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COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

RECORDS 1957, No. 89

FINAL REPORT ON GEOPHYSICAL INVESTIGATIONS OF UNDERGROUND WATER, ALICE SPRINGS, N.T., 1956

by

D. F. DYSON and W. A. WIEBENGA

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ABSTRACT

In response to an application from the Northern Territory Administration, the Bureau of Mineral Resources, Geology and Geophysics investigated certain aspects of the underground water resources at Alice Springs, N.T. The object of the survey was to provide additional data to assist in the further development of the underground water resources in the area.

The resistivity and seismic methods of survey were used. These are briefly discussed with reference to the limitations of each and to the best method of using the techniques to obtain the data required in each area. The limitations include the delineation of the watertable, the contact between sediments and weathered bedrock, and minor facies changes within the major sedimentary sequences. A correlation is also made between resistivity, porosity and the salinity of the underground water.

Three separate areas were investigated, the first of which was the southern section of the Alice Springs Basin, which is the principal source of the town's water supply. In this area the thickness of sediments was known approximately from earlier drilling and it was desirable that further knowledge be obtained of possible aquifers with potable water and the limits of potable water. To solve this problem, resistivity traversing was supplemented by resistivity depth probing with seismic control.

In the Bungalow Area, information about the bedrock profile was desired in order to ascertain the potential of the area as an underground reservoir. The seismic refraction technique was used to obtain depths to bedrock, and was supported by resistivity traversing to indicate possible variations within the sedimentary sequence.

Detailed information of the depth of sedimentation and obscured basement structure in the Farm area was obtained by a seismic refraction survey and the quality of the water was indicated by isolated depth probes.

The results of the geophysical survey are presented critically for each area with recommendations for testing, bearing in mind the requirements in each instance.

1. INTRODUCTION

The town of Alice Springs, approximate position referred to the Army co-ordinate system, 2,043,500 yards North and 164,000 yards East and elevation approximately 1,900 feet above sea level, is situated in the alluvial basin of the Todd River immediately north of Heavitree Gap, through which the river passes.

The porous beds of the basin sediments provide the water requirements of the town by Government operated bores and wells connected to a reticulation system, and also by private bores and wells.

As a result of the recent growth in population and the probability of further increase, a determined effort is being made to utilise by the most efficient and economic means the total available water. The Resident Geologist recommended that a geophysical survey might add appreciably to the information available. An application for such a survey was therefore made to the Bureau of Mineral Resources, through the Northern Territory Administration, and the survey was subsequently made by the Geophysical Section of the Bureau. The initial application was for a survey of the area bounded by the hospital to the north, Heavitree Gap to the south and the exposed bedrock to the east and west (hereafter referred to as the "Basin Area"), and also along the bed of the Todd River northwards from its junction with the Charles River to the native settlement known as the Bungalow (hereafter referred to as the "Bungalow Area"). Subsequent to this, and while the survey was in progress, a further request was made that investigations should be made south of Heavitree Gap, in an area referred to as the "Farm Area". This included a traverse along the bed of the Todd River to meet a north-south traverse 1½ miles in length, the northern limit being a point ¼ mile east of Mt.Blatherskite. These traverses are within alluvial basins, water from which is being increasingly used for farming purposes.

Intermittent investigations have been carried out in the Basin Area since 1939. These include the geological investigations by H.B, Owen (1952 and 1954), which incorporate an analysis of data from Army test bores (a close pattern of drilling conducted during a period of army occupation in the area), and those conducted by the Department of Works (N.T.) and the Resident Geologist, Alice Springs.

The initial request regarding the Basin area was for information, additional to that available before the geophysical survey, concerning the limits of potable water, the capacity of the Basin (i.e. the thickness of the water-bearing sediments), and the possible presence (and depth) of a buried rock bar at Heavitree Gap.

A method employed to increase the capacity of a partially closed basin from which the outflow is suitably restricted, is by the artificial elevation of the level of discharge, e.g. by the construction of a subsurface dam - known as a Mexican Dam. Should a relatively shallow rock bar exist below the river bed and across Heavitree Gap and such a dam was built on it, the present subsurface outflow of water from the basin would be reduced.

The main object in the survey of the Bungalow Area was to locate any small basin which might be present, and which might be suitable for development to augment the present water supply. Such development may include the construction of a Mexican dam on a bedrock bar. The low salinity of well and bore water in this area makes it suitable for future development.

The purpose of the survey in the Farm Area was to determine what order of thickness of water-bearing sediments may be expected south of Heavitree Gap, thereby enabling an estimate to be made of the water reserves:-

(i) between the Gap and Mt.Blatherskite Ridge,

and (ii) south of Mt.Blatherskite Ridge.

The geophysical party consisted of D.F. Dyson (party leader and geophysicist), A. Stocklin (geophysicist) and J. Kronenburg (geophysical assistant). Field hands were provided by the Department of Works, and the topographical surveys were done mainly by the Lands and Surveys Branch of the Northern Territory Administration.

Field operations commenced in early September, 1956 and continued to the beginning of December, 1956. Due to the low moisture content of the surface layers, difficulty was experienced in obtaining sufficiently good electrical contacts with the ground. This was particularly so after the end of September. Less difficulty would probably have been experienced between June and September, when there is a greater possibility of surface moisture from rain and night condensation, and the daily evaporation rate is lower. This fact should be borne in mind if other surveys are envisaged in areas of similar climatic conditions.

2. METHODS

The following methods and techniques were used during the survey:-

(1) Resistivity investigations. These included:-

(a) Resistivity traversing.
(b) Resistivity depth probing.
(c) Resistivity testing of water from bores and wells.

In the resistivity method a current is applied to the ground through two current electrodes, and the potential difference is measured between two additional points on the ground separating the two current electrodes. The ratio of the measured potential to the applied current, multiplied by a spacing factor, is a measure of the ground resitivity. Usually, the ratio of potential to current is measured and directly expressed in ohms. In the Wenner method the four electrodes are equally spaced, and for a homogeneous medium the resistivity is expressed by:-

$$\rho = 2\pi a \frac{V}{I}$$

where ρ = resistivity in ohm-centimetres

V = measured potential difference in volts

I = current in amps

a = electrode spacing in centimetres

When horizontal discontinuities occur in the sub-surface, the same expression is used but the ordinary resistivity is replaced by the "apparent" resistivity ρ_a

i.e. $$\rho_a = 2\pi a \frac{V}{I}$$

It is generally considered that the effective depth penetration of the current is of the same order as the electrode spacing. However, the current penetration depends on the relative resistance values of the various sub-surface layers through which the current passes to close the electrical circuit between the current electrode points. Jakosky (1950, p.509) quotes that the depth penetration ranges from 1/4 to 1/6 of the distance between the current electrodes.

If the electrode spacing (and consequently the depth penetration) is kept constant and the arrangement is moved as a whole, lateral variations in resistivity are determined. This technique is known as "Resistivity Traversing". By using several electrode spacings, a series of profiles is obtained representing the apparent resistivity to different depths.

In the method referred to as "Resistivity Depth Probing" or "Electrical Drilling", the electrode spacing "a" (and hence the depth penetration) is gradually increased symmetrically from a central point. For convenient interpretation the log of the apparent resistivity is plotted against the log of the electrode spacing. The field results obtained are compared with two-layer (Roman, 1930) and three-layer (Wetzel and McMurray, 1937) type curves prepared from theoretical examples and the depth to different resistivity layers is estimated. The accuracy of interpretation is rarely precise. The theoretical curves are based on homogeneous and isotropic layers of infinite lateral extent, the bottom layer extending to infinite depth. Such conditions are rarely encountered in nature and any separately identifiable layer is normally inhomogeneous and anisotropic within itself. The contact between two such layers may consist of a transition zone, itself too thin or lacking in distinctive character to be identified. The human element in the matching of field curves with type curves may also introduce inaccuracies in interpretation.

Ordinary rock minerals have a high resistivity, and for computations in engineering resistivity work are considered to be infinitely resistive. The resistivity of a rock depends mainly on the rock porosity, the degree of saturation with pore solution and the resistivity of the pore solution. The resistivity of the pore solution is inversely proportional to the salinity. Hence, if the rock pores are saturated with pore solution, the resistivity of the rock is inversely proportional to both porosity and salinity.

Summarizing, the interpretation of resistivity data involves the following variables:-

(a) Depth to unweathered rock.

(b) Thickness of weathered bedrock.

(c) Porosity.

(d) Salinity of pore solution.

(e) Degree of pore saturation.

(c) and (d) are related to types of sediments (clays, sands, gravels or weathered bedrock).

The resistivity (and hence the approximate salinity) of underground water can be determined from bore water samples if these can be considered as representative of the underground water.

If the resistivity of a rock is estimated from resistivity depth probing, and the resistivity of the pore solutions can be estimated from measurements on bore water, then the porosity of the rock can be determined (see Appendix A).

This enables an estimate to be made of the water-holding capacity of the rocks. However, it should be borne in mind that a very porous rock is not necessarily a good aquifer unless the rock also has reasonable permeability.

Vice versa, if the porosity of the rock can be estimated and the approximate resistivity is known from resistivity depth probes, the salinity of the pore solutions (and therefore the ground water) can be determined.

(2) Seismic investigations.

The principle objective is the depth determination of the discontinuity between the sediments and the basement rocks. The seismic refraction method depends upon the contrast in the elastic properties of different strata and the discontinuities between such strata. The physical laws involved resemble those of optical phenomena in that energy propagated through the ground undergoes reflection and refraction at discontinuities.

An explosive charge detonated near the ground surface at the "shot point" produces a train of seismic waves, which, upon encountering discontinuities, are reflected and refracted. The part which is refracted at the critical angle moves along the discontinuity and energy is continuously refracted upwards to the surface. The travel times of the waves from the shot point to geophones (detectors) are recorded.

A series of geophones is set up in line at a specific spacing (the arrangement is known as a geophone "spread") and the first arrival times of the recorded seismic waves are plotted against the distance from the shot point. Such a plot is called a "time-distance curve". The slopes of the time-distance curve indicate the velocities of the seismic waves in successive formations, and from this data it is possible to compute the depth to these formations.

The technique known as the "Method of Differences" (Heiland 1946 p.548) is commonly used by the Bureau. In this method, if A is the shot point at one end of the spread, then the time taken for the energy to reach a point B within the spread is T_{AB} and the time to a point C beyond the spread is T_{AC}. Similarly, when shooting from C, the time for the energy to travel from C to B is T_{CB} and the time from C to A is T_{CA}. The energy paths from A to C and C to A are identical and the times T_{AC} and T_{CA} (known as the reciprocal times) should be identical.

The depth is computed from the vertical travel time T_D, which is defined as $\frac{1}{2}(T_{AB} + T_{CB} - T_{AC})$.

The depth, D, is

$$\frac{V_2 V_1}{\sqrt{V_2^2 - V_1^2}} T_D$$

where V_1 is the velocity of the first recorded wave through the layer above the discontinuity and V_2 is the velocity through the layer below.

For $V_2 > 3 V_1$, $\frac{V_2}{\sqrt{V_2^2 - V_1^2}}$ approaches the value 1, and the depth becomes V_1 TD.

If horizontal or near-horizontal discontinuities occur, the intercept method may be applied in the computations (Dobrin, 1952 p. 220). In the Farm area, without using drilled shot holes, insufficient energy penetrated into the ground to permit the siting of shot points at a distance sufficiently great to record events from the lowest refractors continuously along the spread. Under such conditions only the intercept method can be used. The derived expression for the multilayer problem is presented in Appendix B.

Types of geophone spreads used include:-

(a) Normal spreads, in which the geophone spacings were 50 feet or 100 feet; two shots were fired at distances of 50 feet and 200 feet to 500 feet from each end of the spread.

(b) Weathering spreads, in which geophone spacings were usually 10 feet but in some instances 5 feet; shots were fired at several distances from each end of the spread.

(c) Broadside spreads, in which the shot point is on a line at right angles to the middle point of the spread, were used on short cross traverses.

Although the principal objective of the seismic method is the determination of the depth to elastic discontinuities, the seismic velocity is an indication of the physical character and condition of the material. Table 1 presents an approximate interpretation of longitudinal seismic wave velocities in terms of rock type.

TABLE 1.

Velocity in ft/sec.	Rock Description
700 - 1,200	Soil, unconsolidated surface deposits.
1,200 - 4,500±	Unconsolidated clays, silts, unsaturated sands and gravels.
4,500± - 5,500	Saturated sands and gravels, compact clays and silts, completely weathered rocks.
5,500 - 8,000±	Consolidated sediments, probably water-saturated, weathered metamorphic and igneous rocks, weathered shales and sandstones.
8,000± - 12,000	Sandstones, shales, weathered and/or sheared metamorphic and igneous rocks.
12,000 -15,000	Slightly weathered and/or fractured metamorphic and igneous rocks.
15,000 -17,000	Fractured metamorphic and igneous rocks, possibly weathered along fractures.
17,000 -20,000	Unweathered metamorphic and igneous rocks.

To interpret seismic velocities accurately in geological terms a minimum amount of geological control is required (See Table 1).

(3) Interpretation as applied to shallow sediments.

(a) The sediment/bedrock contact.

It is possible, and even probable, that the resistivities and seismic velocities of sediments and underlying weathered bedrock overlap. Under such conditions neither the resistivity nor the seismic method can determine the sediment/bedrock contact accurately.

Even if sufficient seismic velocity contrasts exist between say 3 formations, the intermediate formation must have a certain minimum thickness before its presence can be detected from first arrival seismic events (Leet, 1950).

Both the resistivity and seismic methods normally provide data for the identification of the unweathered bedrock because this unweathered rock almost always has a high resistivity and a higher seismic velocity than overlying weathered material.

(b) The water table.

In "resistivity depth probing" it is not possible, even under ideal conditions (for instance in homogeneous well-sorted sands), to determine the depth to the water table accurately. The main reason is the presence of a transition zone overlying the water table in which the pores are only partially filled with capillary water. Gradual transition zones are not embodied in the interpretation technique because the mathematical treatment of variable resistivity within a formation is too complex.

In the seismic refraction method it is sometimes possible to detect the ground water table under certain favourable conditions. A semi-consolidated rock consists of a frame, made up of grains, and pore space. The pore space may be filled with liquid (water). When seismic energy is transmitted through this rock, waves pass through both pores and frame. If the pore wave, a type of water wave of 4,500 to 5,000 ft/sec. velocity, is faster than all other waves, it may be possible to record it as a first arrival event. In many coarse sands and gravels the observed velocities are close to that which may be expected for a water wave, and it must be assumed that the pores are filled with water.

In unconsolidated plastic rocks such as water-saturated muds, no separate pore and frame waves exist, and the seismic energy is transmitted with lower velocities (2,000 to 4,000 ft/sec.) and lower frequencies (Paterson, 1956). If plastic rocks exist at about ground water level, the water table will not therefore be disclosed because its velocity is too low. However, underlying gravel and sand deposits may still be indicated by their characteristic 4,500 to 5,500 ft/sec. velocities.

If the water-bearing sediments are more consolidated, the frame wave velocity may be greater than the pore wave velocity and will therefore be recorded as a first arrival event.

(c) The shallow sediments.

Thin, alternating layers or lenses of sands, clays and gravels cannot be identified individually by seismic or resistivity methods. Usually, the layers are disclosed as larger groups or units with an average velocity and resistivity.

It has already been mentioned that the resistivity is related to the porosity and salinity of the pore solutions. Unsorted material (e.g. river gravels) has a low porosity, while well-sorted material (e.g. fine sands, clays, etc.) has a high porosity. Hence, river gravels with relatively fresh water as pore solution have a high resistivity compared with clays containing a similar pore solution. It may be remarked that clays often act as a retainer and absorbent for saline solutions formed by weathering (fixed ground water) and hence show a lower resistivity than may be expected (Tolman, 1937).

To judge the average water quality from resistivity measurements of sediments the following data are derived from Figure A1 of Appendix A. For rock porosities of 40, 30 and 20 per cent, and a maximum allowable salinity of 1500 p.p.m. the rock resistivities should be greater than 12, 17 and 30 ohm-metres respectively. As the porosity of a suitable aquifer does not usually exceed 30 per cent, a resistivity of 17 ohm-metres must be considered as a minimum limit for potable water.

Geophysically, a favourable target area for fresh water investigations will be indicated by sediments of sufficient thickness, an average resistivity of 17 ohm-metres or more, and a seismic velocity of more than 4500 ft/sec. With higher seismic velocities the compaction of the sediments will be greater and hence the porosity lower, and the required rock resistivity for potable water will be slightly higher.

3. EQUIPMENT

For resistivity work, several instruments are available, each with its own limitations. These instruments include:-

1. The low resistance "Megger" Earth Tester, manufactured by Evershed and Vignoles Limited, London (Melbourne agents, H.Rowe and Co.), has ranges 0-1, 0-10, 0-100 and 0-1000 ohms. This instrument is not recommended for electrode spacings greater than 100 ft., but is ideal for testing bore waters when used with the mud cell.

2. The Geophysical "Megger" Earth Tester, also manufactured by Evershed and Vignoles Limited, has lower ranges, namely 0-0.3, 0-1, 0-3, 0-10 and 0-30 ohms and is more adaptable for resistivity traversing.

3. A resistivity meter, developed by the Geophysical Section of the Bureau and specially suited for measuring a wide range of resistances, was used for the resistivity depth probes.

To improve the electrode-ground contacts, an electrode may consist of more than one component (e.g. several steel spikes may be used for one electrode contact). When the ground surface is dry it may be necessary to moisten the ground, and in areas where surface resistivity is high, such as in the river bed sands, addition of salt water to the ground at the point of electrode contact may be necessary to obtain a good electrical contact.

The mud cell for testing bore waters is essentially a cylindrical container; each end consists of a current electrode and the potential electrodes are annular rings situated at specific distances along the cylinder.

For the seismic work, a Mid-Western 12-channel Portable Reflection/Refraction seismograph was used, with Mid-Western low-frequency (6.5 c.p.s.) geophones.

4. THE BASIN AREA.

A. GEOLOGY AND HYDROLOGY.

The geology of the area is referred to by Owen (1952 and 1954) and Jones (1957).

Quaternary sediments of sands and clays overlie a bedrock of Archeozoic gneisses and schists with intrusive pegmatites and dolerite dykes. The older gneisses and schists crop out at several places within the area and beyond the limits of the basin, except to the south where the basin is terminated by Heavitree Ridge, which consists of Proterozoic quartzite. A break in this ridge (Heavitree Gap) forms the outflow channel of the Basin Area. A subsurface ridge of quartzite may exist across Heavitree Gap.

Jones (1957) shows the contours of the bedrock as far as is known from drilling. Percussion drilling was employed and the quality of the geological logging by the drillers of these holes is doubtful, particularly as the contours shown are those of weathered bedrock and it is often difficult to distinguish between sediments and weathered bedrock. This is well illustrated near station 500E on Traverse D, where a drill hole (B.M.R. No. 4) encountered weathered bedrock at 46 feet, whereas the records of Army drill hole J nearby indicate weathered bedrock at 60 feet. The accuracy of the bedrock contours given by Jones (1957) and Owen (1954) is therefore doubtful.

The bedrock contours presented by Jones (1957) indicate that bedrock is at relatively shallow depth below the course of the Todd River to a point approximately midway between traverses C and D. Downstream from this point the thickness of sediments overlying the bedrock increases to a point near Heavitree Gap.

The contour plan indicates that the lowest part of the Basin is located about 650 feet west of the intersection of traverses A and D (i.e. about 450 feet west of the railway line), where weathered bedrock is at a depth of 75 feet or slightly more. Furthermore, the contours show that the basin is partly closed.

Several holes drilled by the Bureau's Reflection Seismic party provided further details regarding lithology and depths to bedrock (see Appendix C).

The Army drill holes, drilled prior to 1946 in the southern part of the Basin area, were, according to the available sections (Lands and Surveys, N.T. Administration, Trace No. 36/52), drilled to unweathered bedrock. These holes were not sealed or cemented off, and if saline water is present at lower levels within the Basin, it is possible the holes may form excellent conduits for saline water to enter and contaminate the upper part of the sedimentary section.

The report by Jones (1957) includes a salinity map on which the salinity contours are based on water samples from drill holes. In the construction of the map no differentiation is made between water from bores drilled to bedrock and water from higher levels. The only water samples procurable in some areas were from old unused bores drilled to bedrock. For this reason it is considered that over part of the basin the salinity map indicates the salinity conditions only very approximately. The main feature of the map is the zone of fresh water (less than 300 p.p.m.) which coincides approximately with the surface course of the Todd River.

The requirements for a suitable ground water supply include:-

(a) Suitable thickness of sediments.
(b) Reasonable porosity of these sediments.
(c) Suitable permeability.
(d) Low salinity of the pore solutions.
(e) Sufficient replenishment of water.

Although high porosity is desirable it must be combined with fairly high permeability. Well-sorted material may have high porosity, of the order of 40 per cent, but may not have high permeability. For instance, clays and fine sands, in which the pore openings, although constituting a high percentage of the total volume of the material, are too small to permit the free flow of solutions. Gravels and unsorted sands, although of lower porosity, are usually better aquifers because they normally have high permeability.

A salinity of less than 1600 p.p.m. is necessary for town water supplies, this value being dependent upon the constituent salts.

Saline conditions in an aquifer may be attributed to:-

(i) Introduction of salts with the recharging waters.

(ii) The soluble nature of the aquifer and/or surrounding rocks (e.g. limestone).

(iii) The products of weathering of basement or host rocks entering solution.

(iv) Superficial contamination (not considered here).

Should an area be subject to periodic recharging and the recharging solutions be lower in salinity, then under relatively static conditions the recharge solutions will overlie the more saline solutions. If periodic discharge from the sediments is associated with the recharging, the sediments undergo a flushing action in which the salts, accumulated during a period of little or no water movement, will be removed from the area.

If a ground water source is in the form of a partially closed basin, that is the level of discharge is higher than some of the aquifers, it may be expected that upon periodic recharge no adequate natural flushing will occur at any level lower than that of discharge. Under such circumstances it may be expected that saline conditions will exist below the level of discharge unless the conditions are changed by artificial causes such as pumping. Information regarding the shape of the basin, whether it is closed, partially closed or open, is therefore important.

B. RESULTS.

Plate 2 shows the layout of the traverses, and the location of the resistivity depth probes, seismic traverses (used as control) and drill holes. Plates 3 and 4 show the results of the seismic refraction survey and resistivity traversing (electrode spacing was 100 feet and 200 feet along all traverses and also 300 feet along traverse A). Histograms correlating the results of the resistivity depth probes (from Plate 5) and the seismic results, are also shown on Plates 3 and 4.

The results are discussed below, commencing with the southern part of the area.

In Heavitree Gap the bedrock is shallower between stations A1000N and A 1800N on traverse A, than it is to the north and south of the gap. This is taken as evidence that a rock bar exists at depth beneath the Gap. The depth to bedrock between these 2 stations ranges from 44 to 66 feet, the minimum depth being near station A1350N. The high resistivity readings at this point may be attributed to the shallow depth to bedrock and to the relatively fresh pore water which may be expected to flow over the rock bar. This latter cause results in a high average resistivity value in the sediments overlying the bedrock.

The sediments consist of a thin surface layer (5 to 14 feet) of very low seismic velocity (800 to 1100 ft.) overlying sediments of 5000 ft/sec. velocity and 18 to 24 ohm-metres resistivity. These data indicate that the sediments are most likely water bearing sands with potable water. The bedrock velocities south of station A1500N range from 13,000 to 15,000 ft/sec.; just north of station A1500N the velocity is 16,400 ft/sec. According to the geological information, station A1500N is near the boundary of Proterozoic quartzite (south of A1500N) and Archean rock (north of A1500N). South of Heavitree Gap is a wedge of 8500 ft/sec. velocity (which tapers towards the Gap) between the water bearing sands (5400 ft/sec.) and the bedrock (13,000 ft/sec.). This wedge may be a weathered formation or a more consolidated layer within the sediments.

Near the intersection of traverses A and B the unweathered bedrock is 60 feet deep, and the overlying section has an average seismic velocity of 4000 ft/sec. and an average resistivity of 14 ohm-metres. The drilling carried out by the Bureau (B.M.R. Nos. 1 and 6) indicates weathered schist at 44 feet, and sediments consisting of a mixture of sands and clays (see Appendix C). As the drilling indicates coarse sands and gravel between 29 feet and 45 feet, an aquifer with potable water may be present, but it is considered that the water within the weathered bedrock could be saline. Between Heavitree Gap and the intersection of traverses A and B, the unweathered bedrock is deeper (up to 80 feet), and though the possibility of fresh water close to the surface (to a depth of 45 ft.) is fair, the water is expected to be very saline near to and within the weathered bedrock because the fluids within the deeper parts are not flushed out (see Section 4A).

Fig A1

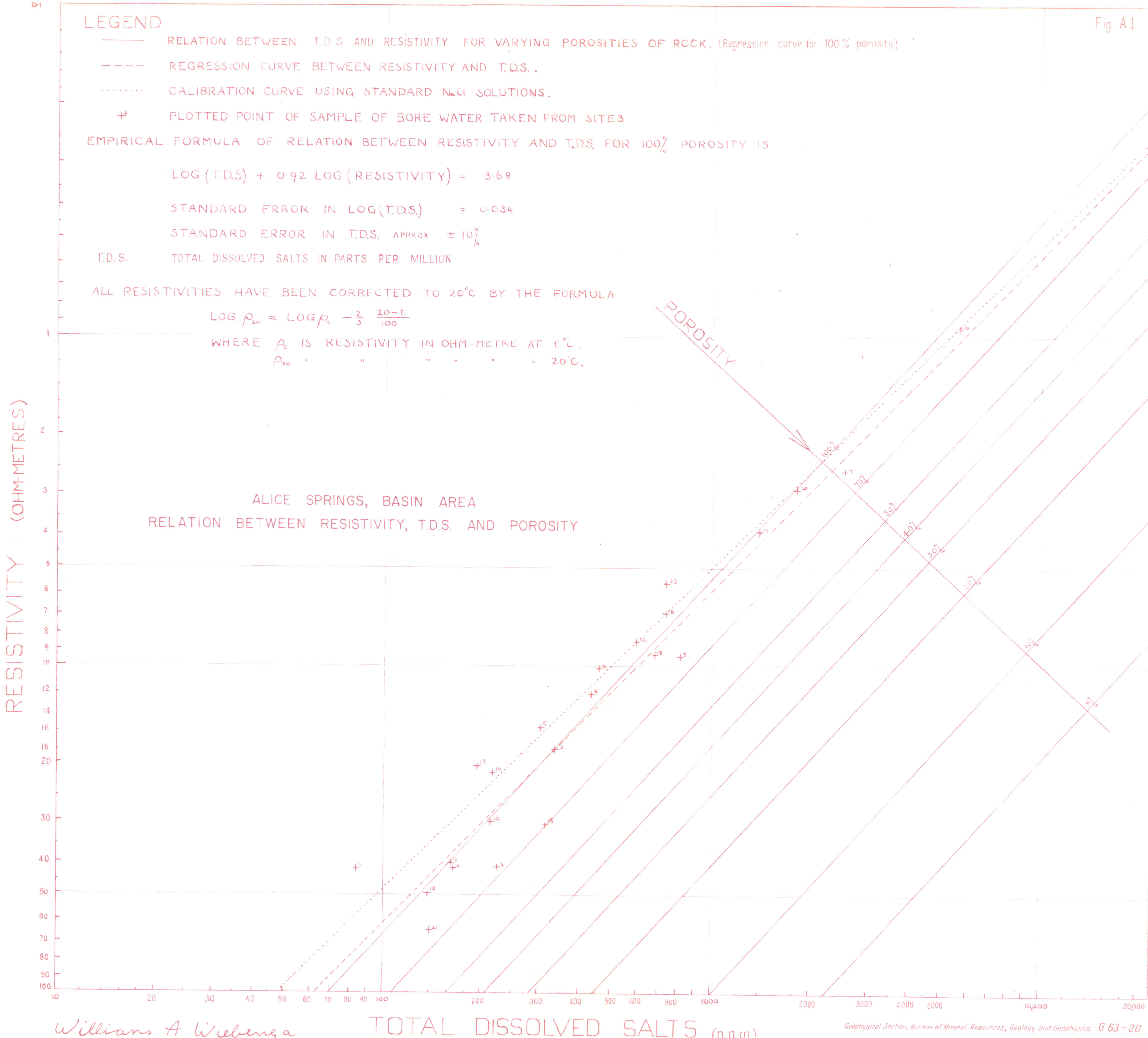

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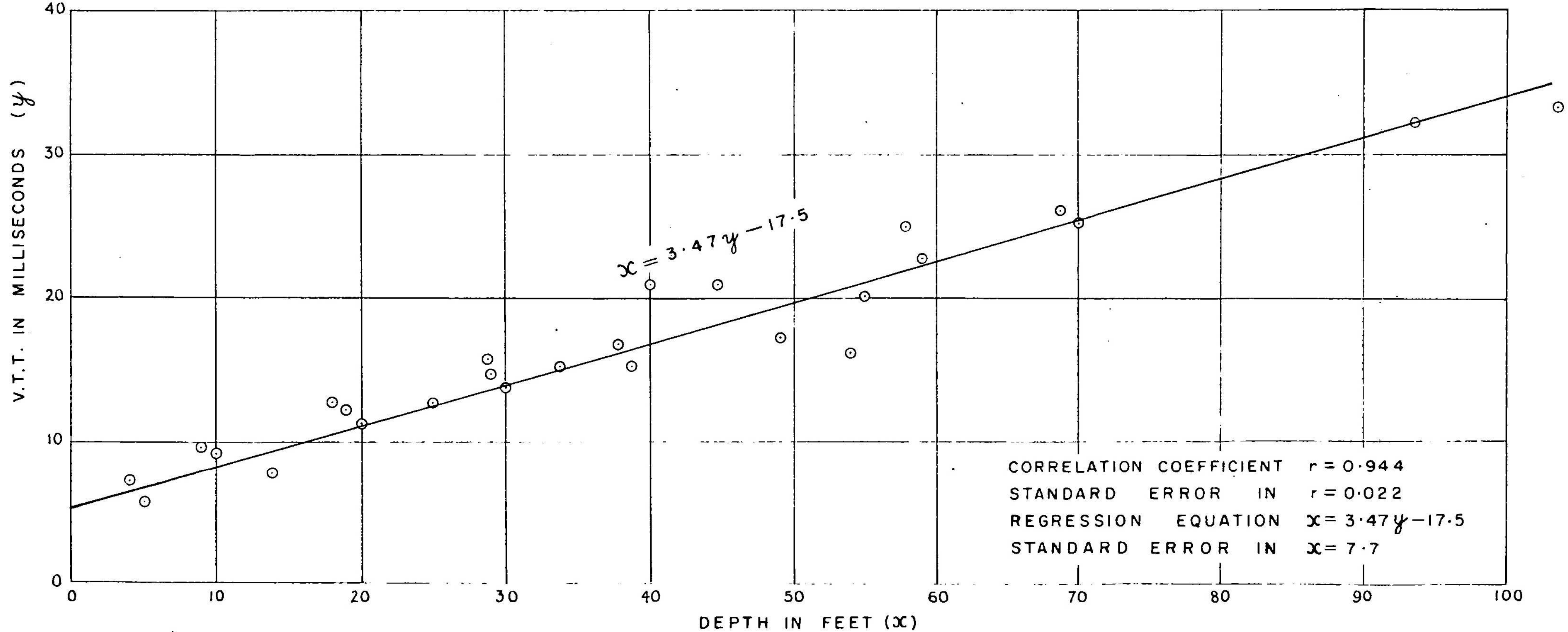
FIG. C1



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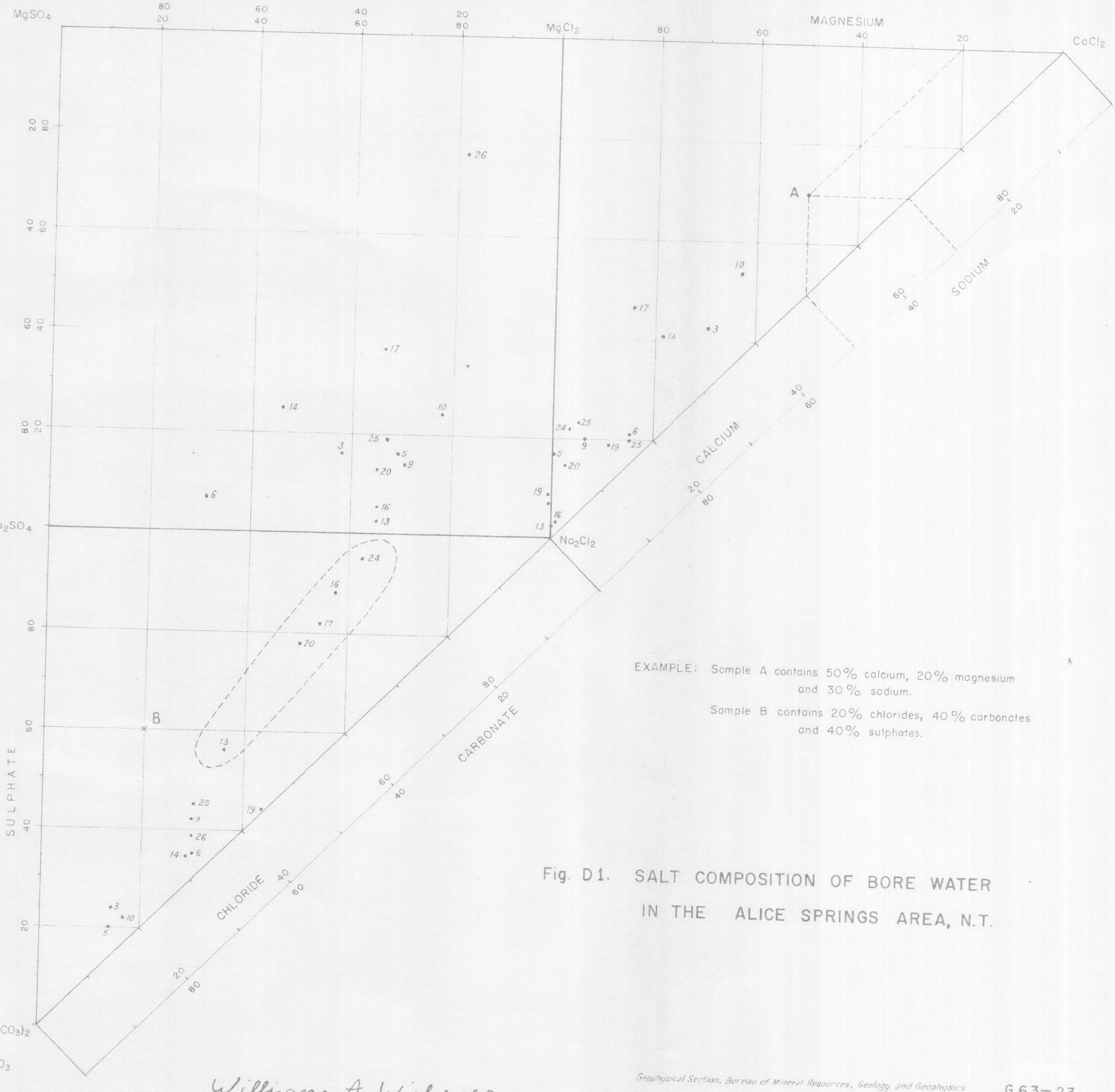
RELATION BETWEEN DEPTH AND VERTICAL TRAVEL TIMES

Geophysical Section, Bureau of Mineral Resources, Geology and Geophysics. G 63-5

TABLE 1.

Drill hole or well number	Drill hole depth Oct.1956 (ft.)	Depth to unweathered bedrock (ft.)	Depth to weathered bedrock (ft.)	Depth of water level (ft.)	T.D.S. (p.p.m.)	$\frac{[SO_4]}{[Cl_2 + SO_4 + CO_3]}$	$\frac{[CO_3]}{[Cl_2 + SO_4 + CO_3]}$	Name
1	20	-	55±	16				Slaughter House bore
2	32		65±	18				Brandt's bore
3	107		31±	33	318	0.10	0.76 V	Hermansburg Mission bore
4	118		36±	20				Wurst's bore
5	24	67	60	21	321	0.06	0.80 V	Army bore "J"
6	38		48±		835	0.05	0.65 V	South Side Motors bore
7	19		60±	18				G. Galotta's bore
8	35		63±	32				J. Weir's No.1 well
9	28		71±	24	425	0.12	0.58 V	J. Weir's No.2 well
10	70-56		37±	28	334	0.05	0.78 V	S. Vale Poultry Farm
11	50		23±	23				De Brenny bore
12	17		37±	13				G.A. Smith bore
13	See footnote		30±		2538	0.20	0.44 V	Tyler's No.2 well
14	18		30 - 34	11±	277	0.06	0.65 V	Tyler's No.3 well
15	22			13	314			Pick's Todd R. well
16	22	45	24±	18	5927	0.30	0.12 V	Gap Gate Bore
17	105	72?	32?	50-70	2364	0.27	0.18	Connellans Hangar bore
18	84			60	678			Carmichael's Stock Route.
19	28	71	56	16	1609		0.56	Army bore Ra (bore
20	50		75±	33	1728	0.27	0.22 V	D.Miller Residential bore
21				18	140			Buck's Well
22	26		47±	21				F.W. Johnson bore
23	48			25	746			Army bore E22
24	71	93?	43	32	7837	0.32	0.05	Army bore Connellans
25	69		70±	22	454	0.15	0.55 V	Bore x
26	30±				358	0.09	0.61 V	Near Bore x

Footnote: Tyler's No.2 Well (drill hole or well number 13) probably yields only seepage water.



EXAMPLE: Sample A contains 50% calcium, 20% magnesium and 30% sodium.

Sample B contains 20% chlorides, 40% carbonates and 40% sulphates.

Fig. D1. SALT COMPOSITION OF BORE WATER IN THE ALICE SPRINGS AREA, N.T.

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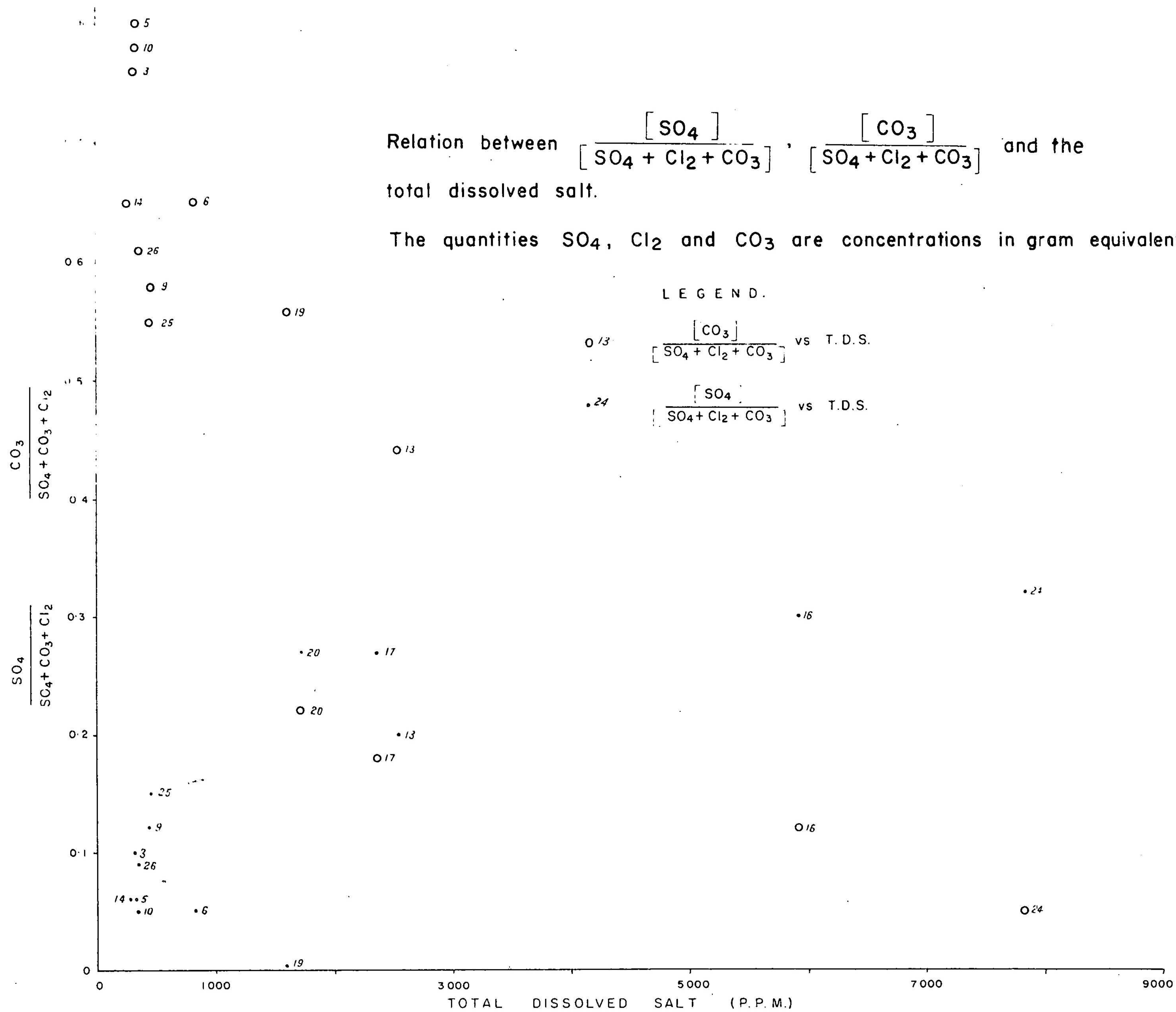
Fig. D2.

Relation between $\frac{[SO_4]}{[SO_4 + Cl_2 + CO_3]}$, $\frac{[CO_3]}{[SO_4 + Cl_2 + CO_3]}$ and the total dissolved salt.

The quantities SO_4, Cl_2 and CO_3 are concentrations in gram equivalent.



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Along traverse B, the resistivity values rise steeply near, and within, the bed of the Todd River. As the bedrock crops out east of the Todd River, this increase in resistivity is adequately explained by shallow bedrock and fresh-water pore solutions.

West of the intersection of traverses A and B, the resistivity profile shows little character except for a small minimum at station B350W.

Detailed seismic and resistivity determinations were conducted at stations A4050N and A5550N and a normal refraction spread was made from A4450N to A5350N. At 4050N, the average resistivity of the material overlying unweathered bedrock (at 75 ft. depth from seismic determination) is about 5 ohm-metres. At A5550N, the average resistivity is 18 ohm-metres to a depth slightly greater than the seismic result of 62 ft to 12,500 ft/sec. (weathered) bedrock. Unweathered bedrock was not recorded.

Conditions at A4050N are unfavourable for the possible supply of potable water. At A5550N it is probable that an aquifer between 31 ft. (top of the 5000 ft/sec. material) and bedrock will yield potable water.

At the intersection of traverses A and C (A4550N), seismic data indicate a depth of about 70 ft. to unweathered bedrock of 16,000 ft/sec. velocity.

The resistivity profiles along Traverse A show a marked increase in resistivity from A4700 N to A6200 N for all three electrode spacings.

Along Traverse C, there is a gradual increase in resistivity eastwards from C600E to a maximum value extending from the river bed and across the intermittently flooded zone to the east, beyond which there is a sudden drop in resistivity. As the average depth to unweathered bedrock increases from 50 ft.(approximately) at C1300E to 65 ft. at C2500E, the higher resistivity values are attributed either to a decrease in porosity or a decrease in the salinity of the pore solutions or both.

At C1200E a resistivity value of 25 ohm-metres and at C1150E a seismic velocity of 5000 ft/sec are indicated to a depth of approximately 60 ft. (drilling, B.M.R. No.2, indicated weathered bedrock at 60 ft.) and at C2200 E an average resistivity of 45 ohm-metres is indicated to a depth of 55± ft. Should suitable water-bearing beds of sufficient permeability be present a high quality water supply would be available.

East of the area which is intermittently flooded (C2600E), the bedrock rises abruptly to 40± ft. below the surface, but the resistivity decreases sharply, to a greater extent with 100-ft. electrode spacing than with 200-ft. spacing. This probably indicates a relatively greater proportion of clays (with higher porosities) and associated higher salinity pore solutions.

West of C00, the 100-ft. spacing resistivity profile shows a relatively high value near C1100W and a general increase to the west of C3000W; the profile for 200-ft. spacing shows little change to C3000W, west of which increased values are indicated. The general character is similar to that along traverse D and is referred to later in relation to the resistivity contour plan.

There is a marked contrast between the character of the resistivity probe curves at C400W and C1100W; the former indicates a low resistivity layer (5 ohm-metres) between approximately 30 and 70 ft., whereas the latter shows a high resistivity layer of 25 ohm-metres from near the surface to high resistivity rock (unweathered bedrock). Seismic investigation at C1100W indicates a 4800 ft/sec layer from 26 ft. to 53 ft., underlain by bedrock, but the velocity of the rock at 53ft. (14500 ft/sec.) indicates that it may be weathered. Near this point, the resistivity for 100-ft. spacing is relatively high compared with the small variation in the profile for 200-ft. spacing, and the depth probe indicates a 25 ohm-metre layer between 26 and 54 feet which may offer excellent possibilities for potable water if suitable water bearing beds are present.

At the intersection of Traverse D with Traverse A (A6300N) the depth to unweathered bedrock as indicated by the seismic data is 80 ft.

Along Traverse D, east from the intersection with Traverse A (D00), there is a gradual increase in resistivity to D1000E, beyond which the values increase more rapidly, the maximum values being near D1800E, which is on the west bank of the Todd River. The 200-ft. spacing profile shows a prominent maximum within the area of generally high resistivity values; this may be due to a bedrock feature.

Although no seismic data are available, the resistivity values at D1400E indicate unweathered bedrock at a depth of about 80 ft. and show the over-lying section to have a resistivity of approximately 35 ohm-metres. At D2100E (in the river bed) an average resistivity of 35 ohm-metres or greater extends to a depth of about 40 ft. (two-layer curve interpretation). This indicates the presence of potable water and available water would depend upon the presence of a suitable water-yielding bed within the sediments.

The generally high resistivity values which extend to D2600E are attributed to the combined effect of relatively shallow bedrock (40 to 50 ft.), lower porosity (unsorted river gravels), and low-salinity pore solutions. The sharp decline in resistivity beyond D2600E is considered to be due mainly to more saline water, although a slight increase in the depth to bedrock over the section to D3000E and an increase in porosity may be contributing factors. Conditions at D3350E, where bedrock is at a depth of 31 ft. and the overlying material has a resistivity of 8 ohm-metres, verify the predominating saline effect.

High resistivity values within and near the Todd River are common to both Traverses C and D, but the higher values on Traverse D indicate the effect of the shallower bedrock compared with the conditions along Traverse C.

A depth probe at D500E indicates relatively unweathered bedrock at 61 ft., the resistivity of the overlying material being approximately 21 ohm-metres. A Bureau test drill hole (B.M.R. No.4) near this point shows weathered bedrock at 46 ft. Any suitable water-yielding bed in this area will probably supply potable water.

West of Traverse A, a high resistivity feature is indicated by the 100-ft. spacing profile near D900W; this feature occurs also on the 200-ft. spacing profile as a less prominent but broader zone. Resistivity values increase gradually west of D3200W.

A depth probe at D900W indicates very high resistivity values of the order of 100 ohm-metres over the section which has a seismic velocity of 5000 ft/sec. (that is from 26 to 50 ft.). A drill hole at this point (B.M.R. No.8) shows weathered bedrock at 54 ft. Between 60 ft. and 185 ft. depth, the resistivity is 26 ohm-metres; this is associated with a bedrock velocity of 12,500 ft/sec. This feature is similar to that at C1100W. The low porosity of the 12,500 ft/sec. material and the high salinity of pore solutions which may be expected in a somewhat weathered material below the zone of flushing may well continue to give a resistivity of the order of 25 ohm-metres. Should the porosity be of the order of 10 per cent, the salinity would be 3,500± p.p.m.

At D3350W, bedrock of seismic velocity 14,000 ft/sec. occurs at 29 ft. and at D3400W a resistivity discontinuity is indicated at 44 ft., above which a value of 5 ohm-metres is indicative of very saline conditions.

The 100-ft. spacing resistivity curve from A6200N to A8800N shows little character; north of A8800N the resistivity increases, with a sharp maximum at A9100N. The 200-ft. spacing indicates a slight average increase north from A8000N; this is also indicated in the 300-ft. spacing, although the values are rather irregular north of A7000N.

The two histograms within this section, representing the characteristics of the sediments at A7400N and A8400N, do not indicate favourable conditions for a suitable water supply; this is particularly so of the histogram for A8400N. Should a permeable bed with freely-moving water exist within the upper section of the water-saturated sediments at A7400N, potable water should be available. The value of 16 ohm-metres is near the lower limit of potable water. If the porosity over a certain depth should be slightly greater than average, or the fixed waters within the clay sediments and within the closed sections (that is below the zone of flushing) be more saline than the free water, then water from a suitable bed would be potable. The drill hole (B.M.R. No.5) at A7300N indicates favourable conditions for a suitable water supply between 33 and 43 ft.

The values on the 100-ft. resistivity profile east of F1600E along Traverse F, appear to be too low when compared with the 100-ft. spacing resistivity values at the depth probe position (F2100E) and with values along Traverse G, and have not been considered in the assessment of the probable ground conditions in this area.

From F00 (A8150N) to F1000E, conditions may be represented by the probe curve for F750E which is of similar form to that for A7400N below 8 ft., and previous remarks concerning the probe at A7400N apply equally to F750E. East of F1000E, there is a gradual increase in resistivity to F1600E, followed by a much more rapid increase.

The probe at F2100E (intersection of Traverses F and G in the river bed) indicates high resistivity values (37 to 49 ohm-metres) to a depth of 50± ft. Seismic determinations along Traverse G indicate bedrock to be at 41 ft. at this point, and the high resistivity values are attributed to the shallower bedrock, lower porosity and fresher pore solutions.

A seismic refraction survey and resistivity traversing were carried out along the whole length of Traverse G, which is within the river bed and intersects Traverse F at G600N. Resistivity probes at F2100E (G600N), G1400N and G1800N indicate high resistivity values overlying the bedrock, and thus favourable conditions for the supply of potable water. This may be expected in the river bed where the salinity conditions should remain relatively constant as the seismic survey indicated no sharp depressions in the bedrock.

The 100-ft. and 200-ft. resistivity profiles along Traverse G are in close agreement with each other, but do not conform with what may be expected from the unweathered bedrock profile. The cause of the disagreement may be due to:-

(a) Changes in facies within the zone overlying the unweathered bedrock and variations in the thickness of the weathered rock. These are indicated by variations in the seismic velocities within the unconsolidated material. The higher resisticity values are attributed to unsorted material, mainly gravels and coarse sands, and the lower values (also lower seismic velocities) to clays and silts.

(b) Variations in the resistivity values of the bedrock. These usually coincide with variations in the seismic velocities.

The 100-ft. spacing resistivity profile along Traverse H (which intersects Traverse G at G2000N) shows rapid variations across the river bed. These may be attributed to the above and also to probable variations in the depth to bedrock, which crops out near the western bank of the river and at no great distance from the eastern bank.

Traverse E extends north-westerly from A9150N. The 100-ft. spacing resistivity profile indicates relatively high resistivity values over the sections E00± 100 ft. and E1100W ± 300 ft.; these high values are not apparent on the profile for 200-ft. spacing. This may be due to a decrease in the porosity of the sediments overlying the bedrock, as indicated by the geological log of the Bureau drill hole (No.3) at E1300W, or to zones of less saline water within these sections. The seismic investigations at E1300W are not conclusive, as the velocity of 6,500 ft/sec. is only vaguely indicated and may not be precise. The resistivity depth probe at this point may also be interpreted in two different ways, one indicating a low resistivity value (8.5 ohm-metres) from 7 ft. to a depth of 46 ft. (drilling indicated weathered bedrock at 44 ft.) and the other a relatively high value (20 ohm-metres) to 76 ft. underlying a 6.7 ohm-metre layer from 12 ft. to 28ft.

A depth probe at E2000W indicates an average resistivity value of 13 ohm-metres between 13 and 54 ft. (which would include at least part of the saturated zone); this value indicates water too saline to be potable.

There is a general increase in resistivity north-west of E2200W on the profile for 200-ft. spacing and north-west of E2500W on the profile for 100-ft. spacing (the sharp maximum peaks on the 200-ft. profile are considered to be due to poor ground contacts). The general increase in values is attributed to a general decrease in the depth to bedrock. Investigations at E2800W, at which point there is a depression in the generally increasing 100-ft. resistivity profile, indicate rather weathered bedrock (13,000± ft/sec.) at 60 ft. The overlying material has a resistivity of 15± ohm-metres which (assuming an average porosity of 30 per cent within the zone of saturation) indicates pore solutions slightly too saline to be potable.

A resistivity depth probe at Tyler's (see Plate 2) indicates high resistivity values within the zone of saturation (to a depth of 40± ft), underlain by low resistivity material to 60± ft; below this depth high resistivity rock is indicated. A drill hole (B.M.R. No.7) at this point indicates weathered schists (bedrock) at 34 ft. The low resistivity values may therefore be attributed to saline solutions in the weathered bedrock.

Plates 6 and 7 present contour plans of the 100-ft. and 200-ft. spacing resistivity respectively, prepared from the profiles shown on Plates 3 and 4. The traverses are too widely spaced for precise contouring but certain trends are indicated. These include the major high-resistivity zone along and near the Todd River and an elongated pattern of alternating minor highs and lows which extends from Traverse B to beyond Traverse D, west of Traverse A, changing direction to intersect Traverse A between Traverses D and F. The minor highs associated with this pattern, particularly on the 100ft. spacing plan, are considered to be significant in respect to underground water development.

Comparison of Plates 6 and 7 with Plate 8, which is a contour plan of the unweathered bedrock prepared from seismic data, reveals how this pattern of minor features is parallel to, and on the western edge of, the deepest section to bedrock within the Basin Area. The seismic control for the unweathered bedrock plan is sparse but the main features on the plan conform approximately with those indicated on the bedrock (weathered) contour plans of Jones (1957) and Owen (1954).

The depth probes conducted at C1100 W and D900W are within the minor resistivity high on the 100-foot spacing plan.

This geophysical pattern of minor resistivity highs may be expected from a buried river course which consists of unsorted coarse sands and gravels. Such sediments would provide an excellent source of water as the northern section indicates a probable underground junction with the present course of the Todd River and recharge waters should be available.

C. <u>CONCLUSIONS AND RECOMMENDATIONS.</u>

The geophysical results do not supply precise information concerning the level of the water table and the surface of the weathered bedrock, and it is therefore impossible to estimate the volume of the water-bearing sediments. The lateral limits of an economic supply of potable water can be indicated only approximately. To determine available water, porosity and permeability values must be known. Both are dependent upon the lithological character of the basin sediments.

In the last paragraph of the chapter on "Methods", the geophysical requirements for potable water within sediments were set out. Based on these requirements and considering the depth but not the lithology of the sediments, the area within which test drilling for suitable water should be conducted is shown on the contour map of unweathered bedrock (Plate 8).

It is considered that the elongated zone extending through C1000±W, D1000±W, A7500±N and Traverse F probably represents an old river bed. It is probable that this bed is connected with the present course of the Todd River and therefore deserves special attention. The Army Town Supply Well and the new Bent Tree Well are situated within or near this zone.

Another favourable area is indicated on Traverse C near station C2400E.

Some general observations include:-

In the deeper sections of the basin, the resistivity results, which in the main give only average values over the water-bearing sections, indicate saline conditions. Where unweathered bedrock occurs at shallower depths and a relatively greater proportion of the water-bearing section is subject to flushing, resistivity results indicate potable water.

The resistivity depth probes at Heavitree Gap indicate the presence of fresh water within the sediments. Fresh water flows over the rock bar at Heavitree Gap, whereas the more saline water remains in the basin, as indicated by the difference between the resistivity values within the water-saturated sections at A1350N (shallowest depth to bedrock) and A1800N.

The construction of a "Mexican" Dam, with consequent raising of the level of discharge, might diminish the flushing out of the basin during the wet season, and on a long term basis the salting up of the Basin would be accelerated, resulting in a rise in the level at which saline conditions may be expected.

5. THE BUNGALOW AREA.

A. Geology and Hydrology.

The Todd river valley north of the junction with the Charles River consists of alluvial deposits overlying a bedrock of Archaeozoic gneisses and schists.

The Todd River Well in the bed of the Todd River (near J00 on Plate 9), a small distance upstream from the junction with the Charles River, yields good quality water.

B. Results.

The traverse plan, Plate 9, indicates that the greater part of the survey in the Bungalow area was confined to the river bed. The methods employed included constant-spacing resistivity traversing (100-ft. and 200-ft. electrode spacing) and the seismic refraction technique, the results of which are presented on Plate 10.

There is good correlation between the 100-ft. and 200-ft. spacing profiles except between J00 and J400S, where the relatively high readings on the profile for 100-ft. spacing may be attributed to the disturbance of surface and near-surface river gravels during the construction of the new Todd Well.

The resistivity profiles have a similar pattern to the bedrock profile indicated by the seismic survey; small deviations in the resistivity profiles may in most instances be attributed to variations in the physical characteristics of the bedrock, as revealed by the seismic velocities.

The principal feature of the seismic profile is the change in the average R.L. of the unweathered bedrock (of the order of 30 feet) between stations 1400N and 2200N along traverse J.

Plate 11, a contour map of the unweathered bedrock, indicates no closed section within the valley, i.e. there are no bedrock bars across the valley. The form of the resistivity profiles indicates uniform resistivity conditions, and consequently uniform porosity and salinity, overlying the bedrock. This may be expected within river sediments subject to periodic flushing.

The contour plan also indicates that the greatest depth to bedrock is west of the present Todd River Well, i.e. underlying the west bank of the river.

Two resistivity depth probes, at J2000N and J4500N, contribute little additional information. The plotted points of these depth probes indicate similar features, namely:-

(i) From a depth of 5 feet to 16 feet, the curves are flatter than the theoretical curves, indicating a decrease in resistivity with increasing depth within these limits,

and(ii) a sharp change in the character of the curves at 16 feet, succeeded by only small changes in actual resistivity values to a depth of 32 feet at J2000N, and a little deeper at J4500N, below which high-resistivity material is evident.

Briefly, high resistivity values are indicated at J2000N from a depth less than that to seismically determined unweathered bedrock, and at J4500N a resistivity of about 44 ohm-metres is indicated from 3 feet to 35 feet. Neither probe indicates the presence of saline conditions.

C. <u>Conclusions and recommendations.</u>

The maximum depth to unweathered bedrock occurs at the southern limit of the area and to the west of the present river bed; upstream from J2200N the thickness of the sediments in the valley is relatively small.

As the present Todd River Well is situated in the sediments on the eastern slope of the bedrock valley, drilling investigations for an additional water supply should be made to the west of the present well site.

The contour map of unweathered bedrock should be utilized in any consideration regarding the construction of a Mexican Dam. Such a structure would not affect the quality of water retained, as constituent salts would be removed together with the water taken from the area to supplement the town's requirements.

6. THE FARM AREA.

A. Geology and Hydrology.

Fresh-water sediments which form the basin range from Cretaceous to Quaternary and overlie a basement of Archaeozoic rocks and a continuous sequence of Proterozoic, Cambrian and Lower Ordovician sediments which dip steeply to the south. This sequence, consisting of quartzites, limestones, shales, sandstones, etc., exists south from the Mt.Blatherskite ridge (Heavitree quartzite).

A fault with easterly strike, between Heavitree ridge and Mt.Blatherskite (Plate 12), results in a fault contact obscured by recent sediments, between Archean gneiss and Proterozoic limestone, and causes a repetition of the geological sequence below the Upper Proterozoic shales (Prichard and Quinlan, 1957). Faulting across the regional strike along Mt.Blatherskite ridge is on a bearing of 340± degrees.

In the Farm Area, the static water level north of Mt.Blatherskite Ridge is 30 feet below the surface, and south of Mt.Blatherskite, 50 to 250 feet below the surface, the greater depths being recorded with increasing distance from the Todd River. In many places where the ground water level is deep, the water level in bores often rises 50 ft. or more above the aquifer (Jones, 1957, p. 10), i.e. the water is under pressure and may be classified as sub-artesian.

The salinities, as given by Jones (1957), are less than 1200 p.p.m., except in places where the water is close to or within limestone bedrock, and in the sanitary disposal area.

B. Results.

Plate 13 shows the traverse plan of the area. The investigation consisted of a seismic refraction survey along Traverses PQ, QR and XY and resistivity depth probes at the four sites indicated.

The seismic profiles are shown on Plate 14 together with the corresponding seismic velocities, which range between 800 ft/sec. and 18,000 ft/sec. It may be noted that velocities computed from the normal spreads do not always conform with those computed from weathering spreads. The reason for this may be attributed to:-

(i) Spreads with large geophone spacings lack precise detail of refraction velocities which is obtained from small geophone spacings.

(ii) Lenticular formations, characterized by specific velocities within the sedimentary section, influence the velocity distribution. Depending on the location of the weathering spread and associated shot points, the top boundary of the lenticular structure may be revealed, whereas with greater geophone spacing and different shot point location, such lenticular structures may not be detected or recognized.

(iii) Differences in charge sizes.

No precise geological control is available to interpret the seismic velocities in terms of rock type. For instance, on traverse QR (Plate 14) the 10,000 to 11,000 ft/sec. refractor may represent a sandstone overlying the Archean (15,000 ft/sec.), or it may represent a fractured and/or weathered part of the Archean. In such instances the term "bedrock" loses practical significance.

The principle features in evidence as a result of the seismic survey are as follows:-

(i) Along Traverse PQ there is a marked increase towards the south in the depth to the deepest refractor (13,000± ft/sec.); this is accompanied by a decrease in the velocity of this refractor.

(ii) An abrupt decrease in the depth to the 10,500± ft/sec layer near Q and the relatively small relief in the plotted profile along Traverse QR from Q to 4,400 feet, although the velocity in the refractor ranges between 10,000 and 14,500 ft/sec. The minimum depth is slightly greater than 100 feet and the maximum less than 200 feet.

(iii) At approximately 4,600 ft along Traverse QR there is another abrupt change in depth to the principal refracting layer. This is accompanied by a change in the seismic velocity of the refracting material from about 11,000 to 15,000 ft/sec.

(iv) The shallow high-velocity refractor recorded south-east of 4,600 feet persists to R and a relevant feature over this section is the absence of a distinct velocity layer between the 2,500 to 3,200 ft/sec layer and the basal refractor, except at each end of the section.

(v) Along Traverse XY, from a point near R (600±ft.), the depth to the deepest refracting layer increases both to the north (for a limited distance) and to the south. The sharpest gradient in the plotted refracting profile is between 1,800 and 2,000 ft.

(vi) From 2,000 to 3,700 feet along Traverse XY, the deepest refractor, of 12,000± ft/sec. velocity, is relatively horizontal and at a depth of 260± feet.

(vii) South of 3,700 feet, a depression in the refractor near 4,500 feet is followed by a much greater depression near 5,700 feet, where the refractor is about 650 feet below the surface. Both of these depressions are characterized by a low-velocity refractor, (8,500± ft/sec.)

(viii) Between 5,900 ft. and 6,500 ft. (approximately), there is an abrupt decrease in the depth to the deepest refractor, accompanied by an increase in the velocity of this refractor.

(ix) South of 6,500 ft., at which point the depth to the refractor is 350± ft., there is a slight decrease in the depth of the refractor to point Y.

The interpretation of the resistivity depth probes is shown with the plotted results on Plate 15 and histograms of the depth probes are shown on Plate 16. The multilayer nature of the sediments reduces the interpretation accuracy and discontinuities may be omitted in the matching with the two-layer theoretical curves.

Precise depth control for the resistivity probes is lacking, although sites 1, 2 and 3 are not far from the seismic traverses, along which the approximate depth to basement is known.

In the area north of Mt.Blatherskite, where Jones (1957) states that the upper limit of the ground water is at a depth of 30 ft., seismic investigations indicate a probable basement depth of 190± ft. near Site 1 and 150± ft. near Site 2.

At Site 1, an initial interpretation based on four layers indicates a discontinuity at 56 ft., above which the resistivity value is 45 ohm-metres and below, about 16 ohm-metres. If readings obtained at 125 and 160-ft. spacing are considered as being reliable, a discontinuity exists within the 16 ohm-metre layer at 150± ft., above which the resistivity value would be more than 20 ohm-metres and below less than 16 ohm-metres. Such interpretation would raise the discontinuity at 56 ft. to 40 ft.

At Site 2, the resistivity value of 19 ohm-metres between 22 ft. and 270 ft. is considered to be a minimum possible value.

In this area therefore, the resistivity values indicate that in the upper saturated sedimentary section (where seismic velocities are of the order of 5,000± ft/sec. and the porosity is about 30± per cent) the water will be potable. In the lower sediments, where higher seismic velocities were recorded, it is reasonable to assume that the porosity is lower, in which case the salinity will be greater for the same resistivity value.

At Site 3, near an Animal Industries Research Institute bore and not far from point Y, an initial simplified interpretation indicates a 15 ohm-metre layer between 30 ft. and 320± ft. The divergence of the plotted points from the interpretation curve would indicate that the 15 ohm-metre layer may consist of two principal layers. The upper of these layers will have a value of about 23 ohm-metres to a depth of about 200 ft. and the lower a resistivity of 14± ohm-metres to a depth somewhat less than 320 ft. Available water above the 200 ft. depth would definitely be potable, whereas water below this level would be slightly saline.

C. Conclusions and Recommendations.

In the absence of data concerning the quality of the water, the two main factors which should govern a first selection for areas to be investigated as possible sources of potable water are:-

(i) The depth to which basin sediments are regularly flushed (thus preventing salt accumulation) is determined by the depth at which bars and ridges occur (closure of basin). Salt may accumulate within the sediments below this zone.

(ii) In bore holes located within the zone of flushing and above a deeper part of the basin, underlying saline water may encroach into the fresh water sediments if lateral flow of water is insufficient to maintain hydrostatic equilibrium.

Hence the most favourable places to explore water development are within the zone of flushing, and in the shallower parts of the basin.

Along Traverse PQ, the maximum depth of drilling should be about 100 feet. This figure is chosen because a rock bar near Q (indicated along Traverse QR), if continuous, may result in a partial closure of that section of the basin to the north of this point; the depth of the bar is only slightly greater than 100 feet. Geologically, this bar could represent the upthrown side (Archean complex) of a major thrust fault underlying the sediments and inferred by Prichard and Quinlan (1957). It is considered that the major fault zone (with subsequent weathering in the zone of fracturing) and limestone bedrock north of the fault may result in saline water within the sediments below the zone of flushing. Initial testing is recommended between stations 00 and 1,000 feet and possibly between 2,000 feet and 2,100 feet approximately.

Along Traverse QR, the abrupt feature underlying the sediments near the station at 4,600 feet may be attributed to faulting on a bearing of $340\pm^{o}$ across the regional strike of the country (Prichard and Quinlan, 1957). This feature could contribute towards the partial closure of the basin, but the resistivity probes at sites 1 and 2 do not indicate excessive saline conditions down to the lowest refractor. It may be concluded therefore, that the shallow structure near station 4,600 feet is not a major obstacle to water flowing through the sediments.

From the point Q to the probable fault at approximately 4,600 feet, potable water could be available within the river bed at a depth of 20± ft; the lower limit of potable water cannot be estimated from resistivity values as the porosities of the deeper, more consolidated sediments are unknown.

South-east of the fault, between 4,600 feet and point R, the average depth of the sediments is too small to warrant further investigation for a water supply.

From the evidence obtained near point R on Traverse XY, it appears that the section of the traverse between the fault and point R is situated over a buried ridge which separates the sediments to the north from those to the south. This evidence, together with the aerial photographs, indicates that the buried ridge is part of the faulted and broken section of the Mt.Blatherskite Range (Jones, 1957) (see Plate 12).

The average seismic velocity of 5,300 ft/sec. along that part of Traverse XY north of this ridge may indicate the presence of water-bearing sediments. South of R, the thickness of the sediments with velocities less than 4,000 ft/sec. (generally considered as unconsolidated and non-saturated or poor aquifers) increases towards the south. Between the stations at 1,000 and 3,000 feet, layers with 5,000± and 7,000± ft/sec. velocity underlie low-velocity sediments. Both these layers are probably saturated sediments, the higher velocity indicating more consolidated sediments. The steep gradient of the profile of the lowest refractor between 1800 and 2,000 ft. and the change in seismic velocity within the refracting layer from about 10,000 to 12,000 ft/sec. may indicate the continuation of the concealed fault revealed along Traverse PQ at 4,600 ft. South from 3,000 feet to point Y, only the average velocity of the sedimentary section (i.e. the sediments overlying the lowest refractor) was determined. As this value is similar to the average values between 1,000 and 3,000 feet, it indicates a similar section of sedimentary layers.

The part of the traverse between 3,800 and 6,600 feet is characterized by a depression up to 650 feet deep in the lowest refractor. This would favour the accumulation of saline waters and, as evidence exists that water in this area rises in bores after penetration of aquifers, care must be exercised not to develop this section to too great a depth otherwise contamination of overlying aquifers containing potable water may occur (see Walker, quoted by Parker, 1955, p.630). By drilling to a maximum depth of about 250 feet on either side of this part of the traverse, with suitably situated pilot bores to check possible encroachment of saline waters, a plentiful supply of water should be available.

7. ACKNOWLEDGEMENTS

It is desired to acknowledge the co-operation and assistance of:-

The Resident Geologist and staff, the staffs of the Animal Industry Division and the Lands and Survey Section, both of the Northern Territory Administration, and the District Works Officer and staff of the Department of Works.

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APPENDIX A

APPLICATION OF RESISTIVITY METHODS TO HYDROLOGICAL PROBLEMS

The simplicity and rapidity of obtaining resistivity observations favours the use of resistivity methods in solving hydrological problems. The establishment of the relations between resistivity, salinity and porosity gives an indication of the manner of application of these methods.

Wiebenga (1955) developed approximate empirical equations for resistivities of solutions of NaCl and $CaCO_3$ viz.,

$$\log \rho + \log S = 4.58 \quad \text{for NaCl} \quad \ldots\ldots(1)$$

$$\log \rho + \log S = 4.60 \quad \text{for } CaCO_3 \text{ i.e. } [Ca(HCO_3)_2] \text{ in solution} \quad \ldots(2)$$

where ρ is the resistivity in ohm-cm,

and S is the concentration of solute in grains per gallon

The important feature of these two equations is that they are practically identical, and therefore no great error is introduced if total dissolved salt content (T.D.S.) is substituted for concentration of solute. This gives:-

$$\log \rho + \log T = \text{constant} \quad \ldots\ldots(3)$$

where T is the T.D.S. in parts per million. That is, there is a direct relation between resistivity and salinity.

Heiland (1946) developed equations which describe the relations between the resistivity of an aggregate ρx, the resistivity of the pore solution ρ_1 and the pore volume V_1. The equations are approximate only and it is assumed that the pores are completely filled with pore solution.

$$\log \frac{\rho x}{\rho_1} = \log (3-V_1)/2V_1 \quad \text{for high porosity} \quad \ldots\ldots(4)$$

$$\log \frac{\rho x}{\rho_1} = \log 3/V_1 \quad \text{for porosities lower than 25 per cent} \quad \ldots\ldots(5)$$

From these expressions an approximate equation can be derived which will be applicable to both high and low porosity ranges, viz.,

$$\log \frac{\rho x}{\rho_1} = 1.25 \log V_1 \quad \ldots\ldots(6)$$

In the Alice Springs Basin Area the resistivities of samples of well and bore waters were measured using a mud cell and a Megger earth tester. These were reduced to resistivities at 20°C by use of the formula:-

$$\log \rho 20 = \log \rho t - \frac{2}{3}\left(\frac{20-t}{100}\right) \quad \ldots\ldots(7)$$

where ρt is the resistivity in ohm-metres at t°C

and $\rho 20$ is the resistivity in ohm-metres at 20°C

Formula (7) may be deduced from international tables for $0 < t < 100$. The corresponding values of T.D.S. were obtained from the Animal Industries Division of the Northern Territory Administration. A statistical analysis of these data gave two regression equations for the relation between resistivity and T.D.S., viz.,

$$\log T + 0.92 \log \rho = 3.68 \qquad \text{..............(8)}$$

$$\log \rho + 1.01 \log T = 3.80 \qquad \text{..............(9)}$$

where T is the T.D.S. in parts per million

and ρ is the resistivity in ohm-metres.

The standard error in log T is 0.032 and in log S, 0.034. Equation (8) gives the regression curve for 100 per cent porosity, so by applying equation (6) a nomogram (Fig. A1) can be constructed for different porosities.

The nomogram of Figure A1 has two applications which show the uses of resistivity methods in hydrological problems.

1. A rapid estimate of the T.D.S. value of a water sample can be made by measuring its resistivity, applying equation (7) and reading the corresponding T.D.S. value from the plot of equation (8) in Figure A1.
2. In interpretation of resistivity depth probes. If an estimate can be made of the porosity of a particular resistivity layer, then by using Figure A1, a corresponding estimate can be made of the T.D.S. of the pore solution.

These two applications give a direct and an indirect method of determining the salinity of subsurface waters.

APPENDIX B.

THE MULTILAYER PROBLEM IN THE SEISMIC REFRACTION TECHNIQUE

In order that the depths to a succession of parallel beds can be determined by the seismic refraction technique, each bed must transmit seismic energy at a higher velocity than the bed immediately overlying it.

When, in a sedimentary sequence with energy-refracting interfaces, refractions are obtained from the (n+1)th bed, the thickness of the nth bed may be determined from the following relation (Nettleton, 1940):

$$Zn = \frac{1}{2}\left(Tn+1 - \sum_{1}^{n-1} \frac{2\ Zm}{Vm,n+1}\right) Vn,\ n+1$$

where Zn is the thickness of the nth bed, Tn+1 is the value at which a straight line of slope $\frac{1}{Vn+1}$ intercepts the T axis of the time-distance curve (x=o)

Zm is the thickness of bed m, where m is an integer in the sequence 1 to n-1.

$$Vm,n+1 = \frac{Vn+1\ \ Vm}{\sqrt{Vn+1^2 - Vm^2}}$$

is a "conversion factor" dependent upon the seismic velocities within layers m and n+1. The value Vm,n+1 is obtained from a nomogram.

For the special case of m=n, Vn,n+1 represents the "apparent velocity" of seismic energy within bed n in relation to the velocity within the refractor n+1.

When using the Method of Differences it is normal to obtain at each geophone placing (a distance x from the shot-point) an average vertical time depth to the deepest refractor. By using the data and the intercept method for determining the thickness of individual beds at each end of the spread, an average conversion factor for the sequence of beds to the refracting layer may thus be obtained $\left(\sum_{1}^{n} Zm/TD\right)$. Provided the relative sequence of beds is uniform along the length of the spread, the product of this factor and the time depth at each geophone placing will give the profile of the refracting surface.

APPENDIX C.

INVESTIGATIONS BY DRILLING

Several holes drilled within the Basin Area by the Bureau's Reflection Seismic Party, using a Failing 750 Rotary Drill, were logged by staff of the Resident Geologist, Alice Springs. A copy of the logs (hereunder) indicates the variations in the lithology within the Basin Area. The logging was done by examining the rock fragments returned to the surface by the drilling fluids. This procedure is not considered to be accurate as regards depth measurements.

Geophysical Test Bores, Town Basin.

No.1 Traverse A, 50 ft. south of intersection with Traverse B.

(i.e. Traverse A, 2,600 ft.)

Feet	
0 - 3	Sand
3 -30	Sandy clay with scattered pebbles.
30 -33	Very coarse sand; small sub-angular pebbles.
33 -38	Coarse sand with some clay.
38 -43½	Pebbly sand with some clay bands.
43½	Total depth

Standing water level 9 ft. 6 ins (from surface).

Hole abandoned because of blockage at 34 feet.

No.2 Traverse C, 1200 ft. E.

Feet	
0 - 2	Soil.
2 -17	Fine sand with sparse coarser grains and small pebbles.
17 -18½	Brown sandy clay.
18½ -20	Coarse sand.
20 -30	Blue-grey sandy clay.
30 -43½	Coarse sand with pebbles, becoming coarser at base.
43½ -57	Very coarse pebbly sand, finer and coarser bands alternating.
57 -59	Fine and medium sand.
59 -60	Medium and coarse sand.
60	Bedrock, weathered.

Hole filled in.

No. 3 Traverse E, 1300 ft. peg.

Feet	
0 - 2	Soil.
2 -16	Medium-fine sand with clay matrix.
16 -21	Brown sandy clay.
21 -22½	Fine sand and clay.
22½-35	Clay with thin sandy bands.
35 -38	Sandy clay.
38 -42	Coarse sand with small pebbles.
42 -43	Coarse sand and clay.
43 -43½	Medium sand.
43½-47	Weathered schist.
43½	Bedrock, weathered.
	Standing water level, 32 ft. 9 ins. (from surface).

No. 4 Traverse D, 500 ft E.

Feet	
0 - 3	Soil.
3 - 6	Brown clayey sand.
6 -12	Clay and sand in alternating layers.
12 -18	Clayey sand with a few pebbles.
18 -20	Sandy clay.
20 -22½	Medium to coarse sand.
22½-24½	Fine sand and clay.
24½-33	Clay (sandy in part).
33 -43½	Clay.
43½-44	Clayey sand.
44 -46	Sand and clay.
46	Bedrock, weathered.
	Standing water level, 20 ft. 4 ins.

No.5 **Traverse A, 7300 ft.**

Feet

0	- 3	Soil.
3	- 12	Fine sand and clay.
12	- 20	Coarse sand.
20	- 28	Clay
28	- 33	Sand, very coarse to medium.
33	- 43½	Very coarse sand with small pebbles.
43½	- 54	Pebble gravel with some clay bands near base.
54	- 57	Fine and medium sand.
57	- 60	Coarse gravelly sand and clay bands.
60	- 65	Coarse sand.
65		Bedrock, weathered.
		Standing water level, 25 ft. 3 ins.

No. 6 **20 ft. E of No. 1, 2 ft. lower.** (i.e. Traverse A, 2600 ft.)

Feet

0	- 9	Soil and fine sand.
9	- 12	Green clay and medium-coarse sand.
12	- 15	Fine sand.
15	- 19	Medium-coarse sand, green clay.
19	- 25	Sand and green clay.
25	- 29	Green clay with some sand.
29	- 33	Very coarse brown sand.
33	- 38	Gravel.
38	- 43½	Clay and gravel.
43½	- 45	Coarse gravel (¾" diameter).
45	- 53	Weathered schist
45		Bedrock, weathered

No.7 **'Tylers'**

Feet

0	- 3	Soil
3	- 22½	Medium-very coarse sand with some gravel.
22½	- 28	Very coarse sand with pebbles.

No.7 (Contd).

Feet

28	- 31	Medium-coarse sand.
31	- 33	Very coarse gravelly red sand with some clay at base.
33	- 34	Medium sand.
34	- 37	Weathered schist.
34		Bedrock, weathered.
		Standing water level, 11 ft. 3 ins.

No.8 Traverse D, 900 ft. W.

Feet

0	- 3	Soil.
3	- 26	Coarse sand and gravel.
26	- 30	Medium sand.
30	- 41	Coarse sand and gravel with occasional seams of green clay.
41	- 43½	Coarse sand with much brown clay.
43½	- 53	Coarse and very coarse sand.
53	- 54	Coarse gravel.
54	- 68	Weathered schist.
54		Bedrock, weathered.

Figure C1 presents the data obtained from down-hole velocity logging conducted in the drill holes listed above and also up-hole times from two drill holes in the Farm Area. The average velocity determined is much lower than those obtained by normal refraction shooting, and, if used for depth computations, would give depths much shallower than those recorded by drilling at specific points.

As the holes are within unconsolidated sediments for the whole or the major part of the total depth, it is reasonable to assume that the drilling has disturbed the beds in the neighbourhood of the hole. Considering the relatively small depths concerned, any such disturbance would cause time errors which are a relatively high proportion of the total travel time.

APPENDIX D.

THE SALT COMPOSITION OF BORE WATER IN THE ALICE SPRINGS BASIN AREA.

Chemical analyses of several water samples from bores at Alice Springs were carried out by the Animal Industries Division of the Northern Territory Administration. The results of those analyses were made available to officers of the Bureau. The location of the bores and the name and number of each are shown on Plate 2. In this appendix, a relation is suggested between salt composition, total dissolved salt content (T.D.S.) and the location of the bore in the light of the geophysical results.

The salt composition of the bore water was recomputed in terms of the main salt constituents (SO_4, Cl_2, CO_3, Na_2, Mg and Ca) expressed as milligram equivalents per litre.

The ratios $\frac{[Na_2]}{[Na_2 + Mg]}$, $\frac{[Cl_2]}{[Cl_2 + SO_4]}$, $\frac{[Na_2]}{[Na_2 + Mg + Ca]}$

$\frac{[Mg]}{[Na_2 + Mg + Ca]}$ $\frac{[SO_4]}{[Cl_2 + SO_4 + CO_3]}$ and $\frac{[CO_3]}{[Cl_2 + SO_4 + CO_3]}$

for the considered salts were computed. In the ratios, the symbols in square brackets are the salt concentrations expressed as milligram equivalents.

Part of the available data for each bore is given in Table 1 at the end of this appendix.

The depths of the weathered bedrock are taken from Jones (1957), who used sections compiled from old army drill holes. The bore depths and water levels were obtained from the Resident Geologist. The bore depths are suspect in that, as a result of caving, the measured depths were in several instances much less than the original depths.

Figure D1 is a graphical representation of the salt composition in a form customarily used in this type of work (Spiro, Gramberg and Vovk, 1953). The square shows the relative amount in salt of $[Na_2]$, $[Mg]$, $[Cl_2]$ and $[SO_4]$; the top right triangle gives the relative amounts of $[Na_2]$, $[Mg]$ and $[Ca]$; the bottom left triangle gives the relative amounts of $[Cl_2]$, $[SO_4]$ and $[(HCO_3)_2 + CO_3]$.

The bottom left triangle, indicating the relative amounts of chlorides, sulphates, and carbonates shows an interesting pattern. The five bores, 24, 16, 17, 20 and 13, form a separate group characterised by high chloride and sulphate content, and Table 1 suggests that the water in these bores is obtained from within the weathered bedrock, or from close to the top of the weathered bedrock. Plate 2 shows that bores 24, 16, 17 and 20 are located in the western part of the basin area, some distance from the part which is intermittently flushed out by fresh river water .Bore 13 is located in the south-eastern part of the area, and yields only seepage water. The above evidence suggests that salt from water close to and within the bedrock is rich in chlorides and sulphates, and poor in carbonates. This is confirmed by evidence from bores 25 and 26. Bore 25 is 69 feet deep (Oct.1956), and reaches approximately to bedrock. The water in the bore can be considered as a mixture of water close to or within the bedrock and fresh river water. Bore 26 terminates at shallower depth (about 30 feet), and the near-surface water is brought in by the river. The relative chloride and sulphate content of salt from bore 25 is higher than that in bore 26, and the relative carbonate content in bore 26 is higher than that in bore 25. Bore 19 (see Plate 2) is a similar example.

The original depth was 73 feet, and the bore reached unweathered bedrock; the present depth (Oct.1956), after caving, is 28 feet. Water from the shallower part of the bore contains practically no sulphates, and the salt is relatively rich in carbonates.

Figure D2 is a graph of the ratios $\frac{[SO_4]}{[SO_4 + Cl_2 + CO_3]}$ and $\frac{[CO_3]}{[SO_4 + Cl_2 + CO_3]}$ against the total dissolved salt content or salinity. The figure clearly shows that for low salinites the carbonate content of salt is high and the sulphate content low, and for high salinities the sulphate content is high and the carbonate content low. The only exception is the abovementioned bore 19 in which, with a salinity of 1600 p.p.m., the carbonate content of the salt is too high and the sulphate content too low to conform with the general pattern.

Summarising, it may be said that this investigation suggests that in the Alice Springs Basin Area there are two main types of underground water, and a transitional type, as follows:-

(a) Water of high salinity (more than 1600 p.p.m.) characterised by a relatively high sulphate and chloride eontent. This water is found in bores in the western part of the basin, within or close to the weathered bedrock. Sufficient evidence is available to assume this water to be present in the deeper part of the basin, within or close to the weathered bedrock, where it cannot be flushed out intermittently by fresh river water.

(b) Water of low salinity (less than about 500 p.p.m.) characterised by a relatively high carbonate content. This water is found in the zone which is intermittently flushed out by river water, within the shallower sediments in the central part of the Basin Area, and close to the Todd River.

(c) Water of intermediate salinity (about 500 to 1600 p.p.m.), with relatively low sulphate content, but varying amounts of chloride and carbonate. This water is a mixture of types (a) and (c), and may be expected near the boundary between (a) and (c). In places where drilling and pumping have disturbed the natural conditions, types (a) and (c) probably mix freely, and water which could normally be expected to be of good quality may become contaminated.

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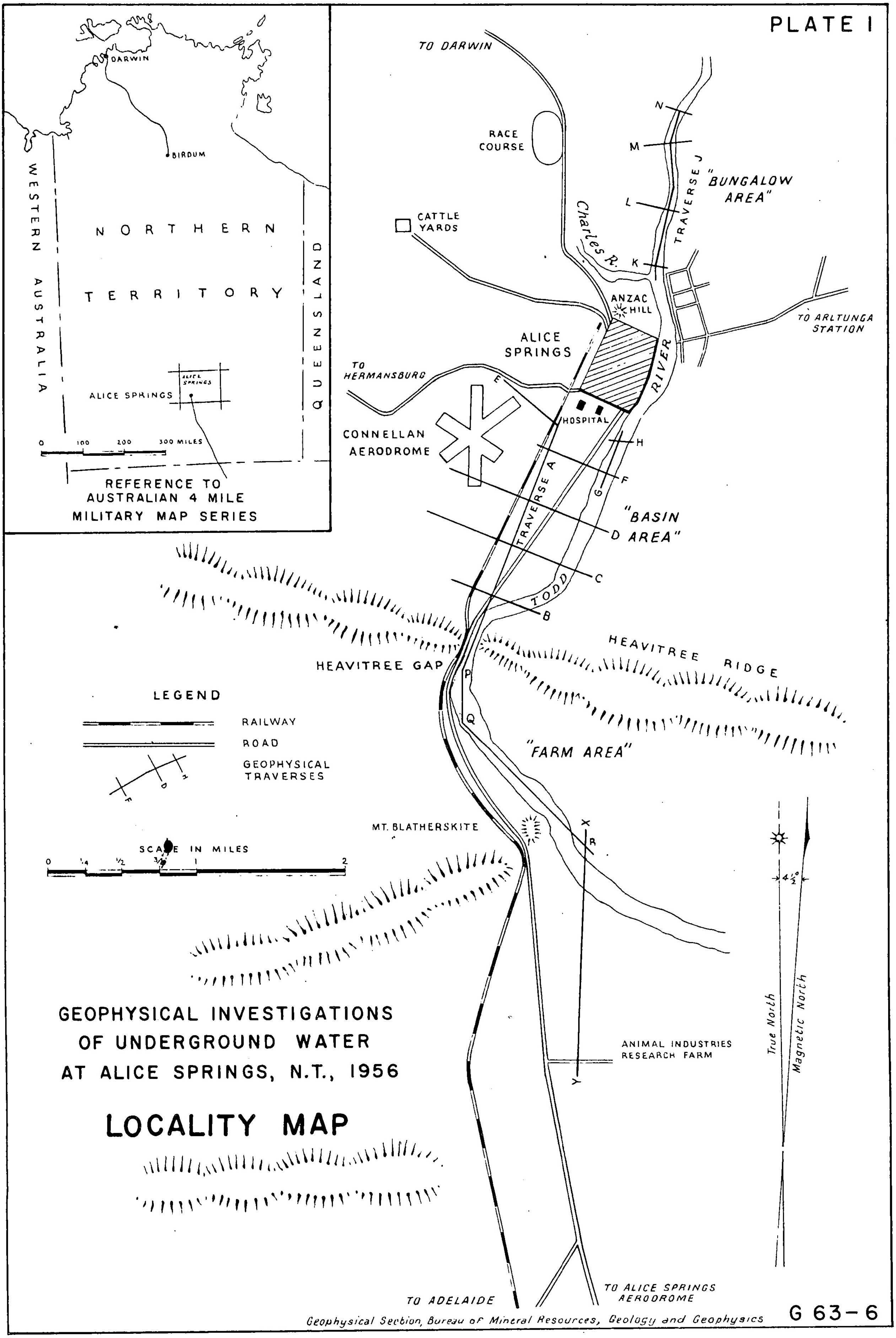
PLATE I



GEOPHYSICAL INVESTIGATIONS OF UNDERGROUND WATER AT ALICE SPRINGS, N.T., 1956

LOCALITY MAP

Geophysical Section, Bureau of Mineral Resources, Geology and Geophysics

G 63-6

PLATE 2

GEOPHYSICAL INVESTIGATIONS OF UNDERGROUND WATER
AT ALICE SPRINGS, N.T.

BASIN AREA TRAVERSE PLAN

GEOPHYSICIST

G 63-7


FT. ABOVE S.L.
SEISMIC VELOCITY FT/SEC
DEPTH
RESISTIVITY OHM-METRES
APPARENT RESISTIVITY IN OHM-METRES
TRAVERSE A'
TRAVERSE A
TRAVERSE B
TRAVERSE C
LEGEND
IRREGULARITY OF SEISMIC PROFILE
(Considered to be caused by surface irregularity)
HISTOGRAMS
SEISMIC DATA
RESISTIVITY DATA
RESISTIVITY INTERPRETION LIMITS
RESISTIVITY PROFILES:
300 FT ELECTRODE SEPARATION
200 FT " "
100 FT " "
2600 SEISMIC VELOCITY IN FT/SEC
4000 AVERAGE SEISMIC VELOCITY IN FT/SEC
GEOPHYSICAL INVESTIGATIONS
OF
UNDERGROUND WATER
AT
ALICE SPRINGS, N.T.
BASIN AREA
SURFACE, RESISTIVITY AND SEISMIC PROFILES
WITH HISTOGRAMS RELATING SEISMIC INVESTIGATIONS
WITH RESISTIVITY DEPTH PROBES
GEOPHYSICAL SECTION BUREAU
OF MINERAL RESOURCES, GEOLOGY
AND GEOPHYSICS
HORIZONTAL SCALE IN FEET
200 0 200 400 600
VERTICAL SCALES
AS SHOWN
GEOPHYSICIST
G63-3A


Ft. ABOVE S.L.
APPARENT RESISTIVITY IN OHMMETRES
SEISMIC VELOCITY FT/SEC
RESISTIVITY OHM-METRES
DEPTH
TRAVERSE D
TRAVERSE E
TRAVERSE F
TRAVERSE G
TRAVERSE H
OBSERVATIONS NOT CONSIDERED RELIABLE
LEGEND
HISTOGRAMS:
SEISMIC DATA
RESISTIVITY DATA
RESISTIVITY INTERPRETATION LIMITS
ALTERNATIVE RESISTIVITY INTERPRETATION LIMITS
RESISTIVITY PROFILES:
200' ELECTRODE SEPARATION
100' " "
SEISMIC VELOCITY IN FT/SEC
3,800
GEOPHYSICAL INVESTIGATIONS
OF
UNDERGROUND WATER
AT
ALICE SPRINGS N.T
BASIN AREA
SURFACE, RESISTIVITY AND SEISMIC PROFILES
WITH HISTOGRAMS RELATING SEISMIC INVESTIGATIONS
WITH RESISTIVITY DEPTH PROBES
GEOPHYSICAL SECTION, BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS.
GEOPHYSICIST
HORIZONTAL SCALE IN FEET
100 0 100 200
VERTICAL SCALES AS SHOWN

GEOPHYSICAL INVESTIGATIONS OF UNDERGROUND WATER AT ALICE SPRINGS, N.T.

BASIN AREA RESISTIVITY DEPTH PROBES

G 63-13

GEOPHYSICAL INVESTIGATIONS OF UNDERGROUND WATER
AT ALICE SPRINGS, N.T.

BASIN AREA RESISTIVITY CONTOURS

100 FOOT ELECTRODE SPACING

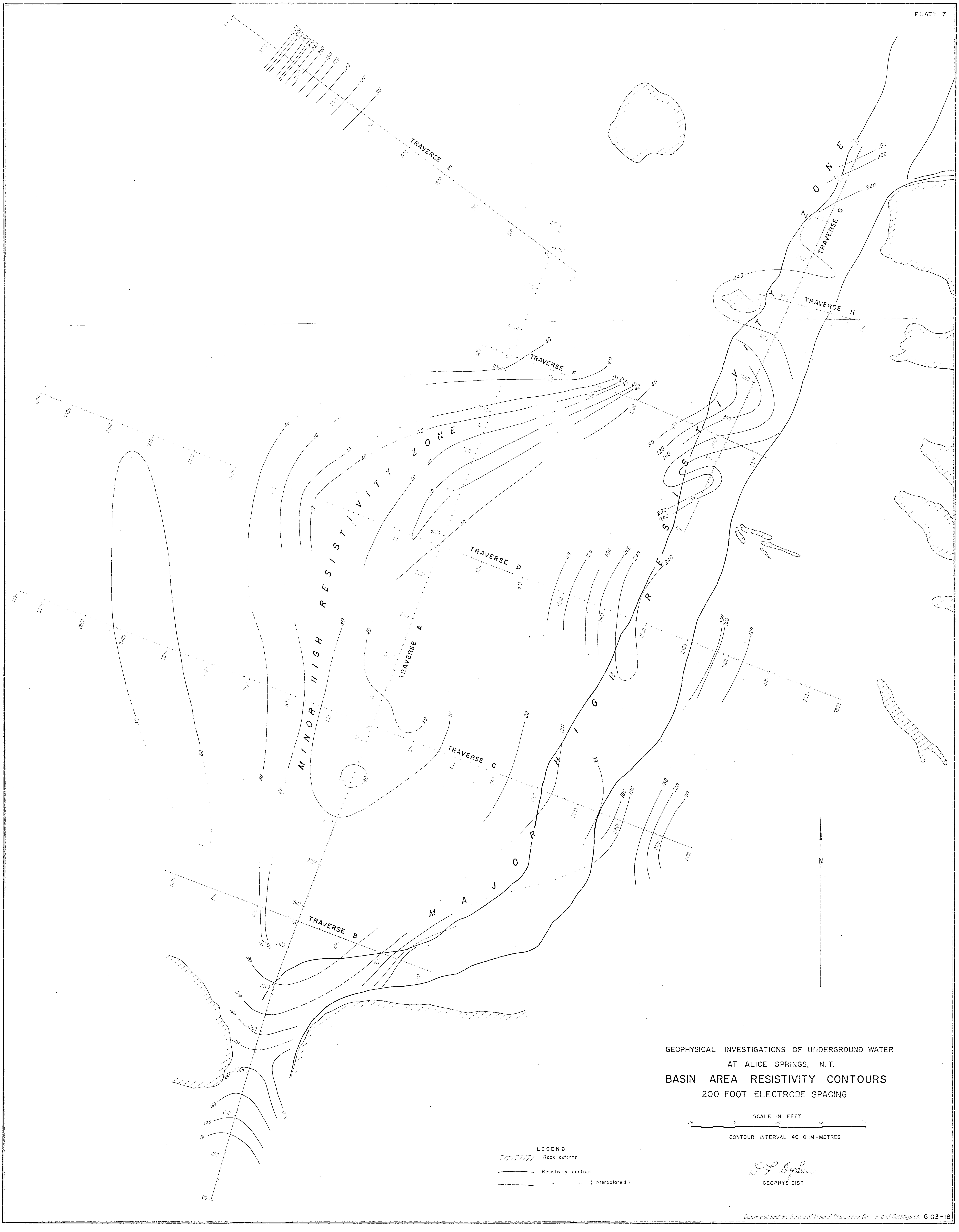
SCALE IN FEET

CONTOUR INTERVAL 20 OHM-METRES

GEOPHYSICIST

G 63-17

PLATE 7



GEOPHYSICAL INVESTIGATIONS OF UNDERGROUND WATER
AT ALICE SPRINGS, N.T.

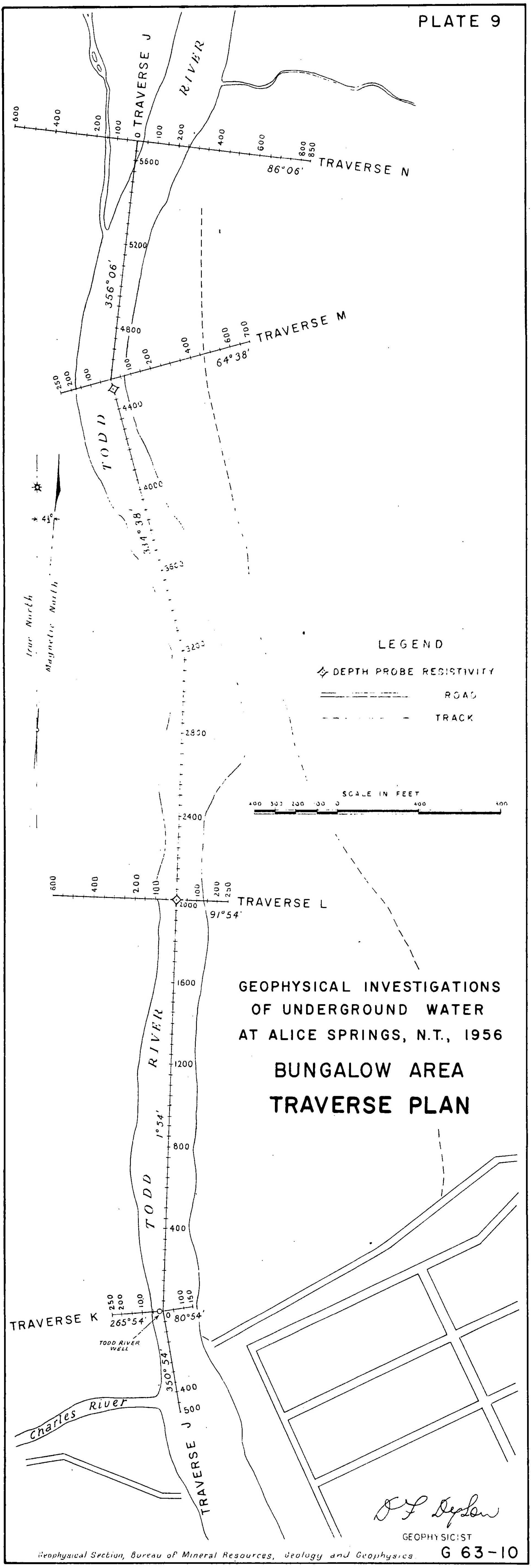
BASIN AREA RESISTIVITY CONTOURS

200 FOOT ELECTRODE SPACING

GEOPHYSICIST

Geophysical Section, Bureau of Mineral Resources, Geology and Geophysics G 63-18


PLATE 8
TRAVERSE E
TRAVERSE F
TRAVERSE G
TRAVERSE H
TRAVERSE D
TRAVERSE A
TRAVERSE C
TRAVERSE B
GEOPHYSICAL INVESTIGATIONS OF UNDERGROUND WATER
AT ALICE SPRINGS, N.T.
BASIN AREA
UNWEATHERED BEDROCK CONTOURS
(SHOWING LIMITS OF RECOMMENDED DEVELOPMENT)
(PREPARED FROM SEISMIC DATA)
SCALE IN FEET
CONTOUR INTERVAL 10 FEET
GEOPHYSICIST
LEGEND
Rock outcrop
Feet above sea level
Limit of recommended
underground water development
G 63-19



GEOPHYSICAL INVESTIGATIONS OF UNDERGROUND WATER AT ALICE SPRINGS, N.T., 1956

BUNGALOW AREA

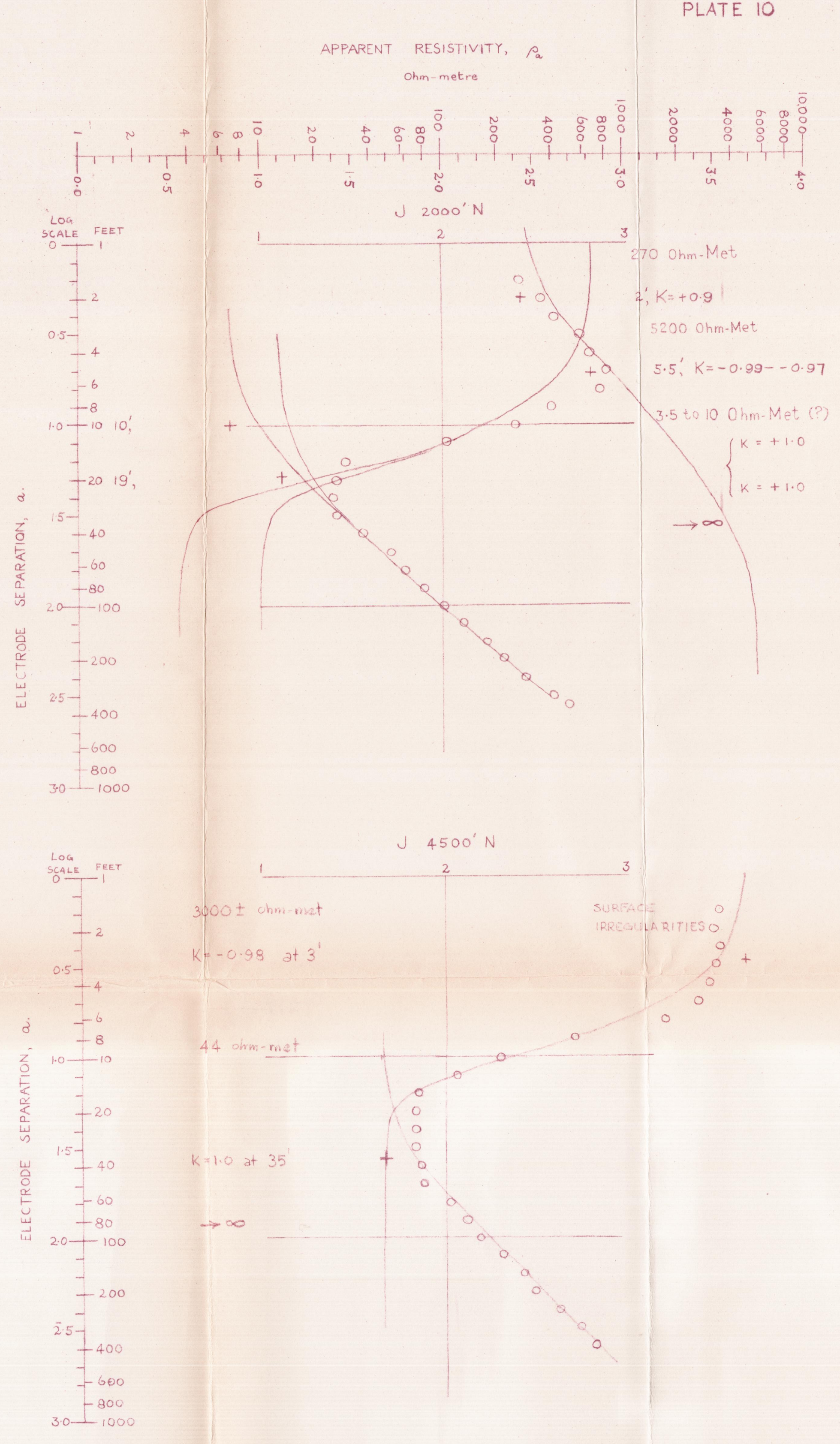
TRAVERSE PLAN

GEOPHYSICIST

Geophysical Section, Bureau of Mineral Resources, Geology and Geophysics

G 63-10

PLATE 10



GEOPHYSICAL INVESTIGATIONS OF UNDERGROUND WATER AT ALICE SPRINGS, N.T..

BUNGALOW AREA

SEISMIC AND RESISTIVITY PROFILES, RESISTIVITY DEPTH PROBES.

GEOPHYSICAL SECTION, BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS.

HORIZONTAL SCALE IN FEET

0 200 400 600 800 1000

VERTICAL SCALES AS SHOWN.

D. F. Dyson
GEOPHYSICIST

G63-11

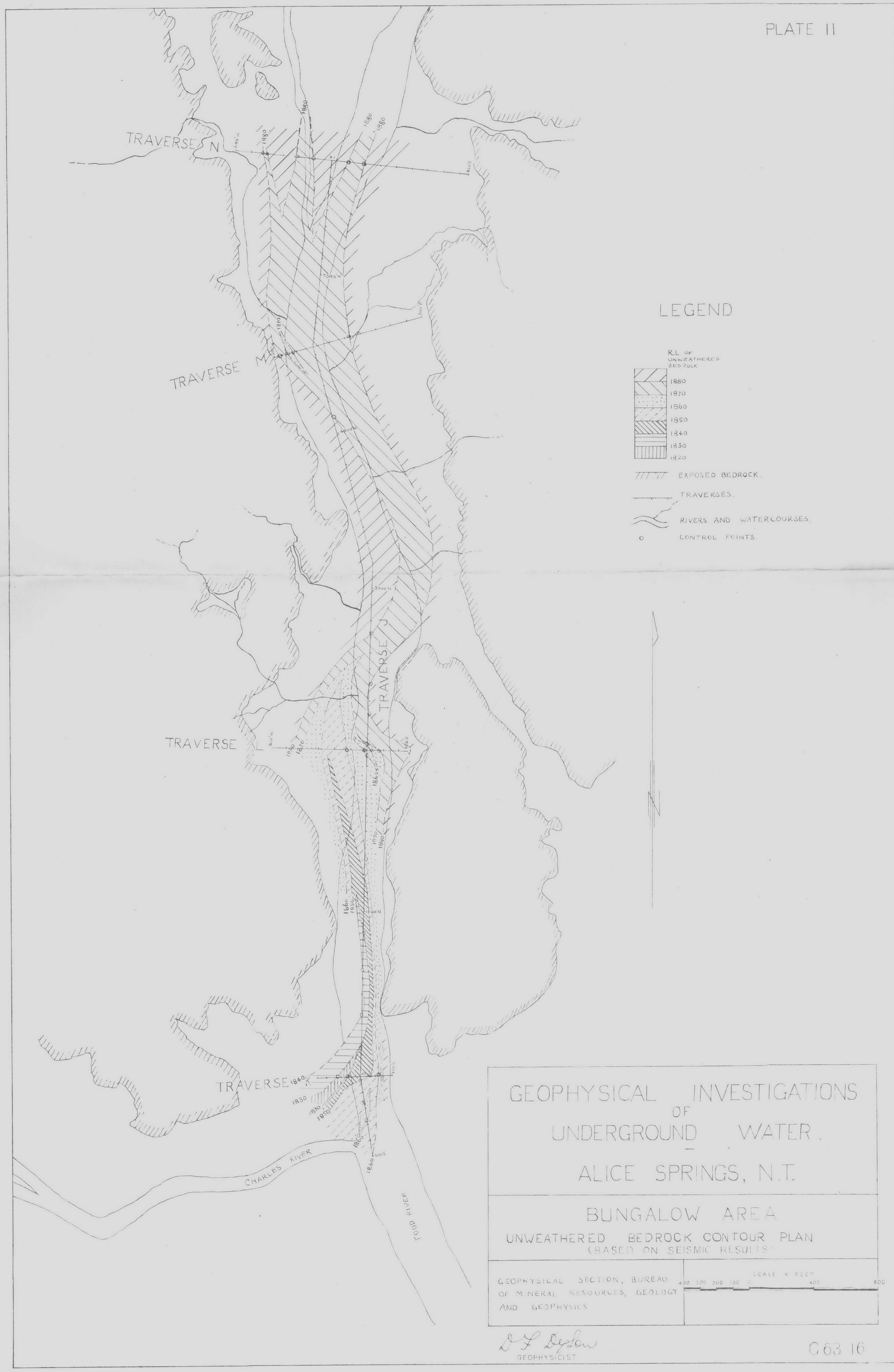
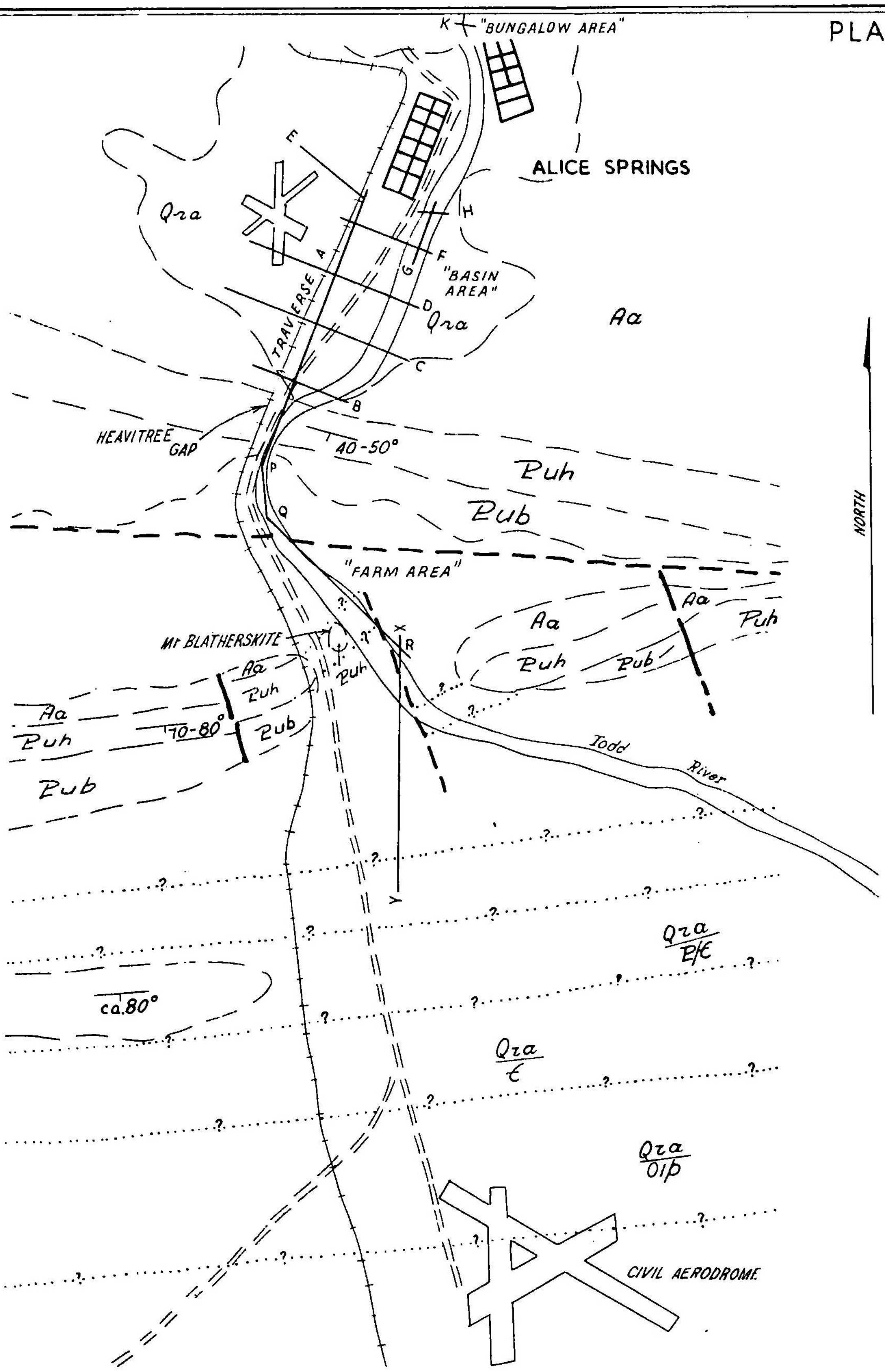


PLATE II
TRAVERSE N
TRAVERSE M
TRAVERSE L
TRAVERSE J
TRAVERSE K
CHARLES RIVER
TODD RIVER
LEGEND
R.L. OF UNWEATHERED BED ROCK
1880
1870
1860
1850
1840
1830
1820
EXPOSED BEDROCK.
TRAVERSES.
RIVERS AND WATERCOURSES.
CONTROL POINTS
N
GEOPHYSICAL INVESTIGATIONS OF UNDERGROUND WATER.
ALICE SPRINGS, N.T.
BUNGALOW AREA
UNWEATHERED BEDROCK CONTOUR PLAN
(BASED ON SEISMIC RESULTS)
GEOPHYSICAL SECTION, BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS
SCALE IN FEET
400 300 200 100 0 400 800
GEOPHYSICIST
G63 16

PLATE 12



APPROXIMATE SCALE IN MILES

1 0 1 2

LEGEND

Quaternary	Qra	Alluvium, Gravels	Proterozoic	Pup	Shales
Silurian	Sb	Conglomerates		Pub	Limestone.
Ordovician	Olb	Quartzite		Puh	Quartzite
Cambrian	Є	Shale, Limestone, Sandstone	Archean	Aa	Granite, Gneiss, Schist
	P/Є	Chocolate Sandstones			

— — Geological Boundary Position (approx) — — Fault Position (approx.)

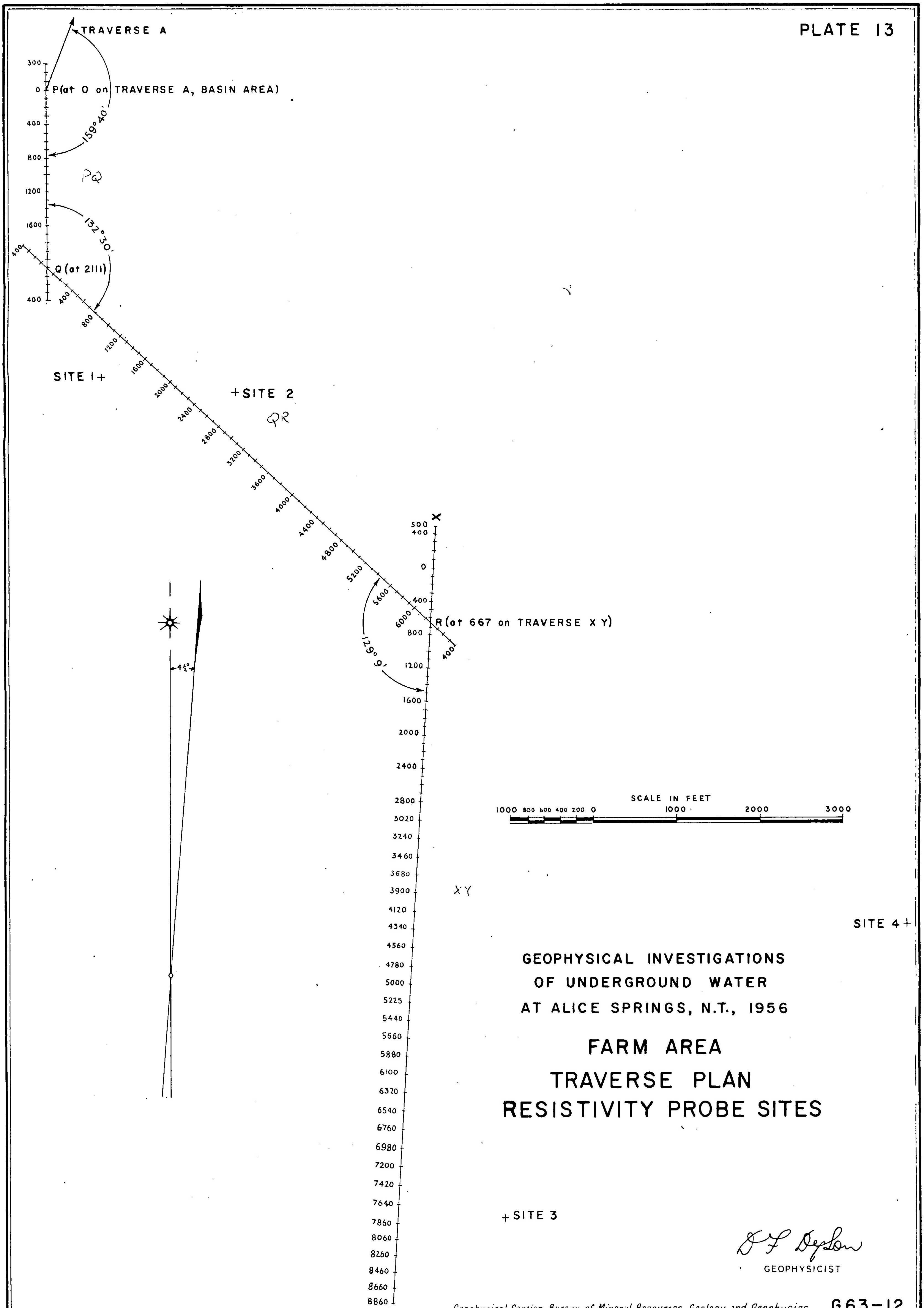
. . . ?. . . . ?. Geological Boundary Concealed — — Fault Concealed

———Y Geophysical Traverse

GEOLOGICAL SKETCH OF THE AREA SOUTH OF ALICE SPRINGS

(AFTER QUINLAN 1957)

GEOPHYSICAL SECTION, BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS. G 63-21



GEOPHYSICAL INVESTIGATIONS
OF UNDERGROUND WATER
AT ALICE SPRINGS, N.T., 1956

FARM AREA
TRAVERSE PLAN
RESISTIVITY PROBE SITES

D F Dyson
GEOPHYSICIST

Geophysical Section, Bureau of Mineral Resources, Geology and Geophysics. G63-12

PLATE 14

GEOPHYSICAL INVESTIGATIONS
OF
UNDERGROUND WATER AT ALICE SPRINGS, N.T.

FARM AREA

SEISMIC REFRACTION PROFILES

G63-14

PLATE 15

GEOPHYSICAL INVESTIGATION
OF
UNDERGROUND WATER
AT
ALICE SPRINGS N.T.

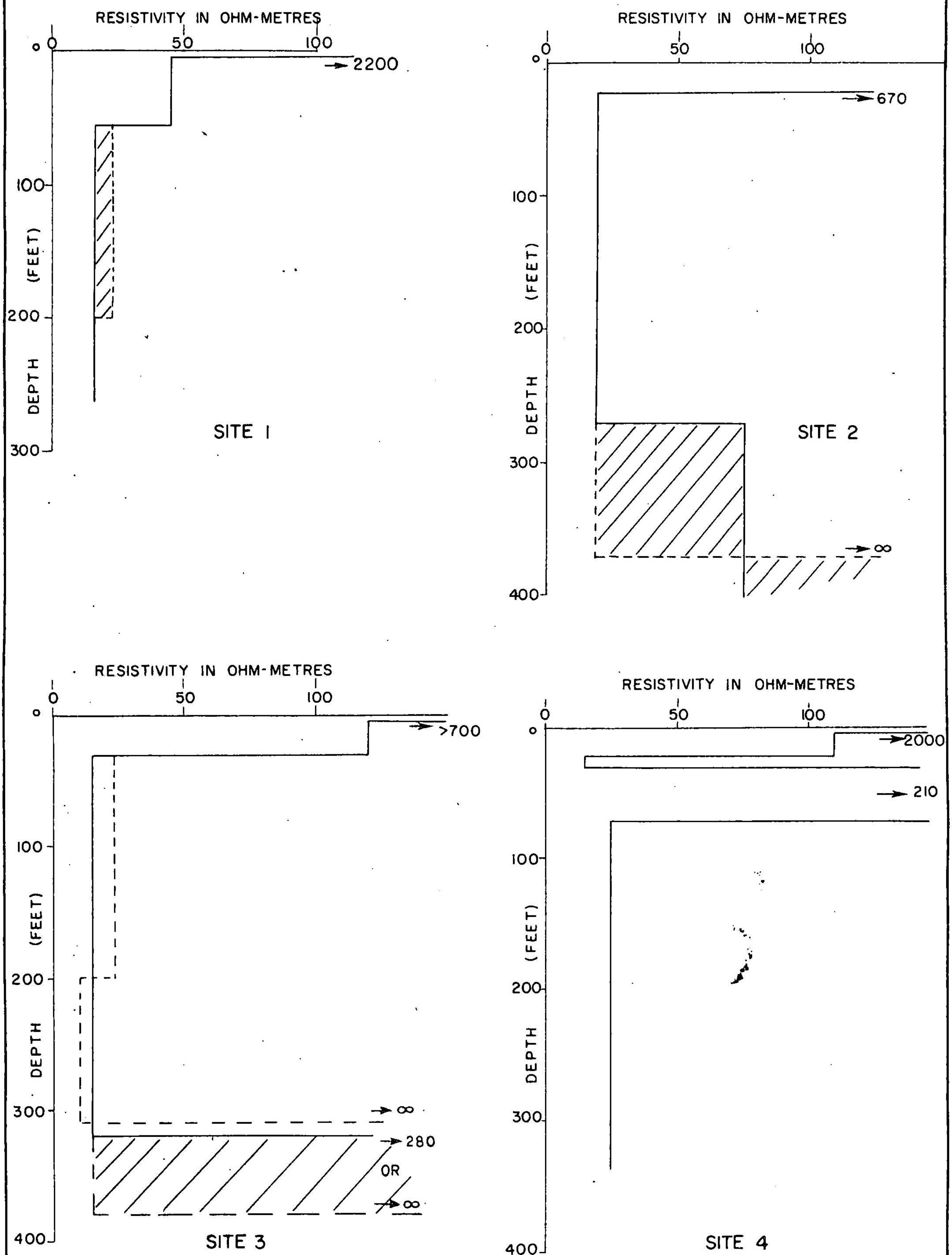
FARM AREA
RESISTIVITY DEPTH PROBES

GEOPHYSICAL SECTION, BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS.

D F Dyson
GEOPHYSICIST

G 63-15

PLATE 16



GEOPHYSICIST

HISTOGRAMS OF RESISTIVITY DEPTH PROBES IN FARM AREA
ALICE SPRINGS