BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

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GEOLOGY AND GROUNDWATER HYDROLOGY OF
FRESHFORD, WEST MURRUMBIDGEE URBAN
DEVELOPMENT AREA, ACT

by

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CONTENTS

FIGURES

PLATES

ABSTRACT

The rocks of the Freshford area, which lies to the west of the Murrumbidgee River on the southern outskirts of Canberra, consist mainly of folded and faulted Silurian acid volcanics and volcaniclastic rocks ranging in composition from rhyolite to dacite with some interbeds of tuffaceous sediments. Overlying them in places are Quaternary colluvium and alluvium, in which heavy clay soils have been developed.

An area of waterlogged soils at Freshford, in the West Murrumbidgee urban development area, has been investigated by drilling and by an assessment of the permeability of saturated alluvial soils. Clayey, sandy, and gravelly colluvial and alluvial soils up to 8 m thick overlie intensely sheared and faulted volcanic and plutonic rocks. Leakage from the underlying fractured-rock aquifers with a high potentiometric surface maintains saturation of the overlying colluvium and alluvium even during prolonged dry weather.

Conventional open or pipe drains set at depths of about 2 m would not intersect the more permeable materials in colluvium, and would make little improvement of the area. Drains would have to be at depths of more than 3 m in order to intersect permeable alluvium/colluvium and provide effective drainage.

The location of the Murrumbidgee Fault zone, which transects the Freshford area, has been defined. As the fault zone is associated with minor stress releases, sites reserved for major structures should be investigated in detail. Major structures should be designed according to specifications in the Standards Association of Australia Draft Code DR76100 for the design of earthquake-resistant buildings.

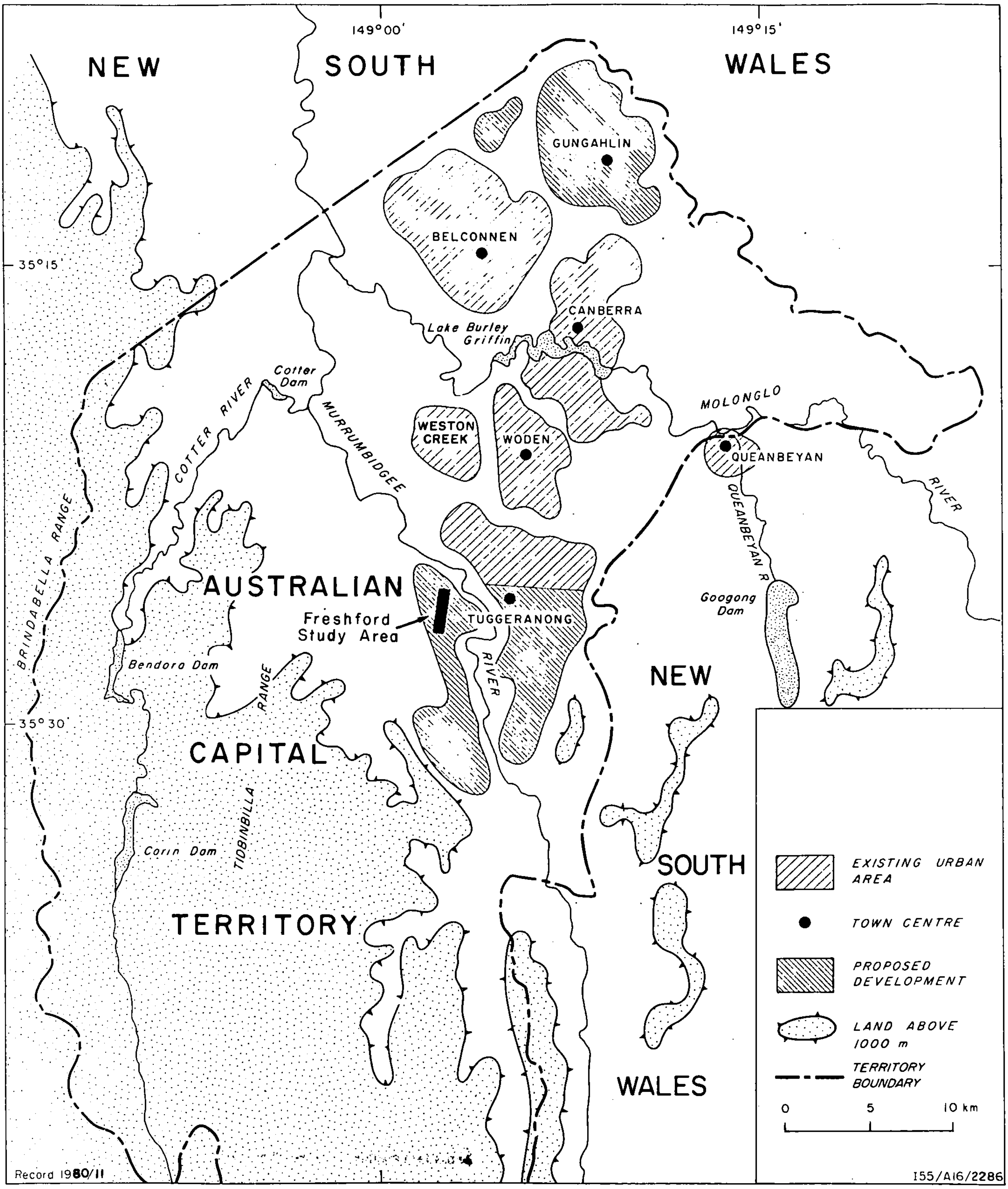


Fig.1, Location map

INTRODUCTION

In 1975-6, in response to a request from the National Capital Development Commission, the Bureau undertook an engineering geological investigation of poorly drained soils at Freshford, which is part of the planned West Murrumbidgee urban development in the Tuggeranong area, ACT (Fig. 1). Attention was first drawn to the problem of waterlogged soils by A.T. Laws, who prepared a map showing the hydrology and drainage characteristics of the Tuggeranong area at 1:25 000 scale (Jacobson & others, 1975).

Previous geological work at Freshford was concerned with the suitability of the area for urban development (Jackson, 1970; Gardner, 1968). Mendum (1975), investigated a damsite on the Murrumbidgee River just east of Freshford. A map of the bedrock geology of the area was prepared by J.A. Saltet (Jacobson & others, 1975) at 1:25 000 scale. The broad geological setting of the area is shown on the Canberra 1:250 000-scale geological map (Strusz, 1971).

The present investigation has included mapping of the bedrock geology of the area at 1:9600 scale by J.P. Ceplecha. Surficial deposits have been mapped and drillholes logged by P.D. Hohnen.

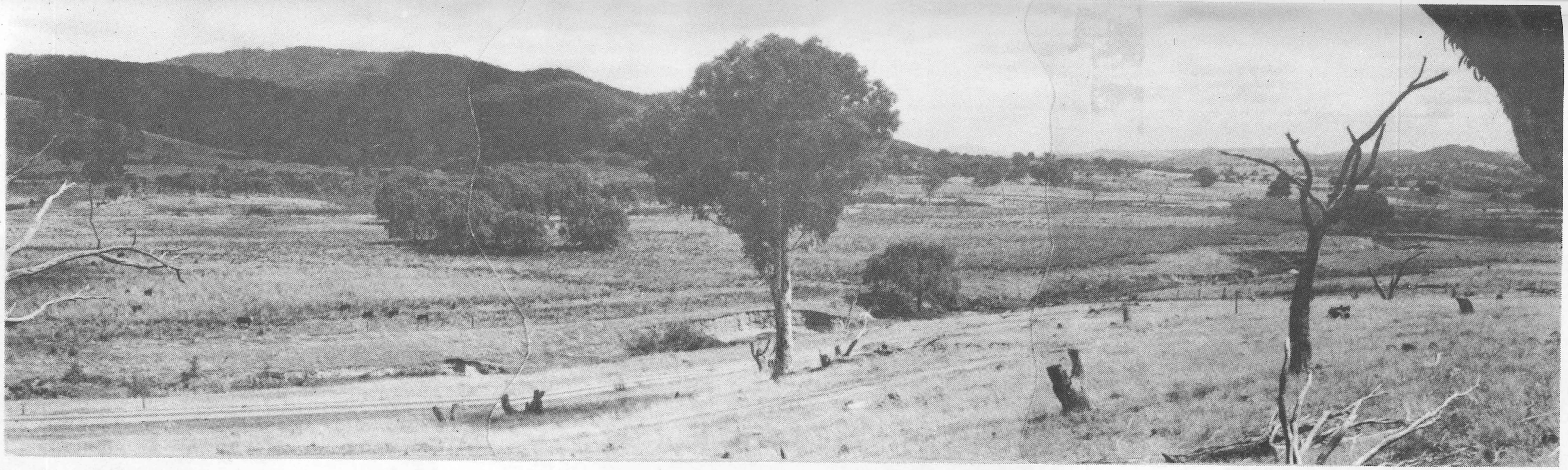
BMR drillers sank a bore close to the Murrumbidgee Fault in 1975 in order to determine the permeability and static head of groundwater in fractured-rock aquifers. In 1976, sixteen auger holes were drilled in alluvium and colluvium to determine the stratigraphy and hydraulic properties of these deposits. All auger holes were equipped as piezometers, and recovery tests were carried out with the aid of a diaphragm pump.

SURFICIAL GEOLOGY AND GEOMORPHOLOGY

The Freshford area straddles part of the boundary between the Canberra Graben and the Cotter Horst (Strusz, 1971). Landforms in the area reflect the tectonism that resulted in these structural features sometime between the Silurian and Holocene. At Freshford the Murrumbidgee Fault, which forms the common boundary between them, is near the foot of an eroded escarpment of Upper Silurian Tharwa Adamellite and Ordovician sedimentary rocks (Fig. 2, Pl. 2). Sediment has been shed from this escarpment onto the lower ground of the Freshford Creek valley (Fig. 2).

Adjacent to the escarpment are colluvial sediments, possibly of Pleistocene age, that have been indurated and show a distinctive polygonal joint structure in the finer grainsize ranges. Much of the colluvium is cemented slatey talus, which shows evidence - such as imbricate structure - of localised reworking by streams. Cobble-size platy clasts of siltstone, slate, and quartzite occur in a matrix of red clay. To the south of Freshford homestead, detritus has been largely derived from the Tharwa Adamellite, and cemented sandy clay characterises the colluvium in this area.

The flat-bottomed valley of Freshford Creek (Fig. 3) lies immediately east of the colluvial piedmont slopes (Fig. 2), and contains up to 6 m of alluvium overlying about 2 m of weathered colluvium. The alluvium is mainly sandy clay or clayey sand, and has been largely derived by erosion of the adamellite. Much of the alluvial and colluvial granitic detritus - apart from quartzose sand - has weathered to clay. Interbedded with the clayey alluvium are well-sorted sand and fine gravel beds. Logs of auger holes in alluvium and colluvium are shown in Appendix 2.

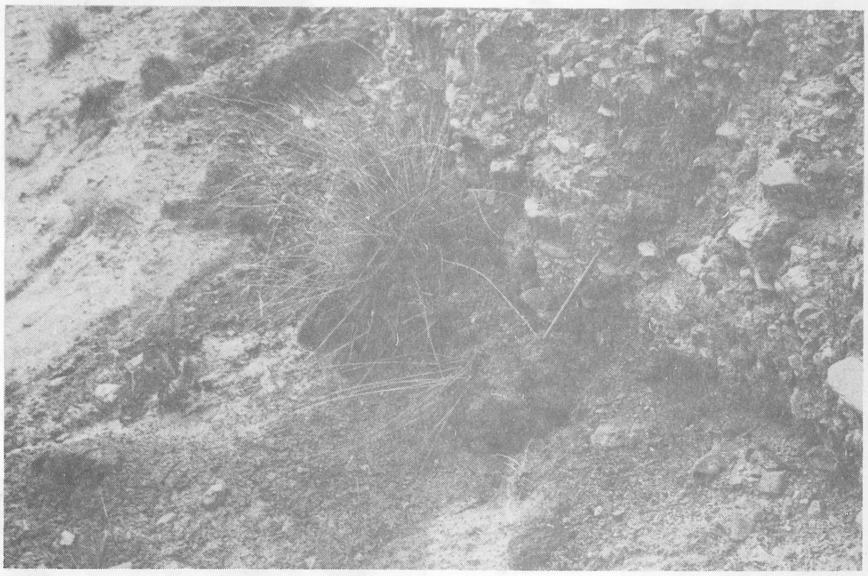


2. Northern part of poorly drained area (indicated by sedge grass) at Freshford, Murrumbidgee Fault escarpment is in the background. View is to northwest (1925 10-13)

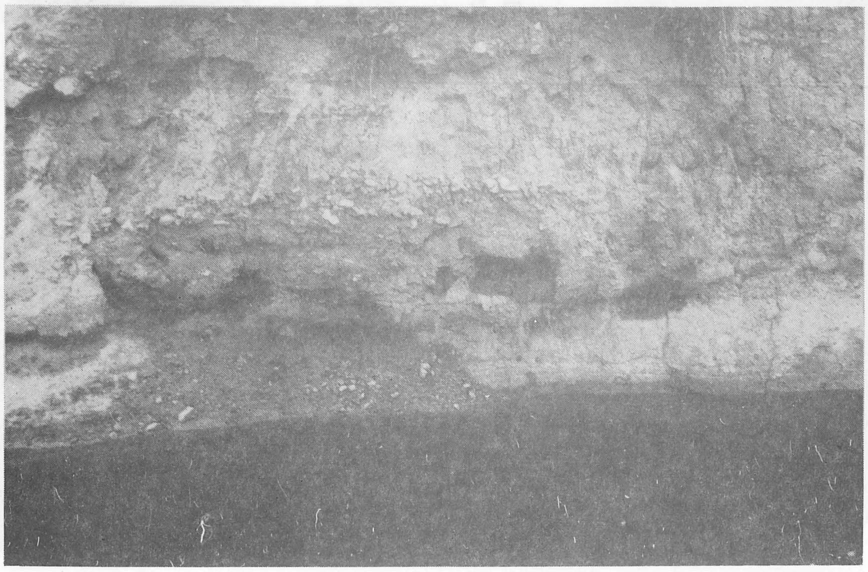
3. Southern part of poorly drained area, showing Freshford homestead left of centre and Murrumbidgee Fault (1925/9)

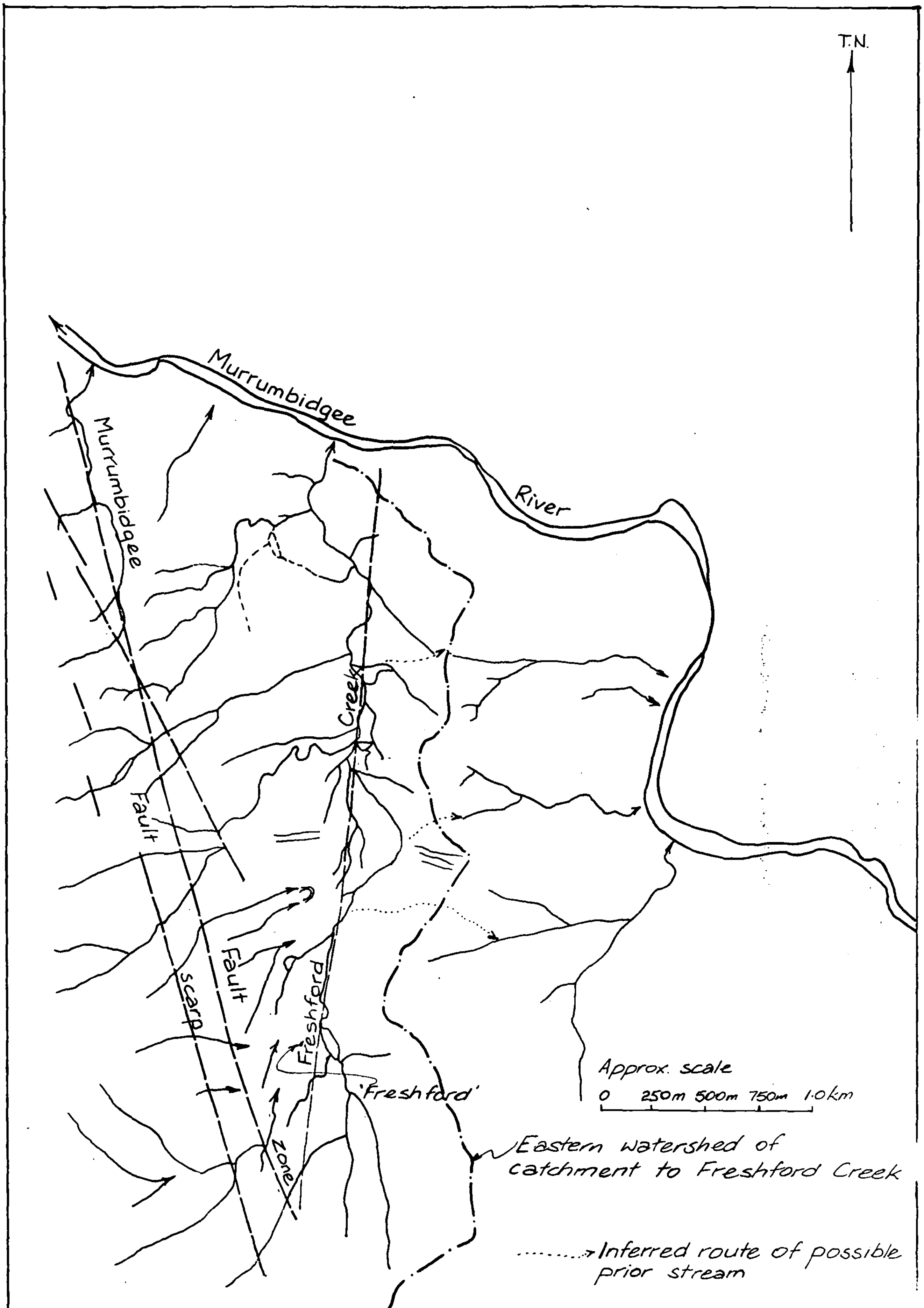
Fig. 4. Eastern boundary of poorly drained area is near foot of hill on volcanic rocks. View is to east. (1925/22)

Fig. 5. Clayey sand and gravel deposits in bank of erosion gully draining eastern margin of ephemeral marsh at Freshford (1925/16)



Figs. 6 & 7 (above) and (below). (gravel aquifers in less permeable alluvium; note seepage from base of shoe-string aquifers (below) (1925/14,15)





INFERRED INFLUENCE OF FAULTS ON DRAINAGE FROM THE MURRUMBIDGEE FAULT SCARP, AND THE POSSIBLE CAPTURE OF PRIOR EAST-FLOWING EPHEMERAL STREAMS BY PRESENT NORTH-FLOWING FAULT-CONTROLLED FRESHFORD CREEK

FIGURE 8

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The alluvium was probably deposited by braided streams of rather limited bed-load capacity. In Recent times, alluvium and colluvium has been dissected by Freshford Creek, which is incised into the sediments to depths of up to 3 m (Fig. 5).

Low hills to the east of the alluvial valley are covered by rubbly outcrops of volcanic rocks and by thin skeletal soils (Pl. 1, Fig. 4).

The drainage pattern between the Murrumbidgee Fault escarpment and the Murrumbidgee River, to the east, suggests that some of the ephemeral streams draining the escarpment once flowed eastwards across the area, and were subsequently captured by headward erosion of Freshford Creek (Fig. 8). This was caused by continued displacement along the fault zone and blocking of drainage paths by rapid sedimentation. The present drainage system is incompletely adjusted to its captured configuration, and the main north-flowing channel is discontinuous (Pls. 1 and 3). This results in flooding of fields adjacent to those areas lacking channels, after prolonged or heavy rain. The northernmost seepage zone (Pl. 1) - just west of the area where one channel of Freshford Creek ends abruptly and is replaced 75 m downslope by a deep gully - is attributed solely to the lack of a stream channel on its western side.

BEDROCK GEOLOGY

The bedrock geology of the area is complex and comprises a sequence of folded and strongly faulted sedimentary and igneous rocks ranging in age from middle Ordovician to post-Late Silurian. Major faulting about the igneous intrusions delimits three geological domains (Pl. 2).

(a) West of the Murrumbidgee Fault zone: A sequence of Ordovician shale, sandstone and quartzite (Os) has been intruded by the Tharwa Adamellite (Smr), partly by a series of fault emplacements.

A chilled zone occurs close to the faulted boundary between the adamellite and the Ordovician sediments. Dyke-like bodies of chilled granodiorite occur within the adamellite along shears. Aplite and microgranite also intrude the adamellite along strongly faulted and sheared zones. Thin sections of mylonitised porphyry and adamellite are described in Appendix 4.

The Murrumbidgee Fault zone includes several parallel shears within the adamellite (Bennett & Polak, 1976), along which lenses of schist have been rafted. The schists were Ordovician sediments which have been caught up in the early stages of faulting and shearing along the fault zone.

(b) Central area, east of the Murrumbidgee Fault zone: This is an area about 1.5 km wide occupied by two intrusive porphyries (Sum_2, Sum_3). A green quartz porphyry (Sum_2) has been intruded by a purple rhyodacite porphyry (Sum_3). The porphyries are transected by numerous faults and shears. The occurrence of aggregates of epidote and purple fluorite adjacent to shear zones within the green quartz prophyry suggests late-stage hydrothermal activity.

(c) Eastern area: This area is characterised by pyroclastic rocks and derived sediments which can be divided into four groups:

(i) Massive blue-green dacitic tuff (Su_4) extends over the northern third and over the southern third of the area. In the north it shows faulted contacts, and in the south it overlies the two porphyries (Sum_2, Sum_3).

(ii) Ashstone and dacitic lapilli tuff (Su_3) underlie the dacitic tuff. These in turn overlie an extensive welded rhyolitic tuff (Su_2), which contains a basal unit of welded rhyolitic breccia (Su_1). About 1 km north of Freshford homestead, this breccia contains an agglomerate unit comprising clasts of purple rhyodacite porphyry.

(iii) The rhyolitic extrusives unconformably overlie a well-bedded sequence of rhyolitic breccia, welded tuff, and tuffaceous sediments called Freshford beds by Jacobson, Vanden Broek, & Kellett (1976)*.
These units crop out in a narrow east-west zone across the centre of the area.

(iv) Steeply dipping fossiliferous shale and tuffaceous sediments (Sum_1) unconformably underlie the Freshford beds (Suf) and unit Su_2, and crop out 1 km west of Point Hut crossing and 1 km north of Freshford homestead.

MURRUMBIDGEE FAULT ZONE: CONSTRAINTS TO DEVELOPMENT

Seismicity

Seismic records have been maintained in the Canberra area only since 1962. These records show that the epicentres of several tremors lie within the Murrumbidgee Fault zone (Cleary, 1967); however, the period of time for which records are available is too short to predict the possibility of, much less the return period of, a damaging earthquake. Such an event is extremely unlikely, but the prominence of the fault and the time of its last displacement, considered to be during the Pleistocene Period (up to 1.8 million years ago), should be considered in planning major construction (see Constraints to development, below).

*Footnote: Although Jacobson & others (1976) described the Freshford beds, they are not shown on their geological map (fig. 4), which is based on a draft 1:25 000-scale geological map compiled by J.A. Saltet. The Freshford beds are shown on Saltet's map, but were not described by him, apart from being ascribed to the Silurian. Saltet stressed that his use of the name Freshford beds was as a field name only. Jacobson & others acknowledged the application of the name by removing Saltet's qualification.

Weathering across fault zone

The zone of faulting and shearing associated with the Murrumbidgee Fault is at least 700 m wide just south of Freshford homestead, and possibly as wide as 1400 m (Pl. 2). The weathering profile across the fault zone has been shown by seismic refraction profiling to be very irregular (Bennett & Polak, 1976). Estimated depths to moderately to slightly weathered rock with seismic velocities of 3400 to 4800 m/s range from 13 to >25 m across individual shear zones.

Constraints to development

Because of the irregular shape of the interface between sound rock and the more extensively weathered overburden, site investigations should be required for major structures. Structures in the area should be designed according to specifications for Zone A of the Standards Association of Australia (1976) Draft Code No. DR76100 'Draft Australian Standard Rules for the Design of Earthquake Resistant Buildings', 15 September, 1976.

GROUNDWATER HYDROLOGY OF FRESHFORD CREEK VALLEY

The catchment area of Freshford Creek is about 8 km^2, or 800 ha (Pl. 2). The most significant recharge area for alluvial and underlying fractured-rock aquifers is the steep, sparsely wooded hillslopes west of the escarpment of the Murrumbidgee Fault zone (Figs. 9, 10).

Fractured-rock aquifers and alluvial/colluvial aquifers appear to be in hydraulic continuity - at least in discharge areas. On hillslopes mantled by colluvium, the potentiometric surface of both aquifer systems is well below the surface, so recharge by infiltration is possible after every rainfall (Fig. 9). On the alluvial flats, however, from auger hole 2F northwards, the potentiometric surface, which in this area becomes a phreatic

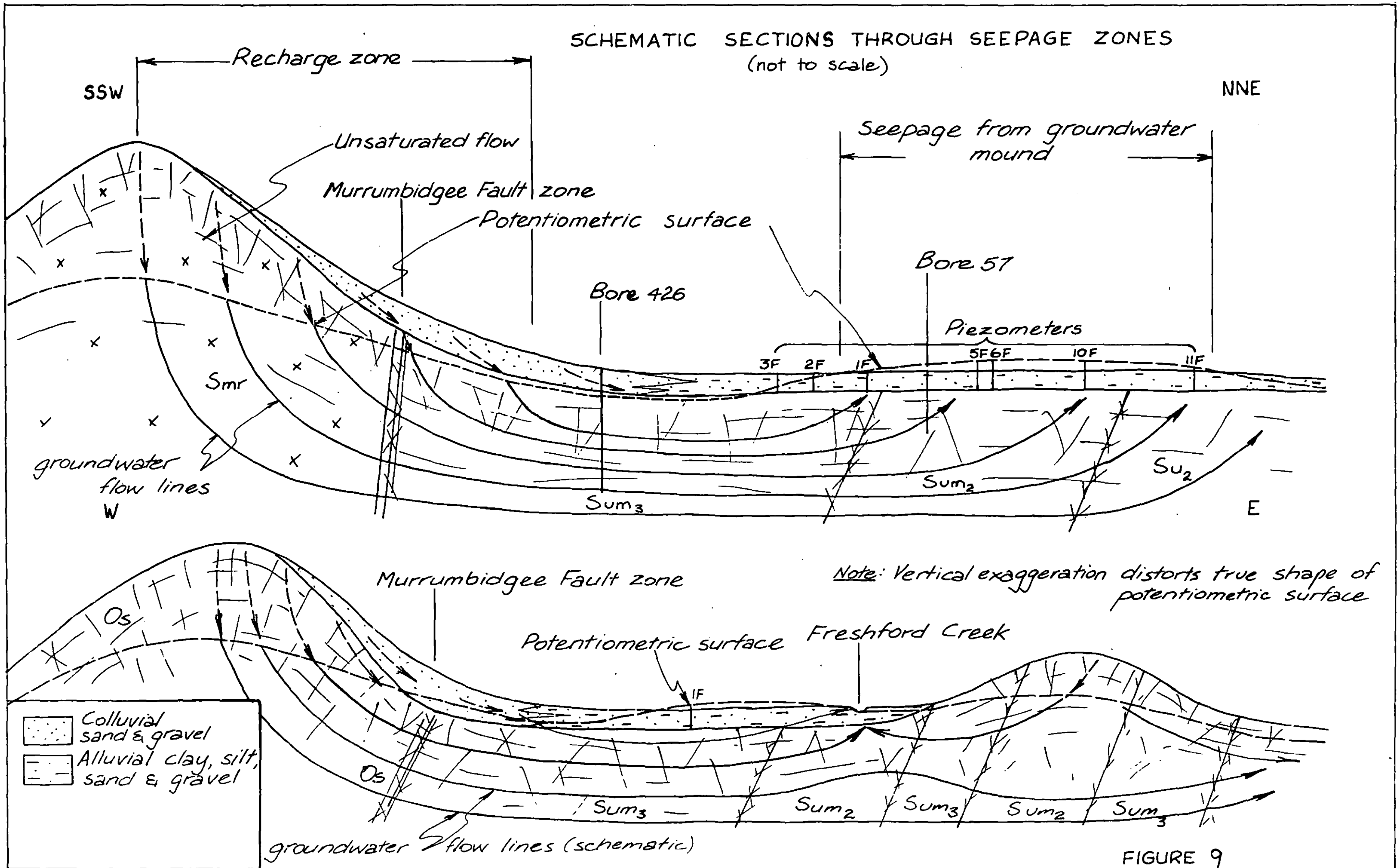

FIGURE 9

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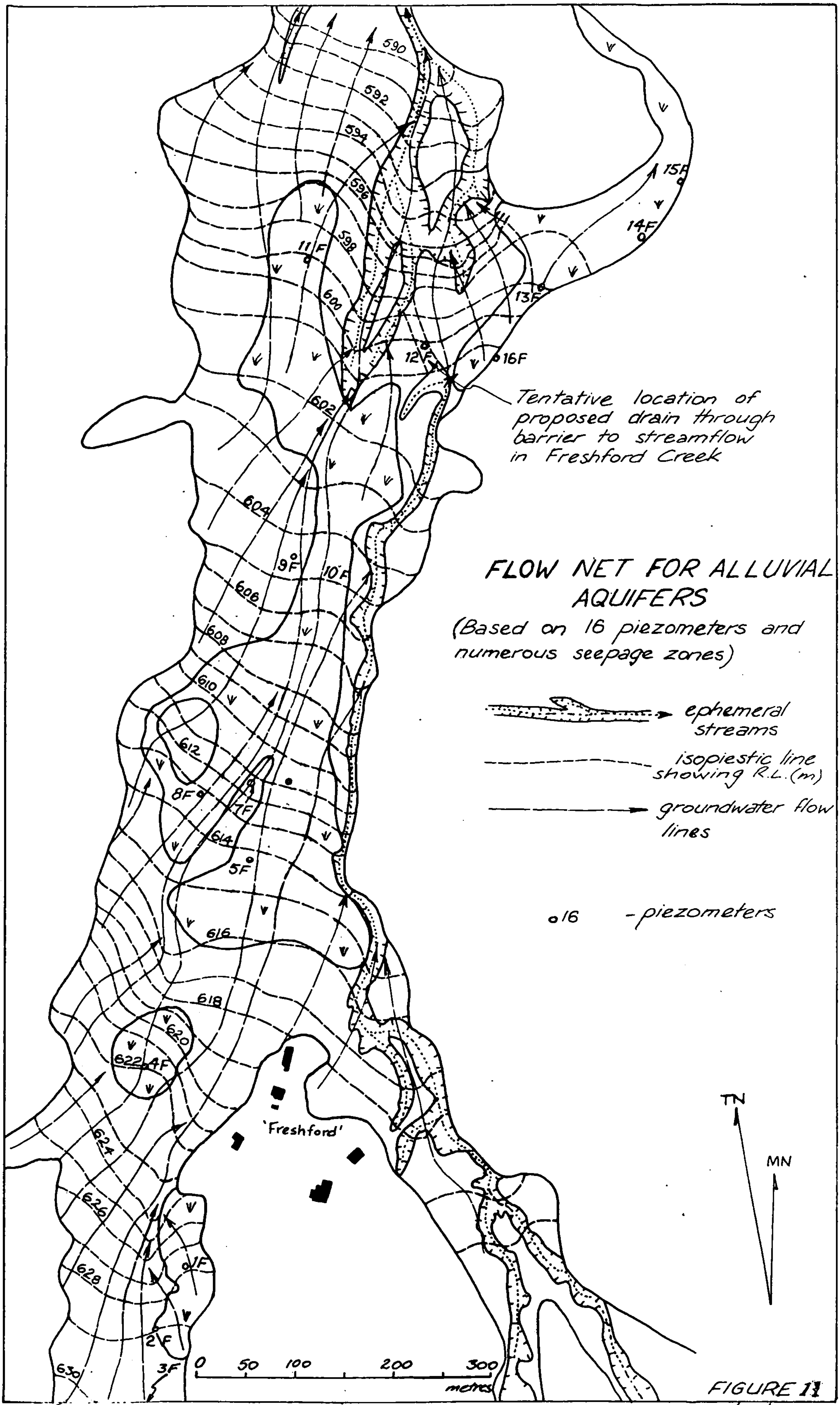
FLOW NET FOR ALLUVIAL AQUIFERS
(Based on 16 piezometers and numerous seepage zones)
ephemeral streams
isopiestic line showing R.L. (m)
groundwater flow lines
o16 - piezometers
Tentative location of proposed drain through barrier to streamflow in Freshford Creek
'Freshford'
590
592
594
596
598
600
602
604
606
608
610
612
614
616
618
620
622
624
626
628
630
1F
2F
3F
4F
5F
7F
8F
9F
10F
11F
12F
13F
14F
15F
16F
TN
MN
0 50 100 200 300
metres

FIGURE 11

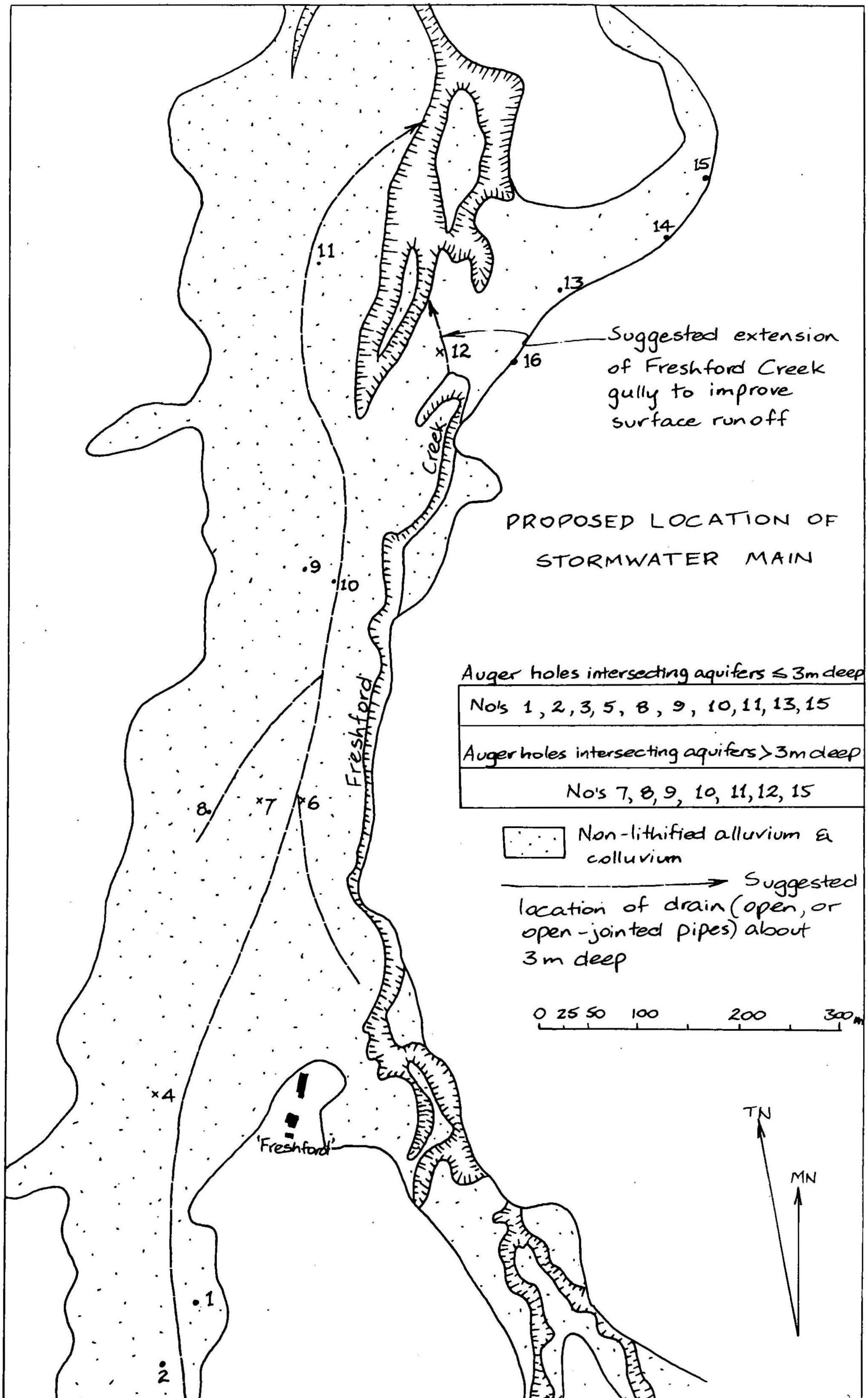

FIGURE 12

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surface, intersects the groundsurface and groundwater discharge takes place (Fig. 9, Pl. 3).

Purple rhyodacitic porphyry (Sum_3, of which T = 0.1 m^2/day; see Appendix 1) underlies the recharge area to the south of Freshford homestead (Pls. 1, 2, 3, Fig. 9). Discharge takes place from a groundwater mound which may be caused by a lower fracture permeability and/or a reduced aquifer thickness in green quartz porphyry (Sum_2) beneath part of the discharge zone. Further down gradient (northwards), the green quartz porphyry (Sum_2) is faulted against welded rhyolitic tuff (Su_2), which may act as a further permeability barrier.

Seepage results from high-permeability alluvial sand and gravel lensing out downslope against finer-grained soils of lower permeability (Pl. 3). The hydraulic gradient (i) of groundwater flowing through sand and gravel with hydraulic conductivities (k) in the range 1-5 m/day is 0.03, from which is calculated a maximum probably flow through this aquifer of 3-15 m^3/day (Q = Aki; where A = 100m^2). This flow rate cannot, however, be transmitted downslope because the sand and gravel lenses out into soils with conductivities of less than 0.1m/day. The result is seepage at the surface wherever the downslope soils have a hydraulic conductivity lower than that of the soil immediately upslope from it.

Four discrete areas of seepage from the alluvium are defined by swamp grass and willows (phreatophytes), and these areas lie along a zone 1450 m long (Fig. 2, Pls. 1, 3).

Seepage from the alluvium is recharged by rainfall and by upward discharge of water from fractured-rock aquifers during periods of high potentiometric surface (Pl. 3). Based on data obtained from a single bore (no. 426; Fig. 10; Appendix 3), the contribution to seepage of groundwater from deep circulation is likely to be no more than 1m^3/day

(Appendix 1). However, other, more permeable, more open-fractured rocks than were intersected by bore 426 probably occur beneath the seepage area, and so higher leakage than $1m^3$/day is likely.

Leakage is transmitted to the alluvium by open fractures: discharge from the fractured-rock aquifers sustains seepage from the alluvium above or downslope of the leakage zone during periods of no rainfall, provided that the potentiometric surface remains above ground surface. A likely source of leakage would be along the major lineament which trends 012^o along the flat alluvial valley at Freshford (Fig. 8, Pl. 1). Seismic refraction surveys (Bennett & Polak, 1976), and airphoto interpretation (Fig. 8) indicate that this lineament may be a fault.

Hydraulic data obtained from auger holes equipped with piezometers

This section describes tests on non-lithified aquifers (alluvium and colluvium). Tests have also been carried out on the only available bore (No. 426) intersecting fractured-rock aquifers (Appendix 1).

Pumping tests

Problems with both the pump and the water-level recorder plagued the pumping tests on auger holes. However, enough reliable data were obtained to make the following assessments of the permeability of the main aquifer types.

Aquifer material	Expected range of hydraulic conductivities
Coarse clean sand and fine gravel (SP, GP)	1-10 m/day
Coarse loose sand (SP)	1-5 m/day
Fine clean sand (SP)	1-5 m/day
Coarse loose, slightly clayey sand (SC)	0.5-1 m/day
Silt (OL)	0.1 m/day
Sandy heavy clay (CL)	0.01 m/day

Water-levels measured in piezometers relative to ground level (Levels shown in m)

R.L.(ground level)	627.5	630	632.5	621	613.5	611	611.5	612.5	605	605	599	600	599	597	596	601 m
Date	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15	F16
	+	+	-	+		+	+	-	-	-	-?	+	-		-?	+
2.11.76	0.40	0.03	2.1	0.27	0.0	0.04	0.47	0.23	1.25	0.98	1.85	0.10	0.06	0.0	3.85	0.09

\+ indicates level above ground;

\- indicates level below ground

? indicates that reliability of reading is suspect owing to incomplete development of piezometer.

Baseflow

Discharge from alluvial aquifers and leaky fractured-rock aqufers also occurs via the erosion gully of Freshford Creek, which drains northwards from Freshford. Chemical analysis of baseflow from this ephemeral stream several weeks after rainfall, shows a total dissolved solids content of 475 mg/1, which is too high for runoff or phreatic water, and indicates that its source is largely deep groundwater. Seepage from deep fractured-rock aquifers moves from the discharge zone into the alluvium and then by lateral flow to the stream banks (see also Figs. 7, 9, Pl. 1).

The stream bed of Freshford Creek is discontinuous about 750 m north of Freshford homestead: after rain water flows out from the streambed across alluvium. The dumping of sediment on the alluvium from earlier floods has built up this section so that water is diverted eastwards in a broad swampy reach around a low hill (Pl. 1, Figs. 10, 12).

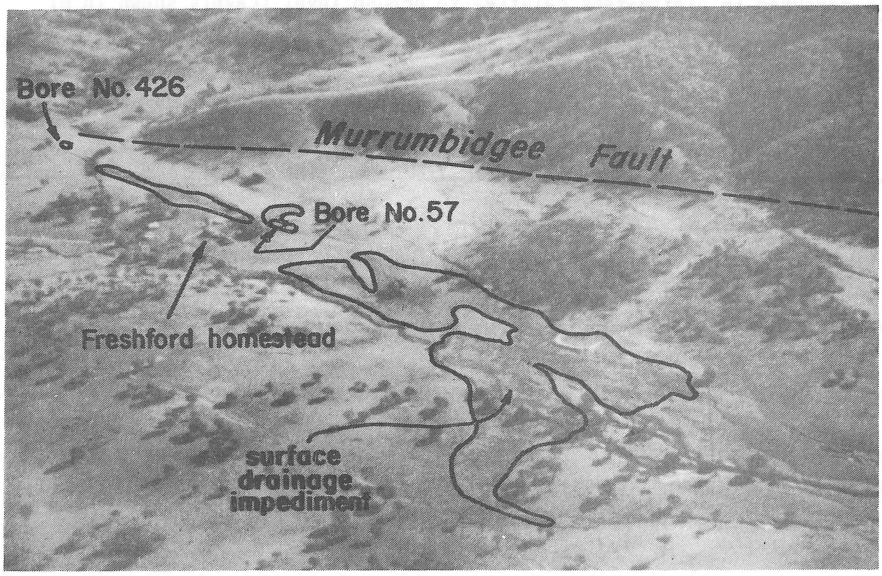

Fig. 10. Oblique airphoto of Freshford, looking southwest, showing seepage areas (darker tones) and Murrumbidgee Fault escarpment. (Film No. 1549).

Proposals for drainage of the area before development

The main points to be made from the study of the hydrology of the Freshford area are as follows:

1. Surface drainage via Freshford Creek is impeded by the absence of a continuous stream channel near auger hole 12F (Pl. 1). Excavating a channel, 75 m long and 1 to 2 m deep, linking the two stream channels would improve the efficiency of Freshford Creek as a drain and would reduce the amount of recharge to the northernmost swampy area (Fig. 12).

2. The large, central swampy area and the two smaller, southern seepage areas (Pl. 1, Fig. 11) are recharged throughout most seasons from deep groundwater sources; conventional pipe drains or open trenches set at depths of less than 3 m are not likely to improve drainage significantly as the material intercepted by the drains would have low permeability, and would not lower the potentiometric surface of the main aquifers.

3. In order to draw down the water-table in swampy areas, two drainage techniques could be considered:

a) Groundwater could be pumped from bores 30-60 m deep intersecting fractured-rock aquifers; however, such a solution is costly to install, and requires continuous pumping and on going maintenance.

b) Gravity drains deeper than about 3 m could be readily excavated in alluvium; trenches would require support, and open drains should have a batter slope of about 45° for stability. The alluvium is up to 8 m deep and ideally drains should be set as close as practicable to the base of the alluvium, consistent with maintaining an efficient grade. If trenches 3 m deep or deeper are to be excavated through the seepage areas for sewerage and other services, then gravity drainage would be prefered because no operating costs would be incurred and minimum maintenance would be required. If deeply set services are impractical, a single stormwater main (3 m deep) about 1.4 km long with some minor but deep collector drains would probably be effective (Fig. 12).

CONCLUSIONS AND RECOMMENDATIONS

1. The main constraint to urban development at Freshford is a groundwater seepage problem. This is caused by groundwater from deep, fractured-rock aquifers with a high potentiometric surface that discharges water to the overlying alluvium. The alluvium ranges widely in permeability and the more permeable materials are generally at depths of more than 3 m and lack continuity in the horizontal plane.

2. Construction of a drainage channel about 75 m long to a depth of between 1 and 2 m linking the two stream channels will improve surface run off from the area by providing a continuous stream channel for Freshford

Creek, but the channel should be designed as part of a major drainage system rather than a short connecting drain which would induce headward erosion in the alluvium.

3. The design of services should ensure that the main aquifers are drained by open-jointed stormwater mains or specially constructed drains set at depths of more than 3 m; a fall will then be assured for any tributary drain that may be required in the future.

4. The location of the Murrumbidgee Fault zone, which is still undergoing minor stress releases, has been accurately determined by seismic refraction as well as by detailed geological mapping. It is recommended that a detailed site investigation be required for structures with high bearing pressures that are planned for construction in the area.

5. High-rise structures to be built within the Freshford area should be designed according to specification for Zone A of the Standards Association of Australia Draft Code No. DR76100 'Draft Australian Standard Rules for the Design of Earthquake-Resistant Buildings', 15 September 1976.

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APPENDIX 1

HYDRAULIC PROPERTIES OF FRACTURED-ROCK AQUIFERS AT FRESHFORD

Two bores have intersected fractured-rock aquifers beneath the Freshford area. A farm bore (no. 57) drilled to a depth of 16.6 m in 1952, was bailed at 4.6 m^3/h for an unrecorded time, and had a drawdown of at least 9 m below an unknown flowing artesian head. The supply came from fractured volcanic rocks (mapped as Sum_2) within the depth interval of 15-16 m.

The other bore (no. 426) was drilled by BMR in 1975 to a depth of 44.5 m. Groundwater was intersected in fractured, moderately to slightly weathered porphyritic rhyodacite (Sum_3) at depths of 11.7 m and 19.4 m. The static head in the bore was only about 30 cm above the upper aquifer, indicating that at this locality the upper fractured-rock aquifer was practically unconfined. Because joints between the two aquifers are mostly filled with pink clay, the lower aquifer is probably at least semi-confined.

Bore 426 was pump-tested at 0.44 m^3/h with pump jet set at a depth of 36.5 m. However, the pump consistently lost suction after about 20 minutes' pumping, so a 'slug test' was carried out to check results of the short-duration drawdown and recovery test. For the 'slug test' the casing was filled to the top (0.72 m above ground) and the fall of the water-level was measured until it recovered to its prior level (before the 'slug' of water was injected).

Results

The drawdown curve, apart from being of rather too short a duration to give accurate results, is stepped. This is probably due to recharge being intersected in several water-bearing fractures close to the upper section of the bore. Both the average gradient of the steeper part of the drawdown curve and that of the longest linear part of the curve were used in the calculation of transmissivity.* The plot of residual drawdown against log (time since pumping started/time since pumping stopped) is a smooth curve that approached linearity in the later stages of recovery.

The 'slug test' was analysed by the method described by Cooper, Bredehoeft, & Papadopulos (1967) and developed by Papadopulos, Bredehoeft, & Cooper (1973). This method, as it was also a short-duration test, was expected to give similar values of transmissivity, but it has the advantage, over the drawdown and residual drawdown tests carried out on the pumping bore, of enabling a value of storage coefficient to be calculated.

Results of the three analyses are summarised below.

Aquifer test	Transmissivity*
'Slug test'	about 0.12 m^2/day
Drawdown test (straight line approximation)	0.08 to 0.12 m^2/day
Residual drawdown test (straight line approximation)	0.07 m^2/day
Average transmissivity:	about 0.1 m^2/day

The 'slug test' analysis indicates that the value of the storage coefficient, S, lies within the following range: $10^{-1} < S < 10^{-2}$. This supports the observation that the fractured-rock aquifers are unconfined or only semi-confined ('leaky').

We can now compare subsurface flow rates for groundwater in fractured-rock aquifers with flow of groundwater in the alluvial aquifers, estimated earlier to be as high as 15 m^3/day.

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*Footnote: Transmissivity (T) is defined as the product of aquifer thickness (b) and hydraulic conductivity (k): i.e. T = kb.

The roughly horizontal flow of groundwater in these aquifers is described by the relation Q (flow) = k.i.A;

where k = hydraulic conductivity (m/day),

i = hydraulic gradient (dimensionless),

and A = cross-sectional area through which flow is estimated to take place. If we assume that flow through the fractured-rock aquifers takes place in a downslope direction through a zone 200 m wide, then

Q = 0.1 m^2/d x 0.015 x 200 m; i.e., throughflow = 0.3 m^3/day, which is small compared to a conservative estimate of throughflow in the more permeable alluvial aquifers, i.e., 2 m^2/d x 0.032 x 125 m = 8 m^3/day.

Conclusions

The fractured-rock aquifers appear to have limited ability to transmit groundwater in the horizontal direction. Downslope of elevations of about RL 630 m, groundwater flow is directed upwards to recharge perched alluvial aquifers. The alluvium then transmits the groundwater laterally if permeability is adequate, or it will discharge water to the surface.

From the above estimates, it appears that the alluvial aquifers would have no trouble coping with recharge from deeper groundwater sources alone. However, additional recharge from interflow from the colluvial hillslopes to the south and west of Freshford, directly to alluvial aquifers, means that zones of lower permeability that occur along the length of the alluvial aquifers cannot transmit all the water received from higher permeability zones upslope (Pl. 3). Water is therefore discharged as seepage to the surface or through the banks of the creek (Figs. 6, 7) to contribute to streamflow. It is this downslope variation in aquifer transmissivities that causes waterlogging of alluvial soils near Freshford.

This is exacerbated by the absence of a continuous stream channel through the alluvial sediments.

APPENDIX 2

LOGS OF UNDISTURBED AUGER HOLES F1 to F16

Fig. A
UNIFIED SOIL CLASSIFICATION SYSTEM

CLASSIFICATION CHART

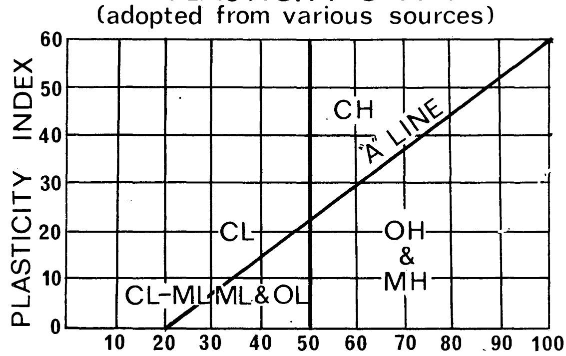
MAJOR DIVISIONS		SYMBOLS	TYPICAL NAMES
COARSE GRAINED SOILS (More than 1/2 of soil > No 200 sieve size)	GRAVELS (More than ½ of coarse fraction > no. 4 U.S. sieve size)	GW	Well graded gravels or gravel-sand mixtures, little or no fines*
		GP	Poorly graded gravels or gravel-sand mixtures, little or no fines
		GM	Silty gravels, gravel-sand-silt mixture
		GC	Clayey gravels, gravel-sand-clay mixture
	SANDS (More than ½ of coarse fraction > no.4 U.S. sieve size)	SW	Well graded sands or gravelly sands, little or no fines
		SP	Poorly graded sands or gravelly sands, little or no fines
		SM	Silty sands, sand silt-mixtures
		SC	Clayey sands, sand-clay mixtures
FINE GRAINED SOILS (More than 1/2 of soil < No. 200 sieve size)	SILTS AND CLAYS Liquid limit < 50	ML	Inorganic silt and very fine sands, rock flour, silty or clayey fine sands or clayey silts with low plasticity
		CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays
		OL	Organic silts and organic silty clays of low plasticty
	SILTS AND CLAYS Liquid limit > 50	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts
		CH	Inorganic clays of high plasticity, fat clays
		OH	Organic clays of medium to high plasticity, organic silty clays, organic silts
	SILTS AND CLAYS Liquid limit ~ 50	CI	Inorganic clays of medium plasticity, sandy clays, silty clays

*fines – portion of a soil finer than a no. 200 sieve

GRAIN SIZE CHART

Classification	Range of grain size: U.S. Standard Sieve Size	Range of grain size: Grain Size in Millimetres
BOULDERS	Above 12"	Above 305
COBBLES	12" to 3"	305 to 76·2
GRAVEL	3" to No. 4	76·2 to 4·76
coarse	3" to 3/4"	76·2 to 19·1
fine	3/4" to No. 4	19·1 to 4·76
SAND	No. 4 to No. 200	4·76 to 0·074
coarse	No. 4 to No. 10	4·76 to 2·00
medium	No. 10 to No. 40	2·00 to 0·420
fine	No. 40 to No. 200	0·420 to 0·074
SILT & CLAY	Below No. 200	Below 0·074

PLASTICITY CHART
(adopted from various sources)



<u>Auger hole FI</u> (6200E 43150S) Locations shown on Plate 1)

Slightly moist	0-10 cm	mod. grey-brown clayey silt (OL)
saturated	10-13 cm	pale yellowish brown, coarse loose sand (SP)
slightly moist	13-100 cm	very stiff, dark charcoal-grey OH clay
	100-150 cm	v. stiff, dark grey OH clay grading down to med. grey OH to CH clay.
	150-165 cm	v. stiff, med. grey with some yellow mottles, CH clay
	165-176 cm	v. stiff, med. grey with some yellow mottles, CH clay
saturated	176-182 cm	coarse, med. grey, loose sand with < 5% clay (SP)
slightly moist	182-192 cm	stratified grey, grey-brown, yellow and grey sandy and pebbly CH clay (CH, CL)
	192-200 cm	stratified grey CH clay with sand and pebbles of volcanic rocks and leachate.
	200-225 cm	no core recovery; possibly sand
saturated	225-235 cm	brownish yellow, fine, clean sand (SP)
	235-260 cm	coarse, clean, granitic sand and fine gravel (< 5mm), becoming clayey towards 260cm (SP,GP)
slightly moist	260-290 cm	pebbly, sandy, silty, clayey alluvium (GC)

<u>Auger hole F2</u> (6100E 43300S)

slightly moist	0-75 cm	dark brown-grey, sandy, silty clay (OH)
	75-90 cm	stratified yellow and pale grey sandy and pebbly clay (CH)
	90-180 cm	30% recovery of stratified, mottled dark grey and orange sandy clay (CL)
	180-225 cm	no recovery; probably gravelly sandy clay
slightly moist	225-255 cm	stratified, mottled pale grey and orange sandy clay (CL - CH)
	255-270 cm	stratified, slightly clayey, sandy gravel - v. well consolidated & well graded but uncohesive (GC)
	270 cm	refusal in well-compacted (probably by auger), pale buff-coloured, sandy, silty slopewash (SM)

Auger hole F3 (6000E 43500S)

moist	0-67 cm	no recovery
	67-75 cm	dark brown silt (OL)
	75-90 cm	dark greyish brown, silty clay (OH)
	90-150 cm	no recovery
saturated aquifer	150-165 cm	grey-brown, loose, silty coarse sand and gravel (GM)
	165-180 cm	yellow-brown, loose, sl. silty, coarse, poorly graded sand (SP)
	180-240 cm	no recovery (probably sand)
	240-250 cm	silty, loose coarse sand (SP)
	250-258 cm	clayey, brownish yellow fine sand (SC)
dry	258-270 cm	stratified and mottled grey, yellow and orange sandy clay giving way to silty, sandy slopewash at 270 cm (CL)
	270-308 cm	yellowish brown, well graded clay - silt-sand-gravel (weathered alluvium or colluvium) (GC)

Auger hole F4 (6200E 42600S)

	0-60 cm	no recovery
slightly moist	60-75 cm	stiff, dark grey silty clay grading downwards to mid grey-brown OH clay
	75-90 cm	stiff, mottled grey and orange clay becoming orange towards 90 cm (CH)
	90-135 cm	no recovery
moist	135-180 cm	orange CH clay with grey horizontal bands
	180-255 cm	no recovery
moist	255-259 cm	dark grey, gravelly, sandy clay (GC)
dry	259-270 cm	mottled orange, grey and red decomposed alluvium and/or colluvium (well graded, silt-sand-gravel, little clay) GM
	270-330 cm	no recovery
dry	330-340 cm	reddish brown, silty fine sand with minor clay (SC)

Auger Hole F5 (6700E 42100s)

slightly moist	0-90 cm	banded dark grey and brown, silty sandy clay (CH) grading to organic clay (OH)
	90-165 cm	medium grey with some orange mottles, clay (CH) with rare, fine to coarse quartz and feldspar sand
	165-175 cm	pale grey, v. sandy clay with orange mottles (CL)
	176-263 cm	diffusely banded greyish and orange, sandy gravelly clay (CL)
aquifer	263-323 cm	v. coarse sand and gravel (mostly 3-6 mm), predominantly quartz, pebbles up to 5 cm; Saturated and uncohesive (GP)
	323-360 cm	stratified coarse sandy grey with orange clay becoming finer and more orange, then more brown with depth (CL)

<u>Auger hole F6</u> (6850E 41900S)

	0-45 cm	no recovery
Moist	45-75 cm	v. dark brownish grey silty clay (OH)
	75-180 cm	dark greyish brown, sandy, silty clay (OH)
	180-270 cm	banded medium grey and orange clay (CH)
saturated	270-338 cm	no recovery, probably loose sand - core barrel contained much water
moist	338-360 cm	banded greenish yellow, pale grey and orange, weathered alluvium comprising clay, sand and gravel (mostly quartz).
saturated	360-450 cm	no recovery, tube full of water
moist	450-480 cm	coarse gravel (5-7 cm), clayey sand, orange, red and brown, in situ weathered river gravel or coarse slopewash (GC)

<u>Auger hole</u> F7 (6750E 41900S)

	0-67 cm	no recovery
slightly moist	67-90 cm	dark greyish brown clayey silt (OL)
	90-135 cm	no recovery

almost dry	135-165 cm	mottled grey, yellowish brown and minor orange, sandy CH clay (approx. 20-30% sand) (CL)
	165-250 cm	v. stiff, dark brownish, olive-grey CH clay
wet clay 270-300 cm	250-340 cm	mottled and banded pale grey and lesser orange slightly sandy CH clay (CH to CL)
dry	340-360 cm	orange clayey alluvium flecked with while sand. Dry and friable.
	360-405 cm	no recovery
saturated	405-435 cm	pale brownish yellow sandy clay-would be mixed up alternate sand and clay layers (CL)
slightly moist	435-450 cm	sl. clayey, friable fine sand containing pebbles (SP)
saturated	450-525 cm	sl. clayey, loose, med. to coarse quartz sand. Pale brownish yellow (SP)
slightly moist	525-540 cm	orange, grey and brownish orange, banded sl. clayey sand with rounded quartz pebble and larger (10cm), highly weathered to mod. weathered granitic cobbles
	540-600 cm	little recovery of clayey sand - probably cave-in material
moist	600-630 cm	banded orange and v. pale grey sandy clay.

<u>Auger hole F8</u> (6500E 41900S)

slightly moist	0-90 cm	v. compacted, dark charcoal-grey clayey silt (OL)
	90-120 cm	no recovery
slightly moist	120-155 cm	dark grey clay (OH) grading down to olive grey-brown sandy clay (CH)
	155-180 cm	mottled medium grey and orange slightly sandy clay (CH) with scattered pebbles
	180-240 cm	no recovery
	240-270 cm	mottled orange and lesser grey clayey sand and gravel becoming dark red rowards 270 cm (GC)
	270-315 cm	no recovery
saturated	315-338 cm	loose, clayey coarse sand and fine gravel (mostly 3-5 mm) (GP)
dry	338-360 cm	banded pale grey and brownish yellow v. fine sand (ML)
	360-390 cm	no recovery
saturated	390-405 cm	loose clayey sand and gravel (cave-in material?) (GC)

dry	405-450 cm	layered and mottled pale grey and yellowish brown fine sand and lean clay (ML-CL)
	450-500 cm	no recovery
saturated	500-520 cm	yellowish brown, sl. clayey medium to coarse sand (cave-in material?) (SC)
dry	520-540 cm	mottled orange, grey and brown, well-graded lean clay, sand and gravel with weathered alluvial pebbles up to 10 cm (GC)
	540-600 cm	no recovery
saturated	600-610 cm	loose sand and gravel (cave-in material?)
dry	610-630 cm	mottled grey, orange and white clayey sand and sandy clay (weathered granitic alluvium) (CL-SC)

<u>Auger hole F9</u> (7000E 41300S)

	0-60 cm	no recovery
moist	60-75 cm	dark brown silt (CL)
saturated	75-90 cm	yellowish brown, silty, gravelly, fine sand (GM)
	90-135 cm	no recovery
saturated (	135-150 cm	brownish yellow, loose, medium grained, well sorted sand (SP)
(	150-170 cm	coarse, loose, gravelly sand (gen. 2-3 mm) (GP)
dry	170-180 cm	v. sandy clay (CL)
	180-225 cm	no recovery
saturated (	225-245 cm	yellowish brown, loose, medium to coarse pebbly sand (probably cave-in material)
(	245-255 cm	yellowish brown coarse sand and gravel with increasing clay with depth
(	255-260 cm	sandy clay (CL)
(	260-265 cm	greenish grey fine sandy clay (CL)
(	265-270 cm	coarse sandy clay/clayey sand (CL/SC)
	270-315 cm	no recovery
saturated (	315-330 cm	clayey, medium to coarse sand (cave-in material?)
(	330-353 cm	greenish grey fine sandy clay (CL)
dry	353-360 cm	mottled orange and grey sandy clay becoming more orange with depth (CL)

Moisture	Depth	Description
saturated	360-420 cm	little recovery- some cave-in material (pebbly sand).
slightly moist	420-438 cm	well graded, clayey silty sandy gravel (mottled orange, grey and brown, red) (GC).
	438-450 cm	pale grey leached silty lean clay (CL)
	450-473 cm	no recovery
slightly moist	473-540 cm	green-grey lean sandy clay flecked with decomposed feldspars and quartz. Looks like in situ-weathered volcanics.
	540-548 cm	green and orange sandy, pebbly clay (CL)
	548-595 cm	no recovery

<u>Auger hole F10</u> (7050E 41350S)

Moisture	Depth	Description
	0-15 cm	dark brown silt (OL)
	15-23 cm	sandy, yellowish brown silt
	23-30 cm	silty sand (SM)
	30-90 cm	no recovery
	90-113 cm	silty sand and sub-angular coarse gravel (GM)
	113-120 cm	silt, fine sand, coarse sand (SM)
	120-180 cm	no recovery
saturated	180-198 cm	coarse alluvial, granitic sand and sub-rounded to moderately rounded gravel (GP)
	198-210 cm	yellowish brown and greyish, clayey fine sand with gravel (GC)
	210-270 cm	no recovery
saturated	270-315 cm	yellow-brown, fine, loose sand
	315-330 cm	yellowish brown, medium to coarse, loose, quartz-lithic sand
	330-360 cm	loose, coarse granitic sand and fine gravel
saturated, well-sorted (poorly graded)	360-390 cm	yellowish brown medium to fine grained, loose sand, grading downwards to:
	390-420 cm	as above but medium to coarse grained, grading downwards to:
	420-443 cm	as above but coarse grained, grading downwards to:
	443-450 cm	as above but medium to fine-grained
saturated	450-540 cm	well-sorted, medium-grained sand with some gravel layers

Auger hole F11 (7200E 40550S)

slightly moist	0-20 cm	dark brown silty (OL)
wet	20-30 cm	yellowish grey v. fine sand or silty sand (SP/SM)
slightly moist	30-45 cm	yellowish and grey sandy clay or clayey sand (CL/SC)
	45-90 cm	no recovery
slightly moist	90-158 cm	mottled orange and grey clayey sand grading down to sandy clay (Cl-SC)
slightly moist	158-173 cm	dark brown with minor orange & brown mottles, CH/OH clay
slightly moist	173-180 cm	mottled orange and grey sandy clay (CL)
very moist	180-240 cm	mottled orange and grey sandy clay/clayey sand (CL/SC)
	240-270 cm	no recovery
wet	270-283 cm	clayey loose sand (SP)
saturated	283-295 cm	silty, sandy gravel (2cm) (GM)
dry	295-315 cm	well graded 'dirty' sand grading downwards to a clayey sand (mottled red, white, brown, grey and orange)
	315-360 cm	no recovery
moist	360-390 cm	yellow-brown fine silty sand with some coarse sand and gravel layers less than 10 cms thick; grades downwards into mottled and banded greenish grey sandy clay.
	390-450 cm	no recovery
saturated	450-510 cm	yellowish and reddish brown, fine to medium grained, well sorted, loose sand with pebbles up to 10 cm
	510-540 cm	no recovery due to pebble jammed in core barrel

Auger hole F12 (7500E 40800S)

very moist	0-15 cm	yellow brown, slightly clayey, silty fine-sand (SM)
very moist	15-20 cm	brown, silty, clayey coarse sand (SC)
very moist	20-33 cm	greyish brown silt (OL)
very moist	33-40 cm	grey brown silty OH clay
very moist	40-65 cm	mottled grey-brown with minor orange, v. stiff sandy, silty CH to OH clay

	65-90 cm	no recovery due to stiff OH clay jamming in barrel
dry	90-112 cm	v. stiff, dark grey OH clay
	112-180 cm	no recovery
moist	180-195 cm	v. stiff, silty, dark grey OH clay
	195-210 cm	mottled orange and dark grey, v. stiff CH and OH clay
	210-218 cm	v. stiff, mottled and banded medium grey and orange CH clay flecked with white clay after feldspars, some quartz sand. (CL)
	218-228 cm	greyish yellow and buff slightly clayey fine sand with coarse gravel fragments (SM/SC)
	228-270 cm	no recovery
saturated (aquifer)	270-293 cm	yellow-brown, clayey fine to medium grained sand (cave-in material?)
	293-330 cm	yellow-brown, fine to medium grained, loose sand with quartz pebbles; yellowish grey medium to coarse sand; thin (< 10 cm) gravel bands (< 1cm pebbles); some slightly clayey sand bands (SP, GP, SC)
	330-340 cm	well compacted, grey, pale brown and orange-banded, silty, clayey fine sand (SC)
	340-360 cm	no recovery
saturated	360-375 cm	mottled brown, grey and orange, silty, clayey fine sand
	375-405 cm	reddish and yellowish brown, well-graded fine sand to v. coarse sand and fine gravel (< 5 mm). Sediment is loose and most grains are well rounded (GW)
	405-418 cm	mottled grey and grey-yellow-brown, silty v. fine sand
moist	418-425 cm	dark brownish grey sandy OH clay
	425-450 cm	no recovery
moist	450-463 cm	greyish brown with orange mottles, sandy silt containing minor clay
	463-483 cm	mottled orange and pale grey, well compacted, fine sandy lean clay (CL)
	483-540 cm	no recovery

saturated	540-615 cm	medium yellowish brown, slightly clayey, medium grained, well sorted, loose sand (SP)
dry	615-630 cm	well compacted, well graded, cream-coloured lean clay, silt and fine to medium grained sand

<u>Auger hole F13</u> (7950E 40700S)

Saturated	0-20 cm	mottled grey, orange, mostly greyish brown silty fine sand grading to clayey sand (SC)
moist	20-30 cm	red clay with grey mottles (CH)
	30-40 cm	cream silty fine sand (SM)
	40-90 cm	no recovery
saturated	90-105 cm	cream to yellow slightly clayey, loose, sandy angular gravel (GP)
	105-113 cm	pale cream fragments of moderately weathered dacite
	113-130 cm	cream, fine sand and lean clay (highly weathered dacite?) (SM, CL)
	130-135 cm	orange and white banded v. fine grained felsic volcanic rock
	135-180 cm	no recovery
saturated	180-245 cm	cream and orange, highly to moderately weathered, fine grained felsic volcanic rock

<u>Auger hole F14</u> (8200E 40600S)

saturated	0-20 cm	brownish grey, clayey silt with a gravel (grains 5 mm) layer 5 cm thick at 15 - 20 cm depth (OL, GM)
	20-41 cm	medium to pale grey CH clay with orange, completely weathered pebbles
	41-51 cm	angular shale fragments cemented by clay (colluvium)
	51-90 cm	no recovery

<u>Auger hole F15</u> (8300E 40500S)

	0-10 cm	brown, slightly clayey fine sand and silt (SC)
	10-15 cm	pale grey, fine, slightly clayey sand (SC)
dry	15-51 cm	medium brownish, yellow, very stiff CH clay
	51-90 cm	no recovery

dry	90-180 cm	compact, banded pale orange and cream, well graded silt- fine sand- medium sand (SM)
	180-190 cm	yellow, very fine sand (SP)
	190-225 cm	very dense, cream and pale orange, well graded lean clay-silt-fine sand-coarse sand (in situ weathered volcanics?) (SC)
	225-270 cm	no recovery
dry	270-390 cm	loose, well sorted, very fine yellow sand (SP)
	390-420 cm	cream, grey, and pale orange banded, very dense lean clay-silt-fine sand (SC)
	420-450 cm	no recovery

<u>Auger hole F16</u> (7800E 40900S)

saturated	0-25 cm	brownish dark grey silt (OL)
dry	25-48 cm	dark, bright red, stiff CH clay with medium grey mottles
	48-60 cm	angular clasts 1-3 cm across, of v. fine sandstone (GP)
	60-90 cm	no recovery
dry	90-180 cm	yellow, very fine to medium grained sand with quartz and sandstone pebbles: some lean clay binding sand (SC)
	180-270 cm	v. fine yellow sand with buff coloured clasts of v. fine sandstone (SP)

APPENDIX 3

GEOLOGICAL LOG OF WATER-BORE 426

BUREAU OF MINERAL RESOURCES, GEOLOGY & GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

A.C.T. No 426

PROJECT FRESHFORD
LOCATION FRESHFORD, WEST MURRUMBIDGEE
ANGLE FROM HORIZONTAL (θ) 90° DIRECTION
COORDINATES 5680E 44960 R.L. OF COLLAR 643m

HOLE NO P13

SHEET 1 OF 3

Rock Type and Degree of Weathering	Description Lithology, colour, strength, etc	Lift and % core recovery	Depth (m)	Structures Joints, veins, seams, faults, etc	Water Level	Water Pressure Test Losses (Lugeons) *
	NO CORE		0–3			
E.W. - H.W. slopewash & talus comprising hornfels, aplite & adamellite clasts	Basal part of core contains indurated scree and slopewash.	20	3–6			
	NO CORE		6–8.6			
M.W. porphyritic rhyodacite	Purple - pink, fine grained Pink feldspars are very small (< 3mm).	40	8.6–10.6	Heavily fractured, most fragments < 7 cm Pink clay on joints.		
M.W. porphyritic rhyodacite	Purple - pink, fine grained Water intercepted at 11.70 m (< 30 g.p.h.)	100	10.6–11.9	Pink, clay filled joints are vertically & horizontally oriented. Epidote veins commence. Fractured rock samples larger ≤ 10 cm.	▽ ▼	S.W.L.
	NO CORE		11.9–15.4			
S.W. rhyodacite porphyry	Very hard rock. Increase in % of pink feldspars which are small (<3-4mm).	100	15.4–16.4	Vertical joints filled with pink clay; sub-horizontal joints with epidote < 2mm Pink veins offset epidote veins		
as above	More brownish - purple	100	16.4–16.7	Rock fragments larger 7-15 cm		
	NO CORE		16.7–20	Water intercepted with higher discharge (at 60 - 70 g.p.h.).	▼	19.40m.

Drill type
Feed
Core barrel type
Driller BMR
Commenced 8.4.75
Completed 29.4.75
Logged by J.P. CEPLECHA
Vertical scale 1:100
Checked by P.D.H.

Notes

Fracture Log — Number of fractures per 25 cm of core. Zones of core loss blocked in.

Bedding and Joint Planes — Angles are measured relative to a plane normal to the core axis.

Defect Frequency — Number of natural defects (shears, joints, fractures) per 25 cm of core occurring at specified intercept angle range.

Water Level Measurements — ▼ Level when hole in progress at specified depth. ▽ Level in completed hole on specified date.

Water Pressure Tests

* *Values in lugeons should be read in conjunction with computation sheets. Test sections are indicated by blocked in strips.*

Core Photograph Negative No.

Depth (m)	Black & White	Colour

BUREAU OF MINERAL RESOURCES, GEOLOGY & GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT FRESHFORD
LOCATION FRESHFORD, WEST MURRUMBIDGEE
ANGLE FROM HORIZONTAL (θ) 90°   DIRECTION
COORDINATES 5680E 44960N   R.L. OF COLLAR 643m

HOLE NO. PJ3

SHEET 2. OF 3.

Rock Type and Degree of Weathering	Description Lithology, colour, strength, etc	Casing	Graphic Log	Lift and % core recovery	Depth and size of Core	Fracture Log (0 6 12 18+)	RQD	Defect Frequency Intercept Angle (0 30 60 90)	Structures Joints, veins, seams, faults, etc	Water Level	Water Pressure Test Losses (Lugeons) *
Fresh porphyritic rhyodacite	Brown - purple. Pink feldspars range 3-5 mm. MW - SW shear zone.		V V	100	21				Vertical joints. Pink clay to 20 m. Shear zone with epidote & slickensides 21·30 - 21·50 m. Epidote veins 1-2mm frequent.		
	NO CORE				22, 23, 24, 25						
Fr. porphyritic rhyodacite	Brown - purple. Pink feldspars more abundant, finer < 2-3mm. Qtz phenocrysts common (3-5 mm)		V V	100	26				< 2mm thick epidote filled fractures are horizontal & 45° to vertical. Show conjugate patterns.		
	NO CORE				27, 28, 29, 30, 31, 32						
Fr. porphyritic rhyodacite	Brown - purple. Fewer pink feldspars. Qtz phenocrysts common (≤ 3-5 mm).		V V	100					Increase in epidote veins. Shear zone 32·30 - 32·60m. Slickensided epidote veins.		
	NO CORE				33, 34, 35, 35, 37, 38, 39						

Drill type
Feed
Core barrel type
Driller BMR
Commenced 8.4.75
Completed 29.4.75
Logged by J.P. CEPLECHA
Vertical scale 1:100
Checked by P.D.H.

Notes

Fracture Log — Number of fractures per 25 cm of core. Zones of core loss blacked in.
Bedding and Joint Planes — Angles are measured relative to a plane normal to the core axis.
Defect Frequency — Number of natural defects (shears, joints, fractures) per 25 cm of core occurring at specified intercept angle range.
Water Level Measurements — ▼ Level when hole in progress at specified depth.
▽ Level in completed hole on specified date.

Water Pressure Tests

** Values in lugeons should be read in conjunction with computation sheets. Test sections are indicated by blocked in strips.*

Core Photograph Negative No.

Depth (m)	Black & White	Colour

record 1980/11

BUREAU OF MINERAL RESOURCES, GEOLOGY & GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT FRESHFORD
LOCATION FRESHFORD, WEST MURRUMBIDGEE
ANGLE FROM HORIZONTAL (θ) 90 DIRECTION
COORDINATES 5680E 44960N R.L OF COLLAR 643m

HOLE NO. P.13
SHEET 3 OF 3

Rock Type and Degree of Weathering	Description Lithology, colour, strength, etc	Casing	Graphic Log	Lift and % core recovery	Depth and size of Core	Fracture Log (0 6 12 18+)	RQD	Defect Frequency Intercept Angle (0 30 60 80 90)	Structures Joints, veins, seams, faults, etc	Water Level	Water Pressure Test Losses (Lugeons) *
	NO CORE				41, 42, 43						
Fresh porphyritic rhyodacite	Brown – purple. Pink feldspars very fine grained < 2mm. and very abundant.		v v	100	44				Epidote veins very common (< 3 mm.) at 30° to horizontal. A few hairline pink clay filled joints.		
	END OF HOLE 44·49m.										

Drill type
Feed
Core barrel type
Driller BMR
Commenced 8.4.75
Completed 29.4.75
Logged by J.P. CEPLECHA
Vertical scale 1:100
Checked by P.D.H.

Notes

Fracture Log — Number of fractures per 25 cm of core. Zones of core loss blocked in.
Bedding and Joint Planes — Angles are measured relative to a plane normal to the core axis.
Defect Frequency — Number of natural defects (shears, joints, fractures) per 25 cm of core occurring at specified intercept angle range.
Water Level Measurements — ▼ Level when hole in progress at specified depth. ▽ Level in completed hole on specified date.

Water Pressure Tests

** Values in lugeons should be read in conjunction with computation sheets. Test sections are indicated by blocked in strips.*

Core Photograph Negative No.

Depth (m)	Black & White	Colour

APPENDIX 4

DESCRIPTIONS OF THIN SECTIONS OF SELECTED ROCKS FROM THE FRESHFORD AREA

(See Plate 2 for sample locations)

Sample 75360043, Tharwa Adamellite (3800E 39200S)

This rock has been intensely strained and is thus pretectonic. The texture is roughly equigranular, and the component crystals are subidiomorphic. Grainsize of primary minerals is in the range 1-5 mm. Quartz crystals are all fractured; some form composite grains and others have markedly undulose extinction. Plagioclase crystals are polysynthetically twinned and are slightly corroded. Potash feldspars are extensively sericitised. Biotite is markedly pleochroic, ragged, and locally chloritised. Twin-planes of plagioclase crystals are slightly bent, and so are cleavage planes of biotite (by as much as 45^{o}). The rock is either a granodiorite or an adamellite.

Sample 75360042, mylonite (5100E 38350S)

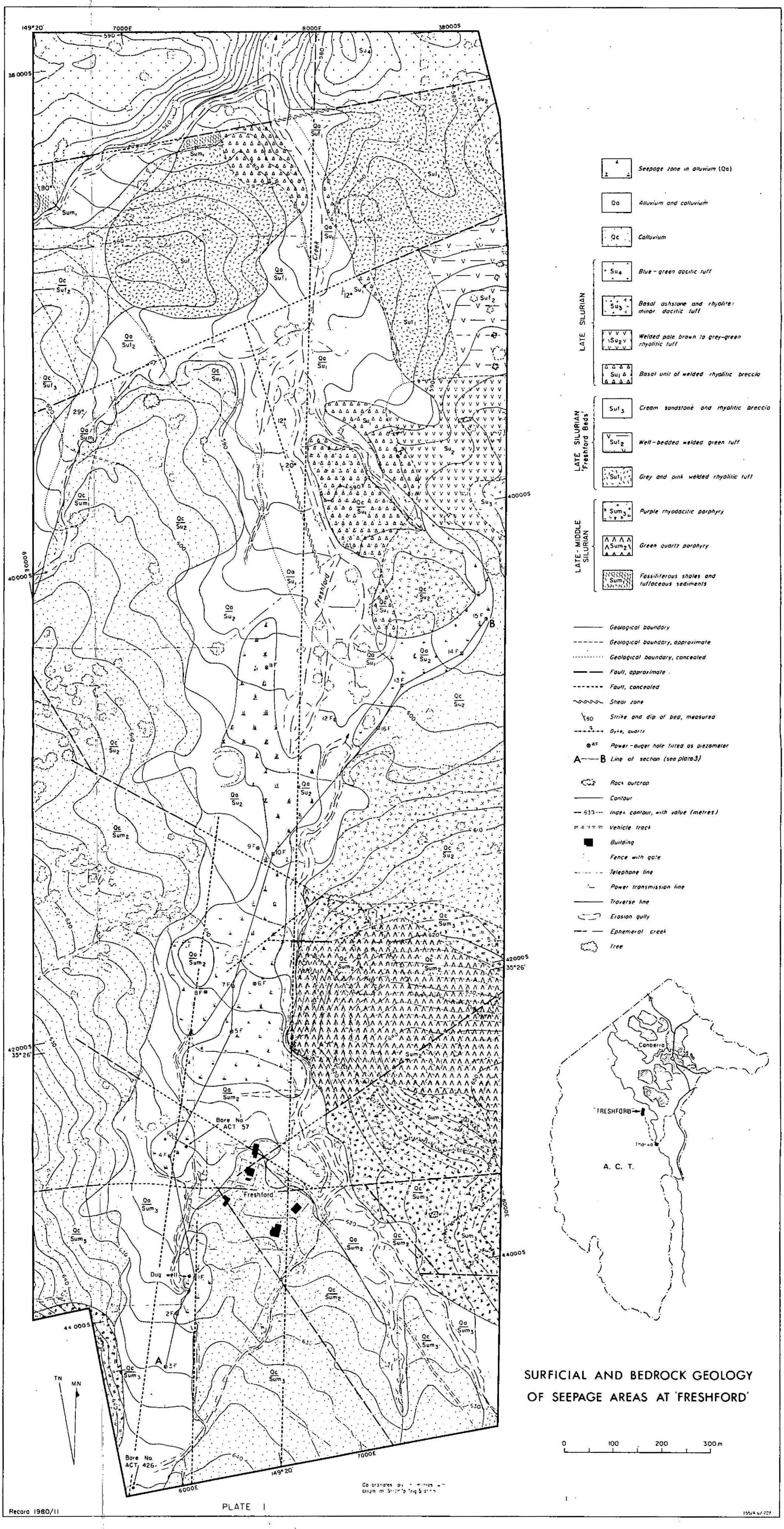
This rock has been intensely sheared. Well-rounded, high-sphericity quartz grains 1-4 mm across are set in a strongly foliated matrix of sericite, very fine-grained granular quartz, and bands of fibrous chlorite. The quartz 'augen' are markedly undulose. Before shearing the rock might have been either a granitoid or quartz porphyry.

Sample 75360041, quartz-feldspar porphyry (5550E 39800S)

This rock comprises subhedral, slightly undulose quartz phenocrysts, subhedral, slightly sericitised orthoclase, and less common, slightly sericitised, multiple-twinned plagioclase. Biotite phenocrysts have altered completely to chlorite and epidote. The groundmass is cloudy and microcrystalline.

Sample 75360040, foliated quartz-feldspar porphyry (?mylonite; 6200E 39550S)

This weakly foliated porphyry comprises coarse-grained, slightly sericitised plagioclase, markedly undulose quartz, incipiently sericitised potash feldspar, and pseudomorphs of chlorite and epidote after biotite, in a streaky matrix of sericite, composite quartz grains, and finely crushed and sericitised feldspars.



Seepage zone in alluvium (Qa)
Qa Alluvium and colluvium
Qc Colluvium
LATE SILURIAN
Su4 Blue-green dacitic tuff
Su3 Basal ashstone and rhyolite: minor dacitic tuff
Su2 Welded pale brown to grey-green rhyolitic tuff
Su1 Basal unit of welded rhyolitic breccia
LATE SILURIAN 'Freshford Beds'
Suf3 Cream sandstone and rhyolitic breccia
Suf2 Well-bedded welded green tuff
Suf1 Grey and pink welded rhyolitic tuff
LATE-MIDDLE SILURIAN
Sum3 Purple rhyodacitic porphyry
Sum2 Green quartz porphyry
Sum1 Fossiliferous shales and tuffaceous sediments
Geological boundary
Geological boundary, approximate
Geological boundary, concealed
Fault, approximate
Fault, concealed
Shear zone
Strike and dip of bed, measured
Dyke, quartz
Power-auger hole fitted as piezometer
A—B Line of section (see plate 3)
Rock outcrop
Contour
Index contour, with value (metres)
Vehicle track
Building
Fence with gate
Telephone line
Power transmission line
Traverse line
Erosion gully
Ephemeral creek
Tree
Canberra
FRESHFORD
A. C. T.
Freshford
Freshford Creek
Bore No ACT 57
Bore No. ACT 426
Dug well
TN
MN
SURFICIAL AND BEDROCK GEOLOGY OF SEEPAGE AREAS AT 'FRESHFORD'
0 100 200 300 m
Co-ordinates are in metres with origin at Stromlo Trig Station
PLATE 1


GEOLOGY of 'FRESHFORD' A.C.T.
PLATE 2
TN
MN
PADDYS RIVER
PARISH OF CONGWARRA
AREA OF SURVEY SEE PLATE 1
Abandoned farm bore No. 57
Freshford
pumped dugwell
Seismic traverse F1
BMR observation bore No. 426
Seismic traverse F2
Seismic traverse F3
Fault Zone
Watershed of catchment to Freshford Creek
Post Silurian
Dolerite dyke
Late Silurian
Microgranite
Aplite
Smr Tharwa Adamellite/chill zone or dyke
Su4 Blue-green dacitic tuff
Su3 Basal ashstone and rhyolite: minor dacitic tuff
Late Silurian
Su2 Welded, pale brown to grey-green rhyolitic tuff
Su1 Basal unit of welded rhyolitic breccia
'Freshford Beds'
Suf3 Cream sandstone & rhyolitic breccia
Suf2 Well bedded welded green tuff
Suf1 Grey and pink welded rhyolitic tuff
Suf0 Bedded tuffaceous sediments including breccia
Middle to Late Silurian
Sum3 Purple rhyodacitic porphyry
Sum2 Green quartz porphyry
Sum1 Fossiliferous shales and tuffaceous sediments
Middle to Late Ordovician
Os Sandstone, shale & quartzite
Seismic traverse (Bennett & Polak, 1976)
Fault, position approximate
Fault marked by quartz veins
Shears (mylonite in adamellite)
Strike and dip of bedding and trend of pitch of lineation
Field observation or sample number
Fossil locality
Strike of major joints
Geology by J. P. Ceplecha
0 100 200 300 400 500 600 700 800 900m 1km
I55/A16/2289
Record 1980/11

VERTICAL SECTION THROUGH SEEPAGE ZONES AT FRESHFORD

(View is to ESE)
[Refer to Plate 1 for line of section]