in surface pavement. Underlying parent material is possibly siltstone, shale and sandstone.

Terrain: Renners land system. Gently rolling plains with slopes up to one kilometre long; very gently rounded crests; minor drainage channels in upper and mid slopes, more pronounced at base of slopes. Local relief up to 15 m.

Position On Slope: Upper mid and lower slopes. Slopes 3% generally ½-2%.
Soils

Desert loams (Dr 1.33) of the Rodinga family. Red texture contrast soils (Dr 1.33); 50% of the unit has a gravelly and cobbly surface mantle. The remainder has a residual loamy sand to sandy loam mantle. The surface mantle has a yellowish red colour in the dry condition. Loamy mantles range up to 20 cm. in depth. Subsoil clay has a blocky to prismatic structure with mostly rough and minor shiny faces on the peds. Loamy mantles are neutral while subsoils are moderately to strongly alkaline. Carbonate is generally present and may be large in quantity in some of the deeper layers.

These soils are suspected to be moderately to highly saline. The stone mantle acts as a good surface mulch and underlying soils remain moist and friable for long periods after rain.

Vegetation

May be absent on stone mantled areas or at best consist of a sparse cover of Sclerolaena spp. Residual soil mantles have a covering of grasses and chenopod shrubs. Species found include Enneapogon spp, Astrebla pectinata, Sporobolus actinocladus, Sida spp., Sclerolaena spp. and Halosarcia spp.

On crests and a few small areas which have lost the stone mantle and occupy colluvial positions open woodland of Acacia aneura and Atalaya hemiglauca occurs. A few broad shallow depressions running down slope
which have lost their stone mantle and are moderately rilled carry a greater density of grasses including a higher percentage of \textit{A. pectinata}. Better water availability and surface soil conditions are the cause. Slight gilgaiing appears to have developed in some of these areas. \textit{A. pectinata} grass tends to colonise other areas where the gravel mantle has been broken sufficiently, e.g. cattle pads, rills areas disturbed by earth moving machinery, etc.

\begin{table}[h]
\centering
\begin{tabular}{|l|}
\hline
\textbf{Erosion} : Protected by gravel mantle from any large scale erosion. Residual soil mantles are subject to soil loss which will further increase the percentage of rubble land. Where the stone mantle is absent some rilling does occur. Very gentle slopes seem to preclude the development of these to any great degree and Surrounds are relatively well vegetated. \\
\hline
\textbf{Wind movement generally absent.} \\
\hline
\textbf{Land Use} : Gravelly pavement is a severe limitation to productivity. Simultaneously it protects underlying soil from erosion and acts as a mulch which results in a longer storage period of soil moisture. \\
\hline
\textbf{Salinity} is a moderate limitation (halophytic spp, grow well here). \\
\hline
\textbf{In 1978 a small trial cultivation with the Paech pitter was carried out in this area. Some areas were seeded with buffel and}} \\
\end{tabular}
\end{table}
others were cultivated without seeding. The treatment has not been very successful. The pits slaked down fairly rapidly, little buffel has established and the hoped for establishment of a bit of mitchell grass from local seed sources has not occurred. The rainfall has been erratic and clay content and soil salinity may present a problem with buffel establishment.
MAP UNIT 7.6 - Gravelly plains of low relief

Field Criteria: Gently sloping plains with dark red ferruginised surface gravel. Moderately to severely eroded, stony, saline desert loam soils. Shrub steppe-grassland vegetation association. Minor mulga on lower drainage ways and scalded areas (high mortality). May have minor low hills or rises.

Lithology: Colluvium derived from ferruginised fine grained shale of Pertatataka Formation.

Terrain: Gently sloping plains of low relief.

Position On Slope: Upper, mid and lower slope positions. 1-3%

Soils: Desert loams (Dr 1.33) of the Rödinga family. Red texture contrast soils (Dr 1.33) where residual mantle found or Uf 6.12 clays where residual mantle has been removed. On the Dr 1.33 soils the loamy sand mantle (15 cm. deep) has a soft algal crust. A gravel layer occurs between 15 and 20 cm. The top of the gravelly medium clay below 20 cm. has a sporadic bleach. The surface is yellowish red when dry, red when moist. Red gravelly clay is found between 20 and 60 cm. below 60 cm, yellowish red light gravelly is found.

pH ranges from 8.0 at surface (no carbonate) to 8.9 at depth with large
amounts of carbonate. Some gypsum evident. Probably most saline of all soils seen.

Vegetation: Chenopod shrubland and minor grassland. Vegetation associations reflect high degree of salinity. Species include Halosarcia spp, Sclerolaena spp, Sida spp, Sporobolus actinoclodus and Astrebla pectinata. In some places, Acacia aneura occurs on lower drainage lines and on margins of scalded lower sites. *A. aneura* mortality is high. *A pectinata* is more prevalent on disturbed sites.

Erosion: Moderate to severe sheet and rill erosion. Concentration of water by road lines etc. results in minor gullyng. Some footslopes are severely scalded.

Land Use: Density of forage is variable, being good on residual soil mantles, sparse to absent on stony surfaces. The Mitchell grass component may fluctuate markedly with seasons.

Care is required with road construction.
Field Criteria: Gently undulating plains with a mosaic pattern of sand mantled areas covering 30% or less of the unit. Dominant soil is a red texture contrast type. Surface colour is yellowish red when dry. Becomes dark red when moist. Vegetation consists of an open mulga shrubland though woodland types such as whitewood occur in some areas. Understorey of short grasses and forbs (sparse). The sand mantled areas have red uniform coarse textured soils. Vegetation dominated by open mulga shrubland over woollybutt grass. A few low rises occur in the unit and may support spinifex on their crests.

Lithology: Conglomerate, sandstone and limestone; quaternary alluvium and aeolian sand.

Terrain: Angas land system. Undulating plains with occasional low rises. Weak drainage network.

Position On Slope: Upper, middle and lower positions. Slopes generally 1½% though may exceed 3% for short distances on rises.

Soils: Desert loams (Dr 1.13) of the D2 family, siliceous sands (Uc 5.11) of the Maryvale family and minor calcareous red earths (Gn 2.13) of the Wyeecha family.
Dominant soils are deep red texture contrast types (Dr 1.13) with a sandy loam surface soil (20 cm.) overlying sandy clay. The surface has relatively well developed algal crust (2mm thick) and infiltration is moderate to good. pHs range from 6.8 at the surface to 8.6 at depth and carbonate occurs below 20 cm. rising to moderate to large below 100 cm. The carbonate occurs as soft patches.

The sand mantled areas have deep, coarse uniform textured profiles (Uc 5.11) of loamy sand to 50 cm. overlying loamy sand to sandy loam to 150 cm. The surface has a slightly firm crust - 2 mm. thick. Infiltration is good. Soil pH ranges from 5.7 at the surface to 6.0 at depth.

Open *Acacia aneura* shrubland dominates this area especially on the sand mantled areas. Ground cover consists primarily of *Eragrostis eriopoda* and *Aristida contorta*.

The vegetation on the texture contrast soils consists of very open *A. aneura* shrubland, some *Atalaya hemiglansa* a few *Cassia* shrubs and the ground cover consists of *Enneapogon* spp, and some *A. contorta* grass and minor *Digitaria coenicola*. Taller perennial grasses such as *Aristida inequiglumis* also occur especially on the interzone areas between the two dominant soil types.
Erosion: Sand mantled areas have a slightly uneven surface indicating some wind movement during drought periods. Slight mounding occurs around mulga and fallen trees. The non sandy areas are subject to slight sheet erosion and small areas of soft scalds do occur. Some wind movement of surface soil material is also evidenced by the presence of mounding.

Overall the unit has a slight erosion problem.

Land Use: The sandy areas are suited to very sparse grazing. A lack of preferred grazing species ensures a reasonably adequate ground cover is maintained though this could be lost during severe dry periods. Chemical fertility is the main limiting factor to productivity. The areas having texture contrast soils have a slight limitation due to erosion. Infiltration of water into the soil and water holding capacity are both moderate to good. The mosaic patterns of the two dominant soil and vegetation types results in an uneven grazing pressure across the land with heavy utilization occurring on the texture contrast areas and light usage on the sandy areas.
Gravelly plains of moderate relief
(slightly dissected)

Field Criteria: Gravel surfaced lands dissected by a moderately well developed reticulate drainage network. The unit supports a moderate woodland cover of mulga, whitewood, witchetty bush, and some ironwood. Ground cover is dominated by oat grass and mulga grass with minor areas supporting umbrella grass. Sporadic blue bush may be observed. Dense mulga occurs in the main waterways. The soil surface is yellowish red and has up to 30% gravel cover (to 3 cm dia.). The Gravel is generally light toned. Red texture contrast soils are found with areas of gradational calcareous types.

Lithology: Sandstone conglomerate and fine grained limestone.

Terrain: Angas land system. Somewhat dissected plains of moderate relief which are undulating parallel to main drainage line. Profile is variable.

Position On Slopes: Upper, middle and lower slopes. Slopes range from 0-4%. Dominant slope is 2%.

Soils: Desert loams (Dr 1.13) of the Orange Creek family, calcareous red earths of the Wyeecha family and solonized brown soils of the Santa Teresa family. Red texture
contrast soils (Dr 1.13). Neutral to slightly acid sandy loams (with surface gravel to 3 cm. dia.) overlying alkaline sandy clays. Moderate to large carbonate at depth. Gradational soils (Gn 2.13) occupy a significant part of the unit with occasional Gc 1.12 types.

**Vegetation**

Moderate open woodland of *Acacia aneura*, *Atalaya hemigluca*, *Acacia kempanea* and *Acacia estrophiolata*. *A. aneura* is dense in drainage lines. Ground cover consists mainly of *Enneapogon* spp, *Aristida contorta* and *Digitaria coenicola*. *Sclerolaena* spp occur in varying proportions and minor areas of *Maireana astrotricha* may be observed.

**Erosion**

Generally slight. Slope factor contributes to sheet erosion. Some evidence of wind mounding in more calcareous areas.

**Land Use**

Capable of producing moderately dense stand of palatable forage. Care required with road construction.
LAND TYPE 8

Mapped in two units.

MAP UNIT 8

- 1. Dune fields with a weak drainage pattern.
- 2. Dune fields without surface drainage.

Field Criteria: Dunes up to 8 to 10 metres high which are generally irregular in alignment. North of the ranges on the eastern side a definite SE/NW and E/W trend is exhibited due to dominant wind direction. Drainage floors carry moderately dense mulga while dune flanks and basal areas have a covering of spinifex and desert oak. Dune crests are often bare. Dunes are relatively short in length and are more sinuous than the long parallel dunes of the Simpson Desert. Interdune areas are sandy and carry little if any mulga in unit 8.2.

Lithology: Quaternary aeolian sand.

Terrain: Simpsons land system. Dune fields. The dominant pattern is irregular or reticulate. A significant area of parallel dunes lies to the north of Walkabout Bore.

Position On Slope: Upper mid and lower slopes. Slopes range from 0% in the swale to 15% on dune flanks.

Soils: Siliceous sands (Uc 1.23) and earthy sands (Uc 5.11) of the Maryvale family. Minor red earths (Gn 2.13) of the Wyeecha family.
and Gn 2.12 soils of the Bond Springs family. Dune crests and flanks - red siliceous sands grading into loamy sands towards the interdune depressions.

8.1 Interdune areas may have clayey sands and red earth soils associated with mulga communities.

8.2 Interdune areas have deep clayey sands.

**Vegetation**

Dune crests are bare or carry a sparse cover of low shrubs or *C. decaisneana*. Dune flanks carry *Triodia* spp under a dominantly *C. decaisneana* top storey. Inter-dune areas have scattered *C. decaisneana*, *A. aneura* and *Triodia* spp in the 8.2 and moderately dense *A. aneura* over *Triodia* and *E. eriopoda* in the 8.1 units.

**Erosion**

Of no major consequence.

**Land Use**

Generally unproductive. The exception to the generalisation is during periods when winter rain produces ephemeral growth. Ephemerals, particularly *parakeelya*, then provide a moderate supply of succulent palatable material. Dune areas adjacent to the Hugh River south of the ranges are probably more productive in this regard. Soil fertility is the dominant limitation to land capability.
LAND TYPE 9

Sand Plain with Exposures of Calcareous Soils

This unit has been arbitrarily broken into two separate map units 9.1 with small areas of calcareous soils, and 9.2 with moderate to large areas of calcareous soils. As the main difference between the two units in the proportion of calcareous soils present they are described as one unit.

Field Criteria: Predominantly mulga covered sand plains with interspersed outcrops of gravelly calcareous soils. The sand plain has a spinifex, woollybutt and mulga grass ground cover. Towards the calcareous outcrops witchetty bush may increase. Soils are generally deep loamy sands/sandy loams. Water way depressions have dense mulga and red earth soils with little ground cover or a mixture of oatgrass, woollybutt and mulga grass.

Outcrop areas are flat to low rounded rises with slightly to very gravelly surfaces and carry witchetty bush, occasionally blue bush and a ground cover dominated by oat grasses.

Lithology: Quarternary alluvium aeolium and mixed tertiary sediments mainly conglomerate.
Terrain: Ewaninga, Angas and Simpson land systems. Flat very gently sloping plains; some gentle rises in sandy surface where aeolian activity has deposited wind blown sands. Calcareous outcrop areas are generally less than 6 metres higher than surrounding areas.

Weakly developed drainage system.

Position On Slope: Flat to slightly uneven (1%) sand plain. Calcareous outcrop areas flat to gently rounded - slope 2%.

Soils: The dominant soils of the sand plain are clayey sands and massive red earths with red brown to red undifferentiated sands occurring in most areas but more so to the north of the hills. The associated outcrop areas consist of shallow to deep calcareous soils.

9.1 units north of the James Ranges may have a scattering of randomly aligned dunes. The sand plain soils are dominated by undifferentiated sands with minor areas of clayey sands. (Maryvale and Bond Springs families). Outcrop areas have calcareous soils. (Orange Creek and Wyeecha families with minor Santa Teresa types). These have sandy loam and clay loam surface soils underlain by varying depths of clay loams and light clay. Generally stony throughout. In some areas oolitic limestone forms this gravelly/stony component. Minor areas of red earth
soils may occur in drainage depressions. These are more common in 9.2 units than 9.1 units.

The deep red sands, clayey sands and red earths are acid to neutral in reaction though clayey sands and red earths may become moderately alkaline with depth. Subsurface alkalinity is more common in deep profiles south of the ranges. Generally finer textures in the areas in the south gives these soils a better waterholding capacity. The southern sand plains are of more alluvial origin than the northern ones which still reflect aeolian deposition. The calcareous soils are usually covered with a moderate gravel layer which reduces impact of erosive forces. May be oolitic limestone in the north and rounded conglomerate in the south.

Vegetation:

Shrubland and woodland communities.

Sandridges and deep undifferentiated sands support sparsely timbered hummock grassland of Casuarina decaisneana over Triodia spp. Other species found include A. aneura, Eucalyptus gamophylla, occasional Atalaya hemiglaucua, Hakea spp and a few A. kampeana. Ephemeral spp. occur in winter if rainfall sufficient.

In the north, the sand plain is likely to be dominated more by Triodia spp than in the south where species such as Eragrostis eriopoda and a range of Aristida spp. grasses occur in the A. aneura shrubland.
Red earths in drainage depressions carry dense stands of mulga with a sparse ground cover including *Aristida contorta* and some *Enneapogon* spp. *Sida* spp. may also be found on these areas.

Calcareous areas carry a sparse to moderate cover of *A. kempeana* and *A. hemiglauca* over *Enneapogon* spp with some *Maireana astrotricha*. In the south, outcrop areas are more in the form of slightly rounded gentle rises and shed water. In the north they frequently occur in lower positions and tend to become run-on areas. Growth of forage species in these areas is much more prolific.

**Erosion**

Generally stable. Some of the calcareous areas not protected by a gravelly surface may be subject to some wind movement. Deflation in low lying areas may produce soft scalds.

**Land Use**

Suitable for very extensive grazing of cattle utilising the pockets of more suitable lands within the units. Unit 9.2 has twice the capacity of unit 9.1 due to the larger proportion of calcareous soils.
LAND TYPE 10

SAND PLAINS

Three different forms are identified at a broad level.

**MAP UNIT 10.1 - Sandplains without dunes**

**Field Criteria**
These occur in the southern part of the property. Level to very gently sloping mulga covered stable plains with loamy sand/clayey sand surface soils which are stone free. Red surface colours. Ground cover dominated by 'woolly butt and vine grass.'

**Lithology**
Quaternary alluvium.

**Terrain**
Singleton land system. Flat gently sloping plains. Surface drainage non-existent except for few broad drainage depressions.

**Position On Slope**
Upper, mid and lower positions. Slopes $\leq \frac{1}{2}$% or less.

**Soils**
Uniform or gradational textured red clayey and loamy sand soils. In lower positions massive red earths are more common whilst higher up slope loamy and clayey sands are more pronounced. Some areas underlain by a light coloured slightly to moderately calcareous layers which may or may not reflect in surface vegetation. Water moves
freely into and through most of these soils. Fertility is variable but usually low.

**Vegetation**

: Acacia aneura shrub lands with Eragrostis eriopoda and perennial Aristida spp., Solanum spp and Sclerolaena spp.

Some A. aneura death has occurred generally as a result of drought, though in some areas hot fires have caused more severe destruction of the shrub cover.

**Erosion**

: Generally stable. May get slight wind movement in drought but surface still friable and no soft scalding is evident.

**Land Use**

: Areas of low fertility and do not produce large quantities of normally palatable forage and hence have a low capability. Main value lies in its being a source of top feed for drought use though again such use is somewhat limited by lack of local permanent watering points.

Such areas should be protected from hot summer fires which will result in high mortality to the mulga. Winter patch burning is recommended when conditions are suitable.
MAP UNITS 10.2 - Sand plain with scattered dunes

Field Criteria

Similar to 10.1 except that scattered small dunes occur throughout. In the north dune crests may be bare; in the south dune crests are covered by vegetation. Mulga shrublands with some desert oak particularly in the north. Soils are sandier and spinifex much more common than in 10.1.

Drainage non existent or only very weakly developed.

Lithology

Quaternary aeolian sand and alluvium.

Terrain

Singleton, Simpson and Ewaringa land systems. Gently undulating due to sand ridges.

Position On Slope

Upper, mid and lower positions. Slopes $\frac{1}{2}\%$ on interdune areas; dunes up to 15% for very short distances on dunes.

Soils

Siliceous sands (Uc 5.11) of the Maryvale family and red earths (Gn 2.12, Gn 2.13) of the Bond Springs and Wyeecha families. Deep siliceous sands on dune crests grade into loamy and clayey sands between the dunes. Acid to neutral pHs, low fertility, and sandy textures are dominant features.

Vegetation

Acacia aneura shrublands with Casuarina decajasneana. Triodia spp. occurs on dune
flanks and deeper sands in the interdune areas. Clayey and loamy sands in lower positions carry grasses such as *Eragrostis eriopoda* and perennial *Aristida* spp.

**Erosion**

: Generally stable.

**Land Use**

: Of limited value as grazing country. Potential for some use of top feed. Dune flanks and deep sands will produce winter ephemerals with adequate rainfall.
MAP UNIT 10.3 - Sand plain water course areas

Field Criteria: Sand mantled areas with weakly to moderately well developed drainage ways. Often remnants of previous streams which have had a sand mantle laid over them. Sandy soils with sparse low shrub cover except in depressions where mulga shrub land exists. Scattered dunes occur in areas. Ground cover is variable. Near the James Ranges red gums may grow along water courses, spinifex is sparse or absent, and oat grasses and witchetty bush become more common. Whitewoods and ghost gums may also occur.

Lithology: Quaternary alluvium overlain by quaternary aeolian sand in many cases.

Terrain: Simpson land system. Flat to gently undulating land with drainage depressions and minor water courses. Old waterway areas are present in some areas. Scattered small dunes.

Position On Slope: Generally lower slopes; ½ - 1%. Slopes up to 15% on dunes.

Soils: Earthy sands of the Maryvale and red earths of the Wyeecha and Bond Springs families. Loamy sands and clayey sands with deeper uniform sands towards the dunes. Often the surface is mounded reflecting wind action.
during dry times. Soft platey surface crusts are present, generally non algal. May get increase in clay content with depth to give sandy loam textures. Deep profiles.

Near the James Ranges deep light coloured (reddish brown/light red) sandy loams occur. These are probably slightly calcareous due to parent material. A soft crust (non algal) is formed on these soils, however, water infiltration is rapid.

Vegetation

On more juvenile lighter coloured soils near the ranges, shrubs and grasses reflecting the calcareous nature of the parent material are common. Acacia kempeana, Atalaya hemiglauc a and Acacia aneura occur with Enneapogon spp forming a dominant part of the ground cover. Where aeolian sand overlies calcareous material, hummock grassland of Triodia spp forms the main ground cover and Eucalyptus gammophylla may be the dominant shrub. Additionally the run of good seasons has resulted in a prolific growth of Acacia murrayana on many of these areas at present. This is a short lived species and will die out in a prolonged dry period. The dead plant material left will possibly pose problems to access by horse or vehicle for some period. The unit in the northeast carries a shrub cover of A. aneura with some A. kempeana Ground vegetation includes E. eriopoda and Aristida contorta and Enneapogon spp. It is difficult to
apportion percentages of each type. 
Sclerolaena, Sida spp and Solanum spp. are also found.

The drainage area in the central north of the property is very sandy. Vegetation here comprises a high proportion of hummock grassland spp. of Triodia with some Eragrostis Eriopoda and perennial Aristida spp. A. aneura occurs in lower lying areas on finer textured soils while scattered C. decaisneana are to be found over the sandier areas and on the scattered dunes.

Stable to water action. There has been wind movement in the past resulting in a fairly uneven surface and it is to be expected again during a prolonged drought or after a wildfire, if follow up rain does not occur.

Areas adjacent to the ranges have a moderate capability for extensive grazing. Useable areas occur as a mosaic separated by less productive sand areas. Such areas would respond well to winter rainfall to give a growth of ephemerals.

The more sandy area in the central north is not so productive though should respond to winter rainfalls.

Firing of some of the more sandy of these areas may reduce the amount of spinifex and increase species diversity enabling more use to be made of them.
Limitations to land capability are fertility, water holding capacity and colony wattle invasion in some areas.
LAND TYPE 11

ALLUVIAL PLAINS AND CLAY PANS

MAP UNIT 11.1: Alluvial Plains

Field Criteria: Located adjacent to Hugh River. Braided areas and old channels carry red gums and have gravel and coarse sand alluvial material. Further away from the channel beds light red reddish yellow sands and loamy sands occur. Vegetation consists primarily of dense shrubs and lignum. In places dense shrub consists of Prickly Wattle whilst in some places recent Colony Wattle growth has occurred. The plains are generally narrow being bounded by hills and dune fields. Occasional pockets of finer textured alluvial material are found and a woodland cover of coolibah trees is encountered.

Within the James Ranges older alluvial terraces are found. These support a cover of mulga and corkwood with oatgrass and woollybutt dominating the ground flora. Yellowish red surface colours are dominant and scalding is prevalent.

Lithology: Alluvium - coarse to medium textured.

Terrain: Gillen, Krichauff and Simpson land systems. Level to gently sloping.
Position On Slope: Gravel bars, old channel beds, lower terraces and older higher terraces. Seldom more than 1 km. wide.

Soils: A range of miscellaneous alluvial soils are found including Uc 5.11, Gn 2.13 and Dr 1.13 profile forms. The Gn 2.13 and Dr 1.13 types can be placed in the Amoonguna family.

Coarse textured gravels and sands occur close to present channels; subject to flooding at times. Finer textured soils not generally subject to flooding are composed of brown to reddish brown fine sands, loamy sands and occasionally loams. They have a slightly to moderately alkaline reaction and traces of carbonate may occur at depth.

Older higher terraces where present, have sandy loam and sandy clay loam surface soils overlying sandy clay loams. Soil reaction ranges from neutral at surface to moderately alkaline with depth.

Vegetation: Coarse gravel areas: dominantly Eucalyptus camaldulensis. Sandy and loamy sand areas carry Acacia victoriae, and occasionally Muhlenbeckia spp. Finer textured soils along the Hugh have Eucalyptus microtheca woodland while within the ranges Acacia aneura and Hakea spp. with Enneapogon spp. and Eragrostis eriopoda are found.

Erosion: Subject to occasional flooding and local changes in stream courses. Where fine
textured soils of the higher terraces merge into the lower terraces, moderate to severe gullying may occur on the flank of the higher terrace. Fine textured soils are subject to moderate soft scalding.

Areas of finer textured soils may be quite productive though are subject to soft scalding.

Coarse gravel areas limited in extent and of little value.

Sandy areas generally carry little useful forage except after winter rain when herbage growth may be profuse. These are often formed by aeolian deposition and are relatively infertile.
MAP UNIT 11.2 - Mulga waterway areas

Field Criteria: Broad drainage floors with slight channel development in places. Dense non-grooved mulga. Sandy red earth soils. May have dense ground cover of perennial or annual grass spp.

Lithology: Quaternary alluvium.

Terrain: Angas, Simpson and Singleton land systems. Level to very gently sloping.

Position On Slope: Alluvial flats. 1% slope.

Soils: Alluvial soils of the Wyeecha (Gn 2.13), Bond Springs (Gn 2.12) and Maryvale (Uc 5.11) families. Sandy red earths. (Gn 2.12), earthy sands (Uc 5.11) and patches of calcareous red earths. (Gn 2.13). All profiles are deep and free draining. Soft surface crust. Gn 2.13 soils may have moderate carbonate below 20 cm.

Vegetation: Closed shrubland of Acacia aneura. Scattered Atalaya hemiglaucha in some areas and minor Acacia kempeana. Ground cover is variable. On coarse textured soils perennial Aristida spp are dominant with Eragrostis eriopoda. On gradational soils annual grasses such as Enneapogon spp and Aristida contorta more prevalent.
<table>
<thead>
<tr>
<th>Erosion</th>
<th>Negligible except in immediate bore areas.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Land Use</td>
<td>Produce dense bulk of grasses but forage value limited by lack of palatability in some cases.</td>
</tr>
</tbody>
</table>
Field Criteria: Depressions which when dry have a hard, fine textured surface often light reddish brown in colour. Generally associated with sand ridges which may completely surround them. South of James Ranges associated with watercourse areas which have been cut off from reaching the Hugh River by aeolian deposits of sand. Often have coolibah trees and some tea trees associated with them.

Lithology: Fine grained tertiary sediments

Terrain: Simpson land system. Flat bottomed depressions with sand plain or dune surrounds.

Position On Slope: Level.

Soils: Unclassified Uf 6.12, Uf 6.21 soils and Gn 2.13 soils of the Deep Well family. Medium to heavy clays. Often have polygonal cracking on surface. Appear to be sub soils of older land surface now covered by sand. Possibly the older drainage lines have been blocked off by encroaching sand. The resultant block to surface drainage has possibly led to salinization with the consequent removal of vegetation and deflation to leave the crusted clay surfaces as now found. They are still highly saline and may contain carbonate and gypsum. Loam and clay loam soils of the
Vegetation

Floors devoid of vegetation. *Eucalyptus microtheca* stands are frequently seen around the fringes and clumps of *Melaleuca gomerata* may occur.

Erosion

Possibly some lateral extension of claypan floors occurs during dry windy periods.

Land Use

Suitable as temporary waters for cattle after rain.
Section I  Tidewater Arch

a) M.V. 1. Prominent flat iron ridges of Tideway Sandstone.
b) M.V. 2a. Slope terraces: gently sloping terraces with step masonry.
c) M.V. 2b. Eroded saline areas at base of 2a.
d) M.V. 2c. Alluvial flats and drainage ways.
e) M.V. 10.1 Sand plain without dunes: pockets of Aeolian sand trapped in wrinkle valleys.
f) M.V. 1. Dissected plateau forming Amoco Sandstone.
g) M.V. 4.1 Strong colluvial area, a remnant of Tertiary sandstone material.
h) M.V. 2a. Colluvial slopes with deep soils. Open woodlands.
i) M.V. 1. Rugged terrain of Tideway Sandstone.
a) Prominent escarp of Mercuric Sandstone plateau.
b) M.V. 2.b. Calcareous slopes. Calcareous red earth, open shrubland.
c) M.V. 2.c. Deep manured earth, bounding incised drainage line.
e) M.V. 2.a. Sloping stone mantled (angular) terraces and margins. Ground mulga.
f) M.V. 1. Rugged rounded terrain of Jacaranda Sandstone.
a) High Plain

b) M.V. 11.1 - Sandy plains bounding High R. Along well-drained gently rolling open sand lands

c) M.V. 7.3 - Highly calcareous plains of low relief

d) M.V. 6.2 - Low strike ridge of Gay level limestone

e) M.V. 7.2 - Highly calcareous plains of low relief
a) M.V. 4.9: Long flat topped ridge remnant of Tertiary Sandstone. Steep margins.

b) M.V. 4.4/c: Sliding colluvial deposit along desert loess; generally minor foothills and drainage ways.

c) M.V. 4.9: Low remnant of Tertiary sandstone (very minor).

d) M.V. 4.3/c: Steep desert loess with minor foothills and drainage flows.

e) M.V. 9.1: Bedrock sand plain with minor exposures of calcareous soils.

f) M.V. 7.3: Highly calcareous plains of low relief with banded outcrops of Jay and Limestone.

g) M.V. 11.2: Mulga cattle area - broad drainage flow with defined channel

h) M.V. 6.4: Colluvial slope associated with a Laceed Sandstone strike ridge.

i) M.V. 6.0: Prominent white ridge - Laceed Sandstone

j) M.V. 6.0: Colluvial slope associated with strike ridge

k) M.V. 11.2: Mulga waterway area

l) M.V. 6.8: Colluvial slope below strike ridge

b). M.U. 24/2e - Colluvial slopes and slipping terraces with rounded margins.

c). M.U. 7.7 - Highly calcareous plains of low relief.

d). M.U. 10.3 - Sand plain interdune areas.


f). M.U. 8.3/11.3 - Sand dune area with minor clay pans.

g). M.U. 11.1 - Sandy alluvial plain.

h). High Lake.
a). MU 3a: High Mesa Top and scarp terrain.

b). MU 3b: Moderate to steep colluvial slopes with crisscross drainage network

c). MU 7-3: Highly calcareous plains of low relief.

d). MU 7-6: Gravelly plains - saline clay desert loams

e). MU 7-7: Highly calcareous plains of low relief.
I) Hugh luv
II) M.U. 11.1: Sandy alluvial plains with silty wash and burly wash
III) M.U. 6.2/11.3: Dune fields with minor areas of clay pans - irregular dunes
IV) M.U. 11.3: Clay pans - bloodwood or fringes otherwise devoid of vegetation
V) M.U. 8.2: Sand dune
VI) M.U. 6.6: Saline desert loams - alluvial plains and drainage lines
VII) M.U. 6.6: Prominent hill - steep litho-sol, perennial land
VIII) M.U. 6.6: Colluvial slopes below ridge and steep; steep desert loams
IX) M.U. 6.6: Prominent ridge; steep lithosol, sparse grass cover
X) M.U. 7.3: Highly calcareous plains - pronounced outliers of Jay Rock limestone with exposed bedding, loose, semi-arid
XI) M.U. 5.6: Colluvial slopes below sliver mesas and looms - steep desert loams
XII) M.U. 5.6: Streak mesa and remnant - steep lithosol; sparse shrub and grass cover
XIII) M.U. 5.6: Colluvial slopes
XIV) M.U. 5.1: Sand plain with minor areas of calcareous silts - muga woodland

Section 5. East of the Two Hills
A number of generalisations can be made about the soils of the area. Many cannot be classified into great soil groups and there are few which can be without reservation. Characteristically, they have low exchange capacities (with calcium as the main cation), phosphorous, nitrogen and organic carbon are invariably low. Zonal features include gravelly or cobbly surfaces, surface crusting, reddish colours and a lack of significant leaching of soluble constituents when these are present in the parent material.

Jackson (1962) described a number of soils in the region and classified them into families. The correlation of families to great soil groups is shown in a later section. Those found on Orange Creek include:

(i) **Amoonguna Family** - These occur on older alluvial plains bounding the Hugh River. The vegetation consists of an open woodland of ironwood, mulga and corkwood. They are considered to be young soils formed on stratified alluvium. Textures are viable and range from sandy loams to sandy clays. Layers of sand, gravel or river stones may be encountered. Carbonate may occur at depth.

(ii) **Bond Springs Family** - These soils are found on stable alluvial plains and are derived from siliceous material. They support a mulga shrubland. Surface textures range from sand to sandy loam and there is a gradual increase in clay content with depth. Sandy clay loams and sandy clay textures are found at a depth of 60 to 90 cm. The pH values range from slightly acid at the surface to neutral or slightly alkaline at depth.
(iii) **Deep Well Family** - These soils are found as small areas of 'swamp' land (e.g. One Tree Hill Dam, Morley Swamp Dam). Coolibah forms open woodlands with occurrences of lignums, blue bushes and salt bushes. The surface is a brown to greyish brown loamy sand to clay loam. Clay content increases gradually with depth to give loam to clay sub-soils. Depositions of lime may occur between 60 and 100 cm. Soil reactions are alkaline throughout.

(iv) **Hermannsburg Family** - These are the soils associated with the terrace gravels of map unit 2.1 and support mulga woodland associations. The soils have medium textures at the surface sometimes grading into fine textures at depth. Surface reactions are slightly acid or neutral though carbonate may occur in the deeper sub-soil.

(v) **Maryvale Family** - Associated with sand plain and dune areas. These are red brown to red undifferentiated sands with little or no increase in clay with depth. They are non-calcareous and reactions are slightly acid at the surface to slightly alkaline with depth.

(vi) **Orange Creek Family** - Occur on rolling country and are assumed to be sedentary on the tertiary conglomerate parent material. A common feature in the pavement of water-worn gravel and cobble. Red brown colours are dominant. Loamy sands and sandy loams are found on the surface and clay content increases fairly rapidly with depth. Subsoils range from clay loams to sandy clays and clays. Carbonate is often present below 15-25 cm. Quantities of fine and concretionary carbonate, etc. may occur at depth and these layers are moderately saline. Reactions are generally alkaline.

(vii) **Rodinga Family** - These occur on undulating topography, pediments or in association with mesa topography. The parent material generally consists of fine grained rocks. Texture
contrast soils with a loamy sand and stony surface overlying clay subsoils are found. Colours range from reddish brown at the surface to dark red at depth. Carbonate occurs below 30 cm and increases with depth; it is present as both fine and concretionary material. Gypsum may occur in deeper layers. The subsoils are moderately saline and the surface soil in lower sites may also be saline (eg. 2.5 km S.E. of One Tree Hill Dam). A characteristic feature of these soils is the gibber pavement of siliceous stones.

(viii) D3 Family - This is a minor group of soils which occur on sites below the Hermannsburg soils. Vegetation consists of a very open woodland of mulga, whitewood and ironwood with a moderate ground cover of perennial and annual grasses. Profiles have sharp textured differentiation between the sandy loam surfaces and clay sub-soils.

(ix) D4 Family - Found as minor constituents in areas dominated by the Rodinga Family. They occur on similar landscapes and have a siliceous pavement embedded in the surface 2 cm of soil. The soil surface is very vesicular with vesicles up to 2 mm in diameter. The surface crust varies from fine sand to sandy clay loam and is strongly bleached. It is 1-1.5 cm thick and overlies red-brown granular clay to 15 cm. Below 15 cm coarse, structured clay is encountered and carbonate occurs below 30 cm. These soils are highly saline and alkaline.

(x) D5 Family - These soils resemble those of the Rodinga Family in many respects but differ in having acid rather than alkaline surface reactions, smaller quantities of carbonate and larger amounts of gypsum. They occur as minor constituents intermixed with the Rodinga soils.

(xi) Santa Teresa Family - Soils associated with limestone and occur on rises and plains approaching a pedeplain condition. These soils are dull brownish to reddish brown and contain...
large amounts of fine carbonate throughout. Clay content increases slightly with depth though the clayier feel to the subsoil may in part be attributable to the high carbonate content. Decomposing fine grained calcareous rock may be encountered in the profile.

(xii) Wyeecha Family - These soils occur on plains and are often associated with some development of sandridges. These soils are reddish brown to red, the hue becoming redder with depth. Surface textures are loamy to clayey sands. At depth loams, sandy clay loams and occasionally sandy clays are found. Reactions are generally slightly acid to neutral at the surface and neutral to alkaline at depth. Except for the development of a surface crust, there is little profile development. Some subsurface layers may be extremely compact. In a few areas, surface gravel may be found.

The parent material is detritus derived from highly siliceous sediments of the James and Waterhouse Ranges.

UNCLASSIFIED SOILS

(i) Sandridges - Dunes 2 to 10 m high are associated with soils of the Maryvale Family and to a lesser extent, those of the Wyeecha Family which occupy the interdune areas. The dunes consist of red-brown to red sands with acid reactions. There is no evidence of clay accumulation in the profiles and they contain no carbonate.

(ii) Claypans - These are areas of hard, fine textured soils in depressions which support no plant life. A slight amount of surface gravel may sometimes be found. They occur along the northern front of the James Ranges to the east of Desert Bore,
and in fairly close proximity to the Hugh River east of Highway Bore. Generally associated with sand dune or sand plain country.

The surface consist of a hard clay crust 1 to 2 cm. thick which cracks into polygonal fragments when dry. Subsurface material is generally clay, occasionally sand. Gypsum and carbonate are common in the subsoil and profiles are generally highly saline. It is considered that the encroachment of sand dunes has impeded surface drainage resulting in salinisation, destruction of plant cover and subsequent deflation.

(iii) Lithosols - Shallow variants of a number of soils may be found. The Rodinga, Santa Teresa and, to a lesser extent, the Orange Creek Families, all have a number of shallow types.

(iv) Miscellaneous Soils - these include:

(a) Minor outwash soils which are found where stream channels deposit their sediment loads in small floodouts (alluvial soils).

(b) Alluvial soils consisting of sand, gravel and very little fine textured material. Found bounding the High River and associated with drainage channels in major strike valleys.
Correlation with Great Soil Groups

a) Alluvial Soils                      Amoonguna Family.
b) Skeletal Soils                    Variants of Rodinga, D3, D4, D5, Santa Teresa and Orange Creek families.
c) Calcareous Red Earths             Some members of the Deep Well, Hermannsburg and Wyeecha families.
d) Stony Desert Tableland Soils      Rodinga, D4 and D5 soils.
e) Grey-brown and Red Calcareous Desert Soils   Santa Teresa family.
f) Desert Sandhills                  Maryvale family.

A number of families do not readily fit into the above soil groups. These include:

(i) Orange Creek Family - a group of calcareous residual soils similar to group e) above but are more variable in texture and have a greater degree of profile development.

(ii) Wyeecha Families - (some members) - non-calcareous soils with acid to neutral surface reactions. May conform to calcareous red earths but lack a carbonate horizon.

As a consequence of this, Jackson grouped the soils into broad categories independent of former classifications:

a) Lithosols $S^{k}, S^{k}, ca$
b) Red Soils with Acid Surfaces    Hermannsburg and Wyeecha
c) Deep Sands                       Maryvale
d) Calcimorphic Soils              Orange Creek; Santa Teresa
e) Alkaline Soils on Alluvial Deposits  Amoonguna and Deep Well
f) Solonetz Soils                  Rodinga, D3, D4, & D5 families.
1. **Clay Content:**

   a) Maryvale: approximately 5% throughout
   b) Orange Creek: 12% at surface
                  25% at depth
   c) Rodinga: 5% at surface
              45-50% at depth
   d) Santa Teresa: 15% at surface
                   15-20% at depth
   e) Wyeecha: 15% at surface
              20% at depth
   f) Sand dunes: less than 5%

Clay minerals are mainly illite and kaolinite.

2. **Soluble Salts:**

The Orange Creek soils are moderately saline, while the Rodinga types are moderately to strongly saline. In soils containing significant amounts of T.D.S., the chloride accounts for 50-90% of the total.

Increases in T.D.S. with depth are largely due to an increase in chlorides. In soils having insignificant T.D.S. the chloride accounts for less than 50% and often less than 20% of the total.

Sulphate is present in significant amounts in most soils and may be quite high. In soils having more than 0.2% T.D.S. sodium is the dominant cation, whereas the high proportion of calcium is a feature of others.
There is a wide range in the concentration of the various cations and anions and the range in the cation to anion balance indicates the occurrence of limited leaching.

(3) Carbonates

The soils may be classed into four groups on the basis of carbonate content:

(i) **Non-calcareous:**
    - Maryvale
    - Sand dune, sand plain

(ii) **Slightly Calcareous:**
    - Wyeecha D5

(iii) **Moderately Calcareous:**
    - Deep Well
    - Hermannsburg
    - Rodinga D3
    - D4

(iv) **Highly Calcareous:**
    - Orange Creek
    - Santa Teresa

(4) Exchangeable Cations

Generally calcium is the dominant cation in both surface and subsurface layers and may account for between 40 and 70% of the exchangeable cations. The proportion of calcium increases with depth. In the Wyeecha Family, hydrogen may be the dominant cation. Potassium is generally in greater proportions in the surface layers. It is low in the Rodinga and D5 families. Magnesium is generally the subdominant cation. Exchangeable sodium is generally low (3%) except in the Orange Creek and Rodinga soils where it may constitute up to 12% and 25% respectively of the exchangeable ions.

The total exchange capacity of most soils is very low. It is often below 10m. equivs./100 g and seldom exceeds 20 m. equivs. Those of
the Rodinga and Santa Teresa families are some of the highest found here.

(5) Wetting Characteristics

(a) Infiltration Rates

<table>
<thead>
<tr>
<th>Family</th>
<th>mm of water absorbed in 2 hours</th>
<th>Infiltration Rate (mm/hr) after 2 hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rodinga</td>
<td>60</td>
<td>5</td>
</tr>
<tr>
<td>Santa Teresa</td>
<td>47</td>
<td>21</td>
</tr>
<tr>
<td>Maryvale</td>
<td>146</td>
<td>74</td>
</tr>
</tbody>
</table>

Most of the soils appear able to absorb almost 50 mm of rain in a two hour period.

(b) Depth of Water Penetration

<table>
<thead>
<tr>
<th>Family</th>
<th>Water (mm) required to wet top 60cm of soil</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rodinga</td>
<td>91</td>
</tr>
<tr>
<td>Santa Teresa</td>
<td>76</td>
</tr>
<tr>
<td>Maryvale</td>
<td>36</td>
</tr>
</tbody>
</table>
(6) **Physical Features of the Soils**

The most common features of the soils are the red colour, surface gravel, surface crust and moderately deep to deep profiles. Of these features, gravel is the only one which is not universal.

(a) **Surface Crusts** - these are fairly universal and vary in their nature and thickness.

The most visible form is the dark algal crust. The algal growth is very thin and covers a weakly platy soil crust underneath. Algal crusts may contribute a small amount of nitrogen to the soil. They are generally firm and there may be a tendency for such crusts to inhibit infiltration. In the undisturbed state they protect the surface from wind erosion.

Non-algal crusts are the most common type. They are weakly platy and range between 1 and 10 mm in thickness. A vesicular form is found on some of the Rodinga and D4 families.

Even in sandy soils weak surface crusts are the rule rather than the exception. They are weakly cemented.

Where there is a large proportion of gravel or cobble on the surface, crust ing still occurs on exposed soil material. Crusts vary in texture but are dominantly sandy loam/loamy sand. A few observed were fine textured and these may form a surface seal inhibiting the entry of water into the soil.

When dry conditions prevail undisturbed crusts will act as a deterrent to wind movement of surface soil material. If the crust is broken up by trampling, surface material is made more readily available for wind movement.

(b) **Surface Stone** - stony surfaces are an obvious feature of many of the land types. Though the term 'stony' is used most of
the material lies within the gravel (up to 75 mm dia) and cobble (75-250 mm dia) ranges.

These stony mantles are composed of the more resistant weathering products of the original parent material. They are a natural feature of the landscape and have not developed as a result of contemporary land use.

Three major types of stone surfaces may be seen.

(i) Subspheroidal silicified material - generally associated with tertiary mesas and mesa remnants and some strike ridges. The material consists of silcrete (grey 'billy') or silicified tertiary sandstone and colours vary from grey to dark reddish brown. There is a discernable decrease in the size of the stone away from the nearest mesa or remnant though not necessarily a decrease in density. These stone mantles are usually associated with Rodinga and D4 soils.

(ii) Rounded waterworn quartzite stony surfaces - mostly found on Orange Creek soils derived from sandstones and conglomerates. D5 soils may also have a dense cover of quartzite stone.

Weathering has resulted in a breakdown of the sandstone leaving the more rounded quartzite fragments. Natural erosion has resulted in the concentration of stones at the surface. Colours may vary from dark reddish brown through reddish brown to greyish white.

(iii) Angular Material - generally composed of fractured sandstone and quartzite and may form a complete cover on the lands of map unit 2.a. These are gently sloping terraces of quaternary material. Colours are generally reddish brown. Dominant size fraction is in the cobble to stone range.
In addition to these major types of stony surfaces, other minor types may be seen. Of these, the most common occurs on some members of the Santa Teresa family. Small to moderate amounts of carbonate gravel cover these surfaces. In this area, the largest areas are mapped as gravelly calcareous plains (map unit 7.4). Gravel cover is very much less than that described under the major types.

(c) Surface Textures - These fall mainly in the sandy loam/loamy sand range. In some cases, there may only be a very thin layer of sandier material overlying well-structured clay (Rodinga, D4, D5 families). Even where there is a well-developed surface crust, a thin coating of sand grains may be found on the surface. On some Santa Teresa soils, field texturing may suggest a high clay content. This may be caused by very fine carbonate.

The sand loam/loamy sand material occurring on the first two stony surfaces described above would appear to be residual soil material. It is considered that the stone mantle developed under conditions of natural erosion over a long period. At a more recent time, soil material has been deposited on the landscape (probably aeolian deposition) and possibly formed a uniform cover over the stony surface. Erosion is now removing this material, producing 'islands' of residual soil overlying the stone layer. It is perhaps a slow process as soil material lost from one 'island' is trapped on another downslope from it and so on.

(d) Subsoil Features

(i) Hardpan - some members of the Wyeecha family may have massive hard layers associated with them. One site had a hard gravelly clay layer between 30 and 80 cm. No surface features indicated the presence of such a layer.
(ii) **Carbonate** - Except in the sandy areas, carbonate content ranges from moderate to extremely high. Some of the Santa Teresa subsoils may consist of nearly pure carbonate.

(iii) **Salinity** - High salinity levels are associated with the Rodinga and moderate levels with the Orange Creek family. In addition, significant levels of salinity may occur in other soils in lower slope positions. This is a feature of arid landscapes. Within the Rodinga and Orange Creek families lower slope and drainage flat sites will have much higher salinity levels than mid and upper slope areas. Salt efflorescence may occur at the surface.
Vegetative cover, in terms of total landscape cover, is remarkably good when one considers the nature of the landscape and a median rainfall of 175 mm. This statement is not to be confused with the status of the rangeland from a pastoral point of view.

The dominant structural vegetation associations are given below.

1. Dense mulga shrublands

Acacia aneura shrublands are located mainly in land types 9 and 10 and 11.2. The mulga in these units has a random distribution. On gentle slopes (e.g. map unit 2.a) groved mulga occurs.

While frequently found as pure stands, there are areas where minor components of other species are found, eg. Acacia kempeana, Acacia estrophiolata, Eucalyptus gamophylla, Casuarina decaisneana. Ground cover in the sandy soils of land types 9 and 10 is comprised of Eragrostis eriopoda, Aristida inequiglumis, Aristida browniana and Triodia spp. Enneopogon spp., and Aristida contorta may form a significant proportion of the grass component in map units 9.1 and 9.2.

The mulga waterway (11.2) units support the greatest density of A. aneura. Cassia spp. and other small shrubs may also occur in all units.

Varying proportions of A. aneura shrubs are to be found on most of the land types on the lease.
2. **Mixed open woodlands**

Probably the most common association to be found in the area. Strike valley, plains and Tertiary sandstone land types are dominated by this structural form. In addition, much of map unit 9.2 supports an open woodland community. The dominant woodland species include *Atalaya hemiglauca*, *A. aneura*, *A. estrophiolata* and *Hakea* spp. *Acacia kempeana* is commonly present. Ground cover is variable but is generally dominated by *Enneopogon* spp. with a minor component of perennial spp. such as *Digitaria coenica* and *Chloris* spp., *Sclerolaena* spp. and a range of forbs may be present.

3. **Sparsely timbered hummock grassland**

These occur on sand dune and sand plain land types. The major species are *C. decaisneana*, *A. aneura*, *E. gamophylla* with minor *Hakea* spp., *A. estrophiolata*, *A. hemiglauca* and *Codonocarpus cotinifolius*. Shrubs may include *Grevillea* spp., *Acacia murrayana* and occasional *A. kempeana* in some cases. Ground cover is dominated by *Triodia* spp. though a component of *A. browniana*, *A. contorta*, *E. eriopoda* and *Enneopogon* spp. may be present. Forbs may be significant, especially following winter rainfall.

4. **Witchetty bush shrublands**

These are found on the calcareous gravelly plains and in association with outcrops of Jay Creek limestone which occur as small rises or banded outcrop in map unit 7.3, the highly calcareous plains. Moderate to severe rates of mortality have occurred, part of which may be attributable to rabbits which favour these areas. Regeneration is poor in some cases. The ground cover is usually moderately dense and dominated by *Enneopogon* spp. with varying proportion of *Sida* spp. and *Sclerolaena* spp. A small *A. aneura* component may be present.
5. **Open Chenopod shrublands**

Mainly found associated with land types 4, 5, 6, and map units 7.5 and 7.6 in the mid and lower slope positions.

The low shrubland is dominated by *Sclerolaena* spp. and *Halosarcia* spp. indicative of saline soils, and, in many cases, ground cover is sparse. On some sites in the above units, *Maireana astrotricha* and *Atriplex nummalaria* may be seen. Blue bush shrub steppe is also associated with map units 2 b/a (north of Eagle’s Nest Bore), parts of 7.3 (south of Nombra Bore) and 7.4.

6. **Low open shrubland**

A variety of forms occur mainly on the more rugged terrain of the James Ranges, mesa tops and irregular plains. A variety of *Acacias* predominate and isolated *Eucalyptus papuana* may be seen in the ranges. *Fremophila* spp. are common. Ground cover is sparse with spinifex comprising the dominant type in the ranges.

7. **Grassland communities**

Treeless grassland areas are limited to parts of the highly calcareous plain units east of Whitewood Bore. There is no evidence of previous tree or shrub cover. These areas support a moderately dense stand of *Enneopogon* spp.

8. **Riverine communities**

Vegetation along the Hugh River is dominated by *Eucalyptus camaldulensis* which grow on the banks and in the channels. *Eucalyptus terminalis* occurs away from the main stream line. Sandy alluvial plains support dense stands of *Acacia victoriae*. Major tributaries such as Tidenvale Creek have a *Eucalyptus camaldulensis*, *A. estrophiolata* and *E. terminalis* association with minor *Hakea* spp. In rocky gullies, *E. papuana* is common and the
short streams emanating from the northern margin of the James Range support *E. camaldulensis*, *E. terminalis* and *E. papuana*. *E. terminalis* is dominant in areas fringing swamps and claypan areas. The claypans are devoid of vegetation.

In sandy areas along the Hugh River, ground cover consists of *A. browniana*, *E. eriopoda* and a range of forbs. Coarse textured alluvial soils bounding tributary channels carry a cover of *Thermeda australis*, *Chloris* spp. and *A. browniana*.
APPENDIX 3

Measured areas of Land Types available off Watering Points
TABLE 1. TOTAL AREA OF EACH PASTORAL MAP UNIT AVAILABLE AROUND INDERA BORE BY DISTANCE FROM WATER

<table>
<thead>
<tr>
<th>Map Unit</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.a.</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>3.5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>4.b.</td>
<td>7</td>
<td>11</td>
<td>14</td>
<td>15</td>
<td>16.5</td>
<td>18</td>
<td>18</td>
<td>18</td>
</tr>
<tr>
<td>4.c.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>2</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>4.b.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2</td>
<td>4</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>9.2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2</td>
<td>4</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>6.a.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>6.b.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>7.2.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>4</td>
<td>7</td>
</tr>
<tr>
<td>7.3</td>
<td>1</td>
<td>4</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>7.4</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>7.8</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>9.1</td>
<td>3</td>
<td>6</td>
<td>11</td>
<td>14</td>
<td>17</td>
<td>19</td>
<td>20</td>
<td>22</td>
</tr>
<tr>
<td>9.2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2</td>
<td>5</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>10.2</td>
<td>1</td>
<td>5</td>
<td>9</td>
<td>11</td>
<td>14</td>
<td>14</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10.3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>11.2</td>
<td>2</td>
<td>5</td>
<td>5</td>
<td>6</td>
<td>8</td>
<td>9</td>
<td>9</td>
<td>9</td>
</tr>
</tbody>
</table>

Total area \( \text{km}^2 \) available by distance from water:

|                | 13   | 29   | 46   | 65   | 82   | 98   | 110  | 114  |

SLCN1 H 2
### TABLE 2. INCREMENTAL AREA OF EACH PASTORAL MAP UNIT AVAILABLE AT KILOMETRE INTERVALS AWAY FROM INDERA BORE

<table>
<thead>
<tr>
<th>Map Unit</th>
<th>Distance Increment (km)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0-2</td>
</tr>
<tr>
<td>4.a.</td>
<td>2</td>
</tr>
<tr>
<td>4.b.</td>
<td>7</td>
</tr>
<tr>
<td>4.c.</td>
<td></td>
</tr>
<tr>
<td>4.6</td>
<td>2</td>
</tr>
<tr>
<td>9.2</td>
<td>2</td>
</tr>
<tr>
<td>6.a.</td>
<td>2</td>
</tr>
<tr>
<td>6.6.</td>
<td>2</td>
</tr>
<tr>
<td>7.2.</td>
<td>1</td>
</tr>
<tr>
<td>7.3</td>
<td></td>
</tr>
<tr>
<td>7.4</td>
<td>1</td>
</tr>
<tr>
<td>7.8</td>
<td></td>
</tr>
<tr>
<td>9.1</td>
<td>3</td>
</tr>
<tr>
<td>9.2</td>
<td></td>
</tr>
<tr>
<td>10.2</td>
<td>1</td>
</tr>
<tr>
<td>10.3</td>
<td></td>
</tr>
<tr>
<td>11.3</td>
<td>2</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>13</td>
</tr>
</tbody>
</table>
APPENDIX I

SOIL PROFILE DESCRIPTIONS
SOIL DESCRIPTIONS

1) Santa Teresa Family

Profile No. 32 Map Unit 7.3.
P.P.F.: Gc. 1.12
G.S.G.: Calcareous Earth.

Site: Gently sloping (½-1%) treeless plain carrying Enneapogon avenaceous and Sclerolaena spp. Ground cover is moderate.

Surface: A slightly hard and slightly algal crust 1 cm. thick. Few scattered limestone gravels to 1 cm. diameter. Becomes dull dusty and prone to wind erosion if disturbed. Surface does not seal, though infiltration appears slow.

<table>
<thead>
<tr>
<th>Depth (cm)</th>
<th>Horizon</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-1</td>
<td>A11</td>
<td>Massive, earthy, dark red (2.5 YR 3/6) when moist, yellowish red (5 YR 5/6) when dry, fine sandy clay loam; dry slightly hard; pH 8.7; carbonate present.</td>
</tr>
<tr>
<td>1-20</td>
<td>A12</td>
<td>Massive, earthy, dark red (2.5 YR 3/6) fine sandy clay; dry slightly hard; pH 8.7; 10% carbonate as soft segregations and earthy material.</td>
</tr>
<tr>
<td>20-90</td>
<td>B2</td>
<td>Massive, earthy, dark red (2.5 YR 3/6) sandy light clay with trace of calcareous gravel; auger friable; pH</td>
</tr>
</tbody>
</table>

SLCN1 C 2
90-100 C

9.0; large amount of carbonate in soil mass and as soft segregations and gravel.
Massive, earthy, reddish brown (2.5 YR 4/4) sandy light clay with moderate amount of highly calcareous gravel; auger friable; pH 9.5; pinkish colour when dry and contains very large amount of carbonate.
Soft calcareous material which could not be lifted in auger.
2) **Orange Creek Family**

Profile No. 12

<table>
<thead>
<tr>
<th>Depth (cm)</th>
<th>Horizon</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-2</td>
<td>A1</td>
<td>Red (2.5 YR 4/6) when moist, red (2.5 YR 4/8) when dry, stony, fine sandy loam to light sandy clay loam; dry slightly hard; rough ped fabric; weak very fine subangular blocky structure; pH 7.3.</td>
</tr>
<tr>
<td>20-40</td>
<td>B1</td>
<td>Red (2.5 YR 4/8) dry hard light clay with trace of stone and gravel; rough ped fabric; moderate very fine subangular blocky structure; pH 9.5; Moderate carbonate present in soil mass and on gravels.</td>
</tr>
<tr>
<td>40-140</td>
<td>B2/C</td>
<td>Red (2.5 YR 4/8) dry hard gravely and stony clay; moderate, very fine subangular blocky structure; rough ped fabric; pH 9.5; large amount of carbonate present in soil mass and as a coating on gravels and stones.</td>
</tr>
</tbody>
</table>

Map Unit 2b_g

Calcareaous Red Earth

Sloping (2%) dissected remants of Tertiary Conglomerate. Vegetation consists of sparse cover of *Enneapogon* spp, *Sclerolaena* spp, *Sida* spp., *Digitaria coenicola* and minor *Maireana astrotricha*.

Approximately 50% stone cover (up to 15 cm dia.). Exposed soil surface has soft, slightly algal crust less than 1/4 cm thick.
3) **Rodinga Family**

**Profile 14**

**P.P.F.:** Map Unit 6.b  
**G.S.G.:** Dr 1.33  
**Site:** Desert Loam

**Surface:** Gently sloping (1½%) Colluvial slope below strike ridge; 50% of surface gravel and stone mantle and 50% covered by a residual soil mantle overlying stone layer. Supports a sparse cover of *Enneapogon* spp., *Digitaria coenica*, *Astrebla pectinata*, *Chloris* spp., *Sclerolaena* spp., *Maireana astrotrichia* and *Halosaicia* spp. Profile is in an area with residual mantle.

**Description**

<table>
<thead>
<tr>
<th>Depth (cm)</th>
<th>Horizon</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-15</td>
<td>A1</td>
<td>Red (2.5 YR 4/8) when moist, red (2.5 YR 5/8) when dry, loose, structureless, loamy sand; pH 7.0; sandy fabric; soft crust on surface. Stone layer with some loamy sand; sporadic bleach evident in parts of this layer and at the top of the one below.</td>
</tr>
<tr>
<td>15-20</td>
<td>A2</td>
<td>Red (2.5 YR 4/8), light to medium clay with trace fine gravel; moist friable; weak fine subangular blocky structure; rough ped fabric; pH 8.0.</td>
</tr>
<tr>
<td>20-60</td>
<td>B11</td>
<td>Red (2.5 YR 5/8), light to medium clay with trace to small amount of fine gravel; moist friable; weak fine</td>
</tr>
</tbody>
</table>
100-130 B13

Subangular blocky structure; rough ped fabric; pH 8.5; trace of carbonate.

Light red (2.5 YR 6/8), light to medium clay with small amount fine gravel; dry, slightly hard; weak, fine crumb structure; rough ped fabric; pH 8.8; moderate to large quantity of carbonate; small amount of gypsum.

Stone encountered.
**4) Uyeecha Family**

**Profile No. 25**

**P.P.F.:** Map Unit 9.2

**G.S.G.:** Dr 4.53

**Site:** No suitable group (Calcareous Red Earth?)

**Surface:** Level sandy plain with a weakly grooved upper story of *Acacia aneura* and scattered *Atalaya hemiglauca*. Ground cover consists *Eragrostis eriopoda, Sclerolaena* spp. with minor *Enneopogon* spp. Evidence of past wind movement.

**Coating:** Coating of fine sand grains over a slightly firm surface crust 0.5 cm thick.

<table>
<thead>
<tr>
<th>Depth (cm)</th>
<th>Horizon</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-1.5</td>
<td>A11</td>
<td>Massive dark red (2.5 YR 3/6) when moist, yellowish red (5YR 4/6) when dry, sandy loam crust; dry slightly hard; sandy fabric; pH 7.0;</td>
</tr>
<tr>
<td>1.5-30</td>
<td>A12</td>
<td>Massive, dark red (2.5 YR 3/6) sandy loam; moist friable; sandy fabric; pH 7.0.</td>
</tr>
<tr>
<td>30-80</td>
<td>B11</td>
<td>Massive, red (2.5YR 4/6) light clay with trace of gravel (sandstone?); dry hard; earthy fabric; pH 8.0.</td>
</tr>
<tr>
<td>80-120</td>
<td>B12</td>
<td>Red (2.5YR 5+4) light clay with moderate gravel; dry slightly hard; weak very fine subangular blocky structure; rough ped fabric; pH 8.5; large amount carbonate as soft segregations and gravel coatings.</td>
</tr>
</tbody>
</table>
120-150  B-C

Massive, yellowish red (5 YR 4/8) light clay with moderate to large fine gravel; rough ped fabric; dry slightly hard; pH 8.5; large amount carbonate as above; gravel is sandstone.
5) Maryvale Family

Profile No. 20
P.P.F.: Map Unit 10.1
G.S.G.: Uc 5.11 (?)

Site: Siliceous Sands.
Level sand plain; scattered dunes occur 500 m south. Tree cover dominated by Acacia aneura with very few Casuarina decaisneana. Ground cover mainly Eragrostis triplinoda and Aristida inequiglumis with a range of Sclerolaena spp. and forbs.
Surface: Soft thin crust (2 mm thick) and loose sand grains.

<table>
<thead>
<tr>
<th>Depth (cm) Horizon</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-95 A1</td>
<td>Massive, red (10R 4/8) loamy sand; moist very friable; sandy fabric; pH 5.7 at surface to 6.0 at depth.</td>
</tr>
<tr>
<td>95-120 B1</td>
<td>Dry, hard, dark red (10R 3/6) clayey sand to coarse sandy loam; massive; sandy fabric; pH 7.0.</td>
</tr>
<tr>
<td>120-150 B2</td>
<td>Red (10R 4/6+8) coarse sandy clay; dry slightly hard; weak, very fine subangular blocky structure; rough ped fabric; pH 8.8; few, fine distinct yellowish-white soft carbonate patches.</td>
</tr>
</tbody>
</table>
6) **Lithosols (SK Ca)**

<table>
<thead>
<tr>
<th>Depth (cm)</th>
<th>Horizon</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-15</td>
<td>A1</td>
<td>Red (2.5 YR 4/6) when moist, yellowish red (5Yr 5/8) when dry, stony and gravelly sandy clay loam; dry soft; weak, very fine crumb structure; rough ped fabric; pH 7.0 at surface and increases to 7.7 at 12 cm;</td>
</tr>
<tr>
<td>15-45</td>
<td>B1</td>
<td>Red (2.5YR4/8) stony and gravelly light clay; dry soft; weak, very fine crumb structure; rough ped fabric; pH 9.0; much of gravel is calcareous material which constitutes 30-50% of soil mass.</td>
</tr>
<tr>
<td>45-</td>
<td>D</td>
<td>Stone.</td>
</tr>
</tbody>
</table>

Profile No. 9  
P.P.F.:  
G.S.G.:  
Site:  
Surface:  

On crest of low rounded rise in area of gravelly plains. Very gently sloping (2%). Scattered *Acacia aneura* and *Acacia kempeana* (mainly dead), *Enneopogon* spp., *Aristida contorta* and *Maireana astroticha* form the plant cover.

Very stony (up to 10 cm diameter); slight algal crust (2 mm thick) which is sandy underneath and fine textured on surface.

Map Unit 7.4  
GN 2.13  
Calcareous Red Earth.

SLCN1 C 10
7) Bond Springs Family

Profile No. 4
P.P.F.: Map Unit 2c.
G.S.G.: GN 2.12
Site: Deep Sandy Red Earth
Level plain bounding main waterway.
Acacia *aneura* shrubland with
*Eragrostis eriopoda* and *Aristida contorta*.
Surface: Fine layer of sand grains over a soft
crust approximately 2 mm thick.

<table>
<thead>
<tr>
<th>Depth (cm)</th>
<th>Horizon</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-4</td>
<td>A1</td>
<td>Dark red (2.5YR3/6), massive, loamy sand; dry loose; sandy fabric; pH 6.5.</td>
</tr>
<tr>
<td>4-60</td>
<td>B1</td>
<td>Dark red (2.5YR3/6), massive, sandy loam; dry slightly hard; sandy fabric; pH 6.5.</td>
</tr>
<tr>
<td>60-160</td>
<td>B2</td>
<td>Dark red (2.5YR3/6), massive, sandy clay loam; dry very hard; earthy fabric; pH 7.0.</td>
</tr>
</tbody>
</table>

SLCNI C 11
8) Alluvial Soils on Older Terraces

Profile No. 1 Map Unit 11.1
P.P.F.: Gn 2.12
G.S.G.: Site:

Old alluvial terrace not subject to contemporary flooding. Supports open woodland of Acacia aneura and Hakea spp. with Enneopogon spp. Eragrostis japonica and Abutilon spp.

Surface: Soft very thin (1-2 mm) crust; scattered coarse sand and fine gravel on surface.

<table>
<thead>
<tr>
<th>Depth (cm)</th>
<th>Horizon</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-20</td>
<td>A1</td>
<td>Massive, dark red (2.5YR3/6) when moist, yellowish red (5YR 4/6) when dry, sandy clay loam; dry slightly hard; earthy fabric; pH 7.0;</td>
</tr>
<tr>
<td>20-50</td>
<td>B1</td>
<td>Massive, red (2.5YR 4/8), fine sandy clay loam; dry, slightly hard; earthy fabric; pH 7.5.</td>
</tr>
<tr>
<td>50-70</td>
<td>B2</td>
<td>Massive, red (2.5YR4/6) fine sandy clay; dry, slightly hard; earthy fabric; pH 8.0; Trace carbonate.</td>
</tr>
<tr>
<td>70-</td>
<td>D</td>
<td>River Stone.</td>
</tr>
</tbody>
</table>

SLCN1 C 12
9) Red Clay Soils

Profile No.8  
P.P.F.:  
H.A.S.:  

Site:  
Gently sloping plain of low relief; grassland area supporting Eragrostis japonica spp., Digiteria coenicola, Sclerolaena spp. and minor solanum spp.

Surface:  
Approaches the self mulching condition; crazed cracking evident; soft algal crust in places; scattering of gravel up to 5 cm diameter.

<table>
<thead>
<tr>
<th>Depth (cm)</th>
<th>Horizon</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-10</td>
<td>A1</td>
<td>Dark red (2.5YR3/6) when moist, yellowish red (5YR5/6) when dry, clay with trace fine gravel and sand; dry slightly hard to soft; moderate, fine subangular blocking structure; rough ped fabric; pH 7.8; trace carbonate.</td>
</tr>
<tr>
<td>10-70</td>
<td>B1</td>
<td>Red (2.5YR4/6) clay with trace fine gravel; dry hard; moderate, fine subangular blocky structure; rough ped fabric; pH 8.3; moderate carbonate.</td>
</tr>
<tr>
<td>70-105</td>
<td>B2</td>
<td>Red (2.5YR3/6) clay; dry, hard, moderate, fine subangular blocky structure; rough ped fabric;</td>
</tr>
</tbody>
</table>
pH 8.6; large carbonate content as fine material in soil mass.
Red(2.5YR4/6+8) clay with small to moderate amount of gravel; dry, hard; moderate, very fine subangular blocky structure; rough ped fabric; pH 8.7; up to 20% carbonate as soft segregations and gravel coatings.