INFILTRATION AND HYDRAULIC CONDUCTIVITY

Infiltration and hydraulic conductivity measurements were taken over the study area in order to determine any differences in hydrological properties between soil types (see map 6).

Infiltration and sorptivity

A simple infiltration model was to determine infiltration and sorptivity characteristics of the soil.

$$I = St^{½} + At$$[1]

Where I = depth of eater infiltrated
S = sorptivity
A= a parameter related to the hydraulic conductivity of the soil.
t= time measured from initial ponding.

Methodology

Given the terrain and time available, single ring infiltrometers were used (30 cm diameter, 30 cm deep). Although there was a possibility for some error as there was no buffer zone around the ring, the generally fast rate of infiltration in the study area reduced the need for a buffer zone, as did the replication of sites.

The infiltrometers were driven into the soil surface approximately 12 cm, this being an average minimum figure as the sloping surface meant the ring had a variable depth in the soil.

Field measurements

There were 27 infiltration sites (see Map 6) giving a total of 66 readings covering all the major soil types. The emphasis of this methodology was to determine the differences between the soil extremes and determine inter-soil variability given the field situation.

The 'timeliness' of these tests (including hydraulic conductivity) is important because of the relevant soil moisture status at different times of the year and therefore any relevant behavioural changes of the tests under study. The initial moisture status is likely to influence the behaviour of the test by determining the soil moisture gradient (and therefore suction) between the incoming moisture and the surrounding soil.

The majority of infiltration and hydraulic conductivity tests were carried out in July, august and September 1982. Rainfall was only 20%, 36% and 93% of the long-term average for these respective months (see table 1 for sites 1 and 2 for the relevant long term averages). This indicates a notably dry winter. Field data were plotted 9drop in 'head' against elapsed time) and sorptivity was then derived.

Results

The results for both infiltration and sorptivity are given in Appendix 3. Plots of this data on a log/probability scales are shown in Figs. 13 and 14. The data show that there is a range of results for all soil types, however certain patterns emerge.

There is a trend of increasing infiltration from 'dry' soil areas to 'wet' soil areas. The exception to this is the gully floor situation which is small (spatially) in comparison. The trend of increasing infiltration is summarised by the relevant geometric mean of the distribution of each soil type.

e.g. G ('wet' soil) = 0.744 mm/s (2678 mm/hr)
G ('dry' soil) = 0.315 mm/s 91134 mm/hr)

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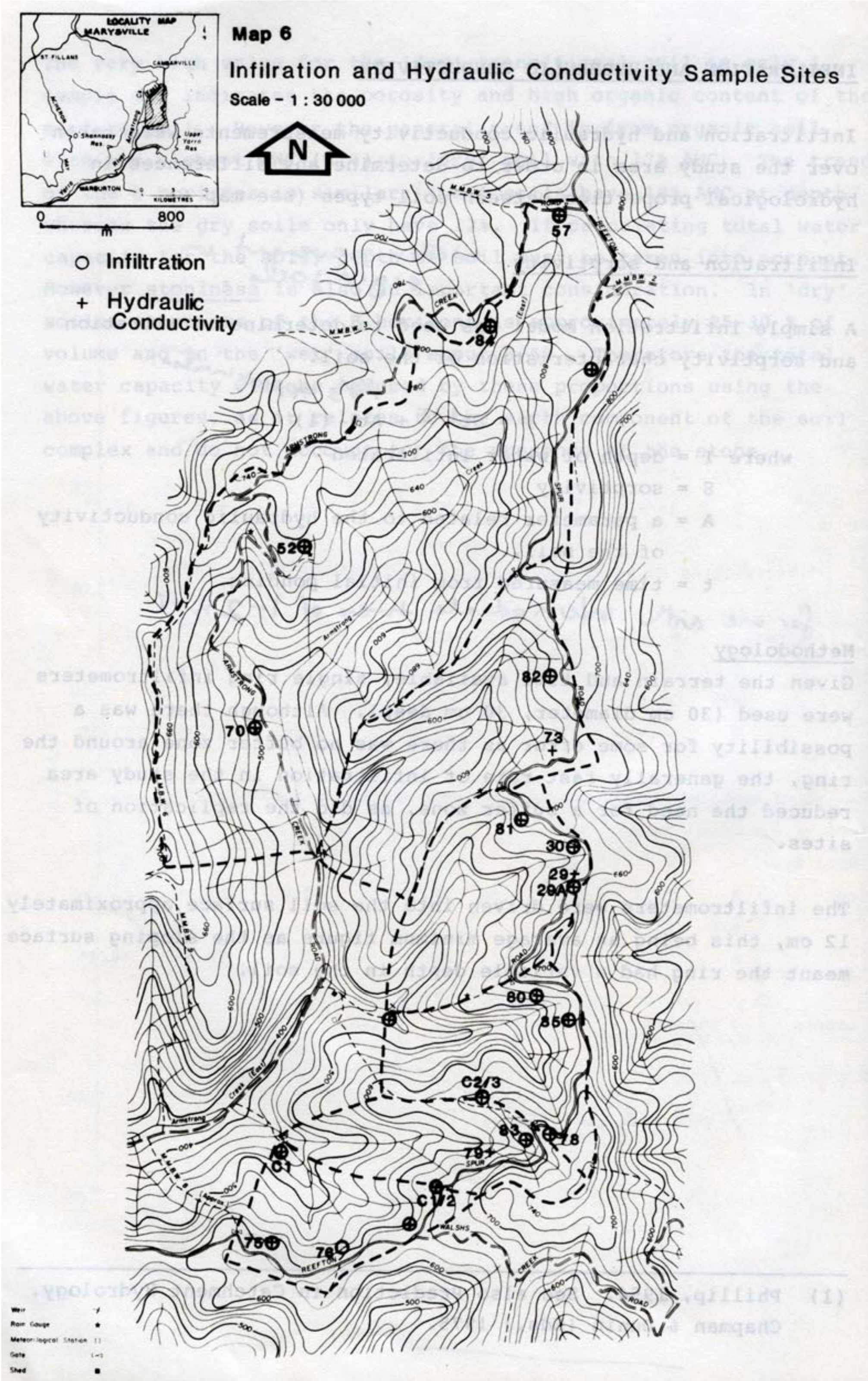
[1] Phillip, 1954. See also Prediction in Catchment Hydrology. Chapman & Dunin (Eds.) 1975



Map 6 – Infiltration and Hydraulic Conductivity Sample Sites

Therefore there seems to be a substantial difference between the infiltration capabilities of the 2 soil types. The values for the two transitional soils fall in between the above figures. (See Table 9)

There is a similar trend for sorptivity, however, due to the relationship of this property to the infiltration the rate is less divergence between soil types.

Infiltration and sorptivity have been plotted on log/probability paper to determine the distribution of data rather than just a mean figure. From the distribution of data there is a converging trend toward a maximum or near-maximum value for both infiltration and sorptivity, particularly for sorptivity. (see also Table 10).

Observations and correlations with other parameters can be made.

Firstly, there is a greater depth of surface organic material within the 'wet' soil areas than in the 'dry' soil areas.

Secondly, the A horizons are deeper within the 'wet' soil areas than the 'dry' soils. In both soils A horizons have lower bulk densities than B horizons, although this is more strongly expressed in the 'wet' soils.

Thirdly, the presence or organic material is significant in producing a more open surface texture, holding water to infiltrate into the soil profile proper and greater porosity.

Although these properties vary spatially for each soil category as the distribution of results shows, the general trend of less infiltration in 'dry' soil areas is evident. Some accelerated surface erosion due to previous logging activity may well have affected the 'dry' soil areas.

Table 9: Infiltration; Geometric mean for each soil type.

Soil type	W	(W)T	(D)T	D
Geometric Mean (mm/s)	0.744	0.629	0.36	0.315

Table 10: Sorptivity; Geometric mean for each soil type

Soil type	W	(W)T	(D)T	D
Geometric Mean ($mm/s^{1/2}$)	12.28	10.45	8.97	7.96

Table 11: Hydraulic conductivity; Geometric mean for each soil type.

Soil type	W	(W)T	(D)T	D	Geometric mean
Geometric Mean (10^{-5}) (m/day)	0.238 (0.206)	0.34 (0.294)	0.2775 (0.240)	0.22 (0.190)	0.267 (0.231)

Hydraulic Conductivity

Methodology

Hydraulic conductivity was measure in-situ. Though more indicative as to the nature of soil water movement, the natural variability of soils under forest vegetation required a sizeable number of samples to be taken. Flora and fauna activity within the soil and stoniness are important to the behaviour of water movement.

The shallow well pump-in method of Talsma and Hallam was used. A hole is augered to a required depth (i.e. 50 cm) and filled with water to a pre-determined mark, in this case 25 cm. The "Talsma" tube, filled with water, is then placed in the hole keeping a constant head of water at the required depth
(25 cm).

Measurements are taken at set time intervals, recording the fall of the water level in the tube.

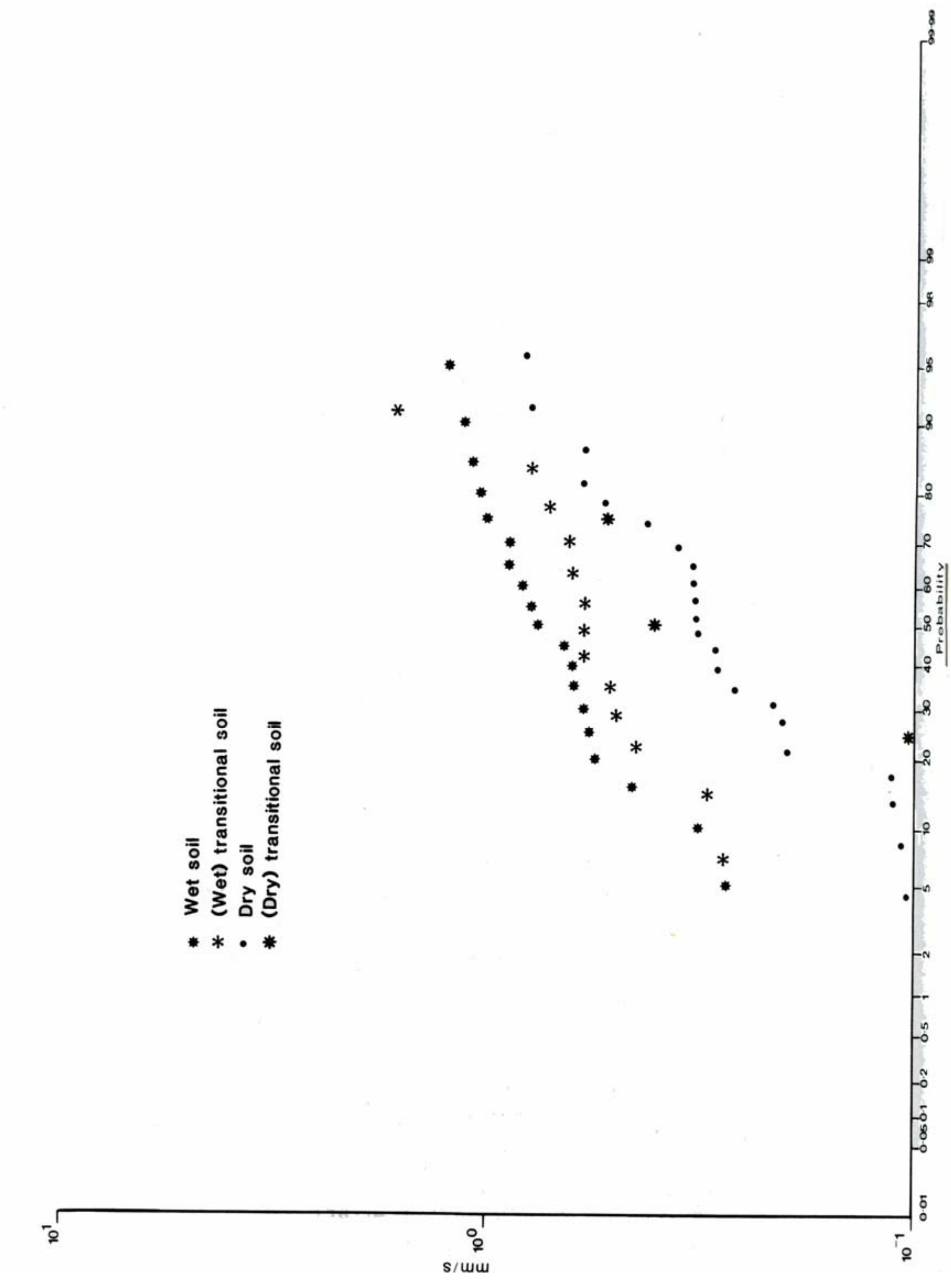


Figure 13 – Infiltration (mm/s)

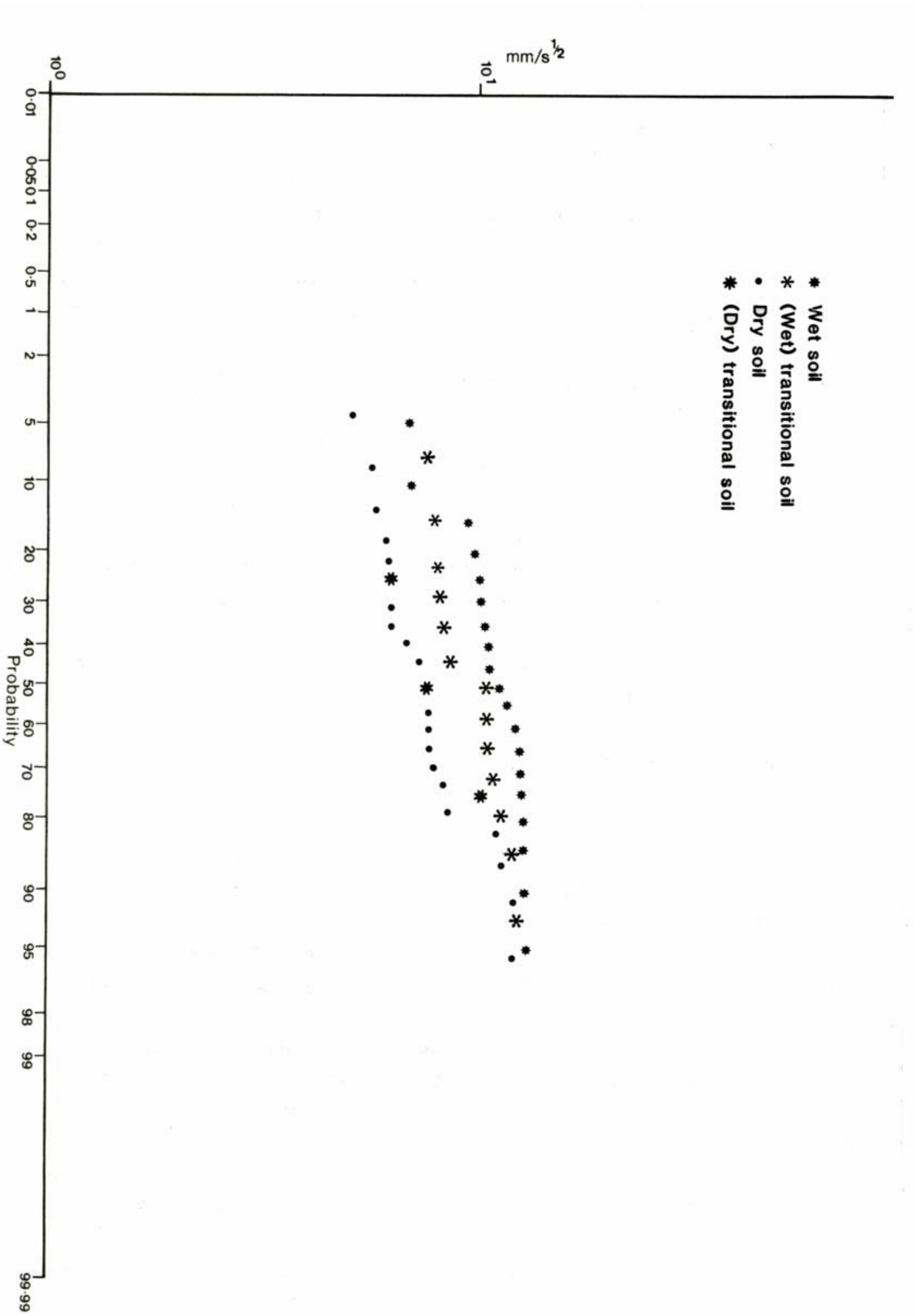


Figure 14 – Sorptivity ($mm/s^{1/2}$)

The data is plotted and hydraulic conductivity results given by using one of a number of formulae depending on the proximity of impervious layers and the radius of the hole augered.

Results

From 22 sites, 107 results were recorded, for a depth range of 25-55 cm 9average figures, giving an average water depth of 30 cm) were recorded. Another 10 results were taken for deeper holes but their reliability was questioned by the need to generate more data to substantiate the existing data.

These results were plotted on log/probability paper to compare the distribution for each soil type, leading to a number of conclusions (see fig. 15).

Firstly, there are similar geometric means for all major soil types. Any suggestion of significant differences between soil types is thought to be unlikely, as extreme results can distort the distribution and its mean. (see Table 11).

Secondly, though the distribution plots are generally similar there is a wide range of hydraulic conductivity values for all soil types which vary and therefore the spatial variability must correspond.

Comparing soil types, other factors should be considered.

Variability is due to internal soil difference, particularly biological activity such as roots and animal activity and stoniness. The geology is an important factor in determining the ultimate behaviour of soil water movement in the soil. In this case the movement along fracture lines and soft vertically-bedded strata means soils water percolates to ground water level without significant sub-surface (soil/rock interface) ponding. The proportion of water movement through the strata and that along the soil/strata interface is unknown at present.

The values calculated for ‘wet’ soils are for a combination of A and B horizons while for ‘dry’ soils, values are predominantly for B horizons due to the shallowness of the a horizons. As well as the closeness of unweathered rock, the high proportion of stoniness in ‘dry’ soils limits available water capacity and therefore limits to some extent the channels for water movement. The stoniness factor could also be a source of error due to disturbance of the area surrounding the auger hole when augering. The movement of stones would create new fracture lines and sloe natural ones, as well as damaging the auger.

Generally, ‘dry’ souls have proportionally lower clay contents than the more deeply developed ‘wet’ soils and bulk densities for ‘wet’ soils are greater at depth.

On average the soil can be classed as having moderately slow hydraulic conductivity, particularly the B horizons. Using classes derived from the USDA, the classification of the Reefton soils into these classes can be made.

Table 12 Hydraulic conductivity classes (metres/second (10^{-5})): Proportions per class (%)

Soil type	v. slow <0.043	Slow 0.043-0.14	Moderately slow 0.14-0.43	Moderate 0.43-1.4	Rapid 1.4-4.3	V rapid 4.3+
W	3.6	32.1	32.1	28.6	3.6	
(W)T		17.4	34.8	39.1	4.35	4.35
(D)T		33.3	26.7	33.3	6.7	6.7
D	11.45	11.45	45.7	20.0	5.7	5.7

The above indicates a generally even distribution of categories except for the ‘dry’ soil type which peaks markedly in the moderately slow category. Standard statistical techniques indicate that there is no significant difference in hydraulic conductivity for this depth range (refer to mean values). The log/probability graphs give the best indications of the distribution of data for each soil type.

Hydraulic conductivity results for greater depth (i.e. 60-85 cm range) drop to approximately 0.1 m/s (10^{-5}). However these results are only preliminary as factors such as soil shearing and smearing, using the auger-hole method, may unduly reduce the 'real' hydraulic conductivity rate. It has been found that though these soils are well structured, they are susceptible to smearing via compaction.

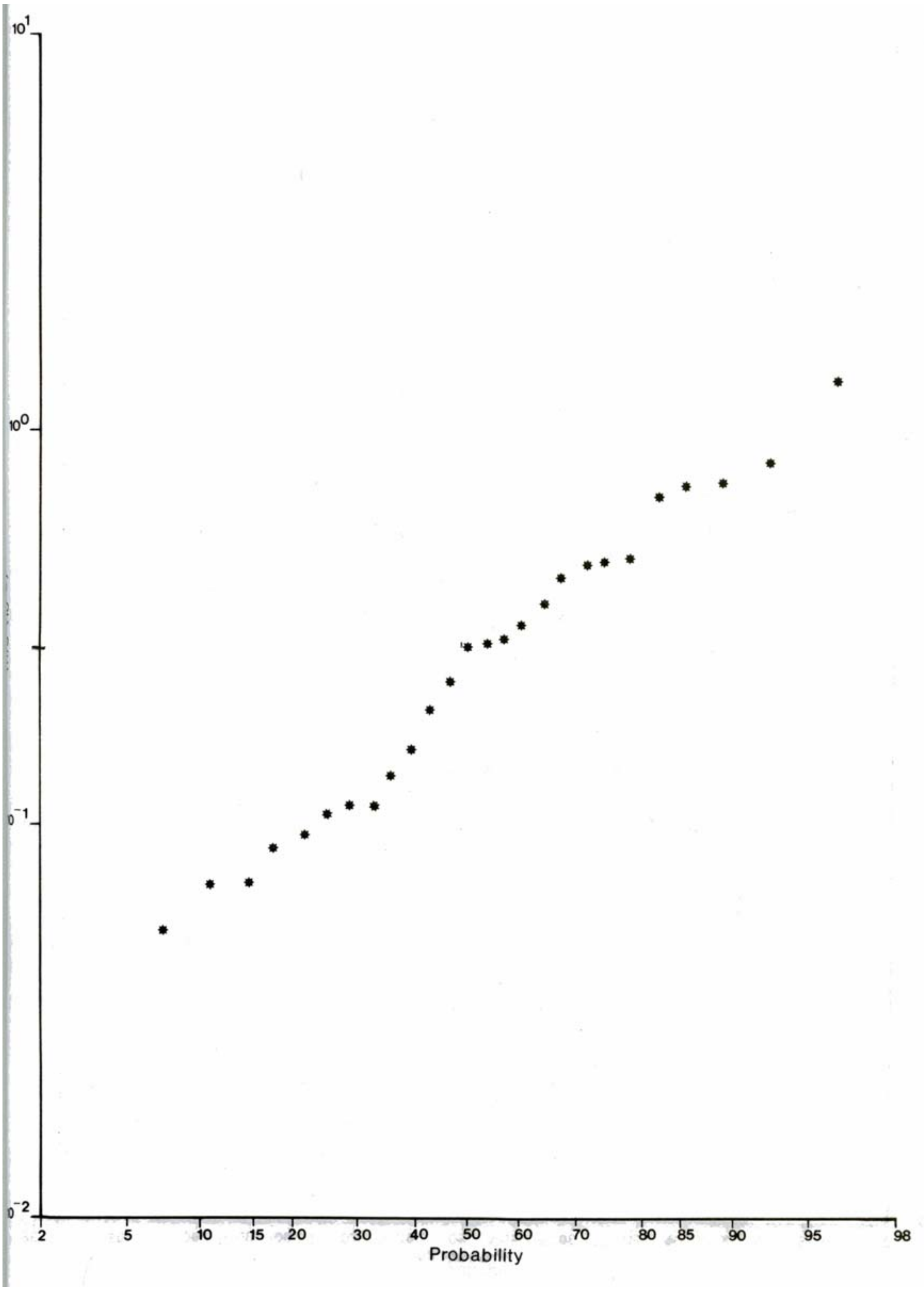


Figure 15 – Hydraulic conductivity – (ii) (Wet) transitional soil

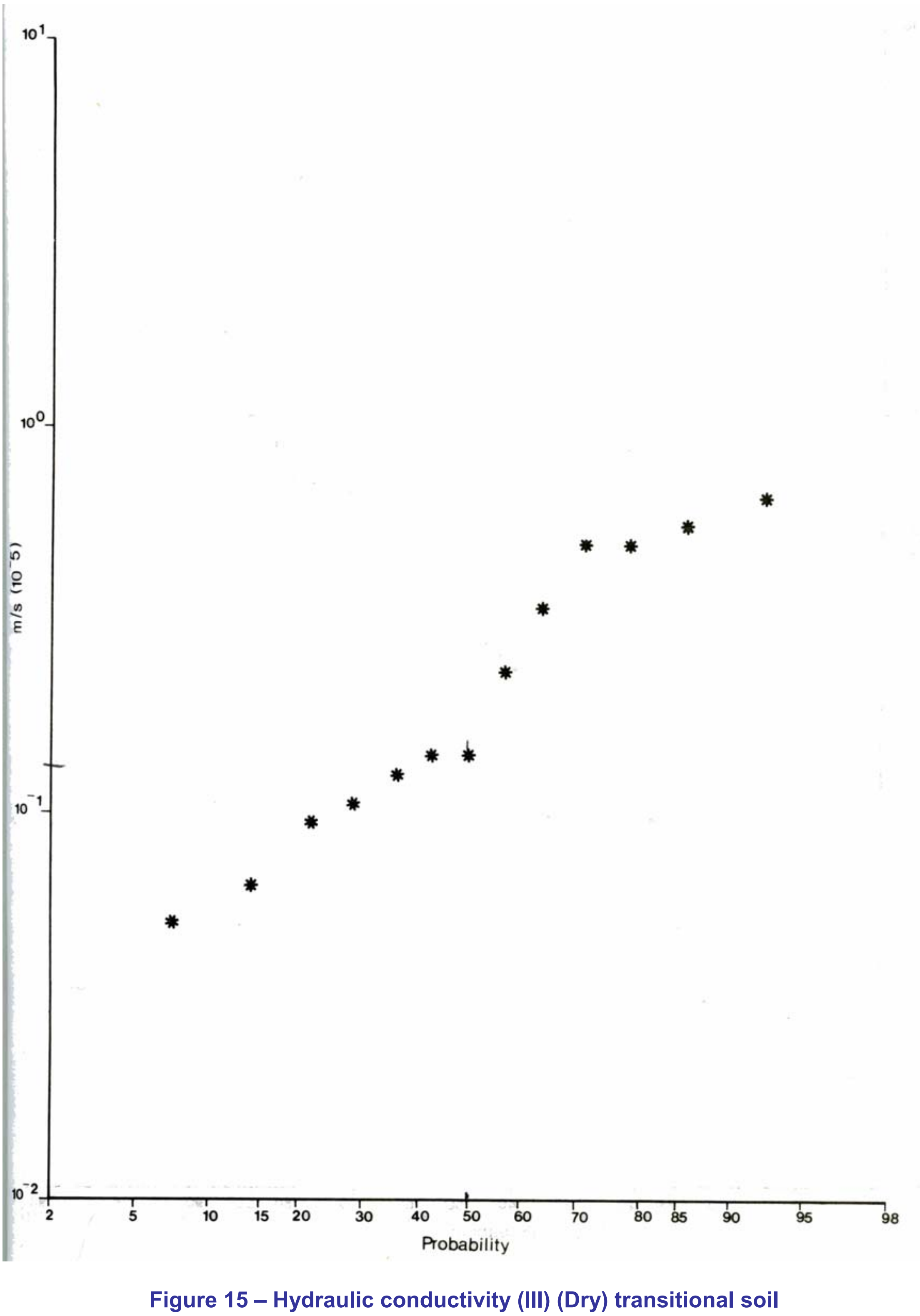


Figure 15 – Hydraulic conductivity (III) (Dry) transitional soil

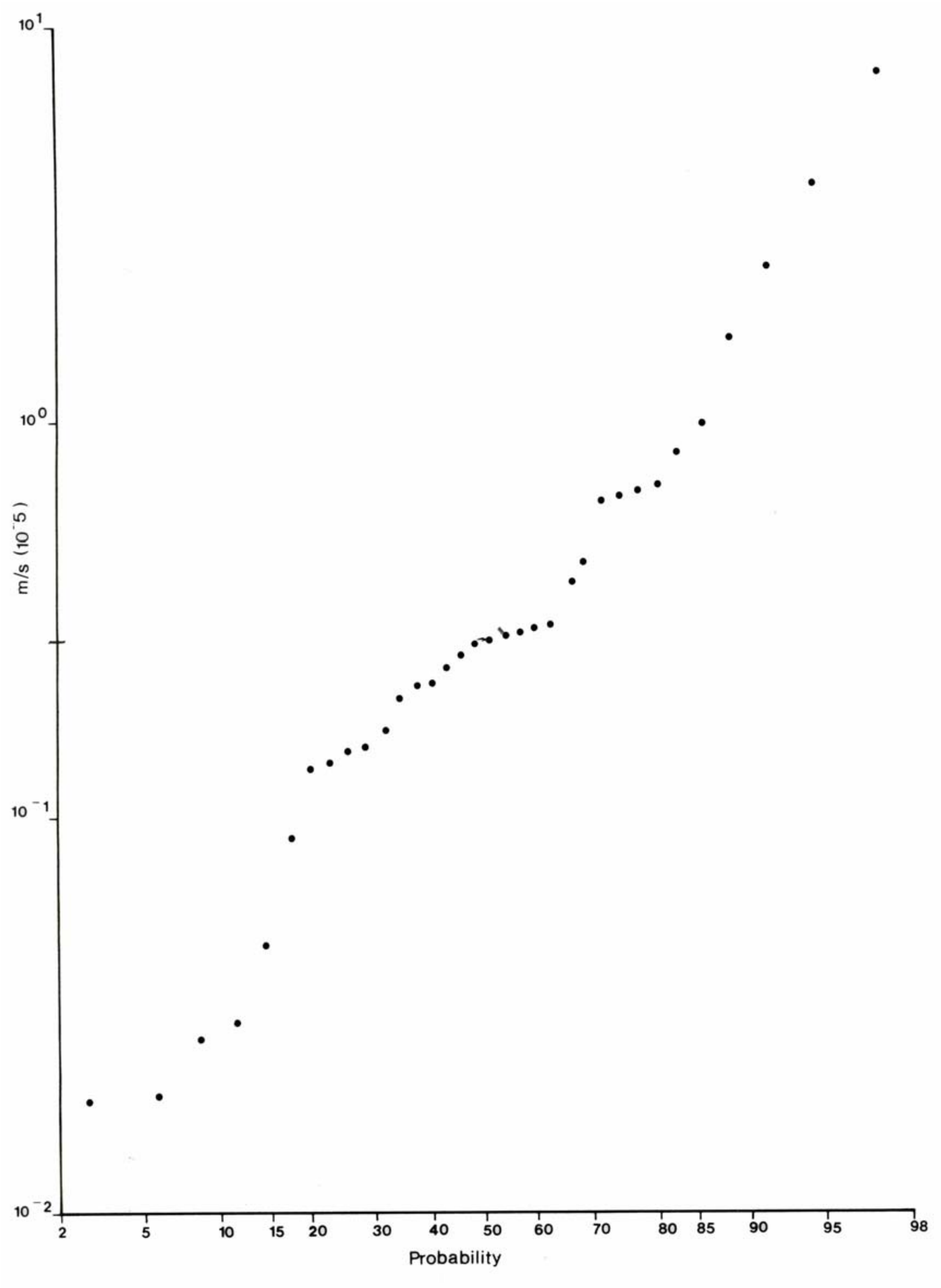


Figure 15 – Hydraulic conductivity (iv) 'Dry' soil