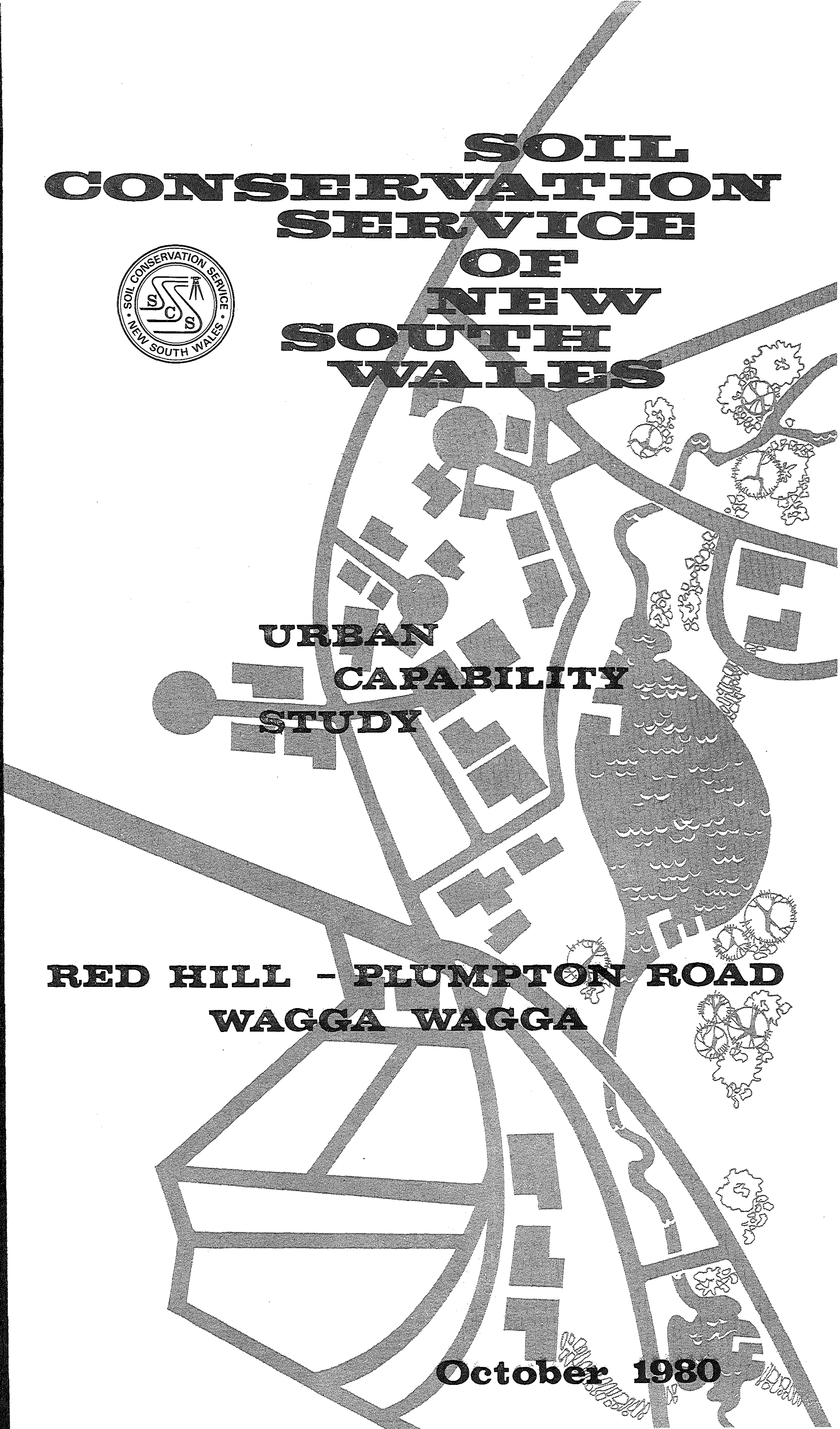

# SOIL CONSERVATION SERVICE OF NEW SOUTH WALES

## URBAN CAPABILITY STUDY

## RED HILL - PLUMPTON ROAD WAGGA WAGGA

October 1980

SOIL CONSERVATION SERVICE OF NEW SOUTH WALES

# URBAN CAPABILITY STUDY

# RED HILL/PLUMPTON ROAD

# WAGGA WAGGA

Prepared for Council of the City of Wagga Wagga

OCTOBER, 1980

This report, and the original maps associated with it, have been scanned and stored on the custodian's intranet.
Original maps drafted at 1:4,000 were catalogued SCS 134822/A -C.
These have been scanned and named "UC_Red Hill_Plumpton_Wagga_theme".
S.J. Lucas April 2014



Report compiled by:

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District Soil Conservationist.

R.J.Crouch,
Soil Conservationist.

# PREFACE

This report is a guide to development potential in terms of the physical limitations of the study area. It indicates the capability of the physical resources of the study area to sustain various intensities of urban use.

While the maps are intended to assist in subdivision planning, it is important that information is not extracted from them at a scale larger than the scale of the originals.

The maps and the written report are not a substitute for specific engineering and design investigations which may be required to more accurately define constraints in the location and design of roads, individual buildings, or recreation facilities. Rather, they provide a basis onto which other town planning considerations may be imposed to derive a development plan.

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## SUMMARY

The study area comprises 230 hectares of land adjacent to Lake Albert, within the southern portion of the city of Wagga Wagga.

The site adjoins the Glenfield study area which was the subject of an urban capability report presented to Wagga Wagga City Council in December, 1976.

From a ridge along its western boundary the land falls to the east toward Stringybark Creek, with attractive views over Lake Albert.

Most of the site is suitable for residential development.

Gradients over most of the area are below 10 per cent, but range up to 30 per cent on the steepest sideslopes.

Three district drainage depressions are present on the upper slopes, but they lose their definition on the lower footslopes. Special attention is directed to this, because flooding of these lower slopes will occur unless runoff is piped or carried in shaped drainage reserves to Stringybark Creek. A drainage proposal using retarding basins is outlined in Appendix II.

The floodplain of Stringybark Creek will be subject to inundation following urbanisation, despite the flood channel diversion to Lake Albert . This land should be developed as a drainage reserve.

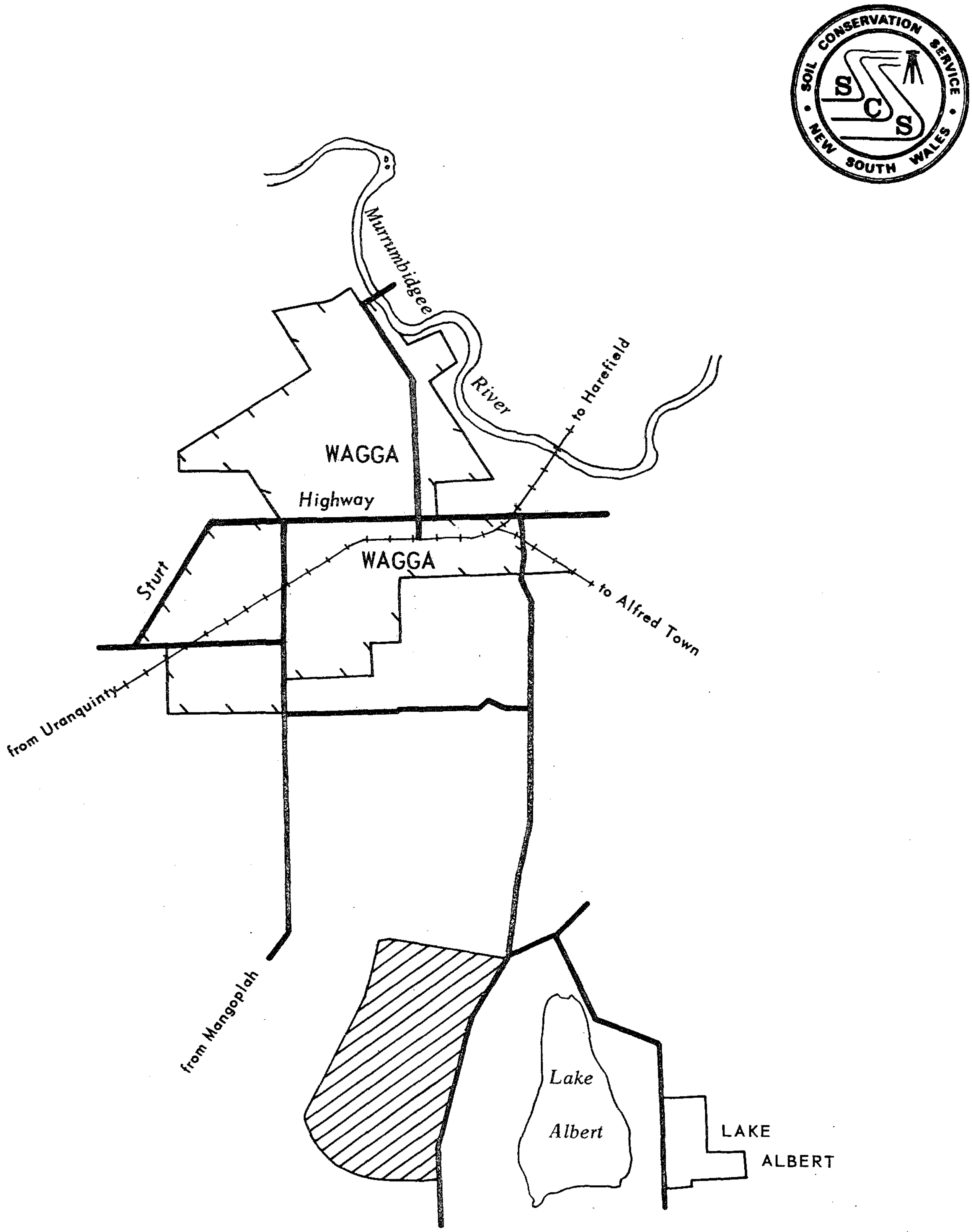
Six major soil types have been identified over the area. High soil erodibility, shallow soil depth, poor drainage, seasonal waterlogging and a moderate shrink/swell potential are characteristics of these soils which place constraints on urban development.

During winter seasonal waterlogging, caused by both poor surface drainage and seepage along soil horizons, will pose practical problems for development over much of the lower footslopes. Design of building and road foundations should take these factors into account. The high shrink/swell potential of the red brown earth soils, and the shallow depth of the ridge soils should also be noted.

Soil erodibility is moderate to high over most of the area and careful planning and management will be needed to re-establish a stable, well grassed and aesthetically pleasing landscape following urban development.

TABLE I. Summary of Urban Capability Land Classes - Red Hill/Plumpton Road - Wagga Wagga City

| Class | Limitations | Capability |
|---|---|---|
| A-o | Nil | Extensive Building Complexes |
| B-v | Shrink/swell potential | Extensive Building Complexes |
| B-s | Slope | Residential |
| B-x | Unconsolidated fill | Residential |
| B-d | Shallow soil | Residential |
| B-ew | Erodibility, seasonal waterlogging | Residential |
| C-ds | Shallow soil, slope | Residential |
| D-ds | Shallow soil, slope | Low Density Residential |
| D-f | Flooding | Drainage Reserve |
| D-f(e) | Flooding, erodibility | Drainage Reserve |




**LOCALITY DIAGRAM**

**RED HILL/PLUMPTON ROAD**

**URBAN CAPABILITY STUDY**

Scale 1 : 50 000

M. N.

S.C.S. 14986

# INTRODUCTION

The Red Hill/Plumpton Road study area consists of 230 hectares of land within the southern portion of the city of Wagga Wagga. It adjoins, on its western boundary, the Glenfield catchment which was the subject of a previous report to Wagga Wagga City Council by the Soil Conservation Service.

Red Hill road comprises the northern boundary and Plumpton Road the eastern boundary of the area. The western boundary is marked by the ridge crest which extends from Willans Hill. The southern boundary was drawn in consultation with Council staff.

This study report is presented in three parts:

Part A - an inventory of the physical features of the site.

Part B - a description of the urban capability of the area.

Part C - drainage proposals and the results of the laboratory analysis of soil samples.

Land slopes, terrain and drainage pattern have been mapped using aerial photographs, followed by field checking. These features are presented on 1:4,000 scale base maps.

Soils have been field surveyed and also mapped onto a 1:4,000 scale base map.

The above physical information has been assessed, and an urban capability map drawn for the area. This describes the capability of the area for urban development in terms of its physical limitations.

While originals of the landform, soils and urban capability maps have been prepared at a scale of 1:4,000, copies presented in this report have been reduced in scale for convenience. Copies at the larger scale are available, on request, from the Soil Conservation Service.

The information provided in this report is a guide to development, based on soil conservation principles. To ensure the effective implementation of the recommendations it contains, consultation with officers of the Soil Conservation Service should be made during both the planning and construction stages of development.

# PART A

## INVENTORY OF PHYSICAL FEATURES

Environmental features that influence land stability and the urban capability of the Red Hill/Plumpton Road area are:

1. Climate.
2. Landform (slope, terrain and drainage).
3. Geology and Soils.

## 1. CLIMATE:

The mean annual rainfall of 579 mm is slightly winter dominant (Figure 2).

Evaporation varies from 235 mm in January to 32 mm in July with an annual mean of 1407 mm.

Monthly maximum temperatures range from 31.0$^{o}$C in January to 12.4$^{o}$C in July (Figure 1).

The climate is characterised by hot dry summers, with occasional high intensity rain storms, and cool moist winters. The summer storms may cause severe erosion and siltation on erodible soils while they are exposed during the development phase.

Rainfall intensities for Wagga Wagga Soil Conservation Research Centre may be derived from Figure 3.

Native vegetation adapted to these climatic conditions are red grass and spear grasses, together with winter annuals such as Wimmera ryegrass, barley grass and subterranean clover.

## 2. LANDFORM:

The study area falls steeply, initially in a general easterly direction, from the ridge that forms its western boundary. Beneath these steep 15 to 30 per cent gradients, are gentler lower sideslopes and footslopes, with gradients ranging from 1 to 10 per cent.

These gentler slopes comprise the major portion of the area. They culminate in a small area of Stringbark Creek floodplain alongside Plumpton Road.

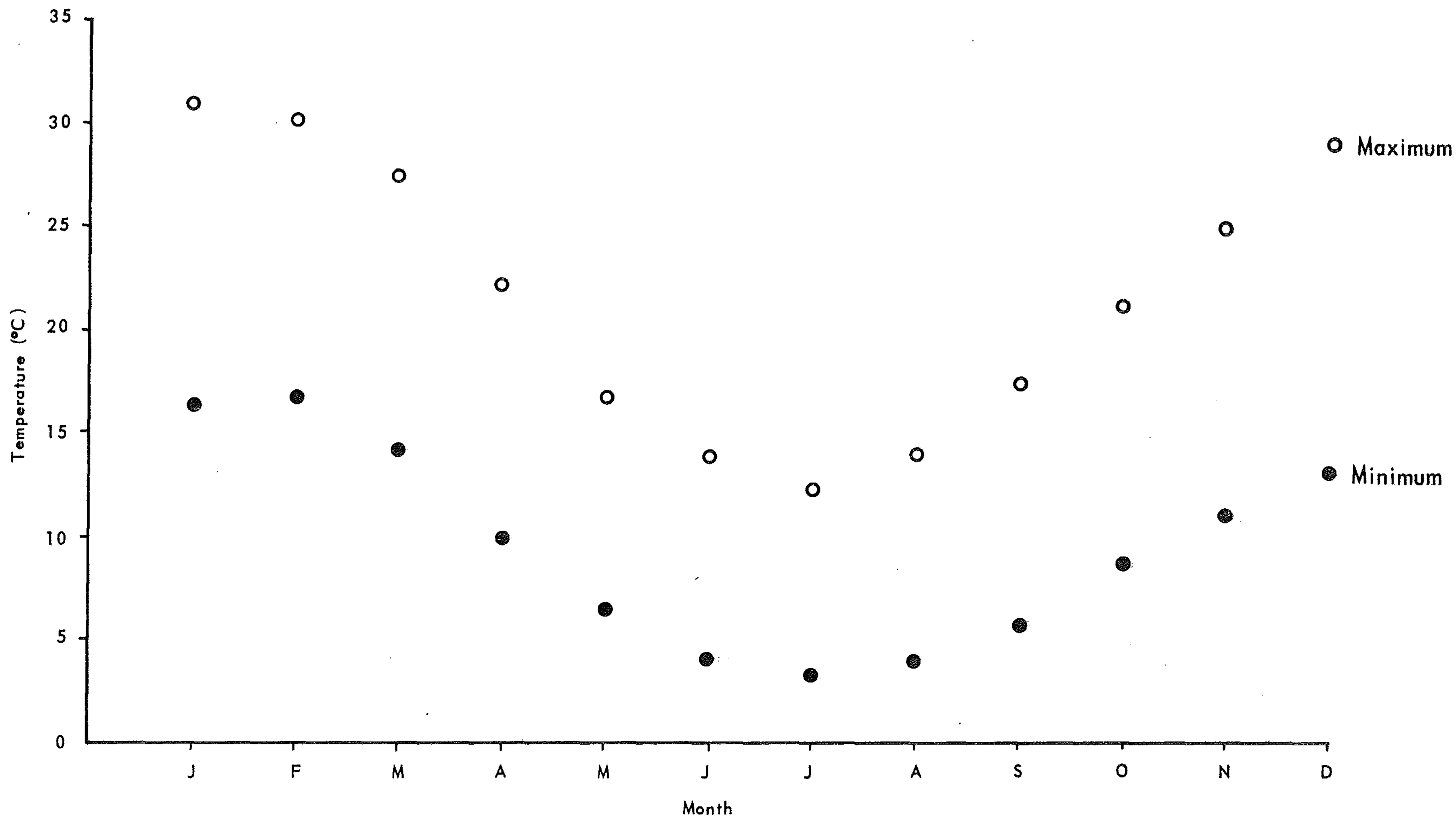



Figure 1 Average Maximum and Minimum Temperatures – Wagga Soil Conservation Research Centre (1948 – 79)

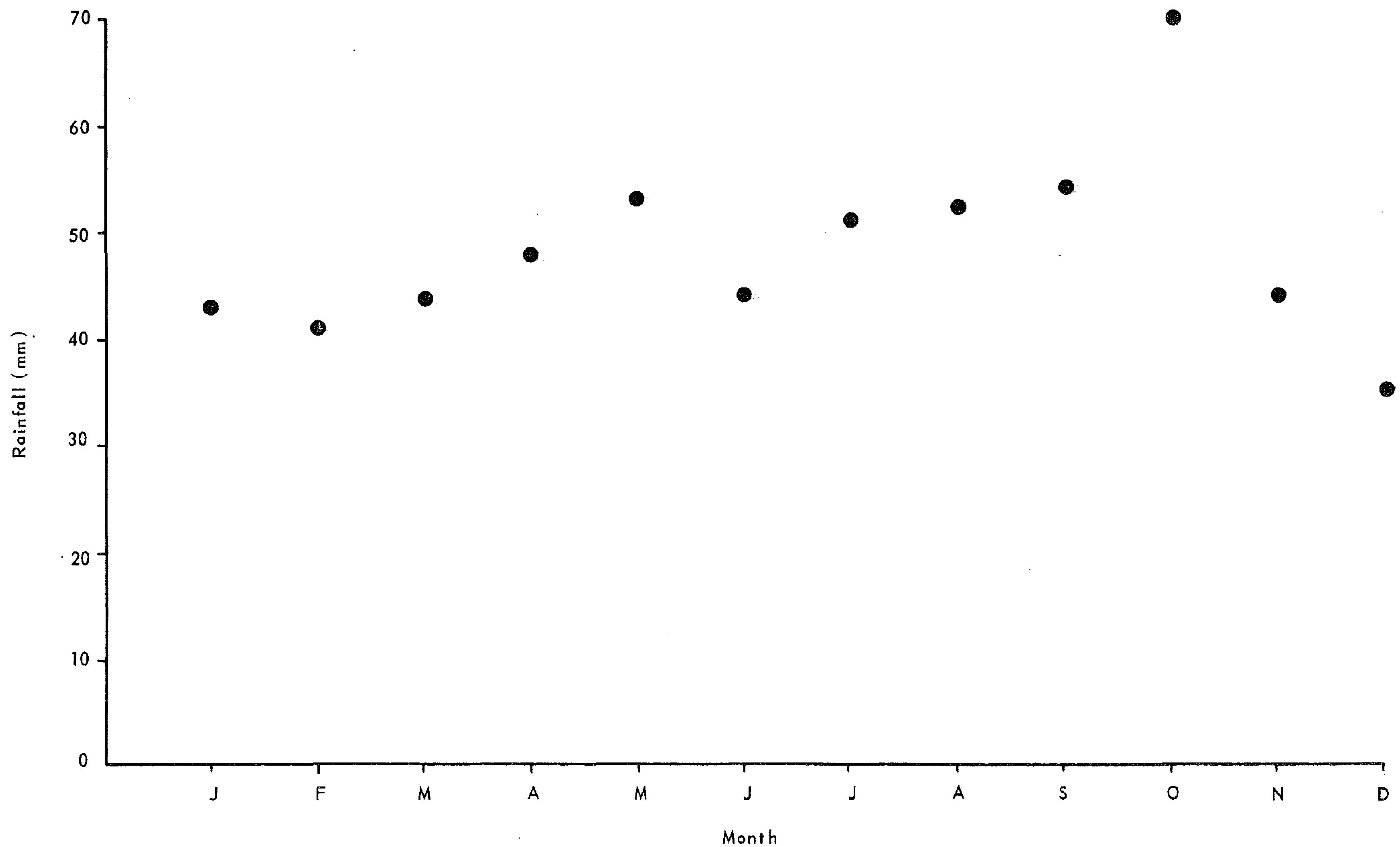
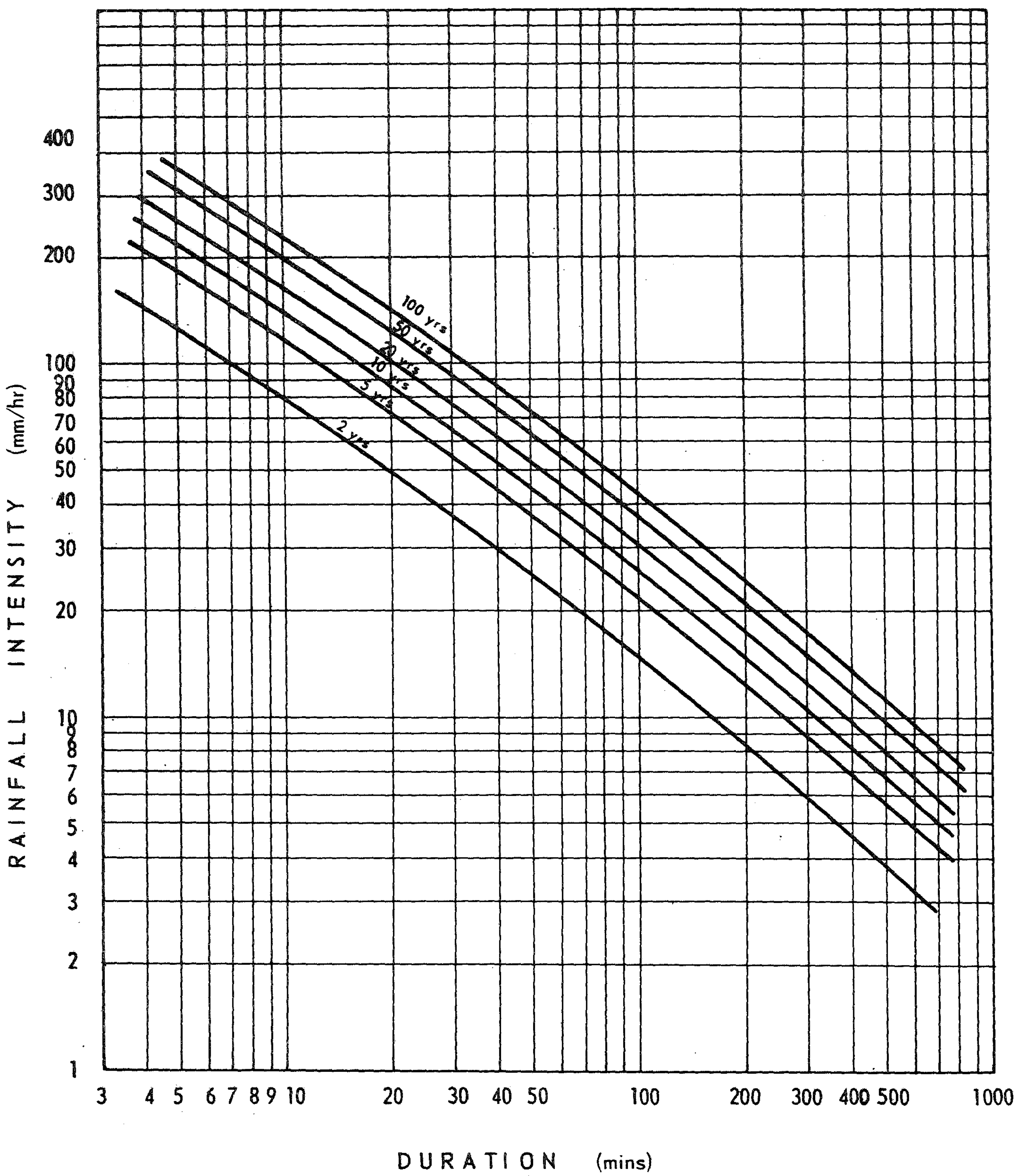



Figure 2 Average Rainfall – Wagga Soil Conservation Research Centre ( 1948 – 79 )

Figure 3 Rainfall Intensity Frequency Duration Curve

WAGGA RESEARCH CENTRE



The following slope and terrain classes are defined on the landform map.

Slope (first numeral)

1. 0-5 %
2. 5-10%
3. 10-15%
4. 15-20%
5. 20-25%
6. 25-30%

Terrain (second numeral)

1. Crest
2. Sideslope
3. Footslope
4. Floodplain
5. Drainage Plain
6. Incised Drainage Channel
7. Disturbed Terrain

## 3. GEOLOGY AND SOILS

The material underlying the area consists of Ordovician sedimentary and metamorphic rocks on the ridge and Quaternary deposits in the lower areas.

The rocks on the ridge are relatively soft in the top 1 to 2 metres and have been mined for gravel (Figure 6).

Soils range from deep medium to heavy clays to very shallow rocky soils. Main soil constraints to urban development are the poor drainage of the lower slope and drainage line soils, moderate to high shrink/swell potential on the low ridges of red soil and the shallow depth to rock on the higher ridges.

The soil survey undertaken for this study was carried out by detailed field reconnaissance, followed by classification and soil sampling for laboratory analysis.

Soils were classified using the Northcote Factual Key (Northcote, 1974) with the Soil Conservation Service extended principal profile form (Charman, 1975).

Soil Conservation Service of N.S.W.
RED HILL ROAD — PLUMPTON ROAD
SUBDIVISION
WAGGA WAGGA CITY
SCALE
METRES
METRES
RED HILL ROAD
KOORINGAL ROAD
PLUMPTON ROAD
2/7
4/2
3/2
4/7
4/2
3/7
2/3
1/3
1/4
1/1
5/2
6/2
6/2
3/2
5/2
1/3
1/4
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2/5
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3/2
1/1
2/1
4/2
3/2
2/3
1/4
4/2
4/6
3/6
2/6
3/2
2/3
1/3
1/7
LANDFORM
SLOPE
first numeral
Percent Code
0-5 .... 1
5-10 .... 2
10-15 .... 3
15-20 .... 4
20-25 .... 5
25-30 .... 6
TERRAIN
second numeral
Component Code
Crest .... 1
Sideslope .... 2
Footslope .... 3
Floodplain .... 4
Drainage Plain .... 5
Incised Drainage Channel .... 6
Disturbed Terrain .... 7
SCS 13462 A

Details of the laboratory analysis of soil samples and a summary of soil properties are presented in Appendix III.

Six soil units have been defined in this area and are shown on the attached map. Five of these units, A, B, C, F, G, are the same as those described in the Glenfield Urban Capability Study. Unit D of the Glenfield Study was not, however, identified on the Red Hill/Plumpton Road site.

Boundaries between units range from abrupt - 2 to 3 metres - for the red podzolic soil unit to gradual - more than 50 metres - for the yellow solodic soil unit.

Unit boundaries have been defined and soil classified from examination of the top metre of the profile. Sampling, in selected locations, extended to two metres to assess variation in the underlying material and to collect samples for analysis.

Surface seepage patches were delineated by the occurrence of actively growing green areas during summer and plant species present. The seepage areas mapped are approximate only, whilst some may not have been detected.

A summary of the soil features that affect urban capability assessment are:-

(1) High soil erodibility of unit B soils.

(2) Seepage problems associated with the soils of unit B, unit C, unit E and unit G.

## Map Units

A. Yellow Solodic Soil (Dy 3.42 - 3/0/40)

This unit occupies a large part of the gently sloping land in the lower sections of the area.

It is composed primarily of a yellow solodic soil that on the higher areas is overlain by 50 cm of red moderately plastic clay.

The $A_2$ horizon is about 20 cm thick and is moderately bleached. It overlies a yellow to red clay B horizon. The profile has a neutral pH at the surface and becomes alkaline at depth (pH 8.5). Some calcium carbonate nodules are present.

Some construction problems can be expected on this unit due to seepage through the $A_2$ horizon during winter. The soil is moderately erodible. Well grassed drainage reserves should maintain stability, while bare excavated channels will readily erode.

B. Yellow Solonetzic Soil (Dy 3.42 - 3/0/65)

This unit is limited to the drainage lines near the hills. Low volume runoff flows will usually keep the area continuously wet during winter. These soils are characterised by a deep bleached $A_2$ horizon which is highly erodible.

The soil is uniform throughout the unit and consists of a yellow gleyed moderately plastic B horizon underlying the deep $A_2$ horizon. It has a neutral pH throughout and is of moderate to high erodibility.

Major constraints to development are:-

(1) The dispersible and highly erodible $A_2$ horizon which extends below the depth of the normal excavation for residential foundation. Deeper excavation for foundations may be required.

(2) Continuous seepage during winter.

C. Red Podzolic Soil (Dr 2.32 - 3/2/40)

Red podzolic soil has formed on the footslopes and low ridges which extend from higher areas.

The loam topsoil includes an $A_2$ horizon which varies in depth. The red earth medium clay subsoil overlies bedrock or deep yellow clay. The B horizon is generally of moderate plasticity which is suited to residential development. However, there are some areas of highly plastic soil. The pH is neutral to slightly acid throughout.

This soil is only slightly erodible. However, seepage patches occur along its upper slope boundary that will present a constraint to development.

E. Alluvial

The alluvial soil has been deposited on the floodplain of Stringybark Creek. This is a variable unit consisting of patches of heavy clay along with areas of lighter textured loam soils.

This area has been subject to regular inundation and despite diversion of Stringybark Creek it is still flooded by local runoff and will carry excess water when the capacity of the diversion channel is

Soil Conservation Service of N.S.W.

RED HILL ROAD — PLUMPTON ROAD

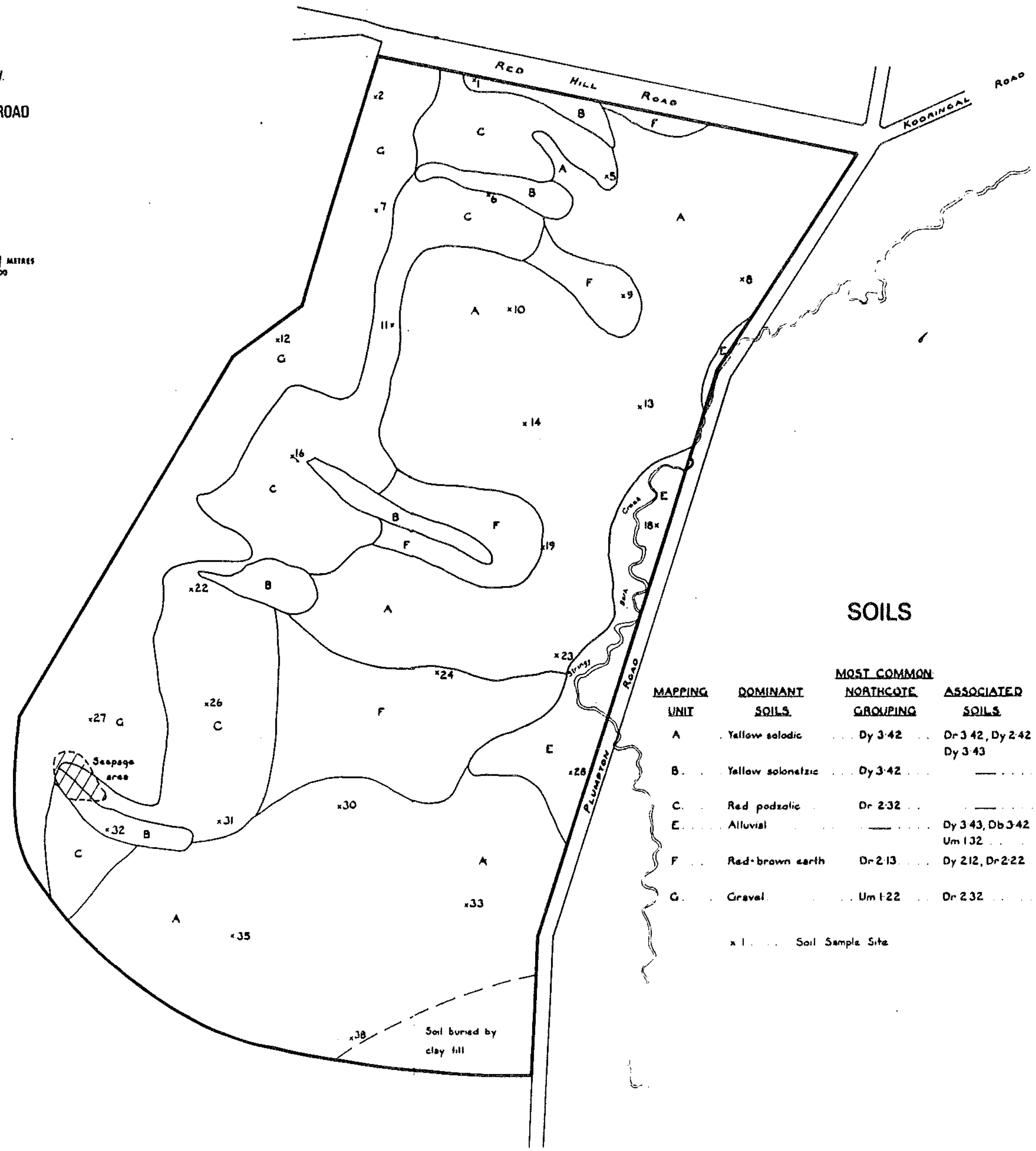
SUBDIVISION

WAGGA WAGGA CITY

SCALE

METRES 100 75 50 25 0 100 200 300 METRES

M N




## SOILS

| MAPPING UNIT | DOMINANT SOILS | MOST COMMON NORTHCOTE GROUPING | ASSOCIATED SOILS | MAJOR LIMITATIONS |
|---|---|---|---|---|
| A | Yellow solodic | Dy 3·42 | Dr 3 42, Dy 2·42 Dy 3·43 | Nil |
| B | Yellow solonetzic | Dy 3·42 | —— | Poor drainage High erodibility |
| C | Red podzolic | Dr 2·32 | —— | Seepage patches |
| E | Alluvial | —— | Dy 3·43, Db 3·42 Um 1·32 | Flooding |
| F | Red-brown earth | Dr 2·13 | Dy 2·12, Dr 2·22 | Moderate shrink-swell potential |
| G | Gravel | Um 1·22 | Dr 2·32 | Shallow soil |

x 1 . . . Soil Sample Site

SCS 13482 B

exceeded.

Therefore, urban development on this soil unit is not recommended.

F. Red-Brown Earth (Dr 2.13 - 3/2/20)

The red-brown earth unit occurs on the low ridges extending out from the main ridge.

It consists of a deep red soil with minimal $A_2$ horizon development overlying a yellow clay subsoil that increases in calcium carbonate content with depth. Patches of this soil also occur throughout unit A.

This is a moderately plastic soil and has a moderate shrink/swell potential. Road and building foundation design should take into account this limitation, which is the major constraint to development on this unit.

G. Gravel (Um 1.22)

This unit is readily recognised by the high stone content of the surface soil. The soil underlying this layer varies from bedrock to a marginal red podzolic soil coinciding with the upper slope boundary of unit C.

The soil rarely exceeds one metre in depth before hard rock is encountered. Therefore, although foundations will largely be placed on rock, problems may be experienced with service installation excavations where soil depth is less than 1 metre.

Extensive seepage patches occur along the junction of this unit with the red podzolic soil. They will pose instability problems during and following any disturbance associated with development.

Major soil constraints to development are soil instability due to seepage and a shallow soil depth to bedrock.

# PART B

# URBAN CAPABILITY

The urban capability map has been developed from an assessment of the interaction of the physical features of the site. It has been divided into four primary classes and into several sub-classes according to the physical constraints to development which are imposed by landform, soils and drainage and the assessed potential for urban development.

Four primary classes of physical limitations are defined on the urban capability map:

TABLE 2. - Definition of Primary Urban Capability Land Classes.

| | | |
|---|---|---|
| Class A | - | areas with minor or no physical limitations to urban development. |
| Class B | - | areas with minor to moderate physical limitations to urban development. These limitations may influence design and impose certain management requirements on development to ensure a stable land surface is maintained both during and after development. |
| Class C | - | areas with moderate physical limitations to urban development. These limitations can be overcome by careful design and by adoption of site management techniques to ensure the maintenance of a stable land surface. |
| Class D | - | areas with severe physical limitations to urban development which will be difficult to overcome, requiring detailed site investigation and engineering design. |

Within these primary classes a number of sub-classes have been defined on the basis of the dominant physical limitations which restrict development potential. Lower case letters have been used to define these physical limitations as follows:

o - no significant limitations

e - soil erodibility

d - shallow soil

s - slope

v - soil shrink/swell potential

w - waterlogging

f - flooding

x - disposal site.

Where one or more of these letters is placed in brackets, it is considered to be of lesser importance among several limitations which are listed in a particular sub-class. Thus, for example, D-f (e) designates land with severe physical limitations to urban development, these limitations being flooding, and high soil erodibility, with the last-mentioned being considered of lesser significance.

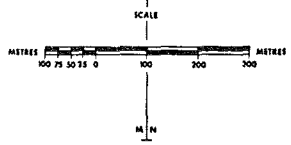
The capability indicated for each sub-class refers to the most intensive urban use which areas within that sub-class will tolerate without the occurrence of serious erosion and siltation in the short term and possible instability and drainage problems in the long term. In assessing this capability, no account is taken of development costs, social implications, aesthetics, or other factors relating to ecology and the environment. Using the capability map for planning at the conceptual level will however, take account of soil and landform limitations, while being generally consistent with preservation of an aesthetically pleasing landscape and minimization of long term repair and maintenance costs.

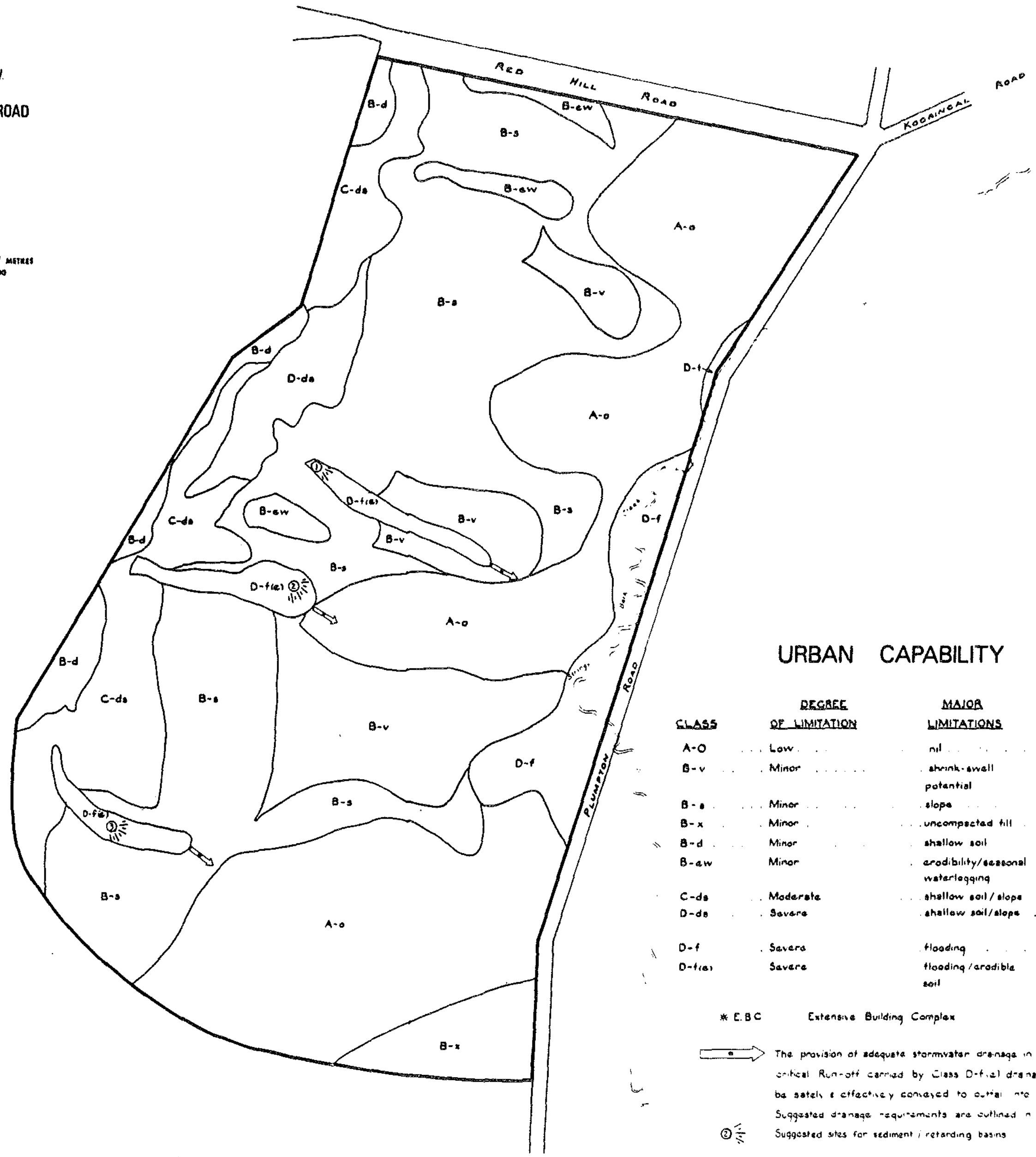
Capabilities as defined relate to the degree of surface disturbance involved in the various categories of urban development. Extensive building complexes refers to the development of commercial complexes such as offices or shopping centres, which require large scale clearing and levelling for broad areas of floor space and parking bays. Residential development infers a level of construction which provides roads, drainage and services to cater for housing allotments of the order of 600 sq. metres or larger. Low density residential development refers to allotments of the order of ½ hectare and larger taking account of the relatively more severe

Soil Conservation Service of N.S.W.

# RED HILL ROAD—PLUMPTON ROAD SUBDIVISION

WAGGA WAGGA CITY




## URBAN CAPABILITY

| CLASS | DEGREE OF LIMITATION | MAJOR LIMITATIONS | CAPABILITY |
|---|---|---|---|
| A-O | Low | nil | EBC * |
| B-v | Minor | shrink-swell potential | EBC * |
| B-s | Minor | slope | Residential |
| B-x | Minor | uncompacted fill | Residential |
| B-d | Minor | shallow soil | Residential |
| B-ew | Minor | erodibility/seasonal waterlogging | Residential |
| C-ds | Moderate | shallow soil / slope | Residential |
| D-ds | Severe | shallow soil/slope | Low density residential |
| D-f | Severe | flooding | Drainage Reserve |
| D-f(e) | Severe | flooding / erodible soil | Drainage Reserve |

* E.B.C Extensive Building Complex

⇨ The provision of adequate stormwater drainage in these areas is critical. Run-off carried by Class D-f(e) drainage reserves should be safely & effectively conveyed to outfall into Stoney Bank Creek. Suggested drainage requirements are outlined in Appendix II

② Suggested sites for sediment / retarding basins

SCS 13482 C

physical limitations to development. The development of reserves, on the other hand, may require shaping and modification of the ground surface and vegetative improvement, but no building and minimal roadway construction is envisaged.

The definition of a site capability for residential development or for the construction of extensive building complexes does not exempt developers from normal site analysis procedures in designing building foundations and engineering roadways. Nor does it imply the capacity of the site to support multi-storey units for major structures. Before structural works of such magnitude are undertaken, a detailed analysis of engineering characteristics of the soil (such as bearing capacity and shear strength) may be necessary on the specific development site.

The assessment of capability is objectively based on physical criteria alone. Thus the classification of various areas as capable of accepting certain forms of development is an assessment of the capacity of those areas to sustain the particular level of disturbance entailed. It is not a recommendation that such a form of development be adopted.

Reference is made in the text that follows to various sections of the Soil Conservation Service Urban Erosion and Sediment Control Handbook. The sections referred to provide detailed guidance on relevant sediment and erosion control and stormwater management measures which might be adopted on the Red Hill/Plumpton Road site.

Advice on specific aspects of these recommendations - such as seed and fertilizer mixture and rates, cultivation measures, and batter slopes - should be sought from the Wagga Wagga Soil Conservation Service office when subdivision works commence.

### Sub-class A-o — Minor or no physical limitations - suitable for extensive building complexes.

This sub-class occupies a large portion of the study area, comprising footslopes with gradients of 0 to 5 per cent. Soils are the yellow solodic soils of unit A.

Shrink/swell potential of this soil unit is low.

Subsoil erodibility is moderate and cut and fill operations necessary for the construction of extensive building complexes should produce only minor erosion hazard, provided simple soil conservation measures are undertaken. These measures include prompt revegetation, and control of runoff from the slopes above, and are more fully outlined in Appendix I and Sections 2 and 6 of the Soil Conservation Service Urban Erosion and Sediment Control Handbook.

Revegetation will be a little difficult due to the hard setting nature of the A and B horizons.

Seepage along the $A_2$ horizon may cause problems with construction during the winter months. This should not however cause instability provided care is taken.

Sub-class B-v — Minor to moderate physical limitations - shrink/swell constraint - suitable for extensive building complexes.

There are three areas of this sub-class, corresponding to three areas of the red brown earths of soil map unit F. They are footslopes with gradients ranging from 0 to 5 per cent.

Shrink/swell potential of the unit F soils is moderate. This constraint does not limit the capability of the land, which is suited to the development of extensive building complexes. However the shrink/swell property of the soil will need to be considered in foundation design so that cracking does not occur in buildings, as a result of soil movement.

The profile drainage of this soil is not a constraint to development. The subsoil has a moderate erodibility.

For the control of erosion and siltation during construction the guidelines in Appendix I and Sections 2, 5.6, and 6 of the Urban Erosion and Sediment Control Handbook should be followed.

Sub-class B-s — Minor to moderate physical limitation - slope constraint - suitable for residential development.

A large area of this sub-class occurs in the study site. It comprises sideslopes of 5 to 15 per cent gradient and soils of map units A and C. These soils are moderately erodible, and no problems of erosion or siltation should occur during residential development if erosion control guidelines are adhered to.

There are significant portions of this sub-class with gradients close to 5 per cent and are adjacent to A-o class land. These areas could support extensive building complexes. The higher erosion hazard associated with any extensive levelling of these slopes would need to be mitigated by strict adherence to the measures outlined in Appendix I and Section 2 of the Urban Erosion and Sediment Control Handbook.

Seepage patches occur along the boundary of this unit with the gravelly soils of sub-class C-ds land. These seepage patches constitute a potential instability hazard and care will need to be taken in the design and development of drainage systems, to ensure long term land stability.

Runoff water from the slopes above will need to be directed into a suitable drainage system to protect development on sub-class B-s land. Appendix II develops this concept more fully.

Sub-class B-x — Minor to moderate physical limitation - unconsolidated fill constraint - suitable for residential development.

This sub-class comprises an area of footslope with a gradient of between 0 and 5 per cent. Unconsolidated clay material has been loosely dumped in varying depths up to approximately 2 metres.

The principal constraint to development of this area is the effect the unconsolidated material will have on foundations. Unless foundations are suitably designed buildings will move and may subsequently crack. Provided this constraint is taken into consideration, this sub-class is suited to residential development.

Difficulty will also be experienced in revegetation of the clay material, and it will be necessary to import topsoil to the site to establish a healthy and protective vegetative cover.

Attention should be paid, during development, to the guidelines in Appendix I and Section 2 and 6 of the Urban Erosion and Sediment Control Handbook.

Sub-class B-d — Minor to moderate physical limitation - shallow soil constraint - suitable for residential development.

Three small areas of this sub-class are found along the ridge crest that forms the western boundary of area. Slopes range from 0 to 10 per cent.

The main constraint to development of this land is the shallow soil. Depth to bedrock is generally around 20 cm, and this will present a constraint to building and roadway construction and the installation of services. In this regard special attention is drawn to the gravel extraction site in the northwest corner of the area.

Drainage may be impeded in some places, and this would make septic tank installation impractical. Further investigation of this factor would be advisable.

The individual areas of the sub-class are too small to allow extensive building complexes, particularly as there is no land immediately adjacent suitable for that purpose.

Erodibility of the soil is low. However, there is little topsoil and it is essential it be retained or stockpiled to allow successful revegetation. Attention should be paid to Appendix I and Sections 2 and 6 of the Urban Erosion and Sediment Control Handbook.

Sub-class B-ew — Minor to moderate physical limitations - erodibility and seasonal waterlogging constraints - suitable for residential development.

Three small areas of this sub-class occur as minor depressions on soil map unit B soils with 5 to 10 per cent gradients.

Main limitations to development of these areas are the high erodibility of the soils, and the occurrence of seasonal waterlogging.

When the subsoil is exposed during development, there will be a high erosion hazard, and effective erosion control measures will be necessary. It will be particularly important that runoff from the slopes above be diverted away from the disturbed areas.

Figure 4. Sub-class D-ds land is suitable only for low density residential development. The steep slopes of 20% to 25% gradient and the shallow soil are severe physical limitations to development.

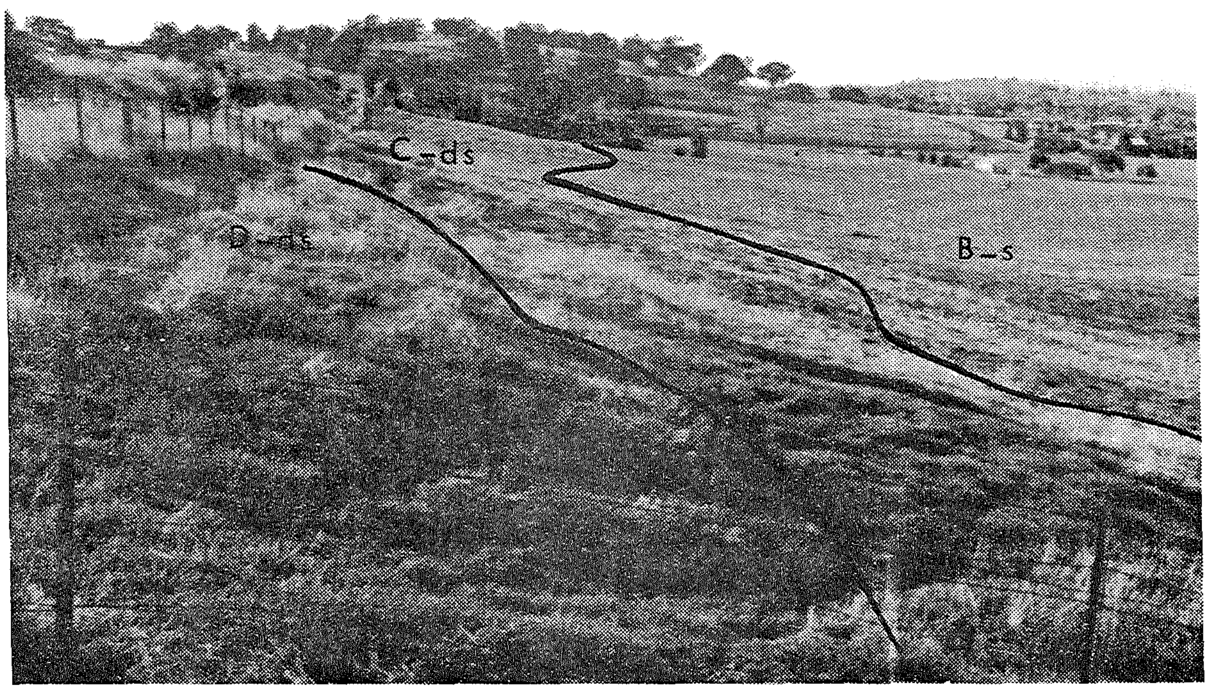



Figure 5. This photograph demonstrates the effect of slope on the urban capability classification. Sub-class D-ds has gradients in excess of 20% and is recommended as suitable for low density residential development.

Exposed subsoil, should be topsoiled and revegetated as soon as possible.

Seasonal waterlogging is caused by a combination of concentration of surface flows, poor profile drainage and seepage, and will need to be taken into account during excavation, and in design of site drainage.

This land is suitable for residential development. Extensive site drainage will overcome the wetness limitation, and care during development can minimize the erosion hazard. However, these three areas would be most readily and cheaply developed, as yard space for houses built on the adjoining sub-class B-s land.

Guidelines in Appendix I, and Sections 2, 5.3 and 6 of the Urban Erosion and Sediment Control Handbook should be followed.

Sub-class C-ds — Moderate physical limitations - shallow soil and slope constraints - suitable for residential development.

Sideslopes, and a small area of hillcrest, which have gradients of 10 to 20 per cent form this class. Soils are the shallow gravelly type of soil map unit G.

Shallow soil and steep slopes are constraints to the development of this land. There is a high stone content in the surface soil and bedrock is encountered mostly at depths below 50 cms. Due to this, difficulty will be experienced in excavating for foundations, roads and underground services. Again, special attention is drawn to the gravel extraction site in the northwest corner of the area.

Seepage patches occur along the junction of this land with the red podzolic soils of the adjoining sub-class B-s land. These constitute a potential instability hazard during development, and a factor to be overcome on the individual building blocks that include these areas of wetness.

This sub-class is suited to residential development. On the slopes approaching 20 per cent gradient, however, it should be recognised that cut and fill earthworks will be fairly extensive, and excavation expensive due to the shallowness and stoniness of the soil. Instability would be reduced if the steepest slopes were allocated for yard space, and house sites and roads located on lower grades.

Particular attention should be paid during development to Appendix I and Sections 2 and 6 of the Urban Erosion and Sediment Control Handbook.

Sub-class D-ds — Severe physical limitations - shallow soil and slope constraints - suitable for low density residential development.

Land with gradients of 20 to 30 per cent and soil map unit G soils comprise this sub-class.

The constraints of shallow soil and steep slope place severe limitations on development. The degree of excavation necessary for medium residential development on these slopes would produce a very high erosion hazard. This land is best suited therefore, to low density residential development and should be subdivided at a variable density to allow a home site area of minimum slope gradient within each block.

The steep slopes of this class could also be used as yard space for houses built on adjoining land classed as B-s and C-ds.

If houses or roads are built on this sub-class, the problems created by shallow soil and seepage patches encountered on C-ds land, will be magnified due to the steeper slopes.

It will be even more important that attention be paid to Appendix I and Sections 2 and 6 in the Urban Erosion and Sediment Control Handbook.

Sub-class D-f — Severe physical limitation - flooding constraint - suitable for drainage reserve.

The floodplain of Stringybark Creek comprises this sub-class and it is recommended that the area be retained as drainage reserve.

The channel recently excavated to divert much of Springybark Creek into Lake Albert will mean a reduction in the incidence of flooding. However, the planned urban development in the study area will increase runoff to the Creek, even though this may be minimised by the retarding basins recommended in Appendix II.

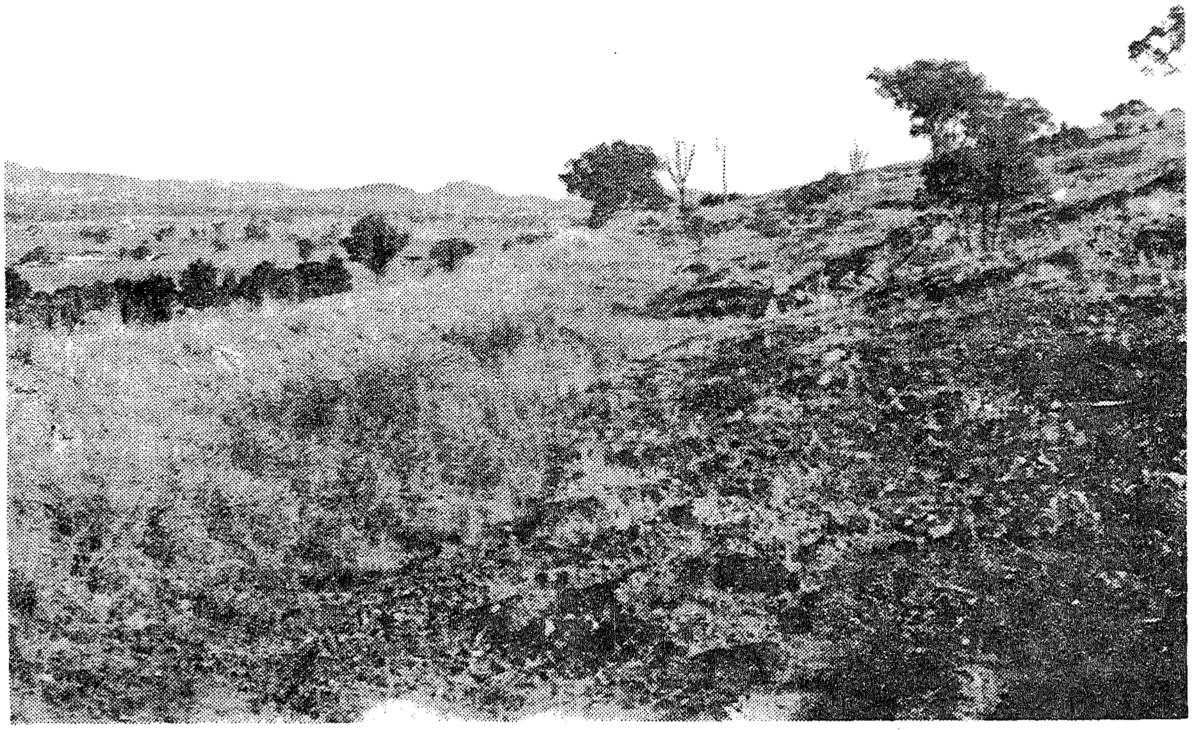


Figure 6. A diversion bank below the gravel extraction site in the northwest corner of the area protects a house below from runoff.

Figure 7. The stony and shallow nature of Map unit A soils can be seen where the topsoil has been removed at the gravel extraction site.

At least three approaches could be adopted to the development of this area, namely,

(1) The floodplain could be filled over large stormwater pipes with buildings sited on the fill. However, this would be expensive and would require careful design and construction to ensure long term stability. This approach is not recommended.

(2) The area could be shaped to a broad parabolic or trapezoidal cross section, and then revegetated. A pipe to carry say 1 in 1 year flows should be installed beneath the shaped sections, with regular inlets, and this would assist in site drainage and maintenance of the area which could then be used for recreation or open space.

(3) Retention of the natural stream channel and topography and development of the area as a nature reserve.

General recommendations for the development of drainage reserves are outlined more fully in Appendix II.

<u>Sub-class D-f (e)</u> <u>Severe physical limitations - flooding and erodibility constraints - suitable for drainage reserve</u>.

There are three drainage lines within the area included in this sub-class. They run in an easterly direction towards Stringybark Creek, but lose their definition on the lower footslopes.

Soils are the highly erodible yellow solenetzic soils of soil map unit B. The slopes are mainly of 5 and 10 per cent gradient, but do range up to 20 per cent in one area. These factors combine to place a severe limitation on the development of this land.

The recommended use of these areas is as grassed reserves, designed to carry runoff from major storms. They should be shaped to a broad parabolic or trapezoidal cross section, and then revegetated.

To prevent flooding of the lower footslopes where these depressions lose definition, a drainage system involving retarding basins is recommended.

This system will minimise the size of pipes necessary to safely carry flows to Stringybark Creek. This is explained more fully in Appendix II.

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# APPENDIX I

## PRINCIPLES AND GUIDELINES FOR SEDIMENT AND EROSION CONTROL.

Proper planning in urban development will maintain the quality of the environment and reduce the severity of soil erosion and sedimentation problems. To deal with these problems, it is recommended that erosion and sediment control principles be included in any development plan. These principles should provide for the use of vegetative and structural measures to provide surface protection to exposed soils.

The technical principles of erosion and sediment control involve:

(i) Reducing the area and the duration of exposure of soils.

(ii) Covering exposed soil with mulch and/or with vegetation.

(iii) Delaying runoff using structural or vegetative measures.

(iv) Trapping sediment in runoff.

Points (iii) and (iv) and discussed in Appendix II, while points (i) and (ii) are broadly covered in the following guidelines.

These guidelines are aimed at the control of erosion and siltation during development of the site. They should be applied once a development form has been selected that is compatible with the physical conditions of the site. Specific advice on the implementation of these can be provided from the Wagga Wagga office of the Soil Conservation Service, while greater detail on these and other measures for erosion control and stormwater management on developing areas is provided in the Urban Erosion and Sediment Control Handbook.

(a) Development should be scheduled to minimise the area disturbed at any one time and to limit the period of surface exposure.

(b) Disturbance of vegetation and topsoil should be kept to the minimum practicable. This provision is most critical on steep slopes.

(c) Where development necessitates removal of topsoil, this soil should be stockpiled for later re-spreading. The stockpiles should not be deposited in drainage lines. If the topsoil is to be stored for lengthy periods (six months or longer), vegetation should be established on the stockpiles to protect them against erosion.

(d) Areas that remain bare for lengthy periods during subdivision development should be afforded temporary protection. This can be provided by a cover crop such as Japanese millet sown in spring/summer or Wimmera ryegrass and ryecorn sown in autumn/winter, or by treatment with a surface mulch of straw or a chemical stabilizer.

(e) Where appropriate, exposed areas such as construction sites may be protected by locating temporary banks and ditches upslope to contain and divert runoff. Simple drainage works will remove local water from construction sites.

(f) Where possible, development should be designed to minimise modification of the natural landscape. Cut and fill and general grading operations should be restricted to the minimum essential for development.

(g) All permanent drainage works should be provided as early as possible during subdivision construction.

(h) Vehicular traffic should be controlled during subdivision development, confining access, where possible, to proposed or existing road alignments. Temporary culverts or causeways should be provided across major drainage lines.

(i) When excavations are made for conduits, topsoil and subsoil should be stockpiled, separately. Subsoil should be replaced in the trench first with topsoil spread later. Subsoil used to backfill trenches should be thoroughly compacted. If the soil is either very wet or very dry, adequate compaction is difficult and the risk of subsequent erosion along the trench line is increased. Backfilling to a level above the adjacent ground surface will allow for subsequent settlement.

Check banks may be required along trench lines to prevent erosion, particularly on long, steep slopes.

(j) Permanent roads and parking bays should be paved as early as possible after their formation.

(k) Borrow areas should not be located on steep areas or on highly erodible soils. Topsoil from these areas should be stockpiled, and erosion control earthworks may be constructed to protect them from upslope runoff.

(l) Areas of fill should be thoroughly compacted before any construction takes place on them.

(m) Cut and fill batters should be formed to a safe slope. Where vegetative - rather than structural - stabilization is proposed, early revegetation of exposed batters is essential.

(i) Plant species which might be considered for seed mixtures may include Wimmera ryegrass, phalaris, couch, sub-clover and Namoi woolly-pod vetch, with cover crops of oats or ryecorn at appropriate times.

Specific recommendation on mixtures and application rates will be provided, on request, from Wagga Wagga Soil Conservation Service office.

(ii) Establishment of vegetation on batters is greatly assisted by spreading topsoil over the surface.

(iii) Batters may be treated with a chemical or an organic mulch following sowing. This provides a measure of stability at an early stage.

(iv) Hydro-seeding is an alternative batter stabilization technique. A mixture of seed, fertilizer, wood or paper mulch and water is sprayed onto the batter through a specifically designed applicator. This is a simple and effective technique for vegetating batters.

(v) Establishment of vegetation is most assured of success if seed is sown in autumn or spring. However, if seed is sown in spring, provision for watering may be required during summer.

(vi) Once vegetation is established on batters, regular topdressing with fertilizer encourages the persistence of a vigorous sward.

(vii) Batters may be protected from upslope runoff by locating catch drains immediately above them. When the batters are more than six metres in height, berm drains should be located at intervals down the batter face to prevent the accumulation of erosive concentrations of runoff.

(n) Following roadway construction and the installation of services, all disturbed ground which is not about to be paved or built upon should be revegetated.

(i) The surface should be scarified prior to topsoil return.

(ii) Topsoil structure will be damaged if it is very wet or very dry when respread.

(iii) Grasses and legumes should be sown into a prepared seed bed. The range of species which may be considered for general revegetation work includes Wimmera ryegrass, phalaris, cocksfoot, couch, sub-clover and Namoi woolly-pod vetch, with cover crops of oats or ryecorn at appropriate times. Legume seed should be inoculated with the correct rhizobium and lime pelleted prior to sowing.

If spring sowing is undertaken, irrigation may be required during summer to ensure successful establishment.

(iv) All revegetation sites should receive an adequate dressing of fertilizer at sowing to assist vigorous establishment and growth.

Specific recommendations on seed and fertilizer mixtures and application rates will be provided on request, from the Wagga Wagga Soil Conservation Service office.

(o) Correct maintenance of all areas which are to remain under a permanent vegetative cover will ensure a persistent and uniform sward. Regular topdressing with fertilizer is necessary in the early years of establishment, while mowing will control weeds and promote a vigorous turf.

# APPENDIX II

## ESTABLISHMENT OF STORMWATER RETARDING BASINS, SEDIMENT BASINS AND DRAINAGE RESERVES.

Drainage will be an important aspect of the development of the study site.

Runoff from the steep sideslopes produces flooding and wetness problems on the footslopes. This is accentuated, as previously noted, by the lack of defined drainage lines on the footslopes. Water reaches Stringybark Creek largely by overland flow.

Overland flow on the footslopes is a problem for the current residents. Most houses have a diversion bank constructed above them to provide protection from flooding.

Uncontrolled urban development will significantly increase this flooding problem, along with the hazard of erosion and sedimentation.

Urbanisation of the sideslopes and upper footslopes will greatly increase the amount of runoff, reduce the time of concentration and increase peak runoff rates. This hydrological change will impose greater erosive pressure on the existing drainage lines. The soils in these drainage lines are highly erodible and gully development will occur unless preventative measures are taken.

In addition, sediment removed by erosion during development of the steeper slopes will be deposited at the lower end of the defined flowlines, and cause sedimentation and flooding problems for roads, drains, culverts and houses on the lower slopes.

The suggested approach to these problems involves the use of grassed drainage reserves in conjunction with sediment and stormwater retarding basins. Details on the location of sediment and retarding basins and the formation of reserves is given below.

### Installation of Sediment and Stormwater Retarding Basins.

A variety of measures can be adopted to delay the flow of stormwater from an area and to reduce flow peaks below that area. These are described in Section 3.2 of the Urban Erosion and Sediment

Control Handbook.

It is intended to deal here only with stormwater retarding basins and sediment basins as the principal recommended approach on the Red Hill/Plumpton Road site. They may be used alone or in conjunction with other measures described in the Handbook.

Three possible retarding basin sites have been indicated on the Urban Capability Map.

Retarding basins are large storages designed to impound runoff and regulate its flow through a pipe outlet. Their effect is to reduce peak discharges by increasing the time of concentration of runoff.

The reduced peak discharge means a much smaller capacity pipe may be used to convey the 1 in 5 year storm flows to Stringybark Creek. This could lead to a considerable saving in the cost of drainage works.

The retarding structures should have provision for flows greater than their flood storage capacity in the form of an emergency spillway. Such flows could then be diverted down grassed waterways, designed to carry runoff from a 1 in 100 year storm event.

Should retarding basins be installed, stringent design and construction controls are essential, as failure of these structures could have serious consequences, causing flash-flooding on areas below.

Installation of the retarding basins prior to any other site construction activity will allow them to function also as sediment basins. Location of sediment filters on their outlets will allow de-watering without draining sediment. When development is completed, sediment should be removed and either stockpiled or spread in a safe location where it will not subsequently erode. They will then continue to function as stormwater retarding basins.

The topography of the study site is suited to the construction of at least three retarding basins. To assist in the early evaluation of drainage alternatives, locations and capacities for three basins are proposed below. This proposal involves division of the sideslopes and upper footslopes into three convenient catchments. The actual catchment sizes following urbanisation, will depend on the location of roads and the peripheral drainage system.

Capacities and pipe sizes have been derived using a Design Criteria Manual (Preliminary) produced by Willings and Partners Pty., Ltd., which relates specifically to the design of minor retarding basins in urban stormwater systems in the Albury/Wodonga area.

Capacities derived from the Design Criteria Manual are slightly conservative for Wagga Wagga, because storm rainfall intensities tend to be higher in Albury.

It is stressed that the capacities and pipe sizes presented for sites 1, 2 and 3 are given as a guide only. Prior to adoption, specific design would need to be done to suit the particular subdivision layout.

Site 1.

The catchment for this site includes the gravel extraction site adjacent to Red Hill Road, and most of the steep portion of the study area which has an urban capability classification of D-ds.

A contour bank has been constructed below the gravel pit, to protect a house below from runoff (Figure 6). This could be modified to discharge runoff at the southern end of the bank. This water in turn could be collected by another bank, lower down the slope immediately below the D-ds land, and diverted into the sediment and retarding basin located at site 1.

Site 1 is located near some existing small cattle yards.

The catchment between sites 1 and 2 could be split, with a portion of the runoff being diverted to the site 1, giving it a total area of 15.4 hectares.

It is probable that urban development may only occur on a relatively small percentage of this sub-catchment. High runoff rates would, however, be experienced regardless, due to poor infiltration in the gravel pit and on the 20 to 30 per cent gradients of the D-ds land. A sediment and stormwater retarding basin is the recommended method of handling this runoff.

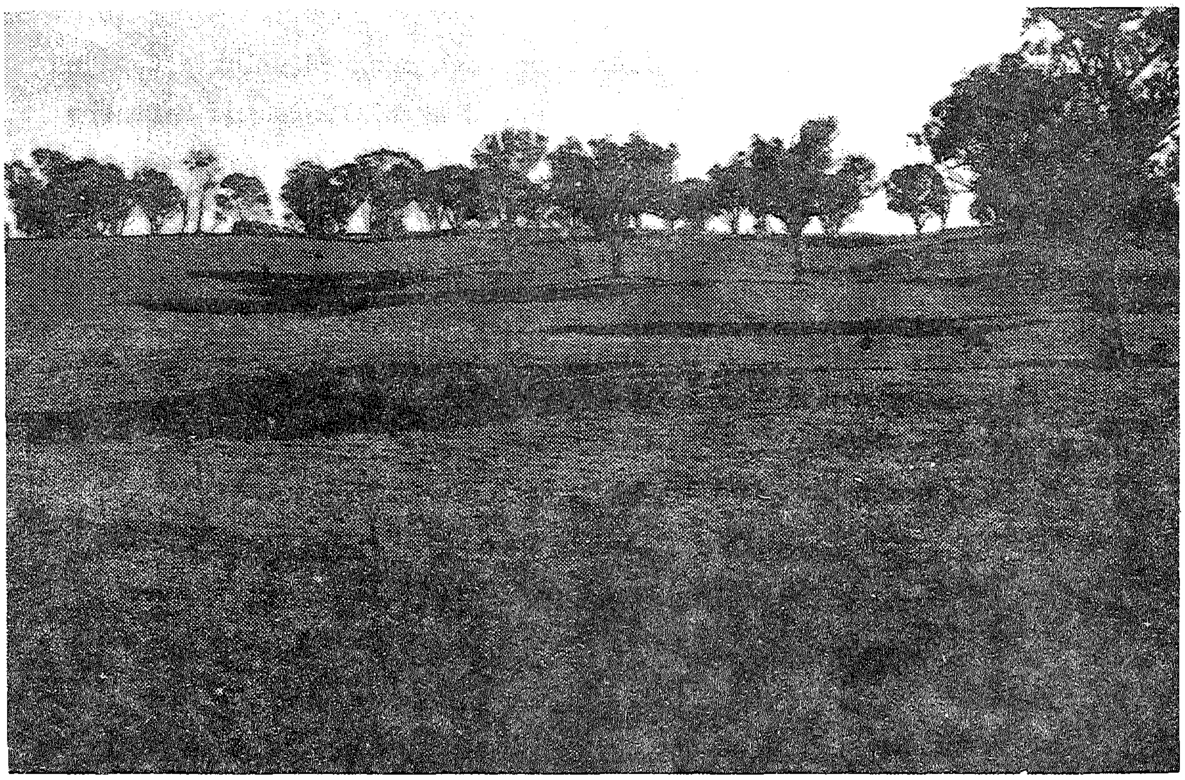

Figure 8. The immediate catchment to one of the suggested sediment basin locations - Site 1. Runoff from these slopes needs to be safely directed to Stringybark Creek if serious erosion is to be avoided.

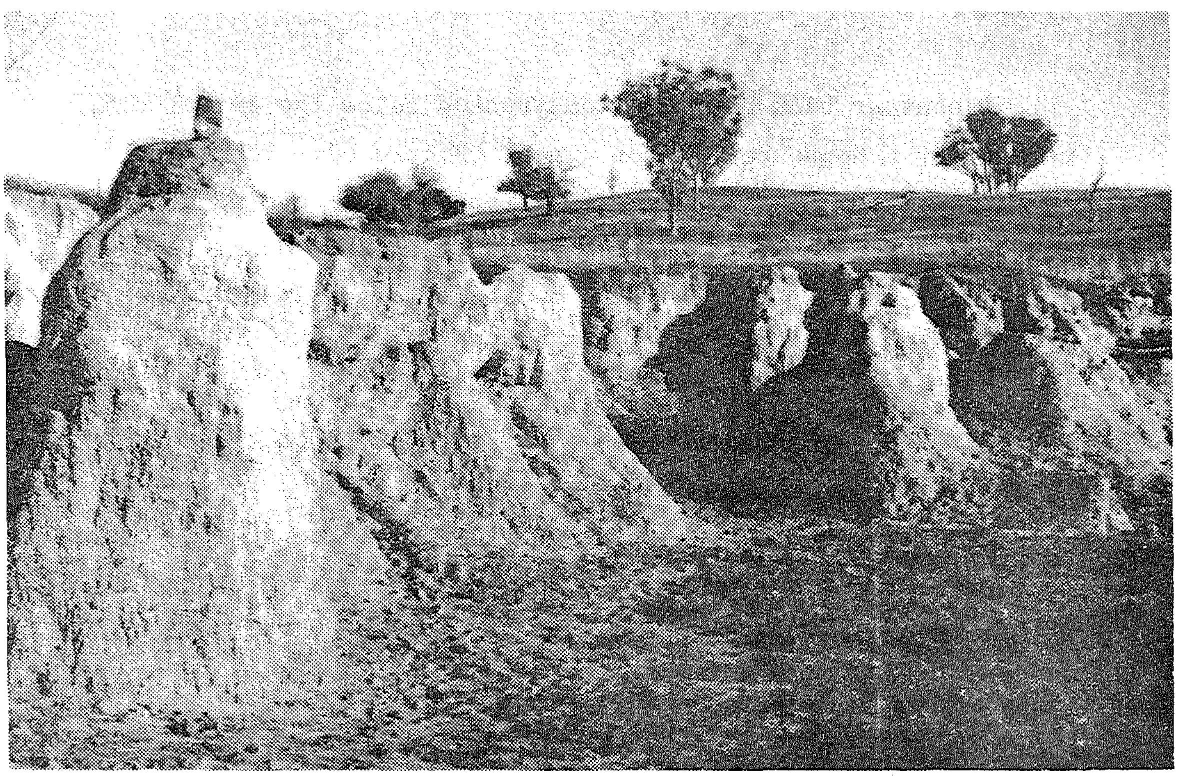

Figure 9. Active gully erosion immediately above the third suggested sediment basin location - Site 3. Without suitable soil conservation measures urban development will cause acceleration of this erosion.

The capacity of the structure would need to be approximately 1140 cubic metres, with an outlet pipe diameter of 300 mm.

The spillway would need to be designed to safely carry a discharge at the rate of 6.0 cubic metres per second. This has been calculated assuming the extreme case in which the structure is already full prior to a 1 in 100 year storm.

Flows from storms with a frequency of less than 1 in 5 years, handled by the emergency spillway, should be diverted down a drainage reserve. Recommendations for construction of such a reserve are given later.

Site 2.

This site is at present occupied by a farm dam, which could be readily modified to function as a sediment and stormwater retarding basin.

Much of the 15 hectare catchment has gradients ranging from 15 to 20 per cent. If residential development takes place here there will be a significant erosion hazard during the construction phase. It is recommended that the structure be installed as a sediment basin, prior to the commencement of works above.

The catchment size of 15 hectares has been calculated assuming diversion banks are constructed at the same contour level as the sediment basin.

The banks would bring runoff to the site from both north and south. The specific location of these banks could be determined at a later stage to suit both topography and subdivision layout.

Assuming the catchment is fully urbanised and the outlet pipe diameter is 300 mm, the recommended sediment basin capacity is 1080 cubic metres.

The spillway should be designed to handle a peak discharge of 4 cubic metres per second. This flow should be carried to Stringybark Creek via a grassed drainage reserve.

Site 3.

This suggested location is at the base of an eroded and incised drainage line. Catchment to this point was calculated at 8.3 hectares.

It is recommended that a sediment basin be constructed here also, prior to urbanisation. Present erosion will be accelerated due to the increased runoff anticipated during and after development.

A sediment basin of 480 cubic metres would be required, with an outlet pipe diameter of 300 mm.

The emergency spillway would carry an anticipated discharge of 3.4 cubic metres per second, following a 1 in 100 year storm, and this should be safely directed into a grassed drainage reserve.

Development of Drainage Reserves.

The benefits of grassed reserves include:

(i) Lower velocities of flow and increased channel storage, which result in a longer time of concentration and lower flood peaks downstream.

(ii) Green belts can be developed along the reserves, providing an attractive break in subdivision. These may be used for recreation and incorporate cycle or pedestrian paths.

(iii) Grassed reserves encourage filtration and/or settlement of pollutants such as silt and oil, washed from urban areas. By comparison, these would flow freely through stormwater pipes or lined channels.

Urban development should not encroach onto the drainage reserves so that they can provide for unimpeded flood flows.

To develop the reserves existing flowlines should be shaped into broad, shallow, parabolic waterways. These should be of sufficient width to carry flows at a velocity not exceeding two metres per second. Flows of greater velocity scour vegetated channels, and structural lining is then required.

After formation, the reserves should be stabilised with vegetation. Phalaris, Victorian perennial rye, Wimmera rye, Woogenellup sub-clover and Dixie Crimson clover are suitable plant species for waterway stabilisation in the Wagga Wagga area. More specific agronomic information can be obtained from the Wagga Wagga office of the Soil Conservation Service.

A heavy dressing of mixed fertilizer should be applied at sowing, followed by annual dressings of superphosphate.

Turf may be laid to protect critical areas such as culvert inlets.

Stabilization will be assisted if a surface binding agent such as jute mesh and bitumen, straw and bitumen, or another suitable chemical or organic mulch is applied at sowing. This will impart temporary surface stability until vegetation is established. It is a particularly desirable measure where reserves are developed after subdivision works commence. If possible, however, the drainage reserves should be formed and stabilised before any major development occurs in their catchments.

Continuous low volume flows should be catered for by providing a small underground pipe beneath the reserves or by locating a half-pipe or a lined invert along the centre. Without this provision these trickle flows will erode the floor of the reserves, while rushes, sedges and other water-loving plants will proliferate along the trickle path.

Where roadways cross drainage reserves, floodways or culverts should be provided, and these should be stabilised to withstand high flows. Rock grouting, hay and wire netting, jute mesh and bitumen, or structural energy dissipators may be required below culvert outlets to alleviate potential erosion problems.

A detailed discussion on formation of drainage reserves is provided in Section 3.1 of the Urban Erosion and Sediment Control Handbook, while revegetation techniques are dealth with in Section 6 of the same Handbook.

# APPENDIX III

## TABLE 3 - MODAL SOIL PROFILE DESCRIPTIONS - RED HILL/PLUMPTON ROAD - WAGGA WAGGA CITY.

### Map Unit A, Yellow solodic soil (Dy 3.42)

Associated soils Dr 3.42, Dy 2.42, Dy 3.43.

| Horizon | Depth (cm) | Morphology |
|---|---|---|
| $A_1$ | 0-15 | Brown (10 YR 4/4) loam fine sandy. Hard setting, apedal, pH 5½. Clear to:- |
| $A_2$ | 15-45 | Yellowish brown (10 YR 6/6) loam fine sandy to silt loam. Dispersible, apedal, pH 6½. Sharp to:- |
| $B_1$ | | 60% Orange (7.5 YR 6/8) 40% reddish brown (5 YR 5/8) medium clay. Coarse blocky to find crumb structure, pH 7. |

### Map Unit B, Yellow solonetzic soil (Dy 3.42)

No associated soils.

| Horizon | Depth (cm) | Morphology |
|---|---|---|
| $A_1$ | 0-15 | Brown (7.5 YR 4/3) fine sandy loam, slight structure, pH 5½. Gradual to:- |
| $A_2$ | 15-50 | Dull orange (7.5 YR 6/4) fine sandy loam apedal, pH 6. Sharp to:- |
| B | 45-100 | 60% Bright yellowish brown (10 YR 6/6)<br>30% Dull yellowish orange (10 YR 6/4)<br>10% Reddish brown (2.5 YR 4/8)<br>medium clay, smooth ped, coarse blocky, pH 7½. |

### Map Unit C, Red podzolic soil (Dr 2.32)

No associated soils.

| Horizon | Depth (cm) | Morphology |
|---|---|---|
| A | 0-15 | Dark reddish brown (5 YR 3/4) fine sandy loam, moderate crumb structure, pH 6. Clear to:- |
| $A_2$ | 15-25 | Dull reddish brown (5 YR 6/3) fine sandy loam apedal, pH 6. Sharp to:- |
| B | 25-120 | Reddish brown (2.5 YR 4/8) light clay medium blocky structure, pH 7. |

Map Unit E, Alluvial.

This is a highly variable unit and no profile is modal.

Associated soils Dy 3.43, Db 3.42, Um 1.32.

Map Unit F, Red-brown earth (Dr 2.13)

Associated soils Dy 2.12, Dr 2.22

| Horizon | Depth (cm) | Morphology |
|---|---|---|
| A | 0-15 | Greyish brown (7.5 YR 4/2) fine sandy loam slight structure, pH 5½. Clear to:- |
| $B_1$ | 15-100 | Reddish brown (2.5 YR 4/8) medium clay, medium blocky, some smooth peds, pH 6½. Clear to:- |
| $B_2$ | 100-180 | 60% Bright yellowish brown (10 YR 6/6) 40% Dull yellowish orange (10 YR 6/4) medium clay coarse blocky, calcium carbonate at 160 cm, pH 8.5. |

Map Unit G, Gravel (Um 1.22)

Associated soil Dr 2.32

| Horizon | Depth (cm) | Morphology |
|---|---|---|
| A | 0-20 | Dark brown (7.5 YR 3/4). Loam fine sandy, apedal, pH 6. Grades into shale. |

TABLE 4. PROPERTIES OF MAJOR SOILS - RED HILL/PLUMPTON ROAD - WAGGA WAGGA CITY

| Mapping Unit | A | | B | | C | | E | | F | | G |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Northcote Code | Dy 3.42 | | Dy 3.42 | | Dr 2.32 | | - | | Dr 2.13 | | Um 1.22 |
| Great soil group | Yellow solodic | | Yellow solonetzic | | Red podzolic | | Alluvial | | Red-brown earth | | Gravel |
| Underlying material | Yellow clay | | Yellow clay | | Shale | | Yellow clay | | Yellow clay | | Shale |
| Depth to bedrock (cm) | - | | - | | 50 - 200 | | - | | - | | 0 - 50 |
| Profile drainage | Moderate | | Poor | | Moderate | | Poor | | Moderate | | Good |
| Sample depth | 45 - 100 | | 50 - 100 | | 35 - 100 | | 45 - 100 | | 20 - 100 | | |
| No. of samples | 8 | | 2 | | 10 | | 2 | | 3 | | |
| | Mean | Range | Mean | Range | Mean | Range | Mean | Range | Mean | Range | |
| Plasticity Index % | 21 | 18 - 28 | 17 | 10 - 24 | 10 | NP - 24 | 22 | 21 - 22 | 23.2 | 18 - 27 | Gravel |
| Linear shrinkage | 10 | 4 - 15 | 7 | 6 - 7 | 6.8 | 1 - 12 | 11 | 10 - 12 | 12 | 12 - 13 | |
| Dispersal Index | 6.0 | 3.4 - 10.3 | 5.5 | 5.3 - 5.8 | 6.3 | 3.8 - 12 | 2.25 | 1.7 - 2.8 | 10.6 | 8.5 - 16 | |
| pH | 7 | | 7½ | | 7 | | 7 | | 6½ | | |
| Erodibility | Moderate | | High | | Moderate | | Moderate | | Moderate | | Low |
| Suitability for ponds | High | | High | | Low | | High | | High | | Low |
| Topsoil quality | Moderate | | Moderate | | Moderate | | Moderate | | Moderate | | Moderate |
| Ease of revegetation | Low | | Low | | Moderate | | Moderate | | Moderate | | Moderate |
| Special features | - | | Seepage | | Seepage | | Seepage | | Shrink/swell | | Shallow soil |

TABLE 5. FIELD DESCRIPTIONS OF SOIL PROFILES - RED HILL/PLUMPTON ROAD - WAGGA WAGGA CITY

| Map Unit | Profile No. | Northcote Code | Texture A Horizon | Depth A Horizon (cm) | Depth Bedrock (cm) |
|---|---|---|---|---|---|
| A | 8 | Dr 3.42 | Fine sandy loam | 30 | > 200 |
| | 13 | Dr 3.42 | Fine sandy loam | 40 | > 200 |
| | 14 | Dy 3.42 | Fine sandy loam | 30 | > 200 |
| | 23 | Dy 3.42 | Loam, fine sandy | 50 | > 200 |
| | 30 | Dy 3.42 | Loam, fine sandy | 40 | > 200 |
| | 33 | Dy 3.42 | Loam, fine sandy | 35 | > 200 |
| | 35 | Dy 2.42 | Fine sandy loam | 35 | > 200 |
| | 38 | Dy 3.43 | Loam, fine sandy | 40 | > 200 |
| B | 1 | Dy 3.42 | Fine sandy loam | 50 | > 200 |
| | 32 | Dy 3.42 | Fine sandy loam | 30 | > 200 |
| C | 5 | Dr 2.32 | Fine sandy loam | 50 | 120 |
| | 6 | Dr 2.32 | Fine sandy loam | 30 | 140 |
| | 11 | Dr 2.32 | Fine sandy loam | 30 | 120 |
| | 16 | Dr 2.32 | Loam, fine sandy | 20 | 140 |
| | 22 | Dr 2.32 | Fine sandy loam | 20 | 60 |
| | 26 | Dr 2.32 | Fine sandy loam | 60 | 80 |
| | 31 | Dr 2.32 | Sandy loam | 6 | 100 |
| E | 18 | Um 1.32 | Silt loam | 30 | > 200 |
| | 28 | Um 1.32 | Fine sandy loam | 10 | > 200 |
| F | 9 | Dr 2.13 | Fine sandy loam | 30 | > 200 |
| | 19 | Dr 2.12 | Fine sandy loam | 40 | > 200 |
| | 24 | Dr 2.13 | Fine sandy loam | 40 | > 200 |
| G | 2 | Um 1.22 | Loamy sand | 15 | 20 |
| | 7 | Um 1.22 | Loamy sand | 15 | 20 |
| | 12 | Um 1.22 | Loamy sand | 15 | 20 |
| | 17 | Um 1.22 | Loamy sand | 15 | 20 |
| | 27 | Um 1.22 | Loamy sand | 20 | 25 |

TABLE 6. LABORATORY ANALYSES FOR INDIVIDUAL SOIL PROFILES - RED HILL/PLUMPTON ROAD - WAGGA WAGGA CITY

MAP UNIT A

| Site No. | Depth (cm) | Clay % | Silt % | Fine Sand % | Coarse Sand % | Gravel % | Stones % | L.L.* % | P.I.* | E.A.T.* | D.I.* | L.S.* % | USCS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 8 | 0-20 | 12 | 24 | 57 | 8 | 1 | 0 | | | 3 | 7.5 | | SM-ML |
| | 20-30 | 24 | 22 | 46 | 8 | 1 | 0 | 22 | 8 | 2 | 8.0 | 6 | CL |
| | 30-50 | 40 | 20 | 34 | 6 | 3 | 0 | 35 | 18 | 2 | 10.3 | 11 | CL |
| | 50-100 | 50 | 12 | 35 | 3 | 2 | 0 | 40 | 19 | 2 | 11.3 | 10 | CL |
| | 100-120 | 50 | 10 | 35 | 5 | 3 | 1 | 42 | 22 | 2 | 6.8 | 11 | CL |
| 13 | 0-15 | 10 | 22 | 58 | 10 | 1 | 0 | NL | NP | 2 | 12.0 | 1 | SM |
| | 15-40 | 8 | 24 | 57 | 11 | 2 | 1 | NL | NP | 2 | 4.7 | 0 | SM-ML |
| | 40-100 | 47 | 12 | 34 | 7 | 1 | 0 | 41 | 22 | 2 | 6.8 | 15 | CL |
| | 100-120 | 60 | 8 | 28 | 4 | 2 | 0 | | | 2 | 3.8 | | CL |
| 14 | 0-15 | 10 | 24 | 57 | 9 | 0 | 0 | NL | NP | 2 | 7.5 | 0 | SM-ML |
| | 15-30 | 18 | 18 | 56 | 9 | 0 | 0 | NL | NP | 2 | 6.0 | 1 | SM-ML |
| | 30-80 | 38 | 16 | 39 | 7 | 2 | 0 | 38 | 22 | 2 | 9.7 | 10 | SC-CL |
| | 80-100 | 40 | 18 | 27 | 5 | 9 | 0 | 40 | 21 | 2 | 4.7 | 13 | CL |
| | 100-120 | 52 | 10 | 33 | 5 | 0 | 0 | 45 | 28 | 2 | 6.8 | 11 | CL |

* L.L. - Liquid Limit

* P.I. - Plasticity Index

* E.A.T. - Emerson Aggregate Test

* D.I. - Dispersal Index

* L.S. - Linear Shrinkage

TABLE 6 (continued) MAP UNIT A

| Site No. | Depth (cm) | Clay % | Silt % | Fine Sand % | Coarse Sand % | Gravel % | Stones % | L.L. % | P.I. | E.A.T. | D.I. | L.S. % | USCS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 23 | 0-20 | 18 | 28 | 46 | 8 | 0 | 0 | NL | NP | 3 | 8.0 | 1 | SC-CL |
| | 20-50 | 18 | 28 | 47 | 7 | 0 | 0 | NL | NP | 3 | 5.3 | 5 | SC-CL |
| | 50-80 | 34 | 16 | 43 | 7 | 5 | 1 | 27 | 16 | 2 | 5.6 | 6 | CL |
| | 80-100 | 38 | 8 | 43 | 11 | 4 | 0 | 34 | 17 | 2 | 7.0 | 11 | CL |
| | 100-120 | 32 | 12 | 46 | 10 | 7 | 1 | 25 | 13 | 2 | 3.0 | 8 | CL |
| 30 | 0-15 | 16 | 22 | 53 | 9 | 0 | 0 | NL | NP | 3 | 7.5 | 2 | SM-ML |
| | 15-40 | 19 | 19 | 42 | 87 | 11 | 1 | 20 | 5 | 2 | 5.5 | 5 | ML |
| | 40-80 | 46 | 14 | 33 | 7 | 6 | 0 | 38 | 21 | 1 | 3.7 | 11 | CL |
| | 80-100 | 56 | 10 | 29 | 5 | 2 | 0 | | | 2 | 4.8 | 13 | CL |
| 33 | 0-20 | 26 | 32 | 40 | 2 | 1 | 0 | NL | NP | 2 | 3.7 | 2 | SM-ML |
| | 20-35 | 28 | 30 | 39 | 3 | 1 | 0 | 22 | 8 | 1 | 1.8 | 6 | CL |
| | 35-80 | 48 | 20 | 31 | 1 | 0 | 0 | 42 | 28 | 2 | 3.4 | 11 | CL |
| | 80-120 | 46 | 26 | 27 | 1 | 1 | 0 | 46 | 25 | 2 | 4.9 | 13 | CL |

Table 6 (continued)

MAP UNIT A

| Site No. | Depth (cm) | Clay % | Silt % | Fine Sand % | Coarse Sand % | Gravel % | Stones % | L.L. % | P.I. | E.A.T. | D.I. | L.S. % | USCS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 35 | 0-15 | 8 | 26 | 57 | 9 | 0 | 0 | NL | NP | 3 | 7.0 | 1 | SM-ML |
| | 15-35 | 18 | 28 | 45 | 10 | 3 | 1 | 17 | 3 | 2 | 3.2 | 3 | SM-ML |
| | 35-80 | 54 | 16 | 26 | 4 | 1 | 0 | 42 | 25 | 2 | 4.1 | 11 | CL |
| | 80-100 | 52 | 20 | 24 | 4 | 1 | 1 | 53 | 36 | 2 | 3.5 | 10 | CH |
| 38 | 0-15 | 18 | 36 | 41 | 5 | 0 | 0 | | | 3 | 9.0 | | SC-CL |
| | 15-40 | 10 | 34 | 52 | 4 | 0 | 0 | NL | NP | 2 | 5.3 | < 1 | SM-ML |
| | 40-60 | 30 | 24 | 42 | 4 | 2 | 0 | 22 | 9 | 2 | 5.0 | 4 | CL |
| | 60-100 | 50 | 10 | 39 | 1 | 1 | 0 | 42 | 24 | 2 | 8.3 | 12 | CL |
| | 100-120 | 38 | 14 | 48 | 0 | 1 | 1 | 38 | 24 | 2 | 9.3 | 11 | CL |

TABLE 6 (continued)

MAP UNIT B

| Site No. | Depth (cm) | Clay % | Silt % | Fine Sand % | Coarse Sand % | Gravel % | Stones % | L.L. % | P.I. | E.A.T. | D.I. | L.S % | USCS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0-20 | 8 | 18 | 61 | 13 | 0 | 0 | NL | NP | 1 | 1.5 | < 1 | SM |
| | 20-50 | 10 | 19 | 56 | 13 | 1 | 0 | NL | NP | 2 | 3.5 | < 1 | SM |
| | 50-100 | 21 | 9 | 39 | 9 | 18 | 4 | 26 | 10 | 2 | 5.3 | 7 | SC |
| 1A | 50-70 | 33 | 11 | 40 | 10 | 5 | 1 | 33 | 14 | 2 | 10.0 | 11 | SC-CL |
| 32 | 0-15 | 10 | 22 | 60 | 8 | 4 | 0 | | | 2 | 5.3 | 1 | SC-CL |
| | 15-30 | 24 | 24 | 47 | 5 | 2 | 5 | 20 | 4 | 2 | 5.8 | 5 | SM-ML |
| | 30-200 | 44 | 38 | 16 | 2 | 2 | 0 | 39 | 24 | 2 | 5.8 | 6 | CL |
| | 200-2m | 22 | 26 | 41 | 11 | 10 | 2 | 33 | 15 | 1 | 3.8 | 10 | SC-C |

TABLE 6 (continued) MAP UNIT C

| Site No. | Depth (cm) | Clay % | Silt % | Fine Sand % | Coarse Sand % | Gravel % | Stones % | L.L. % | P.I. | E.A.T. | D.I. | L.S. % | USCS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 5 | 0-20 | 12 | 27 | 54 | 6 | 0 | 1 | NL | NP | 1 | 2.7 | 1 | ML |
| | 20-50 | 13 | 25 | 54 | 6 | 2 | 0 | NL | NP | 2 | 2.3 | < 1 | ML-SM |
| | 50-80 | 35 | 17 | 39 | 3 | 4 | 1 | 33 | 18 | 2 | 7.0 | 12 | CL |
| | 80-120 | 33 | 12 | 37 | 3 | 14 | 1 | 34 | 18 | 2 | 5.5 | 11 | CL |
| | 100-120 | 48 | 10 | 37 | 4 | 2 | 0 | 38 | 20 | 2 | 9.0 | 13 | CL |
| 6 | 0-15 | 8 | 16 | 63 | 13 | 0 | 0 | NL | NP | 3 | 6.5 | 1 | SM |
| | 15-30 | 9 | 20 | 54 | 10 | 6 | 0 | NL | NP | 2 | 1.4 | < 1 | SM-ML |
| | 30-60 | 36 | 19 | 35 | 7 | 2 | 0 | 32 | 16 | 2 | 3.5 | 10 | CL |
| | 60-100 | 26 | 17 | 45 | 7 | 0 | 6 | 27 | 12 | 2 | 3.8 | 8 | CL |
| | 100-120 | 26 | 24 | 44 | 6 | 3 | 1 | 26 | 11 | 2 | 4.6 | 9 | CL |

TABLE 6 (continued) MAP UNIT C

| Site No. | Depth (cm) | Clay % | Silt % | Fine Sand % | Coarse Sand % | Gravel % | Stones % | L.L. % | P.I. | E.A.T. | D.I. | L.S. % | USCS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 11 | 0-20 | 12 | 16 | 55 | 18 | 0 | 0 | NL | NP | 3 | 2.0 | 1 | SM |
| | 20-30 | 8 | 12 | 54 | 22 | 5 | 1 | NL | NP | 2 | 6.5 | 1 | SM |
| | 30-50 | 18 | 10 | 40 | 24 | 5 | 3 | NL | NP | 2 | 5.3 | 1 | SM |
| | 50-120 | 28 | 10 | 42 | 20 | 3 | 0 | 27 | 12 | 2 | 11.0 | 10 | SC-CL |
| 16 | 0-15 | 17 | 17 | 47 | 14 | 5 | 1 | NL | NP | 2 | 5.0 | 1 | SC-CL |
| | 15-20 | 28 | 18 | 36 | 12 | 5 | 0 | | | 2 | 4.3 | 8 | SC-CL |
| | 20-80 | 44 | 13 | 33 | 7 | 3 | 0 | 37 | 18 | 2 | 8.0 | 12 | CL |
| | 80-100 | 42 | 20 | 31 | 7 | 10 | 0 | 37 | 21 | 2 | 7.8 | 10 | CL |
| | 100-120 | 41 | 12 | 33 | 4 | 8 | 1 | 43 | 23 | 2 | 6.0 | 15 | CL |
| 22 | 0-20 | 11 | 13 | 49 | 23 | 3 | 0 | NL | NP | 3 | 8.0 | 2 | SC |
| | 20-50 | 12 | 15 | 33 | 23 | 10 | 8 | NL | NP | 2 | 3.8 | 1 | SC |

TABLE 6 (continued) MAP UNIT C

| Site No. | Depth (cm) | Clay % | Silt % | Fine Sand % | Coarse Sand % | Gravel % | Stones % | L.L. % | P.I. | E.A.T. | D.I. | L.S. % | USCS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 26 | 0-20 | 12 | 18 | 54 | 16 | 0 | 0 | NL | NP | 2 | 4.3 | 1 | SC |
| | 20-60 | 18 | 14 | 52 | 16 | 2 | 0 | NL | NP | 2 | 14.0 | 1 | SC |
| | 60-80 | 28 | 14 | 45 | 13 | 4 | 1 | 23 | 9 | 2 | 7.0 | 6 | CL |
| 31 | 0-15 | 6 | 22 | 62 | 10 | 0 | 0 | NL | NP | 7 or 8 | 14.0 | < 1 | SC |
| | 15-40 | 10 | 18 | 60 | 12 | 2 | 0 | NL | NP | 2 | 7.0 | < 1 | SC |
| | 40-80 | 36 | 14 | 42 | 8 | 2 | 0 | 31 | 15 | 2 | 9.3 | 10 | CL |
| | 80-100 | 40 | 12 | 40 | 8 | 1 | 0 | 36 | 18 | 2 | 29.0 | 11 | CL |

Table 6 (continued) MAP UNIT E

| Site No. | Depth (cm) | Clay % | Silt % | Fine Sand % | Coarse Sand % | Gravel % | Stones % | L.L. % | P.I. | E.A.T. | D.I. | L.S. % | USCS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 18 | 0-30 | 24 | 34 | 32 | 5 | 4 | 0 | 30 | 9 | 2 | 3.8 | 7 | CL |
| | 30-50 | 16 | 34 | 42 | 8 | 3 | 0 | NL | NP | 2 | 3.8 | 3 | SC-CL |
| | 50-120 | 20 | 22 | 47 | 11 | 0 | 0 | 35 | 21 | 2 | 2.8 | 12 | CL |
| 28 | 0-10 | 20 | 22 | 56 | 2 | 0 | 0 | NL | NP | 3 | 6.3 | 2 | SC-CL |
| | 10-35 | 10 | 28 | 60 | 2 | 0 | 0 | | | 2 | 4.5 | | SM-ML |
| | 35-80 | 50 | 10 | 39 | 1 | 0 | 0 | 39 | 22 | 1 | 1.7 | 10 | CL |
| | 80-100 | 32 | 18 | 49 | 1 | 2 | 0 | 35 | 20 | 1 | 1.5 | 11 | CL |

TABLE 6 (continued) MAP UNIT F

| Site No. | Depth (cm) | Clay % | Silt % | Fine Sand % | Coarse Sand % | Gravel % | Stones % | L.L. % | P.I. | E.A.T. | D.I. | L.S. % | USCS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 9 | 0-15 | 20 | 24 | 47 | 9 | 2 | 0 | NL | NP | 3 | 10.0 | 3 | ML |
| | 15-25 | 48 | 10 | 31 | 9 | 2 | 0 | 39 | 21 | 2 | 4.2 | 13 | CL |
| | 25-100 | 56 | 10 | 29 | 5 | 5 | 0 | 47 | 25 | 2 | 7.4 | 13 | CL |
| | 100-120 | 59 | 8 | 29 | 4 | 0 | 0 | 53 | 30 | 2 | 3.9 | 17 | CH |
| 19 | 0-20 | 33 | 27 | 38 | 1 | 0 | 0 | | | 3 | 1.9 | 1 | CL |
| | 20-40 | 14 | 23 | 50 | 12 | 0 | 0 | 21 | 5 | 2 | 2.7 | 5 | SC-SM |
| | 40-80 | 46 | 12 | 34 | 8 | 2 | 1 | 36 | 18 | 2 | 16.0 | 12 | CL |
| | 80-120 | 48 | 11 | 34 | 4 | 2 | 1 | 41 | 22 | 2 | 5.0 | 15 | CL |
| 24 | 0-20 | 16 | 22 | 52 | 10 | 0 | 0 | NL | NP | 3 | 14.0 | 2 | SC-CL |
| | 20-40 | 12 | 26 | 48 | 14 | 3 | 0 | NL | NP | 3 | 5.0 | 0 | SM-ML |
| | 40-60 | 52 | 6 | 36 | 6 | 1 | 0 | 48 | 20 | 2 | 8.5 | 12 | CL |
| | 60-100 | 58 | 12 | 25 | 5 | 1 | 0 | 46 | 26 | 2 | 4.5 | 16 | CL |

Table 6 (continued) MAP UNIT G

| Site No. | Depth (cm) | Clay % | Silt % | Fine Sand % | Coarse Sand % | Gravel % | Stones % | L.L. % | P.I. | E.A.T. | D.I. | L.S. % | USCS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | 0-15 | 4 | 10 | 19 | 14 | 16 | 38 | NL | NP | 3 | 3.0 | 1 | GM-SM |
| 7 | 0-15 | 2 | 6 | 14 | 7 | 9 | 63 | | | 3 | 4.7 | < 1 | GM |
| 12 | 0-15 | 7 | 13 | 38 | 14 | 15 | 13 | NL | NP | 1 | 2.3 | 1 | GM-SM |
| | 15-25 | 4 | 12 | 35 | 17 | 20 | 12 | NL | NP | 1 | 1.7 | < 1 | GM-SM |
| 17 | 0-20 | 9 | 14 | 20 | 13 | 15 | 29 | NL | NP | 2 | 5.5 | 3 | GM-SM |
| 27 | 0-20 | 5 | 6 | 17 | 9 | 11 | 53 | NL | NP | 2 | 14.0 | 2 | GM |

# APPENDIX IV

## GLOSSARY OF TERMS

### Name of Soil Unit

Descriptive names used are based on the dominant morphological features of the soil profile.

### Atterberg Limits

The Atterberg Limits are based on the concept that a fine grained soil can exist in any of three states depending on its water content. Thus, on the addition of water, a soil may proceed from the solid state through to the plastic and finally liquid states. The water contents at the boundaries between adjacent states are termed the plastic limit and the liquid limit (Lambe and Whitman, 1969).

#### Liquid Limit (L.L.)

The liquid limit is the moisture content at which the soil passes from the plastic to the liquid state. A full description of the liquid limit test is given in Black (ed.) (1965).

#### Plasticity Index (P.I.)

The plasticity index of a soil is the difference between the plastic and the liquid limits. Toughness and dry strength are proportional to the plasticity index. (See Black (ed.) (1965).

### Dispersal Index (D.I.)

The dispersal index of a soil is the ratio between the total amount of very fine particles of approximately clay size, determined by chemical and mechanical dispersion, and the amount of very fine particles obtained by mechanical dispersion only. Highly dispersible soils have low dispersal indices because their very fine particles are already in a dispersed state, and the ratio approaches one. Slightly dispersible soils have high dispersal indices.

The test has been shown to reflect field behaviour of soils in that dispersible soils are often highly erodible and subject to tunnelling, both in situ and when used in earthworks.

A full description of the Dispersal Index test and the background to it is given in Charman (ed.) (1975).

Emerson Aggregate Test (E.A.T.)

The E.A.T. classifies soil aggregates according to their coherence in water. The interaction of clay size particles in soil aggregates with water may largely determine the structural stability of a soil.

The Emerson classes 1, 2, 3 and 4 to 6 generally represent aggregates from soils which are highly, moderately, slightly and non-dispersible respectively.

A full description of the test is given by Emerson (1967).

Soil Erodibility and Erosion Hazard

The erodibility of soil material is an inherent property of that material. It is directly related to those basic properties which make the material susceptible to detachment by erosive forces and which prevent the soil absorbing rain, thus causing runoff. The erosion hazard of a given soil in the field is also controlled by soil profile characteristics, landform characteristics, run-on and land use. The qualitative categories for soil erosion hazard adopted by the Soil Conservation Service are low, moderate, high, very high and extreme.

Linear Shrinkage

Linear shrinkage is the decrease in one dimension of a soil sample when oven dried (at $105^{o}$ for 24 hours) from the moisture content at the liquid limit, expressed as a percentage of the original dimension.

The linear shrinkage test is fully described in the Australian Standard A89, Testing Soils for Engineering Purposes (1966).

Shrink/swell potential is related to linear shrinkage values as follows:

| | % |
|---|---|
| Low - Non-Critical | 0 - 12 |
| Moderate - Marginal | 12 - 17 |
| High - Critical | 17 - 21 |
| Very High - Very Critical | $>$ 21 |

Northcote Code

The Northcote Code represents the characterisation of a soil profile according to a system for the recognition of soils in the field described by Northcote (1974).

The Soil Conservation Service addendum to this code comprises three additional digits representing the surface texture, surface soil structure and depth of the A horizon in centimetres respectively of the soil profile described. Texture classes range from 1 to 6 (sand to heavy clay). Structure classes range from 0 to 3 (structureless to strongly developed structure). These properties are defined by Northcote (1974).

Particle Size Analysis

Particle size analysis is the laboratory procedure for the determination of particle size distribution in a soil sample. The hydrometer method used for this report is given by Day in Black (ed.) (1965).

Unified Soil Classification System (USCS)

The USCS is a classification system which has been correlated with certain engineering properties of soils such as optimum moisture content, permeability, compressibility and shear strength.

A full description of the system is given by Casagrande (1948) or Lambe and Whitman (1969).

Descriptions used in Table 6 are:

CL - Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.

GC - Clayey gravels, poorly graded gravel-sand-clay mixtures.

GM - Silty gravels, poorly graded gravel-sand-silt mixtures.

MH - Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, plastic silts.

ML - Inorganic silts and very fine sands, rock flour, silty or clayey fine sands with slight plasticity.

SC - Clayey sands, poorly graded sand-clay mixtures.

SM - Silty sands, poorly graded sand-silt mixtures.

Soil Drainage

Soil drainage provides an indication of the period for which a profile may be wet during the year. A soil which is very poorly drained may be near saturation for most of the year, while one with very good drainage will be saturated only during or immediately after heavy rainfall.

Rockiness

Rockiness refers to the occurrence of outcropping rock.

Topography or Terrain

This refers to the position of a site in the landscape. Various classes of terrain affect run-on amount and drainage conditions.

D. West, Government Printer, New South Wales – 1980