Soil Conservation Service of N.S.W.

URBAN CAPABILITY STUDY:

Village of Jindera

March 1978

SOIL CONSERVATION SERVICE OF NEW SOUTH WALES

URBAN CAPABILITY STUDY OF

VILLAGE OF JINDERA

Report prepared for the

HUME SHIRE COUNCIL

March 1978

This report, and the original maps associated with it, have been scanned and stored on the custodian's intranet.
Original maps drafted at 1:10,000 were catalogued SCS 12051/A -Z.
These full size maps have been scanned and named "UC_Jindera_Hume_theme".
S.J. Lucas April 2014

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This report is a guide to development potential only in terms of erosion hazard and land stability. It indicates the capacity of the physical resources of the study area to sustain various intensities of urban use.

The maps are for use at the scale at which they have been prepared and, as such, will assist in subdivision planning. It is important that information is not extracted from them at a scale larger than the scale of the originals.

Neither the maps nor the written report are 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.

The report does not constitute an overall recommendation for particular forms of use or development on specified areas, as no account has been taken of other town planning considerations. It forms a basis onto which these may be imposed to derive a development plan.

CONTENTS

SUMMARY

This study covers an area of 590 hectares at Jindera, including existing residential areas.

The landform comprises level to gently sloping terrain dissected by five major streams.

The drainage pattern is a major constraint to urban development. Large areas have slope gradients less than 2% and soil permeability is generally low. Water may lie on the surface for many months. Runoff from a large external catchment (4536 hectares) also enters the village.

The soils are primarily heavy clays and silts developed on colluvium. A granitic outcrop occurs in the north western corner. Maps of selected physical soil characteristics have been prepared. They include, profile drainage, volume expansion and soil erodibility. Most soils are dispersible and, once disturbed, will yield turbid runoff which may degrade the quality of water entering Lake Hume.

Urban capability classes have been assessed from an interpretation of landform and soils data.

Sub-Class A-0 includes broad areas of gently sloping land on well drained loam soils. No major erosion hazards should occur with the development of this land, which is suitable for construction of extensive building complexes.

Sub-Class B-1 is confined to a small area with slope gradients from 5% to 15% on granite derived loam textured soils. Rock outcrops occur. This land is suitable for residential use.

Sub-Class B3 is the dominant land class. Slope gradients are less than 2%. Soils may be of low permeability and high volume expansion and have deep unstable sub soils, or may show high plasticity. This land could support extensive building developments provided detailed site investigations were made to design building foundations.

Sub-Class C-3 includes small isolated areas associated with soils of high plasticity, high volume expansion and low permeability. It is essential that soil investigations for foundation stability be made prior to any development. This land is suitable for extensive building complexes.

Sub-Class C-3,6 is located on drainage plains with soils having poor profile drainage and is subject to seasonal waterlogging. Site investigations for building and road foundation design is essential. Site drainage facilities are necessary. This land is suitable for extensive building complexes.

Sub-Class D-2,3,6 includes the major drainage lines that flow through Jindera. Building is not recommended. This land should be developed as open space grassed drainage reserves that can be used for passive recreation.

Recommendations are given for the development of these grassed drainage reserves.

Changes in land use in the large external catchment may increase the frequency and volume of runoff, with adverse effects to residential areas. The concept of storm water management which could be applied to future development proposals in catchment areas, to maintain runoff at pre-development levels, is discussed.

Full size 1:5,000 maps are available for this study. They are numbered SCS 12051. Scan copies are called UC_Jindera_Hume.......pdf .

INTRODUCTION

The Village of Jindera is located 16 km north of Albury on the Urana Road. It occupies an area of approximately 590 hectares in the Hume catchment. Bowna Creek (or Four Mile Creek) meanders through the Village and flows into Hume Reservoir which is approximately 20 km downstream.

The demand for residential development at Jindera is increasing as it lies within commuting distance of the Albury-Wodonga Growth Centre.

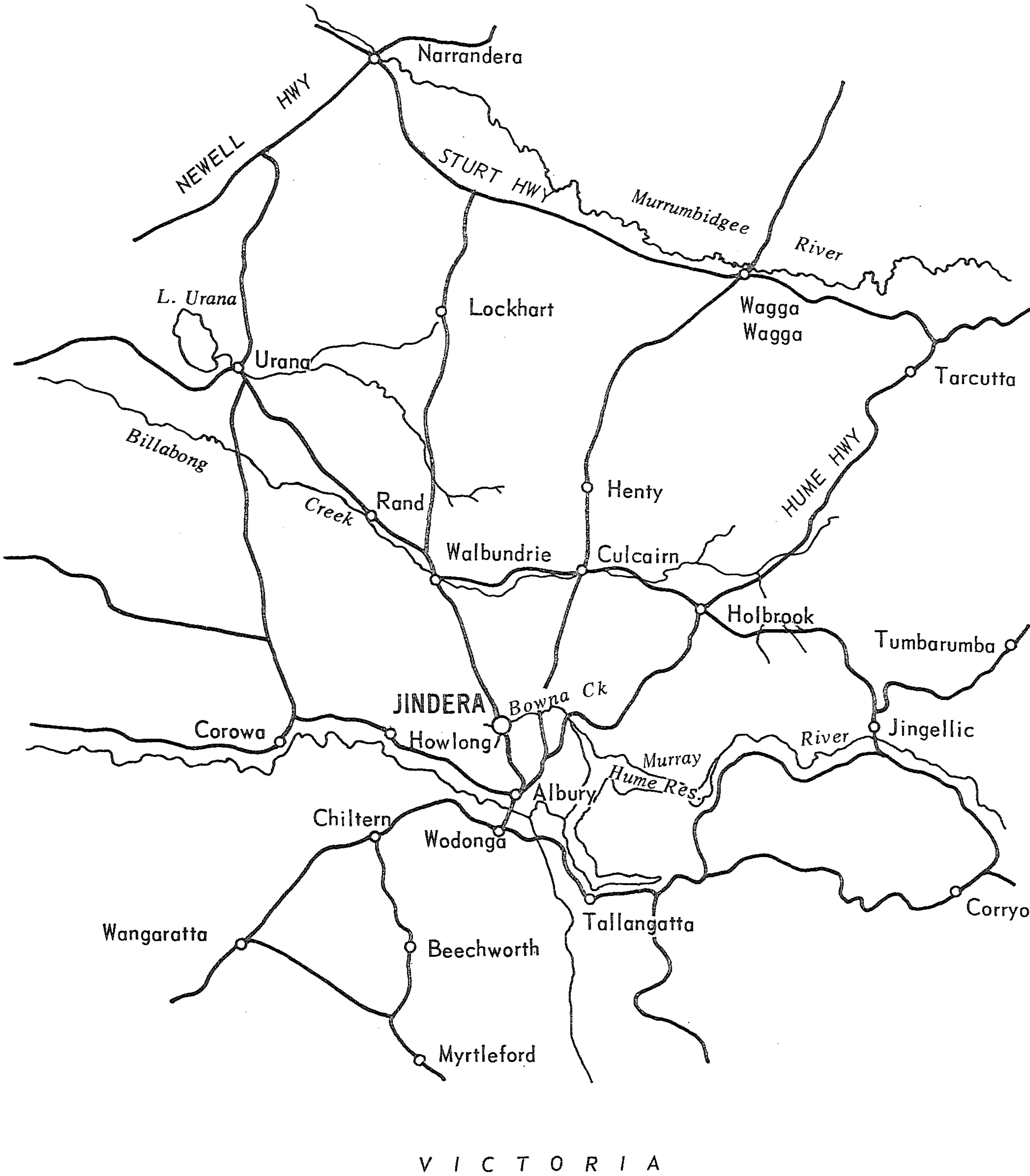
The Hume Shire Council has been aware of difficulties associated with poor soil conditions, drainage and flooding that would affect residential development. The Council requested the Soil Conservation Service of N.S.W. to prepare an Urban Capability Study to identify these areas.

Planned development is essential to minimise soil erosion usually associated with the construction of subdivisions and to reduce siltation of the Hume Reservoir.

The study entailed mapping and identification of individual landform components, mapping, sampling and laboratory analyses of soils, and investigation of peak runoff and catchment hydrology of land above the Village. This information was interpreted to provide an urban capability map (1: 5000 scale) assessing the capability of the area for urban development in terms of site stability and erosion hazard.

Maps of soils and landform were prepared on 1: 5000 scale base plans using aerial photographic interpretation together with detailed ground survey. The drainage pattern of streams that flow through Jindera was mapped on 1: 10,000 scale base plans. The landform, soils, drainage pattern and urban capability maps included in this report have been reduced in scale for convenience of presentation. Copies of the larger scale maps are available, on request, from the Soil Conservation Service.

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



Map 1

LOCALITY MAP

S.C.S. 12051 – D

PHYSICAL FEATURES.

Features of the environment which influence erosion hazard and site stability at Jindera include:

1. Climate
2. Landform (terrain, slope and drainage)
3. Drainage Pattern
4. Soils

1. Climate

The annual median rainfall at Jindera of 600 mm is winter dominant in incidence. During winter, prolonged wet periods cause saturated soil conditions to persist for extended periods on soils with poor drainage. These conditions will cause construction difficulties and produce highly turbid runoff from sites with dispersible soil.

High intensity storms are a feature of the rainfall pattern during summer. These storms may cause severe erosion to excavations and drainage works.

2. Landform

Landform features have been mapped as two elements, a slope component and a terrain component.

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

Slope Class		Terrain Component	
1.	0 - 2%	1.	Hillcrest
2.	2 - 5%	2.	Sideslope
3.	5 -10%	3.	Footslope
4.	10 -15%	4.	Drainage plain
		5.	Floodplain
		6.	Incised drainage channel

Landform Map is presented on Page 8. Original full scale map is SCS 12051A. Digital copies are called Jindera_Hume_Landform.pdf

The terrain component describes the physical appearance of the slopes. It includes:

Hillcrests, which in Jindera are low, rounded crests forming drainage divides with slope gradients that rarely exceed 5%.

Sideslopes are well drained gentle slopes between the hillcrests and the footslopes.

Footslopes have low gradients. Surface drainage is poor which causes soils to remain wet for long periods.

Drainage plains are level areas of footslopes subject to seasonal waterlogging and periodic overland flow. Water may lie on the surface for several months.

Floodplains are areas adjacent to the major watercourses that flow through Jindera. They are subject to flooding.

Incised drainage channels include the steep sided banks and the bed of watercourses that have eroded into the land surface. Man-made drains have also been included.

3. Drainage Pattern

Drainage pattern is a major constraint to urban development at Jindera. Low slope gradients and a large external catchment (4,536 hectares) compound the problem.

The drainage pattern in the Village is defined in the landform map which shows the incised drainage channels of major drainage lines and their associated floodplains. At present the major sub-catchments that contribute runoff through urban areas in Jindera are those indicated as A, B, C, D, and E (Map 3). These enter the area from west and east. They total 2,529 hectares in area.

The drainage patterns of the external catchments have been mapped in detail on a 1: 10,000 scale orthophotomap. They are delineated using a hierarchical system of stream orders (from first to fifth) to classify individual drainage lines.

Stream orders are assigned by subdivision of drainage lines into segments between stream junctions. The first order stream segment runs from the point of origin to the junction with another stream. Where two first order streams join, a second order stream segment begins. This continues until a junction is formed with another second order stream to produce a third order stream, and so on.

This classification of streams relates to their runoff carrying capacity. The higher the numerical order of the stream the more likely that overtopping of the drainage channel will occur.

Hydrological consequences of further urban development

The major streams that flow into Jindera are still adjusting to the consequences of increased runoff stemming from the change from natural forest to rural land use. Further subdivision of properties or intensification of land use will further alter the existing hydrological regime, increasing the erosion hazard and adversely affecting present and future urban development.

A system of storm water management for upstream development is recommended. This will provide a total storm runoff management plan for the whole catchment. It is discussed in the Urban Capability section. Original full size map is SCS 12051/E.

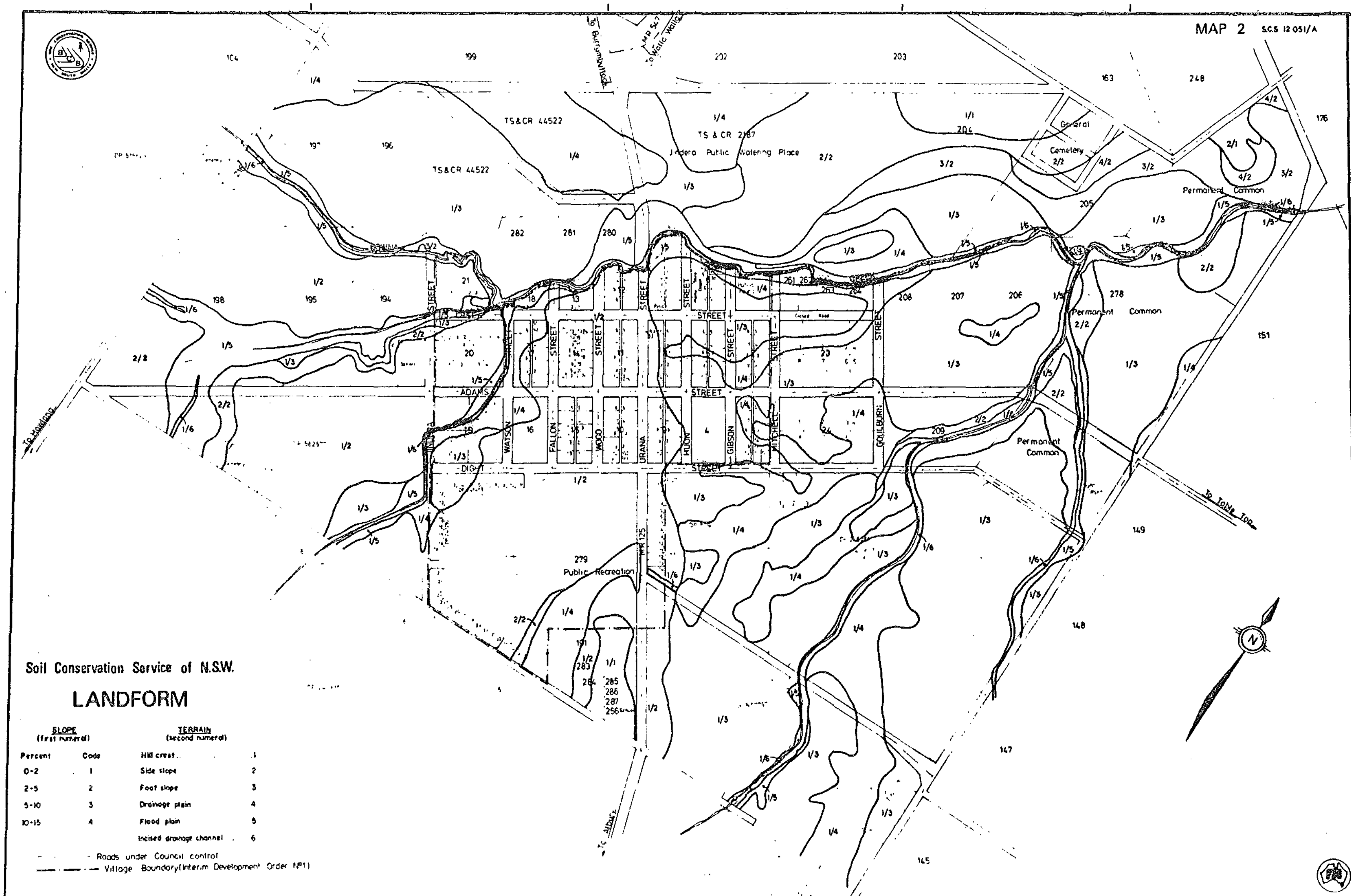
4. Soils

The soils at Jindera have developed primarily on low-lying unconsolidated deposits of clay and silt. North of the Village there are small areas of residual and colluvial deposits derived from underlying granites. These areas contain scattered rock outcrops. The scanned soils map SCS 12051/B is stored as "Jindera_Hume_soils.pdf".

Soils were mapped on 1: 10,000 base plans. Map units were delineated by field investigation at 5 to 500 metre intervals. During this investigation most of the rural section of the area was covered at grid intervals of approximately 100 metres.

Soils were described, classified and sampled for laboratory analysis at selected sites in each map unit. Results are summarised in Table I and presented in full in Appendix I. Descriptions of typical soil profiles for each map unit are given in Appendix II.

Field permeability measurements were made to compare soils in each map unit. The rate of water loss was measured, in centimetres, from the top of a 10 cm diameter auger hole, 50 cm deep, after 3 hours soaking. The results are presented graphically in figure 1. These results are comparative only. They are not quantitative measures of the ability of the soils to absorb water. Map 5 provides a summary

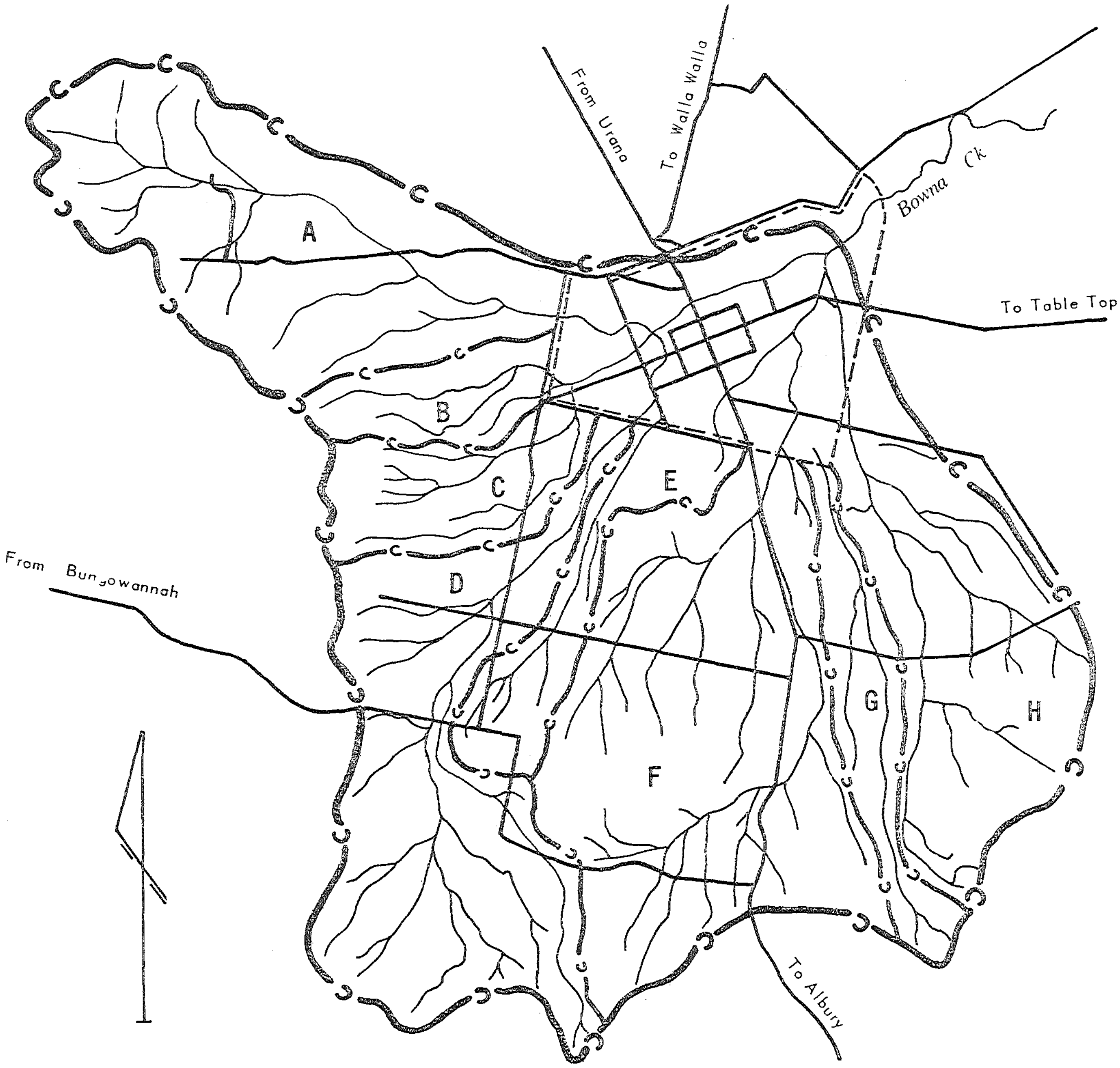


SHIRE OF HUME

VILLAGE OF JINDERA
and adjoining lands

Incorporating amendments up to 1.10.75

Appd	Date	AMENDMENTS	SCALES	GENERAL NOTES	ROAD No.	FILE No.	No. OF SHEETS	SHEET No.
			Plan	Level Datum			1	1
			Longitudinal Section	Formation Width	DESIGNED G Alexander		DRAWING No.	
			Cross Sections	Pavement Width	SURVEYED		DATE 18 9 74	
				Pavement Depth	SHIRE ENGINEER			
				Level Book No.				



Map 3

Scale 1:58,000

DRAINAGE PATTERN – JINDERA

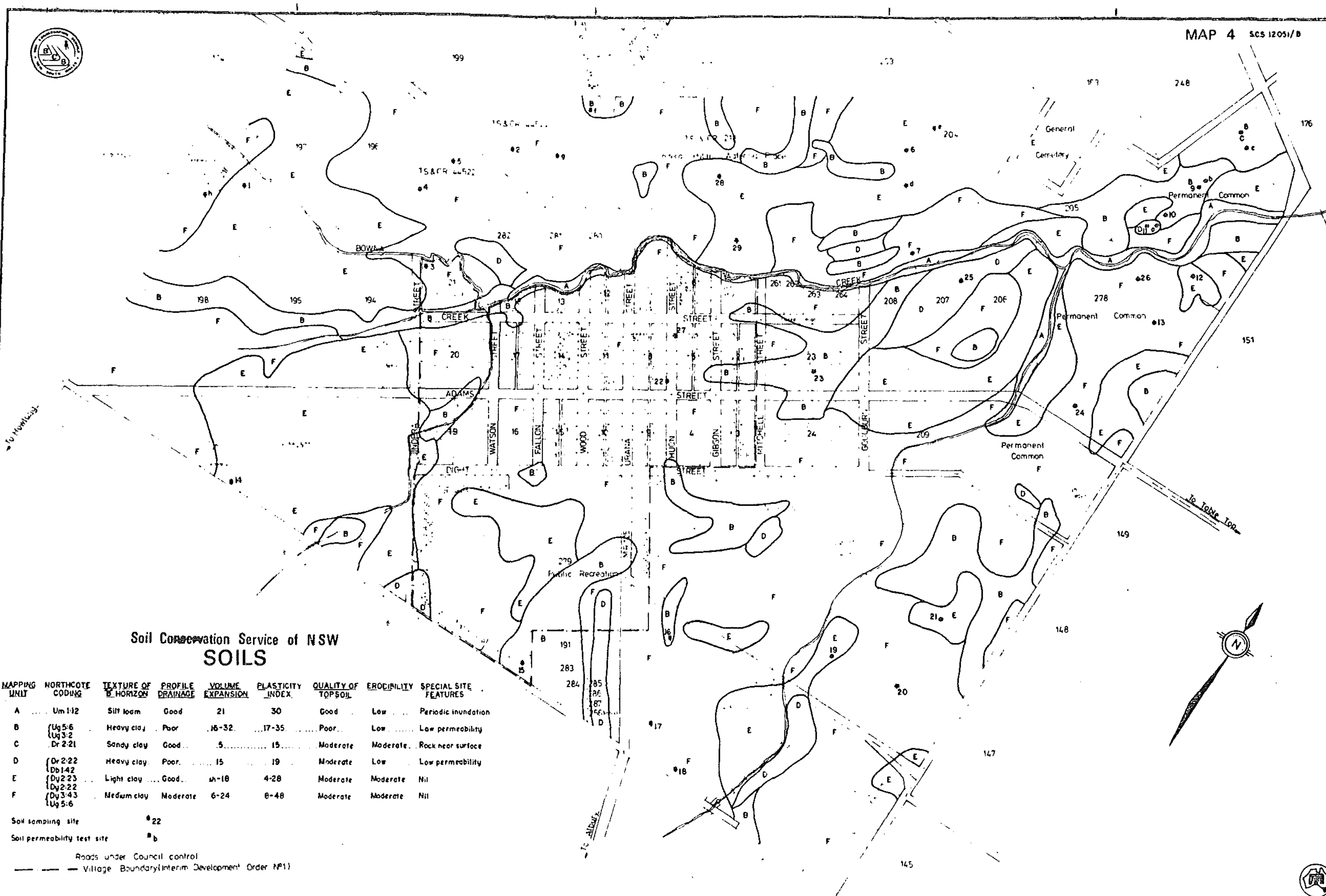
Legend

Catchment boundary ——C——
Sub–catchment boundary ——c——

EXPECTED CATCHMENT DISCHARGES – RURAL LAND USE

Catchment	Area (ha)	Q1 (m^3/sec)	Q20 (m^3/sec)	Q100 (m^3/sec)
A	881	5.49	24.79	34.10
B	161	0.99	7.37	9.88
C	322	1.68	12.81	17.23
D	863	4.08	22.60	30.90
E	302	1.90	10.41	14.28
F	1047	5.93	32.92	44.86
G	325	1.92	10.64	14.46
H	635	2.11	12.20	16.72

MAP 4 SCS 12051/B



Soil Conservation Service of NSW

SOILS

MAPPING UNIT	NORTHCOTE CODING	TEXTURE OF B HORIZON	PROFILE DRAINAGE	VOLUME EXPANSION	PLASTICITY INDEX	QUALITY OF TOPSOIL	ERODIBILITY	SPECIAL SITE FEATURES
A	Um 1·12	Silt loam	Good	21	30	Good	Low	Periodic inundation
B	Ug 5·6, Ug 3·2	Heavy clay	Poor	16-32	17-35	Poor	Low	Low permeability
C	Dr 2·21	Sandy clay	Good	5	15	Moderate	Moderate	Rock near surface
D	Dr 2·22, Db 1·42	Heavy clay	Poor	15	19	Moderate	Low	Low permeability
E	Dy 2·23, Dy 2·22	Light clay	Good	sh-18	4-28	Moderate	Moderate	Nil
F	Dy 3·43, Ug 5·6	Medium clay	Moderate	6-24	8-48	Moderate	Moderate	Nil

Soil sampling site •22

Soil permeability test site •b

Roads under Council control

Village Boundary (Interim Development Order Nº1)

Appd	Date	AMENDMENTS	SCALES	GENERAL NOTES
			Plan	Level Datum
			Longitudinal Section	Formation Width
			Cross Sections	Pavement Width
				Pavement Depth
				Level Book No

SHIRE OF HUME

VILLAGE OF JINDERA
and adjoining lands

incorporating amendments up to 1 10 7?

ROAD No.	FILE No.	No. OF SHEETS	SHEET No.
		1	1
DESIGNED	G Alexander	DRAWING No.	
SURVEYED		DATE	18 9 74
SHIRE ENGINEER			

Map 6 illustrates the soil volume expansion properties.

Soil Erodibility

Laboratory analyses have shown that many of the soils in Jindera have a moderate to high erodibility. The erosion hazard associated with urban development should not, however, be high, as most slope gradients are less than 2%. A potentially high erosion hazard will occur only along drainage lines due to the large volumes of runoff they carry. The development and improvement of these drainage lines, to reduce this erosion potential, is discussed in a later section.

Low dispersal indicies (less than 3.0) are characteristic of soils in all map units except unit A. The fine clay particles from these soils are readily dispersed in runoff water and are retained in suspension for long periods. These dispersible soils will yield highly turbid runoff during construction and degrade the quality of water entering Lake Hume. Soil conservation techniques can be applied to building sites or major earthwork construction to reduce these problems. These techniques are outlined in Appendix III.

Map 7 shows soil erodibility in Jindera.

Description of Soil Map Units.

Map Unit A - Alluvial (Um 1.12 - 3/0/20)

Alluvial soil is limited to the low terrace of the present flood plain of Bowna Creek.

The soil varies, but is generally a layered, medium textured soil, ranging from a sandy loam to a clay loam. It is of low to moderate erodibility.

Alluvial soil, due to its regular inundation, is generally unsuitable for urban development.

Map Unit B - (Ug 5.6 - 5/0/10)

Uniform, cracking, brown to grey brown clay soils occur in some of the drainage lines and in moderately extensive, although scattered, flat areas. They are also found in the centre of larger gilgais.

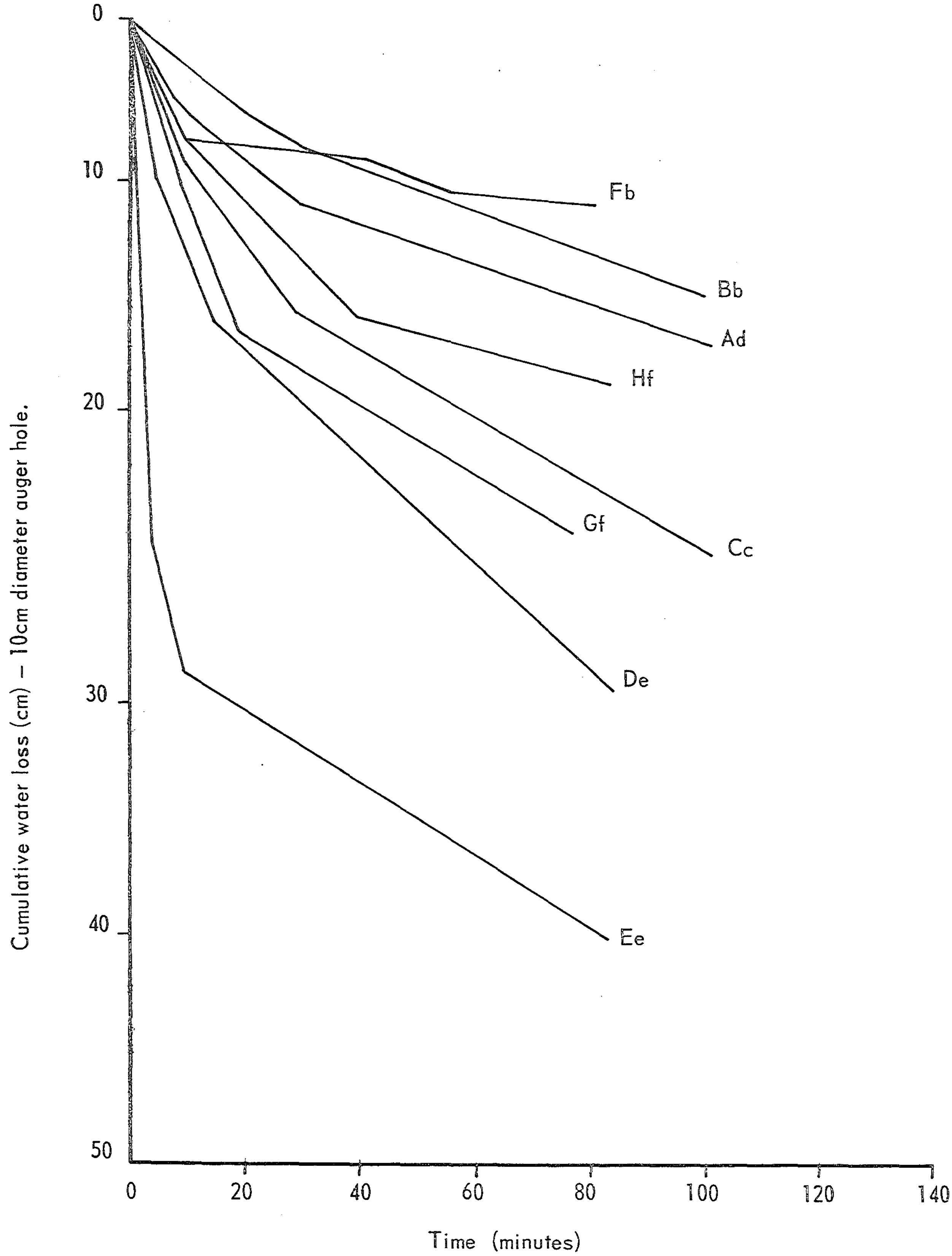


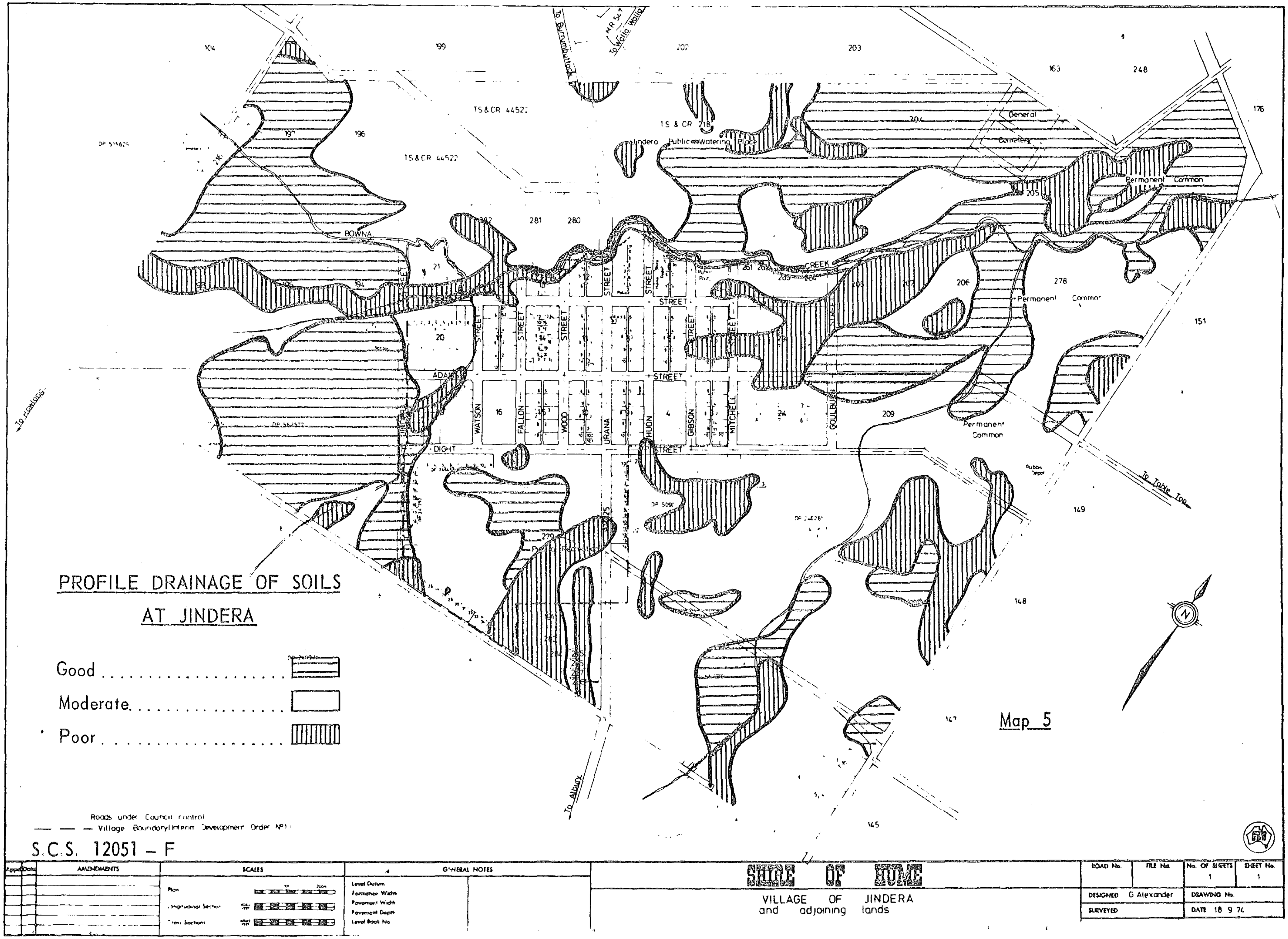
Fig. 1

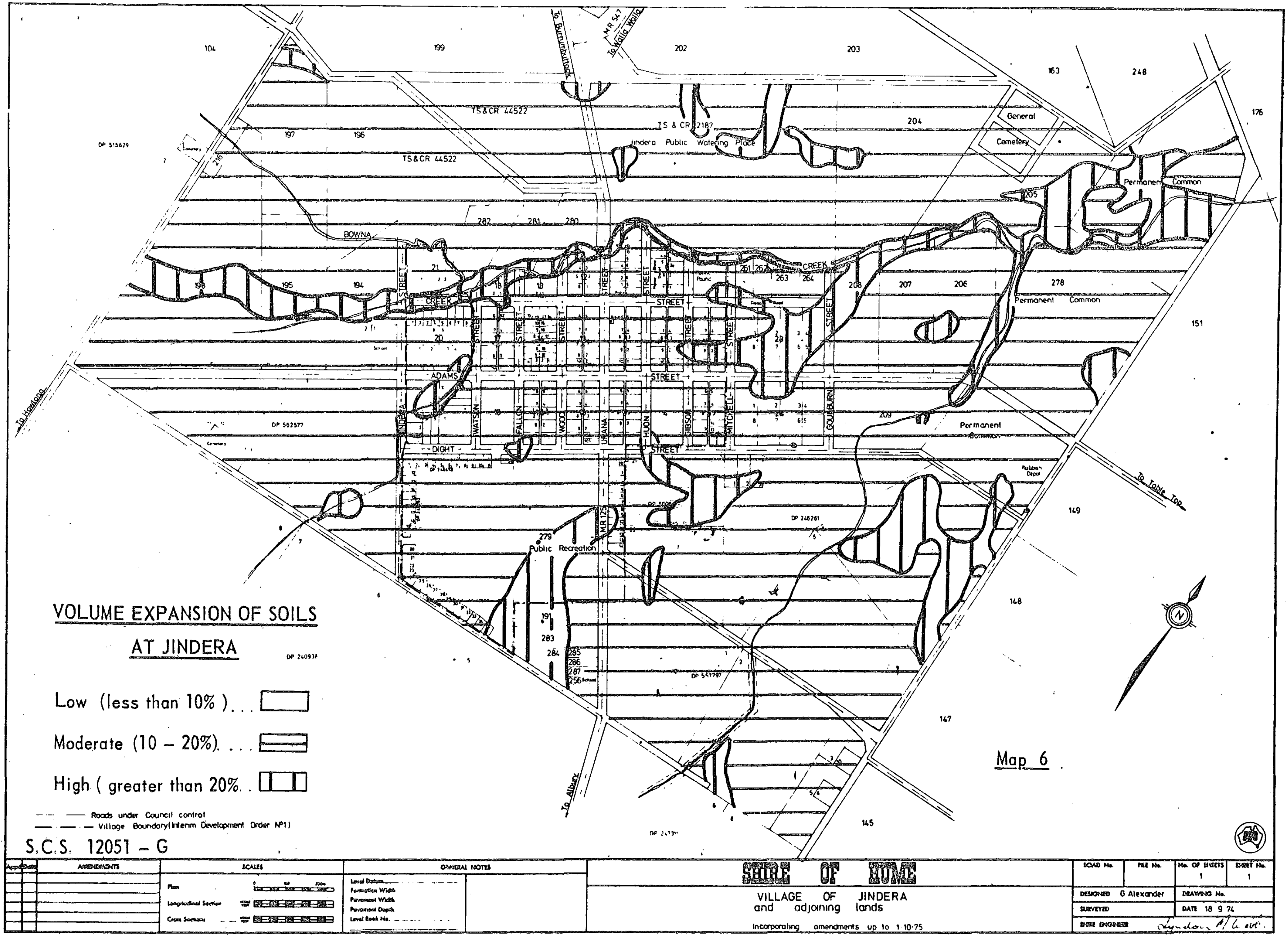
Soil Permeability Tests – Village of Jindera

A,B,C,D,E,F,G,H are the site locations where soil permeability tests were made.
Subscripts a,b,c,d,e,f represent the soil map unit on which the teste were made.

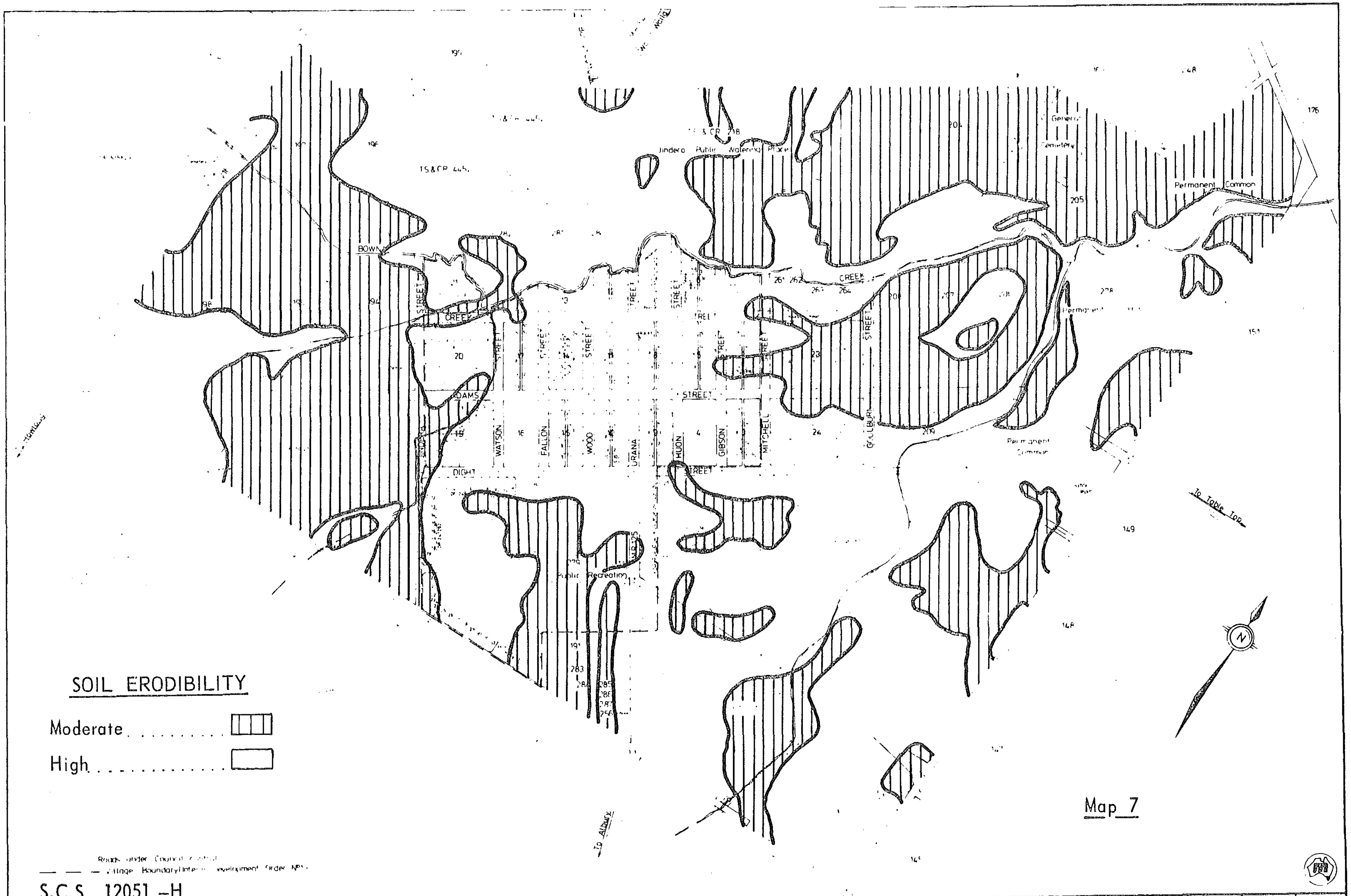
THESE RESULTS ARE COMPARATIVE ONLY.
THEY ARE NOT QUANTITATIVE MEASURES OF
THE SOILS ABILITY TO ABSORB WATER.

S.C.S. 12070


PROFILE DRAINAGE OF SOILS
AT JINDERA
Good
Moderate
Poor
Map 5
BOWNA
CREEK
STREET
WATSON
FALLON
WOOD
URANA
HUON
GIBSON
MITCHELL
GOULBURN
DIGHT
ADAMS
Permanent Common
General Cemetery
Jindera Public Watering Place
To Albury
To Table Top
To Walla Walla
To Burrumbuttock
Roads under Council control
Village Boundary/Interim Development Order No 1
S.C.S. 12051 – F
SHIRE OF HUME
VILLAGE OF JINDERA
and adjoining lands
DESIGNED G Alexander
DATE 18 9 74



VOLUME EXPANSION OF SOILS
AT JINDERA
Low (less than 10%)...
Moderate (10 – 20%)...
High (greater than 20%..
Roads under Council control
Village Boundary(Interim Development Order Nº1)
S.C.S. 12051 – G
Map 6
SHIRE OF HUME
VILLAGE OF JINDERA
and adjoining lands
Incorporating amendments up to 1·10·75
DESIGNED G Alexander
DATE 18 9 74
No. OF SHEETS 1
SHEET No. 1
AMENDMENTS
SCALES
GENERAL NOTES
Plan
Longitudinal Section
Cross Sections
Level Datum
Formation Width
Pavement Width
Pavement Depth
Level Book No.
ROAD No.
FILE No.
DRAWING No.
SURVEYED
SHIRE ENGINEER
To Burrumbuttock
To Walla Walla
M.R. 547
To Howlong
To Table Top
To Albury
TS&CR 44522
TS & CR 2187
Jindera Public Watering Place
General
Cemetery
Permanent Common
Public Recreation
BOWNA
CREEK
STREET
ADAMS
DIGHT
JINDERA
WATSON
FALLON
WOOD
URANA
HUON
GIBSON
MITCHELL
GOULBURN
M.R. 125
Rubbish Depot
DP 515629
DP 562577
DP 246281
DP 557797
DP 240938



SHIRE OF HUME

VILLAGE OF JINDERA and adjoining lands

DESIGNED	G. Alexander	DRAWING No
SURVEYED		DATE 18 9 74
SHIRE ENGINEER		

ROAD No	FILE No	No OF SHEETS	SHEET No
		1	1

This soil has a shallow A horizon of silty clay which is tough, poorly structured and relatively impermeable. It may or may not overlie a thin, sporadically bleached A_2 horizon. The B horizon is invariably a heavy, very strongly structured, olive brown clay.

This soil may be found in other map units and is readily recognised by its shallow A horizon (15cm) and heavy, tough, olive-brown clay B horizon.

Severe urban development constraints are imposed by the moderate to high plasticity, moderate to high shrink swell potential and poor permeability of the soil. For example, special foundation design may be required for buildings and roads, there is a risk of service pipe breakage due to soil movement, and septic absorption fields may be unsuccessful.

Map Unit C - (Dr 2.21 - 2/1/20)

This unit occurs only on the granitic ridge in the north east corner of the area.

It is a shallow, red, duplex soil with a well developed A_2 horizon. It is characterised by a sandy loam, relatively porous A_1 horizon overlying a dispersible sandy clay, non-bleached A_2 horizon. The A horizons are clearly separated from a red, well structured, sandy clay B horizon. This soil is often less than 50 cm deep and is acid throughout.

Rock outcrops and the shallow profile depth are constraints to urban development on this unit.

Map Unit D - (Dr 2.22 - 3/3/10)

The soil in this map unit is a deep duplex type with a red-brown B horizon. It occurs on low ridges adjacent to the heavy soils described in map unit B. It consists of a shallow, brown A_1 horizon and may or may not have a moderately deep, bleached A_2. The B horizon is a tough, red-brown, whole coloured heavy clay of moderate plasticity, moderate shrink/swell potential and low permeability.

The constraint to urban development in this unit results from low soil permeability which may make the area unsuitable for septic absorption fields.

Map Unit E (Dy 2.23 - 3/1/25)

This unit contains the best soil for urban development in Jindera. The predominant soil is well drained, with low to moderate plasticity, very low to moderate shrink/swell potential, and the highest permeability in the area.

It occurs primarily in the west and north, with minor occurrences elsewhere.

It consists of a loam A horizon overlying a non-bleached, relatively shallow A_2 horizon. There is a gradual to clear boundary to a yellow, light clay with an earthy or rough ped fabric. pH of the B horizon varies from 7 to 8.5. Soil erodibility is low to moderate.

Small areas of soils from other units occur in this unit as mapped and these constitute the only soil constraint to urban development.

Map Unit F (Dy 3.43 - 3/0/60)

This is the most variable unit in terms of soil types. It includes several small areas of soil from all other units in a matrix of duplex yellow soil, with red, dull yellow or grey mottles in the B horizon, and a very deep (50 cm) A_2 horizon.

The typical soil, which occupies about 40 percent of the unit, consists of a relatively deep loam A_1 horizon overlying a deep, bleached, A_2 horizon containing manganese nodules. This lies abruptly on a medium clay, predominantly yellow, B horizon, which contains red, dull yellow or grey mottles in various combinations. The depth of the A_2 horizon and the colour of the mottles often varies considerably between sites only a few metres apart.

Constraints to urban development vary with the soil type from none on soils similar to unit E to severe where soils of unit B occur.

TABLE I SUMMARY OF SOIL PROPERTIES - MAJOR SOILS - VILLAGE OF JINDERA

	A	B		C	
Northcote and S.C.S. coding ⊕	Um 1.12 - 3/0/20	Ug 5.6 - 5/0/10		Dr 2.21 - 2/1/20	
Underlying Material	Silt clay	Clay		Granite	
Depth to Bedrock				about 50 cm	
Profile Drainage	Moderate	Poor		Good	
Texture of B horizon	Silt Loam	Heavy clay		Sandy clay	
Horizon (No of samples)	B (1)	A_2 (2)	B (5)	A_2 (1)	B (1)
Liquid Limit	57	NL	36-63	27	56
Plastic Limit	27	NP	18-28	22	31
Plasticity Index	30	NP	17-35	5	25
U.S.C.S. Code	CH	ML	CL-CH	ML	ML
Volume Expansion	21	1	16-32	2	5
Dispersal Index	4.1	2-2.3	1.5-5.0	2.3	5.0
Emerson Class	2	2	2-3	7 or 8	3
Erodibility	High	Mod-High	Low-Mod	Mod	Low
Suitability for Ponds	Poor	Good		Poor	
Topsoil Quality	Good	Poor		Moderate	
Ease of Revegetation	Good	Poor		Moderate	
Special Features	Periodic inundation	Low permeability		Rock near surface	

N.L. Not liquid

N.P. Non plastic

TABLE I (cont'd)

	D		E		F	
Northcote and S.C.S. coding ⊕	Dr 2.22 - 3/3/10		Dy 2.23 - 3/1/25		Dy 3.43 - 3/0/60	
Underlying Material	Clay		Clay		Clay	
Depth to Bedrock						
Profile Drainage	Poor		Good		Moderate	
Texture of B horizon	Heavy clay		Light clay		Medium clay	
Horizon (No of samples)	A_2 (1)	B (1)	A_2 (5)	B (7)	A_2 (9)	B (13)
Liquid Limit	NL	38	NL	23-56	NL	22-77
Plastic Limit	NP	19	NP	18-27	NP	14-29
Plasticity Index	NP	19	NP	4-28	NP	8-48
U.S.C.S. Code	ML	CL	ML	CL	ML	CL,ML,CH
Volume Expansion	Sh	15	Sh-5	Sh-18	Sh-3	6-24
Dispersal Index	1.4	3.8	1.5-3	1.4-14.5	1.8-40	1.0-10.0
Emerson Class	3	3	1,2,3	1,2,3	1,2,3	1,2,3
Erodibility	-	High	Low-Mod	High	Low-High	Low-High
Suitability for Ponds	Good		Good		Good	
Topsoil Quality	Moderate		Moderate		Variable	
Ease of Revegetation	Poor		Moderate		Variable	
Special Features	Low Permeability				Variable	

⊕ See Appendix I - Glossary of Terms

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 a number of classes according to landscape stability and the assessed potential for urban development.

Four major classes of erosion/instability hazard are defined on the urban capability map:

Class A - low
Class B - moderate
Class C - high
Class D - very high

Within these classes a number of sub-classes are defined relating to the dominant physical features which restrict development potential. Numbers used to define these restricting features are:

0 - no major constraint
1 - slope
2 - drainage/flooding
3 - soil characteristic
6 - seasonal high water table

The combination of two numerals indicates two physical features which interact to restrict development.

The physical constraints to development for each sub-class are also itemised in the legend of the urban capability map.

The capability suggested 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. Development which is planned to minimise erosion hazard is, however, generally consistent with an aesthetically pleasing landscape and savings in 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 shopping malls, industrial centres, or other structures which require large scale clearing and levelling for broad areas of floor space and for parking bays. Residential development infers a level of construction which provides roads, drainage and services to cater for 600 square metre housing blocks. 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 extensive building complexes does not exempt developers from normal site analysis procedures in designing and engineering road alignments and buildings. Nor does it imply the capacity of the site to support multistory units or other major structures. Before structural works of this magnitude are undertaken, a detailed analysis of such engineering characteristics of the soil as bearing capacity and shear strength may be necessary on the specific development site.

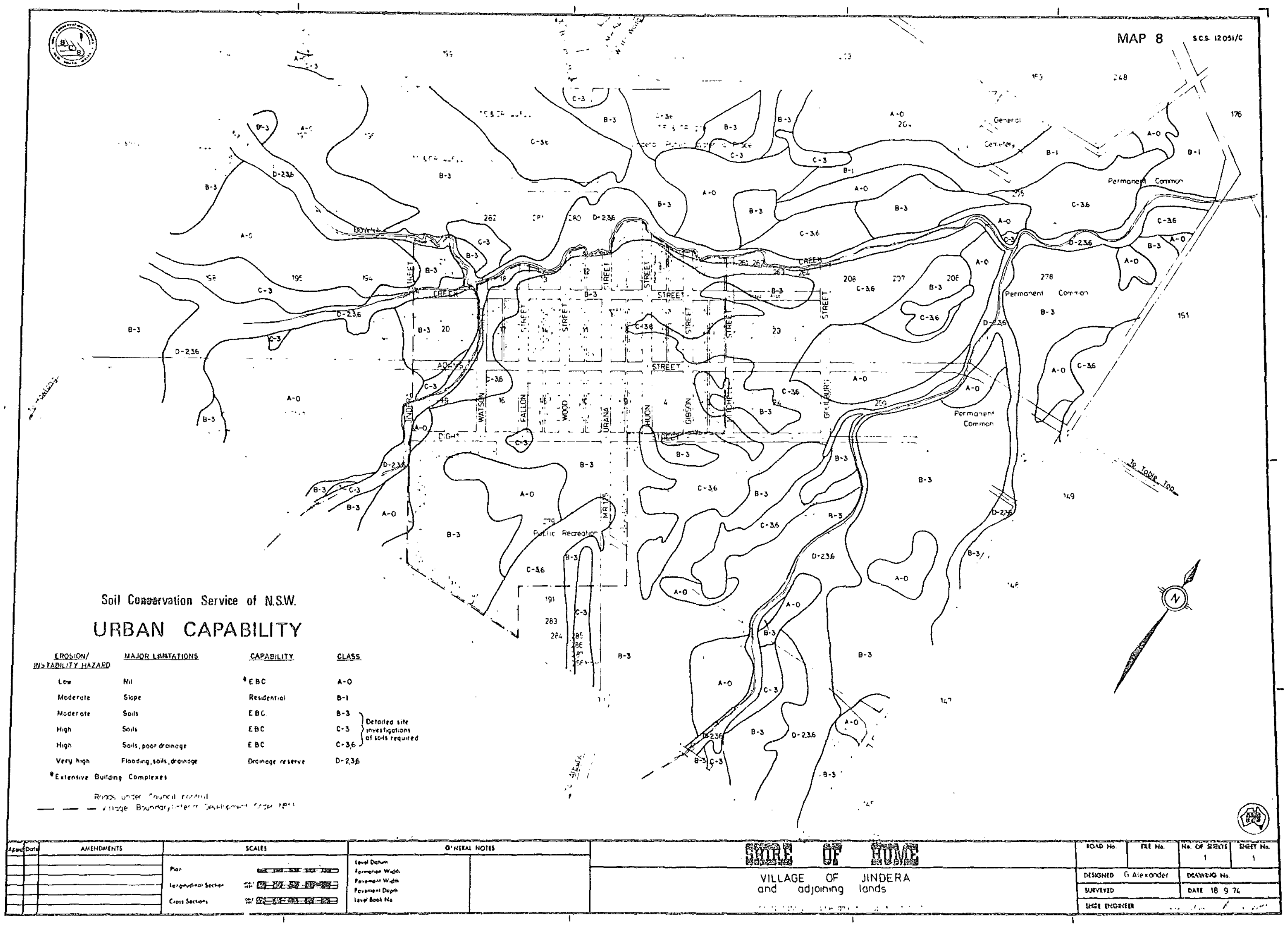
In Appendix III guidelines for stabilisation and revegetation are provided. Specific advice relating to these techniques (such aspects as seed and fertilizer mixtures and rates, cultivation measures, and batter slopes) should be sought from the Albury Soil Conservation office when subdivision work begins.

Sub-Class A-0 : Low hazard - No major constraints - Suitable for extensive building complexes.

This sub-class contains broad areas of level to gently undulating land principally west of Urana Street.

The sub-class boundary is determined by the soil map unit E. These soils are well drained, with a low to moderate plasticity, low to moderate shrink/swell potential and the highest soil permeability in the area. Soil erodibility is high but due to the low slope gradients the soil erosion hazard should not seriously restrict development. However, it is essential that excavation batters be kept below a 1:3 gradient and that all disturbed areas be revegetated quickly.

Land in this sub-class is suitable for extensive shopping or educational complexes, as well as residential subdivision or sporting facilities. Where development occurs, particular attention should be paid to items (a), (c), (d), (h) and (n) of the general guidelines in Appendix III. See SCS 12051/C and "Jindera_Hume_UrbanCap.pdf ".



MAP 8
S.C.S. 12051/C
Soil Conservation Service of N.S.W.
URBAN CAPABILITY
EROSION/ INSTABILITY HAZARD
MAJOR LIMITATIONS
CAPABILITY
CLASS
Low
Nil
*EBC
A-0
Moderate
Slope
Residential
B-1
Moderate
Soils
EBC
B-3
High
Soils
EBC
C-3
High
Soils, poor drainage
EBC
C-3,6
Detailed site investigations of soils required
Very high
Flooding, soils, drainage
Drainage reserve
D-2,3,6
*Extensive Building Complexes
Roads under Council control
Village Boundary
General Cemetery
Permanent Common
Public Recreation
To Table Top
WATSON
FALLON
WOOD
URANA
HUON
GIBSON
GOULBURN
STREET
CREEK
AMENDMENTS
SCALES
GENERAL NOTES
Plan
Longitudinal Section
Cross Sections
Level Datum
Formation Width
Pavement Width
Pavement Depth
Level Book No.
SHIRE OF HUME
VILLAGE OF JINDERA
and adjoining lands
ROAD No.
FILE No.
No. OF SHEETS
1
SHEET No.
1
DESIGNED G. Alexander
DRAWING No.
SURVEYED
DATE 18 9 74
SHIRE ENGINEER

Sub-Class B-1 : Moderate hazard - Slope constraint - Suitable for residential development.

A small area in the north-eastern section of the Village has been included in this sub-class. Slope gradients range from 5% to 15%. The dominant soil is of map unit E associated with the granitic soil of map unit C. Soil erodibility ranges from moderate to high.

The development of commercial, industrial or educational complexes requiring large scale site levelling operations is not recommended. Erosion and siltation can be expected following cut and fill operations on the steeper slopes. If, however, such development is undertaken, the erosion hazard should be minimised by adhering closely to items (a), (b), (c), (d), (e), (f), (h), (i), (j), (l) and (n) contained in the general guidelines in Appendix III.

These lands are suited to residential development without a severe erosion hazard being generated provided the general guidelines are followed.

The development of active recreation areas such as sporting ovals is not recommended, due to the erosion hazard associated with the large scale cut and fill that would be required to provide a level site. Alternate sites should be considered on land classes A-O and B-3.

Sub-Class B-3 : Moderate hazard - Soils constraint - Suitable for extensive building complexes: detailed site investigations required.

Sub-class B-3 is the major land class in Jindera. It contains sideslopes and footslopes with gradients up to 2%.

The soils are as described for map unit F. The main limitation to urban development on this soil is imposed by the deep A_2 horizon (50 cm) which is dispersible and unstable. Profile drainage is moderate but small areas occur which are unsuitable for septic effluent disposal - particularly on the footslopes.

Soil tests have shown that some highly plastic soils occur and it is recommended that where major road or building construction is planned additional soil investigations be undertaken to define these accurately and determine appropriate foundation design.

This land class is suited to the construction of extensive building complexes and active recreation facilities such as sports ovals. Soil tests for foundation design for major development proposals are desirable. In addition, attention to items (a), (c), (d), (g) (n) and (m) of the general guidelines is essential to minimise erosion hazard and pollution by turbid runoff from construction sites.

Residential development should cause few problems. However, where on-site septic absorption fields are proposed, individual site testing of soil permeability should be done.

Sub-Class C-3 : High hazard - Volume expansion and plastic soils constraints - Suitable for extensive building complexes : detailed soil investigations are essential

This sub-class occurs in isolated areas, principally on footslopes with gradients ranging from level to 2%.

The dominant soil, of map unit B, is the major constraint to development. It has a moderate to high plasticity, moderate to high shrink/swell potential and poor permeability. Soils of map unit D with similar properties also occur in this sub-class.

This land could support extensive building or residential development. Where major development is proposed, detailed soil investigations are essential.

Septic absorption systems are not recommended.

Sporting ovals are not recommended due to the poor physical properties of the soil. A high development and maintenance cost would be required to achieve a satisfactory playing surface. This land would be suitable for passive recreation.

Sub-Class C-3.6 : High hazard - Volume expansion, plastic soils and drainage constraints - Suitable for extensive building complexes : detailed soil investigation essential.

This sub-class is located on drainage plains having extensive level areas, with some slopes up to 2% gradient. Soils include those of soil map units F, D and B.

Figure 2. Sub-class A-0 land is suitable for maximum site development.

Figure 3. Sub-class B-3 land is level to undulating but soil type imposes a constraint to building activity, requiring special attention to road and building foundations to ensure their stability.

Figure 4. Sub-class C-3,6 contains poorly drained, heavy clay soils that become waterlogged during winter. Development will require improvement to surface and subsurface drainage and additional soil testing to design building and road foundations. The soil is unsuitable for absorption of septic effluent.

Figure 5. Sub-class D-2,3,6 includes the major drainage lines in Jindera. The encroachment of urban development onto this land must be avoided to reduce flood risk.

Poor surface drainage is an additional constraint to urban development. The land is subject to seasonal waterlogging and periodic overland flow. Surface water may be present for several months.

Specific site investigations for building and road pavement foundation design are essential. Any land filling should be such that free drainage is not impaired. Efficient site drainage will be necessary.

The poor surface drainage and heavy soil texture preclude the use of on-site septic effluent absorption systems.

This land is capable of supporting extensive building complexes but requires specific attention to the soil and drainage constraints. Installation of co-ordinated drainage facilities is desirable prior to development.

Development of active recreation areas is not recommended. Development of passive recreation areas will not present site stability problems.

During development attention should be given to items (a), (c), (g), (h), (j) and (n) of the general guidelines in Appendix III.

Sub-Class D-2,3,6 : Very high hazard - Flooding/soil/poor drainage constraints - Suitable for drainage reserves.

This sub-class includes the major drainage lines which flow through Jindera. Most are well defined watercourses, but some include areas of overland flow where runoff is concentrated during storm events.

Slope gradients of the stream channels are less than 2%. Sideslopes vary from gradual to vertical where active erosion is occurring.

Soils from most soil map units occur in this sub-class. The alluvial soils of map unit A are extensive in the main drainage lines. They are highly erodible and plastic.

It is recommended that building development be prevented due to the very high erosion and site instability hazard and flood liability.

To reduce the impact of urbanisation on flooding and creek bank erosion downstream, it is recommended that the drainage lines

Figure 6. Drainage channels have been formed by the diversion of runoff along roads. These have eroded to become the major drainage lines. They require shaping and development as reserves.

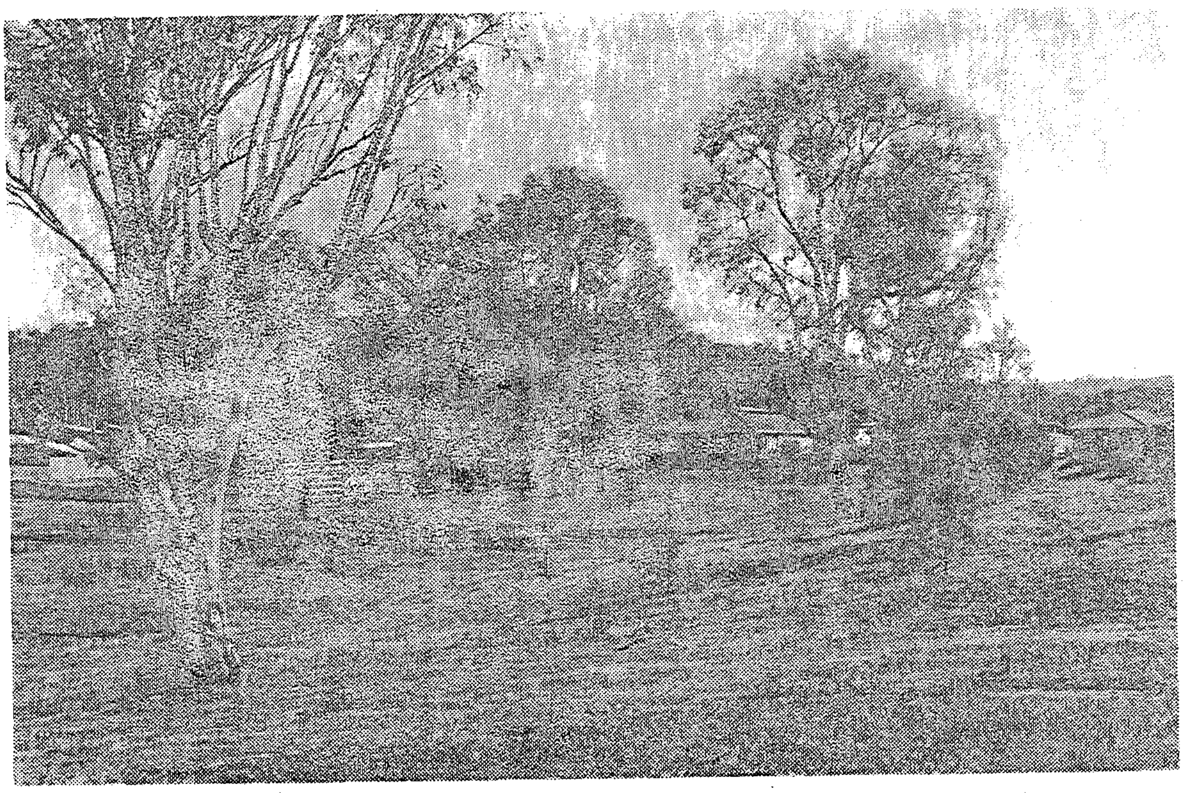


Figure 7. The combination of an underground pipe and grassed waterway is an efficient method of storm water disposal in an urban area. It also provides land for recreation.

and associated drainage plains and floodplains be developed as grassed waterway reserves.

Vegetated channels - by comparison with concrete channels - carry runoff at a low velocity. Retention of meander in natural channels, where practical, also delays flow concentration. These two features, by providing simple runoff detention, reduce discharge peaks.

Vegetated channels are cheaper to install and provide green belts which are an attractive break in the continuity of subdivision roads and buildings. They may also be used as bikeways and footpaths. The vegetation will also trap some silt, while the low velocity of flow will be conducive to precipitation of silt from turbid runoff.

Development of Grassed Drainage Reserves

The conversion of existing natural channels to drainage reserves will involve a certain amount of shaping, followed by the establishment of stabilising vegetation.

To assist the design of these grassed drainage reserves, the expected discharges for various frequencies for existing rural land use are given in Table II. These discharges were calculated using the synthetic unit hydrograph method of Cordery and Webb (1974). Rainfall records from the Hume Reservoir (Snowy Mountains Engineering Corporation, 1976) were used to develop the hydrographs.

The calculations show that high peak discharges from catchments above the Village can be expected for the extreme storm events. Serious flooding will occur in the Village unless adequate drainage reserves are provided when planning urban areas.

The discharge frequencies were selected as a basis for planning a drainage system. This system, which consists of underground pipes and overland channels (Figure 8), is recommended to alleviate flooding. It would also be considerably cheaper than conventional systems and would cause minimal environmental damage.

Proposed Drainage System

. Pipe System

The underground pipe system should be designed to accept the expected 1 year peak discharge. The pipes will also handle persistent trickle inflows which would otherwise damage vegetation in the channels causing erosion.

TABLE II

EXPECTED CATCHMENT DISCHARGES - RURAL LAND USE - JINDERA.

CATCHMENT	AREA -ha	100 Yr.				20 Yr.				1 Yr.			
		Q100 m^3/sec	Runoff Volume m^3x10^3	Storm Duration hrs.	Time at peak hrs.	Q20 m^3/sec	Runoff Volume m^3x10^3	Storm Duration hrs.	Time at peak hrs.	Q1 m^3/sec	Runoff Volume m^3x10^3	Storm Duration hrs.	Time at peak hrs.
A	881	34.1	467.8	3	3.5	24.8	336.5	3	3.5	5.5	59.9	6	4.5
B	161	9.9	85.5	3	2.0	7.4	58.6	2	2.25	1.00	7.6	3	2.5
C	322	17.2	171.0	3	2.25	12.8	117.2	2	2.5	1.7	15.1	3	1.5
D	863	30.9	458.2	3	3.5	22.6	329.7	3	3.5	4.1	58.7	6	4.5
E	302	14.3	160.3	3	3.0	10.4	115.4	3	3.0	1.9	10.5	6	4.0
F	1047	44.8	555.9	3	3.0	32.9	381.1	2	3.0	5.9	71.2	6	4.0
G	325	14.5	172.6	3	3.0	10.6	124.2	3	3.0	1.9	22.1	6	3.5
H	635	16.7	337.2	3	3.0	12.2	242.6	3	3.0	2.1	43.2	6	4.5

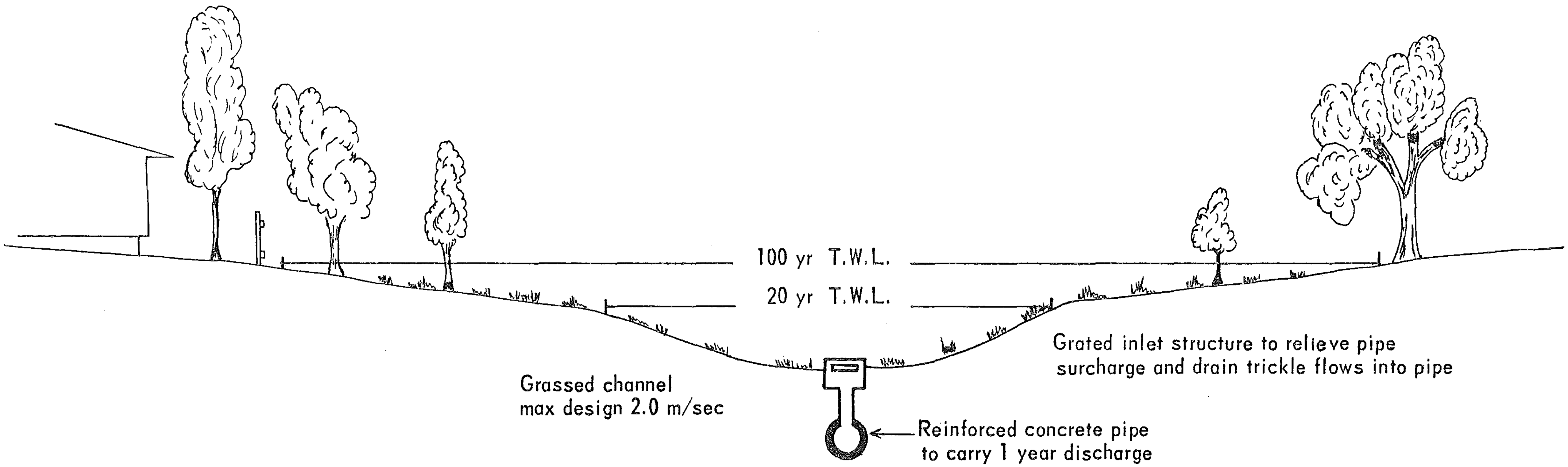


Fig 8 DIAGRAM SHOWING THE PIPE AND OVERLAND CHANNEL DRAINAGE SYSTEM – GRASSED DRAINAGE RESERVES

S.C.S 12069

. Overland Channel System

The capacity of the overland channels should be determined from the 20 year frequency discharge. They should be constructed with a parabolic cross section with batter gradients no steeper than 1:5. They must be vegetated, and maximum flow velocity of 2.0 m/sec should not be exceeded for the lowest retardance condition expected. If high vegetal retardance conditions are experienced, (e.g., in unmown channels) extra capacity will be required.

The overland channel system is designed to handle flows in excess of the capacity of the pipe system. The two systems are therefore interconnected by a series of combined inlet - outlet structures spaced where required. Thus, when discharge exceeds the pipe system's capacity the surcharge can outlet into the overland channel. When pipe surcharge decreases reverse flow from the channel back into the pipe will occur.

The overland channels should be mown to maintain a good stand of vegetation.

. Flood area

For extreme flood events, the 100 year discharge should be used to determine the flood width required for land in class D-2,3,6. Building should not be allowed in these areas and the channel should not be restricted by filling. They are best suited to passive recreation or for use as reserves.

Advantages of the proposed system

1. The pipe and channel system is considerably cheaper than a conventional trunk drainage system where major flows are piped underground.

2. The overland channels and floodplain will provide an aesthetically pleasing environment in the urban area. The vegetated channels provide additional flow retardance, and their cross-sections are safer for children should they be caught in the channel during a storm.

3. Maintenance costs of undeveloped channels downstream will be reduced due to better control over discharge from the system.

4. Increased channel losses of runoff in the system will reduce runoff volume and provide additional groundwater recharge.

The total effect will be to provide a storm drainage system that is stable and environmentally acceptable while still retaining hydraulic effectiveness.

Storm Water Management

The large external catchments that contribute runoff into Jindera will impose a significant constraint to land use and make detailed planning of drainage reserves an integral part of the development requirements of the Village. Changes to rural land use in the catchment will increase the frequency and level of storm runoff.

It is recommended that a storm water management policy be implemented where future subdivisions or substantial developments are proposed in the catchment areas.

The concept of storm water management has been developed in the U.S.A. in the State of Maryland (Nagel, 1975). This requires that development does not increase the 2 year and 10 year flood discharges over the pre-urban level. The expected discharges from the 2 year and 10 year flood frequency events for the major catchments that enter Jindera are presented in Table III.

TABLE III

EXPECTED DISCHARGES FOR STORM WATER MANAGEMENT FREQUENCIES - JINDERA.

CATCHMENT	AREA ha	FREQUENCY Q 2 m^3/sec	Q 10 m^3/sec
A	881	13.3	22.6
B	161	3.6	6.2
C	322	5.9	10.9
D	863	9.8	19.2
E	302	4.8	8.9
F	1047	16.7	28.9
G	325	4.9	9.1
H	635	5.2	10.2

The 2 year flood discharge is recognised as the landscaping discharge for most natural channels. That is, streams will adjust their natural channels to accommodate this discharge. Thus in Maryland, if the 2 year discharge is maintained after development, the natural channel will be preserved.

The 10 year flood discharge is the normal design frequency for minor storm drainage systems in Maryland. To minimise flooding of downstream occupiers resulting from more intensive upstream development, the 10 year discharge is also restricted to the pre-development level.

Storm runoff control is achieved in Maryland using retarding basins. These can be provided for rural subdivision, intensive agricultural development, or complete housing developments. The retarding basins are constructed as an integral part of each land development or building complex.

Retarding basins can be of many forms, but they must all have provision for flood storage, a controlled outlet and an emergency spillway. During construction the basin can also serve as a sediment trap, so preserving channel capacity and reducing channel maintenance costs.

These principles will mitigate future flooding of lower areas, preserve the environment of the natural channels and maintain an aesthetically pleasing landscape.

The Soil Conservation Service could assist Council with further investigations into the concept of storm water management. This would assist preparation of guidelines for land use in the catchments above Jindera.

ACKNOWLEDGEMENT.

The Authors wish to acknowledge the assistance given by Mr. A. G. Welch, Soil Conservationist, Albury, for the preparation of the drainage pattern and subcatchment area map for this report.

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APPENDIX I LABORATORY ANALYSES OF SOILS - JINDERA

SITE	DEPTH (cm)	MAP UNIT	PARTICLE SIZE ANALYSES (g/100 g Soil) STONE	GRAVEL	COARSE SAND	FINE SAND	SILT	CLAY	ATTERBERG LIMITS ($g\ H_2O/100\ g$ Soil) PLASTIC LIMIT	PLASTICITY INDEX	U.S.C.S.	VOLUME EXPANSION (g/100g Soil)	LINEAR SHRINKAGE (%)	D.I.	E.C.T.
1	20-40		0	5	8	44	28	15	NL	NP	ML	Sh	2	2.8	2
	60-80		4	22	5	29	9	32	18	23	CL	Sh	12	1.4	1
	80-120	E	19	39	3	15	4	21	22	27	CL	Sh	15	1.2	1
	120-160		5	17	4	28	8	38	21	38	CL	Sh	13	1.1	1
2	2-35		0	4	8	55	21	13	NL	NP	ML	3	1	4.0	3
	35-45	F	0	6	12	43	15	24	14	8	CL-ML	11	5	4.7	3
	45-100		0	16	5	32	11	36	21	21	CL	15	14	11.5	2
3	5-40		0	3	6	50	27	13	18	1	ML	Sh	1	2.7	3
	40-70		0	11	6	38	16	30	17	22	CL	14	13	3.0	3
	70-90	F	5	40	4	16	6	29	23	36	CH	25	17	2.7	3
	90-120		6	11	6	27	11	39	20	28	CL	21	15	1.3	1
4	20-50		2	2	17	59	15	6	Nil	NP	ML	Sh	0	1.3	2
	50-80	F	5	21	7	24	4	39	20	22	CL	9	14	2.2	1
	80-120		1	12	10	30	5	43	22	45	CH	21	18	2.8	2
5A	0-30		1	3	15	49	21	11	Nil	NP	ML	2	2	3.5	7 or
	30-50	F	12	21	8	32	15	10	Nil	NP	ML	Sh	0	2.5	3
	50-100		6	21	2	23	6	43	29	48	CM	19	19	2.0	2
5B	45-85		1	15	9	32	10	33	25	8	ML	16	10	10.0	2
	85-120	F	10	25	3	22	4	36	27	25	CH	27	15	4.8	2
6	10-25		0	2	9	55	21	13	Nil	NP	ML	5	2	3.0	7 or
	25-100	B	0	4	5	29	8	55	28	16	ML	18	14	14.5	2
7	15-40		0	4	5	55	22	13	Nil	NP	ML	2	1	2.3	3
	40-60		0	6	3	45	13	33	18	13	CL	19	11	3.8	3
	60-120		3	7	9	47	9	25	17	11	CL	13	9	3.5	2

APPENDIX I (cont'd)

SITE	DEPTH (cm)	MAP UNIT	PARTICLE SIZE ANALYSES (g/100 g Soil): STONE	GRAVEL	COARSE SAND	FINE SAND	SILT	CLAY	ATTERBERG LIMITS ($g\ H_2O/100\ g$ Soil): PLASTIC LIMIT	PLASTICITY INDEX	U.S.C.S.	VOLUME EXPANSION. (g/100g Soil)	LINEAR SHRINKAGE (%)	D.I.	E.C.T.
8	5-20		4	35	35	11	5	11	22	5	ML	2	5	2.3	7 or 8
	20-50	C	4	29	22	10	10	24	31	15	ML	5	11	5.0	3
	50-100		3	29	22	14	15	19	36	9	ML	15	11	3.8	1
9	20-40		0	2	3	62	21	12	Nil	NP	ML	1	1	2.0	7 or 8
	40-100	B	0	6	1	42	15	37	18	17	CL	20	13	5.0	2
10	15-25		0	5	4	52	24	15	Nil	NP	ML	1	1	2.3	2
	25-100	B	0	6	1	16	20	57	25	35	CH	16	16	1.5	2
11	25-90	D	0	16	0	21	15	47	27	30	CH	21	18	4.1	2
12	10-60		0	1	10	55	21	12	Nil	NP	ML	Sh	1	1.5	3
	60-90	C	0	2	3	49	17	29	18	11	CL	9	8	5.3	3
	90-100		4	21	1	36	12	26	19	14	CL	14	11	3.6	3
13	10-35		0	5	19	49	15	13	Nil	NP	ML	Sh	1	1.8	2
	50-100	F	4	8	7	28	12	41	19	38	CH	11	17	1.0	1
14	15-40		4	26	11	37	13	8	Nil	NP	ML	Sh	1	2.3	3
	40-120	E	1	22	3	20	8	47	27	28	CH	10	17	3.1	2
15	30-120	B	0	20	3	12	16	50	27	33	CH	23	18	2.0	3
16	40-80		0	11	2	23	14	50	24	22	CL	18	15	3.4	3
	80-100	B	0	19	9	23	21	29	18	15	CL	15	12	3.0	2
	100-120		0	3	1	36	25	36	20	17	CL	6	12	2.1	2
17	40-60		0	5	9	53	17	17	Nil	NP	ML	Sh	1	2.0	3
	60-120	F	0	12	4	16	26	41	21	25	CL	6	13	2.2	2

APPENDIX I (cont'd)

SITE	DEPTH (cm)	MAP UNIT	PARTICLE SIZE ANALYSES (g/100 g Soil) STONES	GRAVEL	COARSE SAND	FINE SAND	SILT	CLAY	ATTERBERG LIMITS ($g\ H_2O/100\ g$ Soil) PLASTIC LIMIT	PLASTICITY INDEX	U.S.C.S.	VOLUME EXPANSION-ION. (g/100g Soil)	SHRINK-AGE (%)	D.I.	E.C.T.
18	40-85		0	20	9	28	8	34	19	19	CL	21	11	2.8	2
	85-120	F	0	2	4	21	23	50	23	19	CL	9	11	1.6	2
19	25-40		0	4	7	40	11	38	19	13	CL	14	10	5.5	2
	40-50		11	37	6	19	5	22	20	20	CL	17	13	7.0	3
	50-90	E	3	22	4	30	4	37	23	32	CH	24	12	2.5	2
	90-120		7	20	3	27	3	40	23	32	CH	29	14	1.7	1
20	20-120	F	4	9	3	28	7	50	25	37	CH	16	15	1.1	1
21	40-60		4	20	12	40	7	18	19	4	ML	2	5	6.0	2
	60-100	E	0	18	7	35	5	35	21	19	CL	12	12	11.0	2
22	10-30		6	19	9	40	15	12	Nil	NP	ML	Sh	0	1.8	1
	45-85	F	4	5	4	34	12	41	20	27	CL	8	10	1.2	1
	85-120		1	13	3	36	8	39	20	25	CL	3	13	1.3	1
23	20-80		0	7	1	10	15	67	28	28	CH	32	16	3.5	3
	80-120	B	3	14	0	34	21	27	21	10	CL	10	6	5.7	2
24	10-40		1	6	15	48	16	13	Nil	NP	ML	Sh	0	2.0	3
	40-120	F	6	27	3	25	4	35	26	39	CH	24	17	4.5	2
25	40-85		0	2	1	36	11	50	24	24	CL	20	13	4.3	2
	85-120	D	12	25	1	36	5	21	18	22	CL	17	12	6.0	2
26	20-50		0	1	5	59	23	12	Nil	NP	ML	Sh	0	1.4	3
	50-85	F	1	17	11	36	10	36	19	19	CL	15	11	3.8	3
	85-120		5	18	2	46	5	26	19	17	CL	15	10	5.7	3

APPENDIX I (cont'd)

SITE	DEPTH (cm)	MAP UNIT	PARTICLE SIZE ANALYSES (g/100 g Soil)						ATTERBERG LIMITS ($g\ H_2O/100\ g$ Soil)		U.S.C.S.	VOLUME EXPANS-ION. (g/100g Soil)	LINEAR SHRINK-AGE (%)	D.I.	E.C.T.
			STONES	GRAVEL	COARSE SAND	FINE SAND	SILT	CLAY	PLASTIC LIMIT	PLASTICITY INDEX					
27	30-45		1	3	16	55	17	7	Nil	NP	ML	Sh	0	1.3	2
	45-50		5	7	11	43	10	24	16	11	CL	10	9	4.7	2
	50-100	F	3	20	6	33	6	31	20	21	CL	17	13	7.0	2
	100-120		17	34	4	22	4	19	29	27	CL	11	14	3.3	2
28	25-35		0	9	8	54	18	11	Nil	NP	ML	5	1	2.7	3
	35-80	E	0	7	4	36	9	44	23	21	CL	13	13	12.5	3
	80-120		8	28	2	21	5	35	26	32	CH	23	17	7.3	2
29	30-100	E	3	19	4	28	9	38	29	11	ML	14	12	8.7	2

GLOSSARY OF TERMS FOR TABLE I AND APPENDIX I.

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, p 33).

Plastic Limit (P.L.)

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

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. (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 Crumb Test

The Emerson Crumb Test (E.C.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 4-6 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).

Erosion Hazard

The erosion hazard is a qualitative assessment of the potential for erosion to occur with consideration given to the whole soil unit, its erodibility and topographic situation. The erosion hazard of an area is also related to the proposed land use.

Northcote Grouping

The Northcote grouping represents the characterisation of a soil profile according to a system for the recognition of soils in the field described by Northcote (1971).

The Soil Conservation Service of New South Wales addendum to this grouping 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 (1971).

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).

Soil Erodibility

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 erodibility of a given soil in the field is also controlled by soil profile characteristics. The qualitative categories for soil erodibility adopted by the Soil Conservation Service of New South Wales are low, moderate, high, very high and extreme.

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).

Volume Expansion (V.E.)

The volume expansion of a soil when wetted is measured by the Keen-Raczowski Volume Expansion Test. It measures the shrink/swell potential of a soil sample. The modified computation procedure of Wickham and Tregenza (1973) is used to calculate the volume expansion by comparing the mass of a saturated expanded portion of soil with the mass of a saturated residual portion.

Suitability for Ponds

Possible values: Good, Moderate, Poor.

Profile Drainage

Assessed from field permeability measurements.

Possible values: Poor, Moderate, Good.

These measurements were made of the rate of water loss from the top of a 10 cm diameter auger hole, 50 cm deep after 3 hours soaking.

APPENDIX II - DESCRIPTIONS OF TYPICAL SOIL PROFILES.

Map Unit B

Site 15 - Ug 5.6

Depth (cm)	
0-10	A dark greyish brown (10YR 4/2) silty clay, structureless, very hard. pH 6, diffuse to:-
10-30	Dark brown (10YR 3/3) light clay, fine crumb structure. pH 7½, diffuse to:-
30-120	Olive brown (2.5Y 4/4) heavy clay, very strong blocky structure. pH 8½.

Map Unit C

Site 8 - Dr 2.21

Depth (cm)	
0-5	Dark reddish brown (5YR 3/4) sandy loam, slight crumb structure. pH 5½, clear to:-
5-20	Reddish brown (2.5YR 5/4) sandy clay loam, slight structure. pH 5½, clear to:-
20-50	Red (2.5YR 4/8) sandy clay, crumb structure. pH 5½, gradual to:-
50-100	Light red (2.5YR 6/8) sandy clay, much gravel and rock fragments. pH 5½.

Map Unit D

Site 11 - Dr 2.22

Depth (cm)	
0-10	Dark brown (7.5YR 3/3) loam, strong crumb structure, hard. pH 5½ gradual to:-
10-25	Brown (7.5YR 5/3) silt loam, strong blocky structure. pH 5½, clear to:-
25-90	Yellow red (5YR 4/6) heavy clay, strong structure. pH 7, clear to:-
90-150	Brownish yellow (10YR 6/6) with 20% grey mottles silty clay. pH 6.

Map Unit E

Site 1 - Dy 2.23

Depth (cm)	
0-20	Dark brown (7.5YR 3/2) silt loam, rich in organic matter, relatively soft. pH 6, clear to:-
20-40	Pale brown (10YR 6/3) fine sandy clay loam, structureless, hard when dry. pH 6, sharp to:-
40-60	Brownish yellow (10YR 6/6) plus 20% red mottles medium clay, fine crumb structure, smooth ped fabric. pH 7, gradual to:-
60-80	Brownish yellow (10YR 6/8) yellowish brown (10YR 5/8) plus some red mottles, medium clay, fine crumb structure, smooth ped fabric. pH 7, gradual to:-
80-120	Yellowish brown (10YR 5/8) medium clay, fine crumb smooth ped. pH 8½.

Site 6 - Dy 2.22

Depth (cm)	
0-10	Dark greyish brown (10YR 4/2) loam, slight platy structure. pH 6, clear to:-
10-25	Light yellowish brown (10YR 6/4) loam, fine sandy, slight structure development, rough ped fabric. pH 6, gradual to:-
25-100	Brownish yellow (10YR 6/8) with 20% red (2.5YR 5/8) light clay, crumb structure, rough ped. pH 7½.

Map Unit F

Site 3 - Dy 3.43

Depth (cm)	
0-5	Yellowish brown (10YR 5/4) silt loam, very hard. pH 6, clear to:-
5-40	Very pale brown (10YR 7/4) clay loam, structureless. pH 4½, sharp to:-
40-70	Brownish yellow (10YR 6/6) with 30% pale brown silty clay, hard when dry. pH 6, clear to:-
70-90	Yellowish brown (10YR 5/4) heavy clay, strong blocky structure. pH 7.

APPENDIX III - GUIDELINES FOR SEDIMENT AND EROSION CONTROL.

A range of general recommendations aimed at the control of erosion and siltation during development applies to the total site. Guidance in the implementation of these should be sought from the Albury office of the Soil Conservation Service as planning and construction proceed.

(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 respreading. 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 by cover cropping with a fast growing species such as millet in spring-summer and cereal rye, oats or barley in autumn-winter, or by treatment with a surface mulch of straw or a chemical stabiliser.

(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 alteration of the natural landscape. In this context, cut and fill and general grading operations should be limited to the minimum necessary for development.

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

(h) The location of temporary silt filters around stormwater inlets and the channelling of runoff through silt basins below construction zones will assist the control of erosion during construction, while the ground surface is bare.

(i) When excavations are made for conduits, topsoil and subsoil should be stockpiled separately. Subsoil should be replaced in the trench first, and topsoil spread later.

Subsoil used to backfill trenches should be thoroughly compacted. If the soil is very wet or very dry, 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 filled trench lines to prevent erosion, particularly on long, steep slopes.

(j) 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.

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

(l) Borrow areas should not be located on steep slopes 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.

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

(n) Cut and fill batters should be formed to a stable slope. Where vegetative - rather than structural - stabilisation of batters is proposed early revegetation is essential:

(i) Possible plant species for this purpose include couch, ryecorn, phalaris cocksfoot and rye grasses for autumn-winter establishment, and couch, fescue, perennial rye and japanese millet for spring-summer establishment. These should be sown at a heavy rate with a liberal dressing of fertilizer. Specific advice on suitable mixtures can be obtained from the Albury office of the Soil Conservation Service.

(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 early stability.

(iv) Hydroseeding is an alternative batter stabilisation technique. A mixture of seed, fertilizer, wood or paper pulp and water is sprayed onto the batter through a specially designed applicator. It is a simple and effective technique.

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

(vi) Batters may be protected from upslope runoff by locating catch drains immediately above them. On high batters, berm drains located at intervals down the batter face will prevent erosive concentrations of local runoff.

(o) 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 should be sown into a prepared seed bed. Species suggested for batter stablisation are also suitable for inclusion in any general revegetation mixture.

(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, to the Albury office of the Soil Conservation Service.

(p) 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.