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Record 1975/93

URBAN GEOLOGY OF TUGGERANONG, A.C.T.

by

G. Jacobson, J.R. Kellett, A.T. Laws, J.A. Saltet
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* Original plates for the Record at 1:25 000 scale were replaced by A4 reductions in some copies of this Record. Plates at 1:25 000 are available from the Bureau of Mineral Resources.

SUMMARY

The Tuggeranong area consists of undulating slopes in the broad valley of the Murrumbidgee River. It is bounded to the east and west by hills that rise sharply from the valley margin. The Murrumbidgee River is incised into the lower part of the valley, and is a substantial stream liable to flooding; it constitutes a major obstacle to access between the east and west sides of the valley.

The rocks of the area are mainly volcanic, and the depth of weathering is irregular but generally less than 15 m.; however, deeper weathering may be encountered locally in fault zones. The residual soils are mainly podzolic clays. Outwash fans at the foot the slopes consist of partly cemented gravels, sands, silts, extensive silty clays, and some dark organic clays; the areas with organic clay in Isabella Plains and to the south at Lanyon will require drainage before development. The high potentiometric surface in the poorly drained areas is attributed to a high water pressure in the underlying fractured-rock aquifer. The aquifer is partly confined by overlying clay soils.

The foundation conditions are generally expected to be satisfactory as the thicknesses of clay soils are not likely to cause differential foundation movement detrimental to single-storey structures; however, special investigation of clays in poorly drained areas is recommended. Structures with high column loads would generally be founded on suitable rock within about 5 to 10 m of the surface.

Sand deposits in the bed of the Murrumbidgee River constitute a major resource. No other materials constitute a unique resource that requires protection. Groundwater is a minor resource only and has some value as a source of supply. The location of sanitary landfill sites in

the aréa will require study to evaluate the risk of pollution in areas with a high potentiometric surface.

The area has a number of geological exposures that should be considered for conservation.

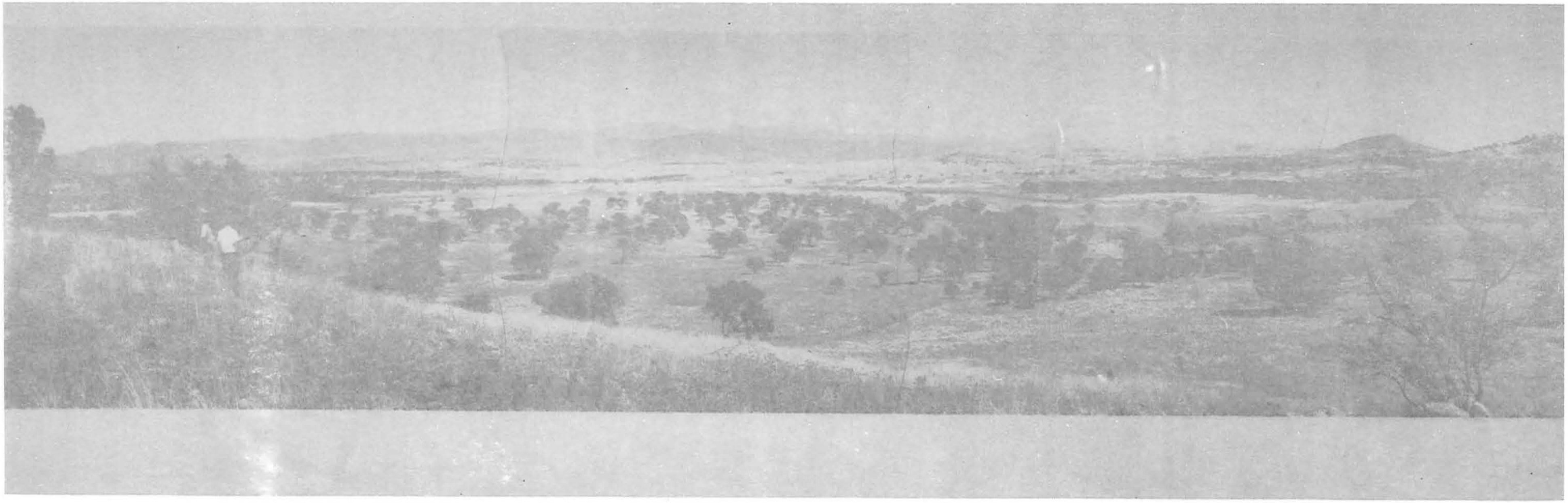


Fig. 1. Panorama of the Tuggeranong urban development area looking northwest.

INTRODUCTION

The proposed urban development area of Tuggeranong (Plate 1) lies immediately south of the Woden/Weston Creek area in which urban development commenced in 1965. Tuggeranong is planned to eventually house up to 180 000 people. Construction commenced in 1974 and will continue for about 10 years.

An environmental geology survey requested by the National Capital Development Commission (NCDC) in 1972 to assist preliminary urban planning was carried out by A.T. Laws, J. Saltet, P.H. Vanden Broek, and J.R. Kellett. It included field mapping of geology, soils, and groundwater conditions, and an assessment of geological constraints which might affect the structure plan.

The information was presented to the NCDC town planners as a series of thematic maps (Plates 2-6). Subsequently, a series of more detailed engineering geological investigations was carried out for the Tuggeranong town centre area (Vanden Broek, 1973, 1974) and for specific drainage problems at Lanyon (Kellett et.al., in prep.) and Isabella Plains.

GENERAL GEOLOGY

The general geology of Tuggeranong is shown in Plate 2, and explanatory notes are given in Table 1. Previous geological mapping by BMR geologists (Gardner, 1968; Jackson, 1970; Rossiter, 1971; Mendum, in prep.) has been incorporated into the map. The geology to the west of the Murrumbidgee River is shown diagrammatically in Figure 2, and the section in Plate 2 shows the relations of the major rock units across the valley.

The rocks of the Tuggeranong area east of the Murrumbidgee Fault comprise Silurian sedimentary rocks (Figs 3 and 4) which are unconformably overlain by Siluro-Devonian volcanic rocks (Figs 5, 6, 7 and 8). Intrusive granite crops out west of the Murrumbidgee Fault, a major fault defining the western margin of the Canberra graben.

All the rock units mapped consists of rocks which are hard and strong where fresh, as in river-bed outcrops (Figs 5 and 6). Elsewhere the rocks are weathered to varying degrees and depths. Dacite, rhyodacite, and rhyolite welded tuff underlie 70 percent of the mapped area, and in these rocks weathering may extend to depths of 15 m or more in places.

The following general weathering profile determined by drilling in the Tuggeranong town centre (Vanden Broek, 1974) is probably representative of a large part of the central area.

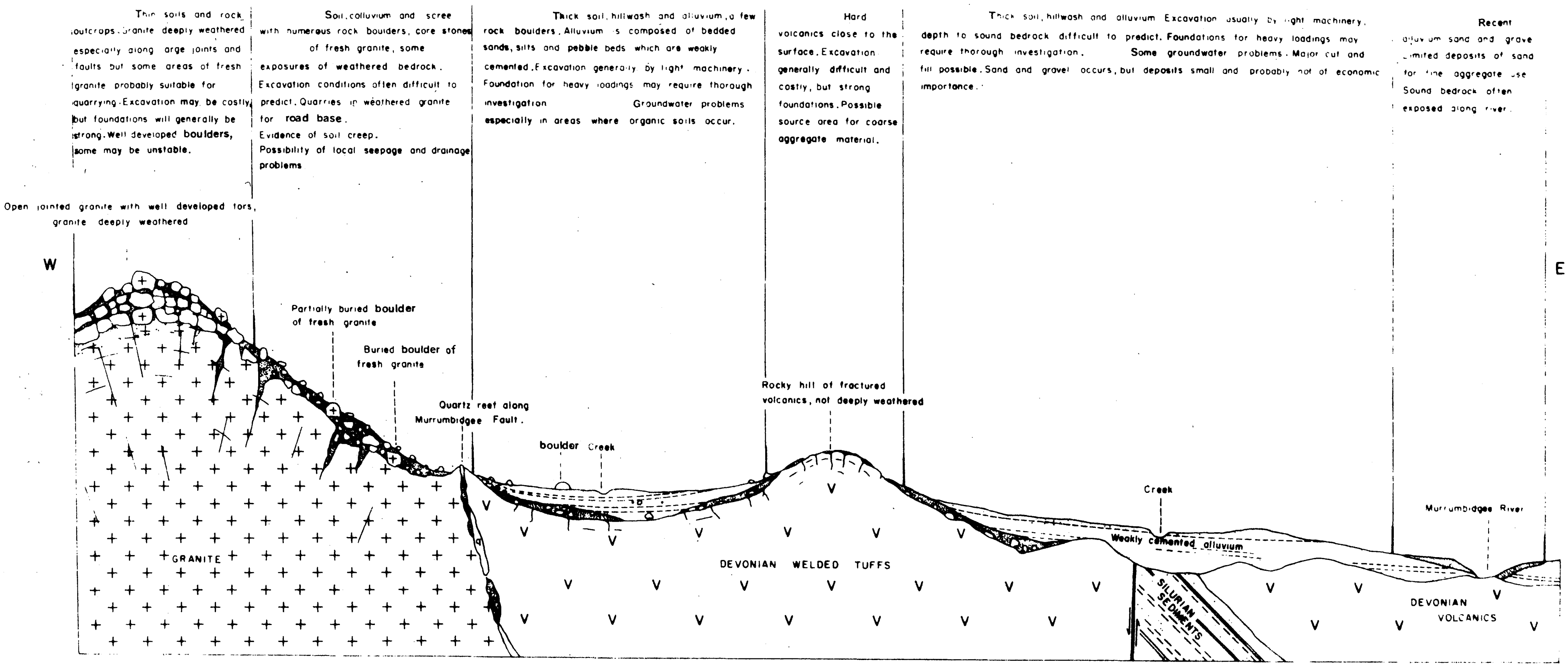
Depth (m)	Description
0 - 6	Extremely weathered rhyodacitic tuff (with soil properties)
6 - 11	Highly weathered rhyodacitic tuff
11 - 14	Moderately weathered rhyodacitic tuff
Below 14	Slightly weathered to fresh rhyodacitic tuff.

GEOLOGICAL HAZARDS

Seismicity

An assessment of seismic risk must be in general terms as detailed records of earthquakes have only been available since 1960 and extrapolation from records covering such a short period of time cannot be regarded as authoritative.

FIGURE 2



GENERALIZED DIAGRAMMATIC SECTION THROUGH THE TUGGERANONG WEST AREA (after JACKSON, 1970)

This is a simplified, schematic cross-section, from west to east across the area. The major landforms and soil features are illustrated and comments on the engineering geology of these are included. The cross-section is not to scale.

Fig. 3. Steeply dipping shale, left bank of Murrumbidgee River, Point Hut Crossing.

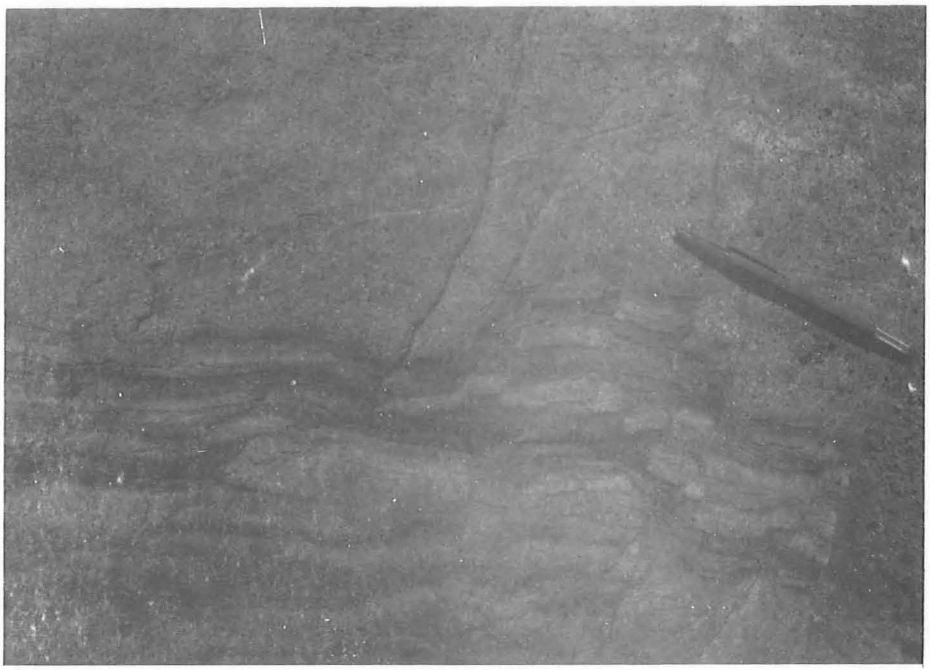


Fig. 4. Penecontemporaneous normal faulting in shale/tuff sequence, left bank of Murrumbidgee River, Point Hut Crossing.

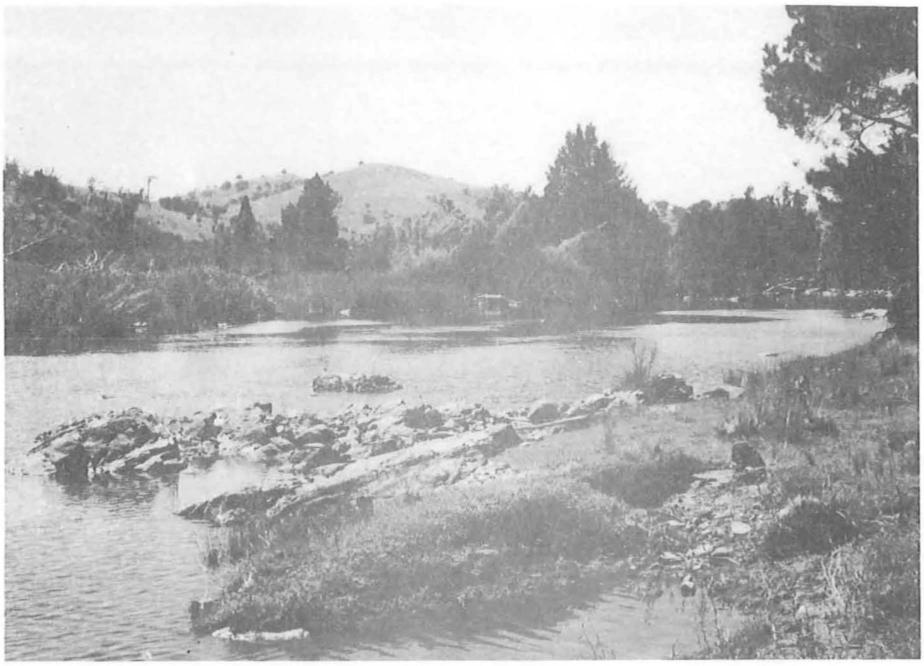


Fig. 5. Outcrops of rhyodacite, right bank of Murrumbidgee River near Pine Island looking downstream towards Urambi Hills.

Fig. 6. Rhyodacitic welded tuff, right bank of Murrumbidgee River near Pine Island.

Fig. 7. Bedded rhyodacitic tuff, right bank of Murrumbidgee River, Pine Island.

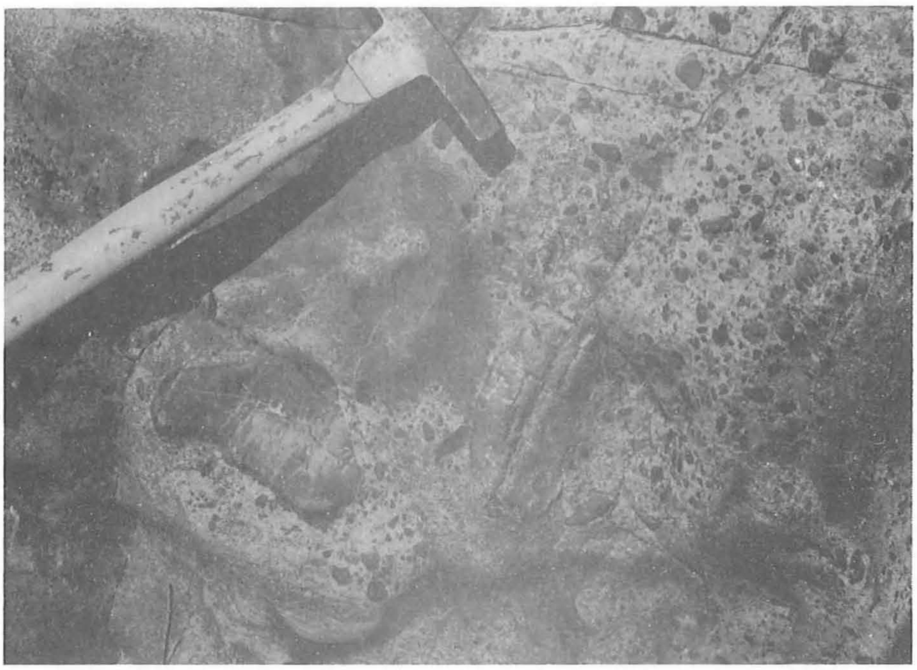


Fig. 8. Agglomerate, right bank of Murrumbidgee River, Pine Island.

TABLE 1

EXPLANATORY NOTES FOR THE GENERAL GEOLOGY MAP

MAP UNIT	PROBABLE AGE	LITHOLOGY	STRUCTURE	STRUCTURAL RELATIONSHIPS	TOPOGRAPHY	WEATHERING	FRACTURING, BEDDING, FOLIATION	EXCAVATION CHARACTERISTICS
Dacitic Porphyry	Siluro-Devonian	Quartz and light green plagioclase phenocrysts (20mm) and some biotite phenocrysts in grey-green groundmass.	Intrusive, no foliation observed. Massive. No folding observed	Intrusive in dacitic and rhyodacitic welded tuff	Crops out only upper slopes, possibly underlying some lower ground in N.W.	Generally slightly weathered in outcrops	Massive, no obvious fracture pattern	Massive, hard, sound rock, difficult to excavate, little to moderate overbreak.
Rhyolite and Rhyodacitic Welded Tuff	Siluro-Devonian	Quartz and plagioclase phenocrysts (5mm), pink orthoclase phenocrysts (10mm) in light to dark pink groundmass, few biotite phenocrysts. Rock is very light to dark pink.	Well bedded gently dipping (20-40°) to E, general strike N - S	Conformably overlying dacitic and rhyodacitic welded tuff	Outcropping on upper slopes and underlying the lower ground, covered with alluvium and soil E of Monaro Highway	Slightly to moderately weathered in outcrops	Well bedded parting along bedding planes	Hard, but well bedded rock, moderate overbreak
Dacitic and Rhyodacitic Welded Tuff	Siluro-Devonian	Phenocrysts of quartz, plagioclase, and pink orthoclase (10 mm) in dark grey to purple or blue grey groundmass. Rock is generally dark	Massive nature of rock makes full structural analysis impossible: where observed mostly moderate to subhorizontal dips, general strike approx. N-S	Unconformably overlying steeply folded Silurian rocks	Crops out on upper slopes of hills and underlies most of the lower ground beneath soil and alluvium, in most of central part of area	Dacitic tuff generally slightly weathered. Rhyodacitic tuff slightly to moderately weathered in outcrops. Weathering may extend to 15 m. or more; weathering pattern regular	Few indications of bedding, main fracture system N-S, vertical	Hard massive, Little overbreak, except in fractured zones
Granite	Siluro-Devonian	Porphyritic texture and pronounced foliation near Murrumbidgee Fault. Westwards becomes equigranular and less foliated	Generally foliated close to Murrumbidgee Fault.	Faulted against boundary dacitic and rhyodacitic welded tuff along Murrumbidgee Fault	Cropping out mainly at higher elevation, but underlying soil and alluvium in depressions in SW and W of Murrumbidgee R	Moderately weathered in outcrops. Weathered profile deeper and more irregular than in the volcanic rocks. Fresh to moderately weathered boulders ("Tors") surrounded by highly weathered rock	Foliation generally 340/vert. Main fracture parallel to foliation	Because of its irregular weathering pattern, major excavations should be thoroughly investigated before construction
Rhyolitic Porphyry	Siluro-Devonian	Phenocrysts of quartz, plagioclase, and characteristic conspicuous pink orthoclase (-20 mm) in dark groundmass	Massive. No apparent structure	Intrusive in Silurian sandstone and shale	Scattered outcrops along Murrumbidgee R. upstream from Point Hut Crossing	Outcrops are moderately weathered	Few fractures, no foliation observed	Massive, hard, difficult to excavate, little overbreak
Freshford Beds	Silurian	Interbedded slate, sandstone, ashtone, and rhyodacite with brecciated structure. Average thickness of beds 10 m	Sedimentary and volcanic components bedded. Strike ranges from N-S to E-W. Dips moderate, average 30°	Unconformably underlies dacitic and rhyodacitic welded tuff. Forms Silurian basement.	On lower ground and creek beds in S.W.	In general - Slate: moderately weathered. Sandstone: slightly to highly weathered. Ashtone: Fresh Rhyodacite: slightly weathered	Main fractures parallel to bedding	Varying lithology, each excavation needs individual assessment
Sandstone, Quartzite, Shale, and Slate	Silurian	Interbedded sandstone, quartzite, slate, and shale. Some calcareous shale.	Well bedded strike; N-S dips: steep, average 80°	Relation to Freshford Beds unknown	Along Murrumbidgee R at and upstream from Point Hut Crossing. isolated steeply dipping lenses exposed in river beneath dacitic and rhyodacitic welded tuff	In general - Slate and shale: moderately weathered. Sandstone: moderately weathered. Quartzite: Fresh	Parting along bedding planes	Varying lithology, excavation easy to very hard.

Felt intensities of earthquakes that have been recorded in the Canberra region are listed in Table 2. A return period of 50 years is estimated for an earthquake with a felt intensity of V on the Modified Mercalli scale (A.J. McEwin, BMR, pers. comm.). Felt intensities are likely to be greater in areas of silty and sandy alluvium and colluvium.

Minor seismicity has been attributed to the release of stress along the Murrumbidgee Fault (Cleary, 1967) but only scarce data are available.

Landslips

Occasional landslips occur on the steeper grassy hill slopes; they generally comprise slope material in a saturated state and do not involve in situ rock. In some places large boulders are potentially unstable, particularly on the northern slopes of Castle Hill (Plate 5).

TABLE 2. FELT INTENSITIES OF EARTHQUAKES IN THE CANBERRA REGION.

Earthquake	Date	Hypocentre Lat.	Hypocentre Long.	Magnitude	Max. Felt Intensity at Epicentre	Intensity Felt in A.C.T. and Environs
Kurrajong	15 Aug 1919	33.5°S	150.7°E	4.6ML	V	I - II
Murrumbateman	6 Mar 1924	34.9°S	149.0°E	5.0MB	IV	I - II
Dalton-Gunning	10 Mar 1949	34.74°S	149.20°E	5-5ML	VIII	III - IV
Rock Flat	1 Sep 1958	36.40°S	149.24°E	4.0ML	V	I - II
Berridale	18 May 1959	36.22°S	148.66°E	5.0ML	VI	III
Robertson-Bowral	21 May 1961	34.55°S	150.50°E	5.6ML	VII	III
Mt. Hotham	3 May 1966	37.04°S	147.13°E	5.7ML	V	II
Dalton	3 Nov 1971	37.76°S	149.16°E	4.2ML	V	III
Picton	9 Mar 1973	34.14°S	150.29°E	5.5ML	VI	IV

Flooding and river erosion

An assessment of flooding of the Murrumbidgee River has been made by the Commonwealth Department of Works (1971), which recommended construction of a series of low flood-control weirs. The area which would be affected by a 100-years average return frequency flood is shown in Plate 4.

River erosion due to the effects of sand-winning operations has also been described by the Commonwealth Department of Works (1971), which recommended strict control of the operations. The construction of flood-control weirs could cause erosion problems downstream of the weirs.

GEOMORPHOLOGY AND SOILS

The geomorphology and soils of Tuggeranong are depicted in Plate 3, and explanatory notes are given in Table 3.

Tuggeranong is in the Murrumbidgee valley which is bounded on the west by the Murrumbidgee Fault scarp (Figs 9 and 10) and on the east by a range of hills, the most prominent of which are Rob Roy (1099 m) and Tuggeranong Hill (805 m). Rejuvenation of the Murrumbidgee River has left a series of pediplain basins in the valley at heights of 30 to 50 m above river level.

The soils of Tuggeranong are related to four main geomorphological settings (Fig. 2). Skeletal soils are present on the higher hill slopes and on those undergoing sheet erosion; residual podzolic soils have developed on the lower pediments and interfluves; cemented hillwash has formed mostly on the pediments; and thick alluvium has been deposited on the pediplains (Fig. 11).

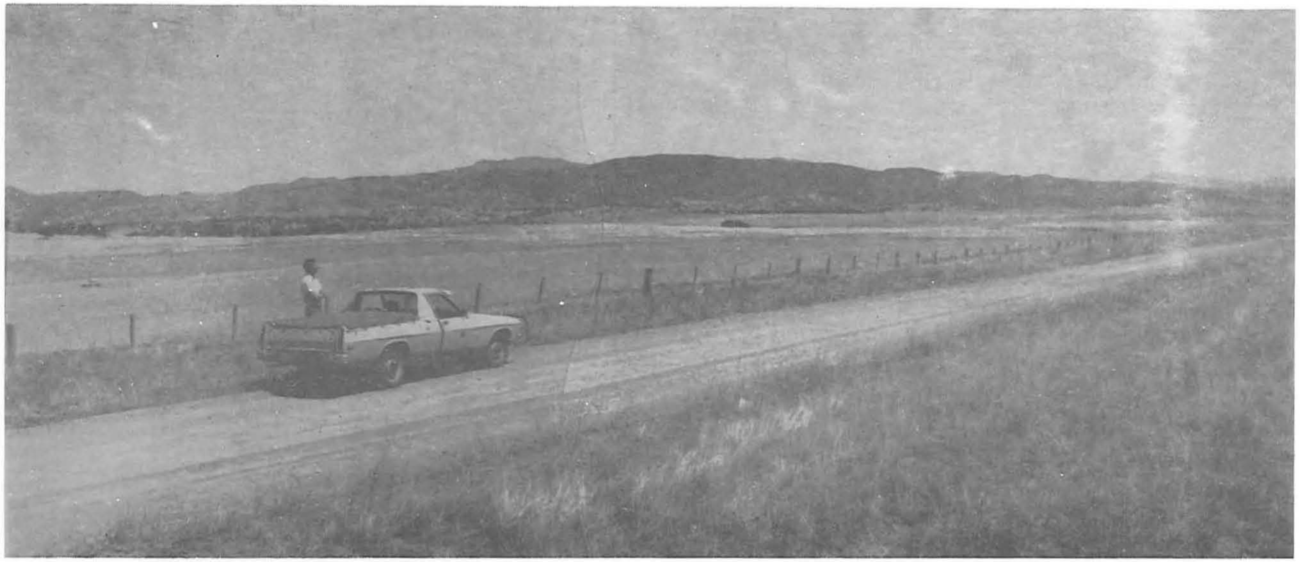


Fig. 9. The Murrumbidgee Fault scarp from Pine Island Road looking west.

Fig. 10. The Murrumbidgee Fault Scarp at Freshford. The fault zone is about 400 m wide and underlies the gently sloping ground in the middle distance.

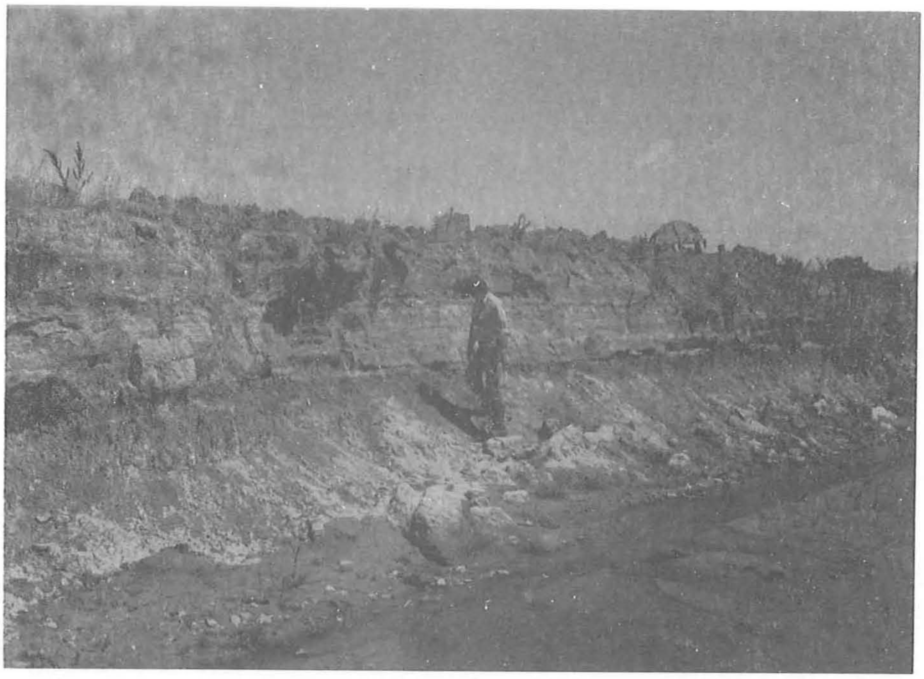


Fig. 11. Stratified alluvium, Isabella Plains; soil profile in the temporary drainage channel.

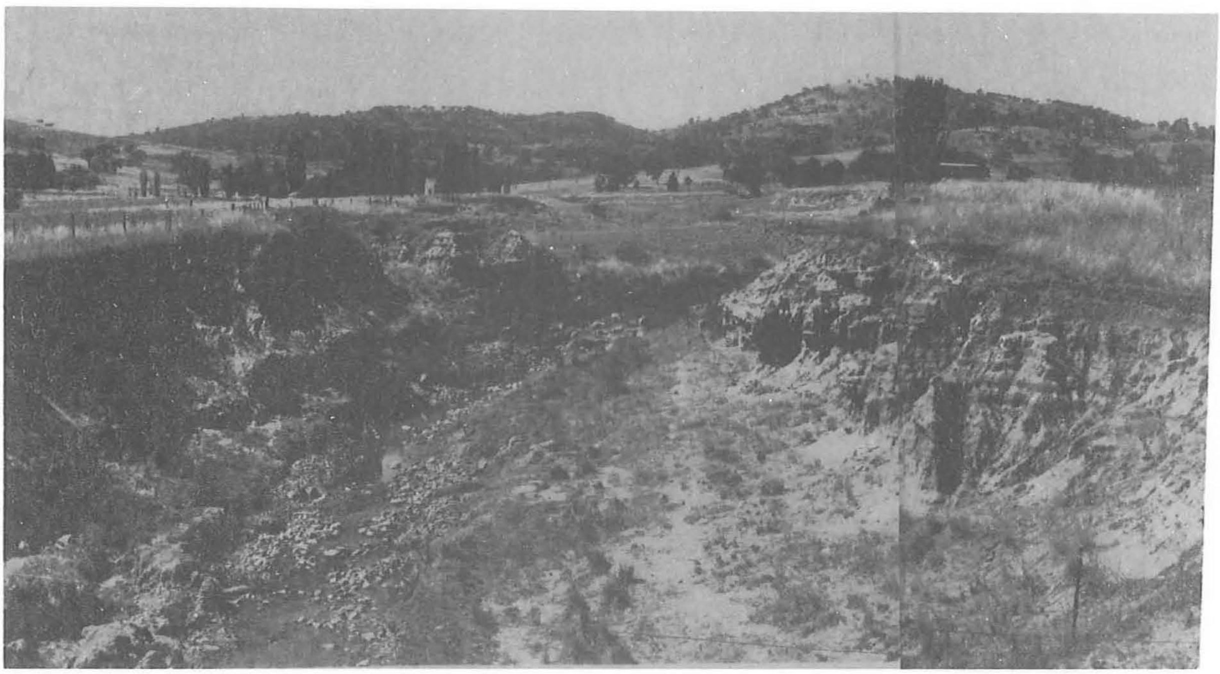


Fig. 12. Soil erosion, Tuggeranong Creek, looking southeast from the bridge on Tharwa Road.

The mapping units in Plate 3 are based on soil thicknesses established from field observations, augering, and photo-interpretation. The soil thicknesses can be used as a guide to expected excavation conditions. Some mapping units, however, for example the lower pediplain alluvium, may overlie the colluvium and podzolic soils of older partly dissected ground surfaces.

Soil erosion in Tuggeranong has been mapped by the Department of Forestry, Australian National University (1970) which noted many occurrences of moderate to severe erosion (Fig 12).

HYDROLOGY AND DRAINAGE

The hydrology and drainage features of Tuggeranong are shown on Plate 4.

There are three types of groundwater aquifer in Tuggeranong: fractured-rock aquifers; lenticular aquifers in colluvial sand and gravel (Fig. 13); and more continuous alluvial sand and gravel aquifers (Fig. 14). Springs are commonly associated with the colluvial aquifers. Fractured-rock aquifers provide the only reliable source of underground water.

Groundwater was formerly extracted from several bores in the valley for domestic and stock use. Yields of the bores ranged from 0.5 to 3.2 m^3/hour; yields were generally low but representative of fractured-rock aquifers. Water quality is variable (Plate 6) with total dissolved solids content ranging from 200 to 1100 parts per million. The chemical composition of some groundwater and surface water samples is illustrated by Figure 15; bicarbonate is the dominant anion in most of the groundwater, with calcium or sodium the dominant cation.

TABLE 3

EXPLANATORY NOTES FOR THE GEOMORPHOLOGY AND SOILS MAP (PLATE 3)

Depth (m)	Morphological Position	Soil Units	Profiles	Origin	Terrain	Landform
0 - 1	Upper slopes	Skeletal soil between areas of solid or scattered rock outcrop	ML/SM/GM	Residual/colluvial	Hilly or mountanous	Ranges of steep hills and isolated steep hills
	Areas under geological control	Skeletal soil between areas of scattered rock outcrops or scattered boulders commonly underlain by completely weathered volcanic rock	ML/SC	Residual	Rolling or undulating; gently sloping to flat	Isolated hills, rises, and low ridges
	Areas undergoing extensive sheet erosion	Skeletal soil between areas of scattered rock outcrop or scattered boulders	ML/GM	Residual/colluvial	Hilly to undulating; steeply to gently sloping	Dissected river valley sides
	Upper pediment	Minimal podzolics. Slope wash	CL/ML/CL/SC OL/ML/SM	Residual Colluvial	Undulating; moderately sloping	Middle slopes
1 - 2	Lower pediment	1. Red and yellow podzolics	OL/ML/OL/CH/SC	Residual	Gently undulating; gently sloping	Lower hill slopes
		2. Layered soils, often truncated	Variable but often significant profile, e.g. OL/ML/CL/CH/MC/CH/ML/SC			
		3. Slopewash	ML;SM	Colluvial		
	Interfluves	Red and yellow earths	OH/ML/CL/GP	Aeolian, alluvial or residual	Gentl- undulating; gently sloping	Low ridge
		Minimal podzolics	OL/ML CL/SC	Residual		
	Small perched basins	Minimal soil developed on alluvium or layered soils	Variable	Colluvial/alluvial	Hilly, moderately sloping	Residual bench
2 - 3	Upper pediplain	Layered soils, colluvium with profile		Colluvial/residual	Gently undulating	Broad depressions
	Old ground surface	Maximal podzolics	OL/ML/CH SC	Residual	Planar;gently sloping	Plains
	Stream deposits	Interbedded gravel, sand, silt, and clay	Variable	Alluvial	Planar; gently sloping	Gullies
	Lower pediplain	Interbedded sand, silt, gravel, and clay including laminated clay, and a possible ground surface	SP to CH	Alluvial, including flood-plain deposits	Planar; flat	Flats
3 - 5	Stream deposits	Interbedded gravel, sand, silt, and clay	GP - CH	Alluvial		
		Interbedded sandy,silty, and clayey organic loams, Heavy organic clays	CL - CH	Alluvial	Planar,gently sloping	Gullies
More than 5	Pediplain basin	Interbedded gravel,sand, silt,and clay including heavy organic clay	GW - OH	Alluvial	Planar;depressions	Swampy ground
[illegible]able	Rive[illegible]its	[illegible]ted s[illegible] gravel	[illegible]P and	Alluv[illegible]	[illegible]nar; f[illegible]	Levees [illegible] bars, braided streams

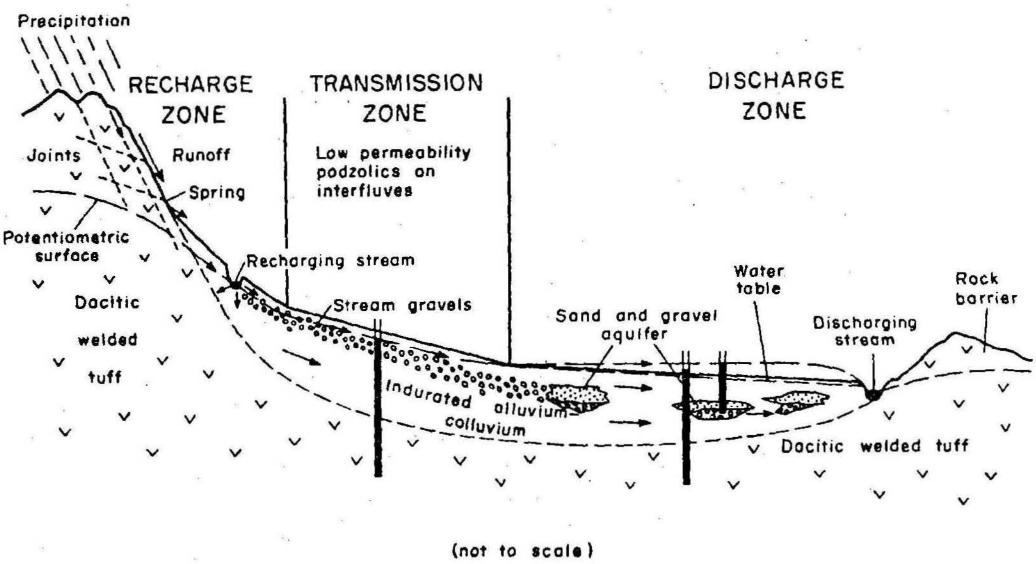


Fig. 13 Lanyon pediment basins

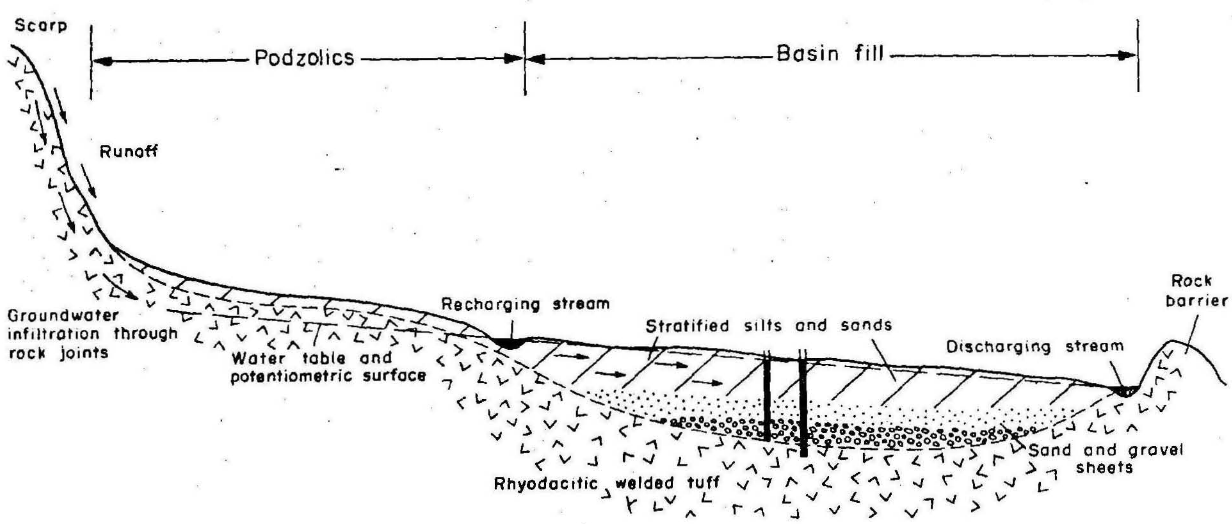
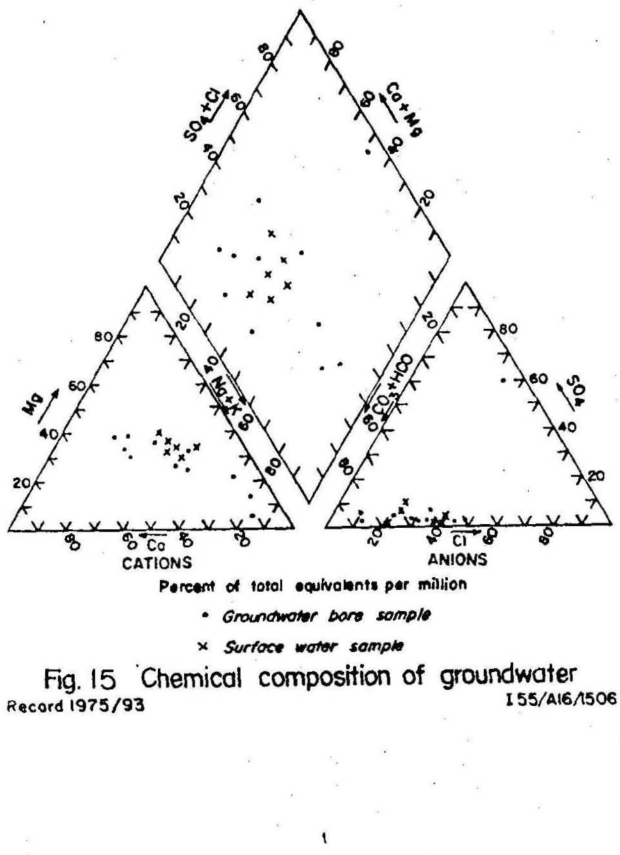


Fig. 14 Isabella plains pediplain basin



Percent of total equivalents per million

• *Groundwater bore sample*

× *Surface water sample*

Fig. 15 Chemical composition of groundwater

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The groundwater level in several bores is being monitored by BMR, and it is possible that groundwater could be used as a secondary water source in some areas of Tuggeranong.

Soil drainage problems are present in the pediment basins where restriction of lateral groundwater movement causes water to emerge at the surface as perennial springs and soaks. The potentiometric surface is above ground level in the worst affected areas and extensive remedial drainage works are required before development of such areas. Detailed investigations of drainage problems have been undertaken at Lanyon (Kellett et. al., in prep.) and Isabella Plains (Figs 11 and 14). Other areas where remedial action will be needed are Woolshed Creek and Freshford on the western side of the Murrumbidgee valley.

FOUNDATION AND EXCAVATION CONDITIONS

Foundation and excavation conditions are shown in Plate 5. These conditions have been estimated from a total of 59 auger holes which were drilled in the area. The nature and thickness of weathered rock are variable in much of the area, and detailed site investigations will be required for the foundations of large structures.

Slope stability in road cuts in fractured volcanic rocks will be governed by the orientation of intersecting rock defects such as bedding and joint planes, and all major cuts will require investigation of such potential wedge failures to ascertain the angle of slope for stability. Slope stability of cuts in the lower pediment podzolics and upper pediplain layered colluvium (Plate 3), will be adversely affected by groundwater seepages from their more permeable beds, and provision should be made during road construction for the recognition of seepage areas during excavation and for the construction of remedial works.

RESOURCES

Natural resources in the Tuggeranong area are shown in Plate 6. There are no known occurrences of metallic minerals in the area.

Deposits of sand in the beds of the Murrumbidgee and Gudgenby Rivers have been worked in the past as a source of supply for Canberra. There are at present some restrictions on winning sand from the Murrumbidgee River because of possible erosion of the foundations of the Tharwa Bridge. Investigations of additional sand reserves have been carried out by the Commonwealth Department of Works (1972) and Coffey and Hollingsworth Pty Ltd (1973).

Terraces in the Murrumbidgee valley between Tharwa and Point Hut may contain substantial reserves of sand and/or topsoil. Alluvial deposits in the valley of Woolshed Creek may be suitable for topsoil. These deposits all require investigation by drilling in order to assess their value as a resource before the land is pre-empted for other uses.

Minor deposits of fine-grained red sand are present at Lanyon and Pine Island.

Several possible quarry sites for crushed rock aggregate are indicated on Plate 6. Most of those within the urban area are likely to be rejected on environmental grounds. Possible sources outside Tuggeranong include a site near Mugga Road to the northeast and other sites near Royalla to the southeast. More detailed investigations will be needed to ensure in adequate supply of rock aggregate for the developing city.

REFUSE DISPOSAL SITES

Optimum conditions for solid waste disposal sites will be found in well drained areas with a deep, moderately permeable, soil profile and a low water table. The sites should not be liable to flooding and pollution of groundwater should be avoided. There are few obvious sites in Tuggeranong with these conditions, and detailed investigations will be necessary; the most likely locations will be in the lower pediment podzolics (Plate 3), not far from the foot of the surrounding hills.

GEOLOGICAL MONUMENTS

Some of the rock outcrops in the Murrumbidgee River are of considerable geological interest and should be preserved as geological monuments.

These outcrops include a volcanic complex exposed in the river banks downstream from Pine Island (Figs 7 and 8), and a sequence of well exposed agglomerate breccia downstream from Point Hut Crossing.

GEOLOGICAL CONSTRAINTS IN PLANNING

1. Groundwater seepage problems are a major constraint. The large pediment basins at Isabella Plains, Lanyon, Freshford and Woolshed Creek will require remedial drainage works. There are, in addition, extensive areas of colluvium containing lenticular aquifers that will cause springs and seepages in excavations, and possible instability in road cuts.

2. Supplies of topsoil, sand, and gravel are limited in the A.C.T. and it may be desirable to exploit the deposits in the Murrumbidgee

valley area before using the land for other purposes.

3. Supplies of rock aggregate will probably have to be sought outside the Tuggeranong development area, but suitable locations for quarries are known in adjacent areas.

4. Geological hazards include possible seismicity associated with the Murrumbidgee Fault; possible boulder slides on steep hill slopes; and flooding and erosion in the Murrumbidgee River.

5. The volcanic rocks which occur in much of Tuggeranong are weathered to variable depths and detailed foundation investigations will be necessary on sites where large structures are planned.

6. Some slopewash might be unstable in road cuts, and unsuitable as a foundation material where springs and seepages keep it saturated.

7. Slope stability of rock cuts will be affected by wedge failure, and the alignment of major cuts should be investigated for unfavourable orientation of rock defects.

REFERENCES

CLEARY, J.R., 1967 - The seismicity of the Gunning and surrounding areas, 1958-61. J.Geol. Soc. Aust., 14, 23-29.

COFFEY & HOLLINGSWORTH PTY LTD, 1973 - Report on the survey of sand resources in the Gudgenby and Murrumbidgee Rivers, Angle Crossing area, A.C.T. Rep. 4750/1 to Comm. Dep. Works, May 1973.

COMMONWEALTH DEPARTMENT OF WORKS, 1971 - Supplementary report on flood levels and recreational lake development on the Murrumbidgee River at Tuggeranong, July 1971.

COMMONWEALTH DEPARTMENT OF WORKS, 1972 - Report on sand quantities in the Murrumbidgee and Gudgenby Rivers in Tuggeranong, April 1972.

DEPARTMENT OF FORESTRY, AUSTRALIAN NATIONAL UNIVERSITY (1970) - An ecological and physiographic survey of the proposed Tuggeranong city area and surrounds, May 1970.

GARDNER, D.E., 1968 - Preliminary notes on the geology of the Tuggeranong urban development area, A.C.T. Bur. Miner. Resour. Aust. Rec. 1968/75 (unpubl.).

JACKSON, M.J., 1970 - Engineering geology of the Tuggeranong West urban development area, A.C.T. Bur. Miner. Resour. Aust. Rec. 1970/68 (unpubl.).

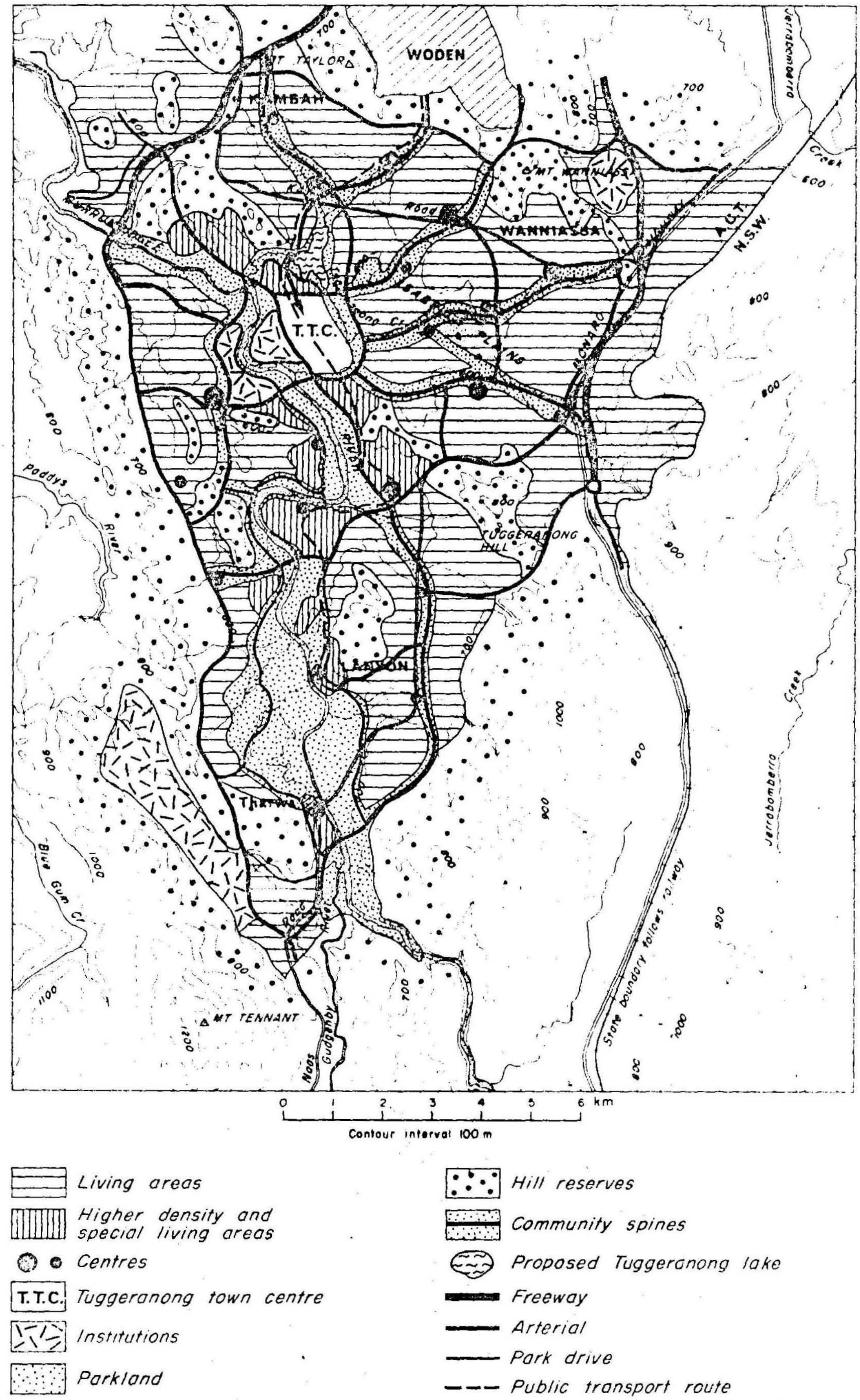
KELLETT, J.R., JONES, P.A., & BAKER, G.C., in prep. - Drainage investigation at Lanyon, A.C.T. 1974. Bur. Miner. Resour. Aust. Rec.

MENDUM, J.R., in prep. - Geological investigation of Tuggeranong damsite, Murrumbidgee River, A.C.T., 1968. Bur. Miner. Resour. Aust. Rec.

ROSSITER, A.G., 1971 - Preliminary notes on the geology of the Village Creek area. Bur. Miner. Resour. Aust. Rec. 1971/11 (unpubl.).

VANDEN BROEK, P.H., 1973 - Engineering geology of Tuggeranong town centre, stage 1, A.C.T. Bur. Miner. Resour. Aust. Rec. 1973/100 (unpubl.).

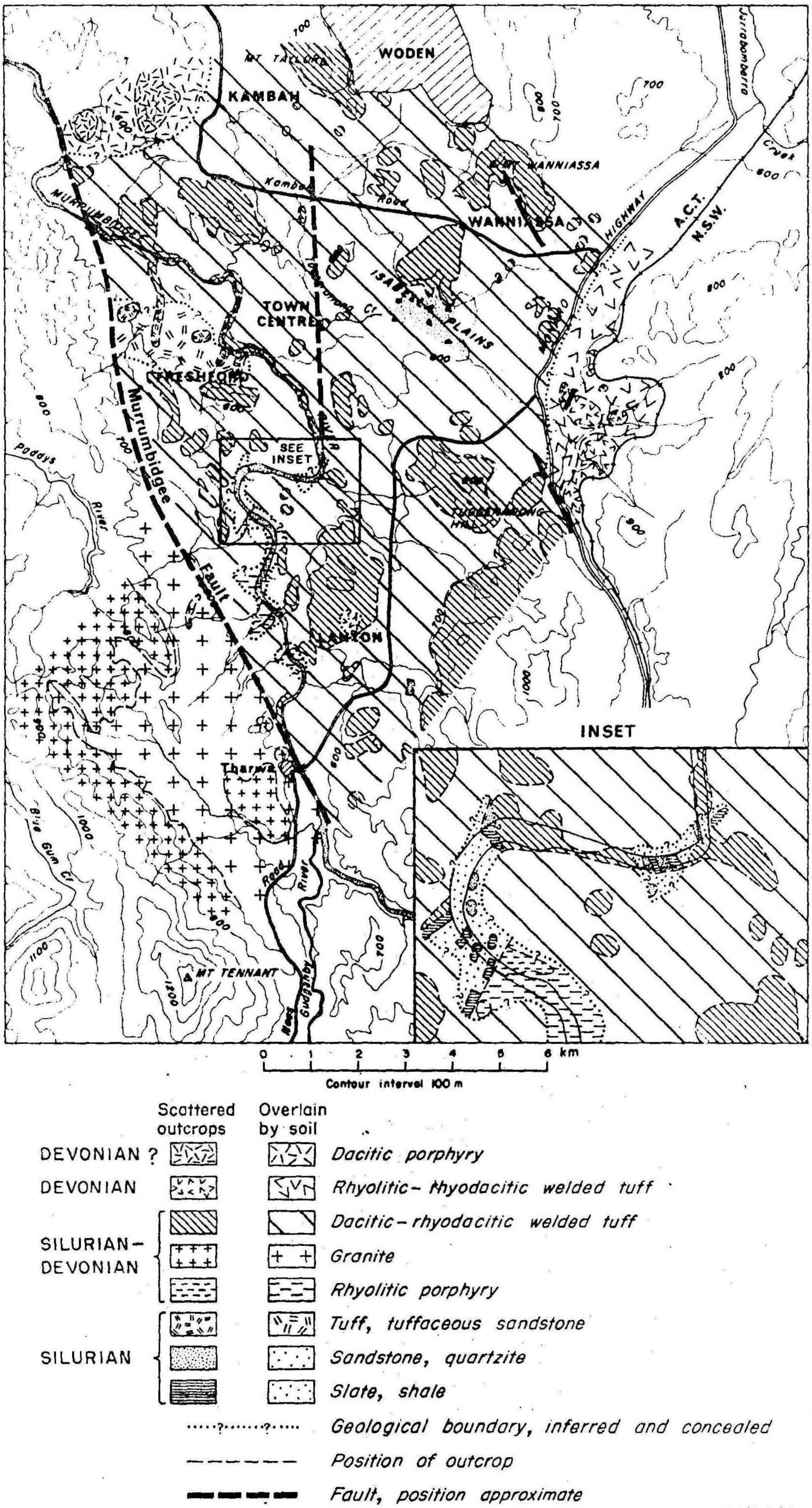
VANDEN BROEK, P.H., 1974 - Engineering geology of Tuggeranong town centre, A.C.T. Bur. Miner. Resour. Aust. Rec. 1974/184 (unpubl.).



Record 1975/93

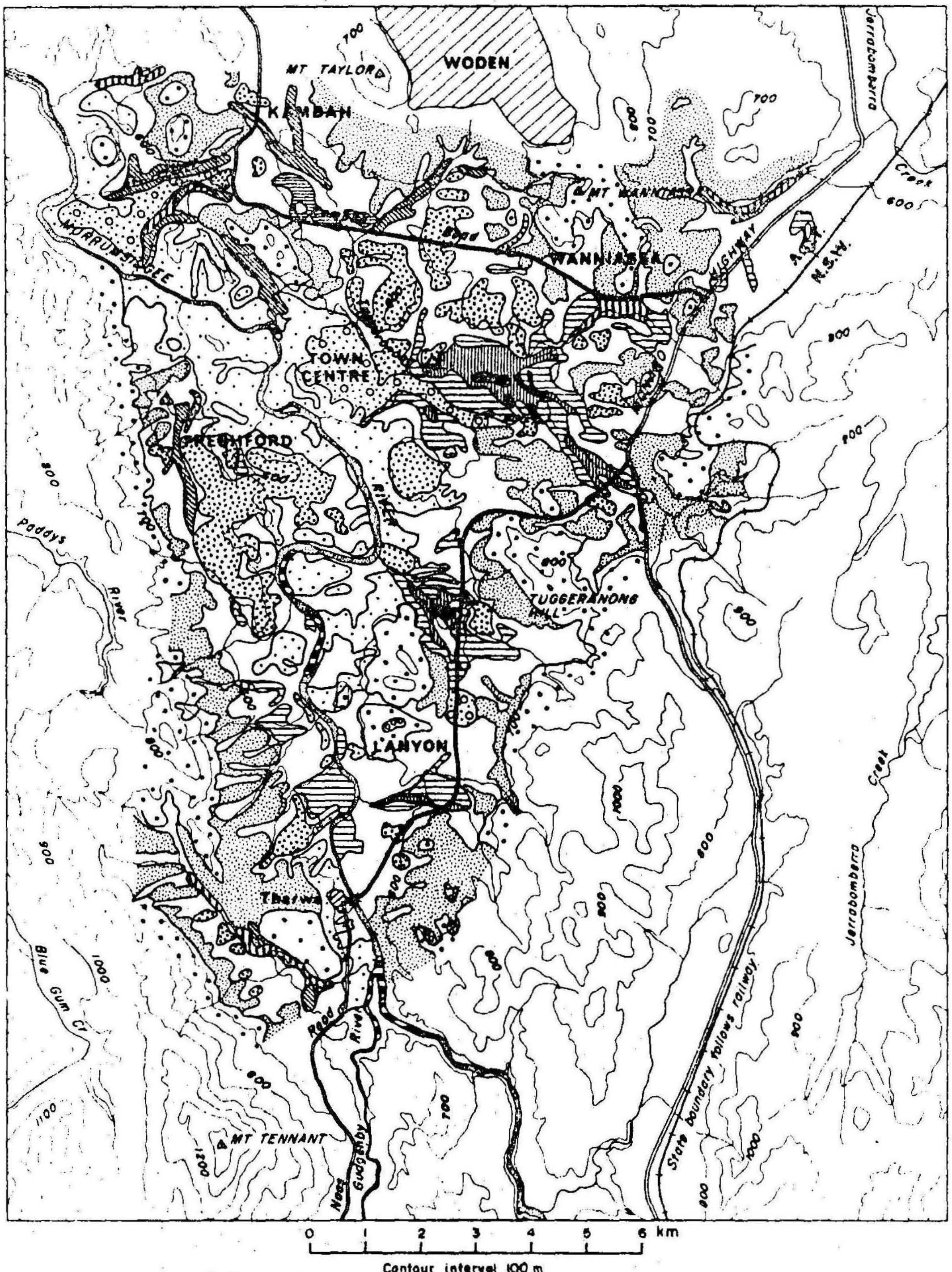
155/A16/1501

Plate 1 Urban outline plan



Record 1975/93 155/A16/1502

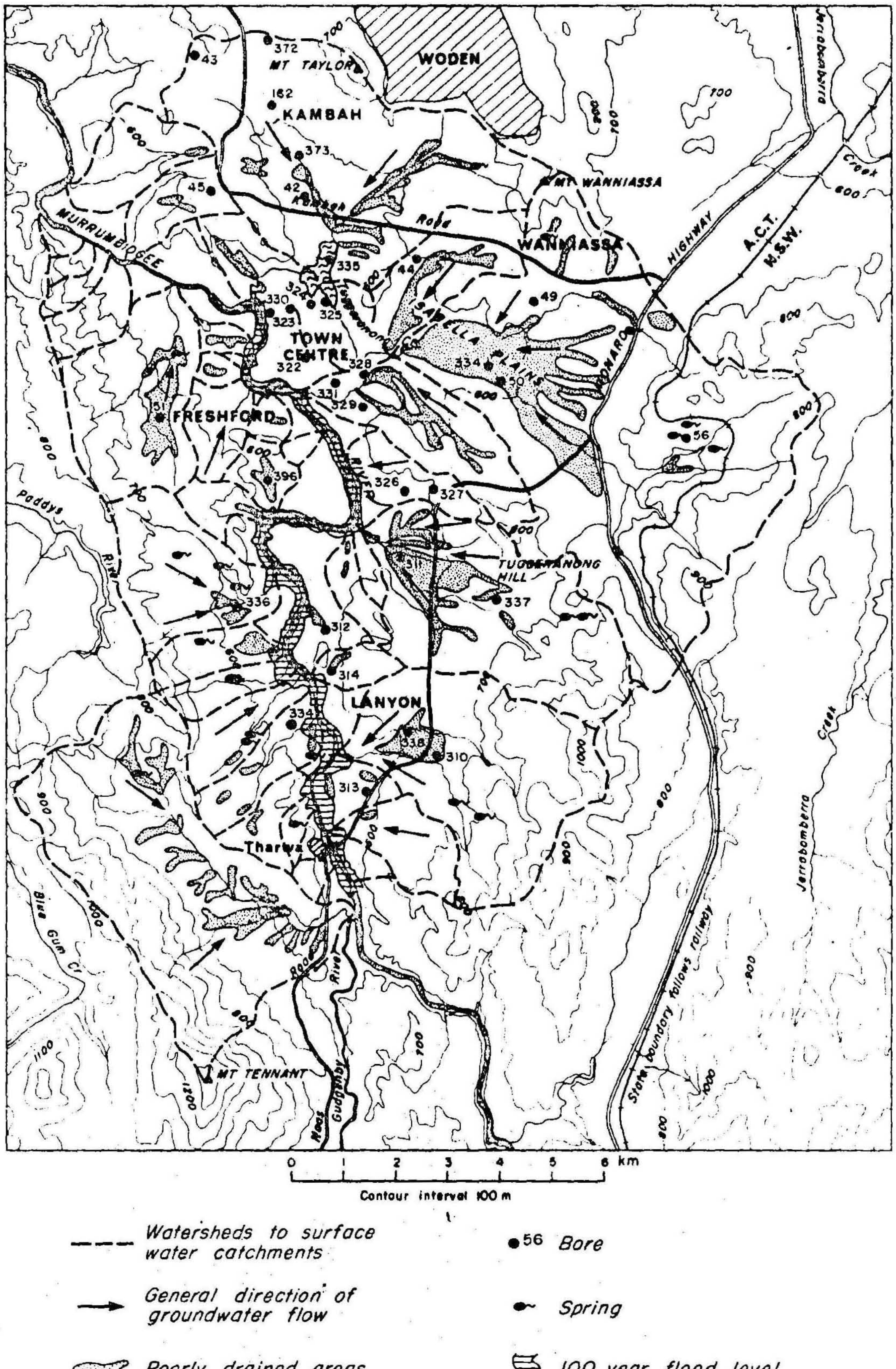
Plate 2 General geology



Soil Thickness	Description
0–1 metres	*Upper slopes: skeletal soil* *Monadnocks: skeletal soil* *Rejuvenated river valley: skeletal soil* *Upper pediments: minimal podzolics*
1–2 metres	*Lower pediments: podzolics* *Interfluves: red and yellow earths, podzolics* *Small perched basins: prairie soil on alluvium*
2–3 metres	*Upper pediplain: layered colluvium* *Older groundsurfaces: podzolics and residual clay* *Stream deposits: alluvium*
3–5 metres	*Lower pediplains: alluvium (poorly sorted)* *Stream deposits alluvium (well sorted)*
>5 metres	*Pediplain basin: alluvium*
variable	*River deposits: alluvium*

Record 1975/93 155/A16/1503

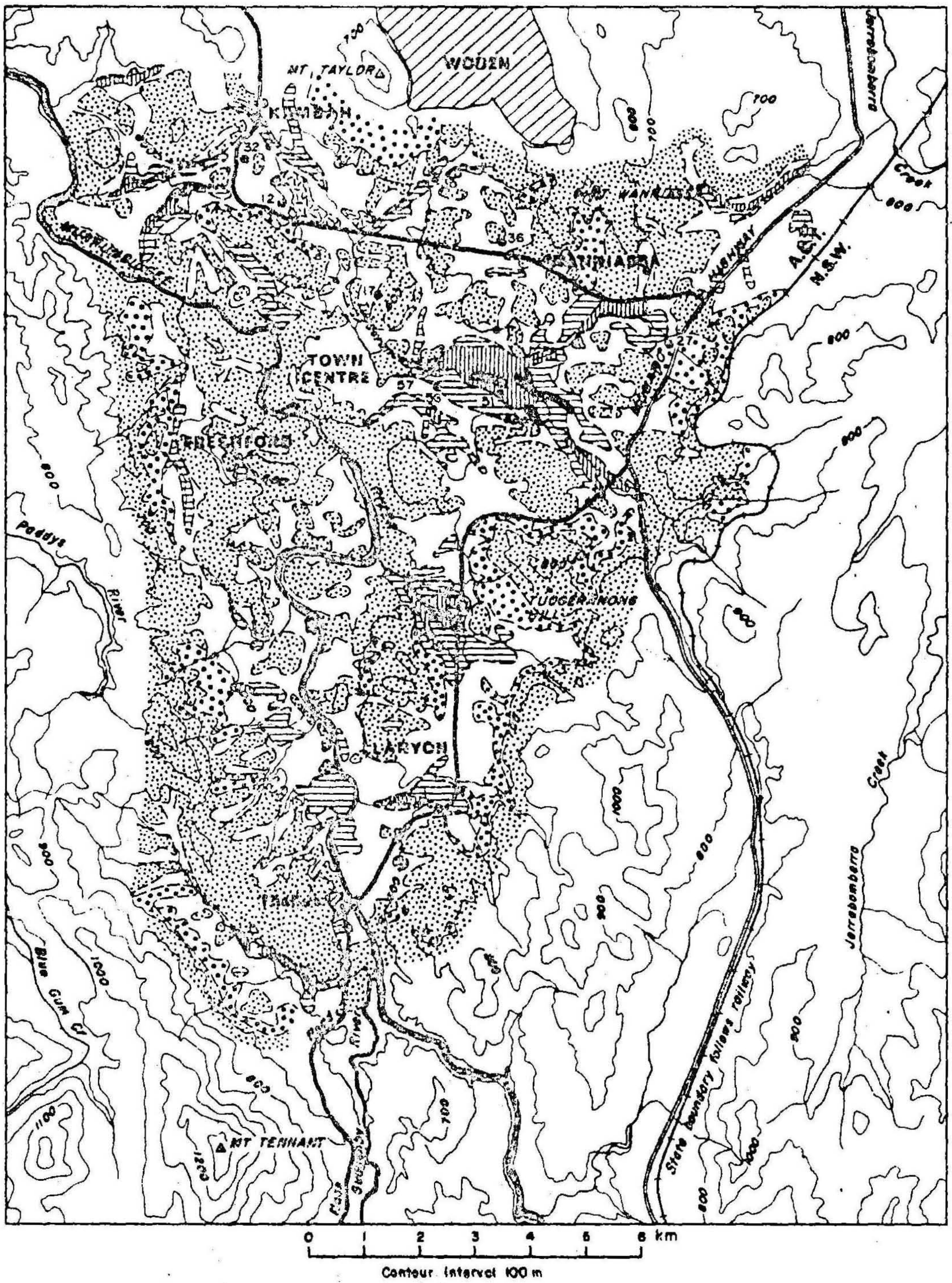
Plate 3 Soil thickness and geomorphology



Record 1975/93

155/A16/1504

Plate 4 Hydrology and drainage



Excavation by blasting
Strong foundations at surface

Excavation by scraping and ripping
Strong foundations below 2 metres

Excavation by ripping and blasting
Strong foundations below 2 metres

Excavation by scraping
Strong foundations below 3 metres

•1 *Auger hole*

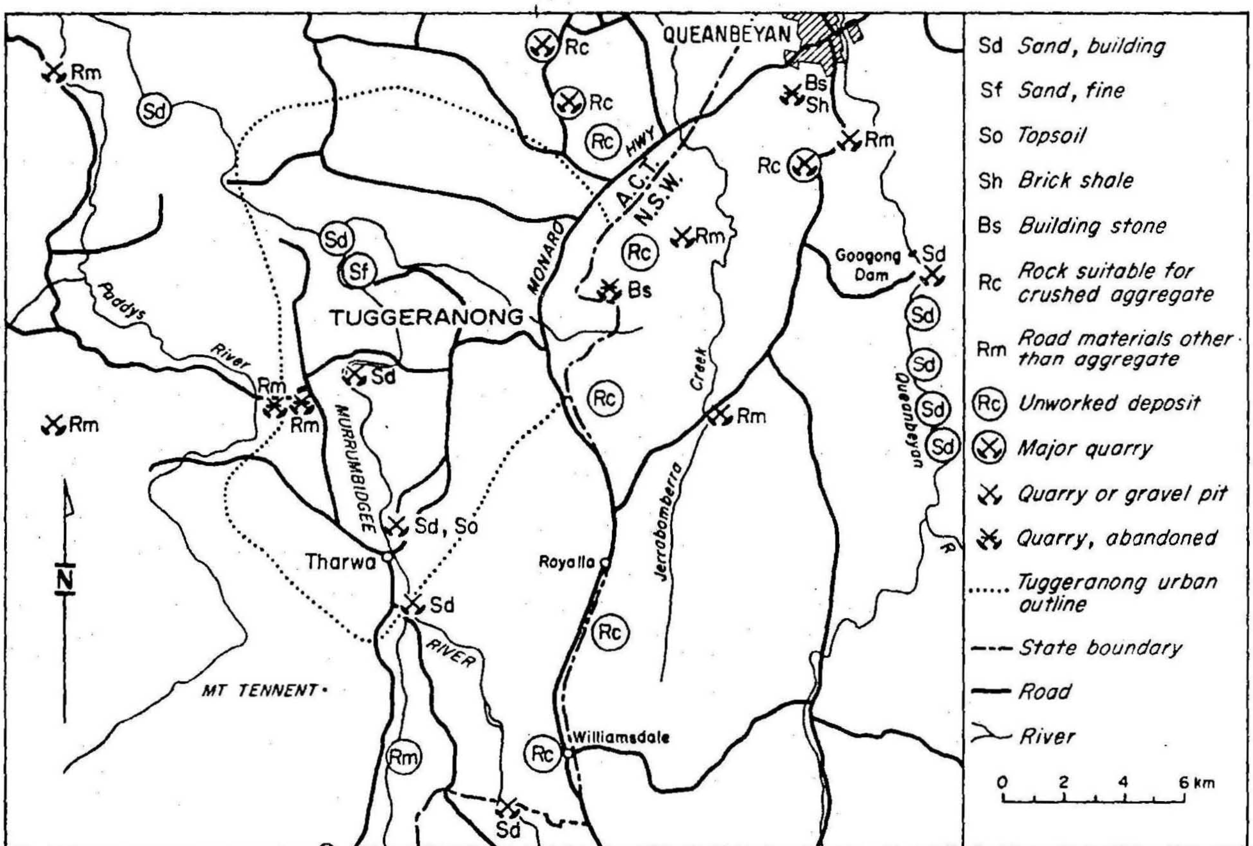
Excavation by scraping
Strong foundations at variable depths below 3 metres

Excavation by scraping
Requires seepage control
Strong foundations below 5 metres

Excavation by scraping
Requires seepage control
Strong foundations at variable depths below 5 metres

Record 1975/93 155/A16/1508

Plate 5 Foundation and excavation conditions



Record 1975/93 Plate 6 Natural resources for Tuggeranong development I55/A16/1512