COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

RECORD No.1962/74

BUNDABERG GEOPHYSICAL SURVEY FOR UNDERGROUND WATER, QUEENSLAND 1960

by

W.A. Wiebenga and P.E. Mann

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ILLUSTRATIONS

SUMMARY

The Irrigation and Water Supply Commission of Queensland requested the Bureau to test geophysical methods in the search for underground water in shallow basins, coastal plains, or river flats. Locations south of Bundaberg were selected as test areas. The application of the seismic refraction method and resistivity depth-probing showed promising results.

In the lacustrine sediments, seismic velocities of less than 3700 ft/sec seem to indicate poor yields; from 3700 to 4600 ft/sec moderate yields, and from 4600 to 6300 ft/sec good or high yields. In resistivity depth-probing, the top of the unweathered to weathered bedrock of shale was indicated as a low-resistivity layer.

A zone where the depth to unweathered bedrock exceeds 200 ft may be interpreted as a large shear-zone, forming the continuation of the Elliott River estuary.

Drilling targets for water are indicated near and south of the Elliott River.

1. INTRODUCTION

Ground water is the main source of water supply for the irrigation of farm crops in the countryside around the town of Bundaberg, approximate co-ordinates 549906 on the Bundaberg sheet of the Australia 4-mile series, Queensland.

To increase the water supply available for agriculture, the Irrigation and Water Supply Commission of Queensland has begun an exploratory drilling programme following several geological surveys in the Bundaberg area. Pumping tests carried out on exploratory boreholes indicate that the water supply is very variable.

Hence, the Commission requested the Bureau of Mineral Resources, Geology and Geophysics to do an experimental survey in shallow basins, coastal plains, or river flats, to find out whether geophysical methods could differentiate between zones where poor and good ground water supplies are located. Bundaberg was considered to be a suitable test area. At the same time the Bureau was requested to test whether the sediments south of the Elliott River are potential areas for ground water development.

The seismic refraction method and electrical 'depth-probing' were used.

For a description of the seismic and resistivity methods, reference is made to Heiland (1940). Experience has shown that the accuracy of seismic depth determination of discontinuities is within about 15 per cent of the depth in the type of work covered by this report. The accuracy of resistivity depth-probing has been discussed by Wiebenga (1955).

The Bureau's geophysical party consisted of P.E. Mann (party leader), D.J. Harwood (geophysicist), and J.P. Pigott (geophysical assistant); four field assistants were supplied by the Commission. The field work lasted from 5th to 29th October 1960.

It is desired to acknowledge the assistance rendered to the party by Mr. W. Roman of the Commission's Bundaberg office.

2. GEOLOGY

The area investigated extends south-south-west from Bundaberg as far as 3 miles south of the Elliott River (see Plate 1). The geological information is given in the form of a plan after N. McTaggart (IWSC plan No. W/FGW-M-210) and drilling logs (see Appendix). The available information indicates the presence of a shallow coastal basin, filled with Tertiary rudaceous lacustrine deposits, and partly underlain by Tertiary argillaceous sediments of the Elliott Formation. The Burrum Coal Measures of Cretaceous age are regarded as bedrock and consist of carbonaceous shale, sandy shale, and sandstone. The top of the bedrock may be weathered, in which case it probably resembles the clay of the Elliott Formation. Aquifers with good water supplies are located in the lacustrine deposits. Experience in drilling for water has suggested that aquifers with good or high water-yields are located east of line Q (see Plate 1), aquifers with poor or low yields are obtained west of line P, and a transition zone exists between lines P and Q. The reasons were not well understood, and it was hoped that the geophysical investigation might provide a contribution to the solution.

In this report the arbitrary terms 'good', 'moderate', or 'poor' supply of bore water (or yield) are used. Based on the information of the bore logs and plans, these terms are defined as follows:

'good' supply - 5000 gallons per hour (gal/hr) or more,

'moderate' supply - 2000 to 5000 gal/hr, and

'poor' supply - less than 2000 gal/hr.

3. APPLICATION OF METHODS

To make full use of the geophysical data, it is necessary to discuss the relations between seismic wave velocity, resistivity, and other parameters such as rock porosity and permeability and the salinity of pore solutions.

Seismic velocities

The seismic velocities in silicate rocks are for the major part controlled by rock porosity, although several other factors have an influence; e.g. cementation or consolidation, hydrostatic and unilateral stress, the degree of saturation with liquids, grain-size and sorting, can be modifying influences.

Plate 6 illustrates quantitatively the relation between porosities and seismic velocities for several rock types. Curve ABCD shows the relation between seismic velocity, porosity and rock type for dry rock under negligible hydrostatic and directional stress (derived from practical experience and from Wuerker, 1956). This curve is applicable to dry rocks above the water-table. Curve EFC gives the seismic velocity in water-saturated, unconsolidated rocks under negligible hydrostatic and directional stress (Hamilton, 1956; Wyllie, Gregory, and Gardner, 1958). The seismic velocity measured in gravelly or sandy, unconsolidated sedimentsis that of the water-wave or pore-wave through the rock pores. A second wave, slower than the pore-wave, is transmitted through the solid rock particles or rock frame. This wave is rarely recorded in field work because it is usually masked by the earlier pore-wave. The first arrival of the pore-wave in unconsolidated rocks can be used to determine the depth to the water-table.

Partially water-saturated or moist unconsolidated rocks, referred to as plastic mud or soil, are shown on the diagram between A and E.

Curve ND shows the seismic velocities of rocks under hydrostatic and unilateral stress and saturated with brine. These velocities were measured on rock samples (Wyllie et al, 1958); they are the maximum velocities likely to be encountered. The seismic velocity in rocks saturated with fresh water will be slightly lower than that in rocks saturated with brine, but the difference is too small to serve as an indicator of salinity.

The effect of hydrostatic stress is diagrammatically indicated by a shift of curve FC to position HK; the effect of unilateral stress is indicated by a further shift to LM. In its extreme position LM coincides with ND.

The hatched area on the diagram represents a zone of water-saturated rocks whose porosities and seismic velocities were measured on rock cores. The data were taken from Nafe and Drake (1957).

The crosses (x) on the diagram represent rocks whose average porosities and seismic velocities were measured in situ in boreholes. It may be observed that they are close to curve ND.

The following conclusions may be derived in relation to practical hydrological work:

(a) In general, the lower the porosity, the higher the seismic velocity. However, the width of the hatched zone indicates that rocks with a considerable range of porosities may have the same seismic velocity. Thus, deep-water sediments (well sorted and therefore highly porous) may have the same seismic velocity as shallow-water sediments (poorly sorted and therefore less porous).

(b) The seismic velocity is higher in water-saturated rocks than in dry rocks.

(c) Hydrostatic pressure and unilateral stress increase the velocity towards a maximum.

(d) In unconsolidated water-saturated rocks the seismic wave through the rock pores may be faster than that through the solids, and hence can be used to determine the depth of the water-table in seismic refraction work.

(e) Rock types with their associated porosities and grain size (Todd, 1960, and Plate 7) under favourable conditions can be correlated with yeild. Hence, seismic velocities, which can be associated with rock types and porosities, can also under favourable conditions give an approximate estimate of the yield.

Table 1 lists a provisional interpretation of the longitudinal seismic wave velocities in terms of rock type as quoted from the borehole logs. The depth to the water-table is interpreted as the depth to a seismic refractor with longitudinal wave velocities of 4500 to 6500 ft/sec.

TABLE 1

Velocity (ft/sec)	Rock Type
800 - 2000	Soil and unconsolidated surface deposits above the water-table.
2000 - 4500 ±	Moist to water-saturated unconsolidated sediments, predominantly clay.
4500 - 6500	Unconsolidated to semi-consolidated, water-saturated alluvium, predominantly sand and gravel; also weathered rocks in situ, e.g. weathered Burrum Coal Measures.
6000 - 8000	Consolidated sediments, water saturated; also weathered rocks in situ, e.g. weathered Burrum Coal Measures.
8000 - 12,000	Slightly weathered to unweathered Burrum Coal Measures.

Resistivity

Electrical resistivity is the rock characteristic used in electrical surveys and bore logging. In the following paragraphs some formulae and concepts are explained (Schlumberger, 1958, p. 11).

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

in which

r	is rock resistivity in ohm-metres
P	is porosity as a fraction
R_W	is resistivity of pore solution in ohm-metres
m	is a cementation constant
F	is a formation factor = P^{-m}
R_W	approximately = 5000/C ohm-metres,

if C represents the salinity in parts per million. For a temperature of about 20°C, and only small temperature variations, a temperature correction is not needed.

The cementation constant m ranges between 1.25 and at least 2.2. In unconsolidated deposits near the surface m equals about 1.25, in moderately-cemented rocks m is about 1.8, and in highly-cemented rocks m may be 2.2 or higher.

Formula (1) is generally used in the linear log form:

$$\log r = m \log P + \log R_W \quad \ldots \quad (2)$$

Plate 7 shows the porosity, specific yield, and specific retention of unconsolidated sediments (Todd, 1959), their grain size, and how their resistivities vary with porosity and salinity. For comparison, the resistivity ranges of some other consolidated rock types are shown.

From Plate 7 it may be observed that

(1) Unconsolidated deposits containing salt water have a much lower resistivity than those with fresh water.

(2) The older cemented igneous and metamorphic rocks have a much higher resistivity (by a factor of 10 or more) than the unconsolidated surface rocks; hence, it should not be difficult for resistivity methods to disclose subsurface valleys filled with unconsolidated deposits. It may also be possible to delineate the salt water zones. In bore logging the difference in resistivity between gravel, sand, and clay are clearly recorded, and with suitable equipment and sufficiently thick layers, accurate estimates of porosity may be given.

In hydrological studies the resistivity of rocks may be classed as one of the most important rock characteristics.

Summary

The requirements for a suitable ground water supply include the following items:

(a) Suitable thickness of sediments

(b) Reasonable porosity of sediments

(c) Sufficient permeability of sediments

(d) Low salinity of pore solution

(e) Sufficient replenishment of water

The seismic refraction method provides information on (a) and (b), and the resistivity method gives a measure for (d). A qualitative estimate of (c) can also be given; in alluvial deposits, seismic longitudinal wave velocities of 4500 to6500 ft/sec are usually associated with sediments of good permeability, because of their coarse grain size.

4. RESULTS

Along the 'Thabeban' and 'Alloway' bore lines (Plate 1, Traverses T, A, and E) investigations were made where some borehole control was available. In the short time available only a few samples could be taken of the remaining area. The results of local seismic traverses and resistivity depth-probes are combined in the histograms of Plate 5. The interpretations suggested below are considered the most probable ones, but are not necessarily unique, and should be checked, where necessary, by drilling.

Thabeban bore line (Plates 2, 3, and 5)

Plate 2 shows the seismic results along part of the Thabeban line. The seismic cross-sections show several breaks which are purposely left in to indicate the limitations of accuracy of seismic depth determination; e.g. at T2700 the depth to unweathered bedrock is determined as 161 and 174 ft respectively by the spreads to the north-east and south-west.

Between T4300 and T200 the intermediate layer with 5500 to 7500-ft/sec seismic velocity could be interpreted either as a compact lacustrine deposit or as weathered shale (clay). The resistivity depth-probes (see histogram T500 and T2500 of Plate 5) show this layer to be of lower resistivity than the overlying layers. A fitting geological interpretation would be that this layer (the low-resistivity layer of 5500 to 7500-ft/sec velocity) is porous, weathered bedrock, and the overlying 3400 to 4500-ft/sec layer with higher resistivity consists of lake sediments. Considering Plates 6 and 7, seismic velocities of 4000 to 4500 ft/sec suggests moderate water-yields for the bores. Between T2700 and T3200, and between T3700 and T4300, the seismic velocities in the intermediate layer above the weathered bedrock are lower than 4000 ft/sec, suggesting a higher clay content, and hence a lower permeability and yield. Between T4300 and T4800 the unweathered bedrock is much shallower, the weathered bedrock layer is missing or too thin to be measured by seismic refraction work, and the intermediate layer with seismic velocity of 3300 ft/sec suggests the presence of a thick, predominantly clay layer, with poor water-yields.

Plate 3 shows a location plan of the Thabeban bore line, with a diagrammatic profile. South-west of B3S3 and T4500 the unweathered bedrock is shallower than north-east of these localities. Also the lacustrine material consists of sediments with velocities below 4000 ft/sec, suggesting that the sediments are predominantly clay.

This analysis of the seismic results along the Thabeban bore line is consistent with the observed decrease in yield in passing from East to West across the line QQ (Plate 1); the yield decreasing with decreasing seismic velocity and presumably increasing clay content.

The following is a discussion of the histograms on Plate 5 which relate to the Thabeban bore line:

T4500: The low seismic velocity above the unweathered bedrock suggests the presence of predominantly clay sediments with low yield. The relatively high resistivities indicate that the pore water in the clays is fresh.

T2500: Above 100 ft depth both the seismic velocity greater than 4000 ft/sec and the relatively high resistivity suggest the presence of unsorted fresh-water sediments with moderate yield. The low resistivity below 100 ft depth indicates the presence of weathered bedrock (clay) with salt water. In this and similar localities drilling should be stopped well before reaching the bedrock. Also excessive pumping of water should be avoided because of the possibility of salt water encroachment from beneath (Parker, 1955). It is probable that the weathered bedrock consists largely of clay of low permeability which may not permit rapid movement of salt water. Nevertheless if the hydrostatic pressure is lowered for long periods in the vicinity of the bore through continuous over-pumping, it is probable that salt water will eventually invade the aquifers.

T500: The same type of interpretation as at T2500 is applicable. Again a warning against overpumping is necessary because of the possibility of saline water in the bedrock.

B3S3: Fresh water with moderate supply in unsorted sediments above 90 ft depth.

B1S4: High resistivity with seismic velocities of 4200 and 6250 ft/sec may suggest good supplies of fresh water. Salt water is indicated in the weathered bedrock below 200 ft.

<u>Alloway bore line</u> (Plates 1, 4, and 5)

Plate 4 shows a location plan of the Alloway bore line, with a diagrammatic profile, similar to the one of the Thabeban bore line. Resistivity depth-probes were made only at A600 and A1100 (600 and 1100 ft east of B4S4) and at Traverse E. The interpretation follows the same lines as in discussion of the Thabeban bore line.

Near B4S4 and west of Traverse A, the seismic velocities in the lacustrine sediments are generally lower than 4000 ft/sec indicating predominantly clay sediments with poor to moderate yields. Histograms A600 and A1100 (Plate 5) indicate salt water in the bedrock. To avoid salt water encroachment, overpumping should be avoided. At Traverse E near B7S7, the seismic velocity of 5700 ft/sec and resistivity of 100 ohm-metres indicate unsorted lacustrine deposits, probably sand and gravel, with a good supply of fresh water. The interpretation near B8S8 is not clear because no resistivity depth-probe was made. Drilling showed the depth to weathered bedrock as 47 ft, and to unweathered shale as 145 ft. A resistivity depth-probe probably would have disclosed a low-resistivity layer (weathered shale) below 50 ft depth. The water yield in B8S8 is only 200 gal/hr because the thickness of the water-yielding sediments (gravel and clay) is very small (18 ft) and close to the surface.

Correlation between water yield and seismic velocity

If the water yield of saturated sediments is not restricted by the limited thickness and lateral extent of the sediments or by rate of recharge, it is controlled only by the permeability of the sediments and the pumping procedure. A study of Plates 6 and 7 suggests that the high yield of some sediments correlates with a certain seismic velocity range. Plate 8, which was drawn from the sparse information available from borehole testing along the Thabeban and Alloway bore lines, shows a graph of the observed seismic velocity against the yield. The graph suggests that with lacustrine sediments the log of the yield may be approximately linearly related to the seismic velocity. The plot suggests the following empirical rule: poor supplies (less than 2000 gal/hr) for velocities less than 3700 ft/sec, moderate supplies (2000 to 5000 gal/hr) for velocities of 3700 to 4600 ft/sec, and good supplies (exceeding 5000 gal/hr) for velocities of 4600 to 6300 ft/sec.

The remaining area, locations B, C, D, D1, F, G, and H(Plates 1 and 5)

In the following section the histograms of Plate 5 not mentioned above, will be discussed and interpreted.

Location B. The ground water level, which is indicated by the rise in velocity to 4000 ft/sec, is at about 23 ft depth. The depth to unweathered bedrock is about 93 ft, corresponding approximately with a large decrease in resistivity at about 100 ft depth. This suggests that the bedrock consists of shale or clay and possibly contains saline water. The 4000-ft/sec seismic velocity combined with a relatively high resistivity of 190 ohm-metres indicates a moderate supply of fresh water. Overpumping should be avoided as it might lead to salt water encroachment. The weathered bedrock is too thin to be detected.

Location C. The depth to unweathered bedrock is about 217 ft. The ground water level may be located at about 38 ft depth where a decrease in resistivity occurs and the seismic velocity rises to 4800 ft/sec. The 4800-ft/sec layer between 38 and 217 ft depth may be interpreted as :

(a) lacustrine sediments with a good supply of brackish to saline water, or

(b) weathered shale or clay bedrock, with a poor supply, or

(c) combination of (a) and (b); that is, lacustrine sediments with a good supply above weathered bedrock at an unknown depth.

Although the water is expected to be brackish, this locality should be tested by drilling.

Location D. Ground water level is at about 14 ft depth; the unweathered shale bedrock is at about 87 ft depth, with a moderate to good supply of fresh water in the lacustrine sediments between 14 and 87 ft. Overpumping should be avoided.

Location D1. Ground water level is at about 6 or 7 ft depth; the unweathered shale bedrock is at about 89 ft depth, with a good supply of fresh water in the lacustrine sediments between 7 and 89 feet. Overpumping should be avoided.

Location F. Ground water level is at about 19 ft depth; the unweathered bedrock is at about 250 ft depth. A low-resistivity layer below 170 ft may indicate approximately the top of the unweathered bedrock, possibly containing saline or brackish water. Between 19 and 170 ft the rock may consist of lacustrine sediments with a good supply of fresh water. Overpumping should be avoided to prevent salt water encroachment.

Location G. Ground water level is at about 3 ft depth; the unweathered bedrock is at about 133 ft. depth. The range between 3 and 133 ft may contain lacustrine sediments with a moderate supply of fresh water, overlying a weathered bedrock with brackish water. Overpumping should be avoided.

Location H. Ground water level is at about 13 ft, and the unweathered bedrock is at about 127 ft depth. Between 13 and 127 ft lacustrine sediments with a good supply of fresh water may occur. Weathered bedrock, although probably present, cannot be clearly distinguished.

On Plate 1 the zone where the unweathered bedrock was found to be deeper than 200 ft is indicated by a hatched area. The zone is situated in the elongation of the Elliott River estuary with a strike of about 045°. One possible interpretation is to regard this as a major shear or fault-zone which played a controlling part in the original formation of the estuary. The low velocity in the bedrock in this zone supports this hypothesis. This zone may form part of a deep channel through which underground water flows.

5. CONCLUSIONS

The seismic and resistivity results along the Thabeban and Alloway bore lines show how geophysical data may be interpreted to indicate the most suitable drilling targets. More specifically, it shows that the lower yields west of the zone PQ (Plate 1) are correlated with shallower bedrock, and with sediments in which the seismic velocity is 3700 ft/sec or less and in which clay and silt predominate. Such sediments have low permeabilities, and hence low yields. Plate 8, showing a tentative relation between bore-water yields and seismic velocities, suggests that in the 4600 to 6300-ft/sec seismic velocity range, good to high bore-water yields may be expected in lacustrine sediments.

With the seismic refraction method weathered shale may be mistaken for lacustrine or alluvial clay or silt sediments. Fortunately, the weathered shale has a low resistivity caused by high porosity and brackish or saline pore-water. Hence, the weathered shale is indicated by a low-resistivity layer in resistivity depth-probes.

In interpreting geophysical data, relatively thin layers are unlikely to be recognised. For instance, a layer of sandy gravel within a sequence of clay sediments usually escapes detection.

The geophysical results have suggested the presence of a buried valley in the bedrock in the elongation of the Elliott River estuary (hatched areaon Plate 1). These results may warrant further investigation of this area as a source of underground water.

The discussion of the results near and south of the Elliott River suggests that good supplies of fresh water may be expected at F, D, H, and D1. Perhaps there is a good supply of fresh to brackish water at C. Moderate supplies may be available at B and G. The above information should be considered in selecting locations for test drilling for water.

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APPENDIX 1

SUMMARY OF BORE LOGS SUPPLIED BY COMMISSION

THABEBAN BORE LINE

B5S1, from plan GW - S124

Yield: 240 gal/hr

Salinity: ——— Hardness: ———

0' - 67': sandy clay and clay

67' - 80': clay shale, or weathered shale, bedrock

B3S3, from GW - S124 and W. Rowan

Yield: 4500 to 5100 gal/hr

Salinity: Chlorine 66 gr/gal; Hardness: 9 - 5 gr/gal

0' - 66': silty and sandy clay, predominantly clay, Elliott Formation

67' - 90': sandy clay and gravel, water beds, Elliott Formation

90' - 130': clay, weathered bedrock, Burrum Coal Measures

130' - 145' : Shale

Bore 3 - South Tower, from Commission file 5682

Yield: ———, town water supply bore

Salinity: ———

0' - 28': predominantly clay

28' - 74': sand, gravel and bit of clay

74' - 103': gravel, water bearing

103' - 109': Silty sand, weathered bedrock

B2S2: town bore on racecourse, from Commission file 29/1/3

Yield: ———

Salinity: ———

0' - 45': predominantly clay

45' - 76': predominantly sand and silt, little bit gravel

76' - 96': silty sand and gravel, water bearing

96' - 119': clay, weathered bedrock, shale

119' - 135': shale

B1S4, from GW - S124

Yield: 25,500 gal/hr

Salinity: 3.6 gr/gal chlorine; total solids: 7.2 gr/gal; Hardness: 0.8 gr/gal

0' - 63': Clay and sandy clay

63' - 122' : Gravel and clay

ALLOWAY BORE LINE

B1S1, from G.W. - M.120

Yield: ———

Salinity: ———

0' - 63': predominantly clay with sands

63' - 90': sandstone, bedrock

90' - 114' : shale

B2S2, from GW - M 120

Yield: ———

Salinity: ———

0' - 12' : clay and gravel

12' - 61' : clay and gravel

61' - 83': clay and sandstone, probably weathered bedrock

83' - 152': shale

B3S3, from GW - M 120

Yield: ———

Salinity: ———

0' - 17' : predominantly clay

17' - 73' : clays with gravel

73' - 151' : shale with bands of sandstone

B4S4, from file 5682

Yield. : ———

Salinity: ———

0' - 28': predominantly clay

28' - 69' : sand., gravel, and clay; water-bearing gravel from 55 to 69 feet

69' - 80' : clay, weathered bedrock

80' - 107': sandstone and shale

Bores 12 and 13, from file 5682/H2

Yield: 360 to 2005 gal/hr

Salinity: ———

0' - 12': soil and clay

12' - 80 ± : predominantly clay and silt with some sand and gravel

80' - 88' : bedrock, weathered basalt and clay, Burrum Coal measures

B7S7 and B16S7, from GW - M 120 and A.J. King

Yield: 8580 gal/hr

Salinity: ———

0' - 17' : clay.

17' - 165' : gravel , sand, and clay, waterbearing below 104' depth

165' - 225' : weathered shale , bedrock

B8S8, from file 5682/H2

Yield: 200 gal/hr

Salinity: ———

0' - 23' : Clay

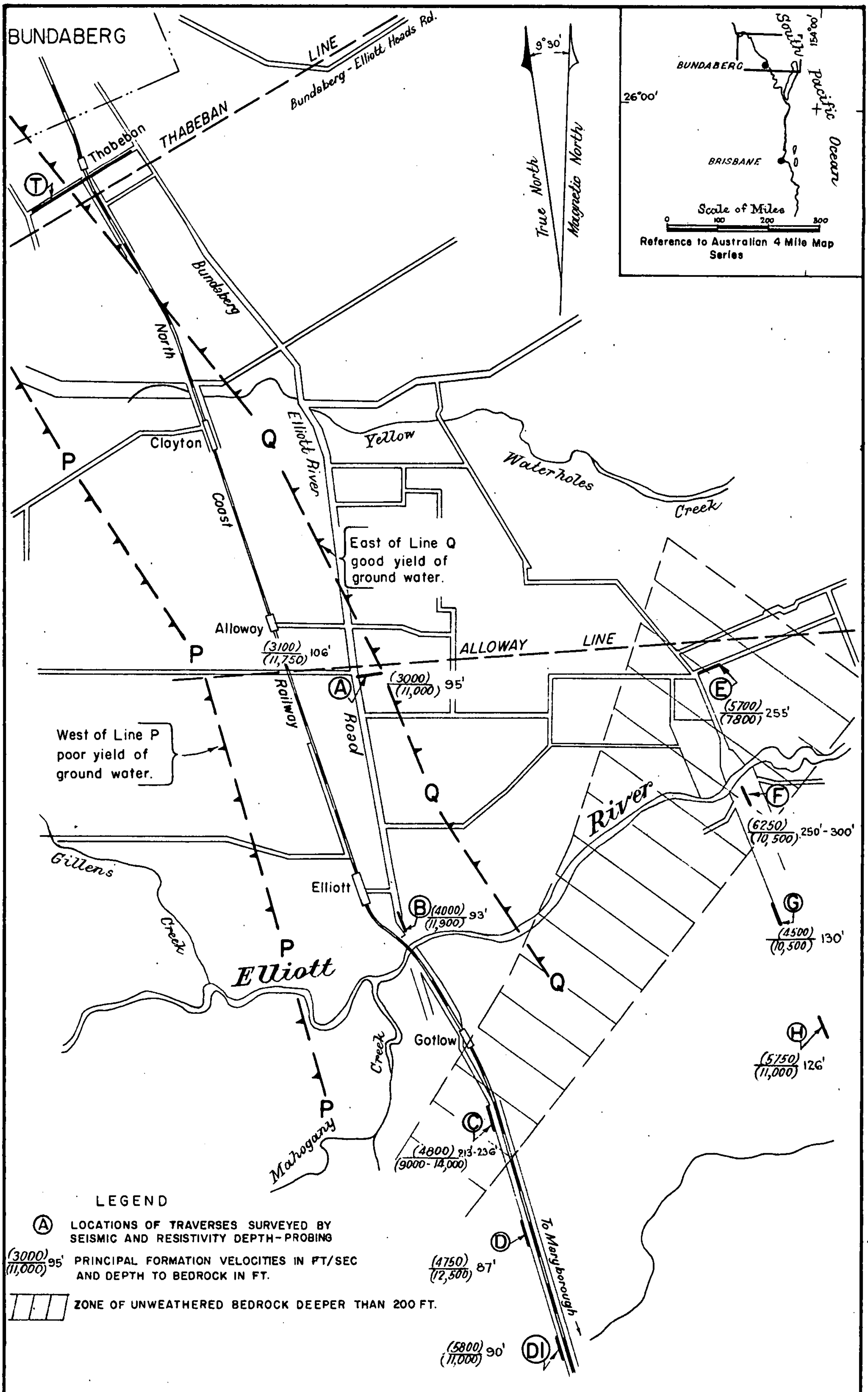
23' - 47' : clay and gravel

47' - 135' : weathered shale and clay, bedrock

135' - 145': shale

gal/hr = gallons per hour

gr/gal = grains per gallon



BUNDABERG, QLD. 1960
EXPERIMENTAL GEOPHYSICAL SURVEY
FOR UNDERGROUND WATER

LOCALITY MAP AND BEDROCK DATA

SCALE IN MILES

1 0 1 2 3 4

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics. G 404-1

PLATE 2

LEGEND

T2700	SEISMIC STATION
83'——	DEPTH TO SEISMIC REFRACTOR
(3400)	FORMATION WITH SEISMIC VELOCITY IN FEET/SECOND
——?——	INTERPOLATED BOUNDARY OF FORMATION
——•——	BOUNDARY OF HIGHEST VELOCITY REFRACTOR

THABEBAN BORE HOLE LINE

SEISMIC SECTION

TRAVERSE T

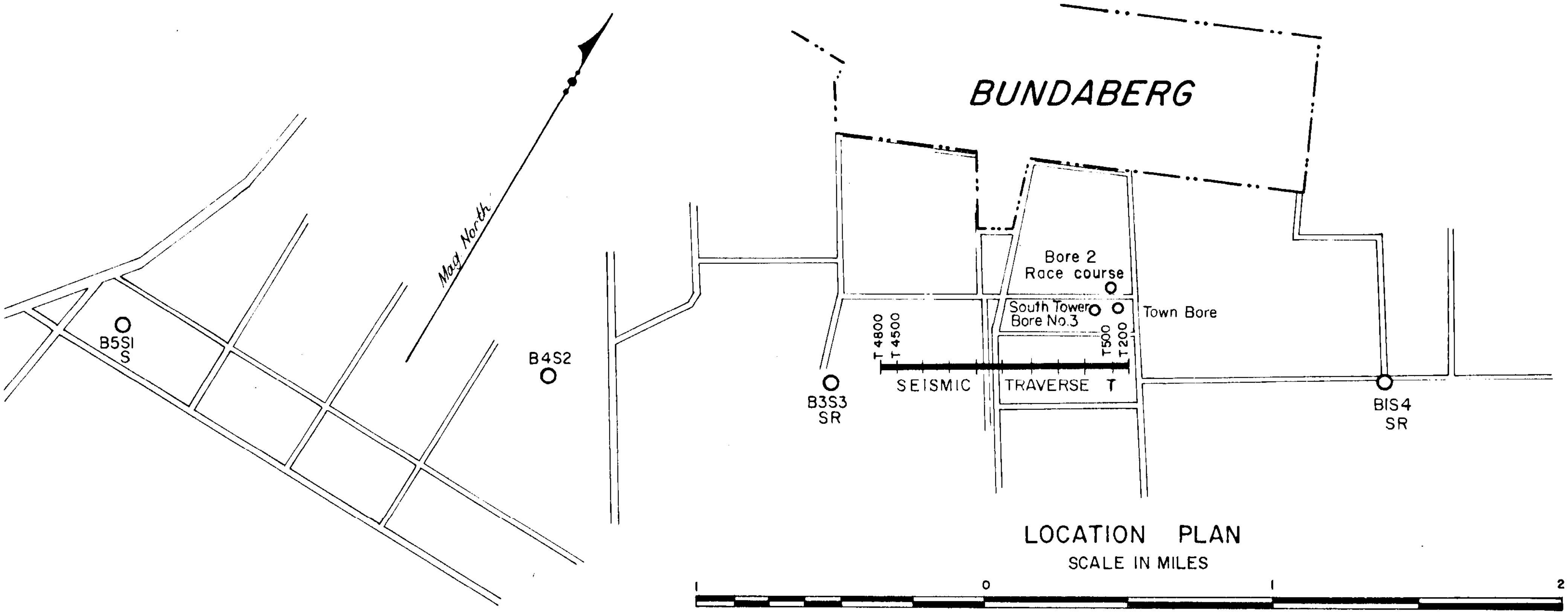
HORIZONTAL AND VERTICAL SCALE IN FEET

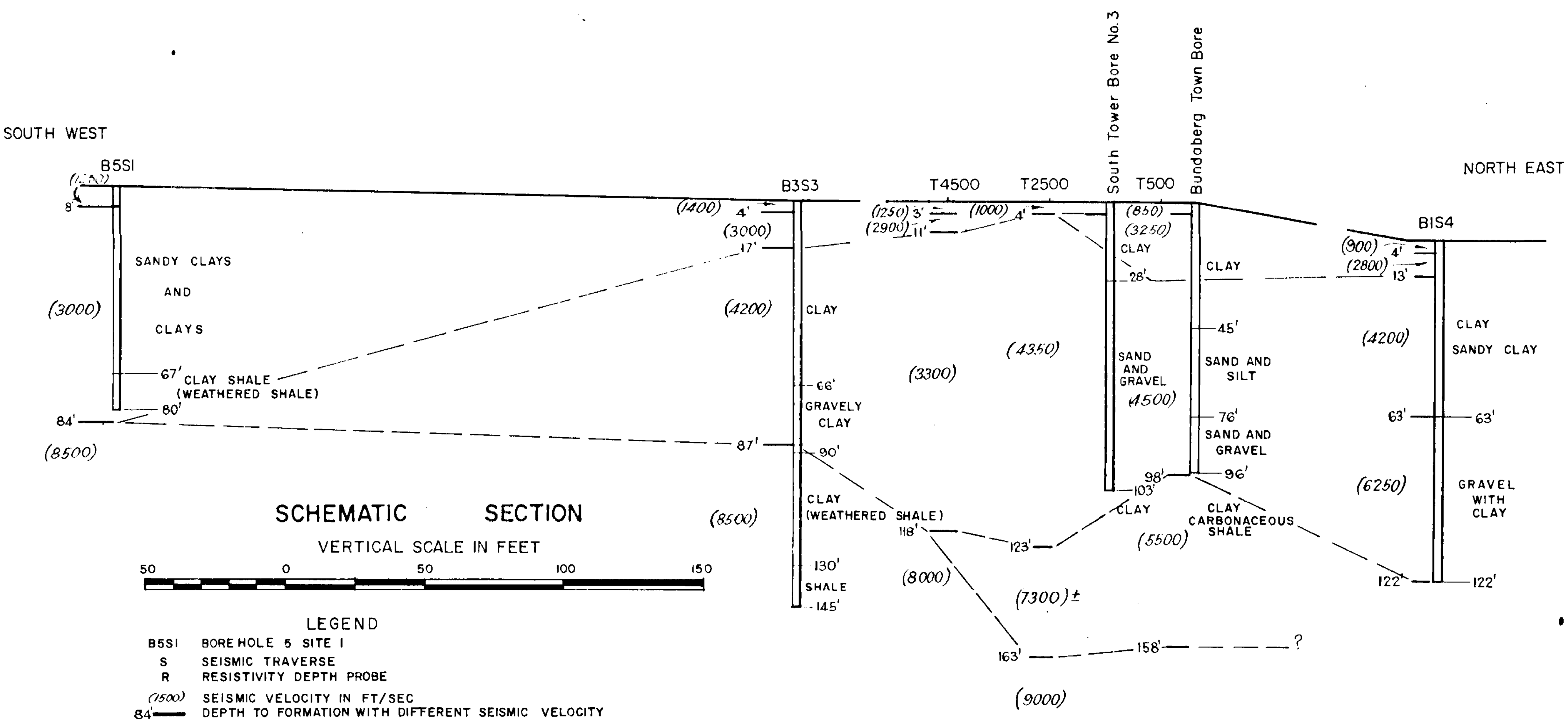
100 0 100 200 300 400 500

Bundaberg Q'ld. Experimental 1960

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics G 404-2

To Accompany Record No.1962/74





LEGEND

B5SI	BOREHOLE 5 SITE 1
S	SEISMIC TRAVERSE
R	RESISTIVITY DEPTH PROBE
(1500)	SEISMIC VELOCITY IN FT/SEC
84'	DEPTH TO FORMATION WITH DIFFERENT SEISMIC VELOCITY
8' CLAY 36'	PRELIMINARY GEOLOGICAL DESCRIPTION AND DEPTH TO GEOLOGICAL BOUNDARY FROM BORE HOLE LOGS
T2500	STATION NUMBER

THABEBAN BOREHOLE LINE

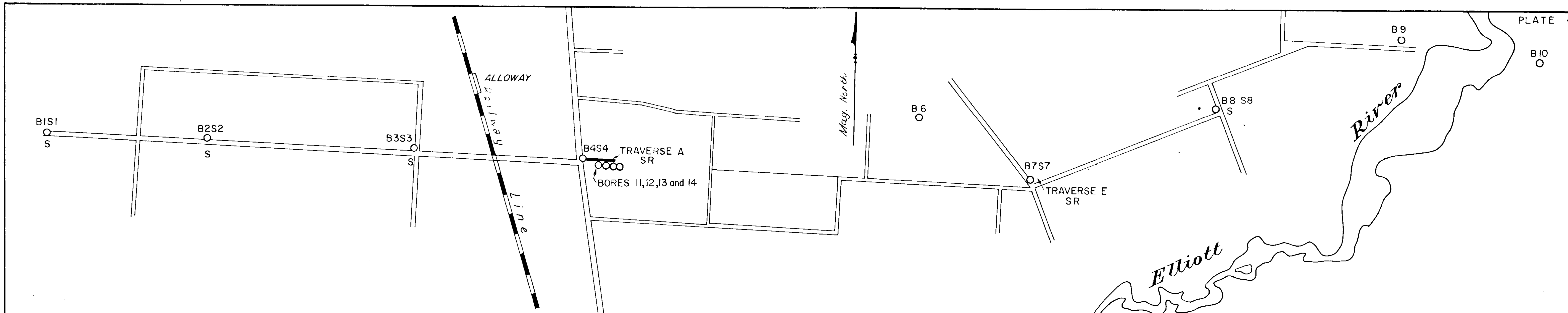
SEISMIC SECTIONS AND BOREHOLE GEOLOGY

BASED ON I.W.S.C. PLAN GW-S-124

Bundaberg Q'ld. Experimental 1960.

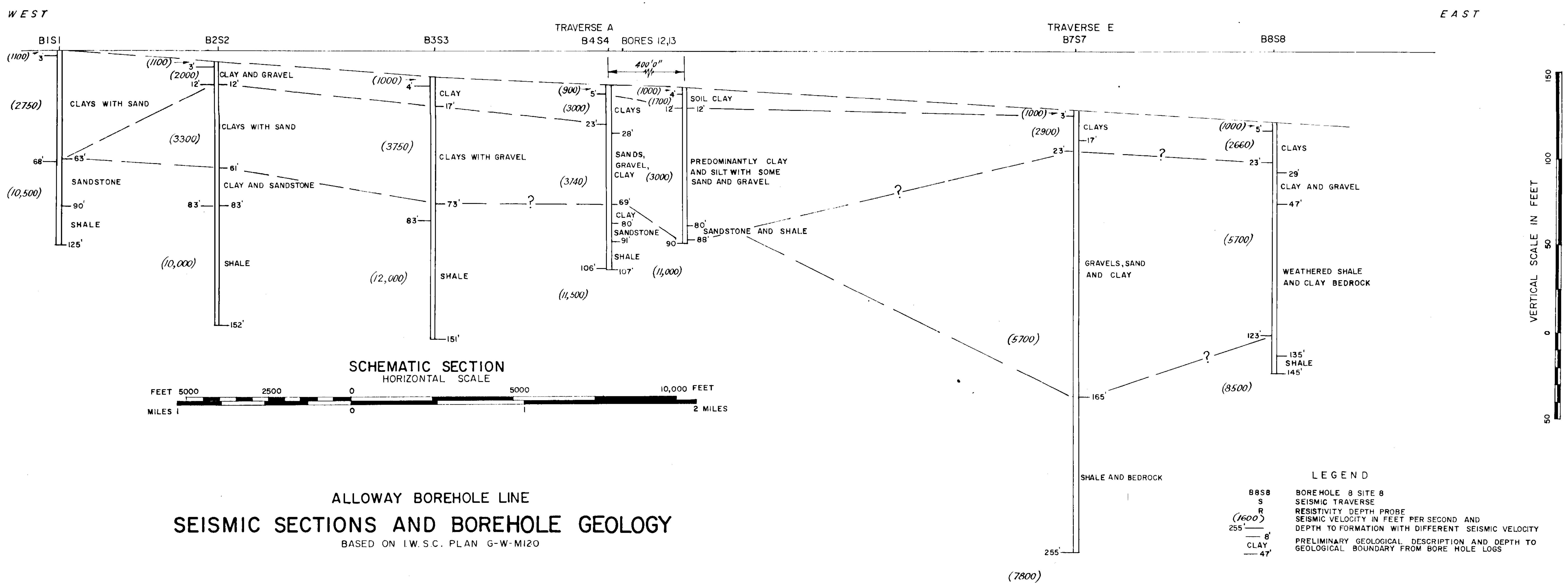
Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics. G 404-3

To Accompany Record No 1962/74



LOCATION PLAN

SCALE IN MILES



SCHEMATIC SECTION

HORIZONTAL SCALE

FEET 5000 2500 0 5000 10,000 FEET

MILES 1 0 1 2 MILES

ALLOWAY BOREHOLE LINE

SEISMIC SECTIONS AND BOREHOLE GEOLOGY

BASED ON I.W.S.C. PLAN G-W-M120

LEGEND

B8S8	BOREHOLE 8 SITE 8
S	SEISMIC TRAVERSE
R	RESISTIVITY DEPTH PROBE
(1600)	SEISMIC VELOCITY IN FEET PER SECOND AND
255'	DEPTH TO FORMATION WITH DIFFERENT SEISMIC VELOCITY
8' CLAY 47'	PRELIMINARY GEOLOGICAL DESCRIPTION AND DEPTH TO GEOLOGICAL BOUNDARY FROM BORE HOLE LOGS

Bundaberg Q'ld. Experimental 1960

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

G 404-4

To Accompany Record No.1962/74

PLATE 5

LEGEND

GWL	Ground Water Level (Interpreted from geophysical data)
Thabeban Bore Line T500	Traverse T Station 500
" " " B3S3	Bore 3 Site 3
Alloway Bore Line A 600	Traverse A Station 600
Traverses	B, C, D, D1, E, F, G, H
— · — · — · —	Seismic Values
————————	Resistivity Values

HISTOGRAMS OF SEISMIC VELOCITIES AND RESISTIVITIES VERSUS DEPTHS

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics. G 404-5

To Accompany Record No. 1962/74

Bundaberg Q'ld. Experimental 1960

Bundaberg Q'ld. Experimental 1960

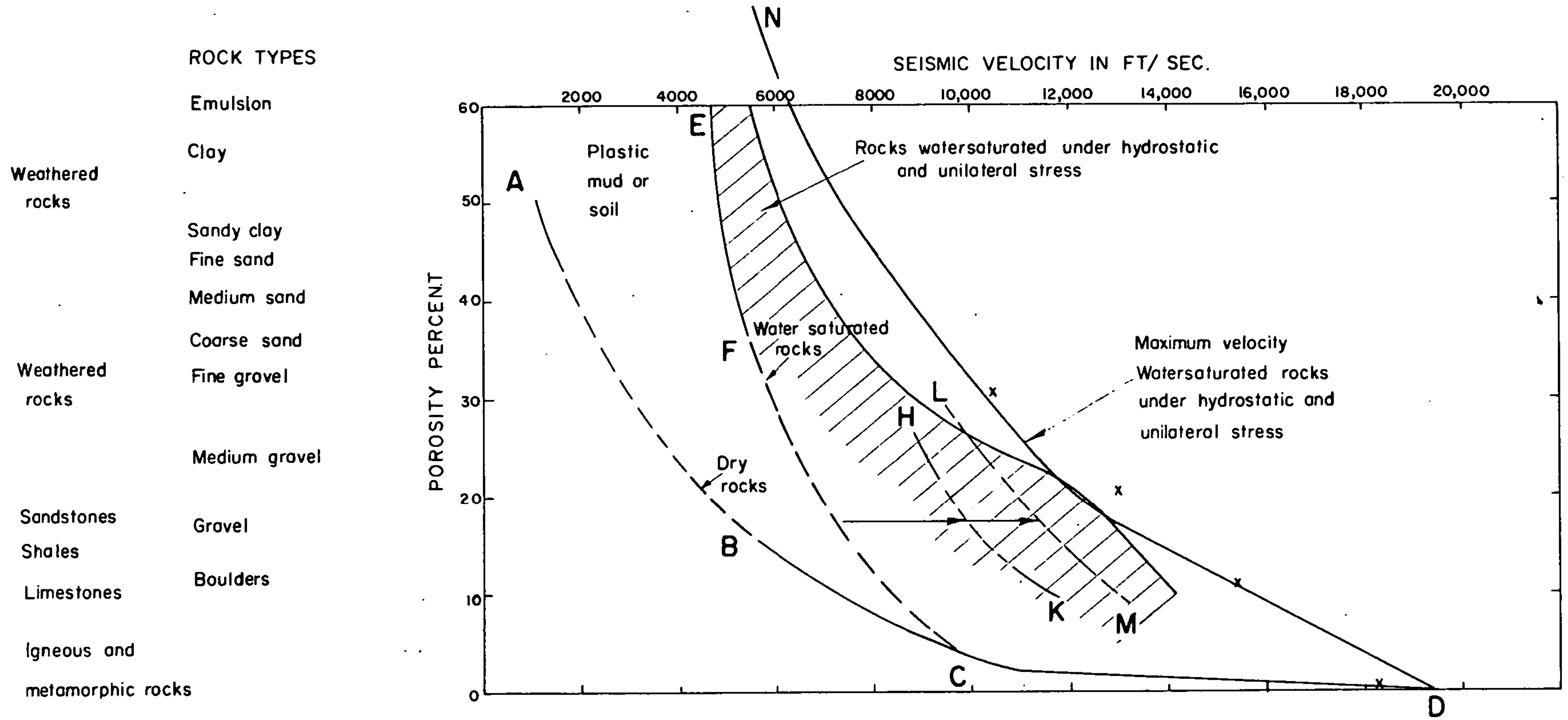


DIAGRAM SHOWING RELATIONSHIP BETWEEN ROCK TYPES, POROSITIES AND SEISMIC VELOCITIES

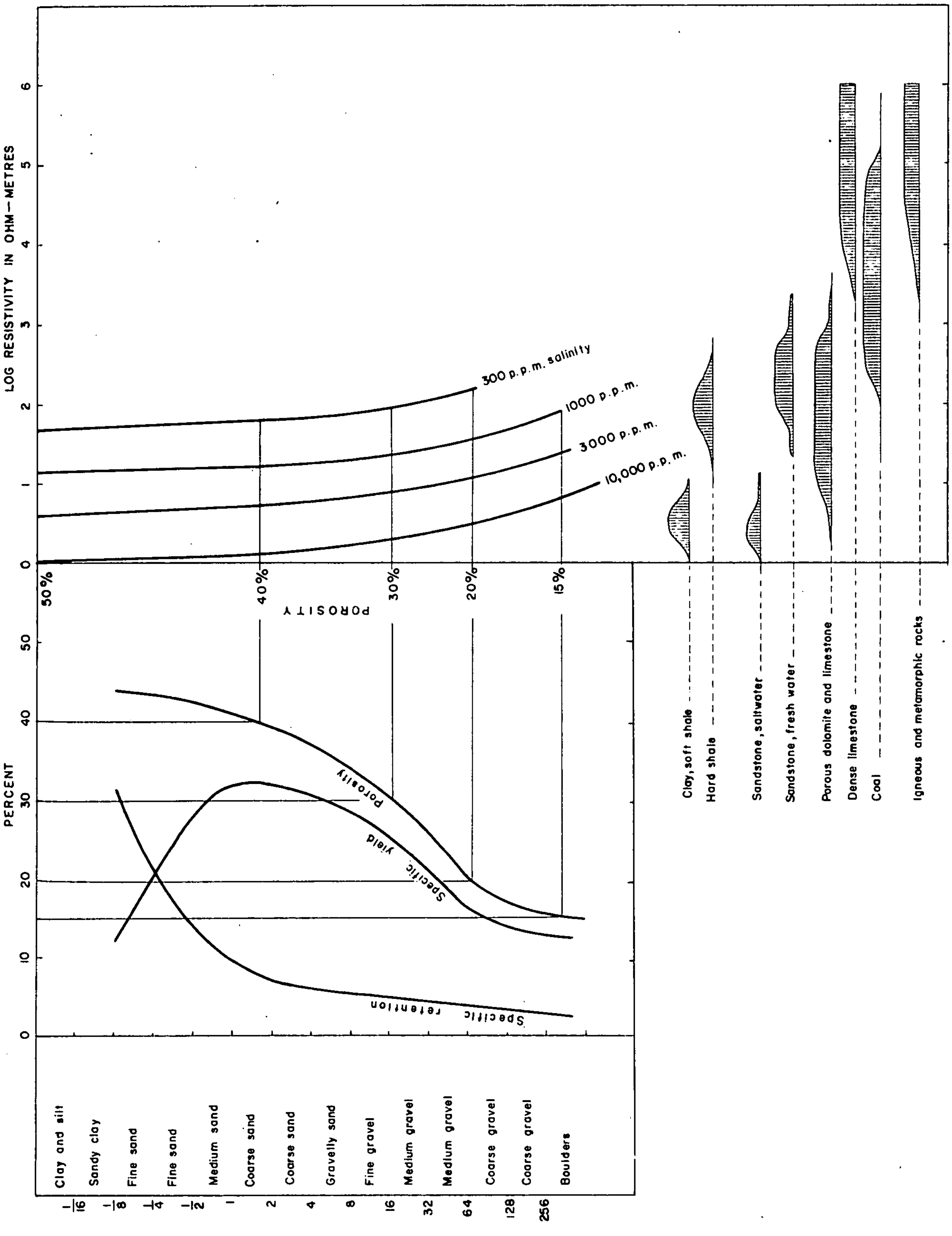
Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics.

To Accompany Record No.1962/74

G.404-6

PLATE 6

PLATE 7



The grain size in which the cumulative total, beginning with the coarsest material, reaches 10% of the total sample.

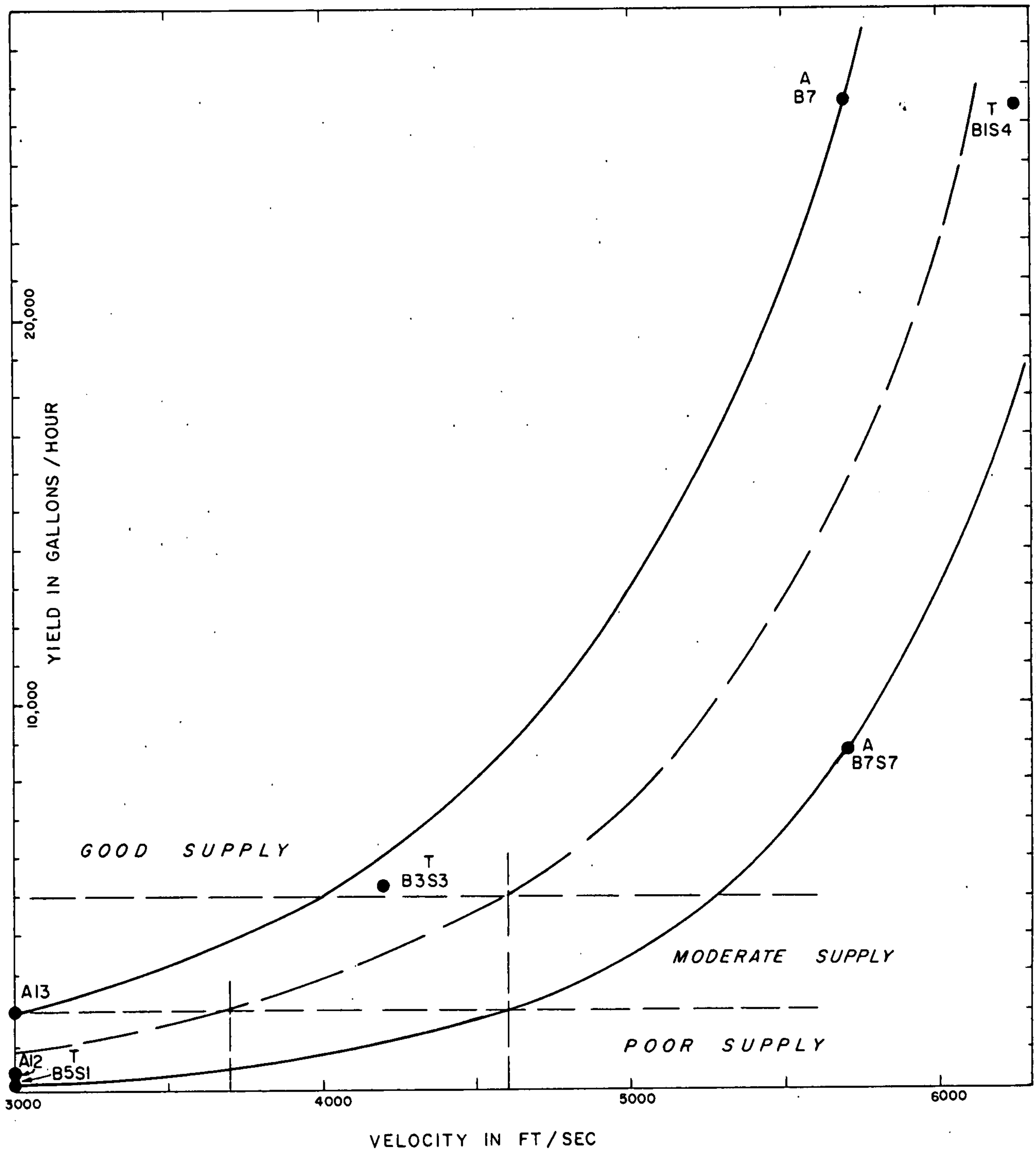
Bundaberg Q'ld. Experimental 1960.

DIAGRAM SHOWING RELATION BETWEEN POROSITY, YIELD, RETENTION, SALINITY, AND RESISTIVITY

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics G 404-7

To Accompany Record No 1962/74

PLATE 8



LEGEND

T BIS4	Thabeban Line Bore I Site 4
A B7S7	Alloway Line Bore 7 Site 7
A13	Alloway Line Bore 13

EMPIRICAL RELATION BETWEEN WATER YIELD AND SEISMIC VELOCITY OF LACUSTRINE SEDIMENTS

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics. G.404-8

To Accompany Record No.1962/74

Bundaberg Q'ld. Experimental 1960