DEPARTMENT OF
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BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

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GOULBURN VALLEY (VICTORIA) DIPOLE-DIPOLE RESISTIVITY SURVEY 1974

by

E.J. Polak & D.C. Ramsay

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SUMMARY

A dipole-dipole resistivity survey was carried out by the Bureau of Mineral Resources, Geology & Geophysics, along two traverse lines in the Goulburn Valley, Victoria. The survey was undertaken to determine an electrode configuration suitable for locating near-surface aquifers.

Using a dipole spacing 'a' of 10 m and n numbers not exceeding 12, a number of well defined anomalous, high resistivity zones were detected. The exact character of these zones will not be known until drilling is carried out, but past experience indicates that these are probably ancestral stream deposits. Apparent resistivities of the high resistivity zones were typically 20-50 ohm-m, and background resistivities were 5-10 ohm-m.

1. INTRODUCTION

This survey is part of an experimental geophysical survey being conducted by the Bureau of Mineral Resources, Geology & Geophysics in conjunction with the Geological Survey of Victoria and the State Rivers and Water Supply Commission. From the first survey (Taylor, Hill, & Pettifer, in prep.) it has been shown that shallow resistivity profiling could reliably locate near-surface ancestral stream deposits.

The purpose of this survey was therefore to find some electrode arrangement which would indicate small variations, both lateral and vertical, in resistivity. The dipole-dipole electrode arrangement was used and proved effective in locating several channels.

The survey was carried out between 18 February and 29 March 1974 by a geophysical party from the Engineering Geophysics Group of the Bureau consisting of E.J. Polak, D.C. Ramsay, B.H. Dolan (Geophysicists) and L. Rickardsson (Field Hand). The State Rivers and Water Supply Commission provided two field hands. The traverses were located along main roads; to provide information on different soil conditions, three different areas were selected.

BMR would like to acknowledge the help given by the staff of the State Rivers and Water Supply Commission from Tatura and Numurkah and from the Geological Survey of Victoria.

2. GEOLOGY

The area under investigation is situated in the southeastern corner of the Murray Basin and is part of an old river plain with unconsolidated sediments varying in thickness from about 160 m to 240 m. These surface sediments are Cainozoic and consist of alluvial deposits of clay, silt, sand, gravel, and boulders. (Bowler & Harford, 1966; Lawrence, 1966; Butler, 1958).

On the flood plains of the present rivers and on the Riverina plains there are buried channels of former streams, creeks, and rivers. The younger ones are called ancestral river channels and the older are called prior-streams.

The ancestral river channels are similar in shape and structure to the present rivers; they have the same meandering character, point bars, bluffs etc. (Twidale, 1968, p. 176). The infilling material of the ancestral rivers varies from mud and silt to coarse sand, similar to that in modern rivers and varying with the local depth of water, current velocity, etc. The prior-streams are relatively straight, wide, and shallow, and are infilled with sand. The ancestral rivers may meander between the banks of the prior-streams (Schumm, 1968).

The shape of the ancestral rivers, and the non-uniform composition of the infilling material, make the geophysical mapping of channels difficult, especially in an area where agriculture has changed the vegetation pattern. Soil and land use maps of the area (Dept of Agriculture, 1962) may indicate the position of ancestral streams, but the fill material is not evident from the map. A typical cross-section of a channel is given by Chalmers (1969).

3. METHODS AND EQUIPMENT

The resistivity of a rock depends on the resistivity of the rock matrix and of the fluid that occupies the spaces within the rock matrix. If the resistivity of the interstitial fluid is constant, the resistivity that is measured depends mainly on the porosity of the material. Even above the water-table there is normally sufficient moisture present for the measured resistivity to be substantially lower than the resistivity of the rock matrix.

In the resistivity method, electric current is applied to the ground through two current electrodes, and the potential difference is measured between two additional points on the ground, the potential electrodes. Various arrangments of electrodes may be used depending on the purpose of the survey. In resistivity traversing, the assembly of electrodes is moved along a line to investigate lateral changes in resistivity. In resistivity depth probing, the assembly of electrodes is expanded in relation to a fixed central point, to increase the depth of penetration. As a result vertical changes in resistivity are measured.

In the Goulburn Valley, a continuous section from zero to about 50 m below the surface was required. The dipole-dipole method (Keller, 1966) was therefore employed. In this method, a collinear array of four electrodes is used. One pair of adjacent electrodes with separation 'a' is used to transmit current into the ground; the other pair, also with separation 'a', receives the signal. The separation between these pairs, or dipoles, is increased with successive readings; it is always an integral multiple of 'a', and is referred to as the 'n' number.

On the Goulburn Valley survey, the traversing method was used with an electrode spacing of a = 10 metres. The transmitting electrodes were fixed and the receiving electrodes were moved in steps of 10 m from n = 2 up to n = 12 (see Plate 3, upper left corner). The calculated values of apparent resistivity are plotted at the intersection point of two straight lines drawn at 45° from the dipole centres. Plotted results give a pseudo-section of the distribution of resistivity with depth. The vertical scale of the section depends on the contrast in resistivities encountered.

During the survey it became evident that this arrangement produces a pseudo-section with more detail than is required in reconnaissance work. It was therefore decided to advance the transmitting dipole by 2a (see Plate 3, station 35 onwards) and then take readings at only the even numbers of n (Plate 3, stations 89 onwards). Later, readings were taken at only n = 2, 5, 8, and 11, as shown in Plate 4. Part-way through the survey, the receiving dipole was kept stationary while the transmitting dipole was moved away in stages. (i.e. reversing roles of transmitting and receiving dipoles). This arrangment removed most of the difficulties viz., variation of contact resistance at the potential electrodes.

During the survey an induced polarization transmitter manufactured by Geotronics Pty Ltd was used. This instrument is rated at 10 kVA and transmits a square wave at constant current with amplitude variable up to 20 amps peak to peak with a maximum of 800 volts potential difference between the current electrodes. The frequency is also variable. During the survey, current up to 2 A was used at a frequency of 0.1 Hz. 0.1 Hz is virtually direct current, and avoids the possibility of errors due to electromagnetic coupling effects.

A telluric current compensator coupled with a digital voltmeter was used as a receiver. No permanent record was obtained; the operator had to record all readings manually.

4. RESULTS

Results of the survey are given in Plates 2 to 9. The pseudo-sections indicate that the resistivities are very low, generally between 5 and 20 ohm-metres, but reach a maximum value of 59 ohm-m at station 21/22 (Plate 3).

Higher apparent resistivities would be measured in areas where sandy porous material is filled with water of low salt content. Lower resistivities may indicate either silt and clay or sand filled with more saline water. It is too early to allocate a particular resistivity value to any group of strata. However, from past experience in other areas, it can be said that the high resistivity in any one section is due to a higher sand content, and greater contrasts in resistivity generally indicate less saline water.

Along the traverses are shown the soil types, taken from soil maps. There is not yet sufficient information to relate resistivity to soil type.

Tatura traverse

Plate 1 shows the location of this 14-km traverse along the main road from Merrigum to Ardmona; there are cross-roads at intervals of 1.6 km (1 mile), and the numbers refer to sections between successive road junctions. Sections 2, 3, and 8 were completely covered and section 1 was partly covered.

Section 1 (Plate 2) indicates that the eastern portion from station 110 contains water of lower salinity. It is possible that this water comes from an irrigation channel running alongside the road. Farther west, lower resistivity may indicate either water of higher salinity or a higher clay content in the strata. The second interpretation is considered more probable.

Section 2 (Plate 3) shows a very well developed stream channel centred at station 20. The definite decrease in resistivity to the east, as far as station 108, indicates increasing clay content. There is a narrow, shallow stream channel centred about station 113, and another small stream channel 100 m farther east.

Section 3 (Plate 4) shows intermediate resistivities along the major part of the traverse. A distinct band of low resistivity is centred on station 40. East of this, two stream channels are indicated, centred at stations 68 and 95. Farther east again, there is a major channel close to an old surface watercourse near station 118; it is possibly fed by fresh water from an irrigation channel at station 106.

Section 8 (Plate 5). This section shows a generally low resistivity. A possible stream channel is indicated, centred at station 107.

Numurkah traverse

The Numurkah traverse (Plate 1) runs along Lorenz's Road, east of and parallel to the Goulburn Valley Highway. It stretches for 8 km from the Katunga road to the Murray Valley Highway. Three sections of the traverse so far completed amount to 5.7 km. This traverse was chosen to locate any stream channels parallel to the present Murray River. The results show a marked difference between this traverse and the Tatura traverse. The resistivities are much lower; the highest resistivity measured here is 26 ohm-m as against 59 ohm-m at Tatura.

Section 1 (Plate 6). With a few exceptions, the resistivities are below 10 ohm-m, indicating that the section is probably characterized by a very high clay content. At stations 80 and 100 there are old irrigation channels which probably introduce rain water into the strata. There is an indication of a stream channel near station 153, but it is much less prominent in the cross-section than the one near Merrigum (Station 20, Plate 3).

Section 2 (Plate 7). This section starts at an irrigation channel, and the relatively high resistivities between stations 1 to 6 indicate a leakage of fresh water into the strata. Farther north, near stations 28, 52, and 62, there are indications of shallow strata with resistivity greater than 10 ohm-m. The highest reading is close to station 52, where a possible stream channel is indicated. From station 65 to 159 the section is probably composed of clay of low permeability: even an old irrigation channel near station 82 does not appear to introduce fresh water into the strata. Irrigation water leaks into more permeable strata at station 161, where the shape of the anomaly suggests that there may be a small ancestral stream. Three more indications of higher resistivity are found near stations 177, 188, and 215.

Section 3 (Plate 8). This section is rather featureless, the only high resistivities being under two irrigation channels, at stations 8 and 135. The channel near station 8 is probably over shallow permeable strata, and the channel near station 135 over impermeable strata.

Seismic spread traverse (Plate 9).

This traverse is located on a seismic spread where several shot-holes proved the existence of sand beds. The resistivity contours indicate the existence of a stream channel. The high resistivity shown near the top of the pseudo-section represents sand above the water-table. The shot-holes in the area provide the following information:

(a) An auger hole 13.5 m deep at SP 2 struck coarse sand (up to 3 mm in diameter) at a depth of 1.5 m, and this material extended to 12 m. Heavy clay occurred below this depth. The sands were completely water-saturated.

(b) Fifteen drill-holes at a location 200 m west of station 0 all penetrated heavy clay to a depth of 16 m followed by 1 m of clayey sand, after which the heavy clay recurred.

5. CONCLUSIONS AND RECOMMENDATIONS

Conclusions

The dipole-dipole resistivity method appears to be capable of locating ancestral streams.

Short dipole lengths must be used to obtain good, detailed results. This condition requires a powerful transmitter, of 1 to 2 kVA. Care must be taken to avoid the possibilities of electromagnetic coupling.

Recommendations

The survey should be continued to complete the two traverse lines, and the usefulness of the I.P. method should be checked, especially in the areas of low resistivity.

One of the major stream channels indicated by the dipole-dipole method should be closely drilled. The bores should be carefully logged geologically, and the resistivity of strata measured at several depths. Core samples should be collected and the resistivity measured when saturated with water of varying salinity. All these data should be compared with the resistivity traversing data.

Computer modelling and/or conductive paper modelling should be undertaken to determine the shape of bodies indicated in dipole-dipole pseudo-sections, to check that some of the indications are not the result of the dipole-dipole electrode geometry.

A comparative table of nomenclature of local soils should be prepared to facilitate relating resistivity to the soil type.

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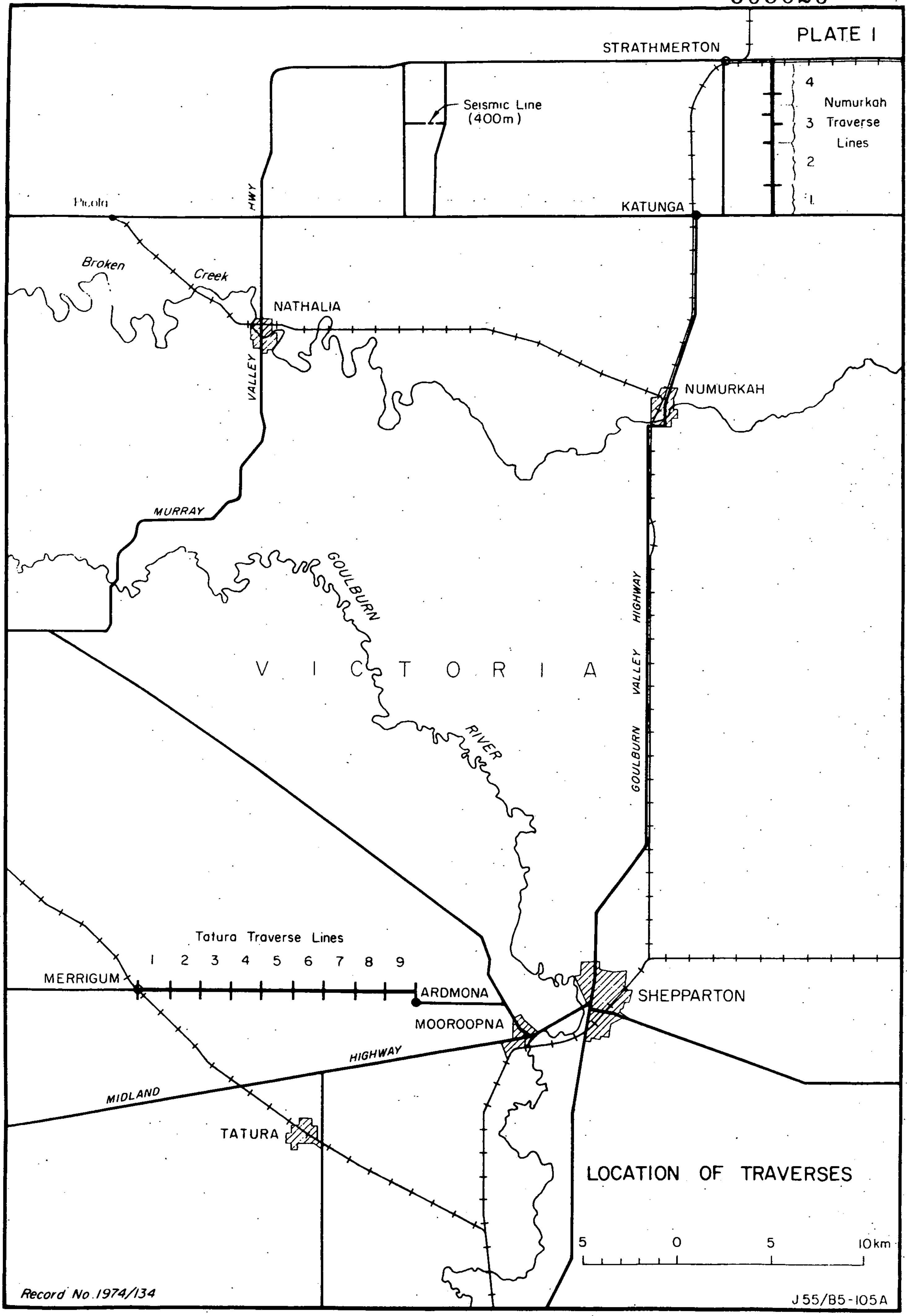
PLATE I
STRATHMERTON
Seismic Line (400m)
Numurkah Traverse Lines
4
3
2
1
Picola
HWY
KATUNGA
Broken Creek
NATHALIA
VALLEY
NUMURKAH
MURRAY
GOULBURN
V I C T O R I A
RIVER
GOULBURN VALLEY HIGHWAY
Tatura Traverse Lines
1 2 3 4 5 6 7 8 9
MERRIGUM
ARDMONA
MOOROOPNA
SHEPPARTON
MIDLAND HIGHWAY
TATURA
LOCATION OF TRAVERSES
5 0 5 10km
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TATURA No.1

RESISTIVITY CROSS-SECTION

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PLATE 3

TATURA No. 2

RESISTIVITY CROSS-SECTION

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PLATE 4

LEGEND

Sfsl	Shepparton fine sandy loam
Gl	Goulburn loam
Gcl	Goulburn clay loam
Ll	Lemnos loam
2	Soils of prior stream beds, Type 2

Horizontal Scale

10 0 20 40 metres

TATURA No. 3

RESISTIVITY CROSS-SECTION

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PLATE 5
W
E
TRANSMITTER
RECEIVERS
n=2
WATER IN DITCH
RESISTIVITY ~ 48Ωm
CULVERT
WATER IN DITCH
RESISTIVITY ~ 67Ωm
CHANNEL WATER
RESISTIVITY ~ 140Ωm
Ll
Gl
Ll
Gcl
Gcl
Sfsl
LEGEND
Gl Goulburn loam
Gcl Goulburn clay loam
Ll Lemnos loam
Sfsl Shepparton fine sandy loam
Horizontal Scale
10 0 20 40 metres
TATURA No.8
RESISTIVITY CROSS-SECTION
(Based on G16-128)
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PLATE 6
S LORENZ'S ROAD
OLD IRRIGATION CHANNEL
Mol
Nl
Kagl
Cl
OLD IRRIGATION CHANNEL (DRIED-UP)
N
BITUMEN ROAD
Bl
LEGEND
Moi Moira loam
Cl Cobram loam
Kagl Katunga gravelly loam
Nl Naringaningalook loam
Bl Boosey loam
Horizontal Scale
10 0 20 40 metres
NUMURKAH No.1
RESISTIVITY CROSS-SECTION
(Based on G16-128) Record No. 1974/134
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PLATE 7

(Based on G16-128) Record No. 1974/134

NUMURKAH No. 2

RESISTIVITY CROSS-SECTION

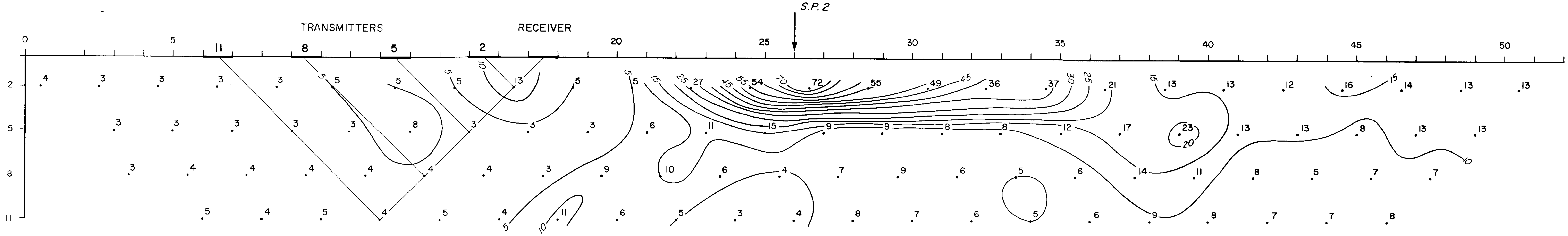
J55/B5-102

505029 PLATE 8

(Based on G16-128) Record No. 1974/134

NUMURKAH No. 3
RESISTIVITY CROSS-SECTION

J55/85-103



SEISMIC LINE
GOULBOURN VALLEY
RESISTIVITY CROSS-SECTION

HORIZONTAL SCALE
10 0 20 40 metres