TR20_226_234

26. Drainage conditions at the Forestry Commission nursery, Perth.

D.J. Sloane

The Forestry Commission requested advice on possible solutions to drainage problems at their pine seedling nursery at Perth [EP151969]. They thought that disease in the young pine seedlings was partly a result of poor drainage conditions resulting in a high water table and surface ponding of water after periods of heavy rain.

The nursery covers about 6 ha and is situated about 500 m north of the Midland Highway bridge over the South Esk River. The land is gently undulating but drops steeply to the South Esk River to the west.

GENERAL GEOLOGY

The geology of the Forestry Commission nursery-Native Point area largely consists of Tertiary sediments associated with a minor amount of Tertiary basalt which crops out on the river bank to the south of the nursery. Ferntree Mudstone of Permian age crops out in a small area of the river bank, west of Native Point. A thin veneer of Quaternary river gravels and sands, and aeolian sands, mantles most of the area.

METHODS OF INVESTIGATION

During preliminary investigations seventeen hand-augered holes were bored to obtain an indication of subsurface conditions. A blanket of windblown sand of variable thickness was found to overlie a heavy grey and brown mottled clay, presumably of Tertiary age. Subsequently some 200 auger holes were bored. These holes were bored on a grid system with a 15 m interval in a N-S direction and a 20 m interval in an E-W direction. The grid was pegged prior to drilling the auger holes and the position and reduced level of each peg was subsequently surveyed. This enabled a ground surface contour map of the nursery to be drawn (fig. 86). The purpose of augering the grid system of holes was to determine the subsurface conditions as accurately as possible. Once the conditions were known, the planning of subsequent drainage could be conducted efficiently. In several areas the complete profile from the ground surface to the heavy clay could be determined, however where the aeolian sand was relatively thick, augering of the saturated sand below the water table was impossible. Augering was conducted using a tractor-mounted post-hole digger to a depth of about one metre. Hand augers were used below this depth. The depth below the ground surface of each soil horizon, the depth to the water table and an estimation of the rate of water seepage, were recorded for each hole.

From the auger hole information, sections have been drawn along lines A, C, E, G, I, K, M, and O. These sections (fig. 81, 82) show the variable thickness of the sand overlying the clay and the possible existence of a sand filled depression in the underlying clay in the central section of the nursery.

In order to obtain an indication of the thickness of windblown sand in the central area of the nursery, two resistivity spreads were carried out, one between Holes A2 and A4 and one between Holes I10 and I12. Between Holes A2 and A4 the clay was believed to be close to the ground surface and to extend to some depth. The use of this spread was to act as a control for the second. Resistivity spreads do not produce an accurate result as far as depths to subsurface horizons are concerned, especially if only a few spreads are used, however the method does allow these depths to be estimated. Using a Wenner electrode configuration the penetration factor is equal to the electrode spacing for uniform unstratified material. Thus for Spread 1 (between A_2 and A_4) the depth to the base of the clay can be determined with reasonable accuracy at about 6-7 m below the ground surface. From the curve obtained for Spread 1, (fig. 83) the clay is overlying a material with higher resistivity. This material could be bedrock, possibly basalt which crops out along the river bank adjacent to the nursery. The second curve shows the same shape as the first but has material of higher resistance, aeolian sand, overlying the clay. From this curve the sand appears to extend to an approximate depth of 3-4 m below the ground surface.

GEOMORPHOLOGY

At the nursery, the sediment overlying the heavy clay is aeolian sand of variable thickness, and belongs to the Panshanger Series of Graley (1961). The sediment has been deposited as a source-bordering sand sheet, probably filling a small depression in the underlying Tertiary clay. The sand sheet was probably deposited during the Last Glacial Stage when aeolian deposition and erosion was associated with more open vegetation conditions and prevailing westerly winds. The sediment was associated with the deflation of the alluvial deposits of the South Esk River. Subsequent leaching of the aeolian sands has resulted in a downward movement of clay particles, forming a clay enriched horizon above the underlying Tertiary clay.

A typical soil profile from the ground surface to the underlying clay consists of three horizons (fig. 84). The uppermost horizon is a dark brown, organically enriched, sand generally about 0.5 m in thickness but thicker where artificially increased (*e.g.* northern end of line A). Below this is a dull yellow-brown to dull yellow-orange horizon of sand in which muscovite mica flakes are readily seen. This is probably the leached A_2 horizon of the soil developed on the aeolian sand. Below this is a horizon of dull yellow-brown to light brown mottled clayey sand, probably a clay enriched B_2 horizon. This overlies a heavy clay which is mottled yellowish brown to greyish yellow-brown and which contains a small percentage of sand- and granule-sized particles. This clay is probably of Tertiary age. Occasionally, small ironstone concretions are present at the top of the clay-enriched sand horizon.

GRAIN SIZE ANALYSIS

Fifty-two samples were obtained by the Forestry Commission at 26 localities (fig. 89) and analysed at the laboratory of the Government Analyst (Appendix 1, table 1). Unfortunately, results were given as percentages of sand, silt and clay and no particle size ranges could be obtained. Forty-four of these samples were uniform in grain size distribution and contained 89-93% of sand and 7-11% of silt and clay. On visual inspection eight samples could be distinguished from the remainder. These samples contained from 62.5-87.5% of sand and 12.5-37.5% of silt and clay. Unfortunately, sample coverage is fairly sparse and only tentative conclusions can be drawn from these results. The samples of higher silt and clay content in the topsoil are at locations 4, 5, 8, J and K, (K may be disregarded as it is an artificially built seed bed). Samples 4, 8 and J are from areas of poor surface drainage, indicating that in these regions the silt and clay content of the top soil horizon is higher than elsewhere.

Three independent samples were also taken and submitted to the Department of Mines Laboratory, Launceston, for grain size analysis (Appendix 1, table 2). Samples S1 and S2 were taken from an area where the aeolian sand cover is thick, at depths of 0.1 m and 0.5 m respectively. The grain size distribution for S1 and S2 is very similar to that obtained by Graley (1961) from analysis of similar soils in the Cressy and Longford areas. The grain

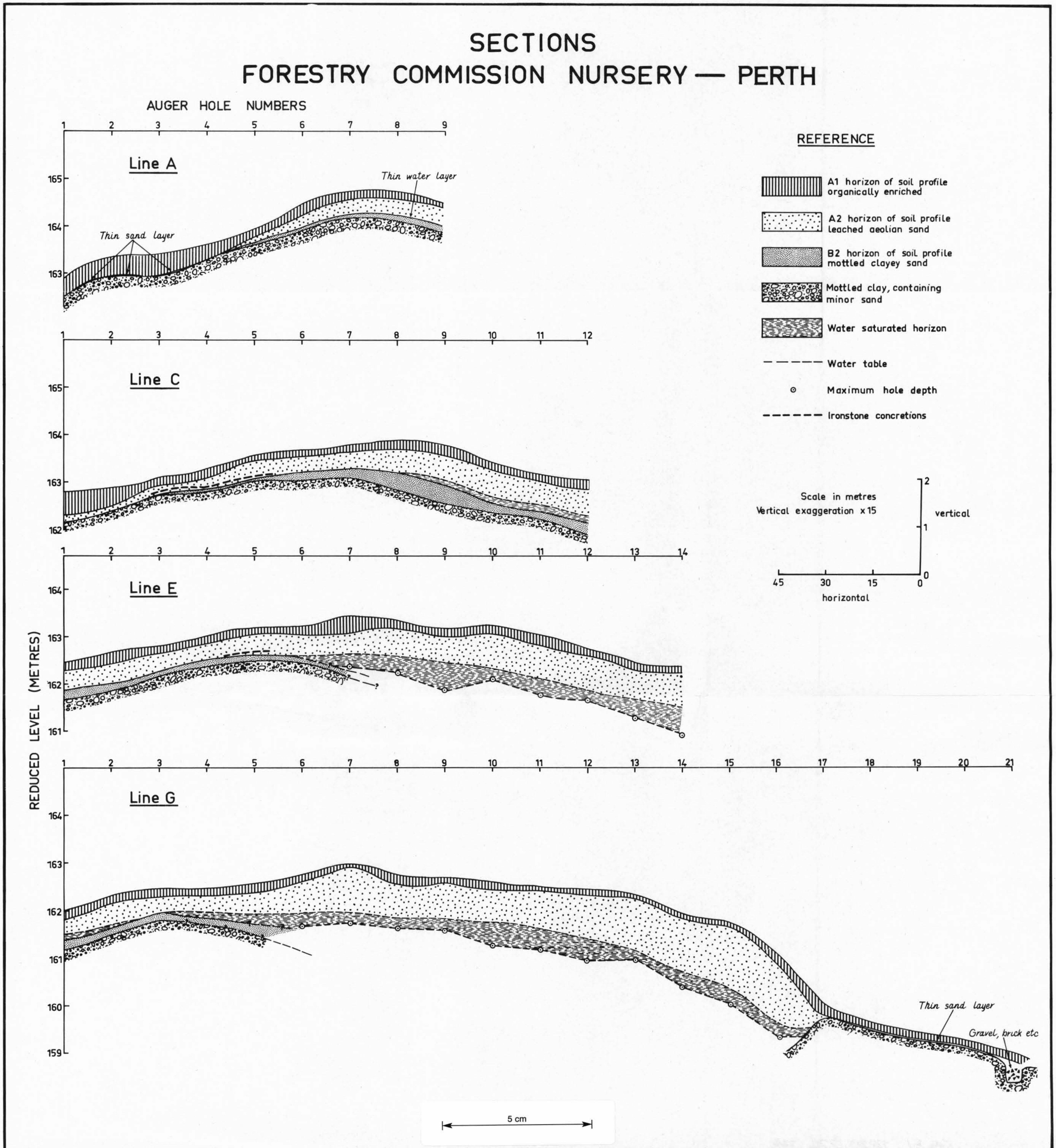


FIGURE 81

TR20_226_234

SECTIONS
FORESTRY COMMISSION NURSERY — PERTH

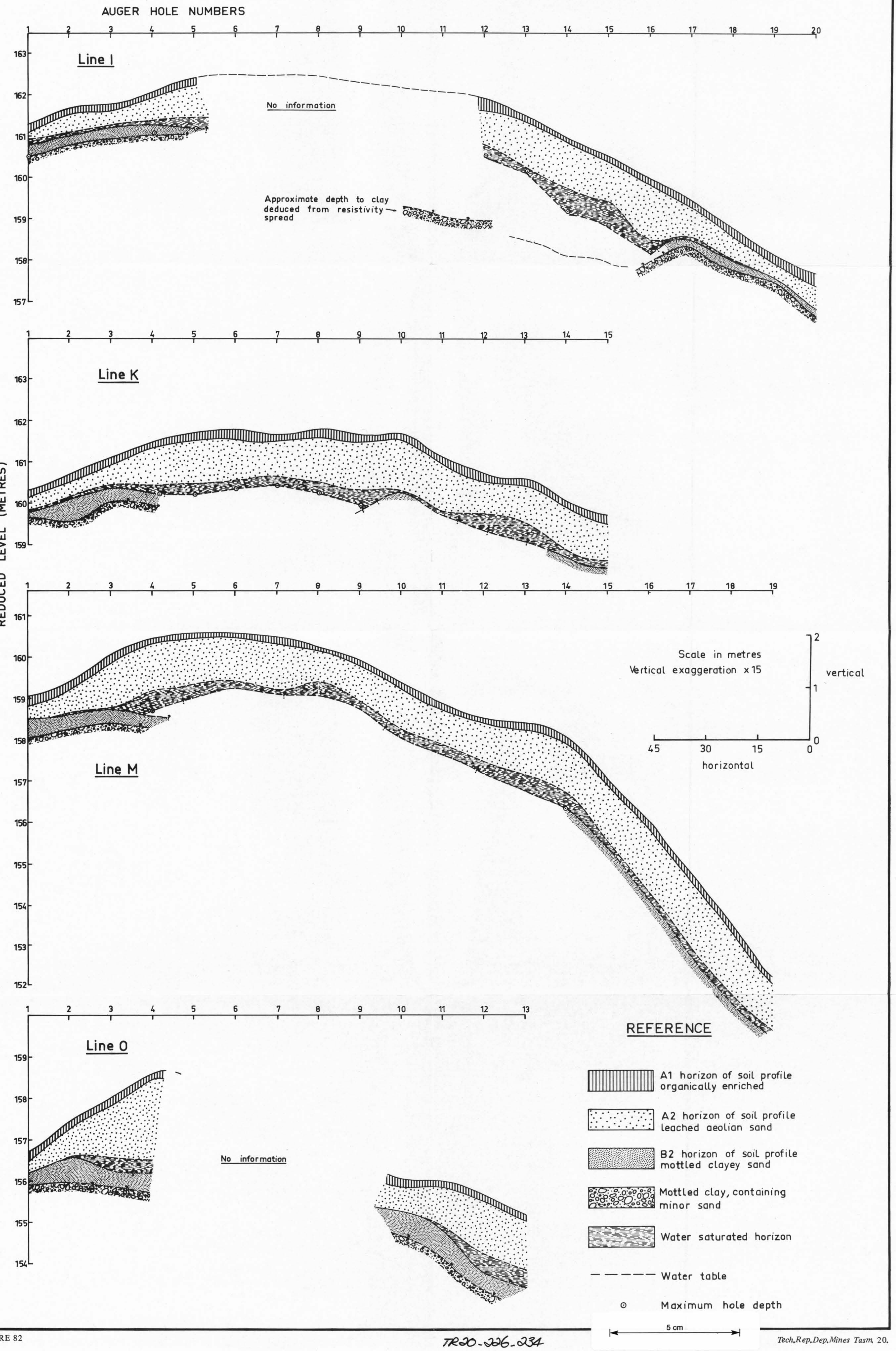


FIGURE 82

TR20-226-234

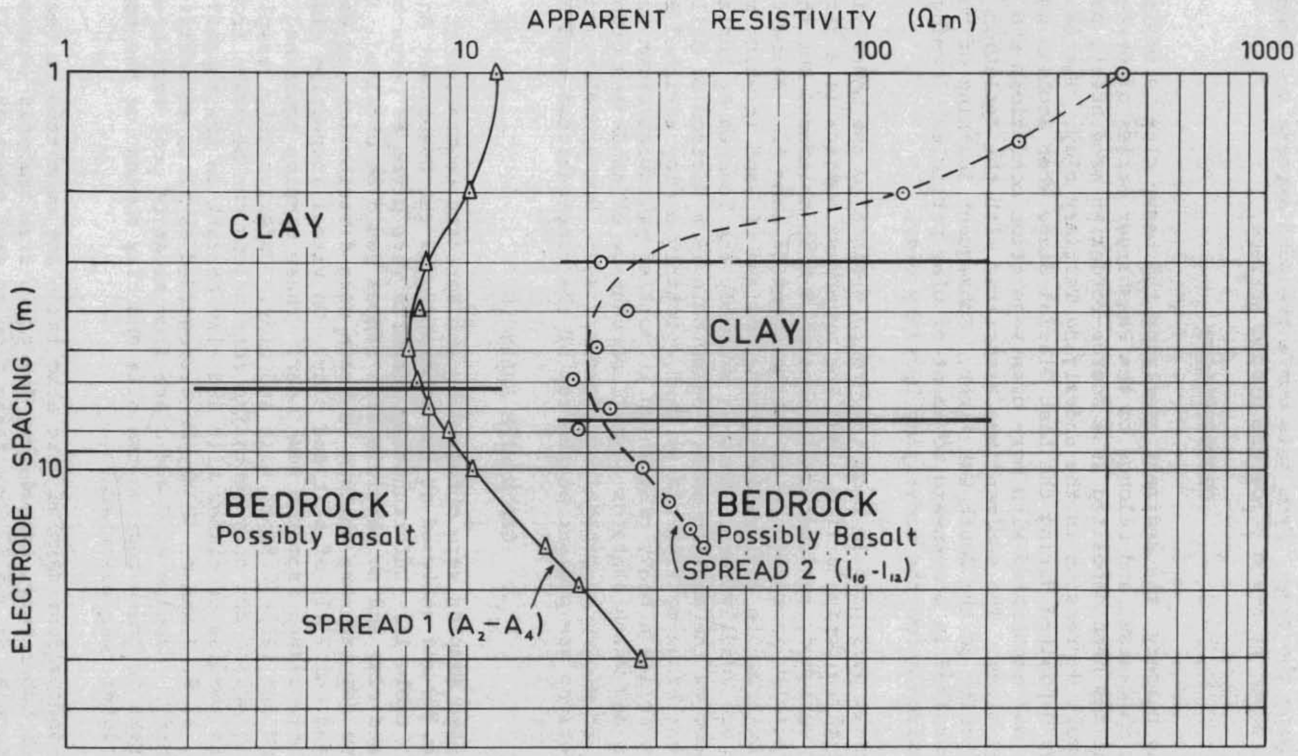
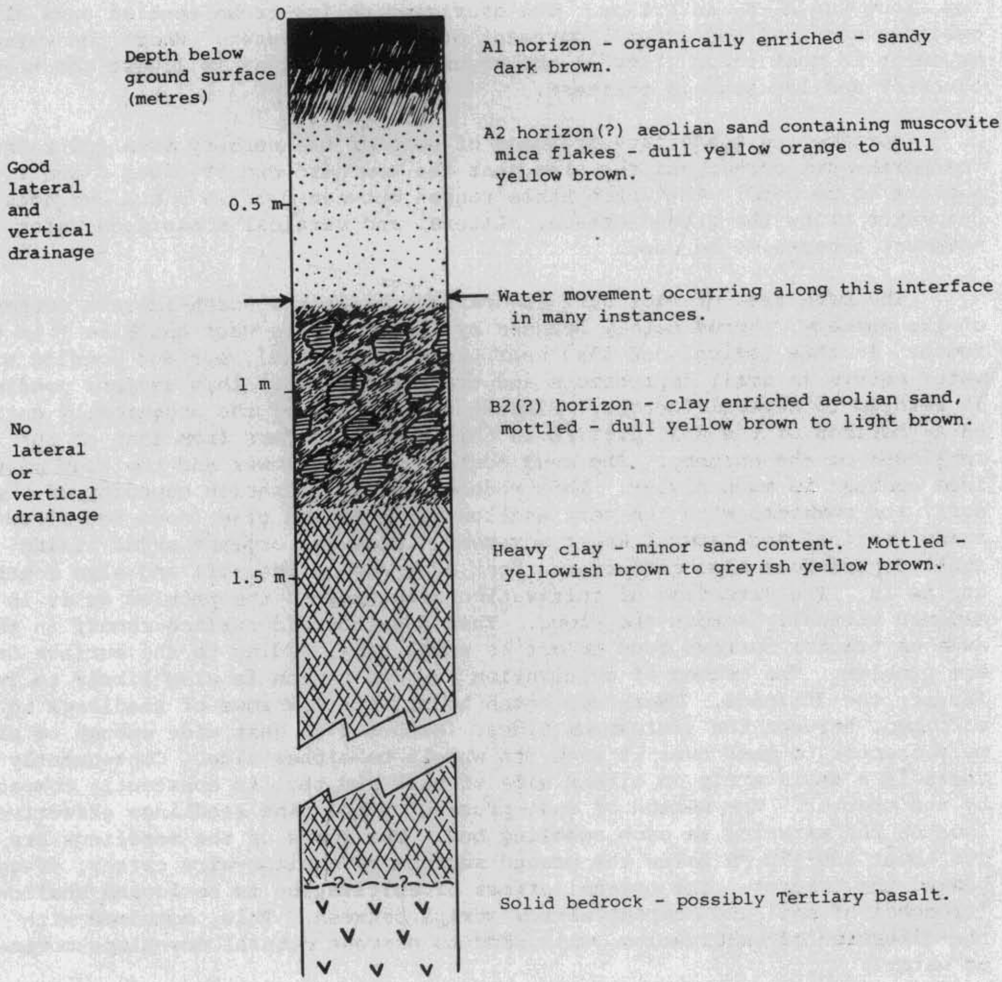


Figure 83. *Resistivity curves, Perth Nursery.*



N.B. Colours are based on the Revised Standard Soil Colour Charts (OYAMA and TAKEHARA, 1967).

Figure 84. *Common soil profile, Perth Nursery.*

size distribution of samples S1 and S2 (fig. 85) shows that the aeolian sand is well sorted and has a median grain size diameter of about 0.2 mm. The sands are positively skewed, that is they show a 'tail' towards the fine end of the grain size distribution curve, a common feature of aeolian sands. Sample S3 was taken at a depth of 0.1 m in the north-eastern corner of the nursery. This clearly shows different grain size characteristics from S1 and S2. It has a smaller median grain size diameter (0.11 mm) and a much larger percentage of particles in the smaller grain size (silt and clay) region.

HYDROLOGY

The water table lies above the clayey sand horizon (B_2) which contains little free water. There is virtually no vertical or lateral water movement through this horizon which acts as an impermeable barrier to water movement and gives rise to a perched water table. This condition is especially noticeable in areas where the clayey sand horizon is within about a metre of the ground surface. In this case water movement can be clearly seen to be occurring along the A_2-B_2 interface. The overlying yellow-brown aeolian sand allows free vertical and lateral movement of the groundwater. Where the water movement is most rapid (fig. 87) the groundwater gradient is lowest and the cover of aeolian sand is thickest.

Surface and subsurface drainage of most of the nursery area apart from the north-east corner and the area near the southern end of Lines G and I, appears to be good. The water table ranges between 0.7-1.5 m and averages one metre below the groundsurface. Lateral and vertical subsurface water movement appears to be good.

The main area of poor surface drainage is in the north-eastern corner of the nursery, approximately bounded by Line F to the west and Line 7 to the south. In this region, and also near Lines G and I (S), surface ponding of water occurs in small depressions and tractor furrows. This surface ponding is related to several factors. Firstly the texture of the organically enriched A_1 horizon of the soil profile in this region differs from that of the remainder of the nursery. The sand content is much lower and the clay particle content is much higher. This reduces the infiltration capacity of the soil, and combined with the very shallow depth to the clay, does not allow ready vertical and lateral water movement. Clay and organic skins lining small depressions also reflect the poor drainage of the soil and also contribute to it. The direction of cultivation also adds to the problem as it is aligned virtually across the slope. This does not aid surface runoff in the area as tractor furrows tend to act as small dams, adding to the surface drainage problem. The method of cultivation in this region is also likely to influence the drainage. There are seven beds, with six rows of seedlings to each bed, between the irrigation lines. Each bed is just wide enough to allow a tractor to pass over it with its wheels on either side. Consequently there is a small strip on either side of each bed that is constantly compacted by the tractor. The method of root-pruning of the pine seedlings effectively loosens the material in each seedling bed. The roots of the seedlings are cut about 100-150 mm below the ground surface by a piano-wire cutter, dragged behind the tractor. The overall effect of cultivation is to loosen shallow 'troughs' of soil and compact narrow strips between. This, combined with the direction of cultivation, will tend to prevent natural downslope movement of water.

A water sample (Appendix 2) was taken from a drain, draining an area between Holes I16-I17 and J16-J17. An old well was situated in this region. The water issuing from this area is of good quality, both for human consumption and irrigation purposes.

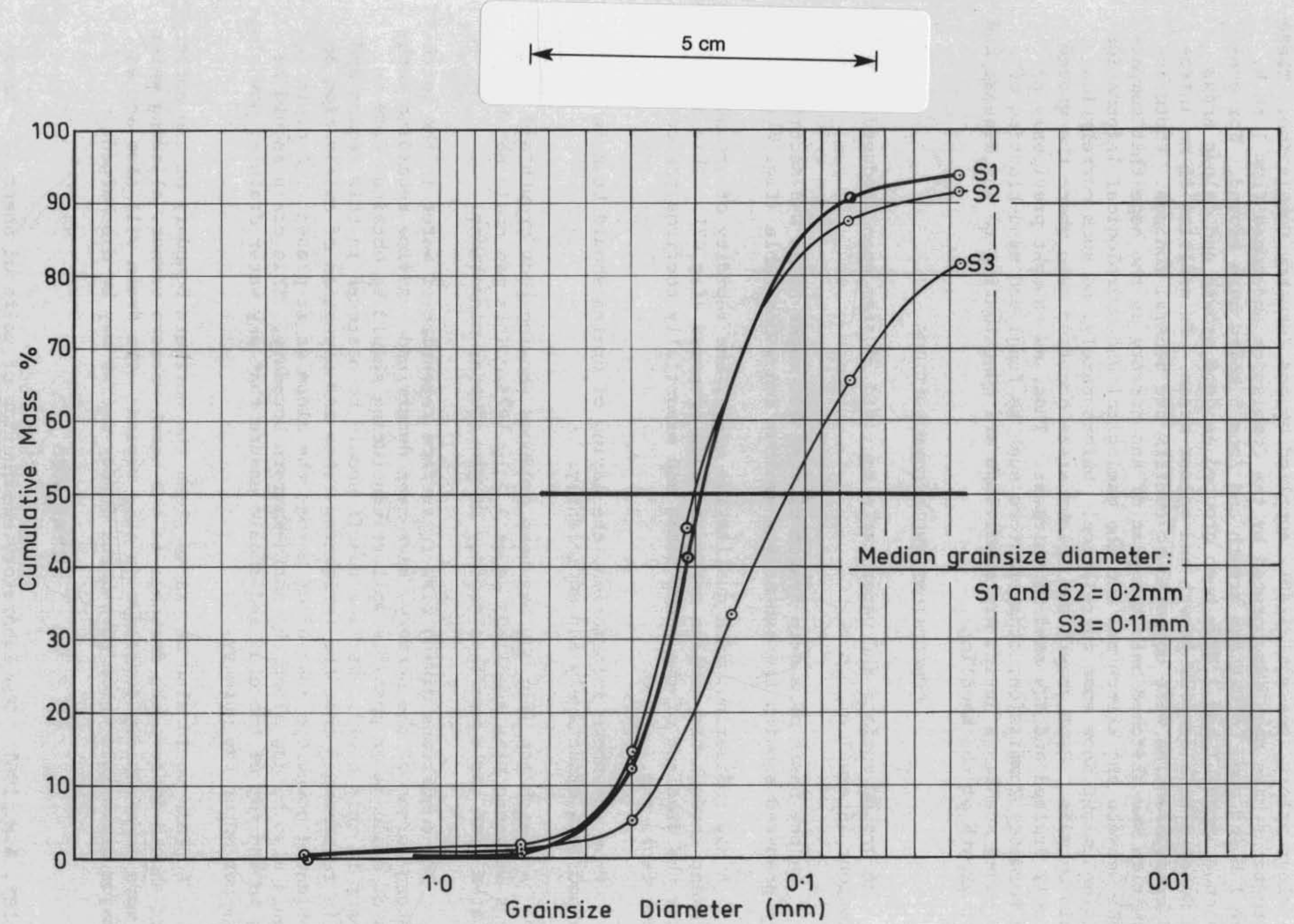


Figure 85. *Grainsize analysis, Perth Nursery.*

SEEDLING GROWTH

A rough sketch map (fig. 88) has been prepared of poor growth and colour areas in the pine seedlings at the Perth nursery. This map has been based on colour prints (scale ∿1:3240), supplied by the Forestry Commission. These photographs have been interpreted by the Commission and zoned from 1 to 5, Zone 1 being good colour and growth and Zone 5 being bare ground. For convenience, Zones 1 and 2 have been grouped as good growth and colour areas and Zones 3 to 5 as poor growth and colour areas. In addition 35 mm infrared transparencies were compared to confirm the general zonings. Photo information was sketched onto the plan of the nursery in the hope that comparisons between the sketch map and the geological and hydrological information obtained might show some correlation. Unfortunately, no such correlation could be made. Poor growth and colour areas occurred even where the ground is well drained and the sand is thickest. Thus, as thought previously by the Forestry Commission, other factors such as fungi and sand-blasting of the young seedlings during dry conditions are contributing to the disease and poor growth of the seedlings.

CONCLUSIONS AND RECOMMENDATIONS

A ground surface and water table map (fig. 86) has been produced, with a contour interval of 0.5 m.

On the basis of a grid system of some 200 auger holes N-S sections have been prepared showing the subsurface geology and water table (fig. 81, 82).

A map indicating, in a qualitative sense, the rapidity of groundwater movement through the aeolian sands has been prepared (fig.87). This indicates the gradient of the water table and essentially confirms the contoured water table map.

From the above information, the laying of drains should be able to be planned more effectively and efficiently.

A sketch map (fig. 88) has been produced showing poor growth and colour areas in young pine seedlings as at 1 July 1975. This map could not be correlated with the subsurface geology or groundwater conditions.

The conditions giving rise to surface retention of water in the north-eastern corner of the nursery, have been determined. Advice regarding methods of drainage or possible soil restructuring should be obtained from an expert in this field. Surface runoff should be hastened in this region and it is recommended that the irrigation lines and direction of cultivation be reoriented downslope instead of across the slope as at present. A drain should also be dug along the north-eastern boundary. This drain should be dug to the top of the clay and should ensure that any water draining downslope does not enter the nursery.

A drain could also be placed along the northern boundary of the nursery. This should improve the drainage in the north-western corner, allowing water to move more rapidly downslope in this region. The drain will also act as a major drain into which subsequent feeder drains may be discharged.

REFERENCES

GRALEY, A.M. 1961. The laboratory examination of soils of sheet 47 - Longford, Tasmania. *Div.Rep.Div.Soils C.S.I.R.O. Aust.* 2/61.

NICOLLS, K.D. 1958. Reconnaissance soil map of Tasmania. Sheet 47 - Longford. *Div.Rep.Div.Soils C.S.I.R.O. Aust.* 14/57.

[4 November 1975]

APPENDIX 1

Grain size analyses.

Table 1. SAND, SILT AND CLAY CONTENT OF SOIL SAMPLES

Sample	Sand (%)	Silt (%)	Clay (%)
1T	91.0	6.0	3.0
1B	93.0	3.5	3.5
2T	90.5	6.0	3.5
2B	90.5	5.5	4.0
3T	91.0	5.0	4.0
3B	91.5	5.5	3.0
4T	83.5	11.0	5.5
4B	91.0	5.5	3.5
5T	82.0	13.5	4.5
5B	92.0	6.0	2.0
6T	91.5	5.5	3.0
6B	92.5	3.0	4.5
7T	92.5	5.0	2.5
7B	93.0	4.0	3.0
8T	87.5	9.0	3.5
8B	86.5	9.5	4.0
9T	91.5	4.5	4.0
9B	92.0	3.5	4.5
10T	91.5	4.0	4.5
10B	93.0	4.0	3.0
11T	91.5	4.5	4.0
11B	93.0	2.5	4.5
12T	89.5	7.5	3.0
12B	90.0	6.0	4.0
13T	91.5	4.0	4.5
13B	90.5	3.0	6.5
AT	89.0	6.5	4.5
AB	91.5	4.5	4.0
BT	92.0	5.0	3.0
BB	92.5	3.5	4.0
CT	91.5	5.5	3.0
CB	91.5	6.0	2.5
DT	91.5	4.5	4.0
DB	91.5	4.5	4.0
ET	90.5	6.5	3.0
EB	90.0	6.5	3.5
FT	91.0	6.0	3.0
FB	92.5	4.5	3.0
GT	90.0	4.5	5.5
GB	92.5	3.0	4.5
HT	90.0	5.5	4.5
HB	89.5	6.0	4.5
IT	92.0	4.5	3.5
IB	93.0	4.5	2.5
JT	82.0	10.0	8.0
JB	62.5	9.5	28.0
KT	77.0	14.5	8.5
KB	77.0	10.5	12.5
LT	91.5	5.5	3.0
LB	90.5	6.0	3.5
MT	89.0	7.5	3.5
MB	89.5	6.0	4.5

Analyses by Government Analyst Laboratory

Table 2. GRAIN SIZE DISTRIBUTION OF SOIL SAMPLES S1-S3.

Reg. No.	*Fraction*	*% Mass*	*Cum. % Mass*
751658 (S1)	+2.36 mm	0.6	0.6*
	+1.18 mm	0.6	1.2*
	+600 µm	0.7	1.9*
	+300 µm	12.2	14.1*
	+212 µm	31.3	45.4*
	+150 µm	23.5	68.9*
	+75 µm	18.4	87.3*
	+38 µm	3.9	91.2*
	-38 µm	8.8	100.0
751659 (S2)	+1.18 mm	Trace	Trace
	+600 µm	0.2	0.2
	+300 µm	12.1	12.3
	+212 µm	29.2	41.5
	+150 µm	27.3	68.8
	+75 µm	21.8	90.6
	+38 µm	3.2	93.8
	-38 µm	6.2	100.0
751660 (S3)	+2.36 mm	0.4	0.4*
	+1.18 mm	0.2	0.6*
	+600 µm	0.4	1.0*
	+300 µm	4.6	5.6*
	+150 µm	28.1	33.7*
	+75 µm	32.1	65.8*
	+38 µm	15.4	81.2*
	-38 µm	18.8	100.0

*Fractions contain wood fragments

APPENDIX 2

Analysis of a water sample

The sample, Reg. No. 751657, was taken from a drain, draining an area between Holes I16-I17 and J16-J17. The following analysis was made by the Department of Mines Laboratory, Launceston.

			ppm
pH	6.4	Mg	42
	ppm	Fe	<0.1
CO_3	0	Al	<0.2
HCO_3	35	K	2.5
Cl	55	Na	30
SO_4	67	T.D.S.	500
SiO_2	15	Hardness (as $CaCO_3$)	260
Ca	32	Alkalinity (as $CaCO_3$)	29

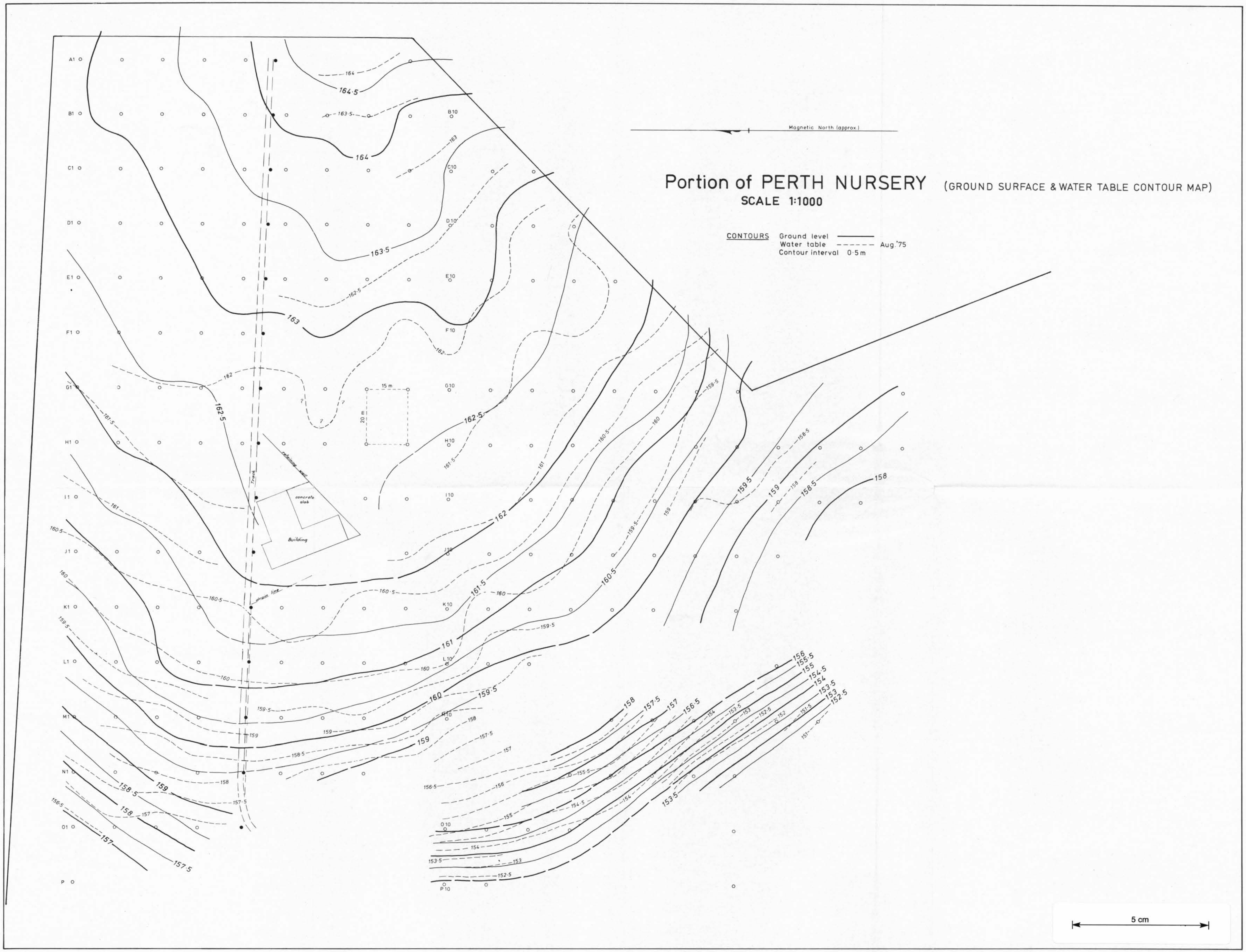

Magnetic North (approx.)
Portion of PERTH NURSERY (GROUND SURFACE & WATER TABLE CONTOUR MAP)
SCALE 1:1000
CONTOURS Ground level
Water table Aug.'75
Contour interval 0·5 m
15 m
20 m
Track
retaining wall
concrete slab
Building
drain line
5 cm

FIGURE 86

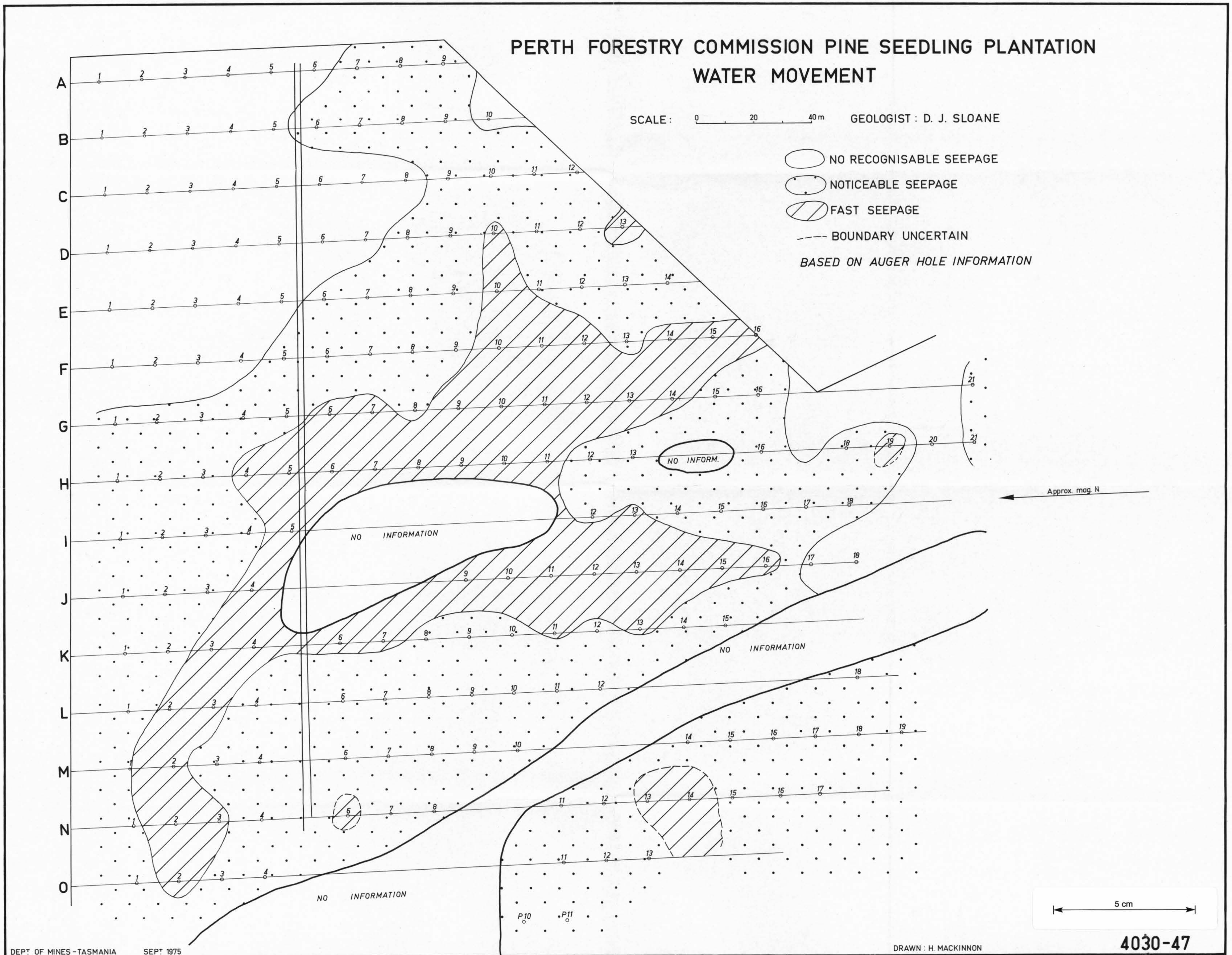

PERTH FORESTRY COMMISSION PINE SEEDLING PLANTATION
WATER MOVEMENT
SCALE: 0 20 40 m
GEOLOGIST: D. J. SLOANE
NO RECOGNISABLE SEEPAGE
NOTICEABLE SEEPAGE
FAST SEEPAGE
BOUNDARY UNCERTAIN
BASED ON AUGER HOLE INFORMATION
NO INFORMATION
NO INFORM.
NO INFORMATION
NO INFORMATION
Approx. mag. N
5 cm
DEPT OF MINES - TASMANIA
SEPT 1975
DRAWN: H. MACKINNON
4030-47

FIGURE 87

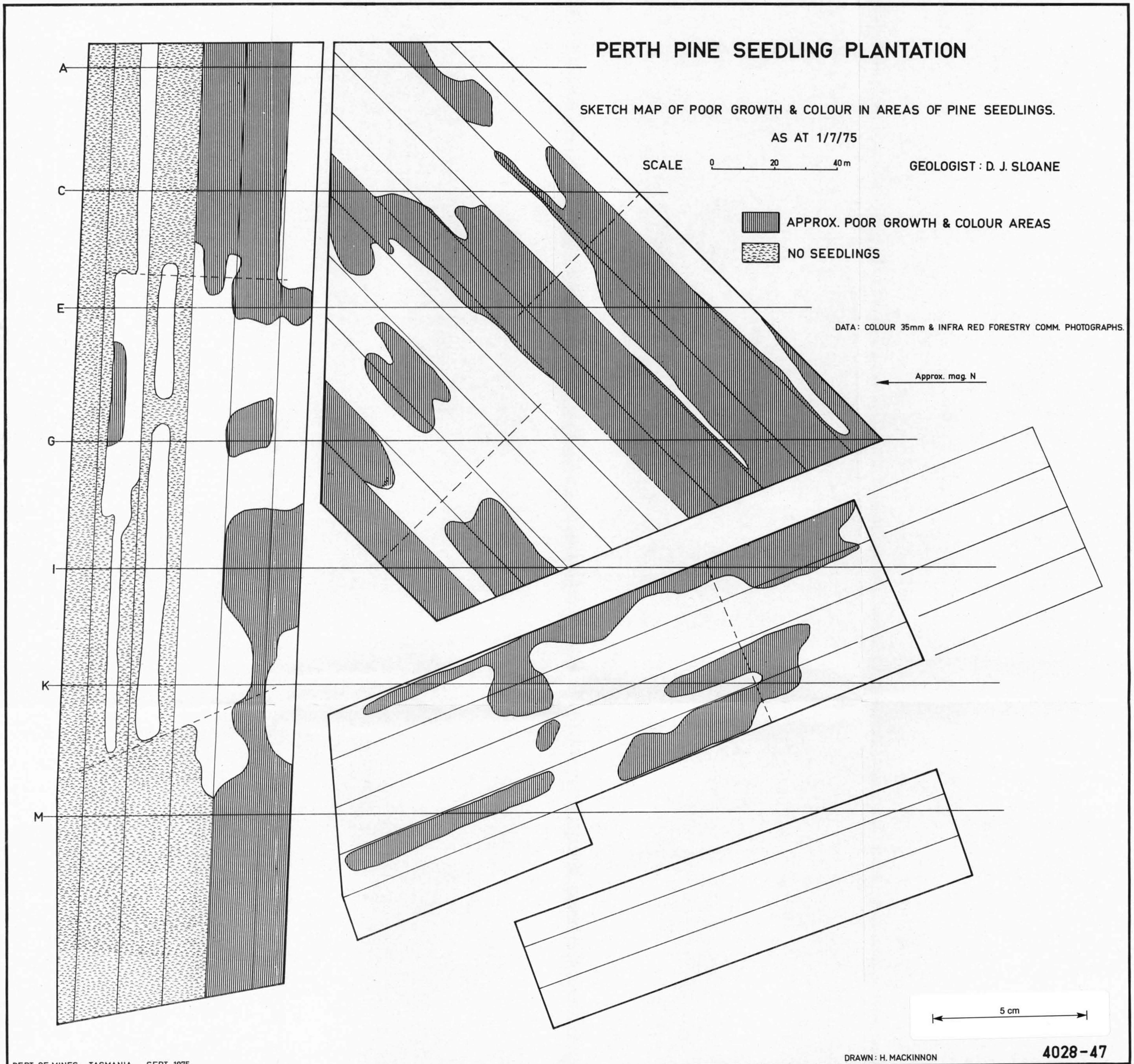
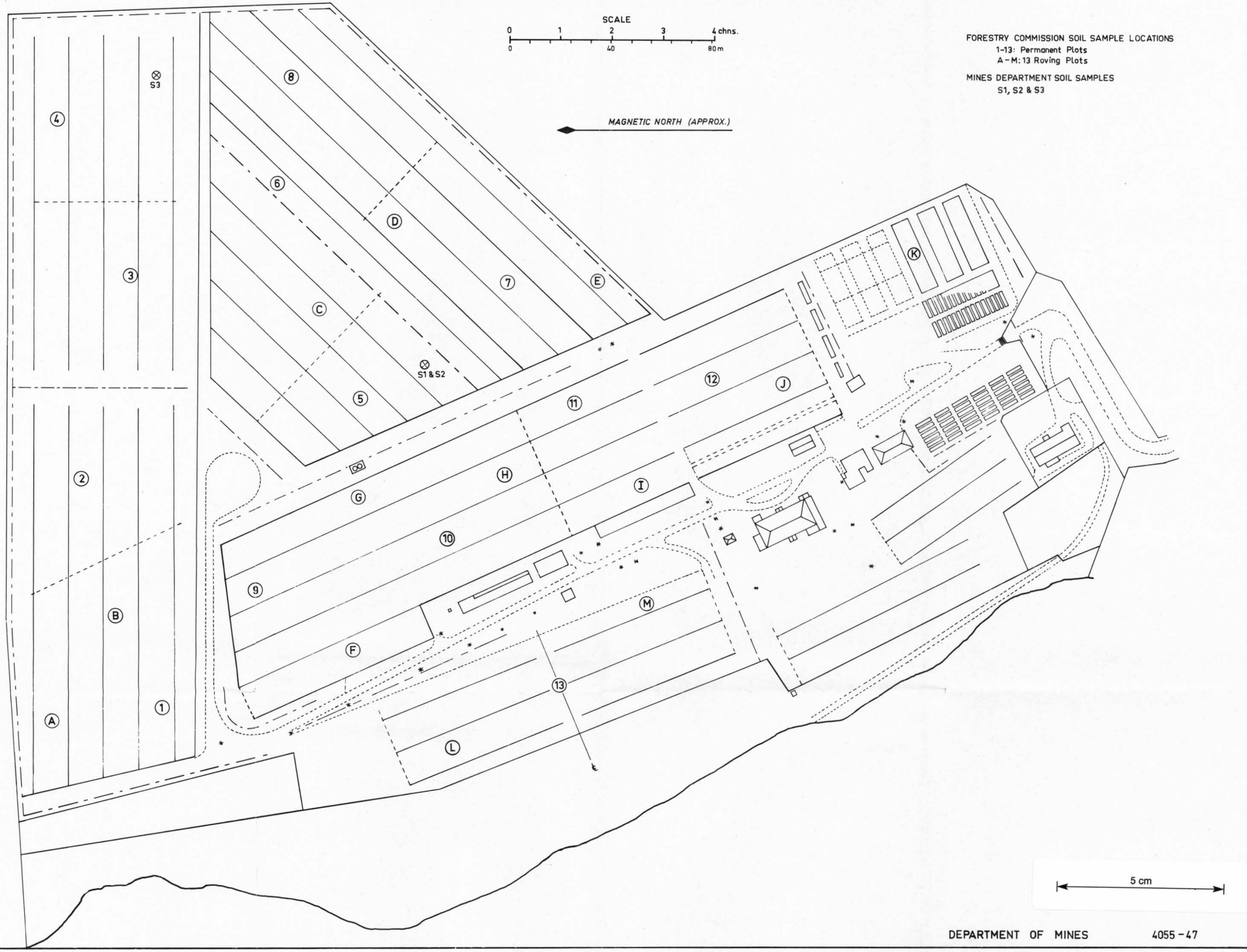

PERTH PINE SEEDLING PLANTATION
SKETCH MAP OF POOR GROWTH & COLOUR IN AREAS OF PINE SEEDLINGS.
AS AT 1/7/75
SCALE
0
20
40 m
GEOLOGIST : D. J. SLOANE
APPROX. POOR GROWTH & COLOUR AREAS
NO SEEDLINGS
DATA: COLOUR 35mm & INFRA RED FORESTRY COMM. PHOTOGRAPHS.
Approx. mag. N
A
C
E
G
I
K
M
5 cm
DRAWN: H. MACKINNON
4028-47
DEPT OF MINES – TASMANIA SEPT 1975

FIGURE 88

PERTH NURSERY – LAYOUT & SAMPLE LOCATIONS



DEPARTMENT OF MINES 4055-47

FIGURE 89