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1959/53

BUREAU OF MINERAL RESOURCES EXPERIMENTAL WATER BORE DRILLING, CANBERRA 1958

by

G.M. Burton and E.G. Wilson

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SUMMARY

The Bureau undertook a small drilling programme of five bores in the Australian Capital Territory late in 1958 to investigate underground water problems. These five holes were to have been as follows:

(1) One deep hole of 200 feet and two observation holes of 60 feet to investigate the safe yield and general pumping characteristics of fractured crystalline rock aquifers;

(2) One shallow bore on the C.S.I.R.O. Experiment Farm to provide underground water for agricultural experiments;

(3) One shallow bore of about 80 feet to try to solve a drainage problem in the suburb of Red Hill.

The first, or deep hole, was a partial failure owing to the intersection of an unexpected thick shale pendant. The bore yielded only about 200 - 500 g.p.h. and so the observation holes were not drilled.

The C.S.I.R.O. farm hole was drilled to 77 feet and yielded over 700 g.p.h. It was decided to drill two shallow observation holes nearby. These were both drilled to 57 feet; one yielded only about 30 g.p.h. and the other about 200 - 300 g.p.h.

The Red Hill hole was drilled to 100 feet and yielded water at the rate of about 600 g.p.h.

These five holes totalling 491 feet of drilling are now ready for research into the behaviour of underground water in crystalline rocks and the techniques of studying this behaviour.

INTRODUCTION

Since 1954 the Bureau of Mineral Resources Miscellaneous Investigation Group has been surveying the underground water resources of the A.C.T. as part of its general engineering geology study of the Territory.

By the middle of 1958 most of the readily available data had been collected and two records summarising this work were being prepared - one, "The Underground Water Resources of the A.C.T.", by G.M. Burton and the other, "Preliminary Pumping Tests of A.C.T. Water Bores", by E.G. Wilson.

The conclusions drawn from these studies were that very little was known about the safe yield of the bores or the possibility of using the water for small scale farm irrigation. As long-range pumping tests could not be run on privately owned bores it was decided to plan a small project of experimental water bores to be drilled by the Petroleum Technology Section of the Bureau. The co-operation of C.S.I.R.O. was promised in testing the suitability of the water for irrigation.

The original drilling plan consisted of one relatively deep hole of 200 feet, together with two shallow observation holes of about 60 feet. These bores were to be drilled on the "Glebe Farm" of the Gribble Estate at Weetangera.

It was also decided to take advantage of the presence of the drill in Canberra to test the possibility of solving a serious ground-water drainage problem in Torres Street, Red Hill (Noakes, 1958) and to drill a shallow bore for water on the C.S.I.R.O's new Ginninderra Experiment Farm.

SELECTION OF SITES

It was considered when arranging the drilling programme that three main problems were connected with the yields of the principal aquifers in the A.C.T.:

(1) What were the long range pumping characteristics of water stored in rock fracture type aquifers?

(2) What increase in yield could be obtained by increasing the depth of the hole to intersect more fractures and joints?

(3) What effect on pumping characteristics of a fractured-type aquifer did an overlying mantle of outwash and/or weathered rock have?

It was considered also that an attempt should be made if possible to improve the flow of water in the bores by fracturing the walls with explosives. The Director of Works for the A.C.T. gave permission for Mr. N. Brown, engineer-in-charge at Mugga Quarry to assist in this experiment.

Prior to the selection of the main bore site two bores had been selected for farmers in the area around Surveyor Hill, five miles west of Hall. Both of these holes (Hall 6 and 9) had yielded low-salinity water in excess of 900 g.p.h. and had held the yield well during tests of ten

hours. The topographical and geological location of these two bores was identical. Both were on small outwash fans which were underlain by partly weathered porphyry. Fresh hard porphyry lay at about 80 feet. Such a succession with a thick cover of soft material makes an attractive bore site because the chances are that water in sufficient quantity for the farmer will be struck before the hole enters hard rock; the hole is thereby completed at the cheapest drilling rate with no risk of abandonment due to hard rock. Moreover, experience suggests that the cost of drilling and equipping a hundred foot hole is about the maximum which most local farmers are prepared to outlay.

In view of the quality and quantity of water obtained and the ease of drilling, it was decided that such a site offered the best type of bore for experimental purposes. If pumping tests were run at various stages during drilling it would be possible to determine the advantages to be gained by deeper drilling.

The site finally selected was near the "Fiveways" on Section 27, Belconnen District, which is part of "Glebe Farm". This is on Commonwealth land leased by the Gribble Estate. The bore was located in outwash overlying fractured porphyry; the porphyry was considered to be part of, or a similar body to, the Painter Porphyry. Local mapping had shown the presence of small shale zenoliths which meant that the site was near the porphyry roof and that the hole should be in porphyry for its full depth. The observation holes were to be drilled in line up the hill at about 70 foot intervals.

Selection of a bore on the C.S.I.R.O. farm was difficult; outcrops indicated that much of the farm was underlain by either massive granite or volcanic rocks both of which were hard and little fractured and thus unlikely to yield good supplies of water. Little of the farm area was underlain by the favoured fractured porphyry, but eventually a site was selected in Section 28, Belconnen.

The site was in a small valley with an excellent catchment; the underlying rock was probably Painter Porphyry. The site was selected sufficiently far back and up grade from the granite contact for the bore to reach one hundred feet before reaching the granite. It was considered that the granite would act as a partial subsurface barrier to the underground water passing down the depression and that local underground storage above this granite would be good.

The site of the Red Hill bore, City 3, was fixed by Noakes in his report (1958) on the drainage problem.

DRILLING AND LOGGING EQUIPMENT

The holes were drilled by the Petroleum Technology Section using one of the Bureau's Failing 750 rigs. Drilling commenced on the 17th November and was completed on the 21st. December. Total footage of the five holes was 491 feet.

A bentonite drilling fluid was employed in most of the drilling. The hole size for the most part was $6\frac{5}{8}$ inches. The top sections of all holes, except Belconnen 5, were reamed to $7\frac{7}{8}$ inches to permit casing and gravelling. Where drilling progress became slow because of very hard rock the hole size was reduced to $4\frac{3}{4}$ inches.

Resistivity, self-potential and radio-active logs were run by Mr. N. Jackson, of the Bureau's Geophysical Section, who used a Widco 2,000 Logger. This logging will be the subject of a Geophysical Record.

DRILLING

Belconnen 5 bore yielded unexpected results. Firstly, there was practically no outwash fan present; secondly, brown and black mudstone and shale were intersected between 35 and 169 feet. This mudstone was hornfelsed in part and several tongues of porphyry were present. This pendant did not crop out and there was no suggestion in the surface mapping that there would be a pendant of such large proportions below the heavy soil mantle. The profile produced by the concealed shale made it appear that the outwash fan extended further down the hill than it did.

These results underline the fact that even with geologists siting bores in this area, failures due to misinterpretation will occur. The chance of failure is higher where outcrop is poor and mapping has not advanced beyond detailed reconnaissance. It should be mentioned however, that the time involved in detailed reconnaissance in the area between Canberra and Yass exceeds what would be needed for detailed mapping in many other areas. This is largely due to lack of outcrop in critical areas to delineate the many similar igneous rocks and their relation to the sediments.

This bore finally entered contaminated porphyry at 169 feet. The presence of the mudstone, which does not normally provide good fractures, reduced the possibility of getting flows of water in the usual zone of good supply between 40 - 150 feet. It is thought that a small flow of water at about 60 feet and another supply at about 180 feet, came from sections of the porphyry. A pump test run on the 1st. December, when the hole was at 178 feet, indicated a flow of 350 - 450 g.p.h. on a short test of about two hours. A further short test of about two hours at the completion of the hole, but before final cleaning showed a flow of about 200 g.p.h. The pump suction was set at about 90 feet and initial standing water level was about 18 feet for these tests. More accurate tests on this and the C.S.I.R.O. holes await modifications to the Bureau's mobile pumping unit. The log of this hole is as follows:-

Belconnen 5.

0 -	11 feet	Soil and clay.
11 -	35 "	Weathered porphyry.
35 -	60 "	Brown shale and mudstone (fossiliferous)
60 -	61 "	Porphyry ?
61 -	70 "	Brown shale and mudstone
70 -	169 "	Black hornfelsed mudstone. Some porphyry at 135 - 138 feet.
169-	200 "	Hard, siliceous porphyry with thin calcite veins. Possible fracture reported by driller at 180 feet.

Cuttings and core from this and subsequent holes have been filed in the B.M.R. Geological Museum at Canberra.

The presence of the large thickness of shale caused an alteration in the drilling plan. There was no point in drilling observation holes adjoining Belconnen 5 because the aquifer was very poor and not representative of those from which farm supplies are commonly obtained. It was decided that if the hole at the C.S.I.R.O. Farm was successful, observation holes would be more useful there.

The main hole at the C.S.I.R.O. Farm, Belconnen 6, was then drilled and completed at 77 feet. Drilling progress became very slow after this hole entered fresh silicified porphyry at 48 feet. Water was encountered probably at about 27 feet, and at various undetermined depths below this. Two short pumping tests were carried out; the first one of about three hours duration when the hole was at about 42 feet; the second one of about one hour, when the hole was at its final depth of 77 feet. The first test gave an initial flow of about 600 g.p.h. on a draw-down from $2\frac{1}{2}$ to 31 feet with suction at 32 feet. The second test gave an initial flow of 700 - 800 g.p.h. with a draw down from $2\frac{1}{2}$ to 17 feet with suction at about 64 feet.

The log of the hole is as follows:-

Belconnen 6.

0 - 4	feet	Clay and soil.
4 - 23	"	Weathered porphyry.
23 - 48	"	Hard porphyry with weathered zones.
48 - 60	"	Increasingly hard fresh silicified porphyry.
60 - 77	"	Extremely hard silicified porphyry, traces of pyrites and thin calcite veins.

The first observation hole, Belconnen 7, was drilled about 60 feet north of No.6. This hole entered fresh silicified porphyry at about 27 feet and drilling became very slow. The hole was abandoned at 57 feet because of slow progress. It yielded water at only about 30 g.p.h. It is thought however, that it will be adequate as an observation hole. Attempts will be made later to increase the yield by fracturing. The log of the hole is as follows:-

Belconnen 7.

0 - 8	feet	Soil, and clay.
8 - 18	"	Weathered porphyry.
18 - 27	"	Fresh porphyry.
27 - 57	"	Very hard silicified fresh porphyry.

Belconnen 8, the second observation hole, was then drilled 60 feet south of Belconnen 6. This hole was also drilled to 57 feet but did not enter the very hard fresh silicified porphyry encountered in the other holes. Water was struck probably between 33 and 50 feet and a short pumping test of about an hour, run when the final depth was

reached, indicated an initial flow of 200 - 300 g.p.h. The log of the hole is as follows:

Belconnen 8.

0 - 4 feet	Soil and clay.	
4 - 18 "	Weathered porphyry.	
18 - 33 "	Hard fresher porphyry.	
33 - 43 "	Softer porphyry with considerable limonite staining.	
43 - 50 "	Slightly to strongly weathered porphyry.	
50 - 57 "	Hard porphyry.	

On completion of Belconnen 8, the drill was moved to Block 15, Section 3, Red Hill, where the drainage investigation hole, City 3, was commenced on the 17th December. The hole was drilled through porphyry to 100 feet. A pendant of the Red Hill Group may have been intersected near the top of the hole, but the remainder of the hole was in Painter Porphyry which was still slightly weathered at 100 feet. Pumping tests during the course of drilling were unsuccessful; this was because sediment lodged in the foot-valve. Subsequent testing with a jack pump set at 90 feet gave an output of 570 - 630 g.p.h.

The log of the bore is as follows:

City 3.

0 - 3 feet	Black soil.	
3 - 20½ "	Deeply weathered porphyry	Weathered Red Hill Group may be present as a pendant.
20½ - 22 "	Hard porphyry	
22 - 30 "	Deeply weathered porphyry	
30 - 42 "	Porphyry with hard and soft zones	
42 - 54 "	Slightly weathered porphyry (hard drilling)	
54 - 55½ "	Deeply weathered porphyry	
55½ - 100 "	Slightly weathered porphyry with deeply weathered bands (joints?).	

FRACTURING

It was decided to postpone until a later date the use of explosives for fracturing the wall rock to increase the water yields. This decision was made after it was found impossible to run sufficiently reliable pumping tests during the course of drilling. There was no point in trying to increase an undetermined water flow. It should be possible in the future, however, to try this experiment on uncased sections of some of the holes.

CLEANING AND CASING

It was necessary to clean all holes before inserting casing because a bentonite drilling fluid was used for much of the lower section of each hole. The control of this cleaning was in the hands of the Petroleum Technology Section.

The casing, which was run in each hole to support the weathered zone, had perforations in the bottom ten feet. The perforations consisted of about 40 - six inch long by one-quarter inch wide blow-torch cuts spread evenly over the ten-foot length.

All the holes, except Belconnen 5, were reamed to $7\frac{7}{8}$ inch size in the weathered zone prior to the insertion of casing. This permitted gravelling with $\frac{5}{8}$ inch crushed Mugga Porphyry between the walls and casing; Belconnen 5 hole had been enlarged sufficiently by the deeper drilling and did not require reaming before gravelling.

QUALITY OF WATER

The use of drilling mud prevented regular tests of water-quality during drilling. Only two samples were taken for analysis, one sample from the bore on "Glebe Farm" and the other from the main bore at the C.S.I.R.O. Farm. The samples were analysed by W.J. Thomas in the Bureau's Canberra laboratory and the results are as follows:

Analysis	Belconnen 5		Belconnen 6	
	p.p.m.	m.eq/l	p.p.m.	m.eq/l
Total Solids (105°C)	950	-	799	-
Calcium	133	6.65	81.4	4.07
Magnesium	85	7.1	55.0	4.59
Sodium	72	3.13	84.5	3.67
Bicarbonate (HCO_3)	606	10.1	408.0	6.80
Sulphate (SO_4)	128	2.66	37.0	0.77
Chloride (Cl)	145	4.08	165.0	4.65
P^H	6.82		7.13	

The Belconnen 5 sample was taken during a pumping test on 22/11/58 when the depth of the hole was 110 feet. It is possible that the underground water was more saline than this sample indicates as part of the sample may have been fresh water left in the hole during cleaning operations.

The Belconnen 6 sample was taken during a pumping test on 6/12/58 when the depth of hole was about 42 feet. It is probably quite representative of groundwater in fractures above 42 feet depth.

CONCLUSIONS

1. The Belconnen holes are now complete and ready for use in underground water research.

2. Before the main research can be undertaken, it is necessary to gather preliminary information on fluctuations of the natural ground-water level in the area and the yield of the bores on short accurate pump tests. This data is being gathered at present.

3. When this information is available in June the final programme will be prepared for the best use of the bores in:

   (a) Testing the safe yields of fractured crystalline rocks,

   (b) Improving and developing the Bureau mobile pumping equipment and water level measuring devices,

   (c) Developing techniques for the study of underground water movement using dyes and radioactive materials,

   (d) Studying the variation of water quality with rainfall and length of pumping,

   (e) Assisting C.S.I.R.O. in testing the agricultural use of the water,

   (f) Testing the effects of fracturing on improving the yields of Belconnen 7.

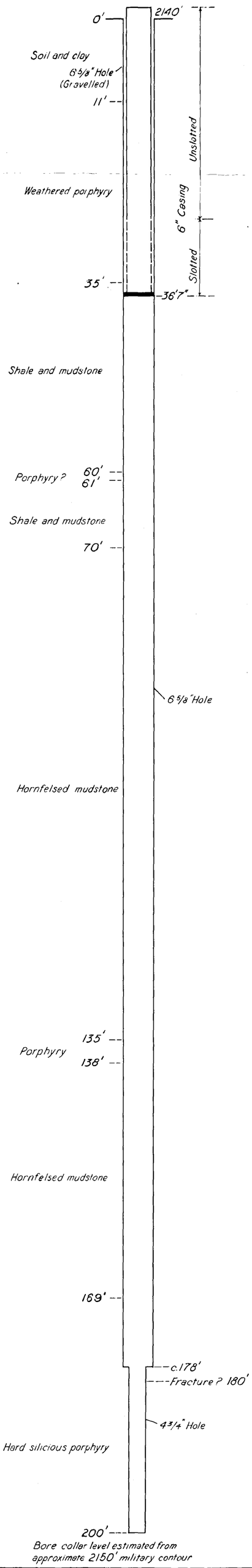
4. The City 3 bore should be given accurate pumping tests of several days duration and the effect of this on the local piezometric surface checked in the existing auger observation holes (This work in fact is almost complete and a Record on the results is being prepared by E.G. Wilson.).

REFERENCE:

NOAKES, L.C., 1958 - Drainage problems at Torres Street, Red Hill. Bur.Min.Resour.Rec. 1958/11.

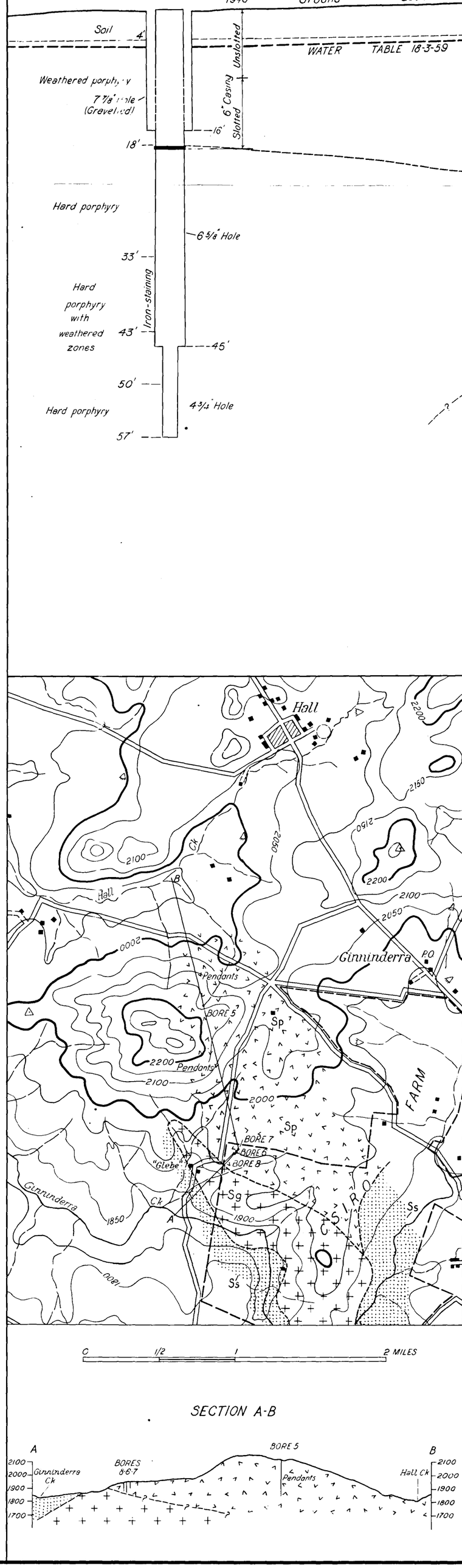
PLATE 1

BELCONNEN 5

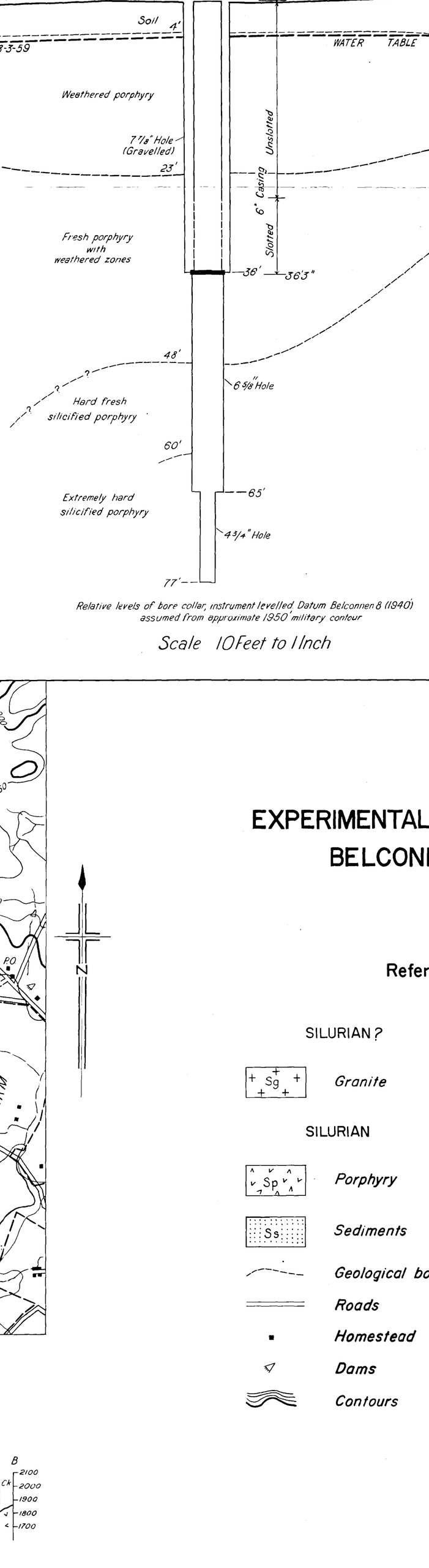


Bore collar level estimated from approximate 2150' military contour

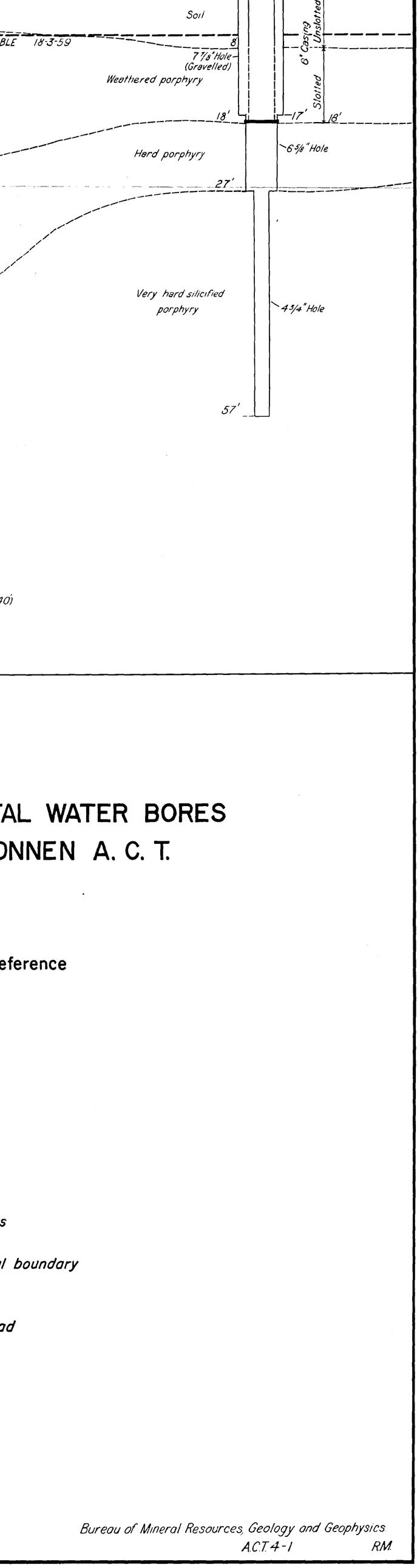
BELCONNEN 8



BELCONNEN 6



BELCONNEN 7



Relative levels of bore collar, instrument levelled. Datum Belconnen 8 (1940') assumed from approximate 1950' military contour

Scale 10 Feet to 1 Inch

N

SECTION A-B

EXPERIMENTAL WATER BORES BELCONNEN A. C. T.

Reference

SILURIAN ?

Sg — Granite

SILURIAN

Sp — Porphyry

Ss — Sediments

Geological boundary

Roads

Homestead

Dams

Contours

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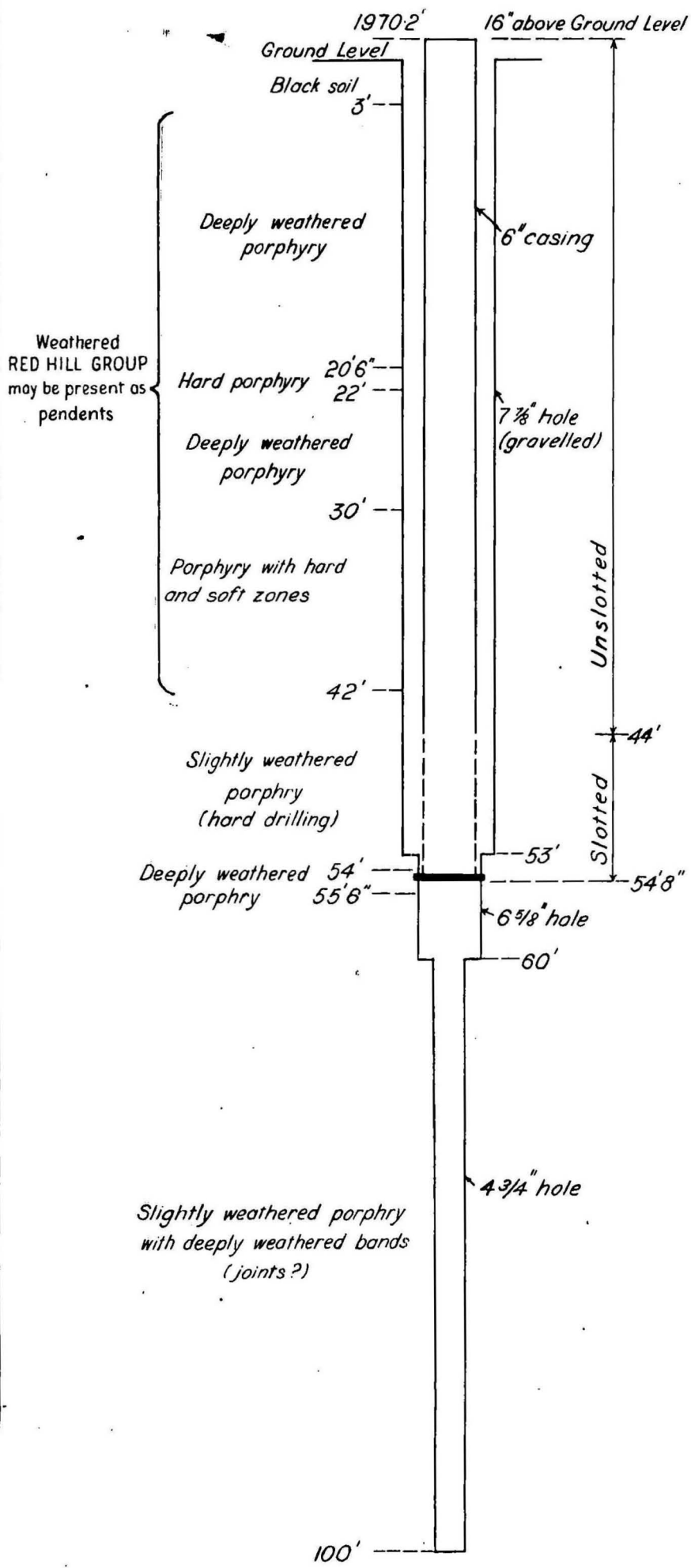
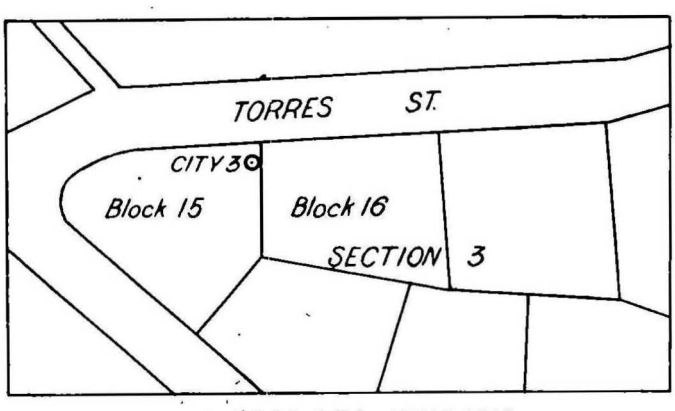
A.C.T. 4-1 RM.

PLATE 2

EXPERIMENTAL WATER BORE CITY 3
RED HILL A. C. T.

0 10 20 30 FEET





LOCALITY SKETCH

ACT 16-41
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