DEPARTMENT OF
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BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

RECORD 1976/102

WODONGA SAND AND GRAVEL SURVEY,

VICTORIA, 1975-6

by

D.C. Ramsay

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PLATES

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SUMMARY

The Bureau of Mineral Resources, Geology & Geophysics carried out an electrical resistivity survey in an area of the Murray River flood plain west of Wodonga, Victoria. The work was undertaken to complement and extend the findings of a previous BMR survey to locate deposits of sand and gravel in the same area.

The results of resistivity traversing and depth-probing confirm the conclusions of the previous survey and indicate further possible deposits of sand and gravel.

1. INTRODUCTION

Albury-Wodonga has been designated a growth centre with a target population of 300 000 by the year 2000. It lies on the New South Wales/Victoria border (Pl. 1) at the point of transition between the foothills of the Great Dividing Range and the western plains. With the proposed expansion there will be an increased demand for building materials, especially clean sand and gravel, located as close as possible to the centre.

At the request of the Albury-Wodonga Development Corporation (AWDC), the Bureau of Mineral Resources, Geology & Geophysics (BMR) carried out a resistivity survey of constant-space traversing and depth-probing to locate deposits of sand and gravel in the flood plain of the Murray River west of Wodonga. Most of the field data was acquired in December 1975; the remainder in February-March 1976 by a subsequent field party. Both parties were manned by personnel from the Engineering Geophysics Group, as detailed in Appendix 1.

This survey extended the areal coverage of a previous BMR survey (Pettifer, Polak, & Taylor, 1975), part of which included resistivity work for the same purpose in the same area. This Record should therefore be read in conjunction with the earlier one, for a more complete assessment of results and descriptions of methods. As an extension of this previous survey, but having no direct bearing on the sand and gravel investigations, a detailed gravity survey of an area close to Wodonga was carried out: this will be reported in a future BMR Record.

2. GEOLOGY

The survey area consists of an old river plain with unconsolidated sediments - alluvial silt, clay, sand, and gravel - up to 100 m or more in depth. In the flood plain of the present River Murray there are buried channels of former rivers and streams which exhibit the same meandering characteristics as present-day rivers. Sand and gravel, including boulders, will generally be found within these channels, though not necessarily in all of them.

More detailed information on the local geology is presented by Pettifer et al. (1975).

Geological control in the area west of Sheathers Road was aided by lines of holes drilled for AWDC (Evans & Associates, in prep.) and by several isolated holes drilled by North Broken Hill Ltd (Plumridge, 1969). The locations of these holes are shown in Plates 2 and 3. Geological sections derived from the logs of the AWDC holes are presented in Plates 9 to 12. In addition, soil samples were obtained from most of the holes drilled by Evans & Associates, and several of them were analysed for particle-size distribution. The results of this analysis are contained in Appendix 2.

3. METHODS AND EQUIPMENT

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 (Dobrin, 1952). Various arrangements 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.

For the traversing method the Wenner electrode configuration was used (Pl. 2, inset) with a constant inter-electrode space 'a' of 10 m. The measured value of apparent resistivity relates to the average resistivity of material below the spread to a depth of about 'a' (=10 m in this case). The assembly of electrodes is moved forward by a distance 'a' after each measurement, thus producing an apparent resistivity profile with discrete readings at intervals of 10 m.

For the depth-probing method the half-Schlumberger electrode configuration was adopted (Pl. 4, inset): with this arrangement the potential electrodes are arranged about a fixed central point; one current electrode (the moving electrode) is moved away from the fixed central point as in the conventional Schlumberger method; and the other current electrode (the fixed electrode) is positioned remote from and at right-angles to the axis containing the other three electrodes so as to have a minimum net effect on the potential electrode pair. Thus, as the moving electrode is moved farther from the fixed central point, apparent resistivities are measured from increasingly deeper sections. The advantages of this method are that with one fixed electrode the field crew can be reduced by one man, and the length of continuous access along the line of expansion of electrodes is reduced by half. On this survey the remote electrode was positioned about 500 m at right-angles to the direction of movement of the other current electrode, which reached a maximum expansion of 300 m.

A null-balance-type Megger earth tester was used for the traversing survey. This is a compact, portable instrument powered by a self-contained hand driven generator. For the depth-probing a motor-generator-powered induced polarization transmitter manufactured by Geotronics Pty Ltd was used, with a Data Precision digital voltmeter as receiver.

4. RESULTS

The traversing profiles obtained are shown in Plates 2 and 3. The locations of the depth probes, the field curves obtained, and their interpretations are shown in Plates 4 to 8. Traverses 23, 24, and 25, and depth-probe 16A, were recorded in February-March 1976; the remainder were recorded in December 1975.

The interpretation of horizontal traversing data is generally qualitative only. With fresh groundwater, the relatively high values of apparent resistivity will probably represent sand and gravel and the relatively low values, silt and clay. By making a sufficient number of parallel traverses, the measured resistivity highs can be linked showing possible continuous channels. Several possible channels are indicated in Plates 2 and 3; they probably contain coarse material close to the surface, but their thickness cannot be determined by this method. Also, channels deeper than the effective penetration depth of the electrode array will not be detected. (For example, traverse line 25A (Pl. 3) passed close to a disused gravel pit yet showed no indication of high resistivity material. Drill hole MG16 proved the existence of sand and gravel from 1.5 to 11 m with clay above and below. The upper part of the sand and gravel body may, however contain sufficient fine material to make the measured resistivity low. Alternatively, the gravel pit may be sited on a discontinuous channel, portions of it having been removed by subsequent migration of the main river channel). For these reasons the horizontal traversing method was complemented by depth-proving which can yield quantitative solutions in terms of layer thicknesses and true resistivities.

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In the interpretation of depth-probe field curves, the subsurface is assumed to be composed of horizontally homogeneous layers. This assumption is not always valid and certainly not in a flood plain containing inhomogeneous meandering channels at varying depths. An additional limitation to interpretation is that the resistivity method, being based on potential theory, cannot provide a unique solution. Nevertheless, by correlating a number of depth probes, by horizontal traversing of the area, and with a general knowledge of the geology, a reasonable solution can usually be obtained (Zohdy, Eaton, & Mabey, 1974). In this case, the field curves were interpreted directly by computer, using a program (Zohdy, 1975) which compares the field curve with the computed curve of a theoretical model and automatically adjusts the model to produce the best possible correlation. Field curves distorted by lateral inhomogeneities (e.g., depth-probe 10B, Pl. 7) are automatically smoothed in the program so that a horizontally layered model solution will still be a reasonable fit.

On Line W (Pl. 4 and 5), depth probes (DP) 8C and 9A at the northern end indicate layers with resistivity about 500 ohm-m going from near the surface to a depth of 10 to 20 m. This was confirmed by the traversing profile 5B (Pl. 3) which indicates high apparent resistivity within the depth range of the electrode array at the positions of DP 8C and 9A. This probably represents a sand/gravel-bearing channel coming to or very close to the surface and trending roughly north-south as indicated in Plate 3. Cross-traverses 17B and 24A confirm this interpretation. Underlying this high-resistivity layer are zones of lower resistivity, possibly representing clayey deposits or weathered bedrock. Farther south on Line W, the near surface layers exhibit decreasing resistivity, indicating a lesser content of coarse material: this again was borne out by the traversing profiles 5B and 16D (Pl. 3).

Line Z (Pl. 8) also contains DP 8C. To the west of this, DP 12B indicates a high-resistivity layer, but at a depth of about 10 m, overlain by low-resistivity material. The high resistivity again probably represents a sand/gravel-bearing channel. To the east of DP 8C the near-surface layers exhibit reduced resistivity, indicating a higher content of finer material. Nevertheless, a basic similarity in the histograms for the four depth probes in this line can be seen.

Line X (Pl. 6) runs from the Murray River in the north to Line Z in the south. All depth probes show layers with resistivity between 250 and 400 ohm-m close to the surface; this is also reflected in the traversing profiles 15B and 5A in Plate 3. The interpretation of DP 12A is that a layer of resistivity 400 ohm-m extends from close to the surface to a depth of about 30 m, and its position coincides with a peak in traversing profile 15B. This has been linked to another peak on profile 15A as a possible continuous (surface) channel. The fact that traversing profiles 5A and 24A do not indicate the same value where they nearly intersect may be partly due to the difference in the height of the water-table at the times they were recorded. DP 16A is on the extension of Line X and is also close to drill hole 2 of Line 4; the interpretation of the depth probe is that a layer with a resistivity of 400 ohm-m extends from 3 to 30 m depth, and is overlain by lower-resistivity material. The drill-hole log (Pl. 12) shows various clay layers to a depth of 3 m, underlain by coarse-grained fluvial sand and gravel to the bottom of the hole at 10.5 m. This sand and gravel correlates with the 400 ohm-m resistivity layer.

Line Y (Pl. 7), which consists of six depth probes, starts close to the Murray River at the northern end and passes west of the Sheathers Road gravel pit; it intersects drill Line 3 (Pl. 11). DP 10C, 10B, 10A, and 10D all show high-resistivity layers close to the surface. DP 11A and 11B, at the southern end of the line, have much lower resistivities, indicating that these two depth probes are probably close to or outside the margin of the sediment-filled river valley; this is confirmed by the low resistivities recorded on traversing profiles 16A and 8A (Pl. 2 and 3). The cross-section through drill Line 3 (including drill hole MG27) shows that sand and gravel, becoming coarser with depth, underlies a layer of clay about 1.5 m thick in all holes except 3/4. This hole intersects only clay, indicating that it is outside the main channel, close to the bank of the river valley. This agrees with the geophysical results. Drill hole MG 27, the deepest of the holes in this line, entered clay at a depth of 12 m: none of the others striking the sand and gravel body did so. If this depth is constant along the drill line, it correlates well with the depth-probe results, which generally show highly resistive layers to a depth of about 10 m underlain by more conductive material. In particular, the interpretation of DP 10D, alongside the Sheathers Road gravel pit, indicates layers with resistivity of 200 ohm-m or more to a depth of about 10 m. This represents the material which was extracted from the pit. Underlying this are layers of lower resistivity which are probably sediment of clayey composition. It is interesting to note that the interpretations of DP 10A, 10B, and 10C all show higher-resistivity layers than in DP 10D, although at the surface DP 10A and 10C show lower-resistivity material than 10D.

5. CONCLUSIONS

The results of horizontal traversing in the area between Sheathers Road and Melrose Drive confirm the positioning of a line interpreted as the 'southern limit of sand and gravel' (Pl. 2), determined by a previous survey (Pettifer et al., 1975). North of this line, several possible near-surface sand/gravel-bearing channels are indicated. East of Melrose Drive and south of the extrapolation of the 'southern limit of sand and gravel' line there are some indications of higher resistivities and also a working gravel pit; continuous gravel channels may underlie this area, though deeper than the limit of detection by the electrode array used in the traversing survey. West of Sheathers Road the results of depth-probing and traversing complement one another and generally correlate well with the drilling results.

The horizontal traversing method proved to be a quick and simple way to delineate areas of high resistivity close to the surface: these would indicate prime targets for extraction of sand and gravel (for example, the area containing the intersections of traverses 5B, 17B, 23A, 23B, and 24A).

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APPENDIX 1

SURVEY PERSONNEL

Those involved in the December 1975 survey were:

E.J. Polak D.C. Ramsay	geophysicists
D.H. Francis	technical assistant
S.A. Green	trainee technical officer
D.G. Bennett M.N. Preston-Stanley	field hands
R.C. Watson	draughtsman

Those involved in the February-March 1976 survey were:

E.J. Polak G.R. Pettifer	geophysicists
E. Chudyk D. Guy	field hands
R.C. Watson	draughtsman

In addition, office accommodation and several field hands were supplied by AWDC on both occasions.

APPENDIX 2

RESISTIVITY OF SAND AND GRAVEL FROM DRILL HOLES

The resistivity of rock is related to the resistivity of the pore fluid by the empirical formula :

$$r = P^{-m} R_W \quad \ldots\ldots\ldots\ldots (1)$$

where r is the resistivity in ohm-m of the rock

P is the porosity expressed as a fraction

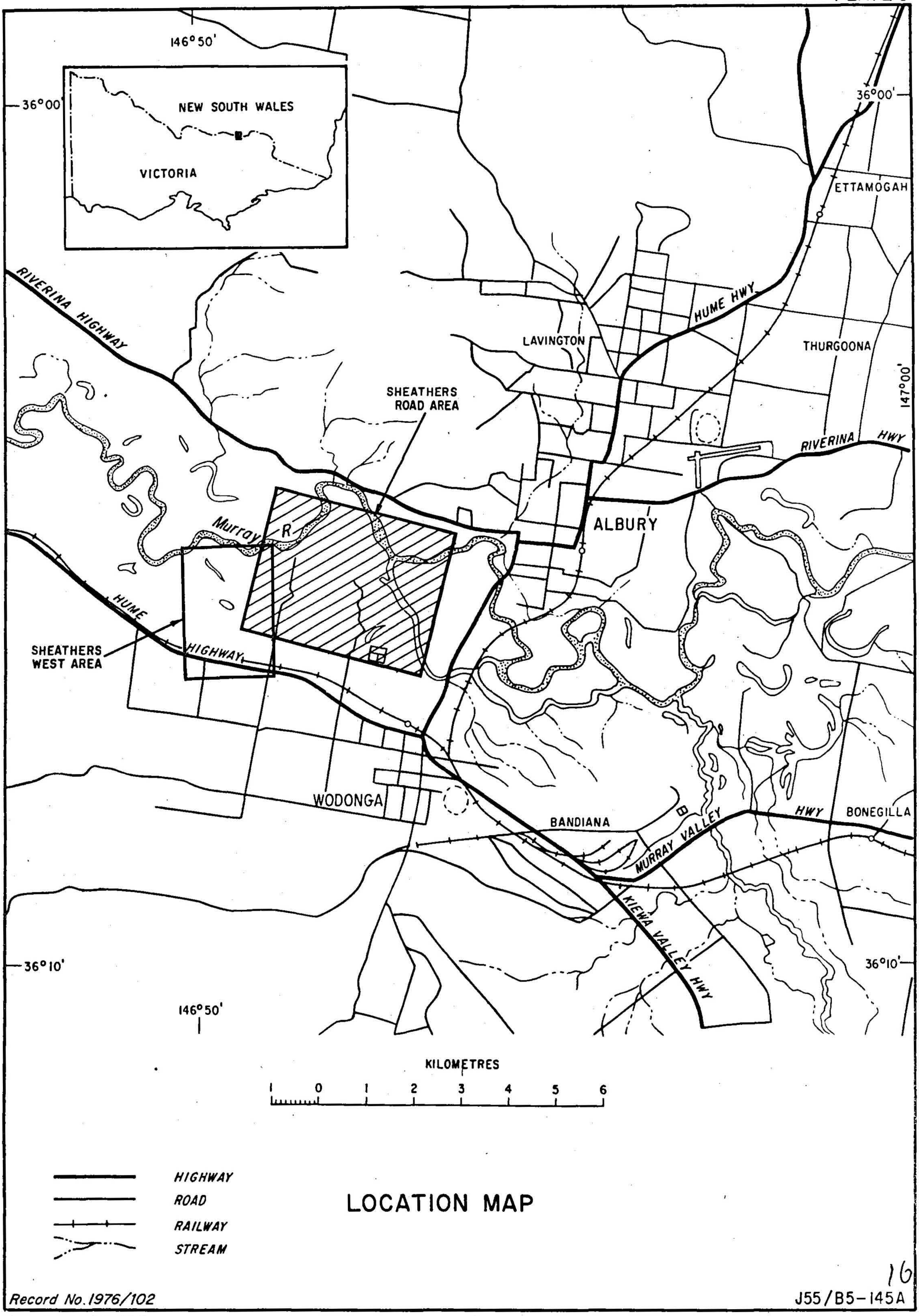
R_W is the resistivity in ohm-m of the pore fluid

and m is a cementation constant, which for unconsolidated deposits near the surface can be taken as about 1.25.

An approximate value for porosity, which is related to the grainsize at which the cumulative total - beginning with the coarsest material - reaches 10 percent of the total sample, can be found from the grainsize distribution chart (Wiebenga & Jesson, 1962). Eight samples of sand and gravel from holes in Lines 1 and 2 were sieve analysed for grainsize distribution. Unfortunately no samples from holes in Lines 3 and 4, which would have been more relevant to the Sheathers Road west area, were obtainable. Most of these samples were from depths greater than 5 m and were noted in the drill logs as coarse-grained sand and/or gravel (see Pl. 9 and 10). The average for the eight samples gave a maximum 10 percent grainsize of 4.8 mm, which corresponds to a porosity of about 0.36.

A water sample from the Sheathers Road gravel pit had a measured resistivity of 70.2 ohm-m. So substituting into formula (1), the theoretical resistivity of the sand/gravel bed is calculated as roughly 250 ohm-m. This is in good agreement with the interpretation of DP 10D positioned alongside the gravel pit. Other water samples collected from around the survey area had measured resistivities between 27 and 115 ohm-m, giving sand/gravel resistivities between 98 and 413 ohm-m. These figures again correspond well with the range of resistivities interpreted as representing sand/gravel deposits in the recorded depth probes.

PLATE 1

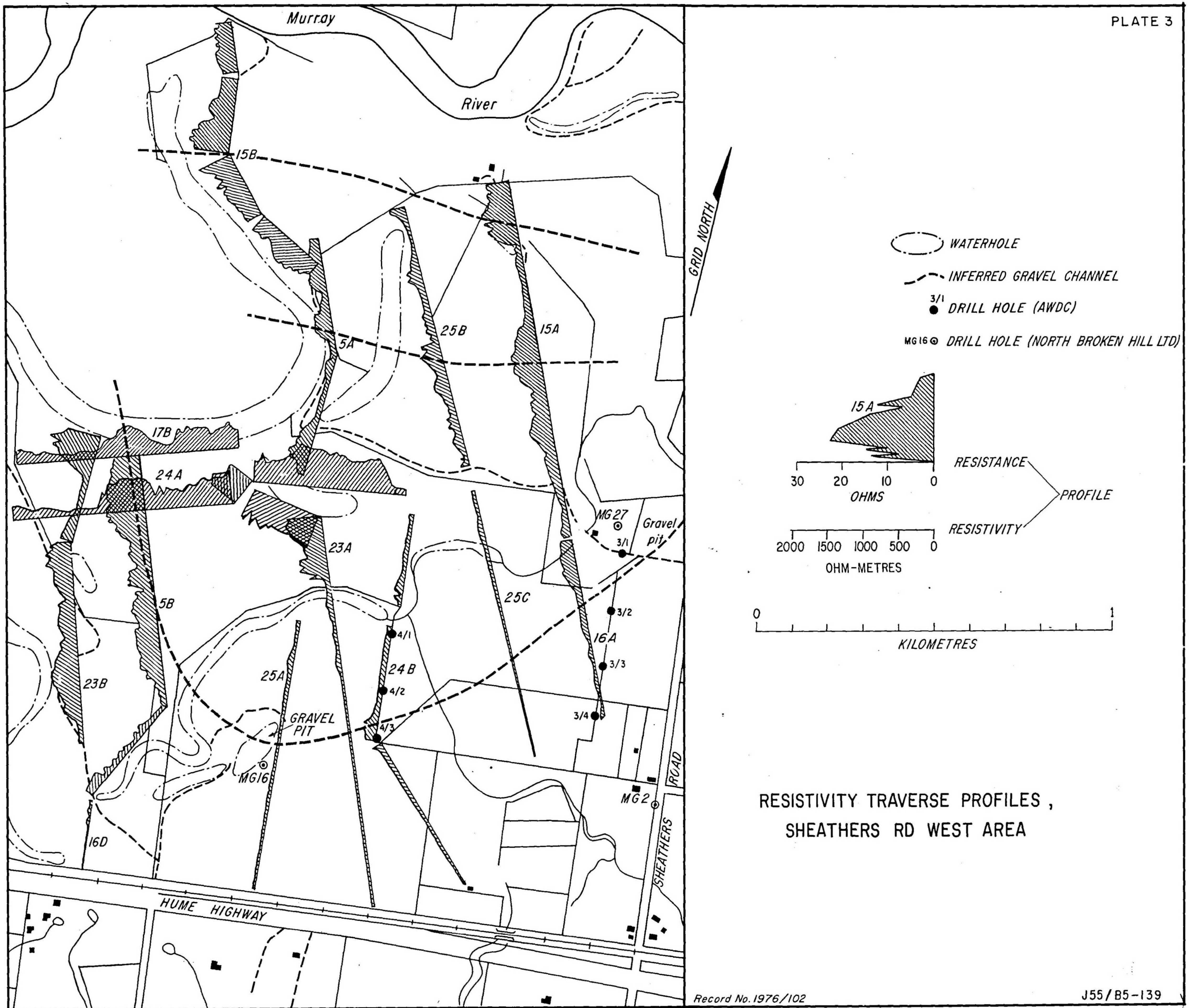


LOCATION MAP

(Based on J55/B0-29A)

RESISTIVITY TRAVERSE PROFILES
SHEATHERS ROAD AND STOCK ROUTE AREAS

PLATE 3



RESISTIVITY TRAVERSE PROFILES , SHEATHERS RD WEST AREA

Record No. 1976/102

J55/B5-139

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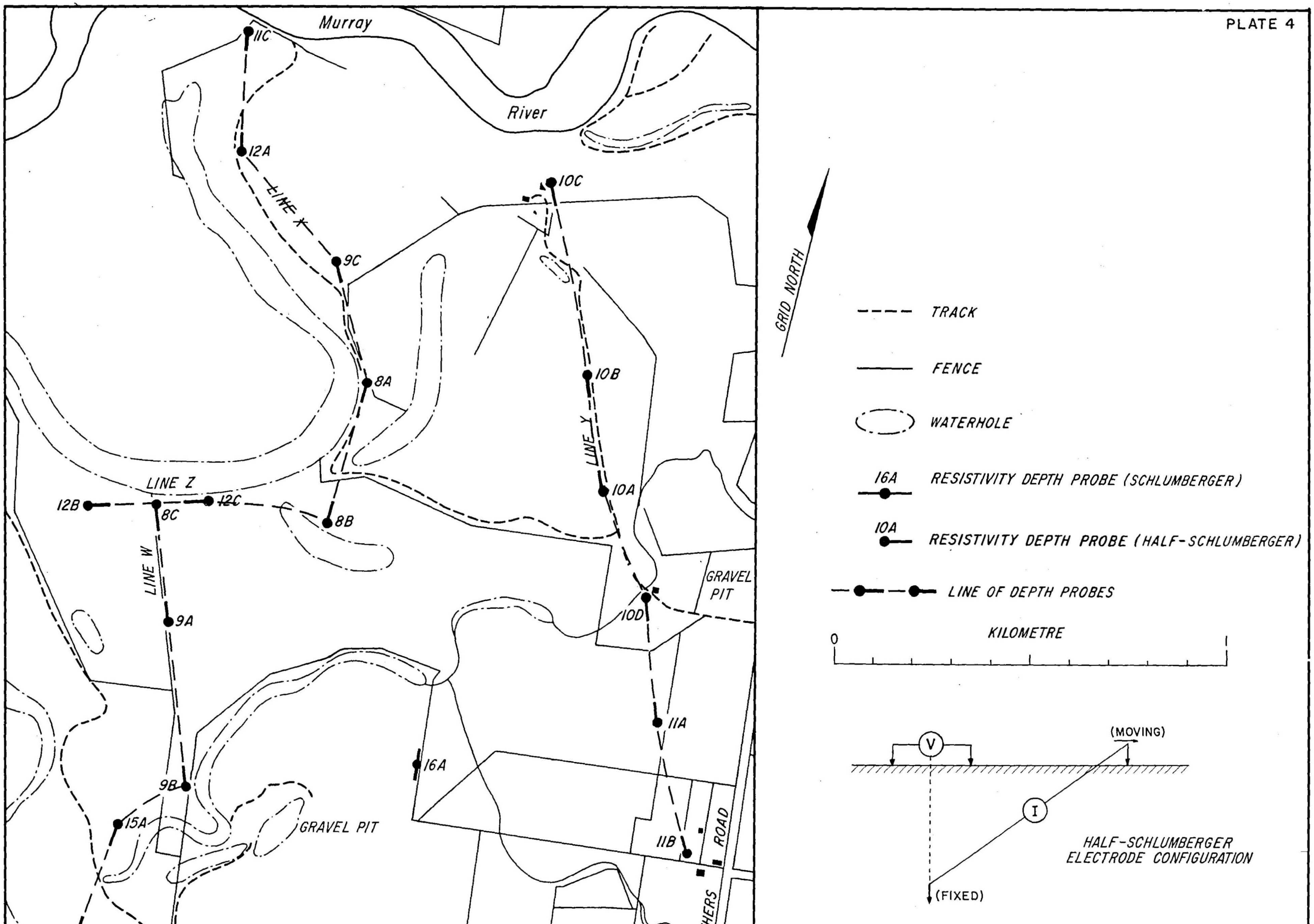
PLATE 4



RESISTIVITY DEPTH PROBE LOCATIONS
SHEATHERS ROAD WEST AREA

Record No. 1976/102

J55/B5-140

DEPTH PROBES 8C, 9A, 9B, 15A AND 15B (LINE W)

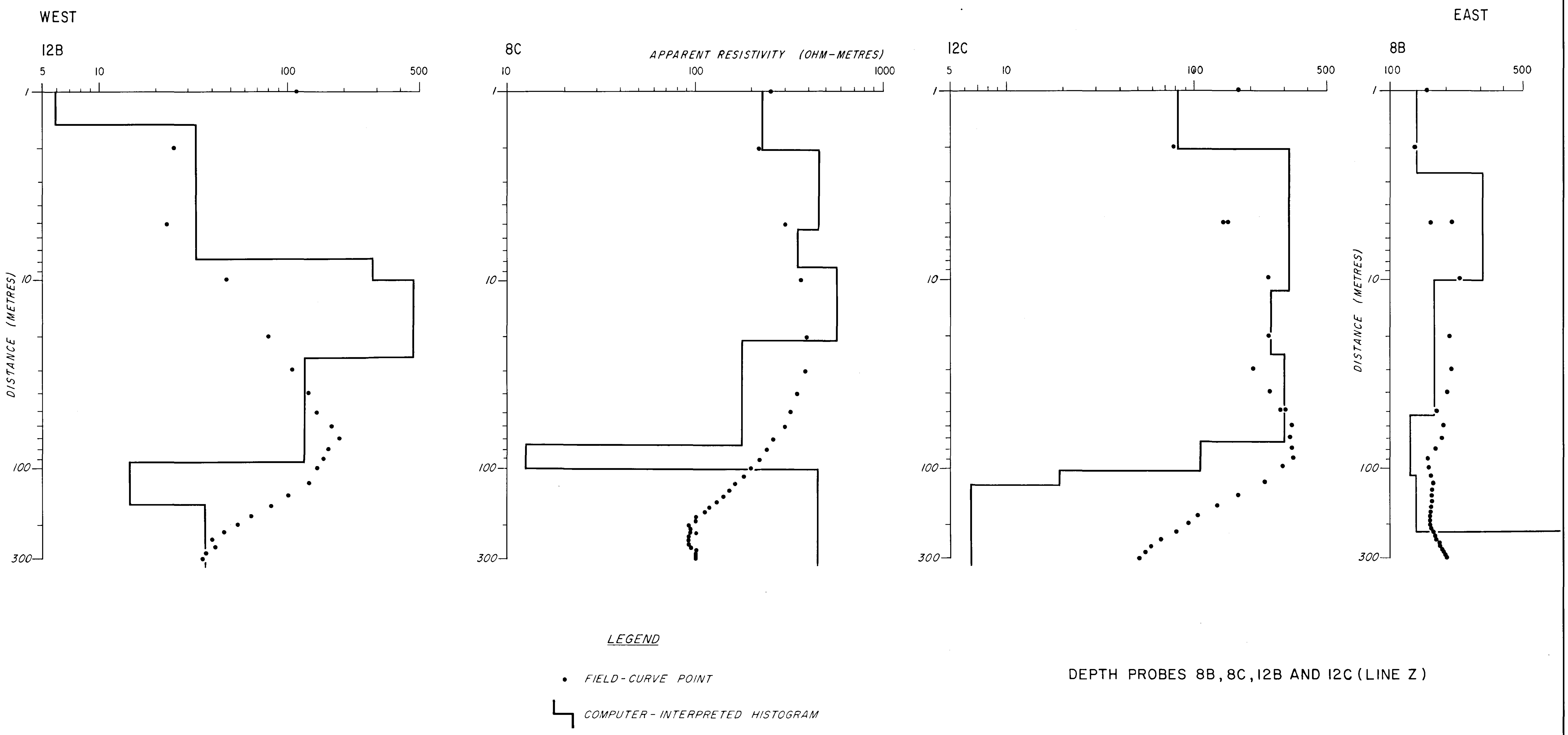
DEPTH PROBES 8A, 8B, 9C, 11C, 12A AND 16A (LINE X)

LEGEND

• FIELD-CURVE POINT

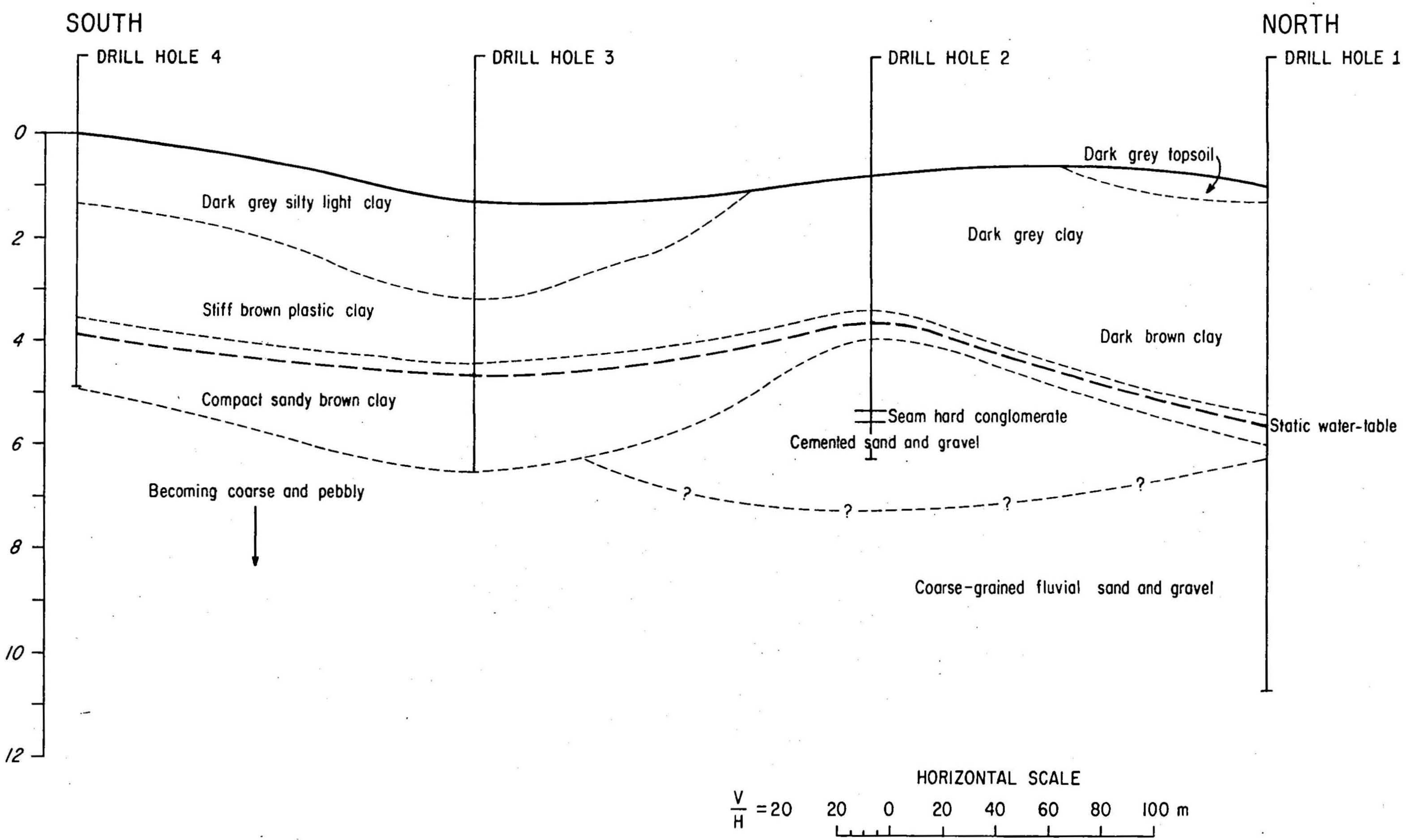
COMPUTER-INTERPRETED HISTOGRAM

DEPTH PROBES 10A, 10B, 10C, 10D, 11A AND 11B (LINE Y)



DEPTH PROBES 8B, 8C, 12B AND 12C (LINE Z)

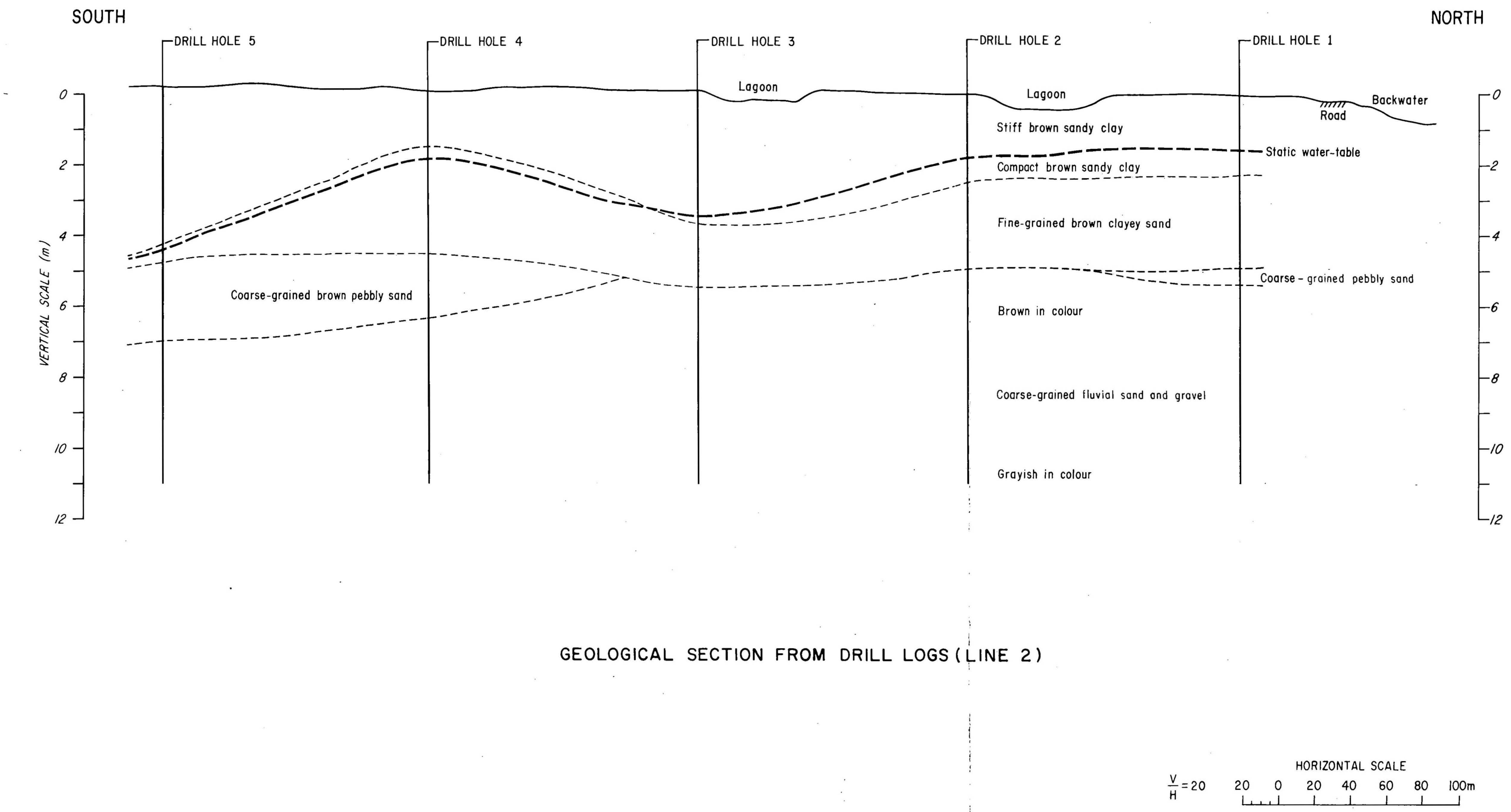
Record No.1976/102



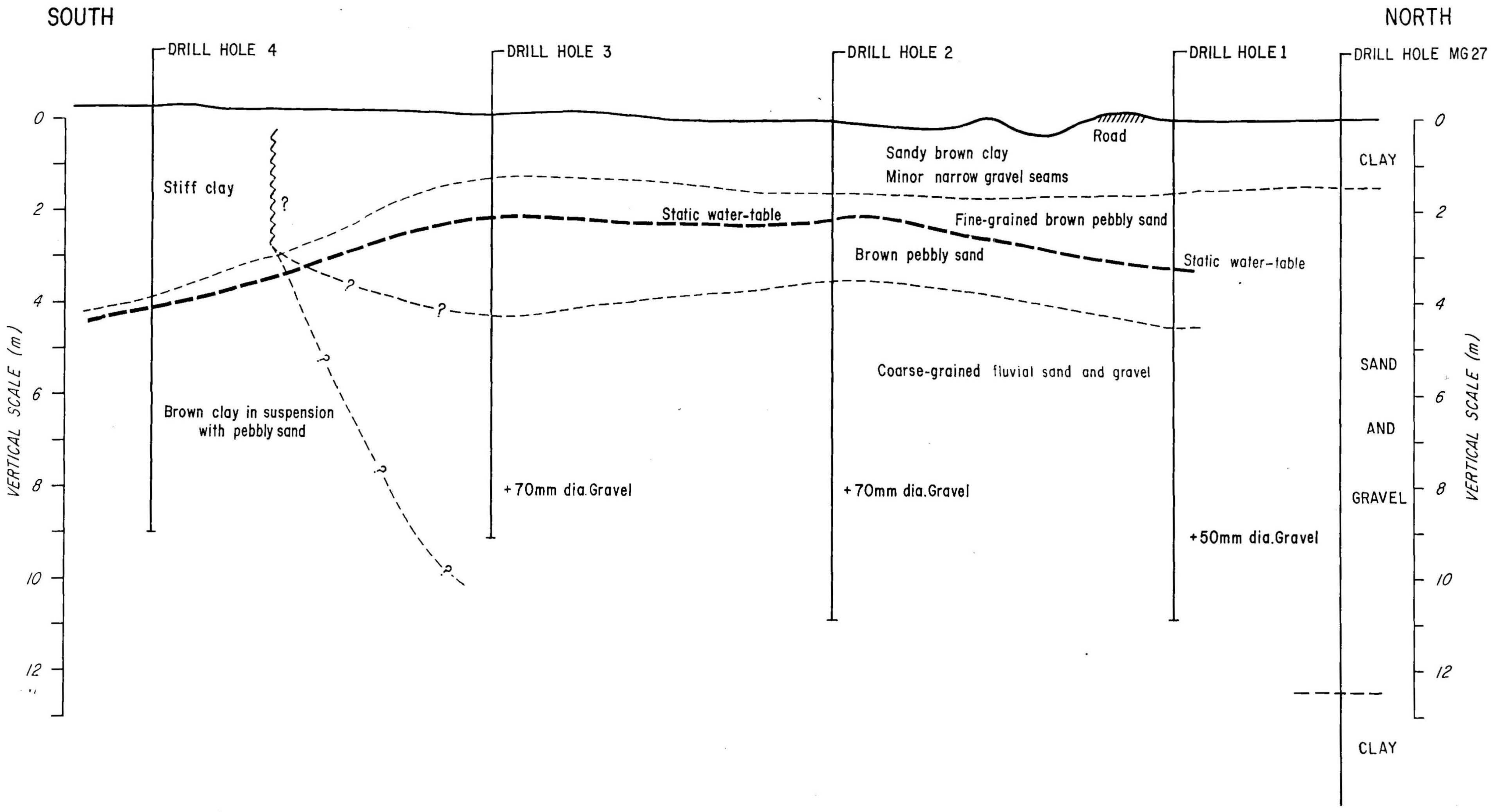
J55/B5-154A

GEOLOGICAL SECTION FROM DRILL LOGS (LINE I)

PLATE 9



GEOLOGICAL SECTION FROM DRILL LOGS (LINE 2)



GEOLOGICAL SECTION FROM DRILL LOGS (LINE 3)

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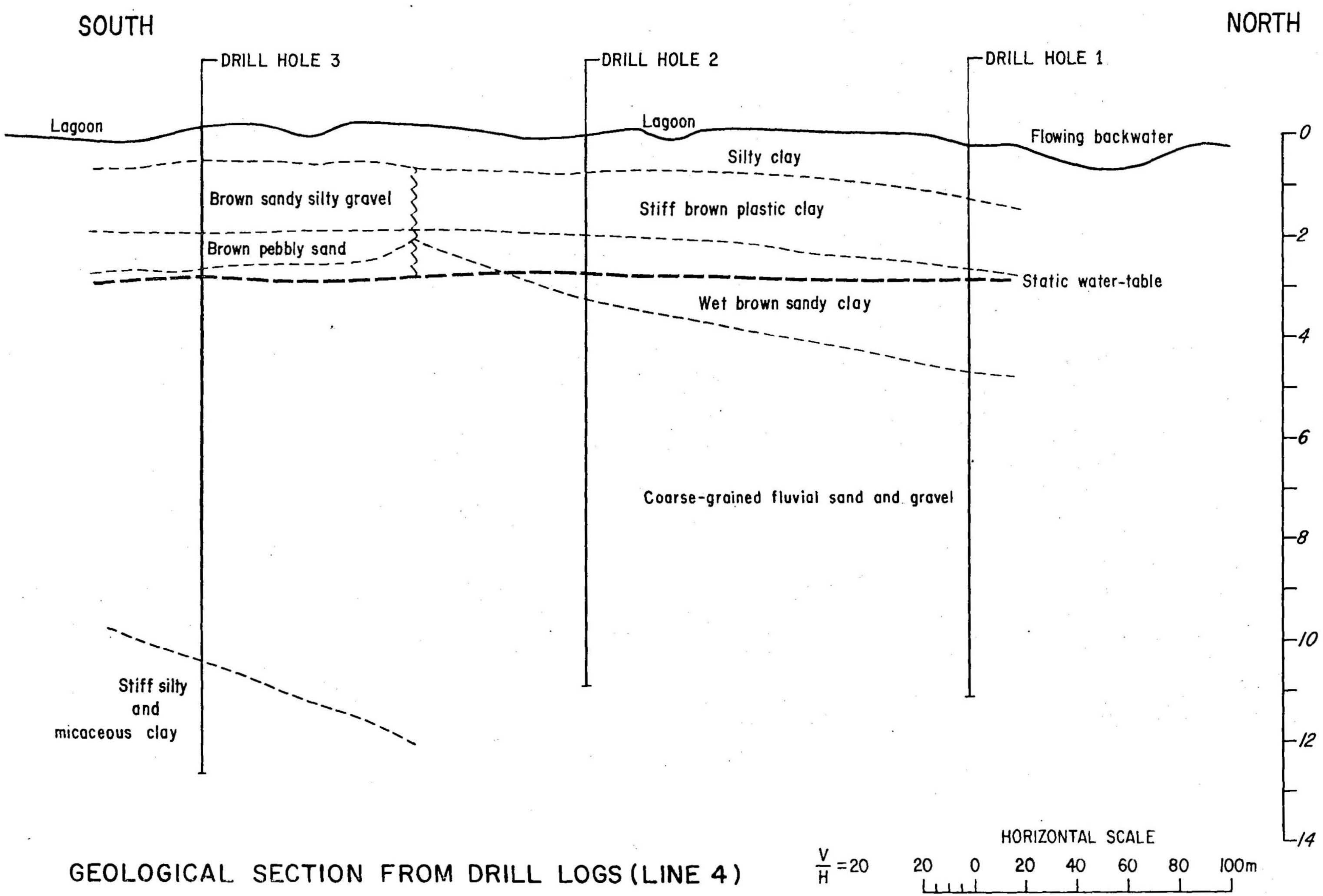
Record No. 1976/102



GEOLOGICAL SECTION FROM DRILL LOGS (LINE 4)

J55/B5-157A

PLATE 12