COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

RECORD No. 1967/32

KERANG RESISTIVITY SURVEY,

VICTORIA 1964

by

P.E. MANN

RECORD No. 1967/32

KERANG RESISTIVITY SURVEY,

VICTORIA 1964

by

P.E. MANN

<u>CONTENTS</u>

<u>ILLUSTRATIONS</u>

Plate 1. Locality map, showing resistivity depth probe stations, bore holes, and geology (I54/B5-3)

Plate 2. Ground water resistivity map (I54/B5-4)

Plate 3. Formation resistivities at 10 ft depth (I54/B5-11)

Plate 4. Formation resistivities at 20 ft depth (I54/B5-12)

Plate 5. Formation resistivities at 40 ft depth (I54/B5-13)

Plate 6. Highest and lowest resistivities at depths of 20 ft or more (I54/B5-14)

Plate 7. Gamma ray log (I54/B5-9)

1967/32

SUMMARY

A resistivity survey was made in the Kerang irrigation district of Victoria at the request of the State Rivers and Water Supply Commission of Victoria in 1964. The results indicate that for shallow depths (10 to 30 ft) it is possible to distinguish clays from sandy clays or clayey sands with a chance of 2 in 3. At deeper levels it is not possible to distinguish a sandy formation saturated with salt water from a saline clay. However, it is possible to predict the ground water resistivity (or salinity) from resistivity depth probes; and salinities can be fairly accurately mapped.

A test of the gamma ray logging method showed it to be an excellent tool for logging cased boreholes, and for providing correlation between boreholes.

1. INTRODUCTION

In the Kerang irrigation district, Victoria, severe salting of the land for many years has caused a deterioration in pasture growth. Poor drainage (due to a high water table) prevents removal of salts introduced in irrigation during the summer months.

The State Rivers and Water Supply Commission of Victoria (SRWSC) is investigating methods to control the ground water level in order to reclaim salt affected areas. One method under consideration is to pump from shallow aquifers. Experiments made at the Kerang Agricultural Research Farm (Garland, 1963) showed that pasture and crops are improved if the water table is lowered.

In response to a request by the SRWSC, the Bureau of Mineral Resources made a resistivity survey to collect subsurface information. This information could then possibly be used to predict the presence of shallow aquifers, for a reclamation programme. Generally the SRWSC felt that any additional information on the complex subsurface problems of the area would be useful.

The approximate latitude and longitude of the centre of the surveyed area is 35°50'S and 144°00'E.

The geophysical party consisted of P.E. Mann (party leader and geophysicist) and K. Reine (driller). The SRWSC supplied four field assistants.

The co-operation of A. Coad, the SRWSC Irrigation Research Officer at Pyramid Hill, is gratefully acknowledged.

2. GEOLOGY

An interpretation of the geology of the area is given by Currey (1963). At Kerang the former Murray Valley is filled with river sediments consisting of clay loam and sandy gravel river deposits to a depth of about 600 ft. The present stream system is superimposed on the earlier alluvial drainage system, which is referred to as 'prior' system. A prior river which formed the main drainage channel of the area cuts across the northern part of the survey area (Plate 1). Climatic changes or orogenic movements caused a diversion of the prior river, a reduction in gradient of the river and its tributaries, and the formation of lakes. Coarser sediments of the prior river, covered with lake deposits of clay, silt, and fine sand, form shallow aquifers. Johnson's Swamp and Two Mile Swamp form remnants of these prior lakes.

Garland (1963) has mapped the probable depth to sand layers in the Kerang district from the results of a 'water jetting' drilling programme along the western edge of the prior river system.

The Victorian Mines Department has logged a deep bore at the Kerang Agricultural Research Farm (K.A.R.F.), approximately in the centre of the surveyed area (Plate 1). An abbreviated log is given in Appendix 1.

C.S.I.R.O. has drilled fifteen boreholes at K.A.R.F. and fifteen on properties adjacent to the K.A.R.F. Generally the boreholes, ranging from 15 to 65 ft, were stopped when they penetrated sand. The logs are given in Appendix 2.

Plate 1 shows the location of bores drilled by the SRWSC as part of an exploratory drilling programme in the southern part of the irrigation district (Coad, 1964). The bores have an average depth of 60 ft. Only on one occasion did a bore penetrate a well-defined aquifer proved by pumping tests: at site K28. The geological logs are given in Appendix 3.

Additional geological information is available from boreholes drilled by the BMR tractor-mounted 'Proline' drill. The driller's logs are given in Appendix 4. Boreholes were drilled at about 50% of the resistivity depth-probe stations. Generally the depths were about 54 ft; at stations 51, 99, and 111 the depth was increased to 72 ft.

3. METHODS

Resistivity

The principles and practice of the two resistivity methods, viz. depth probing and traversing are given by Parasnis (1962).

The instrument used was a 'Terrameter' resistivity meter manufactured by Aktiebolaget Elektrisk Malmletning. The instrument, producing a 6-c/s alternating current, proved reliable, was simple to operate, and generally gave readings with a Wenner electrode spacing of up to 300 ft, the maximum used for the survey. Because of the low ground resistance near the surface of the ground, the instrument had insufficient power to give a correct potential difference reading with electrode spacing greater than about 300 ft.

The survey was started with resistivity depth probes 1, 2, and 3 taken using the Schlumberger electrode configuration (Parasnis, 1962). However, because of the low ground resistances the separation of the potential electrodes had to be increased frequently to obtain reliable readings. The spacing between potential electrodes in the Wenner configuration is greater than in the Schlumberger configuration, and hence gives more accurate readings. Depth probes 1, 2, and 3 were repeated with the Wenner configuration, and subsequently this was the only configuration used. For the Wenner configuration the apparent resistivity is given by

$$R = 2\pi a \frac{V}{I} = 2\pi aRo$$

where R is the resistivity in ohm-metres

V is the measured potential difference in volts

I is the current in amperes

a is the electrode spacing in metres

Ro is the resistance in ohms

Figure 1 shows the standard method of plotting the resistivity field data on logarithmic graph paper. A convenient method of displaying resistivities and depths of the various layers is also shown in Figure 1.

One technique to interpret a field curve is to match the experimental curve with theoretically calculated three-layer curves, such as those published by Mooney and Wetzel (1956). However, few of the field curves could be matched with the three-layer curves, so all the field curves were analysed by matching with two-layer curves (Parasnis, 1962).

The resistivity interpretation of relatively thin layers is to a certain extent ambiguous, as may be observed by applying Hummel's or Maillet's principle (Andrew & Wiebenga, 1965). Thus, for a reliable quantitative interpretation it is necessary to use some depth control, given by drilling or seismic methods. The geological logs of drill holes put down by the SRWSC, CSIRO, Victorian Mines Department, and the BMR (Appendixes 1, 2, 3, & 4) were used to interpret the resistivity field data.

The resistivity of a rock depends on the resistivity of the rock matrix, the degree of saturation of the pores, and the resistivity of the fluid occupying the pore spaces in the rock. Generally the resistivity of the rock matrix is nearly infinite, and assuming that the rock pores are saturated with fluid, the following empirical relation can be used:

$$R_f = R_w/P^m = R_w F \qquad \ldots\ldots (1)$$

where R_f is the formation resistivity

R_w is the resistivity of the pore solution

P is the porosity expressed as a fraction

F is the formation factor = $1/P^m$

m is the cementation constant ranging from about 1.3 to 2.2.

For convenience in computation, m is taken as 4/3. In unconsolidated rocks m = 1.3, in moderately cemented sandstones about 1.8, and in highly cemented sandstones 2.2. Figure 2 shows a graph of equation 1 for m = 1.3.
The formation resistivities R_f can be computed from the field observations, and the water resistivities have been measured at various bores.
The average water resistivity R_{wa} was then computed from n_1 samples:

$$R_{wa} = 1/n_1 \; (\text{SUM } R_w) \qquad .... \; (2)$$

and the average porosity was also computed for n_2 boreholes where water samples were taken:

$$P_a = \frac{1}{n} \; \text{SUM } (R_w/R_f)^{3/4} \qquad .... \; (3)$$

Values of $P = (R_w/R_f)^{3/4}$ greater than 0.6 were excluded.
From equations 2 and 3, the average formation resistivity R_{fa} can be computed by using equation 1.

It is known (Pettijohn, 1949) that clays (a well sorted material) have an appreciably higher porosity than coarse sandy clays or clayey sands, which are unsorted. At the same time it may be noted that the permeability of coarse, sandy clays or clayey sands is much higher than that of clays. Because of the higher porosity and generally higher salinity, it is usual for clays to have lower resistivity than sandy clay or clayey sand.

Equation (1) shows that formation resistivity is both a function of porosity and water resistivity (assuming m = 4/3 to be constant). It may then be attempted:

(a) To predict the nature of the sediments from the resistivity data by comparing the observed formation resistivity with the computed 'average' resistivity R_{fa} using Rwa and Pa from equations 2 and 3.
The formation resistivity average for each depth probe was not used because of the possible influence of near-surface irregularities and faulty instrument readings. Also by computing R_{fa} from a large sample it is expected that irregularities are cancelled in the R_{fa} value used as standard.
If $R_f < R_{fa}$, the formation is predominantly clay.
If $R_f > R_{fa}$, then the formation is predominantly a coarse, sandy clay or clayey sand. This comparison was carried out for depths of 10, 20, and 40 ft.

(b) To predict the resistivity of the groundwater from the resistivity data. To test this possibility, a comparison was made between a water resistivity contour plan and a contour plan giving the lowest formation resistivities for depths of 20 ft or more. If a similarity in pattern between the two plans exists, it may be safely assumed that a good correlation exists between formation resistivity and water resistivity for depths exceeding 20 ft.

Water resistivity

The resistivity of water samples from boreholes and windmills was measured with a cell connected to a d.c. resistance meter. The resistivity values were corrected for temperature to 20°C with the formula:

$\log R_{20} = \log R_t - 0.9\,(20-t)/100$ ..... (4) which is shown in Figure 3 (Dyson & Wiebenga, 1957). Some of the water resistivities at SRWSC bores were estimated from the total dissolved salt content S (in p.p.m.), using the relation (Guyod, 1964):

$$R_w = 5000/S \qquad \text{.... (5)}$$

Gammy ray logging

Gamma ray logging, utilising the natural radioactivity of rocks, can be used to identify and correlate sedimentary strata in boreholes. Clay and shale are generally more radioactive than sand so variations on the radioactive log generally correspond to lithological changes. Additional details on gamma-ray logging are given by Lynch (1962). A 500-ft Widco logger fitted with an Esterline-Angus recorder and a 1-inch diameter gamma-ray probe designed by the BMR was used. The probe consists of a scintillation crystal photomultiplier and preamplifier suspended in the borehole by a waterproof cable. The amplified pulses are counted and the count rate is displayed on the recorder as the probe is lowered or raised in the borehole. Because of instrumental failure only two holes were logged. A typical gamma-ray log is shown in Plate 7. The log shows a low count at a depth of about 37 ft. This is interpreted as a layer of sand or sandy clay from about 35 to 39 ft compared with other sections of the log where it is predominantly clay shown by the higher count.

Drilling

A 'Proline' auger drill (3½-inch diameter) mounted on a Chamberlain tractor was used to drill boreholes up to 72 ft deep to check the nature of the near-surface unconsolidated formations and furnish ground water and mud samples for resistivity determinations.

4. RESULTS

Plate 1 is the locality map, showing the geology of the surveyed area, and the positions of the resistivity depth probes and boreholes.

Plate 2 shows the ground water resistivities measured on water samples from boreholes, or estimated from water salinities. Approximate resistivity contours are drawn. The 0.50-ohm-metre contour corresponds to a salinity of 10,000 p.p.m., and the 0.2 contour with 25,000 p.p.m., using equation 5.

Appendix 4 gives the geological logs of boreholes drilled by BMR personnel and Appendix 5 the analysis of resistivity depth probes.

Comparison of formation resistivities R_f with borehole logs

Following the procedures outlined above, (equation 2), the average water resistivity R_{wa} was determined as 0.28 ohm-metre from 144 samples. This corresponds to about 18,000 p.p.m. salinity.

Using equation 3, the average porosity P_a was determined as 0.38 from 105 determinations.

The substitution of the above values for P_a and R_{wa} in equation 1 results in an average formation resistivity R_{fa} of 1.8 ohm-metres. Following the procedure outlined above, this value is adopted as a boundary between higher resistivity, sandy clays or clayey sands, and the lower resistivity clays. Plates 3, 4, and 5 show where formation resistivities are lower or higher than 1.8 ohm-metres at depths of 10, 20, and 40 ft. To find out whether such information can be used to make lithological predictions, a comparison was made between predictions based on formation resistivities and drilling logs. Table 1 shows the result.

Table 1

Depth (ft)	Number of predictions			Percentage of correct predictions
	Correct	Incorrect	Total	
10	45	27	72	62
20	50	22	72	70
40	35	37	72	49

Table 1 shows that at depths of 40 ft there is less than an even chance that a prediction based on formation resistivity will be correct. There are probably two main reasons for this high failure rate at deeper levels:

(a) The salinity of the ground water probably increases with depth and it is impossible to distinguish sandy material saturated with brine from saline clays.

(b) A calibration test with the 'Terrameter' resistivity meter showed that resistance measurements of 0.005 ohm are 20% too high, and that resistances less than 0.005 ohm cannot be measured reliably (Wainwright, 1966). This means that with the low resistivities encountered at depth resistivity measurements with electrode spacings in excess of 200 ft are valueless.

Comparison between formation resistivity R_f and groundwater resistivity R_w.

In Plate 6 are indicated by contours the location of areas with formation resistivities of higher than 3.0 ohm-metres and lower than 1.1 ohm-metres for depths of about 20 ft or more. There seems to be no obvious relation between the contours and the pattern shown in the geological map (Plate 1). However, the pattern of Plate 6 shows a great similarity with the pattern on the groundwater resistivity map (Plate 2). Areas where higher formation resistivities coincide with higher groundwater resistivities are located north and south of Johnsons Swamp and also near stations 77 and 110 in the north-west corner.

The high formation-resistivity overlying a very low formation resistivity near station 121 in the south is possibly caused by leakage from the fresh water channel (See Plate 4).

The patches of higher groundwater resistivities near stations 86, 38, 4, and 5 (Plate 2) cannot be explained. The water samples from the bores are possibly mixtures of ground water and fresh surface rain water.

The low formation resistivity belt between stations 120, 32, 117, and 116 (Plate 6) coincides closely with a similar low groundwater resistivity belt.

The lowest ground resistivities to the greatest depths occur around station 33 (0.8 ohm-metre to 30 ft, 0.5 ohm-metre to 100 ft). Physically this feature may be described as a saltwater sump.

Some of the low formation resistivities in the areas along the salt drains may have been caused by leakage from the drains.

Summarising, in a depth range of about 10 to 70 ft, the average formation resistivity is 1.8 ohm-metre, the groundwater resistivity is 0.28 ohm-metre, hence the average salinity is 18,000 p.p.m. and the average porosity 38%. At shallow depths, from say 10 to 20 or 30 ft, formation resistivities can indicate with a certain degree of accuracy whether the sediments are clays or sandy clays (clayey sands). Partly this may be due to the higher permeability of sandy clays permitting surface water to mix with saline ground water. A good correlation exists between ground water resistivities measured from bore water samples and high or low formation resistivities at about 20 ft or deeper.

5. CONCLUSIONS

At depths of from 10 to 30 ft, resistivity depth probes can be used to predict whether formations are predominantly clay or sandy clay (clayey sands) with a chance of 2 in 3 of being correct.

At deeper levels this is not possible because of the overshadowing effect of saline conditions. The basic reason is that it is not possible to distinguish with resistivity measurements between a permeable sand, or gravel saturated with salt water, and an impermeable saline clay. However, it is possible to predict with a fair degree of accuracy the salinity of groundwater from resistivity depth probes for depths of 20 ft or more.

Gamma ray logging is an excellent technique to distinguish rock types in cased, shallow boreholes, and for correlation between boreholes.

In areas of saline water, resistivity meters capable of measuring resistances with an accuracy of ± 0.001 ohm should be used if electrode spacings (Wenner configuration) of larger than 100 ft are desired.

6. REFERENCES

ANDREW, T. & WIEBENGA, W.A. 1965 Two-layer resistivity curves for the Wenner and Schlumberger electrode configurations, Bur. Min. Resour. Aust. Rec. 1965/18.

COAD, A. 1964 Results of the drilling survey to investigate the stratigraphy and underground water levels in part of the Kerang irrigation area. Research Investigations, State Rivers and Water Supply Commission (unpubl.).

CURREY, D.T. 1963 The prior river system of the Kerang irrigation area. Geological Notes, State Rivers and Water Supply Commission (unpubl.).

DYSON, D.F. & WIEBENGA, W.A. 1957 Final report on geophysical investigations of underground water, Alice Springs, NT 1956. Bur. Min. Resour. Aust. Rec. 1957/89 (unpubl.).

GARLAND, K. 1963 Distribution of sub-soil sand in the Kerang-Cohuna district. The Journal of Agriculture, Victoria 61, 507.

GUYOD, H. 1944 ELECTRICAL WELL LOGGING. HALIBURTON OIL WELL CEMENTING COMPANY.

LYNCH, E.J. 1962 FORMATION EVALUATION. HARPER & ROW, NEW YORK.

MOONEY, H.M. and WETZEL, W.W. 1956 THE POTENTIALS ABOUT A POINT ELECTRODE AND APPARENT RESISTIVITY CURVES FOR A TWO, THREE, AND FOUR-LAYER EARTH. Minneapolis, University of Minnesota Press.

PARASNIS, D.S. 1962 PRINCIPLES OF APPLIED GEOPHYSICS, Methuen, London.

PETTIJOHN, F.J. 1949 SEDIMENTARY ROCKS. HARPER & BROTHERS, NEW YORK.

WAINWRIGHT, M.	1966	Koo-wee-rup resistivity survey, Victoria 1965. <u>Bur. Min. Resour. Aust</u>. 1966/114 (unpubl.).
WIEBENGA, W.A.	1955	Geophysical investigations of water deposits, Western Aust. <u>Bur. Min. Resour Aust. Bull.</u> 30.

APPENDIX 1

Geological log of the Victorian Mines Department bore at the Kerang Agricultural Research Farm

Data are extracted from a file held at the Reseach Farm office. The bore is 20ft from resistivity depth probe 61.

Depth (ft)	Abbreviated log: Colour	Material
0 - 10	Brown	Clay
10 - 36	Yellow grey	Sandy clay
36 - 48	Yellow grey	Gravelly silts, gravel and coarse sand
48 - 52	Yellow grey	Coarse sand
52 - 71	Yellow grey	Gravelly silt and gravel
71 - 92	Red brown	Gravelly clay
92 - 110	Grey	Clay
110 - 188	Yellow grey	Silt
188 - 280	Yellow and grey	Sand
280 - 330	Grey	Gravel and coarse sand
330 - 597	Grey	Fine sand with carbonaceous material
597 - 640	Grey	Clay with dolomite

APPENDIX 2

Geological log of CSIRO piezometers on the Kerang Agricultural Research Farm and adjacent properties

A. Piezometers on Kerang Agricultural Research Farm

Piezometer No. 1

0	- 3'	Dark red brown clay
3'	- 6'	Lighter colour brown clay
6'	- 12'	Yellow clay
12'	- 20'	Hard yellow clay
30'	- 40'	Softer yellow clay
40'	-	Sand

Piezometer No. 2

0	- 3'	Dark brown clay
3'	- 19'	Light yellow clay
19'	- 23'	Fine brown sand
23'	- 26'	Fine grey sand

Piezometer No. 3

0	- 12'	Brown clay
12'	- 13'	Grey clay
13'	- 39'	Brown clay
39'	-	Brown fine sand

Piezometer No. 4 (Resistivity depth probe 62)

0	- 3'	Brown grey clay
3'	- 19'	Brown and grey clay
19'	-	Sand

Piezometer No. 5

0	- 3'	Yellow grey clay
3'	- 8'	Yellow grey heavy clay
8'	- 35'	Yellow grey and brown clay (very tough)
35'	-	Coarse sand

Piezometer No. 6

0	- 3'	Yellow brown clay
3'	- 12'	Yellow brown clay (soft)
12'	- 30'	Yellow grey and brown clay (very tough)
30'	- 37'	Brown grey clay (softer)
37'	-	Coarse brown sand

Piezometer No. 7

0	- 3'	Yellow brown grey clay
3'	- 9'	Grey brown grey clay (at 6 ft depth traces of gypsum)
9'	- 34'	Mottled grey and brown clay (tough)

Piezometer No. 8 (Resistivity depth probe 44)

0	- 2'	Brown clay
2'	- 18'	Brown and grey clay
18'	-	Sand

Piezometer No. 9

0	– 3'	Brown clay
3'	– 16'	Yellow grey clay
16'	–	Sand

Piezometer No. 10

0	– 4'	Red brown clay	)
4'	– 8'	Yellow brown clay	)
8'	– 11'	Brown clay	)
11'	– 16'	Yellow brown clay	) – Very hard
16'	– 22'	Grey clay	)
22'	– 24'	Grey brown clay	)
24'	– 28'	Grey clay	
28'	– 36'	Yellow brown clay	
36'	– 43'	Grey clay	
43'	– 47'	Grey sandy clay	
47'	– 48'	Grey sand	
48'	– 52'	Sandy grey clay	
52'	– 53'	Brown clay	
53'	– 60'	Grey clay	
60'	– 63'	Grey sand	

Piezometer No. 11

0'	– 4'	Red brown clay
4'	– 6'	Brown clay
6'	– 12'	Yellow brown clay
12'	– 29'	Yellow clay very hard with fine gravel
29'	– 31'	Thin sand layers
31'	– 34'	Brown clay
34'	– 36'	Grey clay
36'	– 40'	Brown clay
40'	– 43'	Grey and brown sand

Piezometer No. 12

0'	– 4'	Red brown clay
4'	– 8'	Brown clay
8'	– 12'	Yellow brown clay
12'	– 18'	Grey yellow clay, very hard with fine gravel
18'	– 29'6"	Yellow brown clay
29'	– 30'6"	Brown sand
30'6"	– 38'	Grey yellow clay
38'	– 40'	Grey sand
40'	– 45'	Grey brown clay
45'	– 54'	Brown and grey sandy clay – various layers
54'	– 56'	Brown sand

Piezometer No. 13

0'	– 2'	Black brown clay
2'	– 4'	Red brown clay
4'	– 8'	Brown clay
8'	– 22'	Yellow brown clay
22'	– 25'	Grey clay
25'	– 26'	Grey sand
26'	– 35'	Grey brown clay
35'	– 36'	Grey clay
36'	– 37'	Grey brown sandy clay
37'	– 39'	Grey clay
39'	–	Grey coarse sand

Piezometer No. 14 (Resistivity depth probe 60 between piezometers 14 and 15)

0'	-	2'	Black brown clay
2'	-	8'	Brown clay
8'	-	19'	Yellow brown clay (very hard)
19'	-	33'	Grey yellow clay
33'	-	40'	Brown coarse sand

Piezometer No. 15 (Resistivity depth probe 60 between piezometers 14 and 15)

0'	-	2'	Black brown clay
2'	-	4'	Brown clay
4'	-	8'	Yellow brown clay
8'	-	15'	Grey clay
15'	-	23'	Light brown clay
23'	-	26'	Brown fine sand

B. Piezometers on adjacent properties

Piezometer No. 16

0'	-	4'	Black brown clay
4'	-	12'	Brown clay
12'	-	13'	Yellow brown clay
13'	-	21'	Grey brown clay
21'	-	24'	Brown sand

Piezometer No. 17

0'	-	2'	Black brown clay
2'	-	4'	Brown clay
4'	-	6'	Yellow brown clay
6'	-	16'	Brown clay
16'	-	20'	Brown sand

Piezometer No. 18

0'	-	4'	Black brown clay
4'	-	11'	Brown clay
11'	-	22'	Grey clay
22'	-	27'	Light brown clay
27'	-	28'	Dark brown clay
28'	-	29'	Brown fine sand
29'	-		Brown coarse sand

Piezometer No. 19

0'	-	2'	Black brown clay
2'	-	5'	Brown clay
5'	-	14'	Brown fine sand
14'	-	16'	Grey sand
16'	-	17'	Brown coarse sand
17'	-	19'	Brown fine sand
19'	-	20'	Grey sand

Piezometer No. 20

0'	- 4'	Grey to grey brown clay
4'	- 13'	Brown clay with traces of sand (fairly soft layer)
13'	- 20'	Brown very hard gravelly clay
20'	- 27'	Grey brown clay
27'	- 35'	Grey brown sandy clay
35'	- 37'	Grey brown fine sand
37'	- 38'	Brown coarse and fine sand
38'	- 40'	Grey brown fine sand

Piezometer No. 21

0"	- 6"	Grey clay
6"	- 7'	Brown clay
7'	- 9'	Brown sandy clay
9'	- 19'	Very hard brown clay with patches of gravel
19'	- 21'	Soft layer of grey brown clay
21'	- 30'	Hard grey brown clay
30'	- 31'	Brown clay
31'	- 35'	Grey brown clay
35'	- 39'	Light brown sandy clay
39'	- 45'	Grey brown clay
45'	- 46'6"	Fine and coarse grey sand
46'6"-47'6"		Brown clay
47'6"-	48'6"	Brown fine sand
48'6"-	50	Brown clay
50'	- 56'	Grey brown clay
56'	-	Fine brown sand

Piezometer No. 22

0"	- 6"	Grey brown clay
6"	- 5'	Fairly soft brown and grey brown clay
5'	- 9'	Hard brown gravelly clay
9'	- 25'	Very hard brown clay
25'	- 35'	Grey, brown and yellow clay (softer layers)
35'	- 36'	Grey brown clayey sand
36'	- 37'	Reddish brown clayey sand
37'	- 40'	Fine grey sand
40'	-	Very coarse sand

Piezometer No. 23

0"	- 3'	Reddish brown clay
3'	- 20'	Brown clay, fairly hard
20'	- 23'	Softer grey brown clay
23'	-	Fine brown sand

Piezometer No. 24

0"	- 5'	Grey clay (fairly soft)
5'	- 15'	Very hard brown grey clay
15'	- 18'	Softer brown grey clay
18'	- 19'	Light brown sandy clay
19'	-	Light brown fine sand

Piezometer No. 25

0"	- 3'	Grey clay	)
3'	- 8'	Brown clay	) - Fairly soft
8'	- 18'	Grey brown clay	)
18'	- 19'	Grey brown sandy clay	
19'	-	Fine brown sand	

Piezometer No. 26

0	-	1'	Dark grey clay
1'	-	6'	Dark brown clay
6'	-	7'	Light brown clay
7'	-	11'	Dark brown clay
11'	-	16'	Grey brown sandy clay
16'	-	20'	Dark brown sandy clay
20'	-	22'	Grey sandy clay
22'	-	26'	Dark brown sandy clay
26'	-		Dark brown sand

Piezometer No. 27

0	-	2'	Dark grey clay
2'	-	6'	Dark brown clay
6'	-	13'	Brown clay
13'	-	22'	Light brown clay
22'	-	25'	Dark brown clay
25'	-	32'	Light brown clay
32'	-	33'	Grey clay
33'	-	36'	Grey sandy clay
36'	-		Coarse sand

Piezometer No. 28

0	-	5'	Red brown clay
5'	-	9'	Soft light brown clay
9'	-	14'	Very hard light brown clay
14'	-	18'	Very hard light brown clay with fine gravel
18'	-	19'	Softer light brown clay
19'	-	23'	Hard light brown clay
23'	-	25'	Hard grey brown clay
25'	-	27'	Hard dark brown sandy clay
27'	-	32'	Grey clay
32'	-	33'	Dark brown clay
33'	-	36'	Grey and light brown clay
36'	-		Coarse grey sand

Piezometer No. 29

0	-	4'	Dark brown clay
4'	-	8'	Light brown clay
8'	-	12'	Brown sandy clay
12'	-	17'	Very hard yellow brown clay with fine gravel
17'	-	23'	Very hard grey clay
23'	-	27'	Softer grey clay
27'	-	48'	Very hard grey clay
48'	-	57'	Hard fine grey sand
57'	-	63'	Grey coarse sand

Piezometer No. 30

0	-	4'	Red brown clay
4'	-	8'	Brown clay
8'	-	27'	Very hard light brown clay
27'	-	28'	Very hard grey clay
28'	-	37'	Light brown clay (a bit softer)
37'	-	46'	Very hard grey sandy clay
46'	-	58'	Light brown sandy clay (hard like stone)
58'	-	66'	Reddish brown hard sand
66'	-		Red brown sand

APPENDIX 3

Geological logs of State Rivers and Water Supply Commission boreholes

Logs adapted and abbreviated from Coad(1964).

Borehole / resistivity depth probe	Depth (ft)	Material	Water salinity (p.p.m.)
K6	0-60	Clay	43,000
K8	0-47	Clay	13,000
	47-60	Sandy clay	
K9	0-47	Clay	57,500
	47-60	Sandy clay	
K10/79	0-47	Clay	53,000
	47-62	Sandy clay	
K11	0-28	Clay	47-500
	28-46	Sandy clay	
	46-57	Sand	
	57-58	Sandy clay	
K14/63	0-60	Clay	26,500
K17/84	0-60	Clay	18,200
K18/58	0-49	Clay	3,850
	49-58	Sandy clay	
K20	0-42	Clay	37,000
	42-60	Sandy clay	
K21	0-47	Clay	4,000
	47-60	Sandy clay	
K23	0-42	Clay	4,000
	42-56	Sandy clay	
K24/59	0-48	Clay	43,500
	48-60	Sandy clay	
K26-13	0-60	Clay	9,000
K27/12	0-60	Clay	
	35-41	Sandy clay	33,000
K28/11	0-35	Clay	9,000

Borehole / resistivity depth probe	Depth (ft)	Material	Water salinity(p.p.m.)
K28/11 (contd.)	35-36	Sandy clay	
	36-46	Gravel	
	46-49	Clay	
K29	0-60	Clay	18,000
K31	0-45	Clay	25,500
	45-60	Sandy clay	
K33	Geological log unavailable		
K34	Geological log unavailable		

APPENDIX 4

Geological logs of BMR boreholes

Bore hole and resistivity depth probe	Depth ft	Material
1	0 - 9 9 - 45 45 - 54	Clay Sandy clay Clay
2	0 - 33 33 - 54	Clay Sandy clay
3	0 - 30 30 - 54	Clay Sandy clay
4	0 - 30 30 - 54	Clay Coarse sandy clay
5	0 - 36 36 - 54	Clay Coarse sandy clay
6	0 - 15 15 - 54	Clay Sandy clay
7	0 - 30 30 - 54	Clay Coarse sandy clay
8	0 - 36 30 - 54	Clay Coarse sandy clay
9	0 - 36 36 - 48 48 - 54	Clay Coarse sandy clay Clay
10	0 - 30 30 - 54	Clay Sandy clay
14	0 - 15 15 - 36 36 - 54	Clay Sandy clay Clay
15	0 - 15 15 - 54	Clay Sandy clay
16	0 - 54	Clay

Bore hole and resistivity depth probe	Depth ft	Material
18	0 - 54	Clay
20	0 - 54	Clay
22	0 - 48 48 - 54	Clay Sandy clay
23	0 - 48 48 - 54	Clay Sandy clay
24	0 - 54	Clay
26	0 - 24 ? 24 - 54 ?	Clay Sandy clay
27	0 - 24 24 - 54	Clay Sandy clay
28	0 - 24 24 - 54	Clay Coarse sandy clay and sandy clay
29	0 - 33 33 - 42 42 - 48 48 - 54	Clay Sandy clay Clay Sandy Clay
30	0 - 33 33 - 54	Clay Sandy clay
32	0 - 24 24 - 54	Clay Sandy clay
34	0 - 48 48 - 54	Clay Sandy clay
36	0 - 36 36 - 54	Clay Coarse sandy clay
37	0 - 42 42 - 54	Clay Sandy clay

Bore hole and resistivity depth probe	Depth ft	Material
38	0 - 54	Clay
39	0 - 45 45 - 54	Clay Clay
40	0 - 54	Clay
41	0 - 45 45 - 54	Clay Sandy clay
42	0 - 54	Clay
43	0 - 21 21 - 54	Clay Coarse sandy clay
46	0 - 39 39 - 54	Clay Coarse sandy clay
48	0 - 36 36 - 48 48 - 54	Clay Coarse sandy clay Clay
51	0 - 39 39 - 72	Clay Coarse sandy clay and sandy clay
52	0 - 36 36- 54	Clay Sandy clay
64	0 - 39 39 - 54	Clay Fine and coarse sand
65	0 - 45 45 - 54	Clay Coarse sandy clay
66	0 - 45 45 - 54	Clay Sandy clay
67	0 - 54	Clay
68	0 - 54	Clay

Bore hole and resistivity depth probe	Depth ft	Material
69	0 – 54	Clay
70	0 – 39 39 – 54	Clay Sandy clay
71	0 – 27 27 – 54	Clay Sandy clay
72	0 – 48 48 – 54	Clay Sandy clay
74	0 – 45 45– 54	Clay Sandy clay
75	0 – 33 33 – 54	Clay Sandy clay
76	0 – 27 27 – 48 48 – 54	Clay Sandy clay Clay
77	0 – 45 45 – 54	Clay Coarse sandy clay
85	0 – 48 48 – 54	Clay Sandy clay
86	0 – 36 36 – 54	Clay Sandy clay
87	0 – 48 48 – 54	Clay Coarse sand clay
91	0 – 24 24 – 54	Clay Sandy clay
92	0 – 27 27 – 54	Clay Coarse sandy clay and sandy clay
94	0 – 51 51 – 54	Clay Sandy clay

Bore hole and resistivity depth probe	Depth ft	Material
95	0 - 54	Clay
96	0 - 45 45 - 51 51 - 54	Clay Coarse sandy clay Clay
99	0 - 72	Clay
111	0 - 30 30 - 72	Clay Sandy clay
114	0 - 33 33 - 54	Clay Sandy clay
115	0 - 39 39 - 54	Clay Coarse sandy clay and sandy clay
116	0 - 24 24 - 54	Clay Fine and coarse sand

APPENDIX 5

Analysis of depth probes

The resistivity field data listed below are to be read as follows:

Resistivity depth probe number 1 has a resistivity of 2 ohm-metres to a depth of 1ft, 2.5 ohm-metres to 15ft, 1.2 ohm-metres to 56ft, etc.

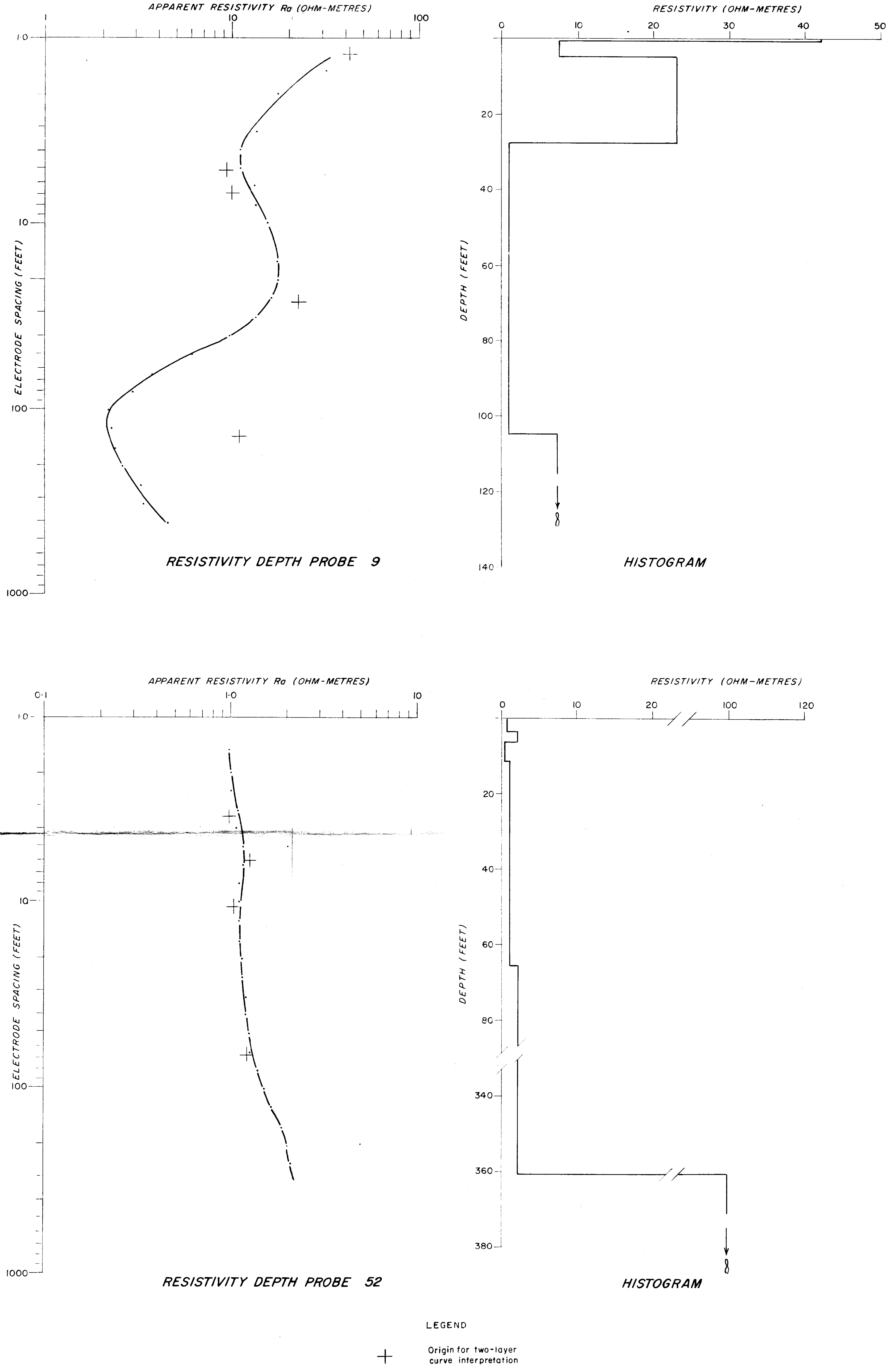
Resistivity depth probe number	Resistivity field data resistivity (depth)
1	2 (1), 2.5 (15),1.2 (56), 3.0 (250), 15
2	2 (12), 2.2 (14), 1.5 (32), 2.2 (160), 16
3	2.5 (1), 1.4 (24), 1.2 (70), 3.0 (240), 17
4	12 (1), 3 (3), 7 (13), 1.4 (90), 10
5	1.2 (2), 1.6 (80), 10
6	4 (2), 2.3 (8), 1.5 (80), 10
7	3.4 (2), 1.3 (75), 8.5
8	3.0 (6), 1.2 (75), 8.0
9	42.0 (1), 7.5 (5), 23.0 (28), 1.0 (105) 7.5
10	1.0 (1), 0.8 (5), 1.3 (115) 10.0
11	3.5 (1), 5.5 (42), 1.5 (155), 25.0
12	1.3 (2), 1.6 (20), 1.3
13	1.0 (2), 1.5 (25), 1.0 (48), 1.8
14	6.0 (2), 3.2 (14), 14.0 (19), 3.8
15	0.8 (2), 0.7 (6), 1.1 (46), 3.0
16	6.0 (2), 9.0 (28), 2.4
17	15.0 (2), 3.5 (9), 2.7 (170), 29.0
18	1.5 (2), 2.1 (14), 1.3 (135), 12.0
19	1.6 (2), 2.4 (17), 4.7 (35), 1.7 (100), 5.5
20	2.7 (2), 5.2 (13), 1.8 (175), 29.0
21	2.8 (3), 2.2 (7), 1.8 (140), 10.0
22	1.4 (3), 0.8 (38), 2.8
23	1.6 (2), 2.3 (4), 1.2 (70), 3.5
24	4.0 (2), 1.5 (115), 8.0
25	6.5 (2), 1.5 (5), 1.1 (90), 11.0
26	2.3 (2), 1.2 (7), 0.7 (90), 1.1 (240), 0.1
27	7.5 (3), 1.5 (9), 2.0 (25), 1.5 (103), 30
28	7.5 (3), 2.5 (8), 1.5 (93), 12.0
29	4.0 (2), 1.5 (110), 15.0
30	2.3 (3), 1.4 (120), 28.0
31	46.0 (1), 8.0 (4), 2.2 (19), 1.0 (105), 1.2
32	2.2 (1), 6.5 (3), 1.3 (23), 1.6 (86), 0.2
33	0.9 (2), 1.6 (7), 0.8 (29), 0.5 (103), 1.1
34	6.0 (2), 4.5 (7), 1.3 (26), 0.8 (80), 6.0
35	1.0 (2), 4.0 (3), 1.0 (5), 3.0 (27), 1.0 (85), 3.0

Resistivity depth probe number	Resistivity field data resistivity (depth)
36	6.5 (1), 3.5 (6), 1.5 (210), 5.0
37	1.3 (4), 1.8 (12), 0.7 (50), 1.9
38	0.8 (1), 1.1 (46), 3.5
39	6.5 (1), 3.2 (8), 1.7 (150), 6.0
40	2.0 (4), 3.0 (9), 1.5 (16), 2.2 (34), 1.7 (170), 8.0
41	1.5 (1), 1.1 (13), 1.9 (150), 6.0
42	3.5 (8), 1.9 (18), 27.0 (25), 1.5 (130), 5
43	15.0 (1), 6.5 (7.0), 2.5 (38), 1.2 (95), 11.0 (105), 2.5 (290), 17.0
44	4.0 (4), 6.0 (26), 1.2 (110), 12.0
45	3.5 (2), 5.2 (19), 1.2 (68), 2.5 (140), 1.2 (180), 10
46	6.5 (1), 2.9 (40), 1.4 (120), 3.0
47	2.4 (1), 1.4 (75), 6.0
48	4.5 (1), 2.5 (8), 1.4 (17), 2.2 (34), 1.3 (90), 6.0
49	4.5 (3), 1.3 (7.0), 6.0 (13), 1.2 (63), 8.2
50	0.8 (3), 1.2 (125), 3.0
51	8.0 (1), 3.3 (8), 1.8 (36), 0.9 (120), 10
52	0.8 (3), 2.2 (6), 0.6 (11), 1.1 (65), 2.4 (360), 100
53	4.8 (2), 2.5 (5), 1.6 (180), 10
54	4.5 (3), 1.7 (10), 1.2 (154), 6
55	2.4 (1), 1.4 (44), 2.4 (290), 5.0
56	34.0 (1), 3.8 (2.0), 3.2 (14), 1.3 (140), 6.0
57	1.6 (2), 2.0 (6), 1.4 (190), 3.0
58	2.5 (2), 3.0 (16), 1.8 (180), 11.0
59	2.5 (1), 0.8 (2), 1.4 (10), 1.1 (80), 5.0
60	1.4 (20), 1.7 (41), 1.2 (63), 26 (110), 3.0
61	14 (1), 6.2 (7), 26 (8), 2.8 (14), 6.0 (65), 1.0 (85), 10
62	3.0 (1), 1.4 (9), 0.4 (12), 1.3 (80), 4.0
63	2.0 (1), 1.0 (7), 2.8 (20), 1.4 (70), 3.0 (300), 5.0
64	8.5 (2), 20 (6), 6.4 (16), 1.0 (170), 30
65	12 (1), 3.0 (3), 2.0 (14.0),40
66	8.0 (2), 20.0 (5), 1.5 (95), 9.0
67	7.0 (2), 1.6 (3), 3.5 (11), 1.1 (21), 1.6 (135), 10.0
68	1.4 (30), 3.2 (44), 0.4 (55), 4.0
69	2.9 (2), 1.3 (110), 13.5
70	1.2 (15), 1.6 (80), 5.0
71	3.6 (1), 1.9 (3), 1.5 (26), 2.2 (37), 1.3 (100), 9.0
72	6.0 (2), 3.2 (6), 1.4 (80), 7.0
73	3.2 (1), 2.1 (7), 1.3 (27), 2.3 (170), 13.0
74	4.8 (3), 3.6 (16), 1.7 (140), 5.0

Resistivity depth probe number	Resistivity field data resistivity (depth)
75	5.0 (2), 1.7 (3), 1.2 (29), 1.0
76	2.5 (10), 1.6 (48), 4.2 (320), 34.0
77	22.0 (1), 11.2 (3), 6.4 (6), 4.0 (40) 1.5 (96), 8.0
78	26.0 (1), 1.0 (53), 6.0
79	0.8 (6), 1.0 (36), 2.0
80	0.3 (1), 4.0 (27), 1.5 (48), 10
81	1.6 (2), 5.8 (15), 2.5 (96), 17
82	5.5 (1), 3.3 (8), 6.0 (22), 1.8 (170), 8
83	1.2 (1), 1.6 (4), 1.2 (18), 1.6 (190), 30
84	8.0 (1), 3.5 (17), 1.5 (68), 3.3
85	5.5 (1), 3.5 (6), 1.3 (34), 3.0
86	2.0 (65), 5.0
87	1.6 (160), 5.0
88	1.4 (2), 2.4 (6), 1.8 (180), 30
89	0.9 (2), 1.3 (17), 2.0
90	0.6 (2), 0.8 (145), 8.0
91	6.3 (1), 4.0 (25), 2.3
92	7.5 (1), 2.4 (8), 1.5 (105), 8.0
93	2.1 (4), 3.4 (8), 1.7 (41), 5.0 (240), 18.0
94	2.5 (2), 1.2 (5), 1.8 (7), 1.0 (28), 2.5 (115), 20.0
95	3.2 (1), 7.6 (3), 2.8 (14), 1.7 (68), 7.5 (200), 15.0
96	10.0 (2), 4.2 (7), 5.8 (17), 1.8 (95), 4.0
97	1.0 (10), 1.5 (52), 0.9
98	3.8 (1), 5.9 (8), 1.4 (100), 5.0
99	0.9 (1), 1.1 (17), 2.3 (120), 5.0
100	2.0 (4), 1.3 (50), 5.0
101	4.5 (1), 1.8 (5), 2.2 (34), 1.4 (113),10.0
102	2.2 (2), 1.4 (150), 9.0
103	2.8 (5), 2.2 (30), 1.4 (180), 10.0
105	0.9 (5), 1.1 (34), 2.5 (180), 11.0
106	7.2 (1.0), 4.3 (13), 1.9 (100), 6.0
107	1.5 (24), 2.0 (90), 10.0
108	2.0 (2), 1.1 (50), 2.0
109	26.0 (1), 60.0 (5.0), 11.3 (55), 15.5 (65), 14.0
110	6.0 (2), 7.2 (27), 2.5 (180), 6.0
111	3.5 (2), 1.5 (80), 7.0
112	6.5 (2), 1.9 (15), 1.5 (101), 7.0
113	16.0 (3), 5.4 (8), 2.5 (140), 6.0
114	3.0 (6), 2.5 (19), 1.5 (130), 15.0
115	20.0 (2), 3.6 (7), 1.6 (140), 35.0

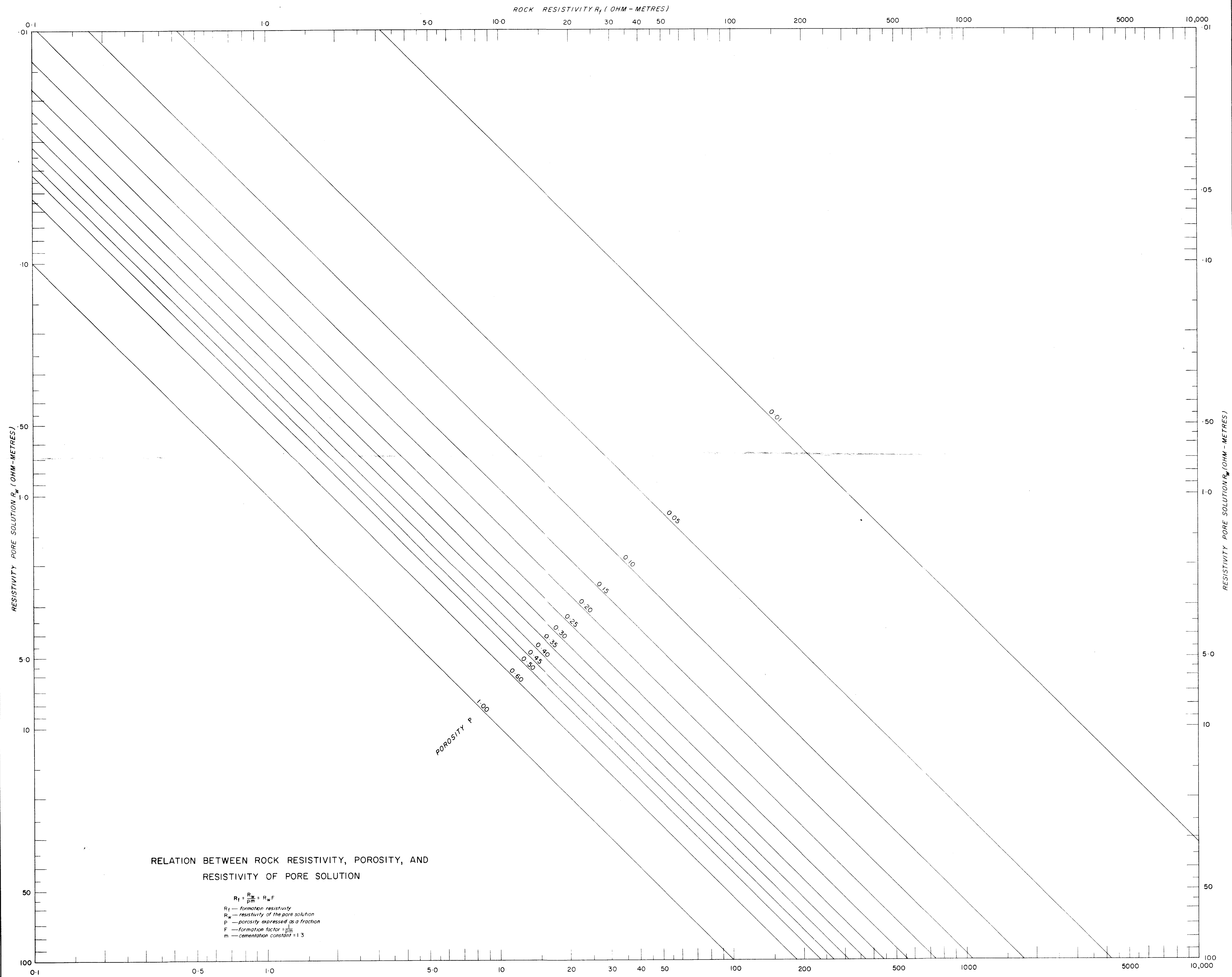
Resistivity depth probe number	Resistivity field data resistivity (depth)
116	3.0 (2), 3.5 (9), 0.8 (11), 2.8 (38), 0.6 (55), 10.0
117	5.5 (1), 1.8 (7), 1.0 (46), 3.2
118	5.0 (2), 2.9 (10), 3.5 (21), 0.7 (63), 10.0
119	1.5 (1), 2.0 (21), 1.2 (140), 12.0
120	2.9 (1), 1.9 (5), 0.5 (20), 1.4 (105), 7.0
121	2.9 (3), 5.2 (20), 0.8 (55), 5.0
122	1.0 (2), 1.3 (7), 1.8 (32), 3.6 (200), 9.0
123	2.2 (5), 1.1 (34), 2.2 (150), 4.3
124	3.6 (2), 1.2 (18), 1.9 (150), 16.0
125	9.3 (4), 1.0 (6), 3.0 (28), 1.4 (110), 15.0

Fig. 1



TYPICAL RESISTIVITY DEPTH PROBE FIELD CURVES

FIGURE 2



RELATION BETWEEN ROCK RESISTIVITY, POROSITY, AND RESISTIVITY OF PORE SOLUTION

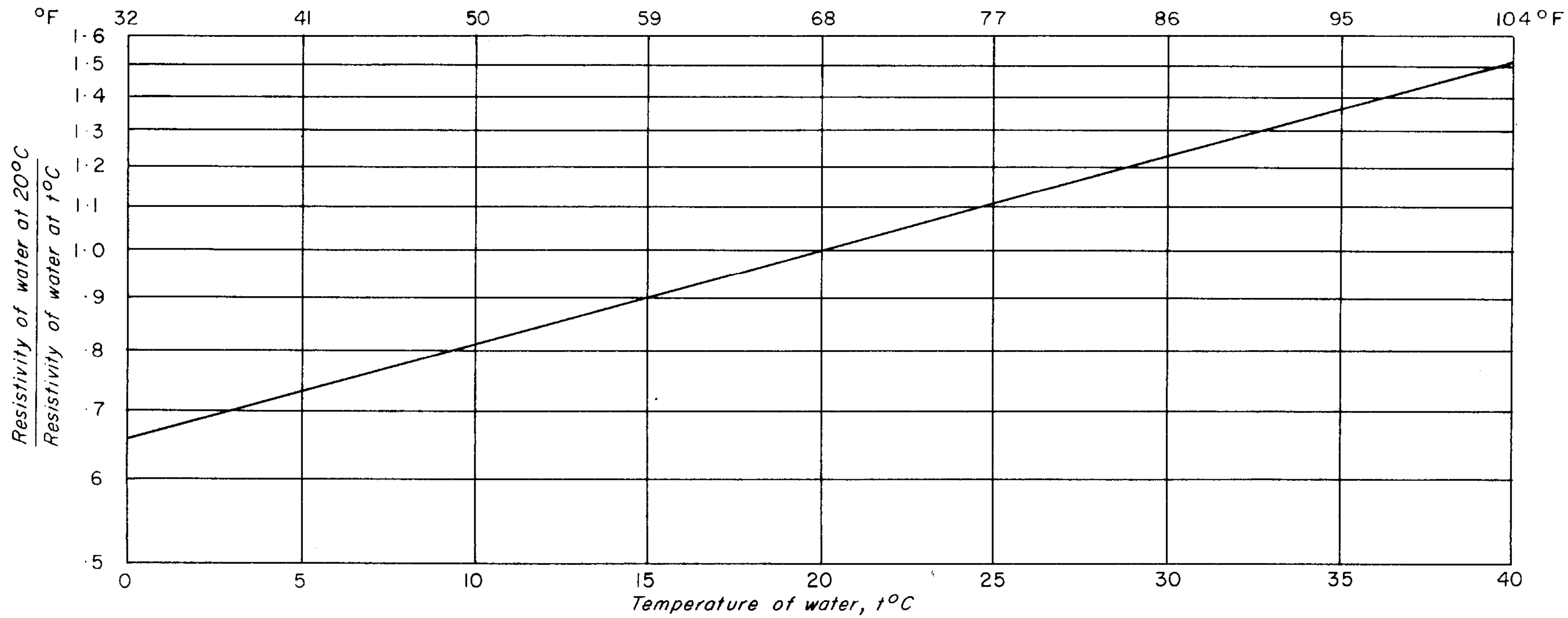
$$R_f = \frac{R_w}{P^m} = R_w F$$

R_f — *formation resistivity*
R_w — *resistivity of the pore solution*
P — *porosity expressed as a fraction*
F — *formation factor* $= \frac{1}{P^m}$
m — *cementation constant* = 1·3

TO ACCOMPANY RECORD No 1967/32

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics

G16–36



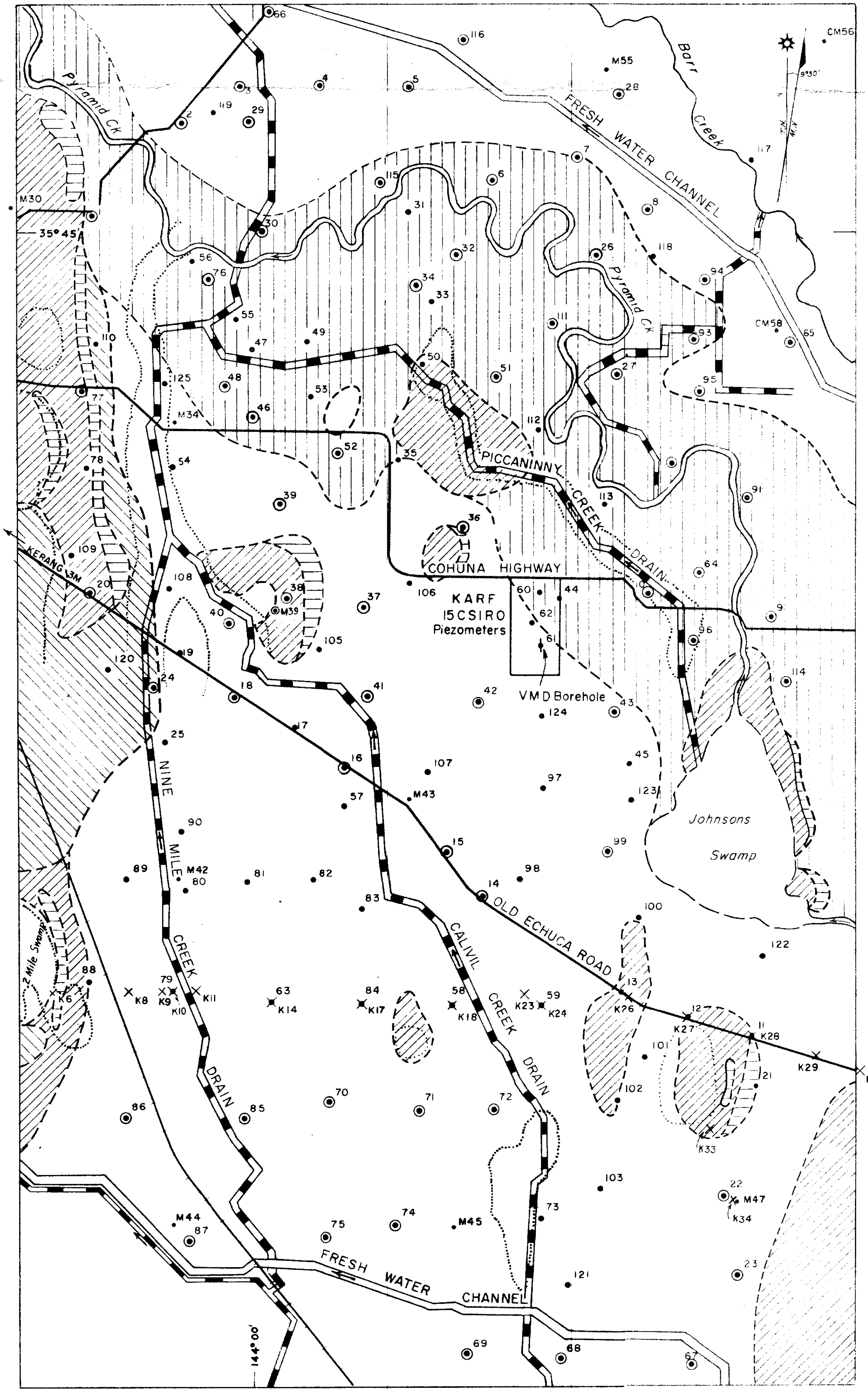
TEMPERATURE CORRECTION DIAGRAM FOR RESISTIVITY

FIGURE 3

Geophysical Branch, Bureau of Mineral Re...ces, Geology and Geophysics.

TO ACCOMPANY RECORD No. 1967/32

G16—35-1



LEGEND

- 35 — Resistivity depth probe number 35
- 8 — Resistivity depth probe number 8 with borehole
- K17 — SRWSC borehole
- 63 K14 — SRWSC borehole and resistivity depth probe
- M42 — SRWSC 10' observation bore
- Lunette
- Approximate area of prior river
- Approximate extension of prior lake
- Approximate area of Loddon River alluvial delta
- Old land surface
- Approximate boundary of marsh or lake circa 1908
- Salt drain
- Fresh water channel
- Road
- Railway

Geology based on SRWSC plan No. 78657 (Currey 1963)

SCALE

1 0 1 2 MILES

KERANG

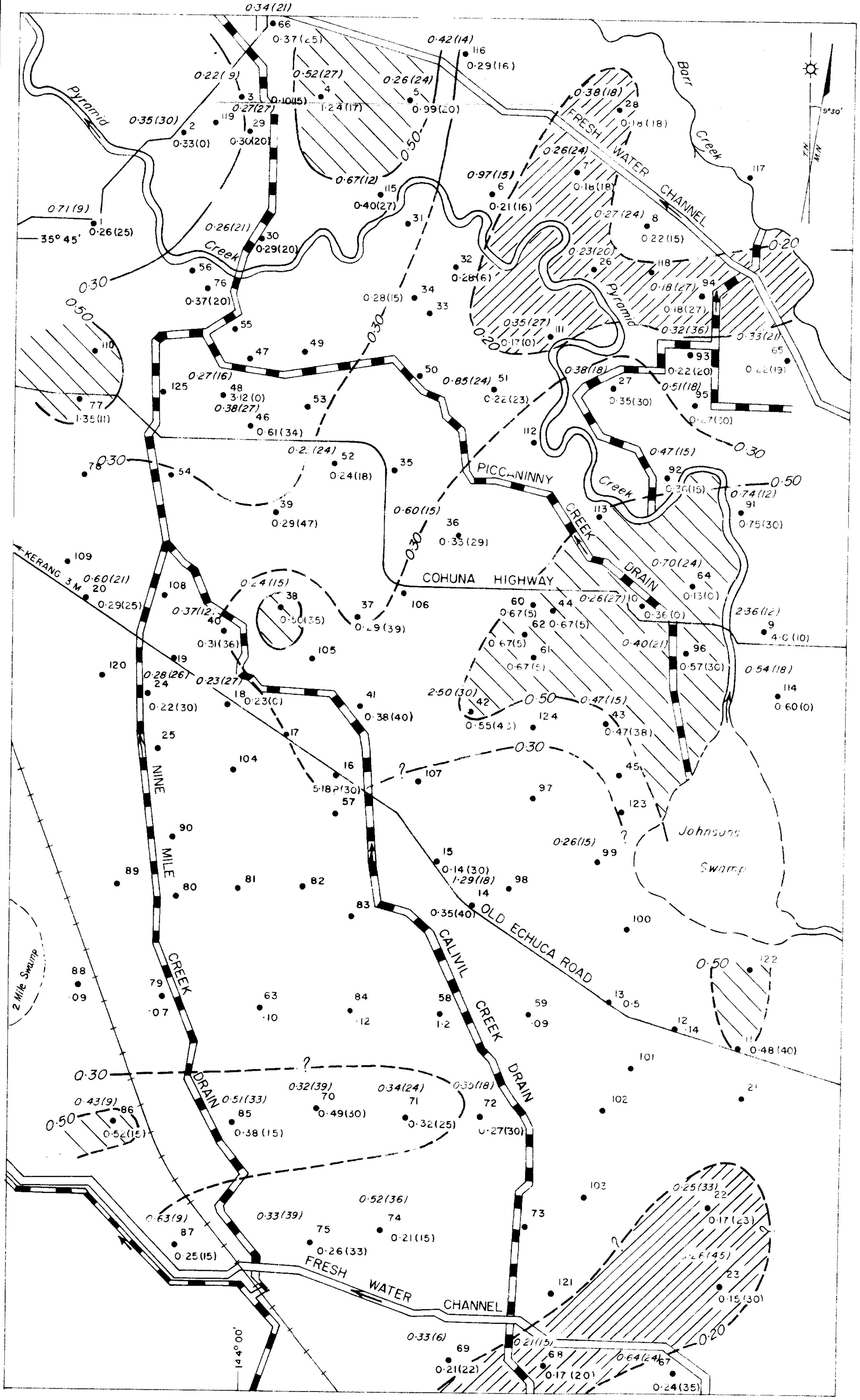
LOCALITY, GEOLOGY AND DEPTH PROBE SITES

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics

TO ACCOMPANY RECORD No. 1967/32

I54/B5-3

PLATE 2



Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics.

LEGEND

- 35 — Resistivity depth probe number
- (15) — Depth of mud sample
- 0·60 — Resistivity of mud
- (29) — Depth of water sample
- 0·33 — Resistivity of water sample
- Salt drain
- Fresh water channel
- Road
- Railway
- 0·50 — Contour of approximate water resistivity 0·50 ohm-metres
- Area of lowest ground water resistivity
- Area of highest ground water resistivity

SCALE

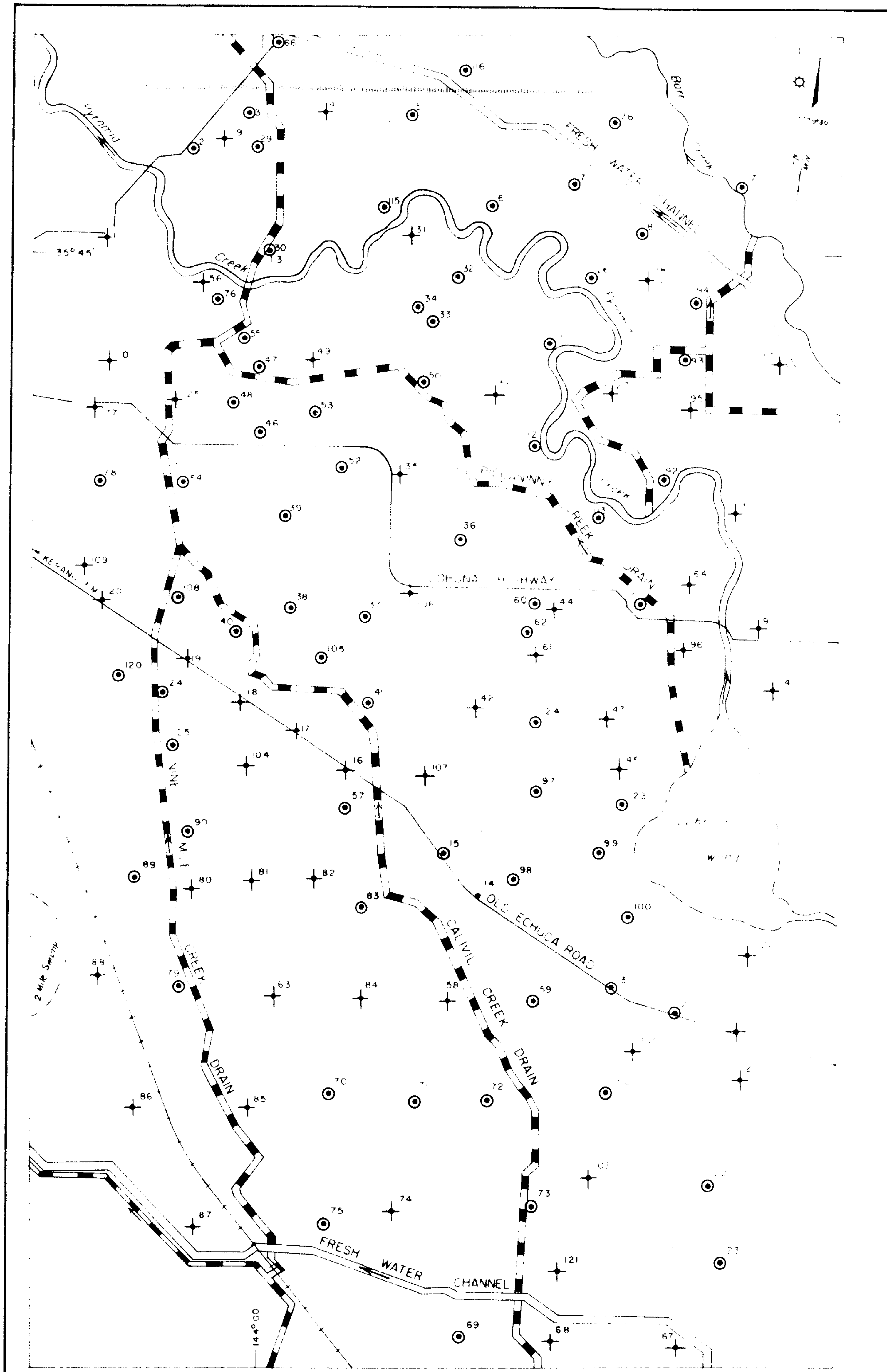
0 — 2 MILES

GROUND WATER RESISTIVITY MAP

TO ACCOMPANY RECORD No 1967/32

I54/B5-4

PLATE 3



Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics.

LEGEND

35 • Resistivity depth probe number 35

Salt drain

Fresh water channel

Road

Railway

Formation resistivity > 1·8 ohm-metres

Formation resistivity < 1·8 ohm-metres

Note: Average formation resistivity is 1·8 ohm-metres

SCALE

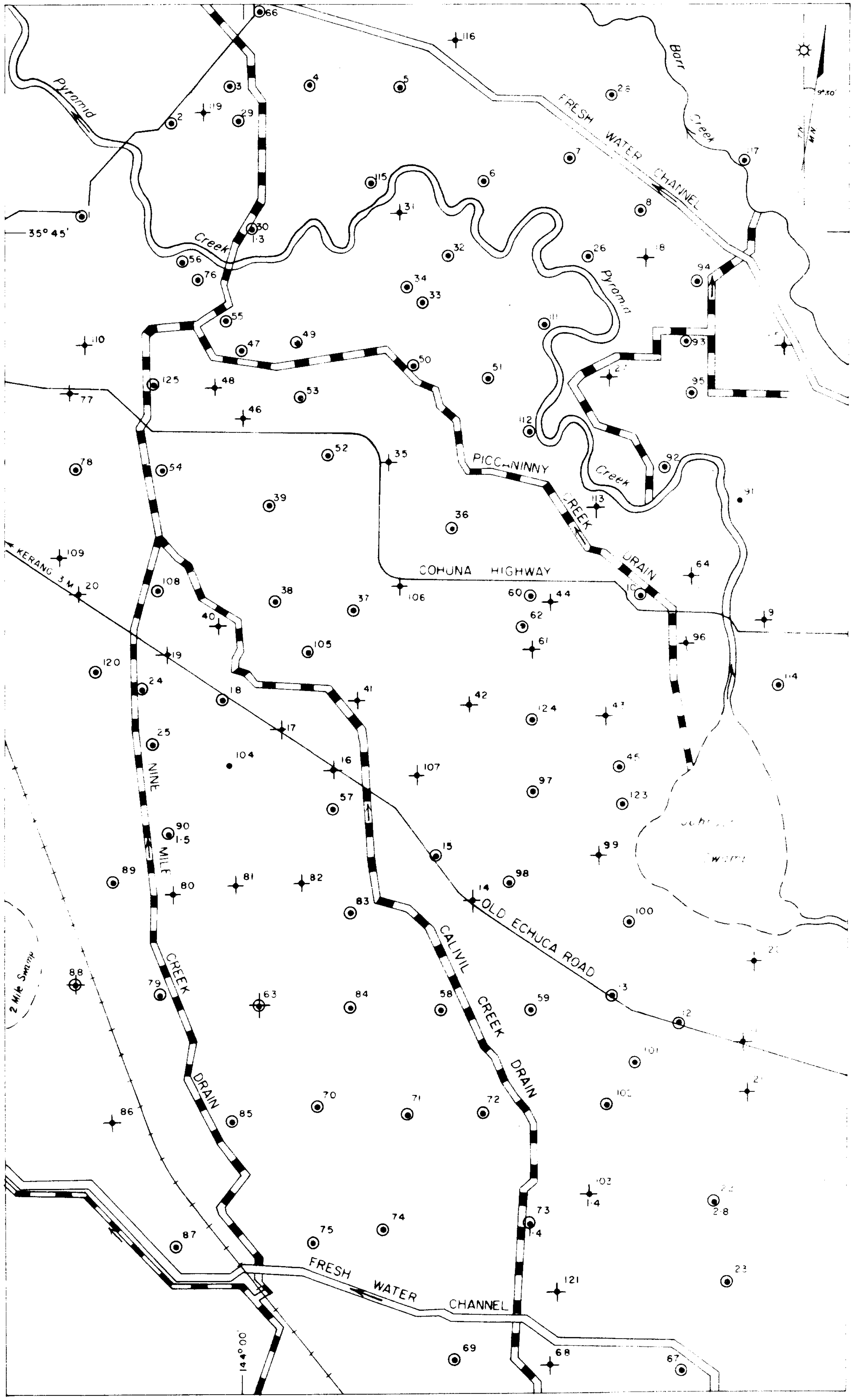
0 — 2 MILES

FORMATION RESISTIVITIES AT 10 FT DEPTH

TO ACCOMPANY RECORD No. 1967/32

I54/B5-11

PLATE 4



Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics.

LEGEND

35 • Resistivity depth probe number 35

Salt drain

Fresh water channel

Road

Railway

Formation resistivity > 1·8 ohm-metres

Formation resistivity < 1·8 ohm-metres

Note: Average formation resistivity is 1·8 ohm-metres

SCALE

0 — 2 MILES

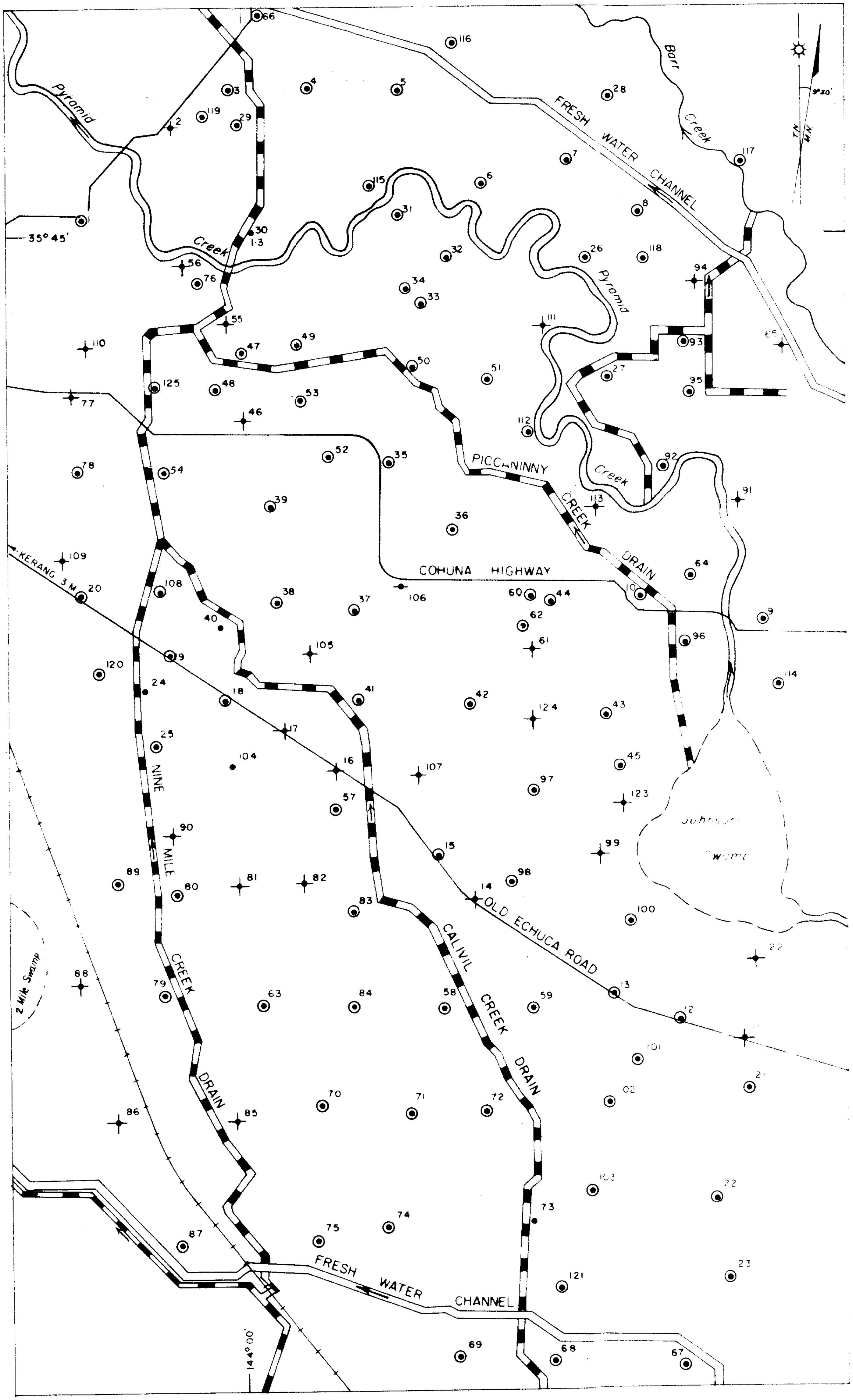
FORMATION RESISTIVITIES AT 20 FT DEPTH

TO ACCOMPANY RECORD No. 1967/32

I54/B5-12

KERANG 1964

PLATE 5



Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics.

LEGEND

35 Resistivity depth probe number 35

Salt drain

Fresh water channel

Road

Railway

Formation resistivity > 1·8 ohm-metres

Formation resistivity < 1·8 ohm-metres

Note : Average formation resistivity is 1·8 ohm-metres

SCALE

0 2 MILES

FORMATION RESISTIVITIES AT 40 FT DEPTH

TO ACCOMPANY RECORD No. 1967/32

I54/B5-13

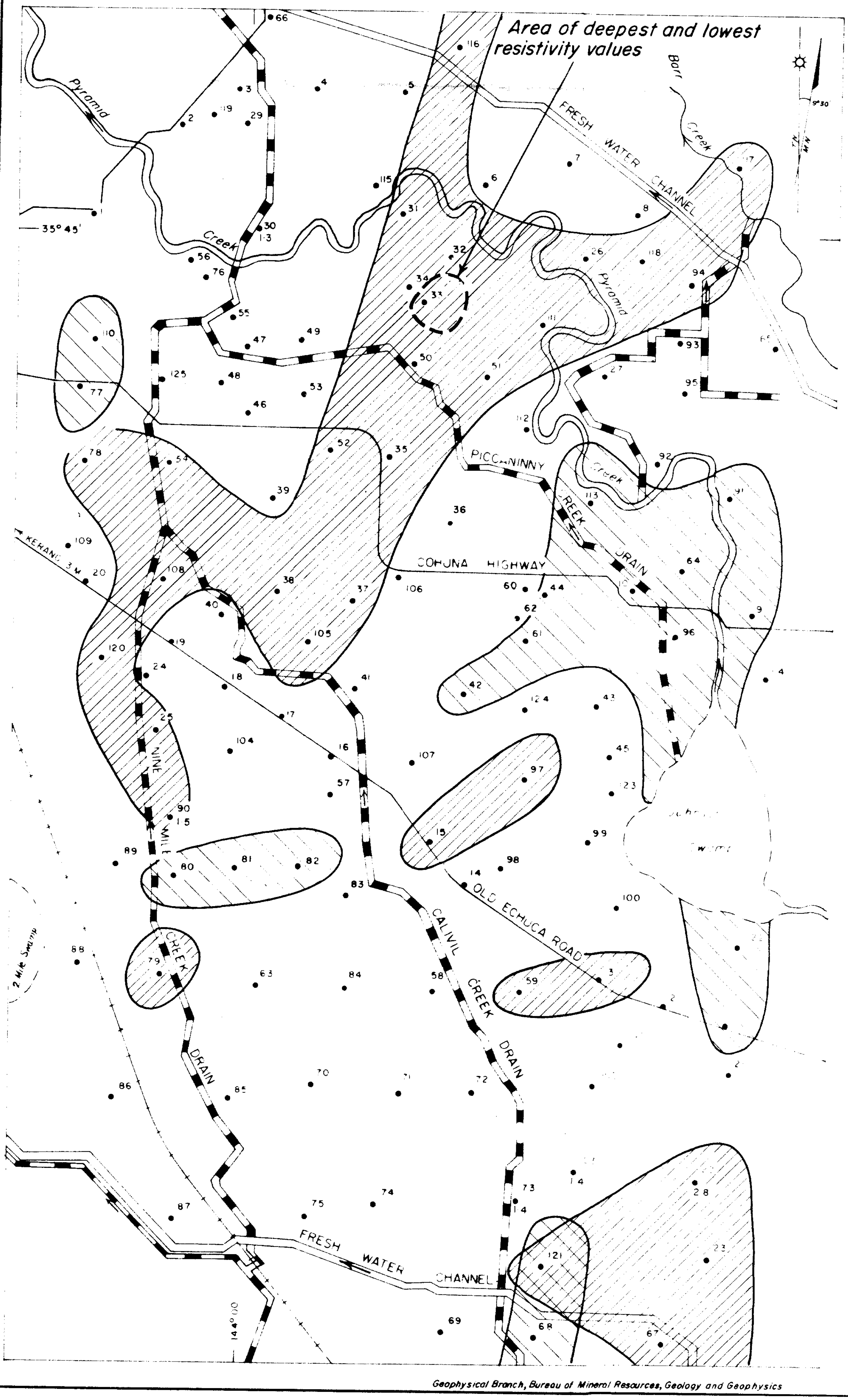


PLATE 6

LEGEND

35 • Resistivity depth probe number 35

Salt drain

Fresh water channel

Road

Railway

Formation resistivity less than 1·1 ohm-metres at depths of 20ft or more

Formation resistivity greater than 3·0 ohm-metres at depths of 20ft or more

SCALE

0 — 2 MILES

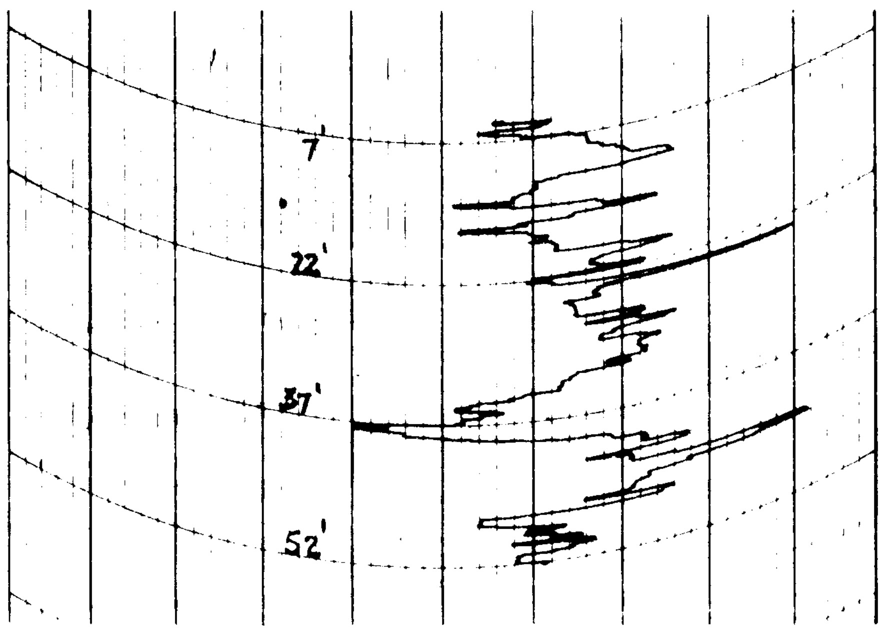
HIGHEST AND LOWEST RESISTIVITY AREAS AT DEPTHS OF 20FT OR MORE

TO ACCOMPANY RECORD No. 1967/32

I54/B5-14

PLATE 7

5



Area: KERANG

Date: 24/6/64

Bore hole: 37

Remarks: UNCASED HOLE 3½" diameter

Time constant: 5 s

Counts per minute: 5 k

Bore hole depth: 52 ft

GAMMA RAY LOG

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics

I 54 / B5—9

TO ACCOMPANY RECORD No. 1967 / 32