3. THE PHYSICAL ENVIRONMENT

3.1 Climate

Recording stations at Natte Yallock, Dunolly and Maryborough provide annual rainfall data relevant to the study area. Rainfall ranges between 450 and 510 millimetres p.a. and falls mainly in the winter months. Temperatures are consistent with a Mediterranean climate averaging 26^{o} – 29^{o} C during summer and 12^{o} – 14^{o} during winter.

3.2 Geology and Geomorphology

A batholith of lower Devonian age (the Natte Yallock Pluton) has a marked influence on the physiography of the area (Figs. 2 and 3). Consisting predominantly of medium grained granodiorite, it presents a landscape of gently undulating hills (slopes to 5%) with rock outcrop on upland crests (slopes to 14%).

A metamorphic aureole of muscovite schist, hornfels, slates and quartzites surrounds the pluton forming Mt Hooghly and the Black Ranges. These ridges rise sharply from the surrounding terrain with slopes exceeding 20%. Skirting them on all sides are colluvial aprons which grade gently 3-8% slopes) into alluvial country.

A wide alluvial plain begins in granitic country near Dunluce, broadening southwards separating the two metamorphic ridges branching eastwards between Bet Bet and Emu Creeks. West of the Black Ranges the alluvial plains of Homebush Creek and the Avoca River are up to five kilometres wide. Deep alluvium covers approximately fifty per cent of the study area to depths of 80 metres and contains occasional limestone deposits at shallow depth (at Timor West for example).

Dissected sedimentary terrain of Ordovician age (tightly folded sandstone and shales) is present south of Bet Bet Creek and on the eastern fringes of the Mt Hooghly range (slightly metamorphosed) with slopes to 14%. A small area of basalt occupies a southern portion of the study area near Wareek. Originating from vents to the south, a tongue of basalt buried beneath 5 – 15 m of alluvium and some fifteen metres thick extends eastwards through the Bet Bet valley. The approximate trace is shown on the geological map (Fig. 2).

Tertiary gravels form hill cappings in the Dunluce area. Remnants of a deeply weathered landscape persist in isolated locations on the upper slopes of the granite country. Tertiary river gravel deposits which occupied valley 3 – 7 million years ago have been buried beneath alluvium. These buried streams, known as deep leads, constitute a significant aquifer system throughout the northern slopes of the Western Uplands.

3.3 Soils

From the geology and soils maps, Figs. 2 and 4 respectively, soil boundaries in most areas are seen to correspond with geological boundaries. Soils were examined and mapped with an emphasis on hydrological properties such as texture, depth and permeability and there are several soil units which overlap geology where properties vary slightly across the boundary. The alluvial soils are particularly complex and have been given special attention.

Sampling traverses and spot checks involving one hundred and thirty-eight sites were used in conjunction with air photo interpretation to define soil boundaries. Field investigation of soil types recognised soil depth, colour, presence of A2 horizon, stoniness, texture and particularly depth of B horizon. Infiltration tests on the clay horizon of different soils, combined with information on soil hydrological properties from Dyson and Jenkin (1981), and field assessment allowed an evaluation of hydrological performance and recharge to be summarized for each soil class.

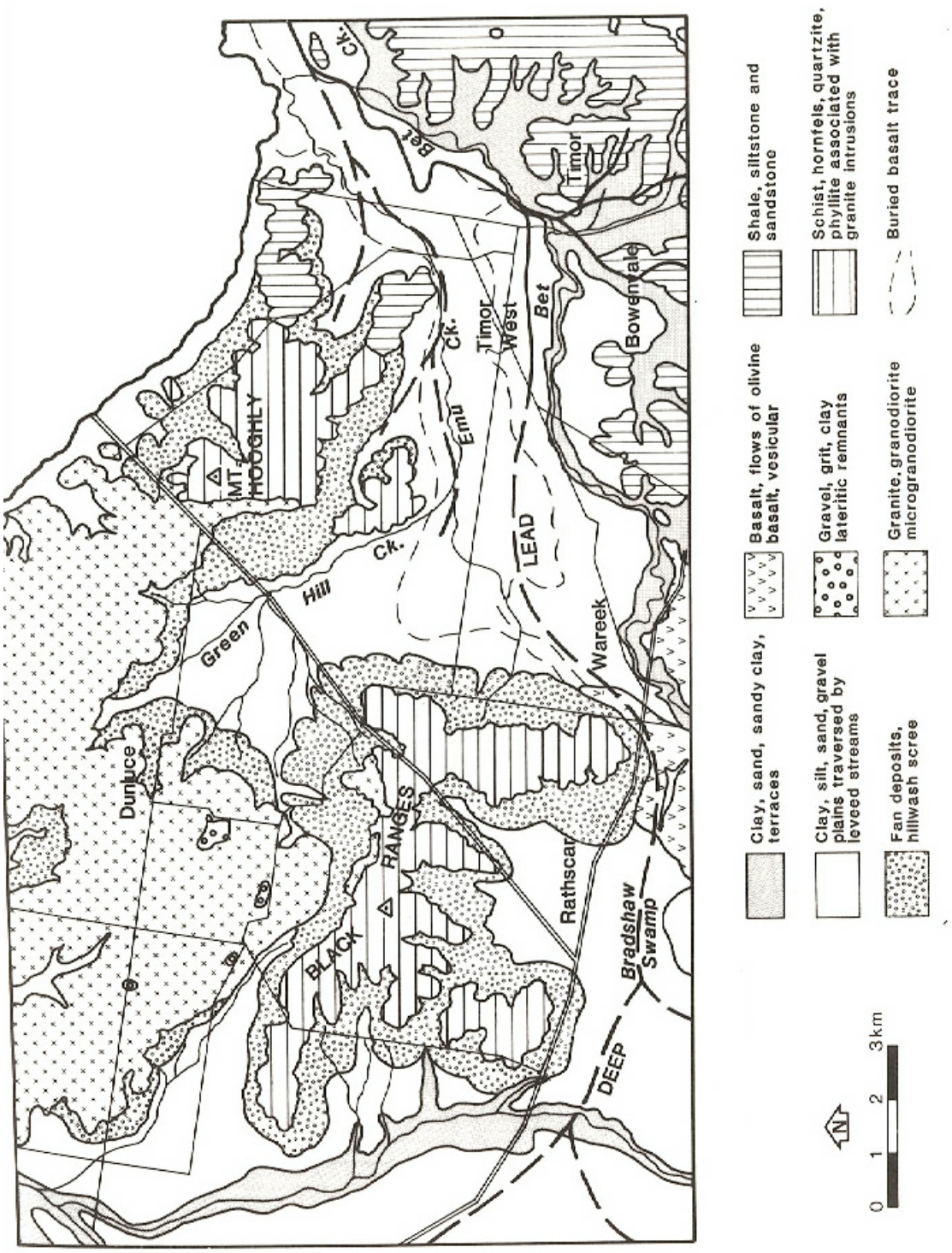

Fig. 2 – Timor – Black Range - Geology

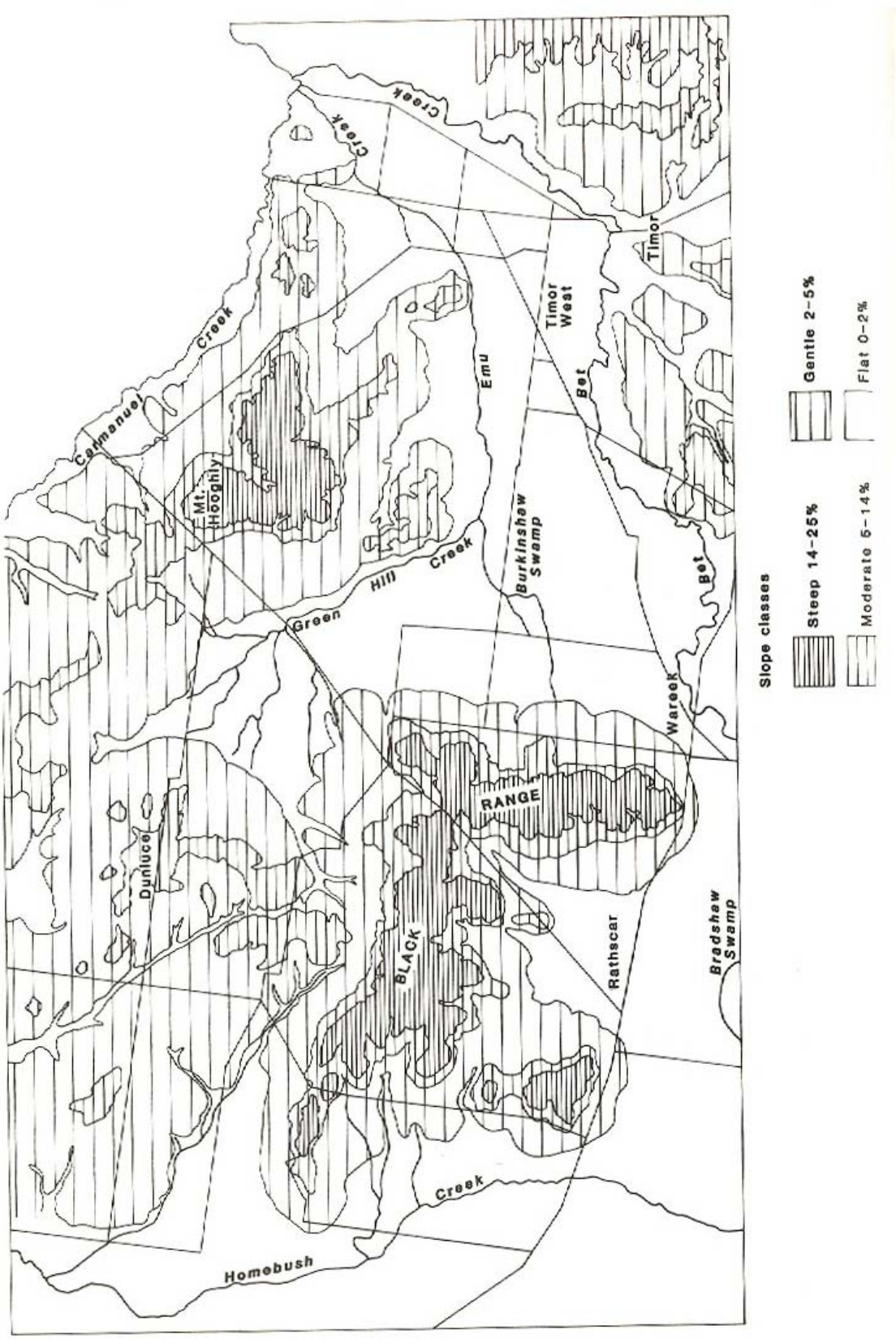

Fig. 3 – Timor West – Black Ranges - Slopes

3.3.1 Soil Descriptions

Soils on metamorphic hills

The steep metamorphic ridges carry shallow stony soils of predominantly uniform texture with gradational soils occurring in pockets on the lower slopes. Infiltration rates are high, often in excess of 3 metres per day, indicating that this terrain should be regarded as having high recharge potential.

Soils on Ordovician terrain

Ordovician sediments typically possess shallow gradational soils on hill crests with red duplex soils on the gentle convex slopes. The low permeability of the B horizon of duplex soils indicates low recharge to groundwater (<3 mm/day).

Soils on granite terrain

On the upslope crests in the Dunluce area boulder outcrop is common. Soils are predominantly yellow/brown sands of uniform texture and variable depth. Permeability is very high although much of the infiltrating water travels laterally above the impermeable bedrock, emerging as seeps or springs on the lower slopes.

On the upper slopes mottled reddish/grey to grey/brown heavy clays have developed, possibly influenced by a sporadic occurrence of remnant lateritic material. A siliceous hardpan exists between 0.5 and 1.5 metres depth over much of the undulating granite landscape, probably due to silica precipitation associated with groundwater fluctuations.

The gentle undulating lower slopes carry red sodic duplex soils above the hardpan. A highly permeable sandy loam A horizon overlies a relatively thin B horizon (20 – 50 cm) of reddish clay. The B horizon restricts deep percolation, evidenced by the saturation of the A2 horizon which becomes 'spewy' during wet periods.

The low permeability of the clay horizon, the siliceous hardpan and the bedrock factors indicate the granite terrain has low recharge potential. The low inherent salt content of granitic bedrock and of groundwater associated with granitic terrain indicates why this terrain is commonly free of salting problems except where deep weathering occurs.

Basaltic soils

Soils formed on the basalt near Wareek are typically grey calcareous uniform textured cracking clays, commonly gilgaied. When soils are dry and cracked, access of rainfall to groundwater is possible, however once wet the clays swell and soil permeability is very low. Basaltic terrain has been assigned a low recharge rating.

Soils on Tertiary gravel cappings

These remnant hill cappings occur in three small locations near Dunluce. Mottled reddish-yellow and duplex soils are common overlying an impermeable cemented gravel bedrock. Recharge to groundwater is very low.

Colluvial soils

Coalescence of broad outwash fans skirting the Black Ranges and Mt Hooghly has formed extensive colluvial slopes above the alluvial plains particularly on the southern and eastern flanks of these hills.

Soils formed on the upper slopes are stony and gradational, with duplex soils of higher clay content occurring on the lower slopes. Stony soils of the upper slopes, having higher recharge than the duplex soils of the lower slopes, are represented as separate soil types on the soils map.

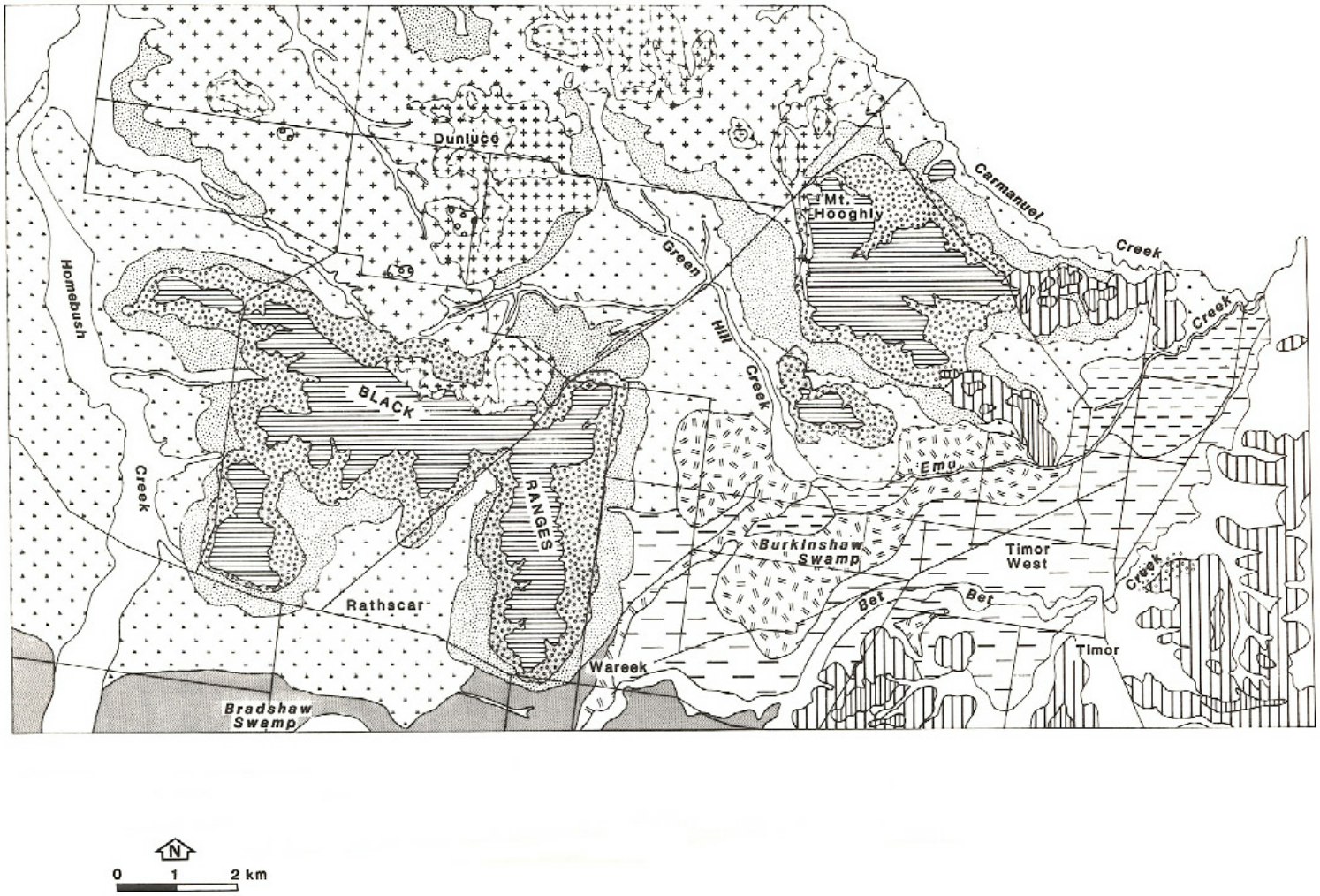

Fig. 4 – Timor West – Black Range – Soils Map

LANDSCAPE KEY

Map Character	Geology	Slope Components	Area sq km	Area %	Soil Types	Soil Infiltration Rates	Groundwater Recharge Potential
	Ms Metamorphic schists, gneiss	Steep ridges + slopes to 30%	18.6	7.3	Thin skeletal soils. Stony with gradational soils on lower slopes.	> 3 metres/day	Very High
	Oll Ordovician sediments	Hillcrests 5-14%	2.8	1.1	Shallow stony gradational soils	2 metres/day	High
		Gentle slopes 2-5%	14.3	5.6	Reddish duplex soils	< 3 mm/day	Low
	Dlg Granite/Granodiorite	Upper crests 5-14%	4.6	1.8	Yellow/brown U sands	> 3 m/day	Low (bedrock impermeable)
		Upper slopes 8% off crests	9.8	3.8	Yellow/brown, grey, red brown clay soils with siliceous hardpan	< 3 mm/day	Low
		Gently undulating terrain 2-5%	27.9	10.9	Reddish duplex soils above hardpan	3-10 mm/day	Low
	Tm Tertiary Gravels	Hillcappings 2-5%	0.3	.10	Reddish yellow mottled clay soils	< 3 mm/day	Low
	Qvn Quaternary Volcanics	Gentle basaltic plains 0-2%	8.9	3.5	Heavy grey calcareous uniform clay soils	< 3 mm/day	Low
	Qrc Quaternary fan deposits	Outwash fan upper slope 5-14%	18.2	7.1	Gradational stony soils	> 3 m/day	High
		lower slope 2-5%	25.1	9.8	Reddish duplex often calcareous at depth	2-7 mm/day	Low
	ALLUVIUM Qc Sands, silts, clays	drainage courses	35.9	14.0	Sands, clay-commonly yellow-brown duplex soils	< 3 mm/day	Low
	1	Alluvial plains 0-1%	51.9	20.3	Reddish calcareous duplex soils	< 3 mm/day	Low
	II Sands, clays gravel, plains traversed by leveed stream Qs	Alluvial plains 0-1%	11.7	4.6	Grey calcareous uniform clay soils	variable 3-50 mm/day	Moderate
	III	Alluvial plains 0-1%	19.5	7.62	Reddish sandy/clay soils	15-30 mm/day	Moderate
	IV	Alluvial plains 0-1%	6.0	2.3	Yellow brown dark duplex soils	< 3 mm/day	Low
		Total	255.5				

The soils of the western and southern slopes of the Black Ranges have a light textured sandy A horizon and calcium carbonate nodules are common at depth in the B horizon. These properties appear less marked east of the Black Ranges. The gentle colluvial slopes associated with granodiorite and Ordovician sediments carry duplex soils and have low recharge potential.

Alluvium and soils formed on alluvium

The alluvial soils constitute the largest soil group in the study area. Mapped as Quaternary sediments on the geological mapsheet (Department of Minerals and Energy, St Arnaud 1:250,000 sheet), the group includes clays, silts, sand, gravel on plains traversed by leveed streams. It is necessary to examine these alluvial soil types more closely and map them separately, on the basis of their hydrological properties. For example, the sandy clays developed on the alluvial plains adjacent to the granitic country will be different from the less permeable cracking clays derived from a basaltic source.

Alluvium derived from granitic, metamorphic and sedimentary parent material

Soils formed on alluvium derived from granite, metamorphic and sedimentary rock are grouped together. Reddish duplex soils, which contain significant amounts of sand where the alluvium is derived from granodiorite, predominate. Infiltration rates are usually less than 5 mm per day.

Alluvium of the Bet Bet valley

The plain between Emu Creek and Bet Bet Creek has a complex depositional history and warranted closer study.

A unit of grey calcareous clay, notably heavier texture near Burkinshaw Swap, conforms to the trace of buried basalt which occupies the centre of the valley. The extent of the soil may be related to the basalt even though the soil is derived primarily from alluvium. Basalt boulders are exposed in drainage lines and dam excavations near Burkinshaw Swamp where the depth to basalt is less than four metres.

A dark grey loamy A horizon some twenty-five centimetres thick overlies a lighter coloured light clay subsoil, containing calcium carbonate nodules. Soil permeability is moderate (up to 45 mm per day) because of the well structured subsoil and occurrence of calcium carbonate. Textural and colour variation appears to be related to surface drainage conditions and the depth of the underlying basalt.

The grey calcareous clay is truncated at Green Hill where an arm of the Ordovician bedrock has narrowed the valley. It is possible that swamp or lacustrine deposition occurred upstream from the barrier and the presence of limestone beds at depths between ten and twenty metres over a large area at Timor West would tend to support a prior lake bed theory. A more likely explanation for the presence of limestone however is the precipitation of calcium carbonate associated with weathering basalt (P. Dyson, pers. comm. 1983).

An area of reddish brown alluvium exists largely south of the grey clay at slightly higher elevation extending from Timor West to Wareek. This area is extensively cropped. The predominant soil has a deep sandy A horizon overlying a highly permeable (50 – 200 mm/day infiltration) light-medium sandy clay B horizon. Northwards towards the confluence of Carmanuel, Emu and Bet Bet Creeks, soils are yellow-brown duplex although the grey calcareous unit persists along the course of Emu Creek.

Green Hill Creek, which drains much of the granite country contained within the study area, carries large peak flows following heavy rains. This has caused extensive gullying and sand deposition in the lower reaches near its confluence with Emu Creek and broad areas north of Burkinshaw Swamp are subject to flooding during peak discharge periods.

In summary, the alluvial soils are commonly ascribed moderate recharge potential because free drainage of alluvial country is often slow, allowing gradual recharge even through duplex clay soils.

The uniform grey clay soils and reddish sandy clay soils of the Bet Bet valley have moderate infiltration rates. The flooding of Green Hill Creek and high runoff from the slopes of the Black Ranges draining into the Burkinshaw Swamp region may cause high groundwater intake through the alluvial soils in this region.

3.4 Soil Infiltration Measurement

Infiltration tests were carried out on six sites within the project area (Fig. 6). Nests of between three and six infiltration rings were driven into the B horizon clay at each site, filled with water and the change in level monitored over time. Care was taken to ensure a constant infiltration rate was attained under saturated conditions.

A generalised infiltration rate of each soil type was used to estimate the recharge for each landscape unit. A map of broad recharge zones (Fig. 6) represents a summary of the soil infiltration data.

Soil Infiltration Measurements

Sample Site		Infiltration Rate	Recharge Estimate
1.	Colluvial slopes, duplex soils	2-7 mm/day	Low
2.	Reddish-brown alluvial duplex soils	30 mm/day	Moderate
3.	Grey calcareous alluvial soils at Timor West	43 mm/day	Moderate
4.	Grey calcareous alluvial soils at Burkinshaw Swamp	10 mm/day	Low
5.	Granitic duplex soils on lower slopes near Dunluce	3-5 mm/day	Low
6.	Reddish duplex alluvial soils near Green Hill Creek	3-5 mm/day	Low

A guide to recharge is as follows:

Low recharge	0-15 mm/day
Moderate recharge	15-80 mm /day
High recharge	80->300 mm/day

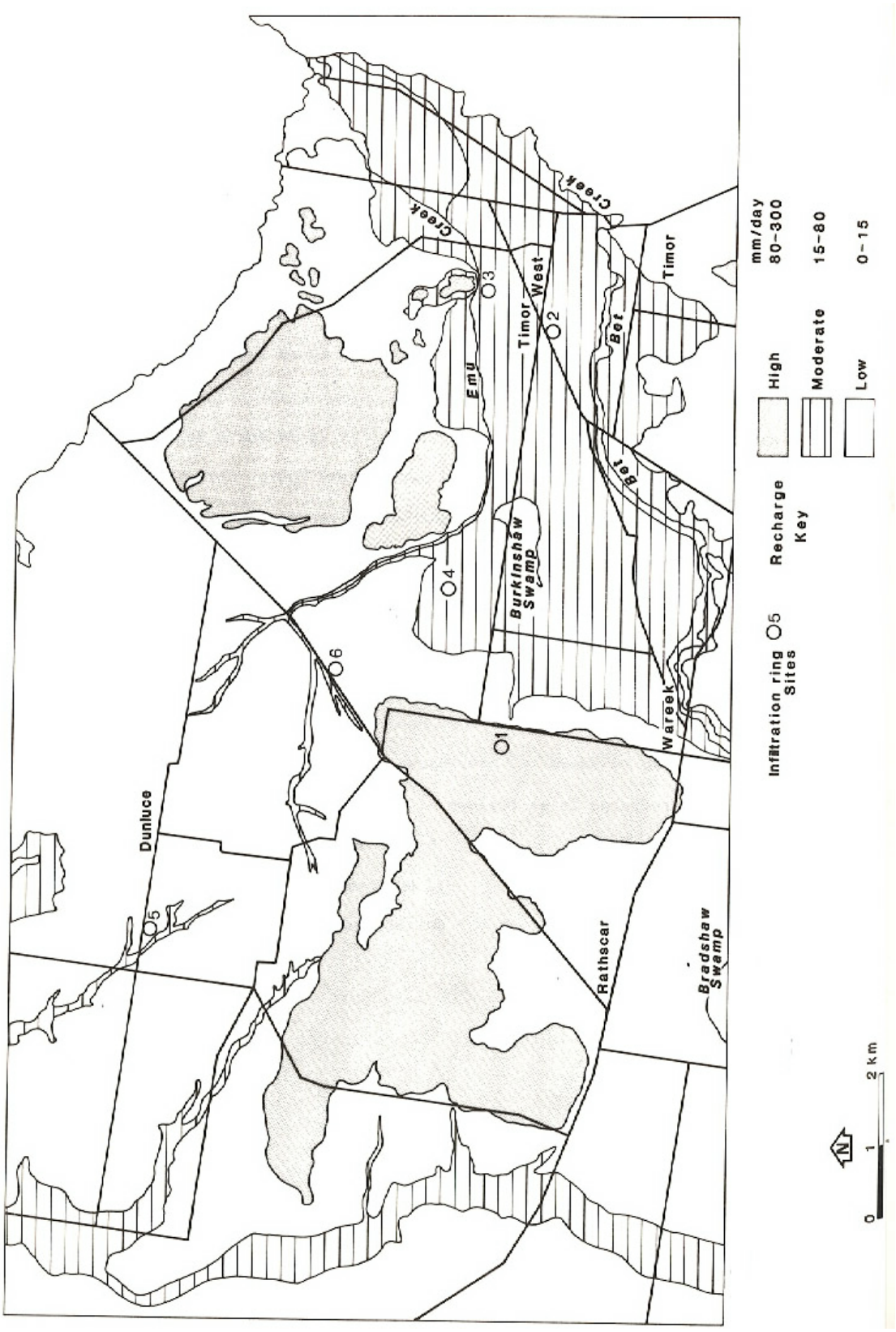

Fig. 6 – Timor West – Black Range – Broad Recharge Zones