COMMONWEALTH OF AUSTRALIA.

DEPARTMENT OF NATIONAL DEVELOPMENT.
BUREAU OF MINERAL RESOURCES
GEOLOGY AND GEOPHYSICS.

RECORDS.

RECORDS 1958/51

THE GROUND WATER PROBLEM AT YUENDUMU NATIVE SETTLEMENT
NORTHERN TERRITORY

by

N.O. Jones and T. Quinlan.

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INTRODUCTION

Yuendumu settlement is approximately 180 miles north-west of Alice Springs (Photo reference Mt. Doreen, Run 4 Photo No.5069). The water supply for the population of 20 Europeans and 480 Natives is obtained from two bores 200 yards north of the settlement.

The water requirements of the settlement are now approximately 10 million gallons per year, and estimated future requirements are of the order of 20-30 millions gallons per year, i.e. about 3,000 gallons per hour.

During 1957 a fall in the yield of the bores was noticed and new development at the settlement made improvements in the water supply necessary. The resident geologists were requested to select a site for a new bore.

T. Quinlan selected a boresite at the settlement, following a geological examination of the area during December, 1957. Further sites were selected by T. Quinlan and N. Jones during February - April, 1958. As drilling progressed it became apparent that the aquifer was of a different type to the broad alluvial basin originally envisaged. Two reports were prepared (Quinlan 1958 (a), 1958 (b)) which cover the initial phase of the investigation.

When No.2 bore was cleared of sand it was found that the water level had fallen approximately 8 feet, and check analysis of the water showed that the nitrate content had risen from 57 to 130 parts per million. This is well above the limit suitable for human consumption.

An aerial and ground examination of the area was made by Jones and Quinlan on 29th April, 1958. The results of this and of previous mapping appear on Plates 1 and 2.

There are three distinct problems which need complete or partial solutions before a suitable supply of underground water can be obtained at the settlement;

1. the nature and extent of the aquifer.

2. the amount and source of recharge water.

3. the source of the high-nitrate water.

If satisfactory solutions cannot be obtained it will be necessary to consider other sources of ground water.

GEOLOGY

The nearest outcrop to Yuendumu is a small one of Precambrian metamorphic rocks, one and a half miles east of the settlement. Outcrops to the west and to the north, and the results of previous drilling, show that bedrock about the settlement is Precambrian metamorphic and igneous rocks.

Two miles to the south, there crops out the northern limb of a major syncline of unmetamorphosed sediments of Upper Proterozoic - Lower Palaeozoic age.

Throughout the area is a widespread but relatively shallow cover of Cainozoic alluvium, scree, sand, and soil.

Precambrian

The oldest rocks in the area are metamorphics of unknown, but pre-Upper Proterozoic age. Gneiss, quartz-mica schist, and amphibolite are intruded by large batholiths of massive granite. The metamorphics have been strongly faulted and folded, and much of the faulting post-dates the intrusion of the granites. The predominant foliation trend is easterly but there is considerable local variation.

The driller's report that the boreholes at the settlement tended to "slip off" to the east, may indicate that the foliation of the schists beneath the settlement area strikes approximately north and dips to the east. The age of these rocks have been shown on Plate 1 as ? Archean.

"Upper Proterozoic - Palaeozoic"

Two miles south of Yuendumu the metamorphics are overlain unconformably by a thick sedimentary sequence, consisting of two arenaceous units separated by a limestone unit. Until further work is done, the thickness of these sediments can not be estimated because of lack of outcrop and possible faulting. Hossfeld (verbal communication) reports probable glacial beds in the lower half of the sedimentary succession further to the west and suggests a probable late Upper Proterozoic age for these beds.

Above the basal sandstones are interbedded limestones and sandy dolomites at least 300 feet in thickness, and these in turn are overlain by interbedded thin limestones and shales. One of the thicker limestones is the aquifer for Penhall's bore.

The highest unit is composed of interbedded sandstone, greywacke, and arkose with some conglomerates and is thought to rest unconformably on the lower units. This unit may be contemporaneous with, and is of a similar facies to the Pertnjarra Conglomerate in the Amadeus Trough, and has been mapped as ? Palaeozoic on Plate 1.

The sediments have been moderately folded and considerably faulted, the intensity of deformation increasing markedly toward the north.

Catley (unpublished note, 1955) suggested a thickness of not less than 10,000 feet for the complete sequence, and it is estimated that most of this thickness would be in the highest unit.

"Cainozoic"

All the Cainozoic deposits are of superficial nature and will be discussed under geomorphology.

GEOMORPHOLOGY

Regionally Yuendumu native settlement is on a saddle connecting the Truer and Reynolds Ranges. Locally it lies close to the headwaters of a broad shallow drainage basin. (Plate 1). The existing surface of drainage is not well defined and has been mapped using the banding in the patches of dense mulga * to indicate topographic form lines. These areas have been mapped as Qm on Plate 1.

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* Mabbutt (Geomorphologist with the CSIRO Land Research and Regional Survey, Verbal Communication) has shown that the mulga banding is controlled by micro relief in a direction at right angles to topographic contours.

The settlement is in an area of little relief with residuals of "Proterozoic - Paleozoic" sediments, gneisses, and schists standing above a ? Tertiary weathering surface developed on the Precambrian Schists. This surface, in which the depth of weathering is estimated to be 100 feet, has been dissected and is preserved only on the drainage divide 2¼ miles north west of the settlement. The degree of dissection can only be guessed at - some indication could be given when the geological character of the aquifer at the settlement is known - but it could be slight because of the position of the settlement in the present drainage basin.

These drainage channels, if they exist, have been filled with alluvium and subsequently the whole area covered with a blanket, up to 20 feet thick, of clay loam and red earths of possible alluvial origin. The present drainage has been superimposed on this blanket.

The existence of drainage channels pre-dating the weathering surface is a possibility which cannot be overlooked. Some information might be obtained if the No.1 hole is redrilled.

HYDROLOGY

Little can be learnt about the ground water near the settlement from surface examination. The logs of the eight holes drilled are shown in Table 1. Some of these particularly the earlier ones, are difficult to interpret in terms of the probable geology of the area.

The Aquifer

The aquifer at Yuendumu is believed to be one of the three following types:-

(a) a post-"laterite"* creek sand
(b) a pre-"laterite" creek sand
(c) a fracture or a crush zone in the metamorphics.

(a) A post-"laterite" creek sand could either lie on the "laterite" surface or in a narrow channel eroded into it. The information from drilling would support the second possibility. Such a channel could be expected to be continuous for several miles and its ultimate drainage would be to the east. The channel would be narrow and winding and therefore difficult to locate, but recharge would probably be fair, and development in an easterly direction from the settlement should yield satisfactory supplies.

(b) A pre-"laterite" creek sand would be of unpredictable extent and such an aquifer might be sealed from adequate recharge. This possibility is difficult to evaluate and is mentioned only because the log of No.1 Bore shows "ironstone" overlying the sand.

(c) The "sand" obtained during the cleaning of the No.2 Bore could have come from an alluvial channel, or from a fracture or a crush zone in the metamorphics. The strike of such a fracture zone would be approximately north as the aquifer was struck at 100 feet in each of the No.1 and No.2 bores. If further bores are drilled to intersect the aquifer and it is of this type, then careful positioning will be required to obtain an intersection within a reasonable and a sufficient depth.

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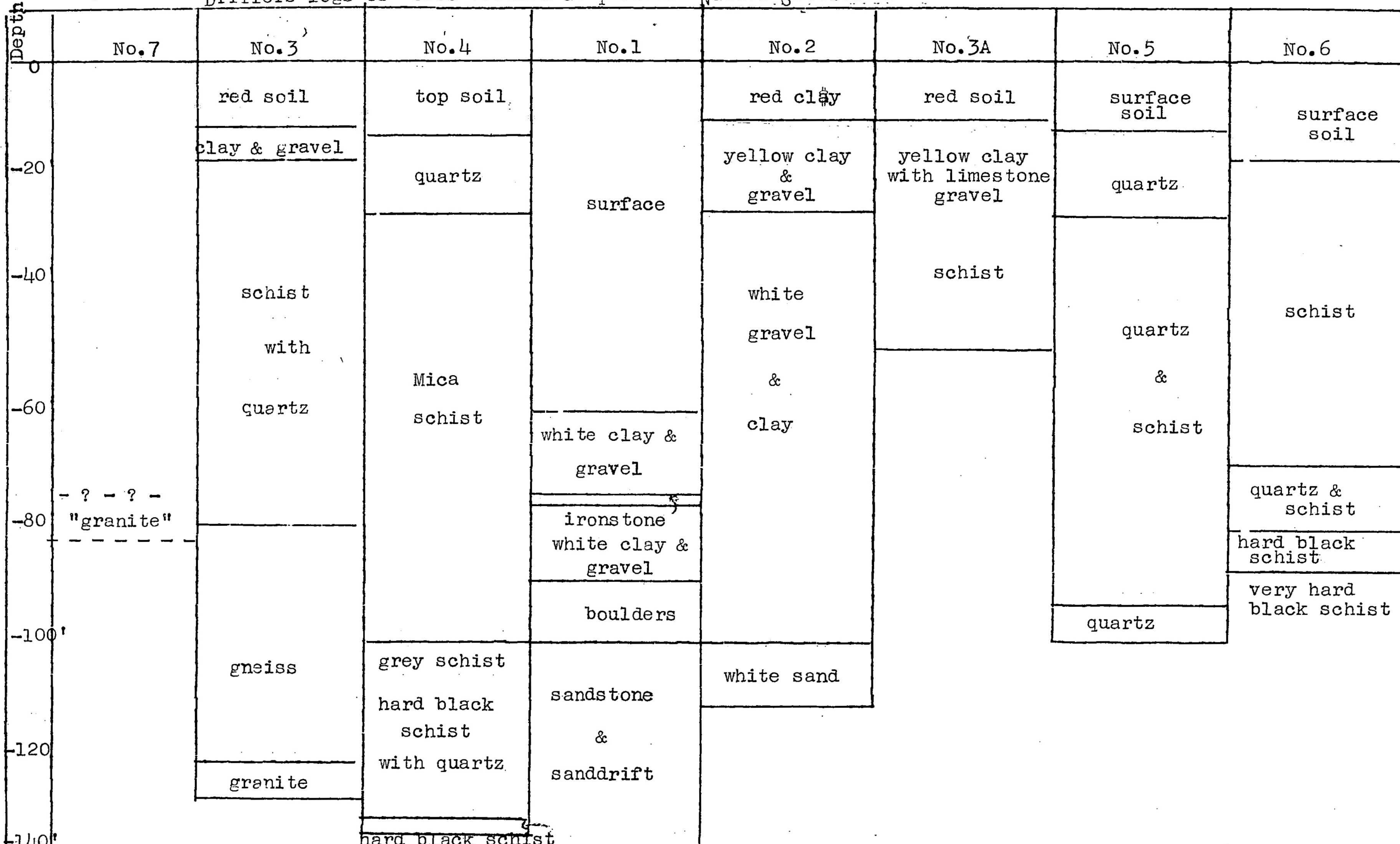
* The term "laterite" is used here as a reference term for the rocks formed during a widespread cycle of weathering of probable Tertiary age.

Drillers logs of bores drilled at Yuendumu Native Settlement



The drillers' logs (see Table 1.) of the Nos.1 and 2 bores suggest that the aquifer is of alluvial material, with the ironstone in the log of the No.1 bore suggesting that the aquifer is pre-"laterite" in age. Nevertheless, weathered metamorphics are frequently logged by drillers as "sand and clay" or as "gravel and clay". The sample of "sand" obtained from the aquifer in the No.2 bore could have been taken from a decomposed or brecciated gneissic rock or from poorly sorted alluvium derived from a source area of gneissic rock.

If the aquifer is a channel sand, its apparent narrowness and depth are not consistent with the present concepts of the geomorphology of the area, in particular with the degree of dissection.

The possibility that the aquifer is a fracture zone with a northerly strike is supported by the fact that sub-artesian water was struck in both the No.1 and the No.2 bores at 100 feet; and by the driller's report that the country "runs off" to the east. Against this is the very low probability of striking a narrow fracture zone in two out of two attempts. Further, the gneissic rock which would give a "sand" of the type in the No.2 bore has not been reported from other holes drilled at the settlement, but the geological environment is not unfavourable to its occurrence.

Recharge

No direct information is available on recharge of the aquifer at Yuendumu. The settlement area lies near the head of a drainage basin with a catchment above the settlement of four square miles. Most of the water course is underlain by a clay loam, several feet in thickness, and theoretical considerations (supported by experience elsewhere in Central Australia) suggest that recharge of the ground water, under such conditions, is poor because of the low infiltration rate in the top veneer of Cainozoic sediments.

Recharge could take place in two ways:

(1) by the infiltration of run-off water into the wash and colluvial deposits at the toe of the quartzite ridge 2 miles south of the settlement. This material should have a high permeability and should provide ready access for recharge waters to the aquifer. The high efficiency of recharge would compensate for the small intake area.

(2) by "sheet flow" above a clay layer and at the base of the red earths and clay loams. Several soaks have been opened up in the past, which obtain their water from this perched water-table, (at a depth of five to six feet below the natural surface.) It is suspected that this "sheet flow" would continue until a break is found in the clay layer, allowing infiltration to an aquifer.

The Ground Water Table and Yield of the Bores

The information available on the performance of the two settlement bores is as follows:

	Initial Yield	Initial Standing Water Level	Present Yield	Present Standing Water Level
No.1 (1945)	*1400+g.p.h. (1945)	----	1000 g.p.h. (Oct-Dec.1957)	-----
No.2 (1953)	*3000+g.p.h. (1953)	85' (1953)	1000 g.p.h.	93' (April 1958)

* Maximum capacity of pump available.

As far as is known, these bores were tested independently and their present combined yield is not known but is thought to be lower than 2100 g.p.h., because of mutual interference between the bores.

The 8 foot fall in water level in No.2 bore in the 5 years to 1958, is due to one or more of the following:

(1) A change in the measuring point.

(2) Seasonal fluctuations.

(3) Permanent drawdown.

(4) Interference due to heavy pumping from No.1 bore.

The relative contributions from each of these factors to the fall in water level cannot as yet be assessed. However it is thought that the effect of (1) and (2) is small, probably accounting for 12 inches of the fall; (3) probably contributes at least half of the total fall; and the effect due to (4) is unknown, but is probably as much as four feet.

As the settlement is close to a drainage divide, and presumably to a ground water divide, the area of any aquifers (and hence the volume of water stored) topographically above the 100 foot level in the No.1 and No.2 bores will be small. Therefore any fall in the level of the water table is significant and ominous. It is important to realize that the area of the aquifer referred to is not the whole topographic area above the 100 foot level, but is only a small fraction of it if the aquifer is a channel sand and even less if the aquifer is a fracture zone.

The decline in the yields of the two bores could be due to either:

(1) the decline in head and/or the total amount of water available within a system of restricted (small) aquifers, which may or may not be well interconnected and which have unknown permeabilities,

(2) the packing of low permeability material around the bores,

or (3) a combination of both factors.

Any future drilling in this area should be done so that the aquifer is "intersected" at a greater depth, and each bore should be properly developed. If the aquifer is a channel sand, there will be a definite limit to the depth to which it could be developed; on the other hand, a fracture zone could be developed at a greater depth than a channel sand.

The amount and type of total dissolved solids in bores Nos.1 and 2 is similar. Over the period 1955-1958 there has been an increase of some 15 per cent in the total dissolved solids of the water pumped, accompanied by a marked (130 per cent) increase in the nitrate content from 57 to 130 parts per million.

THE NITRATE PROBLEM

The source of the nitrate in the ground water is obscure. Until this source has been determined it will be difficult to recommend action to be taken to obtain low-nitrate water. Possible sources are:-

(1) Draw from a high-nitrate water in an adjoining area.

(2) Solution of nitrogen-bearing minerals in the metamorphics and/or Cainozoic deposits.

(3) The increasing addition of nitrogenous material originating from the settlement.

The marked increase in nitrate content compared to the small increase in total dissolved solids may be a "seasonal" fluctuation of obscure type or else due to the activities of the settlement either in providing a new source of nitrates or in creating a cone of depression which draws water from a high-nitrate source. If more bores were drilled into the aquifer an estimate of the source of the nitrate might be possible, by contouring of the nitrate content of the water.

Analysis of the ground water at regular intervals will show if there is a seasonal fluctuation (possibly from sources (2) and (3) in the nitrate content. These analyses together with regular readings of the static water levels may show if the nitrate is derived from a high-nitrate water in an adjacent area. If nitrogenous material is entering the aquifer from the rubble drains used for disposal of waste water from the settlement, a continuous high-nitrate content may be anticipated.

None of these possibilities can be eliminated at this stage, although the chemists of the Animal Industry Branch at Alice Springs do not consider the nitrate to be of organic origin. To support this they give the following reasons:

(a) there was no trace of organic material in the water samples submitted.

(b) there was an increase of approximately 10 parts per million in the hypothetical sodium chloride content and an increase of 73 parts per million in the nitrate content. The addition of this quantity of nitrates should be accompanied by an increase of 100 parts per million of sodium chloride, if the nitrate is of organic origin.

In spite of these strong arguments, one of the authors (T. Quinlan) feels that the nitrate could still be, originally, organic in origin; for the following reasons:

(1) Associated with the settlement are four large concentrations of waste organic material. These are the goat yard (approximately 100 yards north of the No.1 bore) and the rubble drains which receive water from the school showers, the laundry and the kitchen.

(2) Access to the aquifer from any one of these sources could be provided by:

(a) surface waters which run off to the area about the bores and follow the outside of the casing down to the aquifer. In this way was the town water supply at Minneapolis, Minnesota, U.S.A. contaminated (Bennison 1947 p. 287, 290.).

(b) sheet flow above the clay layer (the alternative method of recharge discussed previously) at a depth of five to six feet below the natural surface. It is thought that this water could easily become contaminated by the waste water in the rubble drains which are six to seven feet deep. This contaminated water would at some stage follow the outside casing down to the aquifer.

(c) if the aquifer is a shear zone, it would be present at a shallow depth (approximately 20 feet) below the settlement and the distance over which contaminated water would have to travel is reduced.

OTHER SOURCES OF GROUND WATER

Should testing of the present area fail to disclose adequate reserves of good quality ground water, further search in areas with "metamorphic" bedrock is not recommended.

The sedimentary succession to the south has yielded one good bore (Penhall's) and appears promising as an area of further search. It may be possible to develop useful supplies of water in this area at 2 - 3 miles from the settlement. Considerable geological investigation will be required before bore sites are selected in this area.

RECOMMENDATIONS

Trial Drilling

It is recommended that:

1. A bore should be drilled near No.1 bore and in lines with the No. 2 bore.

2. Clean samples should be taken at 5 foot intervals. A large sample (milk tin) should be taken from the aquifer. The nature of the aquifer could then be definitely determined.

3. If a considerable thickness of aquifer is penetrated, samples of water should be taken at intervals of 20 feet.

4. Eight inch blank casing should be used during drilling.

5. This bore should be pump tested under the supervision of the Water Use Branch, using No. 1 and No. 2 bores as observation holes.

6. Either this bore or No. 1 bore should be equipped to enable regular measurements of the static water level to be made.

7. Possible further trial drilling on the completion of any geophysical surveys.

Geophysical Survey

It is recommended that a geophysical survey of the resistivity type be carried out to determine:

(a) if there is an anomaly associated with aquifer. (stage 1)

(b) the extent of this anomaly and if other anomalies exist in the area about the ~~settlement~~. (stage 2)

This survey will save the considerable expense involved in prospecting by trial drilling

It is suggested that, in order to detect an anomaly associated with the aquifer, a constant depth traverse may be made from No. 3 bore to No. 3A (See Plate 26) and that three more traverses be made parallel to this one and spaced at distances of 100, 200, and 300 feet to the north. If necessary they could be tied together by a traverse from No. 3A to No. 5 bores.

It is suggested that at least two of the traverses be duplicated at a different depth, so that if the aquifer is a fracture zone, some indication will be given as to its dip.

The selection of traverse lines to determine the extent of the anomaly and if other anomalies exist in the area will depend on the results of stage 1 and will have to be made in the field.

The Nitrate Problem

If the source of the nitrates is high-nitrate water in an adjoining area or nitrogen-bearing minerals in the metamorphic and/or Cainozoic rocks, nothing can be done to prevent the contamination of the ground water in the settlement area. In which case the area must be abandoned, unless a duplicate reticulation system is installed to provide the settlement with drinking water, and the present system is used to supply water for washing and for gardens. A supply of drinking water could probably be obtained in the area 2 to 3 miles south of the settlement (see "Other Sources of Ground Water").

A test pit should be excavated around the casing of No. 2 bore to a depth of 10 feet. Samples of the moist soil and the soakage water, if any, at this depth should be submitted to the Animal Industry Branch, Alice Springs for analysis of the nitrate and organic content. This will show if the aquifer is being contaminated by water moving down the outside of the casing. Grouting between the casing and the country rock to a sufficient depth will stop this means of contamination.

ACKNOWLEDGMENTS

The Animal Industry Branch of the Northern Territory Administration, Alice Springs have carried out analysis of water samples and considerable help has been given by the officers of that Branch in discussions on the nitrate problem.

Verbal information from P. Hossfeld and D. Catley has been of much assistance.

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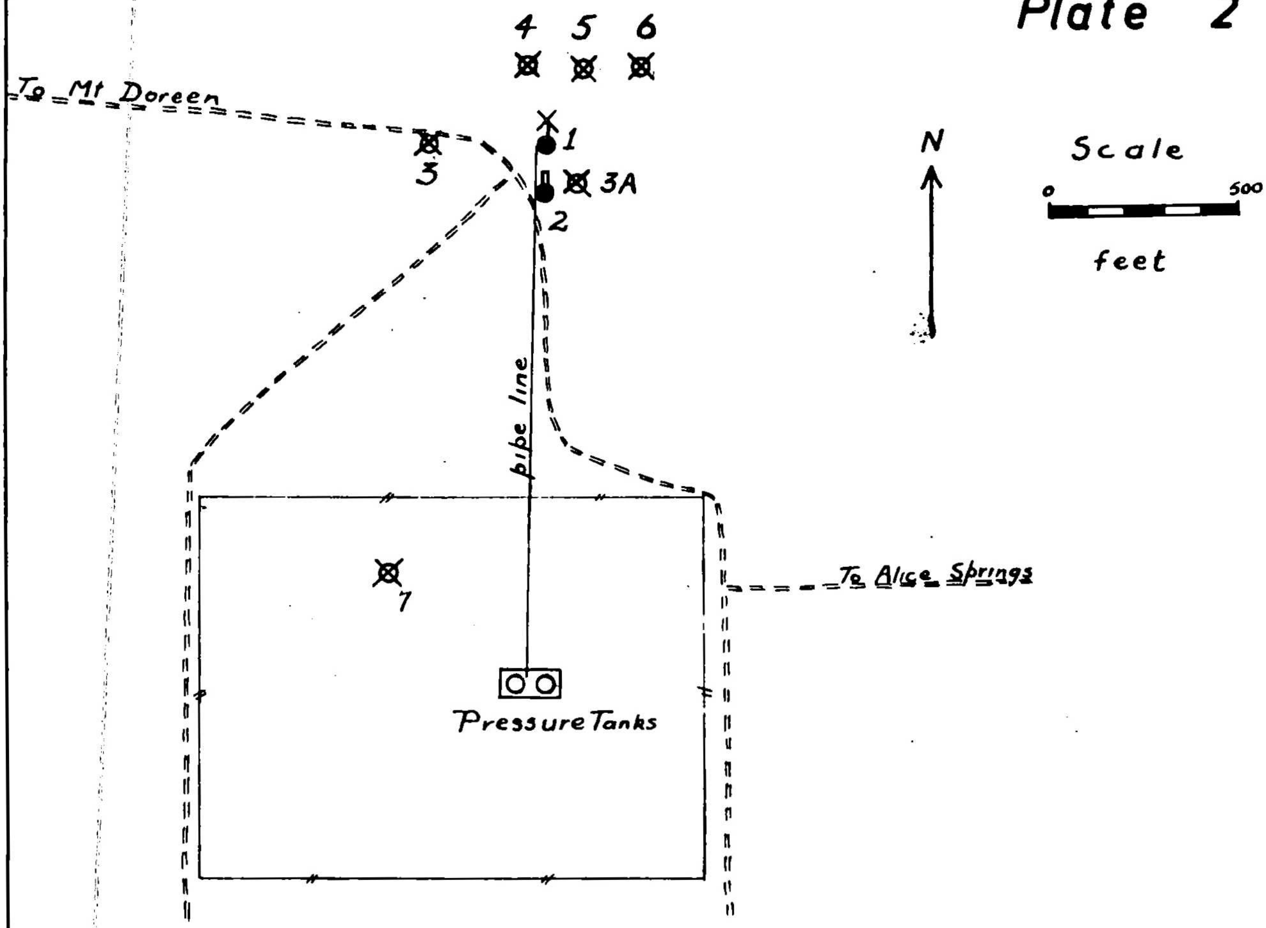
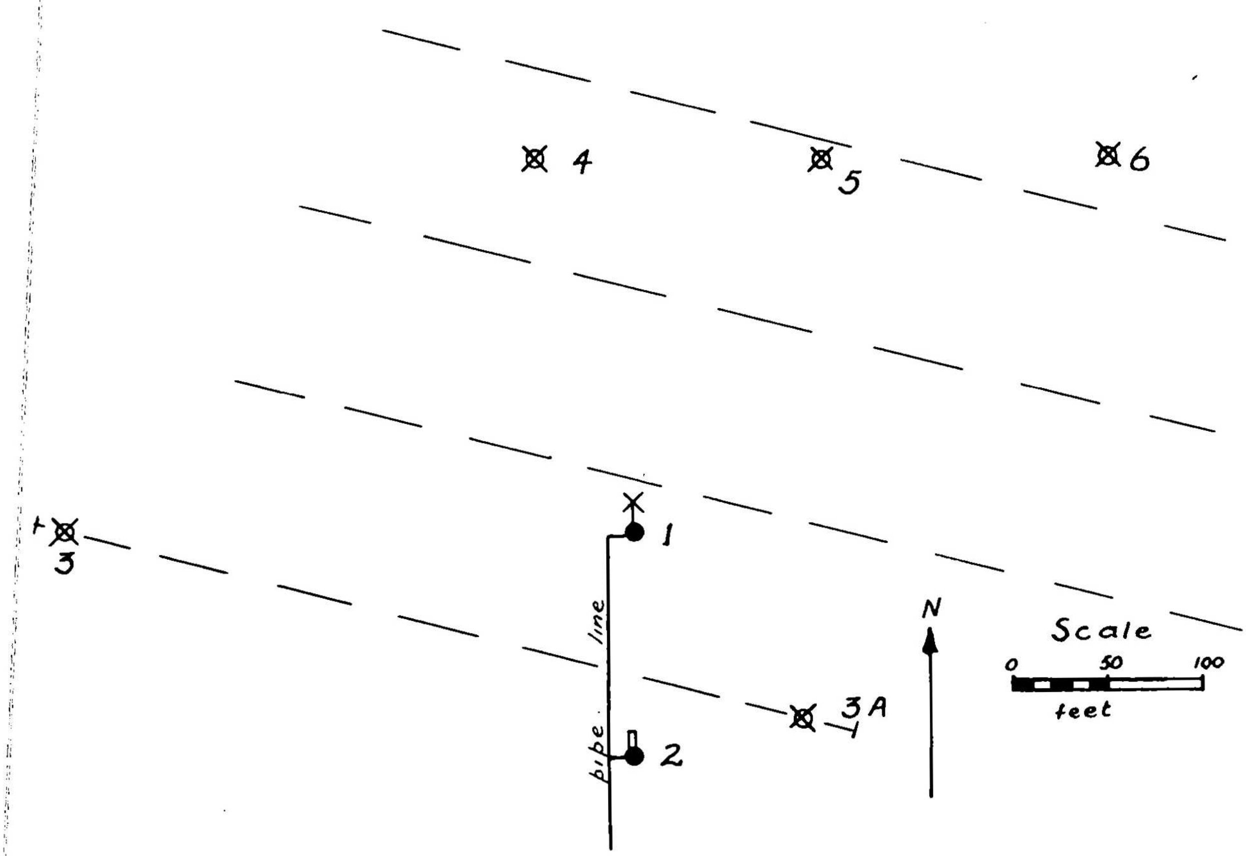
Quinlan, T. 1958 (b) "Supplementary Report on Ground Water Prospects, Yuendumu Native Reserve." Resident Geologists Office,Alice Springs. (unpublished) Rep.

Resident Geologist's Office,
Alice Springs,
30th June, 1958.

Plate 2



(a) Location of bores at Yuendumu Settlement.



(b) Suggested lines of traverse for resistivity survey (stage 1)

Legend

- Bore w windmill
- Bore w pumpjack
- Bore dud

Resident Geologists Office
Alice Springs.
May 1958.