DEPARTMENT OF MINES
SOUTH AUSTRALIA

GEOLOGICAL SURVEY

HYDROLOGY SECTION

THE HYDROLOGY OF PART OF COUNTY CARDWELL, IN THE UPPER SOUTH EAST OF SOUTH AUSTRALIA

by

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G.S. No. 1480
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ABSTRACT

In an area covering parts of three Hundreds in Northern Co. Cardwell, the groundwater underlying the sandy heath terrain occurs at a depth varying from 9 to 80 feet. The groundwater has a gradient on the hydraulic surface of 1:5,000 towards the sea, into which it presumably discharges.

The penetration of rainfall directly into the deep sand in wet winters is about thirteen feet, and does not effectively recharge the aquifer. Local recharge can only occur if the rainwater is added to by surface runoff.

Stock water is available in some areas only, and owes its occurrence to the accumulation and downward penetration of surface runoff to reach the water table beneath the lowlying flats.

Any type of land development which may prevent or severely restrict local runoff will eliminate a source of good quality intake to the groundwaters. Subsequent pumping and use for stock would then cause the volume of usable groundwater to decrease and deteriorate to the point where stock water might no longer be available.

1. INTRODUCTION

That portion of South Australia, designated the Ninety Mile Plain, comprises a large tract of country of uniform appearance, the soils of which, for the most part, are infertile sands, but are clothed nevertheless by a relatively flourishing vegetation of low shrubs. Shallow groundwaters are found over most of its extent. There is much virgin country, though it is rapidly being cleared and developed for pasture production and in the process the shallow groundwater plays an important part, because it may represent the only source of both stock and domestic water supply. This is particularly the case in the country between the eastern shore of the Coorong and the Mt. Boothby Range, where the waters occurring at shallow depth in the limestones and sands

are hydrologically separate from their equivalent in the main part of the Murray Basin, while the deeper seated pressure waters of the Knight Group sands either do not occur, or are believed to be of high salinity. As a consequence, the stock grazing the developed pastures are watered entirely from wells equipped with windmills in which the water level is commonly 20 to 40 feet from the surface.

In 1949, the Land Development Executive of the South Australian Department of Lands, sought the assistance of the Department of Mines in determining the availability of stock waters in the area with a view to pastoral development. The Department of Mines sank nineteen shallow bores and one deep bore during 1950 and after carrying out appropriate pump testing, recommended a substantial programme of further test boring.

This recommendation was adopted in 1955-56 and the Department of Mines sank a further 106 bores and carried out pump tests.

The original drilling was planned on the assumption that the dunes acted as collectors of rainwater, and therefore that the best quality shallow groundwaters would occur in bores sited on or close to them. Poorer quality water was expected beneath the interdune flats, where saline waters were anticipated. These expectations were not borne out, although this did not become apparent until near the completion of the drilling programme, when the salinity pattern apparent on the accompanying plans began to emerge.

Subsequently, some thought having been given to the possible effect on the groundwater, of the replacement of native vegetation by deep-rooting plants such as lucerne, the Department of Mines invited the interest of the Division of Soils of the Commonwealth Scientific and Industrial Research Organisation in the problem of determining the depth of rainwater penetration into the soil. As a result, the investigation of the soil moisture regime was undertaken by

that organisation. For reasons indicated above preliminary discussions did not include the investigation of the interdune flats or low lying enclosed drainage basins. It was subsequently found that the latter were of local importance in their effect on salinity.

A detailed description of the C.S.I.R.O. contribution to this investigation is the subject of a separate paper (J. W. Holmes in C.S.I.R.O. report in press).

2. LOCATION

The area investigated lies on either side of the Woods Well - Culburra Road and includes the greater part of Hundred of Colebatch, the southern part of Hundred of Field and Section 34, Hundred of Richards. The western boundary of the area lies within 5 miles of the Coorong and extends easterly for a distance of approximately 18 miles. The total area is approximately 180 square miles, and the elevation is, on the average, about fifty feet above sea level. Although the whole area may be regarded as part of a very extensive plain, the local topography is broken into a system of sand rises which are apparently fractured portions of former dunes. Shallow, enclosed basins, also of sandy soil occur commonly and there is no surface drainage out of the area. This type of drainage is often referred to as internal drainage, which implies accession of water to the groundwater table, whence, by subsurface flow, the shallow aquifer discharges into the sea. In fact, the investigation to be reported in this paper will show that the shallow groundwaters of the area under experiment are basically of a saline nature, and in a few places only are connected with local surface drainage. Only in certain enclosed surface basins where runoff concentrates after heavy rain, and augments the rainwater precipitation penetrating downwards into the underlying rocks, is it possible for any refreshment of the saline groundwater to occur.

3. PHYSIOGRAPHY

The most prominent feature of the area is a high ridge trending northwesterly through the eastern part of Hd. Colebatch, having an elevation of more than 170 feet above sea level at the point where it is crossed by the Woods Well - Culburra road. The highest point of the ridge in this area is Mt. Boothby, rising to almost 300 feet above sea level and situated about 2½ miles north of the road. The ridge is quite prominent to the north of the road and can be traced for a considerable distance in that direction. To the south the ridge flattens and eventually cannot be distinguished from the other low dunes of the area.

The area generally is occupied by a succession of relatively low poorly consolidated sand dunes rarely rising to more than 100 feet above sea level. However, several isolated dunes rise to 200 feet or more above sea level. The dunes generally are trending east-west but with many local variations, so that in places the interdune depressions are completely enclosed.

There are occasional areas of almost flat country where the surface elevation varies by little more than 3-4 feet, the most prominent being the flat adjacent to the Woods Well road in the vicinity of the track to the Camp Bore, lying at a general elevation of about 52 feet above sea level. Other flats also occur further west along the Woods Well road and in the vicinity of Mt. Loggie.

In profile the larger dunes usually have a gentle slope on the northern side and steep southern slopes, indicating that stronger and more persistent winds came from the north during their formation. The smaller dunes are more rounded and generally more irregular than the larger dunes.

Average rainfall over the area is about 18 - 19 inches per annum, with possibly slightly increased precipitation in the vicinity of the high ridge, the nearest towns where rain-

fall records are known being Meningie, with an average of 18.14 inches per annum; Coonalpyn, 17.71 inches and Tintinara, 18.77 inches. Most of the rain falls during the months June, July and August, with occasional summer falls, and surface run-off is negligible, except after very heavy showers, when parts of the flats may be covered with water for short periods. This surface ponding, although intermittent, later proved to be of considerable hydrological importance.

In most parts of the area the dunes are "fixed" by a "desert heath" type of vegetation, including scattered and rather stunted mallee, much of which has apparently been burnt by several series of bushfires. In the vicinity of granite outcrops the mallee is taller and denser, possibly because of increased run-off and the presence of a certain amount of clay which retains moisture.

4. GEOLOGY

Granitic bedrock of probably early Palaeozoic age outcrops in certain areas, particularly along and in the vicinity of the high ridge, the rock being medium grained, grey in colour when fresh and brownish grey in the weathered zone. Occasionally it contains xenoliths of fine grained dark grey mica schist. The surface of the outcrops is generally smooth and rounded with jointing and fracturing sometimes well developed. In two localities the rock has been quarried for road metal. No granite outcrops are known in the western part of the area and the upper surface of the bedrock is most irregular as shown by logs of various deep bores.

The granite has apparently intruded mica schist which is not known to outcrop but has been intersected in a number of bores within the area and in its vicinity. The area thus forms a part of the Padthaway platform extending northward from the vicinity of Kington-Naracoorte railway and west of the railway through Coonalpyn, and is a zone of relatively shallow bedrock.

Overlying bedrock, which lies at a maximum known depth of almost 400 feet, is a succession of sand and clay, lignitic in part, and with some fossiliferous sand horizons. This succession has a thickness of at least 200 feet and appears to be the equivalent of the Knight Group, (Ludbrook 1956) which is lower Tertiary in age. The upper 150-200 feet of sediments in the area consists predominantly of aeolianite with some young limestone and occasional thin lenticular sandy clay horizons and these sediments are regarded as Pleistocene to Recent, possibly grading to upper Tertiary in the bottom 30 to 40 feet.

The aeolianite is usually fine grained and poorly consolidated particularly in the upper part of the succession, being composed of well rounded sand grains cemented in parts by calcium carbonate, and occasionally containing shell fragments. Apart from the travertine limestone the sediments to a depth of 40-50 feet are generally soft and friable, and it is likely that some of the calcium carbonate has been leached from these sediments by the action of groundwater and re-deposited as travertine limestone.

The travertine occurs as a thin crust at or close to the surface and often outcrops along the tops of the dunes where erosion has removed the sand. At the surface the sand is fine grained, loose and varies in colour, being generally white on the dunes and discoloured to grey by organic matter in the interdune depressions. In the depressions it is often very fine and silty and occasionally contains a small proportion of clay. These were possibly former swamp areas, in which the ground water table may have been at or above the surface. Sludges from a deep bore on Section 12, Hd. Colebatch have been submitted to a preliminary palaeontological examination with the following results:-

0 - 161 feet:	Predominantly aeolianite of known Pleistocene-Recent age.
161 - 191 feet:	The fossils are a mixture of Pleistocene and Tertiary forms and the sediments are considered to be mainly Pleistocene with some re-worked Tertiary.

At 191 feet the drill entered definite Tertiary formations, which are Eocene-Oligocene in age, continuing to a depth of 326 feet where weathered schist was encountered.

Fig. 2 shows the physiography and general geology of the area investigated. Aerial photos, which were taken subsequent to drilling operations, enabled the positions of the bores to be plotted accurately.

Fig. 3 is a cross section in an east-west direction across the area and indicates the various formations encountered during drilling.

5. METHODS OF INVESTIGATION

1. Groundwater studies

Testing of the underground water prospects in the area of about 180 square miles described above was first commenced by the Department of Mines in 1950, following an earlier regional survey of the area by T. A. Barnes and D. King (unpublished Departmental Report).

As the area was undeveloped and the groundwater prospects were then largely unknown, 20 test bore sites were selected at wide intervals in Hds. of Field and Colebatch. In the northern part of Hd. Field drilling and well sinking by various landholders had shown that the water occurring at shallow depth was generally quite saline, and for this reason the first of the 20 test bores was drilled in this area. It was continued to bedrock to test the deeper waters. All waters to a depth of 392 feet were found to be highly saline, and the bore was subsequently abandoned, it being considered that further testing of the deeper waters was not warranted at that stage.

The remaining 19 bores of the original programme were then drilled to test the shallow supplies. Some of these

encountered good quality water, although the aquifer generally consisted of a very fine sand which was liable to cause difficulties during development and pumping. Five of the bores were subsequently abandoned because of high salinity and a number of the others were taken over by landholders for stock watering.

In 1955 five of these bores were cleaned out and fitted with screens, and a further 100 bores drilled. In 1956 six bores were drilled, to five of which, water stage recorders were fitted. The total number drilled was 126 bores, 64 of which were preserved by lining with bore casing and the insertion of a screen into the aquifer.

At the five bores equipped with water stage recorders,* a continuous record of the water level was kept for a period of over 12 months. In the remainder, the water levels were measured by plumb-line at monthly intervals. Bore head levels were measured accurately and related to the Railway datum at Culburra.

The main test drilling programme was undertaken mainly during the winter of 1955 because of the difficulty of moving heavy plants through the soft dry sand in the summer.

The bores were drilled to water level, cased with 5" casing and if field salinity tests showed the water to be suitable for stock, a screen and pump were fitted. These were made as one unit in the form of a spear point which was forced into the fine sand of the aquifer below the casing, the supply being then developed by pumping for a 4 hour period, water samples being collected at hourly intervals and tested for salinity.

Of the total of 106 bores drilled during 1955-6, 48 yielded water of 1,000 grains per gallon or more and were subsequently abandoned. In addition to the remaining 58,

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* Type C. Water Stage Recorder, marketed by E. Esdaile & Sons Ltd. This recorder has an 8-day clockwork mechanism and a 24" range.

5 bores drilled in 1950 were reconditioned and fitted with screens, and an old well (68) was also included in the pump testing and subsequent sampling. Thus a total of 64 stock water supply points were established, including 5 water stage recorder bores not fitted with pumps. At the end of April 1956, when maximum salinities were anticipated, test pumping for four hours produced no abnormal salinity increases, though in several cases, notably bore Nos. 25 and 45, the original salinity of which was close to the limit for stock, the slight rise in salinity was sufficient to render them doubtful as permanent water supply points.

In some bores the original supply was found to have diminished considerably, this probably being a mechanical failure caused by fine sand blocking the screens.

In addition to the original samples, the water in the bores was sampled at three-monthly intervals to enable salinity variations to be observed. This sampling was also done by pumping, the pumps having been originally set within the topmost one to two feet of the aquifer, for the reason that the best quality water was expected at this upper surface.

2. Soil Moisture Studies

These were undertaken by the Commonwealth Scientific and Industrial Research Organisation, and are being reported on in detail elsewhere by J. W. Holmes, Senior Research Officer, for which reason they will be only briefly dealt with here. Two sites were chosen, one in a thinly established lucerne paddock and the other in an area of native heath, where soil moisture profile was measured by means of a neutron moisture meter. The technique has been described by Holmes and Jenkinson (1959). Observations were continued at approximately three-weekly intervals for two years, commencing in April 1956, and covered an extremely wet winter period when rainfall was considerably in excess of the average. A standard 8 inch rain gauge at each site was used to measure the rainfall accumulating during the interval between visits.

6. HYDROLOGY

1. Rainwater Penetration

Briefly, the soil moisture studies showed that, for the two sites investigated, local rainfall penetrated not more than about thirteen feet into the deep sand during a very wet winter. Since the water table is almost everywhere below this depth it follows that in the native heath country lenses or zones of good quality water floating in a surround of more saline water do not owe their existence to direct downward percolation of rainwater alone. A greater depth of penetration can be achieved when the rainwater precipitation on any area is augmented by surface runoff, however, and this phenomenon is believed to be responsible at least for the good water zone lying along the Hd. Field - Hd. Colebatch boundary.

Whether a significant increase in the depth of penetration from rainfall alone would result from the substitution of shallow rooting pastures for the types of vegetation covering the test sites, could not be ascertained without further investigation.

2. Deep waters

As a result of a number of deep bores drilled during the investigation it has been found that the deeper aquifers are highly saline. The deep bores are at wide intervals through the area and it appears that, apart from a narrow zone along the extreme eastern edge the water from these aquifers is quite unfit for stock.

Bore No. 51A may be taken as typical and its log is as follows:-

0 -	1'	Dark grey siliceous medium-coarse sand.
1 -	3'	Buff medium grained calcareous sand.
3 -	6'	Brownish yellow coarse grained sand.
6 -	20'	Buff calcareous silt.
20 -	42'	Buff calcareous silt - partly consolidated
42 -	46'	Greyish yellow soft limestone.

46 - 64'	Cream soft limestone.
64 - 90'	Pink soft limestone.
90 - 120'	Pink highly calcareous fine grained sand (partly consolidated) with fragments of limestone.
120 - 130'	Brownish yellow calcareous coarse grained sand.
130 - 165'	Dark grey to black lignitic clay.
165 - 195'	Dark grey clay with fragments of pyrite.
195 - 230'	White clay with small quantities of quartz grit.
230 - 270'	Light brown clay.
270 - 320'	Light green clay with some quartz grit.
320 - 323'	Light brownish-grey calcareous and siliceous grit.
323 - 340'	Light brown quartz grit with some calcareous fragments.

Water was encountered at 37, 42, 60 and 320 feet and the respective static levels were 37, 37, 37, and 300 feet. The salinities of the various waters were 1200, 630, 1140 and 2800 grains per gallon respectively. Usually the static level of the deepest aquifer is within 40 feet of the surface. This bore may therefore have been drilled into a deep depression in the bedrock and encountered only connate water.

All other deep bores in the area have yielded water of a similar quality from the deeper aquifers, apart from a bore on Section 119, Hd. Richards in which water of about 600 grains per gallon occurred.

Water under considerable pressure occurs in the sands of the Knight Group and has been utilized for stock purposes on the eastern side of the ridge towards Culburra. Its quality deteriorates markedly in a westerly direction from Culburra and within the area concerned it is apparently too saline for stock use, excepting in a zone along the western boundary of Hd. Richards.

A deep bore drilled on the property of A.A.D. Kings, Section 35, Hd. Richards, yielded a flowing supply from sand associated with lignitic clay at a depth of 240-270 feet. The

salinity of the water was almost 600 grains per gallon and the bore appears to be close to the western limit of usable stock supplies from this aquifer.

Approximately 7 miles to the south west another deep bore on Section 12, Hd. Colebatch obtained water in quartz grit at 265 feet, its salinity being 2,700 grains per gallon, and water at 318 feet in calcareous sand was also found to have a salinity of approximately 2,700 grains, the static water level in each case being 29 feet below the surface. Both aquifers lie beneath carbonaceous clay beds which are 28 and 5 feet thick, respectively, and belong to the Knight Group.

Similar results were obtained from other deep bores in Hds. of Field and Colebatch. As an example, bore No. CAR 1 Section 19, Hd. Field, drilled in 1950, yielded waters of more than 1,600 grains per gallon from two aquifers at 200 and 380 feet. In view of these results no further deep drilling of the area was undertaken until 1956, when five of the new bores numbered, 9^{A}, 17^{B}, 38^{C}, 51^{A}, and 77 respectively were drilled to a depth of 100 feet or more. These either hit bedrock at shallow depth, or cut salt water, which is probably connate and not influenced by any recharge, local or otherwise.

It is thought that the Knight Group sediments were deposited generally on a very irregular bedrock surface, the higher parts of which have interrupted their continuity, so that the sediments fill only the valleys and depressions. Under such conditions the general westerly movement of the pressure water is impeded, or prevented altogether, and as the Knight Group beds were deposited in what is considered to have been a somewhat saline environment, with occasional periods of marine sedimentation, any water trapped in the sediments would be saline.

The deeper waters within the Pleistocene-Recent formations are quite saline too, one known exception being bore No. 51^{A}, where the shallow water was unfit for stock purposes, but the deeper water cut at 42' was of better quality.

3. Shallow groundwaters

The pattern of the water table is shown in Figs. 4 and 5, which were compiled from measurements taken in July and November 1956, and show minimum and maximum water levels respectively.

Over most of the area there was very little change in water level over the period July - November, 1956. However, in November 1956 the water table reached its maximum level in the eastern part of the area, following heavy winter rains. Minimum water level for the whole period of investigations occurred in a number of bores along the eastern margin during July 1956, and thus Figs. 4 and 5 illustrate the maximum variation of the water table, mainly in a relatively narrow zone along the eastern margin of the area. The form of the water table, as shown by these two plans, was similar throughout the period of investigation. The general westerly fall of the water table, as shown on Figs. 4 and 5 is also indicated on the cross section (Fig. 3).

Hydrographs of bores 3 and 72 are shown in Figs. 6 and 7. These two bores are situated near the western and eastern boundaries respectively. The water level of bore No. 72 showed the greatest variation of any bore with pronounced crests toward the end of each year, particularly 1956. On the other hand the hydrograph of bore No. 3 shows a more or less continuous rise throughout the period. These two graphs are typical of the behaviour of the water at the eastern and western boundaries of the area. Hydrographs, compiled from water stage recorder graphs for test bores 2 and 3, are shown in Figs. 8 and 9. The recorders were in operation for about 15 months and in the area of Test bores 2 and 3 it is apparent that there was a slight but general rise of the water table throughout this period. Fig. 10 is a water stage recorder graph for a period of 1 week and shows a marked diurnal variation of the water table. Maximum variation of water level is about $\frac{1}{2}$ inch with the crests occurring about 8 a.m. on each day. These variations are considered to be caused by

changes in barometric pressure and temperature.

From east to west over a distance of 18 miles the water table falls from approximately 40 to 18 feet above sea level, an average gradient of little more than 1 foot per mile. Locally this gradient may be steeper, as in the vicinity of bore No. 72.

West of the granite outcrops the water table falls fairly regularly, minor fluctuations probably being caused by variations in permeability which affect the rate of movement of the groundwater. In this area there appears to be little if any correlation between salinity and the direction of movement. It is also worthy of note that the presence of the granite outcrops, which might be assumed to affect intake, has very little apparent effect on the groundwater contours.

In the more northerly area around bores 51, 46 and 48, the water table is almost flat, indicating either relatively high permeability or very limited intake. The latter is believed to be the case in this particular area as the sediments generally have a low permeability, and the salinity plans indicate a low salinity area immediately to the eastward. Another is recorded east of Mt. Loggie where the water table is higher than elsewhere in the area, but the refreshing effect of such intakes appears to be localized, as the salinity increases quite sharply to the westward, the water becoming too saline for stock use within a distance of about three miles.

Along the Hd. Field - Hd. Colebatch boundary another zone of good quality water occurs, its north-south axis cutting straight across the direction of the slope of the water table. Salinities within this zone showed some seasonal variations, but in several bores the water was more or less continually below 150 grains per gallon. In the case of Bore 36, there appears to be no explanation for this circumstance, unless it be assumed that it is a results of local intake. This central low salinity zone appears to continue southward beyond the vicinity of the area investigated, but is also believed to results from local intake. The alternative of a more distant

southerly intake seems unlikely as the water table locally does not indicate any northward component of movement, and recent drilling in the adjacent area to the north shows that the groundwater there is of noticeably higher salinity.

The contours of the water table for the period under review do not show any significant variations in the general pattern. In detail it can be seen that there is a gradual dissipation of seasonal high water levels in the eastern part of the area whereas toward the western boundary the water table varied little.

An examination of graphs of water levels in some bores showed marked variations, particularly in the south eastern part of the area.

Bore No. 72 shows the greatest variation in any bore of the whole area with a range of 6.8 feet, the maximum water level of this bore being 43.4 feet above sea level and 15.1 feet below ground in November 1956. This followed a winter of above average rainfall in the area, the upper limit of the static water levels in 1955 and 1957 being more than 4 feet below the maximum.

The hydrograph for bore 73 (Fig. 7) shows a rough wave motion with crests in the months of December, November, and October for the 3 years 1955, 1956, and 1957 respectively. In June 1956 the water fell to its lowest level of 36.6 feet above sea level, but rose rapidly following heavy rains and in the period August-September a rise of 3.5 feet was noted. The fall in water level during the early part of 1957 was slower than the rise in the latter part of 1956 and it levelled off in July at a value 1.2 feet above the previous year's minimum. After a winter of low rainfall the maximum for 1957 was only 0.2 feet above the minimum for that year. The hydrograph of bore 72 indicates that 80% of the high water (level) of 1956 was dissipated in approximately 8 months.

Other bores in the area show similar, but less marked variations in water level. In the area of Tolmer Rocks the bores tend to show a high water level at the end of 1956 after

which there is a slight fall followed by a continuous rise. Further north, bores show a general but slight rise throughout the period.

The maximum water level in Bore No. 30 was recorded one month after that of Bore No. 72 and about 130 chains further west in Bore No. 27 the maximum was not reached for another 3 months. This indicates a crest in the static water level moving very slowly west. In fact the movement is very slow and water levels in the western part of the area had not reached a maximum by January 1958, an example being Bore No. 3 where the water level has shown a more or less continuous, though small rise since July 1956.

There are exceptions to this general rise in the western part, particularly Bores Nos. 4 & 5 where the water level reached a maximum in December 1956. Local replenishment of the groundwater may occur, particularly in areas where it lies at shallow depth.

Of interest from a salinity viewpoint in the broad depression of the ground centreing around Bores Nos. 22 and 36, just east of the Hd. Colebatch border. If the low salinity zone extending northward past Cambalapien Well is refreshed only from the southward, no salinity decrease in the waters of these bores could be expected in, say 1956, when even with the unusually wet season no directional tilt of the hydraulic surface occurred. However, at Bore No. 36 the salinity was 207 grains per gallon in April 1956 following a dry hot summer, but declined to 71 grains in October 1956 after a wet season. The water surface is 34 feet down, much further than the depth of penetration of normal rain unless this is augmented in some way, and as the bore is surrounded by others whose salinity is higher, and showed much less variation, the logical conclusion is that local surface runoff increased the volume penetrating downward, to the point that additions to the groundwater occurred. Other examples of bores in which the water is of better quality than that common to the vicinity are Bores Nos. 52 and 54, at each of which it is difficult

to imagine a cause other than some local recharge which would result in the existing conditions. Such a reinforcement of the normal rainfall by local runoff is possible only in certain places where conditions are favourable, and does not appear to occur over much of the area. It is important to note that if the zones of better quality water depend on surface runoff for their occasional replenishment, any change in the surface conditions which prevents runoff could adversely affect the local water quality, particularly if the groundwater is at the same time being depleted by pumping.

In order to check the possibility of a wave motion in the water table through the area, 6 observation bores were drilled, five of which were equipped with water stage recorders. Graphs on the recorders were changed weekly to supply a continuous record of water level. The graphs generally show a slight but continuous rise from early in September, 1956 until January 1958, a crest being reached in only one bore (No. 4), during the period March-May 1957. This bore is situated toward the southern part of the area where it is possible that the rate of movement of groundwater is more rapid than further north. The graphs also showed small daily variations in water level, probably brought about by changes in temperature and pressure of the atmosphere.

The general conclusion from the water level measurements is that the aquifer seems to be recharged at the eastern boundary of the region studied and discharges its water to the Coorong and the sea. Moreover, a high static water level in the intake area following heavy rains may at first disperse fairly rapidly but the movement gradually slows down. A slight wave motion apparently results but it moves extremely slowly to the west, its complete dispersal being achieved over a number of years. Under the existing very flat hydraulic gradient, the overall rate of movement of water from east to west must be extremely slow.

Salinity of the Groundwater

The salinity plans show that a zone of highly saline groundwater occurs in the vicinity of the granite belt and

extends southerly to bores 77 and 78. Other areas of saline water are shown, particularly in the vicinity of bores 6 and 17. It has been noted that, with very few exceptions, bores situated in the higher parts of the area have yielded saline water. Thus, where the water table lies at more than 40 feet below the surface it is almost invariably saline. There are exceptions; the shallow water is occasionally saline, particularly bore C.A.R. 10 which is situated in an area of saline swamps.

To the east and west of the area of saline groundwater good quality stock water occurs and would appear to be derived from local rainfall percolating downward through the sand. However, this would only occur during average seasons where the water tables lies at a depth of 12 feet or less. Investigations in the western part of the area showed that the maximum penetration following the unusually heavy rainfall of 1956 was only approximately 16 feet.

Groundwater moving slowly westerly would be expected to become progressively more saline, but this effect is not observed except in the eastern area adjacent to the intake. On the western side of the granite belt there is practically no correlation between direction of movement and salinity of the groundwater. Hence the occurrence of fresh groundwater in the vicinity of Bore No. 22 is obviously influenced by local rainfall.

Bores where the highest water levels were recorded, at the end of 1956, did not yield better quality water at the time, and much of the water entering the area must be quite brackish. It might be argued that as the fresher water probably occurs as a relatively thin skin it is possible that the water samples taken had a higher salinity than that of the top water, since some of the pumps, which were used to sample the bores, were presumably several feet below the water level at the end of 1956. However, it is significant that in the case of Well No. 68, which was not equipped and from which the samples were taken at the water surface, it is found that

at the time of minimum water level in July 1956 the salinity was also at a minimum of 187 grains per gallon. Maximum salinity of 356 grains was recorded at a time of high water level in January 1957. This high water level is considered to be part of a wave of groundwater moving slowly westerly and it apparently confirms the general brackish nature of intake water. In this well the static water level is at an average depth of about 13 feet below the surface and it is therefore probable that a proportion of the groundwater is derived from local rainfall. Water at such shallow depth may also be affected by evaporation and this would tend to increase salinity in summer.

Such conditions do not seem to apply in the area of Bores Nos. 70, 70^{A}, 70^{B}, where the water table lies at a depth of 9-15 feet. Bore No. 70^{A} was abandoned as the water was almost 1,000 grains per gallon and the other two yielded brackish water throughout the period. In this area local rainfall does not seem to have any marked direct effect on salinity possibly because of low permeability of the surface sediments. The maximum salinity of 695 grains in Bore No. 70^{B} was recorded in July 1956, 3 months after minimum water level. Thereafter the salinity fell progressively to a minimum of 440 grains in October 1957 and coincided with the high water level of that year. Similar results were obtained for Bore No. 70 but the salinity fluctuated considerably with a minimum of 730 grains in October 1957.

The hydraulic surface indicates a very slow westerly movement from an intake area in the western part of Hd. of Richards, and the saline zones are believed to reflect the original character of the water in which the rocks were deposited. This general pattern of saline water has since been considerably modified by the influx of fresh surface waters following exceptional rains.

South of Cambalapien Well the largest of the good water zones is clearly visible on the salinity plan, but recent drilling in the northern part of Hd. Messent indicates

that it does not extend any great distance southward, forming in fact an island of fresher water in a more saline surround. Such an occurrence can only be satisfactorily explained as resulting from local replenishment, and it is probable that this occurred perhaps more than once, following an exceptionally wet season and the accumulation of surface flood waters in the near vicinity north of Alfred Flat.

The swamps of Alfred Flat are fed by Bakers Range drain and during 1956, a year of high rainfall, surface water reached to within one mile of the southern boundary of Hd. Colebatch. Remnants of that flooding still exist in the form of swamps, the most northerly having a salinity of 212 grains per gallon when sampled in November 1958. It is therefore possible that at an earlier period surface flow reached a point much further north, thus modifying the shallow groundwater considerably. The intake east of Mt. Loggia appears to be outside the area studied, but cannot be Lake Ellen, which is saline.

7. CONCLUSIONS

1. Deep Waters

A number of bores in the area investigated were drilled to test the deeper waters occurring in the Tertiary sediments, and in all cases these yielded highly saline water, normally under pressure. Usable stock water from the Tertiary aquifers apparently only occurs along the eastern margin. Further east the quality of the water from these aquifers improves considerably.

The general westerly movement of the pressure water is impeded by an area of bedrock "high", which in places outcrops at the surface. This has resulted in high salinity on the western side of the Mt. Boothby range, where much of the water is probably connate and not influenced by any recharge.

Apart from a zone along the eastern side of Mt. Boothby range, the deeper water is quite unfit for stock.

2. Shallow waters

The depth of occurrence of the groundwater in all the bores drilled was on the average about 37 feet, but it ranged between 9 and 80 feet. There is a fairly uniform downward gradient of the water table towards the west of 1:5,000, which means that the westward rate of movement of the groundwater under existing conditions is extremely slow.

The quality of the groundwater is very variable, ranging from more than 2000 grains/gallon to 150 grains/gallon with large tracts of the groundwater falling in the range 700-1500 grains per gallon, and water suitable for stock use is not everywhere available.

The groundwater discharges into the Coorong and the sea, and is recharged by surface runoff accumulating in local depressions, so that there may be no recharge during dry winters. On past occasions surface draimage water may have entered the area from further south, but such occurrences, if they took place at all, must have been infrequent. The main intake is, on the evidence of the hydraulic gradient, in the east, but the salinity rapidly increases with distance westward, and stock waters are available in the area studied, only as a result of local refreshment, generally where surface runoff accumulates.

There may be small local recharge by rainfall direct to the groundwater during wet winters, wherever the groundwater is shallower than 12 feet below the surface. Since the land surface area, where the water table is so shallow, is a small fraction of the whole, it is considered that this contribution is negligible. In the vicinity of Bore No. 36 the small zone of good quality water can only be satisfactorily accounted for if the normal rainfall percolation is added to by surface runoff, to provide sufficient water to wet the whole subsoil profile down to the water table, and allow the groundwater to be refreshed.

At the two soil moisture test sites, neither the native heath vegetation, or an established lucerne field used

any water from the water table itself, and no water from rainfall penetrated to the water table significantly at these two localities. Shallower rooting pastures, based on sub-clover and summer-dormant grasses, might use less water for transpiration and permit some deeper percolation during wet winters to the water table, but over much of the area the water table is at sufficient depth to render this unlikely.

The most important conclusion is that in areas where usable stock water now occurs, any process of land development which severely reduces or wholly prevents surface runoff from occurring and accumulating in the lower flats will eliminate further refreshment of the groundwater in those places. If this effect is accompanied by pumping out and use of the groundwater for stock, the water supplies will gradually decrease and deteriorate to the point where stock water will no longer be available.

8. ACKNOWLEDGEMENTS

Very sincere thanks are due to the management and in particular to Mr. G. Jones of Naranga Pastoral Company for their hospitality and ready co-operation received during the investigations, some of which were on Naranga property.

The Commonwealth Scientific Research Organisation readily made personnel and equipment available for the soil moisture studies, which formed a very important part of the investigation, and this work, as well as the friendly co-operation of Mr. J. W. Holmes, Senior Research Officer, and Mr. M. W. Hughes, Technical Officer, is very gratefully acknowledged.

9. REFERENCES

HOLMES, J.W. (1958) - The neutron scattering technique for measuring moisture of soils and other materials. Aust. Atomic Energy Commission Symposium on Peaceful Uses etc. 1958.

HOLMES, J.W. and JENKINSON, A.F. (1959) - Techniques for using the neutron moisture meter. J. Agric. Engin. Res. 4: 100-109.

LUDBROOK, N.H. (1956). - A reference column for the Tertiary sediments from the South Australian portion of the Murray Basin. J. and Proc. Roy. Soc. N.S.W. 90; 174-180.

SPRIGG, R.C. (1952) - The Geology of the South-East Province, South Australia, with special reference to Quaternary Coast-line migrations, and modern beach developments. Geological Survey of S. Aust. Bull. No. 29.

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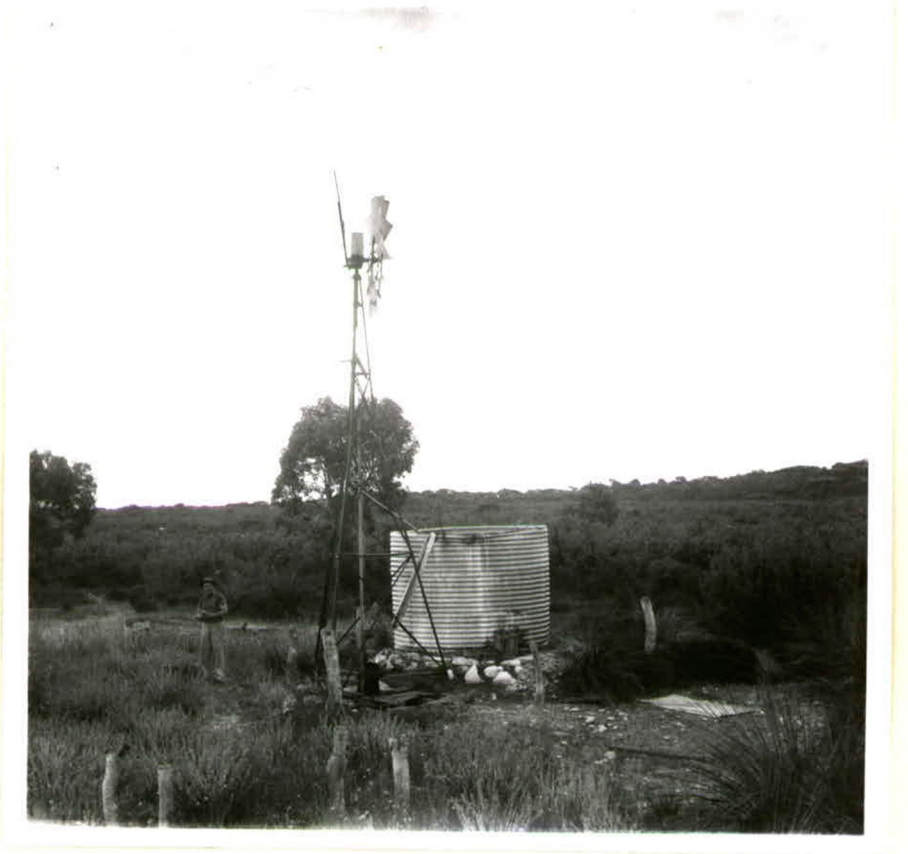
Senior Geologist

R. G. Shepherd
Geologist

EPO'D:RGS:CERF
8/12/59

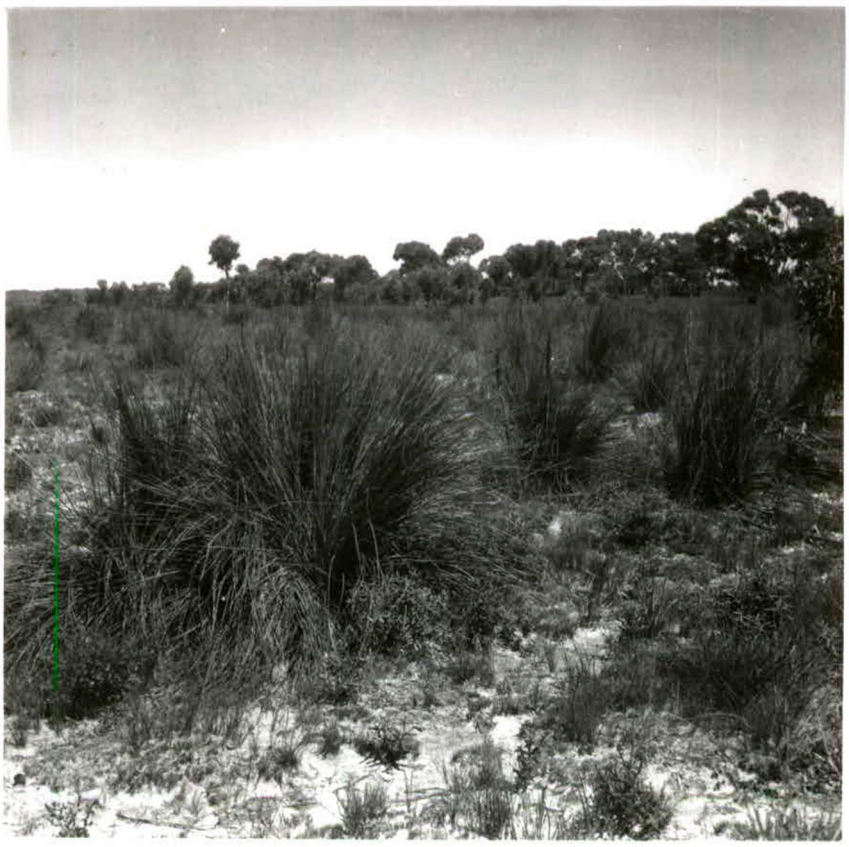
1. Prominent granite outcrop, ¾ mile north of Bore No. 59



2. Well No. 68 and its vicinity.

3. Bore No. 22, equipped with pump and tank

4. General view looking south towards Bore No. 15.



5. General view in vicinity of Bore No. 13

6. General view showing Bore No. 34A.

7. View of vegetation of the area.

S.A. DEPARTMENT OF MINES

Table No......

SUMMARY OF BORE RECORDS

Hundred.....FIELD.....

Ground Water Survey

County.....CARDWELL.....

BORE	SECTION	DEPTH *in feet below surface*			SUPPLY	SALINITY		HEIGHT *above sea level*	*Strata passed through*	*Remarks*
		Total	Water cut	Static level	*Gallons per hour*	*Grains per gallon*	*Analysis No.*			
C.A.R.1	19	392	40 200-240 380-388	355 35 70	- - -	1740 1620 1666.34	960/50 961/50 977/50	60	0-13' Fine yellow siliceous sand, somewhat clayey. 13-30' Calcareous sandstone (cream coloured) with hard limestone layers. 30-32' Hard cream-yellow limestone-fossil impressions. 32-64' Fine yellow sand - somewhat calcareous. 64-67' Yellow sandy limestone (Hard) with numerous small shell fragments. 67-80' Yellow and mottled sandy clay. 90-120' Very fine pale yellow calcareous sand - possible fossil traces. 120-124' Hard bars of light-coloured shelly limestone and dark brown sandy limestone. 124-140' Fine pale yellow-brown sand with a bar of sandy limestone, traces of shell fragments and fine gravel. 140-146' Blue grey clay with some sand - occasional limestone gravel and traces of carbonaceous material. 146-149' Hard grey siliceous limestone. 149-208' Soft yellow brown limestone - traces of bryozoa. 208-240' Pale buff-coloured soft limestone - traces of bryozoa, some blue clay with shell fragments. 240-334' Blue-grey clay - some medium gravel - possible traces of shell fragments. 334-339' Blue-grey clay with considerable medium gravel - possible traces of shell fragments. 339-361' Dark blue-grey clay - traces of medium gravel - fossil shell fragments? 361-380' Dark greenish grey clay - some pieces of purple slate. 380-388' Chocolate clay - numerous fine-mediun gravel. 388-392' Red and blue slate angular gravel - ranges from fine to coarse pink granite bottom (resembles Grotty's Knob granite).	Abandoned.
C.A.R.16	14	31	28	26	40	977.57	491/50	-	0-10' Fine white sand, mainly siliceous but also contains considerable lime carbonate. 10-18' Fine yellow sand, mainly siliceous with some lime carbonate. 13-25' Fine deep yellow siliceous and calcareous sand, bearing minute shell fragments. 25-31' Fine yellow siliceous and calcareous sand, abundant minute shell fragments.	Abandoned.
1	14	30	29	28	360	680	1385/56	43.1	0-3' Dark-grey siliceous sand (top soil). 3-5' Pale sandy highly calcareous clay (partly consolidated). 5-10' Dark-yellowish medium coarse sand. 10-24' Buff clayey calcareous sand (partly consolidated). 24-27' Buff-yellowish medium grained sand. 27-30' Buff medium-coarse siliceous sand.	
2	14	28	27½	26	50	800.74	1355/55	-	0-6' Dark-grey fine sand. 6-12' Buff-yellowish medium to fine grained sand. 12-15' Dark-yellow medium coarse siliceous sand. 15-26' Dark-yellow fine clayey sand. 26-28' Dark-yellow medium grained sand (water).	Abandoned.
2A	14	46	43	42	720	880	1386/56	58.3	0-1' Dark-grey siliceous sand. 1-11' Whitish-grey highly calcareous consolidated sand (sandstone). 11-40' Yellowish-grey fine grained sand. 40-46' Yellow fine to medium coarse sand.	
3 (C.A.R.18)	14	35	30	27	-	490	1387/56	44.4	0-6' Fine white siliceous sand. 6-35' Fine yellow siliceous sand - beach sand.	
4	14	30	29	28	60	450	1388/56	47.2	0-9'6" No samples (reported outcrop limestone) 9'6"-19' White-grey highly calcareous clayey sand. 19-29' Brown-yellowish medium grained sand. 29-30' Pale very fine grained sand.	

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S.A. DEPARTMENT OF MINES

Table No.....

SUMMARY OF BORE RECORDS

Ground Water Survey

Hundred..... FIELD

County ..... CARDWELL

BORE	SECTION	DEPTH *in feet below surface*			SUPPLY	SALINITY		HEIGHT *above sea level*	*Strata passed through*	*Remarks*
		Total	Water cut	Static level	*Gallons per hour*	*Grains per gallon*	*Analysis No.*			
5	14	43	41	40	150	801.24	1357/55	-	0-3' Dark-grey siliceous sand (Top soil). 3-12' Buff-brown highly calcareous clayey sand. 12-22' Buff calcareous fine grained sand. 22-32' Buff-greyish clayey sand (highly calcareous). 32-41' Pale medium grained calcareous sand. 41-43' Yellowish-grey medium grained sand.	Abandoned.
5A	14	60	58	58	360	680	1389/56	72.3	0-2' Buff fine grained sand. 2-14' Buff silty calcareous sand. 14-19' Pinkish calcareous silt. 19-37' Brown fine grained sand. 37-50' Buff highly calcareous fine sand partly consolidated (sandstone) 50-60' Buff yellowish fine grained sand (drift sand).	
6	14	45	40	37	400	1006.82	1358/55	-	0-3' Top soil. 3-10' Brown highly calcareous fine grained sand. 10-16' Brown highly calcareous clayey sand. 16-20' Buff calcareous fine grained sand. 20-28' Yellowish-grey highly calcareous fine grained sand. 28-33' Buff highly calcareous medium grained sand. 33-40' Yellowish brown medium grained highly calcareous sand (partly consolidated). 40-45' Buff highly calcareous medium to coarse grained sand.	Abandoned.
6A	14	81	81	80	-	942.61	1471/55	-	0-2' Brown sand. 2-5' Brown sand and clay. 5-9' Limestone. 9-18' White sand. 18-38' Brown sand. 38-46' Limestone. 46-51' Sandstone and sand. 51-68' Brown sand. 68-75' Limestone. 75-81' Sand. (Driller's Log).	Abandoned.
6B	14	86	84	80	100	934.47	1960/55	99.5	0-5' Grey fine siliceous sand. 5-15' Pinkish soft limestone. 15-28' Brown fine clayey sand (highly calcareous). 28-46' Light brown fine calcareous sand. 46-54' Pinkish soft limestone. 54-79' Yellowish soft (sandy) limestone. 79-86' Buff fine calcareous sand.	Abandoned.
7	14	40	29	29	180	380	1390/56	49.3	0-15' Light-grey fine grained siliceous sand. 15-25' Yellowish fine grained sand. 25-31' No samples. 31-36' Limestone) 36-40' Fine sand) Driller's log.	
8	14	36	33	32	60	348	1391/56	53.2	0-9' Buff medium grained siliceous sand. 9-16' White-grey fine clayey highly calcareous sand, cemented to sandstone. 16-22' Yellowish-grey medium to fine grained sand. 22-36' Yellowish-brown fine grained sand (drift sand, water).	
9	14	35	34	-	45	830	1392/56	52.4	0-4' Pale mediun grained sand. 4-14' Pale-greyish medium to fine grained highly calcareous sand (partly consolidated). 14-35' Dark-yellowish calcareous fine grained sand (drift sand, water).	
9A	14	165	41	36	1000	960	1574/55)	49.5	0-3' Brown yellowish calcareous fine grained sand. 3-12' Buff yellowish calcareous fine grained sand. 12-22' Dark yellow highly calcareous fine grained sand. 22-30' Yellow fine grained sand. 30-46' Yellow fine grained calcareous sand (partly consolidated to sandstone). 46-50' Buff fine grained calcareous sand. 50-56' Grey-green (mottled) plastic highly calcareous clay with fragments (concretions) of limestone. 56-58' Light-grey siliceous medium grained sand. 58-60' Grey medium grained sand. 60-68' Grey medium grained sand with shell fragments (? beach sand). 68-80' Grey yellowish medium grained sand. 80-95' Dark yellow medium grained sand. 95-100' Dark-grey-bluish sandy (Contd. over)	Abandoned.
			70	65	750	1120	1575/55)			
			115	100	500	826.72	1611/55)			
			158	50	1000	1300	1614/55)			

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Table No.....

S.A. DEPARTMENT OF MINES

SUMMARY OF BORE RECORDS

Ground Water Survey

Hundred..... FIELD .....

County ..... CARDWELL .....

BORE	SECTION	DEPTH *in feet below surface*			SUPPLY	SALINITY		HEIGHT *above sea level*	*Strata passed through*	*Remarks*
		Total	Water cut	Static level	*Gallons per hour*	*Grains per gallon*	*Analysis No.*			
9A (Contd.)	14								highly calcareous clay with shell fragments. 100-115' Black plastic clay with numerous shell fragments. 115-123' Dark-grey fine grained calcareous sand. 123-125' Dark-grey fine to medium grained sand. 125-140' Dark-grey micaceous calcareous fine grained sand. 140-154' Dark-grey fine grained sand. 154-158' Dark-grey-greenish plastic clay with shell fragments. 158-160' Yellow coarse sand and gravel 160-165' Dark-grey-greenish plastic clay.	Abandoned.
10	15	36	34	33	-	500	1393/56	58.4	0-7' Pale medium coarse siliceous sand. 7-16' Pale yellowish highly calcareous very plastic sandy clay (partly consolidated). 16-28' Dark-yellow medium to fine grained sand (drift sand). 28-36' Pale-yellowish medium grained sand (water).	
11	15	36	30	29	100	168	1394/56	52.9	0-6' Buff-greyish siliceous fine grained sand. 6-14' Buff-yellowish highly calcareous sandy clay. 14-20' Buff-yellowish highly calcareous fine clayey sand (drift sand). 20-28' Yellowish-grey fine grained sand with some calcareous inclusions. 28-30' Pale-grey fine grained sand with some shell fragments (water). 30-36' Pale-grey medium coarse siliceous sand with numerous shell fragments.	
11A (C.A.R.20)	15	37	35	29	-	197	1395/56	53.7	0-10' Fine yellow siliceous and calcareous sand - minute shell fragments. 10-25' Yellow clayey calcareous sand - possible shell fragments. 25-30' Fine-medium pale yellow siliceous sand bearing considerable lime carbonate. 30-37' Fine white siliceous sand, slightly calcareous.	
12	15	34	31	30	500	236	1396/56	52.0	0-8' Grey siliceous medium coarse sand. 8-25' White grey highly calcareous consolidated clay (limestone). 25-31' Dark yellow medium grained sand. 31-34' Yellowish grey medium siliceous sand.	
13	15	39	-	27	750	260	1397/56	51.9	0-28' Grey yellowish medium coarse sand. 28-30' Yellow medium coarse sand. 30-38' Dark grey siliceous fine grained sand with shell fragments.	
14	15	45	42	42	50	470	1398/56	61.5	0-7' Dark-yellowish fine grained siliceous sand. 7-36' Buff-yellowish highly calcareous clayey sand (partly consolidated). 36-42' Yellow fine grained calcareous sand.	
15	15	39	36	34	60	308	1399/56	55.1	0-3' Dark grey siliceous sand. 3-5' White-yellowish highly calcareous sandy limestone. 5-10' Buff-yellowish medium coarse sand. 10-25' Yellowish-brown fine grained sand (reported sandstone). 25-33' Brown-yellowish fine grained sand. 33-39' Brown-yellowish medium grained sand (drift sand-water).	
16	14	37½	34	31½	80	1070	1156/55	-	0-12' Dark-yellowish highly calcareous fine clayey sand. 12-27' Yellow highly calcareous clayey sand. 27-34' Grey-whitish highly calcareous sandstone (water). 34-37½ ' Unknown.	Abandoned

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Table No.....

S.A. DEPARTMENT OF MINES

SUMMARY OF BORE RECORDS

Ground Water Survey

Hundred..... FIELD

County ..... CARDWELL

BORE	SECTION	DEPTH *in feet below surface*			SUPPLY	SALINITY		HEIGHT *above sea level*	*Strata passed through*	*Remarks*
		Total	Water cut	Static level	*Gallons per hour*	*Grains per gallon*	*Analysis No.*			
16A	14	44	40	39½	200	590	1400/56	61.7	0-4' Dark-grey siliceous sand (Top soil). 4-8' Buff highly calcareous clayey sand (partly consolidated). 8-12' Buff-yellow highly calcareous fine grained sand (partly consolidated). 12-27' Buff highly calcareous clayey sand (partly consolidated). 27-39' Buff-yellowish clayey sand. 39-44' Buff-yellowish fine grained sand (sand drift - water).	
17	14	24	-	-	-	-	-		0-24' Sandstone.	Abandoned.
17A	14	82	81	80	200	1016.81	1364/55	-	0-40' No Samples. 40-45' Brown-yellowish fine sand. 45-55' Yellowish-grey very fine calcareous sand. 55-65' Buff highly calcareous fine sand with numerous fragments of consolidated calcareous sand (sandstone); some fragments are 2 inch in size. 65-70' Buff highly calcareous fine sand; calcareous fragments of sandstone are numerous, some of them are 2 - 3 inch in size. 70-80' Buff fine sand calcareous (less than the upper bed); small angular fragments of sandstone are numerous. 80-82' Buff-yellowish micaceous fine sand, calcareous (but no fragments of sandstone).	Abandoned.
17B	14	195 156 190	126 100 165	100 100 165	2000 1000 700	1120 1180 1040.72	1472/55 1473/55 1580/55	-	0-3' Brown medium coarse siliceous sand. 3-14' Buff highly calcareous fine grained sand (partly consolidated to sandstone). 14-27' Brown highly calcareous fine grained sand. 27-59' Buff highly calcareous fine grained sand (partly consolidated to sandstone-limestone). 59-90' Buff highly calcareous fine grained sand. 90-216' Brown-yellowish calcareous medium coarse siliceous sand. 126-130' Brown-yellowish calcareous coarse grained siliceous sand (partly consolidated to sandstone). 130-137' Calcareous sandstone. 137-156' Brown-yellowish medium coarse calcareous sand. 156-165' Brown-yellowish highly calcareous fine grained sand (partly consolidated to sandstone). 165-190' Dark-grey-bluish sandy highly calcareous clay with shells.	Abandoned.
17C (C.A.R.17)	14	30	27	25	-	290	1401/56	46.1	0-2' Fine white siliceous sand. 2-27' Yellow highly calcareous sand - some shell fragments and quartz sand. 27-30' Yellow brown fine and medium siliceous sand.	
18	14	48	42	42	300	540	1402/56	60.1	0-4' Sand (topsoil)) 4-9' Limestone) Driller's log 9-40' Soft sandstone) 40-48' Yellowish fine grained sand (drift sand).	
19 (C.A.R.19)	14	23	21	21	30	510	1403/56	40.7	0-10' Fine pale yellow siliceous sand bearing considerable lime carbonate. 10-23' Fine-medium yellow siliceous sand bearing considerable lime carbonate.	
20	14	28	25	21	350	372	1404/56	41.7	0-6' Buff calcareous fine sand. 6-12' Buff-yellowish fine sand. 12-18' Buff-yellowish fine sand partly cemented. 18-25' Yellowish fine sand. 25-28' Yellowish medium sand partly cemented.	
21	14	28	23½	22½	360	216	1405/56	46.1	0-3' Top soil (no sample). 3-11' Buff highly calcareous fine grained clayey sand. 11-28' Yellow calcareous medium grained sand.	

S.A. DEPARTMENT OF MINES

Table No......

SUMMARY OF BORE RECORDS

Hundred..... FIELD ..... Sheet 5

Ground Water Survey

County ..... CARDWELL .....

BORE	SECTION	DEPTH *in feet below surface*			SUPPLY	SALINITY		HEIGHT *above sea level*	*Strata passed through*	*Remarks*
		Total	Water cut	Static level	*Gallons per hour*	*Grains per gallon*	*Analysis No.*			
37	17	40	39	38	150	1694	1428/55	-	0-2' Brown-yellowish medium grained siliceous sand. 2-8' Brown-yellowish sandy plastic clay slightly calcareous. 8-15' Yellow-brown medium to coarse grained sand. 15-21' Yellow-brown coarse grained sand. 21-33' Brown-yellowish very coarse grained calcareous sand. 33-40' Brown-yellowish very coarse grained sand with numerous angular cemented fragments of calcareous sandstone.	Abandoned.
37A	17	55	54	50	500	1722.18	1691/55	-	0-3' Dark-grey siliceous sand. 3-6' Dark-yellow plastic sandy clay. 6-20' Yellow fine grained sand. 20-30' Buff-yellow fine to medium grained sand. 30-40' Buff-yellow medium coarse sand. 40-50' Yellow-brown fine to medium grained sand. 50-55' Buff calcareous medium grained sand.	Abandoned.
38	17	41	40	37	250	1414.12	1429/55	-	0-2' Buff siliceous fine grained sand. 2-20' Yellowish-brown fine grained sandwith calcareous patches. 20-22' Yellow-brown very fine slightly calcareous sand. 22-37' Buff-yellowish very fine micaceous sand. 37-41' Yellowish very fine sand.	Abandoned.
38A	17	55	54	52	-	1559.28	1617/55	-	0-2' White sand. 2-8' Yellow sand. 8-20' Sand. 20-35' Sandstone. 35-50' Sand. 50-55' Limestone. (Driller's log).	Abandoned
38C	15	120	41	-	-	1440	Field Test	80	0-1' Dark-grey fine siliceous sand. 1-10' Grey fine siliceous sand. 10-30' Grey fine clayey sand (consolidated). 30-38' Yellow fine clayey sand. 38-45' Yellow fine sand. 45-47' Brownish-yellow sandy clay. 47-49' Multicoloured sandy clay. 49-58' Greyish-yellow clayey sand. 58-70' Grey fine sand. 70-79' Grey coarse sandstone. 79-81' Yellowish coarse sand. 81-109' Grey fine sand partly consolidated to sandstone. 109-113' Dark yellow fine sand. 113-120+ Buff fine sand with shells.	Abandoned
39	15	35	34	33	180	620	1416/56	54.2	0-4' Buff-yellowish fine sand. 4-12' Yellow-brownish clayey sand. 12-22' Yellow-brownish very fine sand. 22-35'Dark-yellow fine (clayey) sand.	
41B	15	70	40	38	-	Salt	-	79	0-6" Dark-grey fine siliceous sand. 6"-3'9" Grey fine sand. 3'9"-8' Grey soft limestone. 8-17' Yellow clayey sand. 17-29' Yellowish sandy clay. 29-45'6" Brown clayey sand consolidated to sandstone. 45'6"-48' Yellowish-grey sandstone. 48-70' Yellowish-brown fine sand.	Abandoned.
Camp Bore	14	60	30 41	27 27	700 700	420 510	1413/55 1384/56	49.5	0-1' Dark brown calcareous sandy clay. 2-10' Buff highly calcareous clay with fragments of limestone. 10-15' Buff highly calcareous clay with hard fragments of limestone. 15-20' Yellowish fine grained sand (calcareous). 20-30' Yellowishbrown fine-grained sand. 30-37'6" Buff medium grained siliceous sand. 37'6"-41' Light-grey medium grained sand with shell fragments. 41-50' Light-grey fine grained sand with shell fragments and angular fragments of highly consolidated limestone (1-2 inch). 50-60' Grey medium coarse sand (drift sand).	

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Table No.....

S.A. DEPARTMENT OF MINES

SUMMARY OF BORE RECORDS

Hundred FIELD

Ground Water Survey

County CARDWELL

BORE	SECTION	DEPTH *in feet below surface*			SUPPLY	SALINITY		HEIGHT *above sea level*	*Strata passed through*	*Remarks*
		Total	Water cut	Static level	*Gallons per hour*	*Grains per gallon*	*Analysis No.*			
T.B.1	14	40	35½	35	-	357.5	1486/56	56.8	0-1' Light grey fine siliceous sand. 1-21' Buff fine to medium grained siliceous sand with some angular quartz fragments. 21-35'6" Pale yellow brown fine siliceous sand. 35'6"-40' Light greyish brown fine grained calcareous sandstone (aeolianite).	
T.B.2	14	27	27	22		385.4	1487/56	43.5	0-2' Greyish brown fine grained siliceous sand. 2-8' Fine yellow brown siliceous sand, slightly clayey. 8-15' Yellow brown fine siliceous sand. 15-23' Light yellow brown fine grained calcareous sandstone. 23-27' Light greyish brown fine grained calcareous sandstone.	
T.B.3	9	40	33	33	-	452.8	1488/56	52.6	0-2' Greyish brown fine siliceous sand. 2-10' Buff fine calcareous and siliceous sand with calcareous nodules. 10-25' Fine light yellow brown slightly calcareous sand. 25-33' Light yellow brown fine grained siliceous limestone with calcareous sand. 33-40' Partly consolidated light yellow brown calcareous sandstone, fine grained.	

Table No.....

S.A. DEPARTMENT OF MINES

SUMMARY OF BORE RECORDS

Hundred COLEBATCH

Ground Water Survey

County CARDWELL

BORE	SECTION	DEPTH *in feet below surface*			SUPPLY	SALINITY		HEIGHT *above sea level*	*Strata passed through*	*Remarks*
		Total	Water cut	Static level	*Gallons per hour*	*Grains per gallon*	*Analysis No.*			
C.A.R.2	11	22	20	18	100	619	813/50	-	0-3' Fine white siliceous sand. 3-7' Hard limestone - no sample. 7-22' Fine white highly calcareous sand.	
C.A.R.3	12	33	(18 (23 (30	20 22 28	40 - -	571.94 563 3,600	562/50 560/50 561/50	-	0-6' Very fine white siliceous sand. 6-23' Pale yellow fine siliceous sand - slightly calcareous. 23-28' Very fine pale grey siliceous sand. 28-30' Pale yellow-grey fine calcareous sandstone bearing small shell fragments. 30-33' No sample.	Abandoned.
C.A.R.4	9	21	21	15	50	600.40	563/50	-	0-4' Pale grey fine siliceous sand and surface soil. 4-18' Fine-medium pale yellow siliceous sand - a little admixed clay. 18-21' Pale yellow siliceous and calcareous fine sand with layers of hard limestone with fossil shell impressions.	
C.A.R.5	9	31	30	28	60	654	814/50	-	0-6' Fine white siliceous sand. 6-18' Pale yellow-fine-medium siliceous sand and grit bearing considerable lime carbonate. 18-31' Pale yellow fine siliceous sand - slightly calcareous with layers of hard limestone (no sample).	
C.A.R.6	9	23	21	19	80	477.94	874/50	-	0-2' Fine white siliceous sand. 2-17' Hard yellow-brown clayey and calcareous sandstone. 17-23' Fine-medium pale grey siliceous sand bearing some lime carbonate.	
C.A.R.7	9	30	27	22	900	53.38	485/50	-	0-5' Fine white siliceous sand. - slightly calcareous. 5-10' Fine white siliceous and calcareous sand. 10-25' Deep yellow siliceous fine sand - slightly calcareous. 25-30' Fine pale yellow siliceous sand containing considerable calcareous material.	
C.A.R.8	12	38	36	34	40	645.13	875/50	-	0-3' Fine white siliceous sand and surface soil. 3-25' Fine yellow siliceous and calcareous beach sand. 25-38' Fine yellow siliceous and calcareous sand with layers of hard sandy limestone with shell fragments.	
C.A.R.9	11	33	31	29	80	1370	564/50	-	0-4' Fine white siliceous sand. 4-16' Pale yellow-fine-medium siliceous sand. 16-18' Yellow calcareous sandy clay. 18-22' White limestone with some hard bars. Fossil shell impressions. 22-33' White sandy clay - no sample.	Abandoned.
C.A.R.10	11	40	(18 (38	13½ 13	100 800	2140 3340	815/50 486/50	-	0-3' Fine white siliceous sand. 3-14' Yellow brown high calcareous fine sand. Some shell fragments. 14-20' Dirty grey clayey siliceous sand. 20-31' Soft white limestone bearing considerable fine quartz sand. 31-40' Green laminated clay bearing some fine siliceous sand and abundant shells.	Abandoned.
C.A.R.12	10	38	(25 (33-38	19 17	60-80 + 500	1136.59 1740	477/50 ?	-	0-2' Fine white siliceous sand. 2-5' Fine yellow brown clayey sand - calcareous with minute shell remains. 5-13½' Pale yellow calcareous and siliceous fine sand - some quartz grit. 13½-19½ White fine lime sand with some admixed clay and shell fragments. 19½-33' Soft white limestone - abundant small shell fragments (resemble coxiella). 33-38' Fine to coarse limestone gravel with shell fragments and quartz grit.	Abandoned.

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Sheet 2

Table No......

S.A. DEPARTMENT OF MINES

SUMMARY OF BORE RECORDS

Ground Water Survey

Hundred.....COLEBATCH.....

County.....CARDWELL.....

BORE	SECTION	DEPTH *in feet below surface*			SUPPLY	SALINITY		HEIGHT *above sea level*	*Strata passed through*	*Remarks*
		Total	Water cut	Static level	*Gallons per hour*	*Grains per gallon*	*Analysis No.*			
C.A.R.13	8	34	33	33	80	1138.42	487/50	-	0-3' Fine white siliceous sand loose. 3-8' Yellow brown siliceous sand with admixed clay. 8-12' Highly calcareous yellow brown sandy clay - shell fragments? 12-22' Fine and even-grained yellow siliceous beach sand. 22-28' Fine grained white limestone and quartz grit. 28-33' Fine to coarse yellow siliceous sand.	Abandoned.
C.A.R.14	8	35	(31 (34½	24 24	80 600	1200 1280	488/50 489/50	57	0-2' Fine white siliceous sand and grit. 2-10' Pale brown clayey fine quartz grit. 10-12' Ydlow clayey fine quartz grit. 12-18' Yellow-brown clayey fine quartz sand and grit. 18-23' Red-brown sandy clay - puggy. 23-28' Cream coloured limestone bearing abundant shell fragments. 28-31' Hard white limestone with fossil shell impressions. 31-32½ Fine white highly calcareous sand. 32½-34½ Hard white limestone with fossil shell impressions. 34½-35' Limestone sand and gravel bearing abundant shell fragments and some quartz grit.	Abandoned.
C.A.R.15	8	40	37	34	50	916.39	490/50	-	0-28' Fine white and yellow siliceous sand. 28-40' Pale grey siliceous sand with minute shell fragments and hard bars of limestone.	Abandoned.
22	8	(62 (orig.32	32 ?	30 36	200 720	159	1406/56	51.2	0-10' Buff medium to fine grained sand. 10-19' White - grey highly calcareous plastic clay. 19-29' Yellowish clayey fine grained sand. 29-32' Unknown. 32-52' Sand (Driller's log from 32') 52½-62' Grey sand.	
23	8	37	36	35	300	175	1407/56	51.1	0-2'6" Buff mediu m to fine grained siliceous sand. 2'6"-25' Yellow medium grained clayey sand. 25-32' Brown-yellow medium grained sand. 32-35' Brown-yellow calcareous medium grained clayey sand. 35-37' Brown medium grained sand.	
24	8	36	34	33	350	174	1408/56	55.2	0-2' Black - grey siliceous sand. 2-10' Yellowish fine calcareous sand. 10-16' Buff fine sand. 16-20' Buff highly calcareous fine sand partly cemented. 20-24' Buff highly calcareous fine sand with flint. 24-31' Buff fine sand. 31-36' Buff fine sand.	
25	8	37	33	31	200	980	1409/56	58.4	0-1' Dark-grey fine-grained siliceous sand. 1-3' Brown-yellowish fine grained siliceous sand. 3-18' Dark-yellow clayey sand (partly consolidated to sandstone) with white patches of calcareous material. 18-27' Light-grey highly calcareous fine grained sand. 27-30' Dark-yellow fine grained sand. 30-37' Brown-yellowish fine grained sand.	
26	8	32	29	27	150	252	1410/56	53.9	0-2' Dark grey fine grained siliceous sand. 2-4' Brown-yellowish fine grained sand. 4-13' Buff-yellowish highly calcareous fine sand (Partly consolidated to sandstone) 13-20' Grey-yellowish calcareous fine grained sand (partly consolidated to sandstone) 20-28' Light grey fine to medium coarse siliceous sand, slightly calcareous. 28-32' Brown-yellowish fine grained siliceous sand.	
27	8	46	44	44	150	690	1892/56	64.4	0-1'6" Dark-grey siliceous sand (top soil). 1'6"-10' Brown-yellow medium grained sand. 10-25' Light-brown medium grained sand. 25-46' Brown medium grained clayey sand.	

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Table No.....

S.A. DEPARTMENT OF MINES

SUMMARY OF BORE RECORDS

Ground Water Survey

Hundred..... COLEBATCH

County ..... CARDWELL

BORE	SECTION	DEPTH *in feet below surface*			SUPPLY	SALINITY		HEIGHT *above sea level*	*Strata passed through*	*Remarks*
		Total	Water cut	Static level	*Gallons per hour*	*Grains per gallon*	*Analysis No.*			
28	8	37	36	35	200	976.66	1422/55	64	0-2' Dark-grey medium coarse sand. 2-6' Brown-yellowish medium coarse clayey sand. 6-12' Grey-yellowish fine grained clayey sand. 12-19' Brown-yellowish fine grained clayey sand. 19-26' Grey slightly calcareous sandy clay. 26-31' Yellow-brown clayey sand. 31-34' Dark-yellow slightly calcareous fine grained sand. 34-37' Dark yellow calcareous fine grained sand (water).	Abandoned.
28A	8	36	34	29	300	790	1411/56	60.8	0-1' Dark grey fine siliceous sand. 1-3'6" Buff calcareous fine sand. 3'6"-5' Brownish ferruginous sandy clay. 5-9' Brown plastic clay with fragments of grey limestone. 9-22' Greyish yellow sandy clay. 22-34' Grey clayey sand. 34-36' Buff highly calcareous fine sand partly cemented to limestone.	
29	8	32	30	30	150	924.96	424/55	58	0-1'3" Dark grey siliceous fine grained sand. 1'3"-12' Buff highly calcareous clayey fine grained sand. 12-18' Grey calcareous sand (Partly consolidated). 18-26' Light grey highly calcareous clayey sand (partly consolidated) 26-29' Light grey medium coarse sand. 29-32' Grey-yellowish calcareous clayey sand (partly consolidated).	Abandoned
29A	8	44	42	-	180	1386	Field Anal.	68	0-2' Dark-grey fine siliceous clay. 2-10' Buff fine calcareous sand. 10-20' Grey calcareous cemented sand (sandstone) 20-28' Light-grey fine calcareous sand. 28-39' Yellowish-grey sandy clay. 39-44' Dark yellow clayey sand partly consolidated (sandstone).	Abandoned
30	8	32	30	30	100	720	1412/56	57.1	0-6' Dark-grey siliceous sand. 6-12' Yellowish fine sand. 12-16' Buff highly calcareous fine sand partly cemented. 16-24' Yellowish fine calcareous sand. 24-28' Yellowish medium sand. 28-32' Buff medium sand.	
31	8	35	33	31	250	1600	1475/55	67	0-3' Black-grey siliceous sand. 3-27' Brownish-yellow siliceous cemented sand (sandstone) 27-31' Whitish-grey calcareous fine sand partly cemented (sandstone-limestone). 31-35' Buff fine calcareous sand.	Abandoned
31A	8	47	45	43½	-	1300	1966/55	53	0-5' Pink calcareous fine sand. 5-10' Yellowish fine sand. 10-23' Yellowish fine sand with some clay. 23-26' Yellowish fairly coarse sand. 26-47' Yellowish - brown gritty siliceous sand.	Abandoned.
32	8	39	37	36	60	1450	1821/55	-	0-2' Dark-grey siliceous sand. 2-8' Brownish-yellow calcareous fine sand partly cemented (sandstone). 8-25' Whitish fine calcareous sand partly cemented. 25-28' Buff fine sand. 28-34' Buff fine sand partly cemented. 34-39' Buff fine calcareous sand.	Abandoned.
33	8	45	43	41	400	1200	1436/55	-	0-2' Dark-grey siliceous sand. 2-4' Buff medium sand. 4-8' Buff medium sand. 8-15' Buff calcareous clayey sand, partly cemented. 15-18' Buff sandy clay. 18-25' Yellowish clayey sand. 25-29' Buff cemented silt (limestone) 29-34' Buff fine sand. 34-45' Yellowish fine sand.	Abandoned.
33A	8	49	47	44	250	V.Salt		-	0-9" Dark-grey fine siliceous sand. 9"-6' Light grey fine siliceous sand. 6-16' Yellow fine sand partly with clay. 16-22' Buff fine sand. 22-29' Buff fine sand partly with clay. 29-37' Whitish-grey limestone. 37-49' Light-grey calcareous fine sand partly consolidated to limestone.	Abandoned.

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Table No.....

S.A. DEPARTMENT OF MINES

SUMMARY OF BORE RECORDS

Ground Water Survey

Hundred COLEBATCH

County CARDWELL

BORE	SECTION	DEPTH *in feet below surface*			SUPPLY	SALINITY		HEIGHT *above sea level*	*Strata passed through*	*Remarks*
		Total	Water cut	Static level	*Gallons per hour*	*Grains per gallon*	*Analysis No.*			
34	8	40	38	37	-	924.17	1425/55	57	0-3' Grey fine grained siliceous sand. 3-5' Yellowish grey fine grained siliceous sand. 5-7' Yellow fine grained sand with white-yellowish calcareous highly cemented inclusions (concretions). 7-14' Yellowish-grey fine calcareous sand. 14-21' Yellow clayey sand, calcareous. 21-28' Yellow fine calcareous sand. 28-40' Buff very fine highly calcareous sand.	Abandoned
34A	8	42	40	39	90	530	1413/56	60.3	0-1' Dark grey siliceous sand. 1-10' Buff calcareous fine grained sand. 10-29' Dark-yellow clayey sand. 29-33' Yellow fine sand. 33-42' Grey-yellowish fine sand and highly calcareous sandstone.	
35	8	33	31	29	150	316	1414/56	55.8	0-3' Dark grey siliceous fine-grained sand. 3-5' White-grey siliceous fine grained sand (loose). 5-11' Buff yellowish highly calcareous clayey sand with numerous white inclusions. 11-28' Yellowish-white highly calcareous clayey (fine-grained) sand (cemented) with calcareous inclusions. 28-33' Pale yellowish-grey very fine ocalcareous sand with some white calcareous inclusions.	
36	8	43	40	34	250	156	1415/56	59.0	0-3' Dark-grey siliceous sand (top soil). 3-10' Buff-yellowish medium grained sand. 10-18' Grey-yellowish medium grained sand. 18-27' Dark-yellow medium grained sand. 27-34' Yellow medium grained sand. 34-43' Dark-yellowish fine grained sand (drift sand, water).	
40	3	44	42	39	200	1850	1589/55	77	0-1' Reddish-brown sandy clay. 1-4' Yellowish sandy calcareous clay. 4-15' Buff-yellowish fine sand partly cemented. 15-36' Yellowish medium sand. 36-44' Whitish-yellow clayey sand.	Abandoned.
41	3	50	48	45	200	1350	1477/55	-	0-2' Brown medium coarse siliceous sand. 2-8' Brownish-yellow medium sand. 8-20' Buff calcareous silt. 20-35' No sample. 35-46' Buff highly calcareous silt partly cemented. 46-50' Brownish-yellow medium sand.	Abandoned.
41A	8	96	40 90	37 37	-	Salty		80	0-6" Dark-grey fine siliceous sand. 6"-5' Grey fine siliceous sand. 5-15' Greyish-yellow fine clayey sand partly consolidated. 15-20' Yellow clayey sand. 20-37' Brownish-yellow clayey sand. 37-46' Greyish-yellow medium sand partly consolidated to sandstone. 46-60' Yellowish medium sand. 60-75' Buff-grey medium sand partly consolidated to sandstone. 75-86' Grey gritty sand. 86-96' Brown coarse sandstone	Abandoned.
42	8	43	43	42	-	1260.79	431/55	61	0-2' Dark-grey fine-grained siliceous sand. 2-4' Buff-yellowish fine medium grained siliceous sand. 4-5' Yellow clayey sand (illuvial horizon). 5-18' Yellow fine grained sand, consolidated to some degree (reported as sandstone), highly calcareous, (white calcareous inclusions are numerous). 18-26' Yellowish-grey plastic sandy clay slightly calcareous (not as much as the upper bed). 26-28' Yellowish fine grained sand slightly calcareous. 28-36' Buff fine to medium grained sand with some grey clayey seams, slightly calcareous. 36-43' Yellowish-brown medium to coarse grained sand.	Abandoned.

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Table No.....

S.A. DEPARTMENT OF MINES

SUMMARY OF BORE RECORDS

Ground Water Survey

Hundred..... COLEBATCH

County ..... CARDWELL

BORE	SECTION	DEPTH *in feet below surface*			SUPPLY	SALINITY		HEIGHT *above sea level*	*Strata passed through*	*Remarks*
		Total	Water cut	Static level	*Gallons per hour*	*Grains per gallon*	*Analysis No.*			
42A	8	61	59	59	-	1650	1590/55	72	0-2' Dark grey siliceous sand. 2-26' Buff yellow siliceous fine grained sand. 26-33' Yellow fine grained sand. 33-46' Buff-yellowish fine grained sand. 46-57' Yellow fine grained sand. 57-60' Yellow fine grained sand (drift sand).	Abandoned.
43	3	57	56	56	30	1700	1787/55	87	0-1' Dark-brown fine sand. 1-8' White-pinkish limestone. 8-20' Buff fine calcareous sand partly consolidated to limestone. 20-57' Light-brown fine sand.	Abandoned.
44	8	41	39	37	200	1300	1872/55	64	0-4' Buff fine calcareous sand. 4-12' Yellow clayey sand. 12-20' Yellow calcareous fine sand consolidated to sandstone. 20-23' Buff calcareous fine sand. 23-26' Light brown medium calcareous sand. 26-41' Brownish-red medium sand partly consolidated.	Abandoned.
45	8	54	52	48	50	960	1899/56	72.35	0-2' Dark-grey siliceous fine sand. 2-9' Grey medium siliceous sand. 9-12' Whitish soft limestone. 12-25' Grey medium sand (consolidated). 25-36' Yellowish coarse sand partly consolidated to sandstone. 36-54' Yellowish coarse sand.	Backfilled to 48'.
46	10	48	40	38	720	270	1418/56	70.3	0-1' Dark-grey siliceous sand. 1-3' Buff fine sand. 3-9' Brownish-yellow clayey sand. 9-14' Yellowish clayey sand. 14-20' Buff (yellowish) calcareous fine sand. 20-28' Yellowish medium sand. 28-37' Buff-yellowish clayey sand. 37-43' Buff fine sand. 43-48' Whitish cemented sand.	
47	10	43	41	39	480	570	1419/56	71.60	0-10' Dark-grey fine siliceous sand. 10-29' Yellow clayey sand. 29-39' Buff clayey fine sand (partly consolidated) 39-43' Whitish-grey soft limestone.	
48	10	44	39	34	300	179	1420/56	67	0-2' Dark-grey siliceous sand. 2-4' Light-grey fine sand. 4-5' Reddish-brown sandy clay. 5-12' Brownish-yellow clayey sand. 12-36' Brownish-yellow fine sand. 36-39' Buff highly calcareous cemented silt (limestone) 39-40' Whitish-grey plastic clay. 40-44' Buff fine calcareous sand.	
48A (C.A.R.11)	10	39	37	30	60-80	670	1421/56	65.7	0-2½' Fine pale grey siliceous sand. 2½-6¾' Deep brown clayey sand and grit. 6¾-11½' Yellow brown fine siliceous sand, some clay and grit. 11½-26½' Pale yellow fine and even-grained siliceous sand. 26½-28½' Yellow brown clayey limestone with minute shell fragments. 28½-39' Hard pale yellow limestone with fossil impressions.	
49	10	41	40	39	125	550	1422/56	71.7	0-4' Dark-grey fine siliceous sand. 4-9' Reddish calcareous sandy clay. 9-11' Grey sandy calcareous clay. 11-13' Reddish-yellow sandy clay (partly consolidated) 13-25' Grey sandy clay. 25-39' Yellow clayey sand (consolidated) 39-41' Light-grey marl (soft).	
50	10	48	47	47	320	740	1423/56	74.6	0-2' Sandy loam. 2-10' Yellow sand. 10-34' Limestone. 34-48' Limestone. (Driller's Log).	

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Table No.....

S.A. DEPARTMENT OF MINES

SUMMARY OF BORE RECORDS

Ground Water Survey

Hundred..... COLEBATCH

County ..... CARDWELL

BORE	SECTION	DEPTH *in feet below surface*			SUPPLY	SALINITY		HEIGHT *above sea level*	*Strata passed through*	*Remarks*
		Total	Water cut	Static level	*Gallons per hour*	*Grains per gallon*	*Analysis No.*			
51	10	43	41	41	120	860	1424/56	71.7	0-2' Dark-grey siliceous sand. 2-8' Buff fine calcareous sand. 8-12' Yellowish fine sand. 12-20' Yellowish calcareous clayey sand. 20-30' Buff (whitish) cemented sand (limestone) 30-43' White calcareous cemented sand (limestone).	
51A	10	340	(37 (42 (60 (320	37 37 37 300	1500 250 1000 1000...	2800	1791/55	-	0-1' Dark-grey siliceous medium coarse sand. 1-3' Buff medium grained calcareous sand. 3-6' Brown-yellowish coarse grained sand. 6-20' Buff calcareous silt. 20-36' Buff calcareous silt partly consolidated. 36-42' Buff calcareous silt partly consolidated. 42-46' Grey-yellowish limestone (loose material). 46-60' Cream-coloured limestone. 60-64' Cream-coloured limestone (partly loose material). 64-90' Reddish-cream limestone (partly-loose material). 90-104' Pinkish highly calcareous fine grained sand (partly consolidated). 104-120' Pinkish highly calcareous fine grained sand with limestone fragments. 120-130' Brownish yellww calcareous coarse grained sand. 130-140' Black lignitic clay. 140-165' Dark grey lignitic clay. 165-195' Dark grey clay with fragments of dark grey pyritic rock. 195-230' White clay with small quantities of quartz grit. 230-270' Light brown clay. 270-320' Light greenish clay with some quartz grit. 320-323' Light brownish grey medium calcareous and siliceous grit. 323-340' Light brown medium grained quartz grit with some calcareous fragments.	Abandoned.
51B	10	41	39	38	80	710	1425/56	68.2	0-2' Light grey medium grained siliceous sand with some calcareous fragments. 2-4' Buff medium grained siliceous and calcareous sand. 4-20' Buff highly calcareous clay with some quartz grit. 20-31' Light brown slightly clayey limestone. 31-36' Buff friable marly limestone with some quartz grit. 36-39' Cream limestone; consolidated, and containing fossils. 39-41' Light brown medium grained siliceous and calcareous sand.	
52	8	48	48	43½	50	450	1426/56	73.4	0-3' Brown medium siliceous sand. 3-6' Brown-reddish fine calcareous sand. 6-10' Pinkish limestone (soft). 10-22' Yellowish-brown coarse sand. 22-29' Buff coarse siliceous sand. 29-34' Buff fine calcareous sand partly cemented to limestone. 34-41' Buff soft limestone. 41-47' Yellowish-brown very fine sand. 47-48' Yellowish-grey sandy clay.	
53	8	43	41	31	240	904.51	1976/55	62	0-1' Ferruginous sandy clay. 1-15' Dark-grey calcareous sandy clay (partly consolidated to limestone. 15-40' Buff-yellow calcareous fine sand. 40-43' Brownish-yellow coarse sand partly consolidated (sandstone)	Abandoned.
54	8	46	44	42	50	940	1427/56	70.3	0-5' Grey fine siliceous sand. 5-9' Brown clayey fine sand. 9-13' Brown clayey fine sand, partly consolidated. 13-16' Grey sandy clay. 16-32' Buff calcareous fine sand consolidated to limestone. 32-36' Brownish-yellow fine sand. 36-42' Buff coarse sand partly consolidated to limestone. 42-44' Grey fine sand. 44-46' Yellow medium sand partly consolidated.	
55	8	52	49	44	100 +	1129.94	1977/55	69	0-9' Dark-grey fine siliceous sand. 9-20' Buff-yellowish calcareous fine sand. 20-32' Yellowish medium sand partly cemented. 32-49' Brownish-yellow coarse sand. 49-52' Yellowish-grey coarse siliceous sand.	Abandoned.

Table No.....

S.A. DEPARTMENT OF MINES

SUMMARY OF BORE RECORDS

Ground Water Survey

Hundred..... COLEBATCH

County ..... CARDWELL

BORE	SECTION	DEPTH *in feet below surface*			SUPPLY	SALINITY		HEIGHT *above sea level*	*Strata passed through*	*Remarks*
		Total	Water cut	Static level	*Gallons per hour*	*Grains per gallon*	*Analysis No.*			
56	8	40	38	29	400 +	1219.85	1978/55	54	0-1' Dark-grey fine siliceous sand. 1-3' Buff-medium calcareous sand. 3-6' Yellowish-grey fine sand. 6-8' Yellowish calcareous fine sand. 8-20' Yellow very fine calcareous sand. 20-30' Whitish-grey highly calcareous sandy clay with fragments of limestone. 30-40' Yellowish fine sand.	Abandoned.
57	8	40	37	34	200	1053.78	1979/55	62	0-1' Dark-grey siliceous medium sand. 1-3' Buff medium sand. 3-6' Light-grey medium sand. 6-10' Brownish-yellow medium sand. 10-18' Brownish-yellow calcareous medium s and. 18-30' Buff-yellow clayey sand. 30-35' Whitish-grey highly calcareous sandy clay. 35-40' Light-grey highly calcareous clayey sand.	Abandoned.
58	10	53	49	48	360	1152.11	1740/55	-	0-1' Dark-grey fine siliceous sand. 1-10' Buff calcareous fine sand. 10-35' Buff highly calcareous sand cemented to limestone. 35-41' Whitish-grey highly calcareous silt partly cemented to limestone. 41-49' Greyish-yellow medium sand partly cemented to limestone. 49-53' Whitish limestone.	Abandoned.
59	10	39	37	35	80	480	1428/56	67.3	0-8' Dark-grey siliceous fine sand. 8-19' Yellowish sandy clay. 19-37' Yellowish fine clayey sand. 37-39' Yellow fine sand.	
60	10	42	39	37	360	947.57	1743/55	-	0-7' Dark-grey fine siliceous sand. 7-18' Buff fine sand. 18-30' Yellowish fine sand (clayey) consolidated 30-42' Light-grey very fine sand (reported as lime-stone).	Abandoned.
61	10	51	49	42	300	1620	1744/55	-	0-1' Dark-grey fine siliceous sand. 1-9' Brownish-yellow fine sand. 9-14' Ferruginous sandy clay. 14-20' Brownish-yellow sandy clay. 20-24' Yellowish-brown plastic clay with calcareous inclusions. 24-27' Brown calcareous sandy clay. 27-49' Brownish-yellow sandy clay. 49-51' Buff fine sand.	Abandoned.
62	10	36	32	29	60	530	1429/56	61.7	0-1' Dark-grey fine siliceous sand. 1-8' Buff fine calcareous sand. 8-24' Yellow plastic sandy clay. 24-30' Whitish-grey calcareous plastic clay. 30-36' Grey medium siliceous sand.	
63	10	38	36	35	-	1300	1748/55	-	0-3' Dark grey fine siliceous sand. 3-11' Yellow fine calcareous sand. 11-24' Dark-yellow clayey sand. 24-36' Buff-grey calcareous clay partly consolidated (limestone). 36-38' Grey calcareous clay partly consolidated.	Abandoned.
70	11	26	23	22	300	905	1434/56	48.8	0-4' Dark grey fine siliceous sand. 4-7' Buff fine calcareous sand. 7-9' Greyish-yellow sandy clay. 9-22' Buff clayey sand. 22-26' Grey clayey sand.	
70A	11	55	(20 (52	15 15	300 300	970.73 1850	1900/55 1901/55	-	0-6" Brown fine siliceous sand. 6"-4' Grey limestone 4-19' Brownish-yellow sandy clay. 19-26' Yellow clayey sand with shells. 26-37' Yellow fine sand with shells. 37-49' Greenish-grey plastic clay. 49-55' Grey clayey sand with numerous shells.	Abandoned
70B	11	50	(18 (48	10 -	160 -	695 1470	1435/56 1875/55	44.9	0-2' Dark grey fine siliceous sand. 2-10' Light-grey fine highly calcareous sand. 10-35' Yellowish-grey fine sand. 35-40' Whitish-grey sandstone. 40-48' Whitish-grey sandy clay. 48-50' Grey fine sand with shells.	Back filled to 20'

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Table No.....

S.A. DEPARTMENT OF MINES

SUMMARY OF BORE RECORDS

Hundred COLEBATCH

Ground Water Survey

County CARDWELL

BORE	SECTION	DEPTH *in feet below surface*			SUPPLY	SALINITY		HEIGHT *above sea level*	*Strata passed through*	*Remarks*
		Total	Water cut	Static level	*Gallons per hour*	*Grains per gallon*	*Analysis No.*			
71	11	32	30	21	60	755	1436/56	56.5	0-2' Light greyish brown fine grained siliceous sand. 2-10' Buff fine grained siliceous sand with some quartz grit. 10-26' Buff fine grained calcareous sand, partly consolidated. 26-28' Buff fine grained siliceous sand, calcareous in part. 28-32' Light greyish brown fine grained partly consolidated sandstone, highly calcareous.	
72	11	32	30	20½	192	685.83	1837/55	58.5	0-2' Dark-grey fine siliceous sand. 2-12' Buff fine calcareous sand. 12-14' Whitish highly calcareous fine sand partly cemented to limestone. 14-24' Yellowish very fine calcareous sand consolidated to sandstone. 24-30' White marl. 30-32' Greyish-white clayey sand (highly calcareous).	
73	11	37	35	20	360	730	1437/56	53.5	0-2' Dark-grey fine siliceous sand. 2-18' Buff calcareous fine sand. 18-22' Greyish-yellow sandy calcareous clay. 22-24' Grey plastic clay partly cemented (limestone) 24-34' White consolidated (hard) clay. 34-37' Grey medium sand.	
74	11	36	36	35	100	1070.90	1905/55	60	0-2' Dark grey fine sand. 2-4' Buff calcareous sand (fine) 4-23' Yellow clayey sand partly consolidated (sandstone) 23-34' Whitish-grey highly calcareous clay partly consolidated (limestone). 34-36' Grey calcareous clayey sand.	Abandoned.
75	11	34	31	27	240	372	1438/56	58.6	0-1' Dark-grey fine siliceous sand. 1-10' Buff fine calcareous sand. 10-12' Greyish-yellow sandy clay. 12-18' Greyish-yellow sandy clay partly consolidated. 18-24' White soft limestone. 24-34' Grey clayey sand partly consolidated (limestone).	
76	11	29	27	-	-	1005.33	1878/55	49.8	0-1' Dark-grey fine siliceous sand. 1-14' Buff very fine calcareous sand. 14-24' Grey sandy clay. 24-29' Yellowish fine sand.	
77	11	100	(26 (43	20 -	1000 -	1300 1250	1882/55 1881/55	54	0-5' Dark grey fine siliceous sand. 5-9' Yellow clayey sand. 9-21' Grey-yellow sandy clay. 21-27' Grey clay and limestone. 27-29' Buff calcareous clay. 29-42' Whitish-grey compact clay. 42-45' Grey calcareous medium sand with shells. 45-60' Buff medium sand with shells. 60-64' Yellowish fine sand. 64-79' Grey clayey sand with shells. 79-100' Grey-greenish clayey sand.	Abandoned.
78	11	44	39	31	-	1170	1883/55	67	0-2' Dark grey fine siliceous sand. 2-18' Yellow fine sand. 18-24' Yellow fine calcareous sand partly consolidated. 24-30' Buff highly calcareous sand consolidated to limestone. 30-33' Greenish-grey sandy clay (compact). 33-38' Light-grey very fine calcareous sand. 38-44' Grey very fine calcareous sand.	Abandoned.
T.B.4	8	33	26	25	-	180.2	1489/56	50.2	0-2' Greyish brown fine siliceous sand. 2-7' Light yellow brown fine siliceous sand. 7-25' Buff fine calcareous sand, partly consolidated. 25-33' Light yellow brown fine grained calcareous sandstone (aeolianite).	
T.B.5	8	43	37	37	-	811.0	1605/56	63.2	0-1' Greyish brown fine siliceous sand. 1-7' Buff sandy limestone, fine to medium grained. 7-12' Greyish brown clayey sand with calcareous nodules. 12-43' Yellow brown fine calcareous and siliceous sand with scattered calcareous nodules.	

5M—11.58 4005

Table No.....

S.A. DEPARTMENT OF MINES

SUMMARY OF BORE RECORDS

Hundred COLEBATCH

Ground Water Survey

County CARDWELL

BORE	SECTION	DEPTH *in feet below surface*			SUPPLY	SALINITY		HEIGHT *above sea level*	*Strata passed through*	*Remarks*
		Total	Water cut	Static level	*Gallons per hour*	*Grains per gallon*	*Analysis No.*			
T.B. 6	10	41	36	36	-	128.7	1606/56	67.9	0-2' Light grey fine siliceous sand. 2-17' Light yellow brown fine sand, slightly calcareous and with scattered calcareous nodules. 17-26' Buff fine grained calcareous sandstone with quartz grit. 26-36' Light yellow brown fine calcareous sand with quartz grit and scattered calcareous nodules. 36-41' Buff sandy limestone gravel.	

S.A. DEPARTMENT OF MINES

Table No.....

SUMMARY OF BORE RECORDS

Ground Water Survey

Hundred..... RICHARDS

County..... CARDWELL

BORE	SECTION	DEPTH *in feet below surface*			SUPPLY	SALINITY		HEIGHT *above sea level*	*Strata passed through*	*Remarks*
		Total	Water cut	Static level	*Gallons per hour*	*Grains per gallon*	*Analysis No.*			
64	34	43	40	38	240	760	1430/56	67.4	0-2' Dark-greysfine siliceous sand. 2-11' Buff medium calcareous sand. 11-19' Yellowish clayey sand. 19-22' Grey clayey sand. 22-34' Buff medium sand. 34-36' Bluish-grey sandy clay. 36-39' Buff calcareous sandy clay. 39-43' Yellowish medium sand.	
65	34	38	36	33	120	445	1431/56	64.9	0-2' Dark-grey fine siliceous sand. 2-8' Reddish-brown calcareous sand (fine). 8-11' Buff calcareous clayey sand. 11-35' Grey sandy clay. 35-38' Grey fine calcareous sand.	
66	34	36	34	32	450	1600	1798/55	"	0-4' Dark grey fine siliceous sand. 4-12' Dark-yellow calcareous clayey sand. 12-19' Yellowish-grey sandy clay. 19-33' Buff calcareous clayey sand. 33-36' Grey highly calcareous clay (?limestone).	Abandoned.
67	34	39	38	25½	180	525	1914/56	61.9	0-2' Dark-grey fine siliceous sand. 2-6' Light grey fine siliceous sand. 6-8' Yellow sandy clay (calcareous) 8-15' Yellowish fine grained calcareous sand partly cemented to sandstone. 15-20' Yellow fine calcareous sand. 20-23' Bluish-grey calcareous clay. 23-36' Grey calcareous clay partly cemented to limestone. 36-39' Light grey very fine sand.	
68	34	20	"	"	100+	187	1432/56	53.1	No log (Well).	
69	34	24	"	"	450	1094.13	1802/55	56	0-4' Grey fine siliceous sand. 4-8' Buff-yellowish fine calcareous sand. 8-20' Grey-yellow clayey sand. 20-24' Buff fine calcareous sand.	Abandoned.
69A	34	25	22	14	220	690	1433/56	56.8	0-5' Grey fine siliceous sand. 5-8' Buff calcareous clayey sand. 8-18' Buff clayey sand partly consolidated (?limestone). 18-(?limestone).	

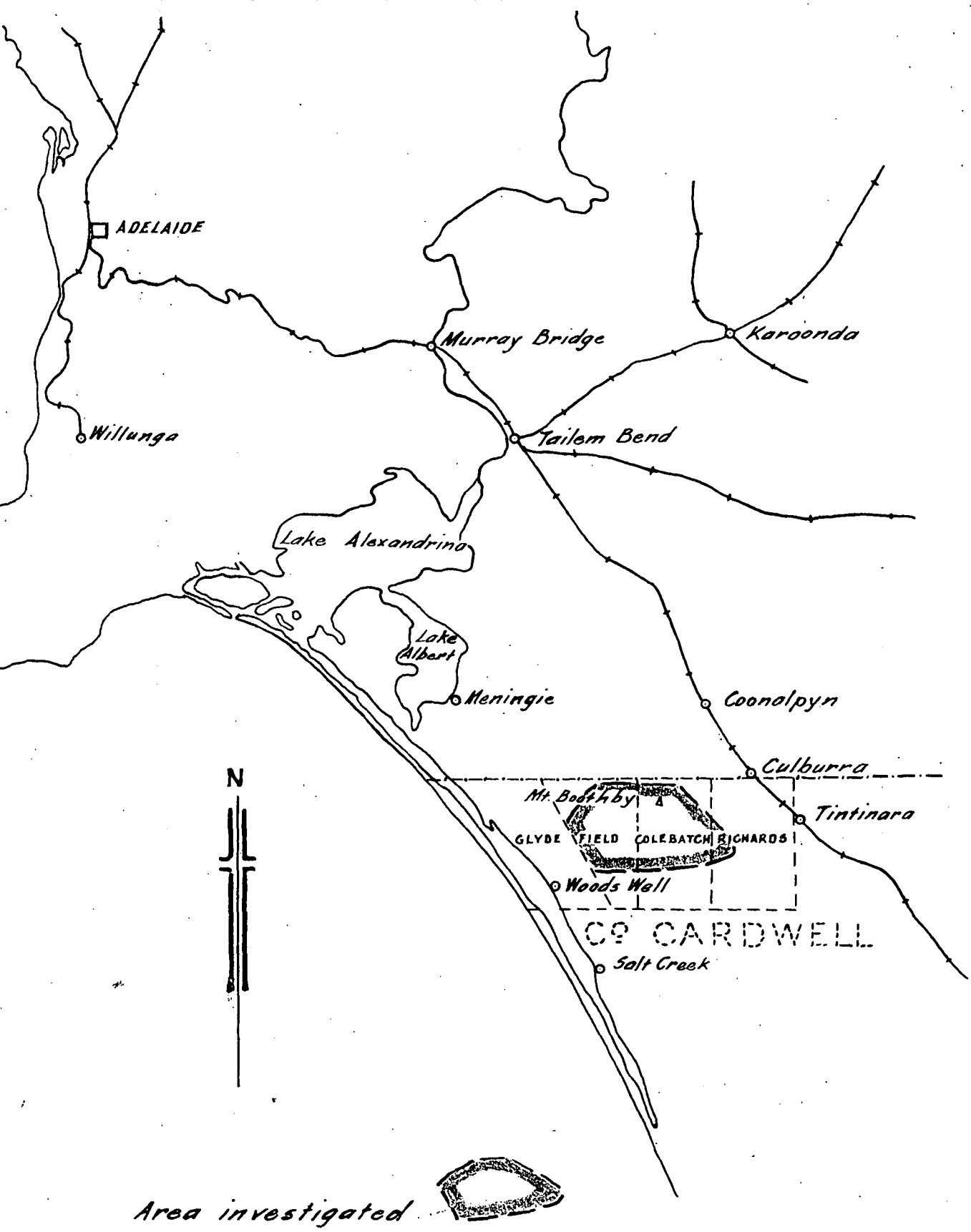


FIG. 1.

To accompany report by E.P. O'Driscoll and R.G. Shepherd.

S.A. DEPARTMENT OF MINES					
Approved	Passed	Drn.	GROUNDWATER INVESTIGATION	D.M.	Scale: 16 Miles to 1 in.
		Tcd. R.R.	PTN Co CARDWELL	Req.	S 2303
		Ckd.	LOCALITY PLAN		Ka 4/6
Director		Exd.			Date 19-11-59

—8.50 2776

JEFFRIES | STRAWBRIDGE | CONEYBEER

FIELD | COLEBATCH | RICHARDS

GLYDE

MT. BOOTHBY RANGE

& Mt Boothby

Quarry

Quarry

Sand Bore

Tolmer Rocks

Reedy Walls

Lamboolaparen well

King H.S.

Mt Leggie

Heatlie H.S.

Lake Ellen

A

A'

N

Scale

PLEISTOCENE

Yellow brown fine sand and travertine

Saline Swamps

Prominant Dunes - Trend Lines

?EARLY PALAEOZOIC

Medium grained grey granite

Bore 73 / 153·2

Surface Contours (approx) 25' intervals — 150 —

Salt swamp

Limits of investigations

Granite outcrops

Bore 16 Survey No.

DATUM - L.W.O.S.T. Pt Adelaide 100·00 Feet

FIG. 2

		Req. No.	S.A. DEPT. OF MINES	Approved	Passed		Scale: 1 mile to 1 inch
		D.M.	GROUNDWATER INVESTIGATIONS - PORTION OF Cº CARDWELL			Drn.	59-349
		Compiled from	PHYSIOGRAPHY AND GENERAL GEOLOGY			Tcd. G.S.	Ka 4/6
Associated Drawing No.	No. Amendment Ext. Date			Director of Mines		Ckd. A.R. Ext.	Date 7-9-1959

JEFFRIES | STRAWBRIDGE | CONEYBEER

FIELD | COLEBATCH | RICHARDS

GLYDE

Mt Boothby

Ready Wells

Camp Bore

Tolmer Rocks

King H.S.

Mt Loggie

Lake Ellen

Combalapien Well

Weslip H.S.

N

Contour interval :- 1 Foot

Salt swamp

Limits of investigations

Granite outcrops

Bore ○16 Serial N°

Scale

mls 1 0 1 2 3 4 mls

FIG. 4

S.A. DEPT. OF MINES

GROUNDWATER INVESTIGATIONS - PORTION OF Co CARDWELL

WATER TABLE CONTOURS

JULY 1956 (Minimum Levels)

Req. No.
D.M.
Compiled from

Approved | Passed

Director of Mines

Drn.
Tcd. G.S.
Ckd. R.K.
Exd.

Scale : 1 mile to 1 inch

59-348
Ka 4/6

Date 7-9-1959

Associated Drawing No.

No. | Amendment | Ext | Date

JEFFRIES | STRAWBRIDGE | CONEYBEER

FIELD | COLEBATCH | RICHARDS

GLYDE

Mt Boothby

Treeby Wells

Quarry

Camp Bore

Tolmer Rocks

Mt Loggie

Lake Ellen

Measlip H.S.

Kelly H.S.

Cambalapien Well

DATUM :- L.W.O.S.T. Pt Adelaide 100·00 Feet

Salt swamp

Limits of investigations

Granite outcrops

Bore ○16 Serial No

Scale

mls 1 0 1 2 3 4 mls

FIG.5

S.A. DEPT. OF MINES

GROUNDWATER INVESTIGATIONS - PORTION OF Co CARDWELL

WATER TABLE CONTOURS

NOVEMBER 1956 (Maximum Levels)

Req. No.
D.M.
Compiled from

Approved | Passed

Director of Mines

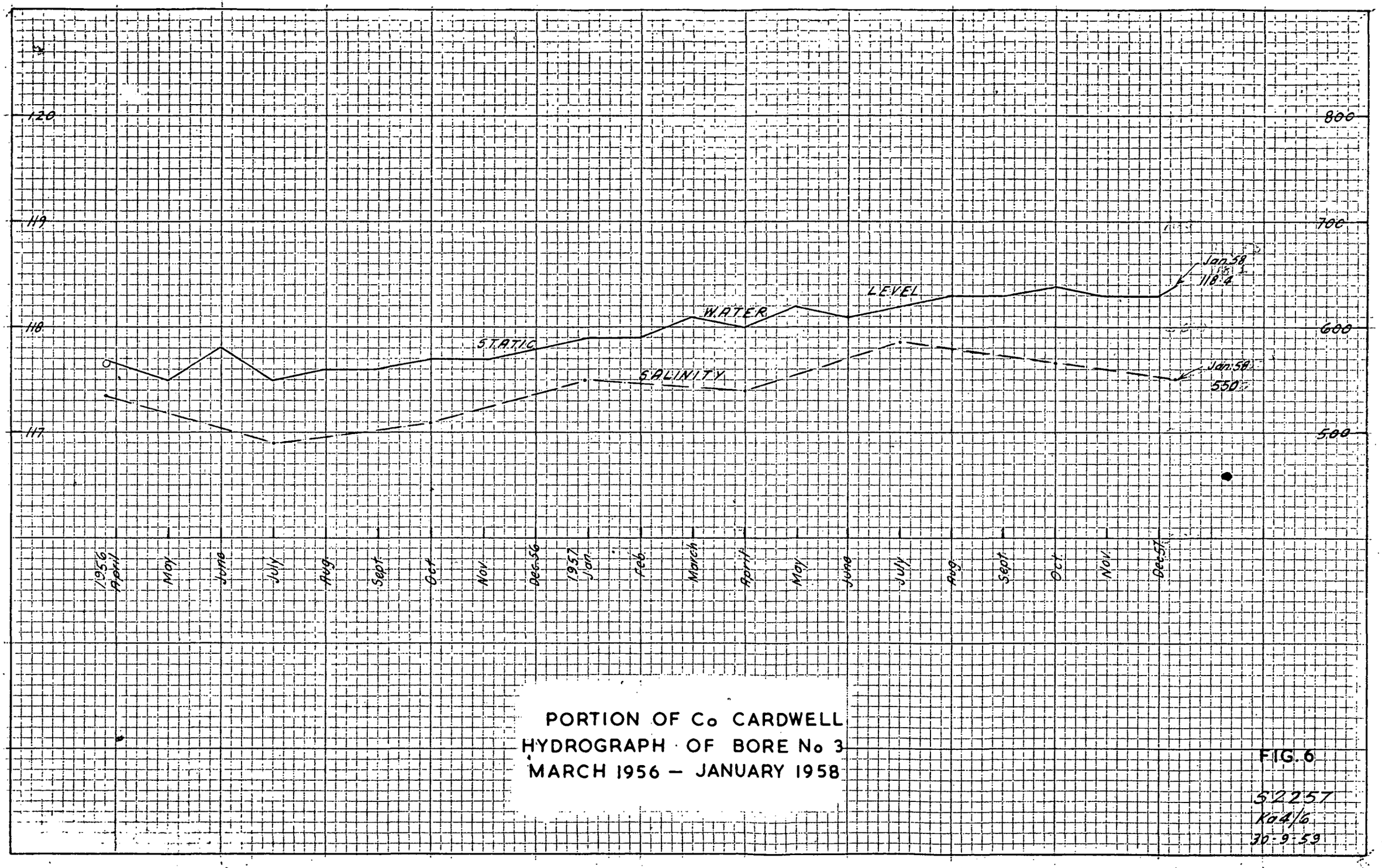
Drn.
Tcd. G.S.
Ckd. A.K.
Exd.

Scale 1 mile to 1 inch

59-347
Ka 4/6

Date 7-9-1959

Associated Drawing No. | No. | Amendment | Exd. | Date



PORTION OF Co CARDWELL
HYDROGRAPH OF BORE No 3
MARCH 1956 — JANUARY 1958

FIG. 6

S12257
Ka4/6
30-9-59

144
143
142
141
140
139
138
137
136

STATIC WATER LEVEL

No Record

Jan.58
137·5

Oct.55 Nov. Dec.55 1956 Jan. Feb. March April May June July Aug. Sept. Oct. Nov. Dec.56 1957 Jan. Feb. March April May June July Aug. Sept. Oct. Nov. Dec.57

PORTION OF Co CARDWELL
HYDROGRAPH OF BORE 72
OCTOBER 1955 – JANUARY 1958

FIG.7

52256
K.A.16
30-9-59

FIG 8

BORE No. 2

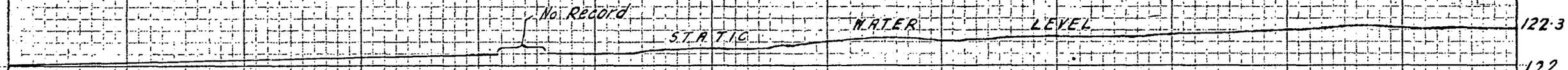
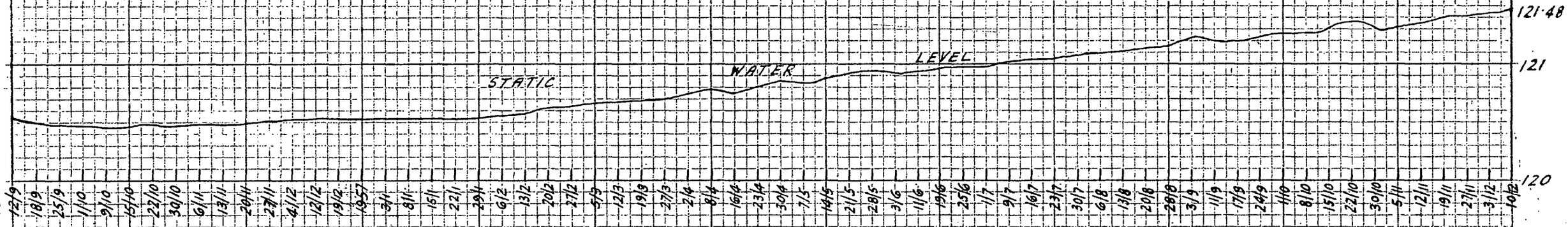


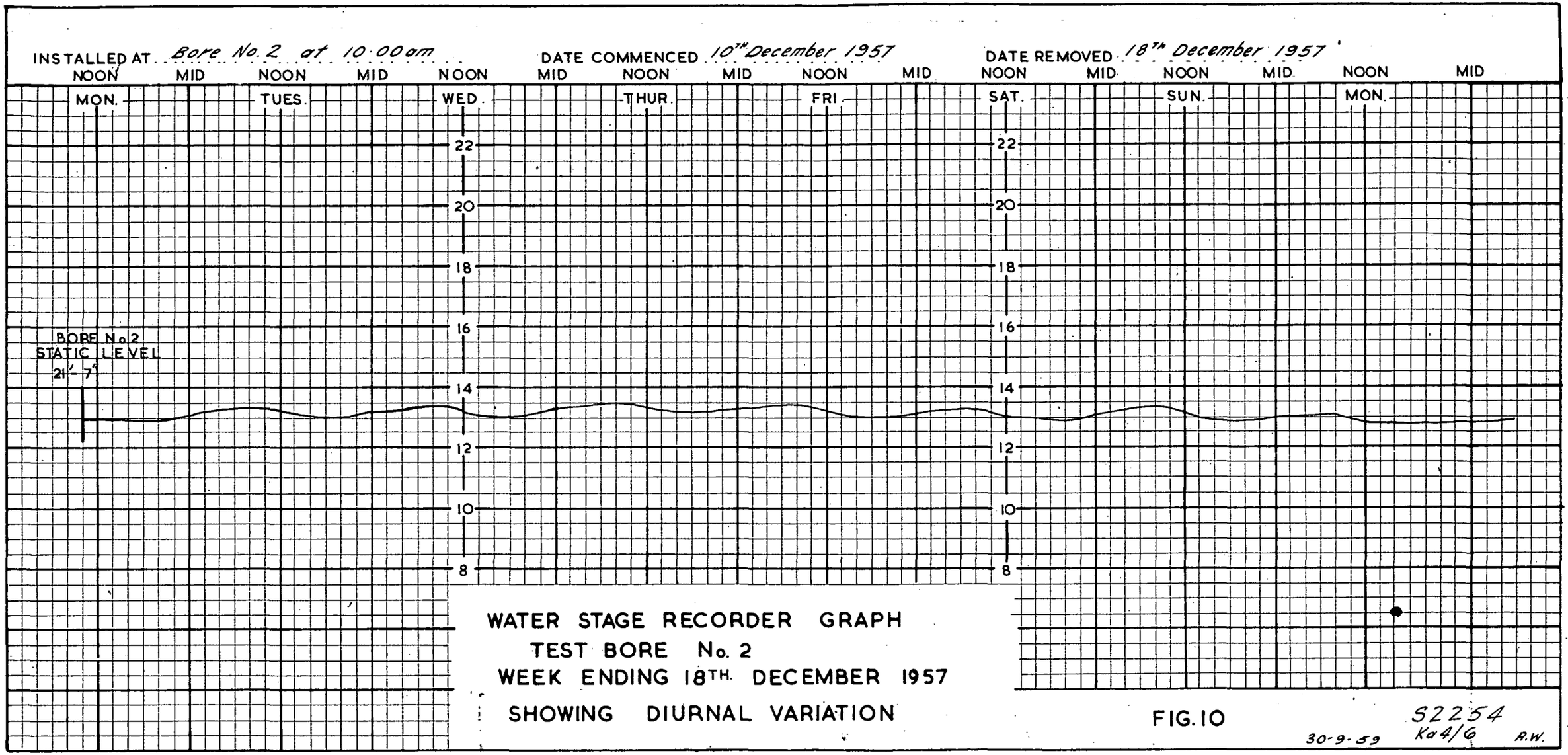
FIG 9

BORE No. 3



PORTION OF Co. CARDWELL
HYDROGRAPHS OF TEST BORES 2 & 3
SEPT. 1956 — DEC. 1957

52255
Ko.4/6
30-9-59


INSTALLED AT Bore No. 2 at 10·00 am
DATE COMMENCED 10th December 1957
DATE REMOVED 18th December 1957
NOON MID NOON MID NOON MID NOON MID NOON MID NOON MID NOON MID
MON. TUES. WED. THUR. FRI SAT. SUN. MON.
22
20
18
16
14
12
10
8
BORE No 2
STATIC LEVEL
21' 7"
WATER STAGE RECORDER GRAPH
TEST BORE No. 2
WEEK ENDING 18TH DECEMBER 1957
SHOWING DIURNAL VARIATION
FIG. 10
S2254
30-9-59
Ka 4/6
R.W.

S 2254
Ka 4/6

JEFFRIES | STRAWBRIDGE | CONEYBEER

FIELD | COLEBATCH | RICHARDS

GLYDE

N

Mt Boothby

Ready Wells

Quarry

Camp Bore

350

150

Tolmer Rocks

Cambalapien Well

King H.S.

Mt Lyons

Lake Ellen

Hesslip H.S.

0 - 150 grains per gallon

150 - 350 " " "

350 - 550 " " "

550 - 850 " " "

Over 850 " " "

Salt swamp

Limits of investigations

Granite outcrops

Bore ○16 Serial N°

Scale

mls 1 0 1 2 3 4 mls

FIG. 11

S.A. DEPT. OF MINES

GROUNDWATER INVESTIGATIONS - PORTION OF Cº CARDWELL
ISOHALSINES (Minimum)
OCTOBER 1956

Req. No.	Approved	Passed		Scale : 1 mile to 1 inch	
D.M.			Drn.	59-351	
Compiled from			Tcd. G.S	Ko4/6	
			Ckd. R.R		
Director of Mines			Exd.	Date 7-9-1959	

Associated Drawing No.	No.	Amendment	Exd.	Date

JEFFRIES | STRAWBRIDGE | CONEYBEER

FIELD | COLEBATCH | RICHARDS

GLYDE

N

Mt Boothby

Ready Wells

Quarry

Tunkas Rocks

Cambalapien Well

King H.S.

Mt Lodge

Lake Ellen

Heaslip H.S.

0 - 150 grains per gallon

150 - 350 " " "

350 - 550 " " "

550 - 850 " " "

Over 850 " " "

Salt swamp

Limits of investigations

Granite outcrops

Bore ○16 Serial No

Scale

mls 1 0 1 2 3 4 mls

FIG. 12

S.A. DEPT. OF MINES

GROUNDWATER INVESTIGATIONS - PORTION OF Co CARDWELL
ISOHALSINES (Maximum)
JULY 1956

Req. No.
D.M.
Compiled from

Associated Drawing No. | No. | Amendment | Exd. | Date

Approved | Passed

Director of Mines

Drn.
Tcd. G.S.
Ckd. K.K.
Exd.

Scale: 1 mile to 1 inch
59-350
Ka4/6
Date 7-9-1959