SOUTH AUSTRALIA.

DEPARTMENT OF MINES.

Geological Survey of South Australia.

BULLETIN No. 11.

SOME DEVELOPMENTS IN SHALLOW WATER AREAS IN THE NORTH-EAST OF SOUTH AUSTRALIA.

By R. LOCKHART JACK, B.E., F.G.S., Deputy Government Geologist.

Issued under the authority of

The Honorable A. A. KIRKPATRICK, M.L.C., Minister of Mines.

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LETTER OF TRANSMITTAL.

Geological Survey of South Australia,
Adelaide, December 15th, 1924.

Sir—I have the honor to submit to you the report that has been prepared by Mr. R. Lockhart Jack, B.E., F.G.S., Deputy Government Geologist, on recently acquired information regarding the occurrence of underground water in the north-eastern portion of the State.

This report deals with the most important factor of settlement in the drier regions, and it will be found that there are several localities which receive separate treatment, in view of the different features of occurrence in each. This mode of treatment is essential in the discussion of the occurrence of underground water throughout a wide region. No brief generalisations are applicable to areas in which the structural conditions vary from point to point. But, when the structures are studied, and the results of well-sinking and boring are correlated, it is possible to establish on a firm basis the explanation of the known occurrences, and to indicate the sites at which it is advisable to make search for further supplies. This method of treatment involves the preparation of plans and sections such as accompany this report and serve to render more easy the study of problems of development.

One of the most important results of the investigations here recorded is the recognition to-day of the value of supplies of water that were formerly neglected, and in many instances passed by without testing during the progress of boring operations. This development shows very clearly the need for the full testing of every supply of water found in boring, both as regards quantity and quality. It is inadvisable to disregard any supply whatever till it has been tested fully.

Another very interesting result of recent work in the development and study of the artesian water resources of the State is concerned with the recognition of the existence of several distinct basins each with its own separate intake area; and in some districts one basin has been found to overlie another, the upper being fed by a source quite distinct from that which supplies the lower, and the waters in each being distinguished by differences in the proportion of dissolved salts. And, when each basin is studied in detail, the waters in separate aquifers are found to be characterised by differences in salinity and in the proportion of salts in solution. These features, which have a direct economic application, indicate the necessity for detailed investigation in every case.

The conservation of the deeper supplies of artesian water, by means of the development of those which occur at shallower depths, is desirable in the interests of future generations, and should be encouraged wherever practicable. It is all the more necessary in those cases in which the lower supplies, when tapped by bores, are forced to the surface by natural pressure in such abundance that the flow exceeds the demand for the water at the bore sites, even where all possible measures are taken to utilise to the uttermost the water that reaches the surface from the subterranean reservoir.

The study of the underground water resources of South Australia is one of the most important duties performed by the geologists, and the extension of this work into other regions than those dealt with in this report is projected. There is much work of this kind yet to be carried out in all parts of the State, not only within the pastoral holdings and the territory now unoccupied, but also within the surveyed counties. It is highly specialised work, requiring both training and experience, and can be performed best by the geologist, who has made a special study of the principles involved, and who is practised in their application. Reliance on other advice in the formulation of developmental schemes may involve serious waste of time and expenditure.

I have, &c.,

L. KEITH WARD, Government Geologist.

The Honorable A. A. Kirkpatrick, M.L.C., Minister of Mines.

Submitted for approval to print as a Bulletin of the Geological Survey of South Australia.

Approved,

A. A. KIRKPATRICK, Minister of Mines.

PREFACE.

In assembling and co-ordinating the accumulated data for various pastoral areas, the writer feels that publication of the work done, the successes and the failures, will serve a useful purpose as a guide to the possible more intensive development of the water resources of the regions discussed. In addition, the possibility or otherwise of extending in certain directions are indicated. At the same time, the writer is keenly aware that all the information possible has not been collected in the regions discussed, and that only a portion of that recorded has been verified by personal examination, and realises that, with additional information, more precise conclusions could be reached.

The writer is indebted to the Engineer-in-Chief's and the Surveyor-General's Departments, to pastoralists, and to well-sinkers and drillers for logs supplied to the Geological Survey over many years, and which, considered areally, furnish most valuable information as to extensions of water supply. In some cases it has been possible to check the logs against samples, and, if necessary, re-describe a bed in more precise terms when the descriptions are vague. At the same time, they furnish a valuable record of strata passed through and waters cut, and the writer deeply regrets that many more bore and well logs, whether recording successes or failures, are not sent by contractors or owners to the Geological Survey for filing and subsequent recording and utilisation.

The copies of analyses sent in are also of great value, and, with the numerous analyses made for the Department by Mr. W. S. Chapman, Departmental Analyst, throw much light on the behaviour of the water, its variations, its source, and its utilisation.

R. LOCKHART JACK.

Department of Mines, Adelaide,
December 15th, 1924.

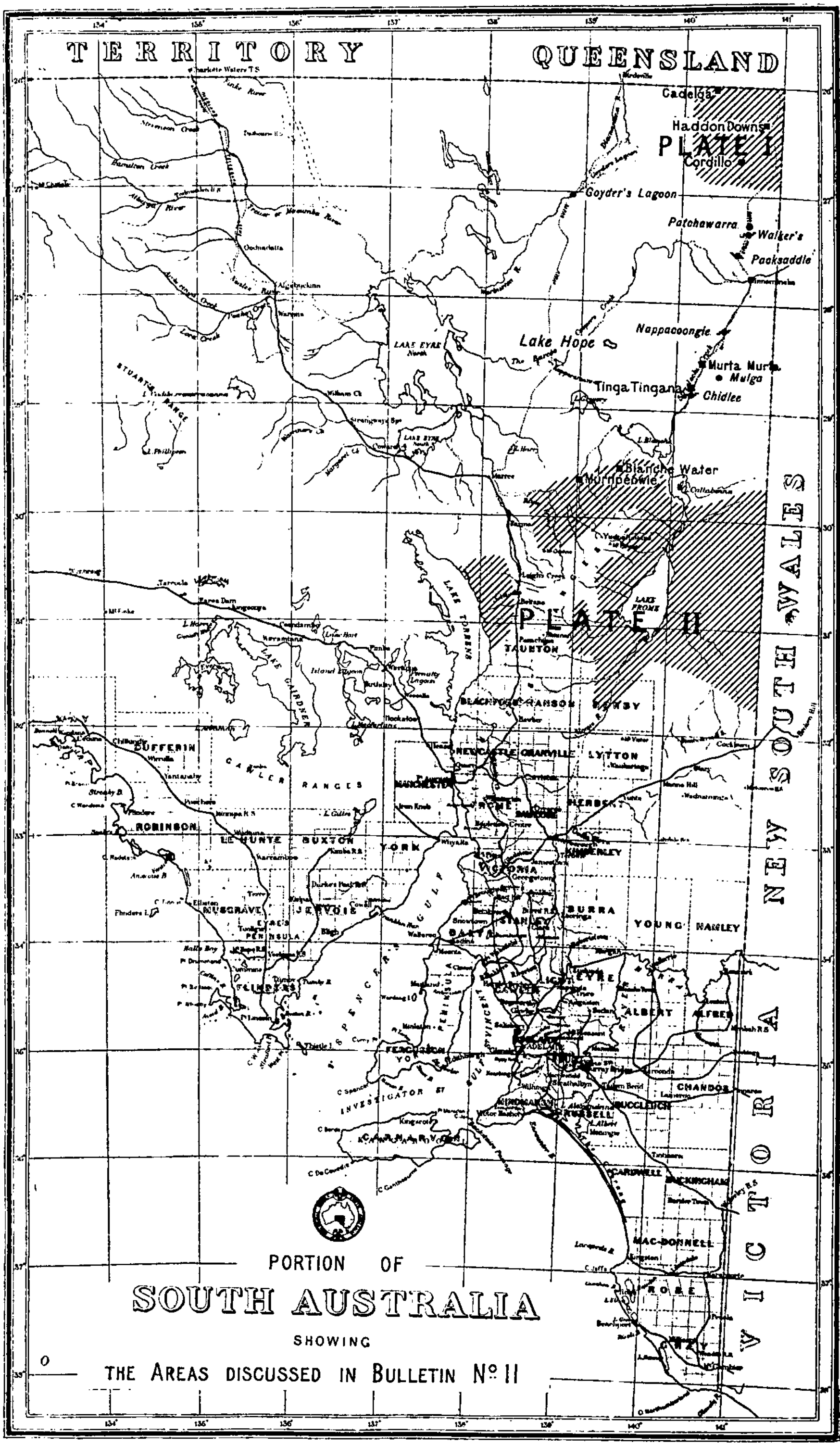
TERRITORY
QUEENSLAND
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PLATE I
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Chidlee
Blanche Water
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TAUNTON
PORTION OF
SOUTH AUSTRALIA
SHOWING
THE AREAS DISCUSSED IN BULLETIN No. 11

Some Developments in Shallow Water Areas in the North-East of South Australia.

For some years past information has been accumulating in the Geological Survey branch of the Department of Mines concerning occurrences of underground water in the pastoral areas. Some of the material consists of logs and records of bores and wells supplied by the courtesy of pastoralists and drillers, analyses supplied by the owners, and samples collected by the Geological Survey, and analysed by W. S. Chapman, Departmental Analyst. Many official bore logs are available from the Engineer-in-Chief, and the data afforded by them has been set out and discussed in the following pages. Finally, several trips made by the writer in connection with special investigations as to the possibilities of adding to the water resources of specific districts gave facilities and information for correlating much of the data now available. The information is by no means complete for any district, and cannot be so until definite areas of considerable size can be studied in the fullest possible detail. Nevertheless, the information now available is likely to be of value, not only for the regions examined, but as a guide to further development in adjacent areas.

No discussion of the Great Artesian Basin water is included, as this source of supply is fully dealt with in the various publications of the Interstate Artesian Water Conferences and elsewhere.

The areas concerning which information has been collected are:—

(1) The extreme north-east corner of the State, and some notes on the route to it. The question of shallow underground water in this area is of particular importance; in the first place, because the main artesian waters lie at such a depth as to be out of economic reach; and in the second, that by the time the surface waters dry up the stock routes are closed from the same reason, and stock would perish unless reliable underground waters are available.

(2) The area east and south-east of Lake Frome. Some of this area lies above the main artesian basin, but the southern portion has been dependent on dams until the success of bores between the Barrier Ranges in New South Wales and the South Australian border led to the prospecting of the area for shallow sub-artesian supplies such as occur in New South Wales, and were proven by, but neglected in many of the bores of the Great Australian Artesian Basin to the north of the Dewdney Bore.

(3 The area south of Lake Frome, a potential source of water that may be called the Siccus Basin.

(4) The piedmont plain, to the east of the Flinders Range, which has been proven to contain much shallow water.

(5) The area east of Lake Torrens and west of the railway to Oodnadatta.

(6) The bedrock wells of Lyndhurst Station.

The country seen in detail is essentially sheep country, and closely-spaced waters are necessary for its full utilisation.

The country between Cordillo Downs on the north and Mulyungarie, and to the east of Lake Frome is cattle country. Some of it along the Strzelecki was at one time used for sheep but reverted to cattle.

Cattle can range much farther out from water than sheep (but require better quality water), so that the close spacing of wells or bores is not essential. Cattle also are not affected by dingoes to any extent, and vermin fencing is not required.

Much of the cattle country is very sandy, and the consequent liability to drift over vermin fences is a serious disability. Yet, if shallow waters can be found in this stretch of country, there are areas that could, and doubtless, in time, will be fenced against the wild dogs, and so provided with water as to make it possible to carry sheep, if such a course promises a more profitable utilisation of the country.

While examining the occurrence of underground water on Western Eyre Peninsula in 1912 the writer found from the records of wells used and the experience of farmers that the saline limits of water for various uses were as follows:—

Up to ½oz. of salt per gallon is regarded as domestic or potable water, though up to 1oz. water has been used by settlers for considerable periods.

Horses will work and keep condition on water up to 1oz. per gallon and will live on 1¼ozs. water.

Cattle will live on water up to 1½ozs.

Sheep will live on water up to 2½ozs.

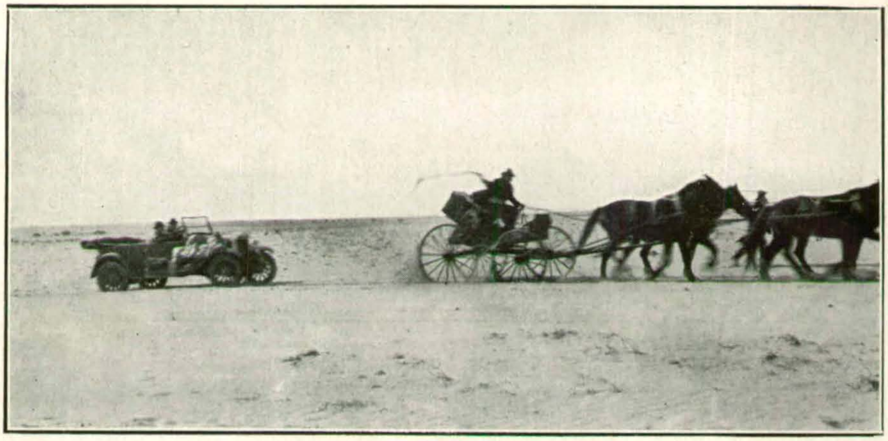
If the water is bitter from the presence of magnesium salts a lesser proportion of salts is permissible.

These figures are the uppermost limits for grass country, and for the saltbush country of the areas discussed in this bulletin the figures would be too high. For sheep 1¾ozs. to 2ozs. would appear to be the extreme salinity possible and proportionately less for other stock.

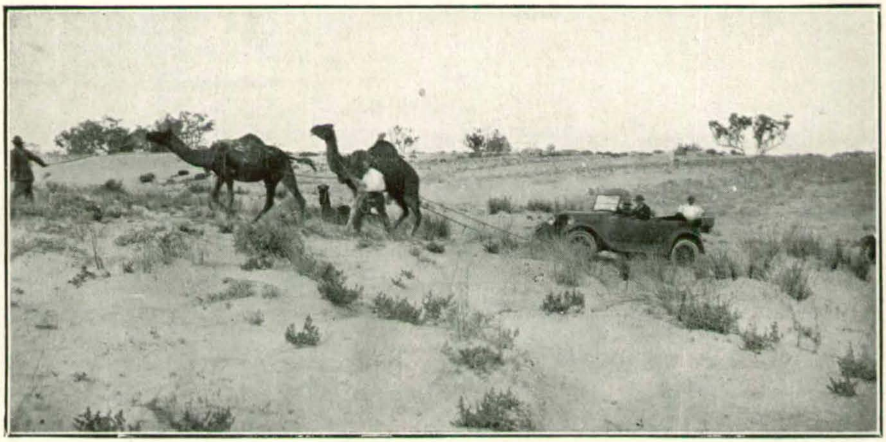
NOTES ON THE ROUTE FROM MT. LYNDHURST STATION TO CORDILLO DOWNS.

After leaving the Upper Precambrian rocks of Mt. Lyndhurst Station (east of Farina), the road to Cordillo Downs crosses table-land country (the so-called Desert Sandstone of Upper Cretaceous age) on the way to Lake Crossing. This formation rests unconformably upon the blue shales of the Lower Cretaceous on Murnpeowie Station. Its uppermost layer is a dense siliceous porcellanite or quartzite crust formed by the silicification of the superficial rocks by silica-laden water of meteoric origin in an arid climate. This series was examined in some detail at Cordillo, and the crust overlies soft sandstone and light colored shales, which, in many places, show a conchoidal fracture. When these beds are exposed by erosion there appears to be a tendency for siliceous crusts to form on a lower horizon if erosion is not too rapid to allow the silicification to become visible. The siliceous material is relatively indestructible, and even when the table-land country is eroded the capping, which has broken up, sinks with the surface of the land, and forms a mantle of stones or gibbers. These gibbers are of all sizes, but as they break down by insolation they tend to assume a spheroidal form owing to the flaking off of angles through temperature changes.

This desert sandstone is crossed as far as Blanchewater Station, where it shows a distinct easterly dip. Beyond Blanchewater only small gibbers are seen, the crust having broken up. Lake Crossing bore may be in the lower formations of the series to 104ft., and Montecollina bore to 148ft. Below these depths the bores penetrate the fresh-water series of Middle Cretaceous age, and the underlying marine series.



Crossing "The Cobbler" Sandhills between Montecollina and Lake Crossing en route from Innamincka.



Accalana Crossing on the Strzelecki.

The Ferry on Cooper's Creek at Innamincka.

To face page 10.]

From Montecollina to Innamincka the road follows the Strzelecki over silts and sands, and the country on either hand is very sandy. When the Desert sandstone is again seen near Innamincka it gives the impression of having a low dip to the westward.

It thus appears that there has been a depressing of the Upper Cretaceous between Innamincka and Blanchewater, accompanied by some erosion. Nappacoongie Well, 70ft. to 80ft. in depth, passed through reddish sandstone and sand and reddish clays, materials more characteristic of the Upper Third of the Desert sandstone series than of the recent silts of the Strzelecki, which are grey in color, or of the underlying Middle Cretaceous. Patches of coarse gibbers are exposed in the creek bed 8 and 14 miles downstream from Innamincka; and at Chidlee, 85 miles distant, the stone used for building (a crustal quartzite) was stated to have been taken from a bar two miles upstream. The fold is evidently very small, not more than a couple of hundred feet, but it is important in that the upper members of the Desert sandstone are pervious, and therefore, if sufficiently below the creek level, potential storages for underground water.

This depression has its major axis on a north-north-west-south-south-east line. The Goyder's Lagoon Bore shows a considerable thickness of Desert sandstone material, including the siliceous cap, and the upper members must outcrop to the west of the Innamincka-Patchawarra track. They are eroded between the track and the table-land one to five miles to the east of the tracks; and wells sunk, as Packsaddle and Walker's are, in the lower and denser shale get, in consequence, comparatively poor supplies.

Packsaddle Well is 88ft. deep, 50ft. to water, and has a small supply of good quality water. The dump shows fairly sandy material, with nodular boulders of dense white limestone, having a pisolitic surface.

Walker's Well (100ft. deep) has good quality water in trifling amount, in clay and sandy clay. It appears to have been sunk in the relatively impervious middle third of the Desert sandstone formation.

Patchawarra Bore, sunk four to five miles west of the table-topped hills, passes through a few feet of alluvium, and through a layer of residual quartzite gibbers. (The record of the Engineer-in-Chief's log and the samples have been examined by the writer; and the writer has interpreted the data in the light of the visit to the country and by correlation with all other available bore logs).

Broadly speaking, the section exposed here is:—

Feet.	
0-6	Alluvium.
6-50	The bottom portion of the upper third of the Desert sandstone.
50-153	The shaly middle third of the Desert sandstone.
153-345	The lower beds of the Desert sandstone.
345-3,878	The lignite-bearing grey green shales and sands of the Middle Cretaceous (Winton beds of Queensland).
3,878-5,438	The marine blue shales and limestones of Lower Cretaceous age.

At this point work was abandoned owing to the difficulty of reducing casing. It is probable that the Jurassic water-bearing sands are within 500ft. and possibly not more than 300ft., from the bottom of the bore.

Ground water was cut at 83ft., and this water is developed by a well.

A strong supply of water, containing ⅜oz. salts to the gallon, was cut at 450ft., in greyish sandstone, and rose to 94ft. from the surface.

A little water was struck at about 1,600ft. in sandy formation; and at 2,910ft. in hard sand-rock, water rising to 63ft. from the surface was cut. There is no record of the quality. At 3,380ft. (the bottom of the Winton series) a little water was reported, and the log states that from about 4,000ft. a supply of about 200galls. per day rises to the surface. This is still flowing, and the analysis of a sample recently collected is given on page 59.

Of greater importance than the deep water is the information yielded by the bore. It clearly indicates that the upper member of the Upper Cretaceous dips to the westward and is concealed beneath the silt and sandhill topography of the Cooper flood plain. As the outcrop of this member is crossed by and receives the drainage of many creeks, from Providence Creek to the Cooper, it seems probable that there exists to the west of the Bradey's Waterhole to Patchawarra and Innamincka road a very considerable area, in which useful waters can be got where required at depths of less than 300ft., and probably in most cases between 50ft. and 150ft.

To the south of the Cooper and on and west of the Strzelecki similar conditions should apply for some distance. To the east of the Strzelecki the conditions do not appear to be equally favorable. Probably the upper Cretaceous strata are present beneath the sandy country, but the probable outcrops of these potential water-bearing beds are not crossed by satisfactory feeders.

Mulga Bore, about 13 miles south-east of Murta Murta, is stated to be about 300ft. in depth and to yield a supply sufficient for from 200 to 300 cattle, but not of particularly good quality.

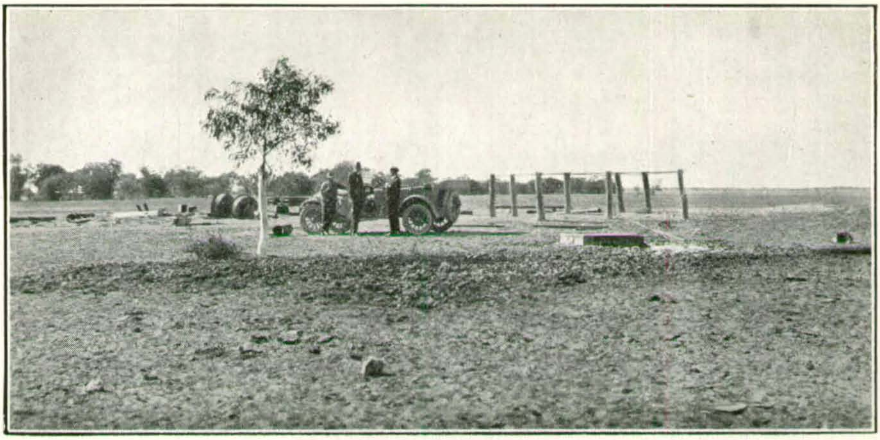
As this is on the less favorable side of the Strzelecki, it appears reasonable to suppose that on the western side useful water should be found at least as far south, and it is even possible that the area of undeveloped country north of a line between the Strzelecki and the Cooper at Lake Hope contains useful water at a fairly shallow depth. The Strzelecki was evidently at one time a much more important channel than it is to-day, and lost its importance when the sinking of the area between Innamincka and the Birdsville Track permitted the Cooper to break away to the westward. The country on both sides of the Strzelecki is very sandy, and is a region of low rainfall. It, however, carries a growth of grass and herbage, and responds very quickly to light rainfall. It is stated to be suitable for cattle and horses, but, being outside vermin fences, cannot be used for sheep. There would probably be a difficulty in maintaining dingo-proof fences, owing to the prevalence of sand drift when the country is stocked.

The area east of the Strzelecki and south of the Mulga bore is not so promising for water, as was mentioned above. At the southern end is Box Flat Well, a shallow well in drift sand on a clay or silt bottom. This well has a small supply of good water, and may be classed as a sandhill or sand-soak well. There are many sand-soak wells in the bed of the Strzelecki, south of Tinga Tingana.

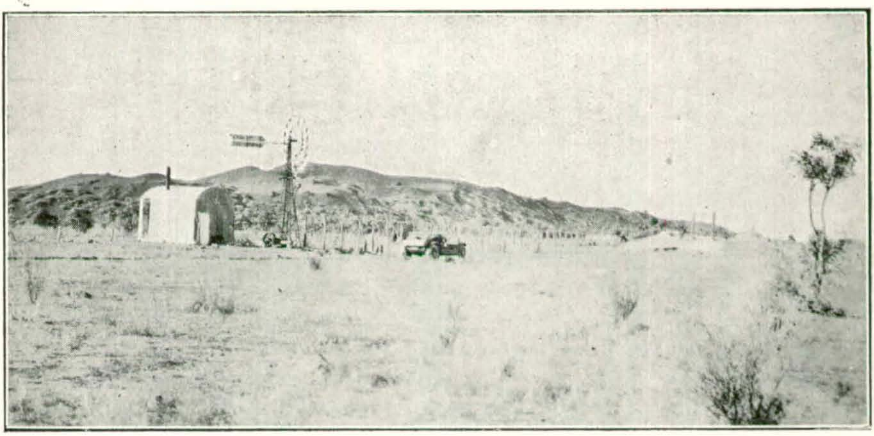
The well at Chidlee, on the left bank of the Strzelecki, about a quarter of a mile distant, is shallow, and contains good water, the analysis of which is given on page 59.

In the Montecollina Bore, a few miles to the north-east of Box Flat Well, the only shallow water recorded was cut at 256ft., and rose to 23ft. from the surface. It contained 9oz. of salts per gallon.

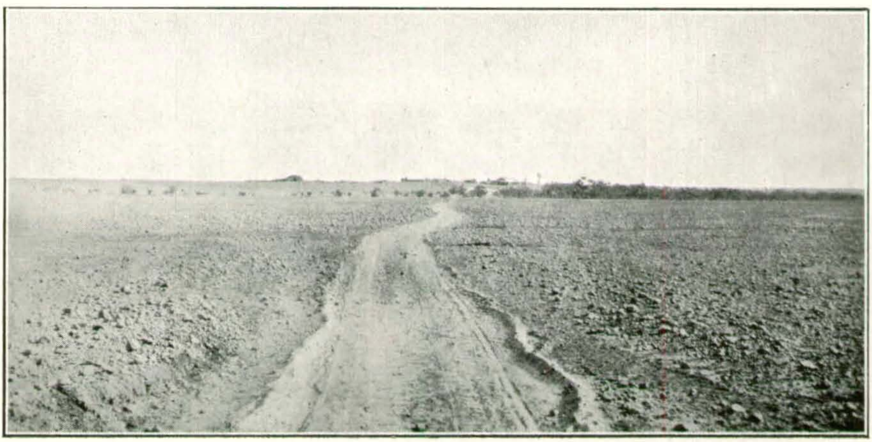
Windmill Well, 15 miles north-north-east of Montecollina, is reported to have been fresh, but to have turned salt. Borehole Well, 19 miles north-north-east of Montecollina and 8 miles east of the Strzelecki, is reported to



Patchawarra Bore (5,458ft.). Main water not reached.



Union Well Bore and Sandhill, Cordillo Downs.



Cordillo Downs Station, showing Gibber Strewn Surface and Gums on Waterhole.

To face page 12.]

be 60ft. deep, on fresh water. North of this again Mr. J. A. Paterson, of Tinga Tingana, has done a considerable amount of hand boring east of the Strzelecki, without result. Shallow boring thus appears problematical, except to the north of Mulga Bore, or fairly close to the Strzelecki, where there has been an opportunity for the pervious beds to be fed.

It is possible, however, that there is still a chance for water in the upper porous beds of the Middle Cretaceous (Winton beds) series, which underlie the Desert sandstone, and which on Cordillo and at Patchawarra carry useful water.

While their attitude is unknown at present in this area, it appears that if any trial boring was to be done it should be in the northern portion, as any exposed intake would be better served by feeders, and as Montecollina has proved that at the southern end no useful shallow water is obtainable. A bore of 500ft. to 700ft. would carry out the necessary prospecting for this part.

CORDILLO DOWNS AREA.

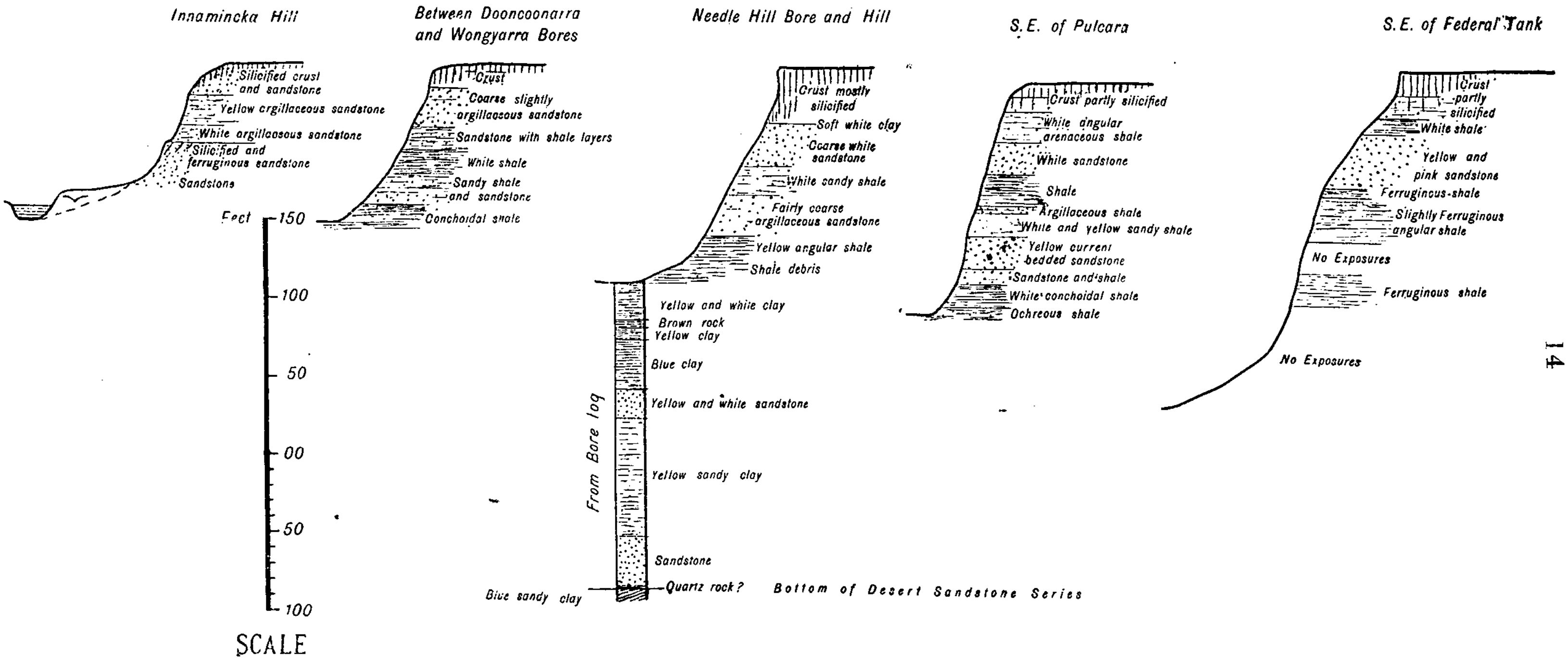
The area occupied by Cordillo Downs Station lies in the extreme north-east corner of South Australia. Broadly speaking, the central portion is occupied by hills of Upper Cretaceous rocks (Desert sandstone), attaining a height (aneroid) of about 660ft. above sea level. Earth movement subsequent to Cretaceous time has resulted in the doming of the Desert sandstone. This dome, perhaps 60 miles in diameter and 500ft. in height, has quaquaversal dips on the west, south, and east, and probably to the north (which was not seen by the writer), and has been partly dissected by erosion into the typical table-topped hills of the Desert sandstone.

The sections on the next page show the structure of the upper portion of the formation.

Wells and bore logs enabled the full thickness to be determined as approximately 360ft. Of this, the upper third is essentially arenaceous, and shows current bedding, the middle third is argillaceous, and the bottom portion variable. The formations are light colored, or stained with ferric oxides. These variations have their bearing on the success of existing wells, and on the problem of increasing their number.

Beneath the Desert sandstone lie the fresh-water beds of Middle Cretaceous age. They are lignite-bearing, and as a whole show a greenish-grey coloration, quite distinct from the bluish-grey of the Lower Cretaceous marine, "Blue Shale." These middle beds are also characterised by being more sandy, and by the presence of sand or soft sandstone beds. They were only seen on the surface at two localities, wells near the Providence and Pulcara Tanks in the valley of Providence Creek. They are, however, cut by the bores put down on the station, and it is possible to correlate the logs of these bores and so to arrive at a conception of the underground structure of the Middle Cretaceous.

The Middle Cretaceous rocks are soft, argillaceous for the most part, but with beds of sand and sandy clay. This softness and the method of drilling together with slight variations in the nomenclature of different drillers, makes the correlation somewhat uncertain, and this would seem to be intensified by local variations in individual beds. For example, a water-bearing sand cut in the outermost holes of a line of three has not been recorded as water-bearing in the middle hole, but may be identified as a "sandy clay" stratum occurring in the correct position. The waters, however, fall into groups when the salts contained in them are compared, and this materially aids in the correlation of beds.



Sections showing the beds of the Desert Sandstone near Cordillo Downs.

Beneath the Winton beds lie the Lower Cretaceous Blue Shales and the water-bearing Jurassic sands of the Artesian Basin. The depth to this water is probably not less than 3,500ft. on the north to 5,000ft. or more on the south end of the run, so that boring for it is out of the question on economic grounds, as the low rainfall of the country does not permit the density of stocking requisite to justify the expenditure of so much money on one bore that could only serve a limited area. It was for this reason that a good deal of work has been done by the lessees in providing shallow bores.

The region is fairly well watered by waterholes that last from two to nine months after rain, and in one or two cases even longer. They are, however, insufficient owing to long intervals between replenishment, and may not be so placed as to make all the country accessible to stock. They also have the disability that by the time they are dry the stock routes, or avenues of outlet, are also impassable for lack of feed and water. The need for wells and bores is thus imperative as drought insurance, as well as to ensure a proper utilisation of the pasturage.

It may be mentioned that sheep can normally feed back about four miles from water, and that it is economically unsound to force them to travel farther in search of feed. This means that provision should be made for water on at least each 70 square miles. As a matter of station management, if there are ephemeral water-holes on such an area, the area is stocked while the water lasts, and then the sheep are moved on to more permanent waters, around which the pasturage has been reserved in the meanwhile, while vegetation round the depleted water is allowed to recuperate. The average carrying capacity of the northern country, with a rainfall of 5in. to 6in. per annum, is probably 15 to 25 sheep per mile, or, say, an average of 20. This average will be raised with the provision of additional waters on many stations in South Australia, as there are many patches included in the runs, which are so far from water that they are, to all intents and purposes, unstocked country, and reduce the average for the station. This means that a well, stocked throughout the year, would only serve sufficient feed to constantly maintain 1,400 sheep, or, if used for portion of the year only, a proportionately greater number. This limits the capital cost or value of a water supply, and makes the sinking of very deep bores to the main artesian water uneconomic unless drains can be designed to carry the outflow within reach of a large extent of country. This is being done in New South Wales, and in South Australia on Murnpeowie Station, where conditions are favorable for maintaining drains. As each nine miles of drain extending from a bore doubles the area served by it (as far as sheep are concerned) the possibility of distributing the water may justify a considerably greater expense to get a flowing bore than would be permissible if a well or sub-artesian bore only is to be developed.

On Cordillo there are several potential water-bearing horizons, but the question of adequate intakes or feeders should be considered in connection with them.

The uppermost is the 120ft. or so of arenaceous rocks that make up the top of the Desert sandstone. Owing to the domed structure this is high above the drainage lines of the country, where it is typically seen in the central portion of the dome. Beyond the central plateau of the dome it has been largely eroded into undulating hills, and removed to expose the argillaceous middle beds of the Upper Cretaceous. Still farther out, although there has been more or less erosion, pieces of the crustal quartzite *in situ* prove that there are considerable depths of the pervious upper third remaining. This is a very satisfactory aquifer if it is sufficiently low-lying to absorb water from the creeks. This condition obtains in the southern and western portion of Cordillo, and from information supplied to the writer, it appears that the wells on the eastern side of the Desert sandstone range just across the border in Queensland and to the north of Arrabury are also in this upper series of porous beds.

The following wells are dependent on water in this zone:—

Pillathilparie Well, 117 feet, passed through this into the middle shales. The quality is good (see page 60), and the well is capable of watering 1,500 sheep.

Elba (reported), 90ft. in sandstone. Good quality and supply.

Nada, 56ft. 10,000galls. per day, sunk in yellow sandstone (vide page 60). This water is of very good quality, containing only .06oz. of total salts per gallon.

Cooroondoona, 70ft. in reddish sandstone, 7,000galls. per day. Good water (vide analysis on page 60).

Durrembinnie Well, 60ft.; traces of sandstone and yellow soil on dump. 10,000galls. per day. Quality, .76oz. (vide analysis on page 60).

Horseshoe. About 25ft. to water, in red and yellow sandstone underlying a thin surface deposit of dense limestone. Quality, .42oz.

Dundoona. About 60ft., in grey clay, and water found in reddish sandstone and white sandy clay. Supply, 700galls. per hour; quality, almost fresh.

All these wells are not only in the upper member of the Desert sandstone, but they adjoin Nilpie Nilpie Creek or its tributaries.

South of Dundoona, Horseshoe, and Cooroondoona Wells, the gibber plains become more and more sandhill-covered, and the intervening flats become more silty. There is no doubt whatever but that the porous beds that contain the above wells persist into Innamincka Station country, and that useful wells could be got from some little distance east of the Nilpie Creek, and through the sandhill country as far west as Mudcarnie Creek, and south of a line joining Beefwood dam and Ootadoola Hill, to as far south at least as Toorawatchie Well. This well appears to be in the silty alluvium of Nilpie Creek rather than in the more deeply buried Upper Cretaceous beds.

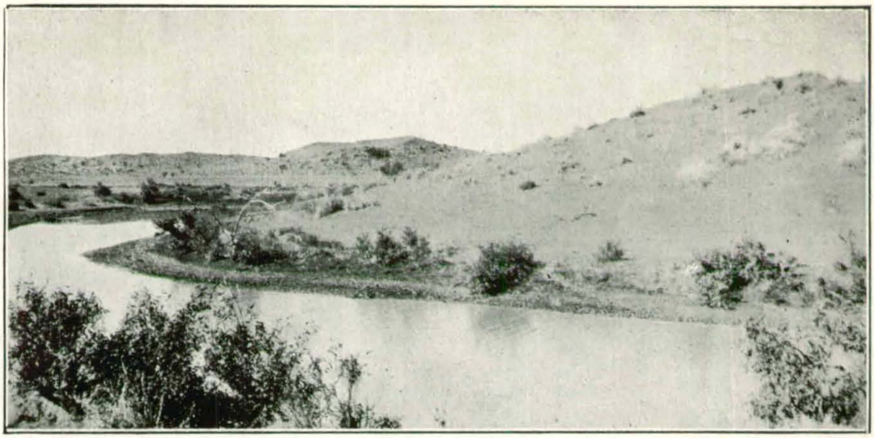
To the westward *Union Well* passed from the upper third to the middle third of the Upper Cretaceous, and had no great supply, while the bore alongside it gets its water from the bottom third of the series.

White Well is in the sandstone of the upper third, but the supply was small, and the well has been superseded by a bore (Peetana) to a deeper bed.

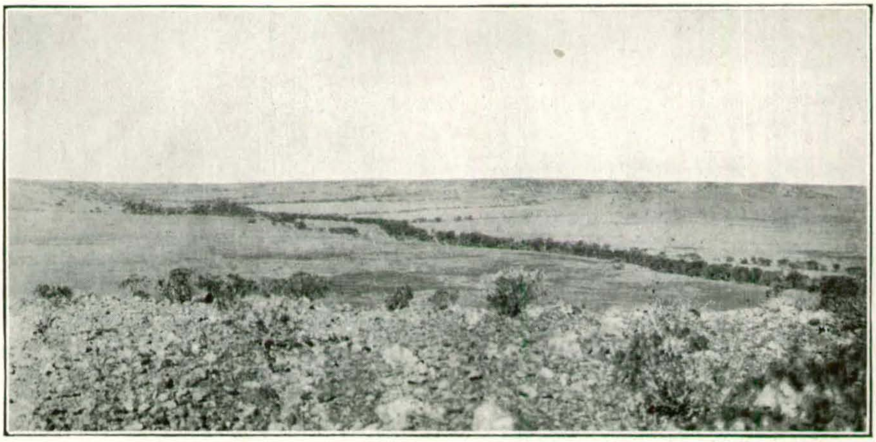
Koora Well, 80ft., is also on this horizon, and shows red sandstone. It is on a wide plain, and some distance from any feeder, and perhaps for this reason the water is of indifferent quality, though usable for sheep (vide page 60).

Cadelga Well shows soft red sandstone, and is about 40ft. deep. The water is reported to be of good quality, and in moderate quantity.

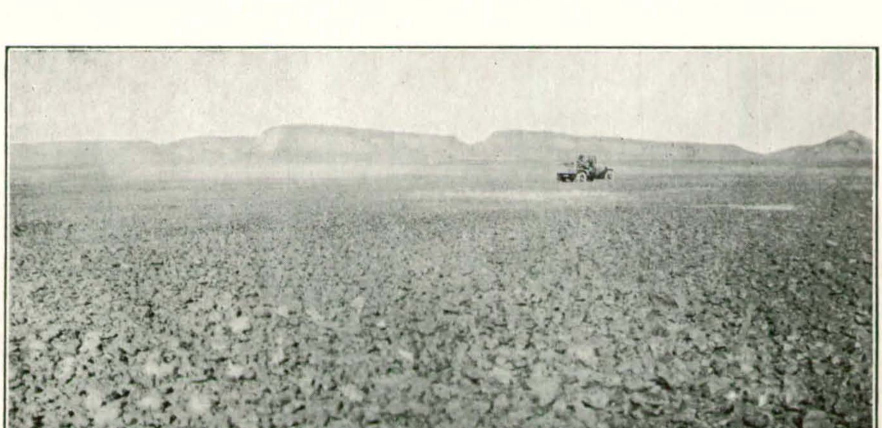
Frew's Well, 20 miles west of Cadelga, was not seen. It is reported to have a small supply of good water, and it was also reported that a very hard bed was passed through in an adjacent hole. This hard bed may be the buried crust of the Upper Cretaceous.



Purnoo Waterhole (on Creek) and Sandhill, Cordillo Downs.



Needle Creek looking East from above Needle Hill Bore. Typical desert sandstone table land country with courses of creeks shown by red mulga vegetation.



"Gibbers" derived from Erosion of Siliceous Capping of the Desert Sandstone Hills (in background).

To face page 16.]

The log of Goyder's Lagoon Bore, 90 miles to the south-west, shows 272ft. of strata that may be Upper Cretaceous capped by 12ft. of hard white siliceous rock that is almost certainly the capping. Two ounce water is recorded at 60ft. from the surface.

The exposed edge of the upper members of the Upper Cretaceous—more or less denuded, with consequent disintegration of the hard crust—is fairly well proven by the line of wells from Cadelga through Koora, west of Bull's Hole, through Peetana, south of Union Well, and thence to Cooroondoona and as far north as Nada Well.

Further wells may very reasonably be expected if this bed is penetrated farther to the west and south. If such wells are to be developed it would be advisable to choose sites along watercourses, or down grade from where they die out, that is, approximately speaking, to the south-west. Only when these sites are fully and successfully proved would it be advisable to attempt to fill in the gaps between the watercourses, where, as in the case of Koora Well, the possibility of getting inferior water will be much greater.

Frew's Well shows that the width of this probable water-bearing zone is very considerable. Beyond that well it is probable that the floodwaters of the Diamentina will afford useful ground water at a comparatively shallow depth. The ground water of Goyder's Lagoon Bore is probably derived from these floodwaters, but the presence of 2oz. of salt per gallon suggests that the bore is beyond the southern limit of useful widespread stock water.

The middle third of the Upper Cretaceous series is essentially argillaceous, and so not favorable for large supplies. East and West Pinandinna and Melon Wells have penetrated into these shales, and do not obtain large supplies. The wells about eight miles westerly from Nada Well probably failed from the same cause.

On Haddon Downs three wells were seen.

Terrietcha, the easternmost, was sunk in soft red sandstone, and a little white limestone was visible on the dump. This formation is probably the top member of the Upper Cretaceous, but to the eastward there must, in that case, be a reversal of dip, as a table-topped range just across the Queensland border is at a higher elevation than the well. The quality is good and the supply large.

A well, 4½ miles east-north-east of Haddon, is 80 feet deep in white clay, sandstone, and some white limestone. The supply is trifling, but the water is of good quality.

McCormac's Well, sunk 122ft., is capable of watering 4,000 sheep for six months. Its dump shows yellowish-brown sandy clay, with a greenish tinge and reddish sandy clay, and the well may have passed through the latter into the uppermost member of the Middle Cretaceous, but obtains its water from the Upper Cretaceous. The water contains 0.12oz. per gallon of salts (vide page 60).

THE LOWER THIRD OF THE UPPER CRETACEOUS.

This series, on the information afforded by bore sections, should be reasonably pervious, but, being capped by the middle bed, it has no great possibilities of being fed, except in one or two instances. The valley of Providence Creek has been eroded through the dome of Upper Cretaceous rock, and exposes the lowest beds. They also appear to be near the surface in the valleys of Needle and Marabooka Creeks, to the north of Needle Well.

The waters of Union and Cordillo Bores are derived from this series, as is the water of McCormac's Well above-mentioned, and of Needle Well. On the other hand, there is no record of this water being cut in Needle Hill Bore.

On the north of Providence Creek the dips are still to the southward, so that the tendency would be for the bed to feed the creek, and not receive water from it. The possibility of obtaining water in this formation does not appear to be promising in this direction until erosion considerably farther to the north has removed the overlying clay series to permit the percolation of water.

THE MIDDLE CRETACEOUS, OR "WINTON BEDS."

That portion of the Cretaceous system that lies above the marine blue shale is essentially of fresh water origin, and is characterised by the occurrence of lignitic matter. In Queensland the series is known as the "Winton Beds." The beds extend at Patchawarra to a depth of 3,880ft. from the surface and underlie the whole of Cordillo.

They are covered uncomformably by the Desert Sandstone, which, however, has been cut through for some distance by Providence Creek, and are exposed in its valley in wells at Providence and Pulcara Tanks. They have also been affected by the tectonic movements that produced the doming, or at the least the pitching anticline that is apparent in the Desert Sandstone; and before the Desert Sandstone was laid down had already been subjected to stresses which resulted in a dip to the southward.

The examination and plotting of the logs on sectional lines show that the strike swings from north to south in the north-west of the area through east by north, or even east-north-east at the south, and to the north-east on the east of Cordillo. The dip outwards (*i.e.*, to west, south, and south-east) ranges from 20ft. to 40ft. to the mile, while the dip of the Desert Sandstone is about half that amount.

Essentially argillaceous, the beds of the Middle Cretaceous contain interstratified thin sandy to sandy clay beds that carry water in portions at least of their extent. These interstratified beds appear to vary considerably in porosity, as some beds have been penetrated without yielding supplies; and also there are areas for each bed of which the intake is capped by the argillaceous members of the Desert Sandstone. The writer has provisionally named these sandy beds from the bore in which they are most typically developed, with the exception of the so-called "Main Bed."

The uppermost is the Needle Well Bed, tapped by Needle Well and Pillathilparie bores. The salts in the waters of these bores, though differing in concentration, so closely resemble one another in the ratio of their mineral constituents that it can only be assumed that they derive some at least of their salts from a common source, either from the same surface supply, or, more probably, from passing through the same bed.

Examination of all the logs and their correlation was not entirely satisfactory, owing to the similarity of the impervious material between the various water-bearing horizons preventing absolute identification.

The examination of all water analyses showed that the waters could be grouped, and that each bed had given certain characteristics to the water derived from it. The plotting of sections in the light of bore logs and analyses gave a very satisfactory concordance.

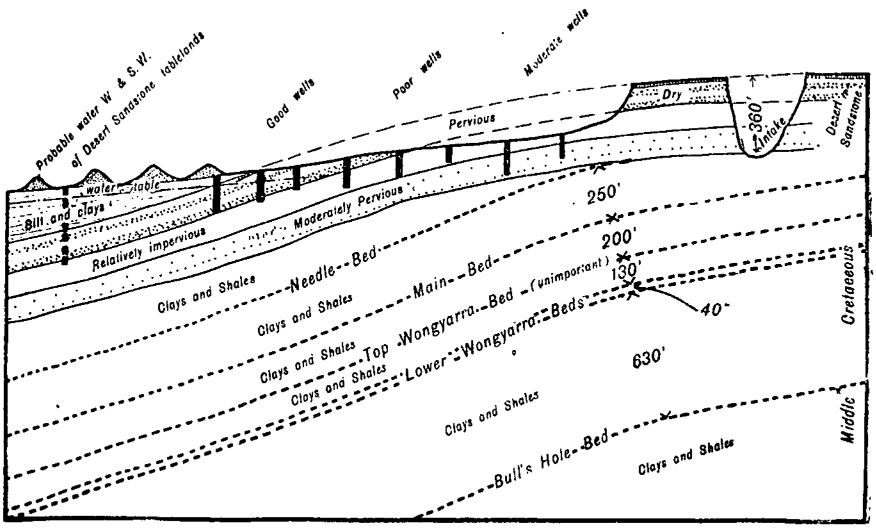
None of the water-bearing beds was seen on the surface, their outcrops being for the most part covered by the Desert Sandstone series. The edge of the Needle Well bed should lie, approximately, two miles east of Piniewirrie, three miles west of Dooncoonarra, five miles north-east and three miles south-east of Wongyarra, at Indranie, two miles north of Pulcara Hill, five miles north-north-west of Needle Hill bore, at Cliffs, and four miles south of Turlie Tudda. It should be crossed twice by the Haddon Creek and twice by Providence Creek, and so has fairly efficient intakes. It dips west, south, and south-east.

Needle Well, Mirakoonda, and Pillathilparie Bores get their water in this bed; while Piniewirrie, Wongyarra, Indranie, Bull's Hole, Peetana, and Needle Hill Bores passed through it, getting insufficient or no water.

The so-called "Main Bed" lies 250ft. below the Needle Well Bed. It probably reaches the bottom of the Desert Sandstone four miles east of Piniewirrie, one mile east of Dooncoonarra, three miles north of Kertiemucka Hill, and thence to Turlie Tudda Bore. The greater portion of this line is covered by the Desert Sandstone, but there should be a poor intake on it north of Dooncoonarra and a better one in the vicinity of Turlie Tudda.

Piniewirrie, Indranie, and Peetana Bores tap this bed successfully; while Dooncoonarra, Wongyarra, Bull's Hole, Needle Hill, and Cliffs Bores got little or no water in it.

The third (or Wongyarra) Bed consists of three water-bearing strata 200, 330, and 370ft. below the Main Bed. Only the lower two appear to be of importance. It gives the water of Dooncoonarra, Wongyarra, and, on chemical analogy, Turlie Tudda. Bull's Hole and Needle Hill Bores passed through the bed without it being reported. When Needle Hill Bore reached 1,827ft. it transpired that this water-bearing bed had been cut between 1,000ft. and 1,030ft., and contained 1¼oz. water. The supply was not tested. Neither was a supply of similar quality that was cut between 1,300 and 1,350ft. reported or tested for supply at the time, though this was a bed hitherto unknown.



The Relation of the Water Beds at Cordillo Downs.

The casing of Needle Hill Bore has been slotted opposite the 1,000-1,030ft., 1,300-1,350ft., and 1,600-1,650ft. (Bull's Hole) beds, and the bore proved to be capable of yielding 1,000galls. per hour, without appreciably lowering the water level from 150ft. The quality of the mixed waters is shown on page 59.

The bed probably outcrops, or at least reaches the base of the Desert Sandstone, to the north and north-west of Turlie Tudda, inside the State boundary, but the approximate location cannot be indicated.

The Bull's Hole Bed has been cut only in the bore of that name, and should be about 630ft. below the lowest Wongyarra Bed*. From the disposition of the overlying water-bearing horizons the Bull's Hole bed cannot outcrop in the State, but must derive its water from the north or north-east, perhaps from the Diamentina, or, more probably, from its tributary Farrar's Creek, in Queensland.

It is probably at its shallowest in South Australia some 10 to 15 miles west of the north-east corner of the State, where it should be within 500 to 700ft. of the surface. The bed is not a thick one where cut at Bull's Hole, but when the distance from the nearest possible outcrop (and intake) of 70 to 80 miles is considered, it seems likely that the bed is fairly pervious and so should yield widely distributed water.

Bores sunk, working out from the point indicated above, should get this water at gradually increasing depths to south-west, west, and south-east, and, as it becomes too deep, there is the chance of the Wongyarra beds coming in with shallower supplies.

The tables (pages 21-27) show the logs from which the sections shown on pages 14 and 19 and next page 63 have been constructed, in greater detail than the scale of the sections permitted.

A considerable number of water samples were collected by the writer, and in addition, through the courtesy of the Beltana Pastoral Company, copies of analyses by C. M. Hallett were made available, as well as copies of the logs from which the underground structure was worked out.

These analyses are given on pages 59-60, arranged in groups, according to the stratum from which they are derived. It will be noted that in the "assumed composition of salts" the Needle Well Bed is characterised by the absence of calcium sulphate and chloride, but magnesium and sodium carbonates are present.

The Main Bed carried lime sulphate and chloride, and magnesium chloride, but no sodium carbonate.

Wongyarra Bed has no calcium chloride or magnesium carbonate, but contains magnesium sulphate and chloride.

The analyses of water from Bull's Hole Bore, 1,625ft., are irregular. Those made on July 19th, 1924 (0.25oz.) and October 10th, 1924 (0.28oz.) were of samples taken when the bore was not in use; while those of July 27th, 1923 (0.91oz.) and January 15th, 1925 (0.92oz.) were made of samples taken when the water was being drawn upon. It would, therefore, appear that the .91 oz. water is the normal Bull's Hole water and that the ¼oz. water is contamination. A possible explanation is that a leaky joint in the casing allows ground water to trickle in and gradually drive down the main water in the casing.

The 0.91oz. water is very like that cut in the Needle Hill Bore between 1,600ft. and 1,650ft.

*Since the writer's visit Bull's Hole Bed was cut, at 1,600-1,650ft. below the surface in Needle Hill Bore. (See logs and sections).

CORDILLO BORES.

Bull's Hole Bore.

Height above sea level, 175ft.

Upper Cretaceous—

Feet.	
0-6	Red clay.
6-40	Rubble and boulders.
40-75	Red rock.
75-110	Yellow clay.
110-145	Pipeclay.
145-190	Grey clay.

Middle Cretaceous—

190-320	Sticky blue clay.
320-465	Sandy shale (includes Needle bed)
465-510	Green sandy shale.
510-652	Black sandy shale (includes Main bed).
652-1,628	Blue shale.
1,628-1,639	Hard sandstone. Water rose to 60ft. from surface.
	Bull's Hole Water-bed.
1,639-1,872	Blue shale.

Pumping 1,000galls. per hour the water stands at 240ft.

(Wongyarra beds should be about 1,000ft.)

Cliffs Bore.

Height, about 460ft. above sea-level.

Upper Cretaceous—

Feet.	
0-7	Red clay.
7-10	Gravel.
10-16	White clay.
16-28	White with soapy heads.
28-74	Yellow clay. Soak at 74ft.

Middle Cretaceous—

74-105	Green sandstone.
105-107	Blue rock.
107-126	Green sandy clay.
126-132	Brown clay.
132-166	Green sandy clay.
166-178	Hard blue sandstone.
	(Needle bed.)
178-198	Hard brown clay.
198-245	Green sandy clay.
245-276	Hard green sandstone.
276-298	Hard clay.
298-345	Brown sticky clay.
345-406	Brown clay.
406-429	Blue sandstone. Very little water.
	(Main bed.)
429-454	Blue sandy clay.
454-467	Brown clay.
467-524	Blue clay.

"Bore a failure." Should be deepened to next bed.

The Lower Wongyarra beds may be expected at 780ft. and 820ft. and the Bull's Hole bed at 1,450ft.

Cordillo Bore.

Height, 250ft. above sea level.

Upper Cretaceous—

Middle Third—

Feet.	
0-10	Clay and pebbles.
10-20	White rock. [Conch. silic. shale.]
20-24	Yellow clay and gravel.
24-41	White clay.

Lower Third (Water zone)—

41-50	Yellow sandstone.
50-147	Yellow clay and sand.
147-150	Red clay.
150-155	White clay.

Middle Cretaceous—

155-320	Blue clay.
320-330	Grey rock.
330-335	Blue shale.
335-570	Sandy shale.

(Needle Well water-bed should be 400-410ft.).

Small supply of water from between 97ft. and 130ft.

Large supply of water from between 130ft. and 147ft.; rises to 50ft.

Dooncoonarra Bore.

Height above sea level, 158ft.

Upper Cretaceous—

Feet.	
0-7	Clay and stones.
7-92	Red rock.
92-150	Yellow clay.
150-180	Blue clay.
180-200	Sandy clay. (Main bed). (185ft., small supply fresh.)

Middle Cretaceous—

200-248	Blue clay.
248-592	Sandy clay.
592-595	Hard rock. (Wongyarra lower beds).
595-655	Green sandstone.
655-680	Blue clay.

12,000galls. per day of 1.40 oz. water at 595ft., rising to 75ft.

Indranie Bore.

Height above sea level, 184ft.

Upper Cretaceous—

Feet.	
0-8	Red clay.
8-20	Gravel and boulders.
20-60	Red rock.
60-80	Flint boulders.
80-90	White rock.
90-100	White clay.
100-150	Yellow clay.

INDRANIE BORE—*continued.*

Middle Cretaceous—

150-200	Black and green sandstone (includes Needle bed).
200-220	Sandstone.
220-264	White sandy clay. (A little fresh water between 250ft. and 264ft.).
264-270	Blue sand, a little clay.
270-300	Blue sandstone.
300-360	Green sandstone.
360-380	Blue sandstone.
380-390	Blue sandstone, with good supply of water. "Main-Water Bed."
390-400	Blue sand.
400-458	Blue clay.

A good supply of 1.7oz. water cut between 380ft. and 390ft.

Wongyarra Beds should be present at depths of 720ft. and 760ft., and Bull's Hole Bed at 1,390ft.

MIRAKOONDA BORE.

Height above sea level, 163ft.

Upper Cretaceous—

Feet.	
0-12	Red Clay.
12-70	? Red clay.
70-76	Boulders, small supply water.
76-90	Hard red rock.
90-112	Grey clay.
112-129	Blue sandy clay.
129-141	Yellow clay.
141-160	Blue clay.
160-216	Pipeclay.

Middle Cretaceous—

216-432	Blue clay.
432-434	Hard rock.
434-472	Sandy clay.
472-557	Blue clay.
557-575	Sand rock (Needle bed, yielding a good supply of water, rising to 60ft.).
575-720	Sandy clay.

NEEDLE HILL BORE.

Height above sea level, 355ft.

Upper Cretaceous—

Middle Third—

Feet.	
0-14	Stony rubble, yellow clay, and white shale.
14-24	White clay (shale).
24-29	Brown rock.
29-36	Yellow clay.
36-68	Blue clay.

Lower Third—

68-70½	Yellow sandstone.
70½-87	White sandstone.
87-162	Yellow sandy clay.
162-193	Sandstone.
193-195	Quartz rock (?)

NEEDLE HILL BORE—*continued.*

Middle Cretaceous—

195-240	Blue sandy clay.
240-240½	Rock (water 241ft.).
240½-308½	Blue clay.
308½-451½	Blue sandy clay.
451½-497	Blue clay or shale.
497-800	Blue clay or shale.
800-1,000	Blue clay or shale.
1,000-1,030	Water-bearing bed, 1¼oz. (Wongyarra Bed.)
1,030-1,300	Clays.
1,300-1,350	Water-bearing beds, 1¼oz. (hitherto unknown).
1,350-1,600	Clays.
1,600-1,650	Bull's Hole bed.
1,650-1,770	Blue shale.
1,770-1780	Grey siliceous and argillaceous silt with lignitic films.
1,780-1,827	Clays or shales.

Needle bed (dry) should be about 330ft.

Main bed missed.

Wongyarra bed, 1,000ft.-1,030ft.

Unknown water bed, 1,300ft.-1,350ft.

Bull's Hole bed, 1,600ft.-1,650ft.

2.05oz. water at 241ft., rising to 168ft.

1¼oz. water at 1,000ft.-1,030ft.

1¼oz. water at 1,300ft.-1,350ft.

.91oz. water, 1,600ft.-1,650ft., rising to 180ft., 400galls. per hour.

On slotting opposite three lowest waters the water rose to 150ft., and yields over 1,000galls. per hour of 0.92oz. water.

NEEDLE WELL BORE.

Height above sea level; 275ft.

Upper Cretaceous—

Middle Third—

Feet.	
0-4	Clay.
4-11	Rubble.
11-22	White rock.
22-41	Red rock.
41-55	Brown rock.

Lower Third—

55-77	Red sandstone.
77-82	White sandstone.
82-146	White clay.
146-169	Yellow clay.
169-180	Red clay.
180-189	Yellow clay.
189-199	White clay.

Middle Cretaceous—

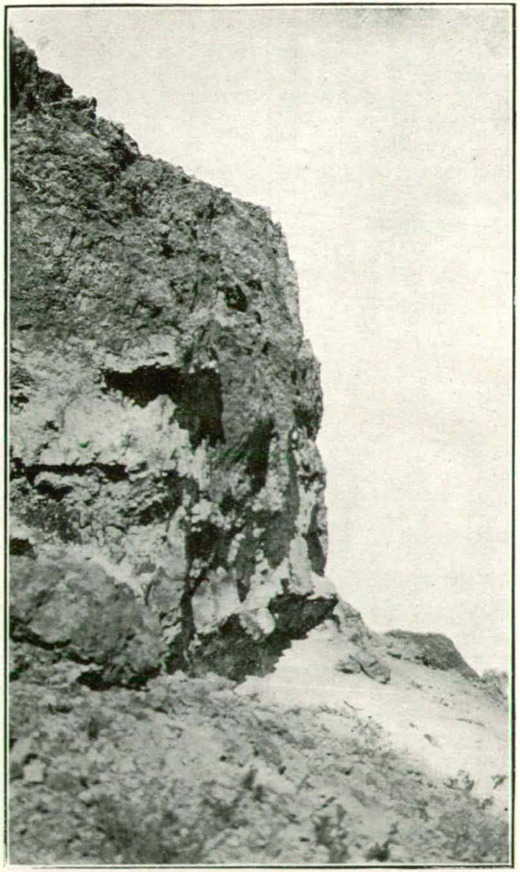
199-209	Grey clay.
209-249	Blue clay.
249-254	Blue sandstone, water.
254-277	Blue clay.
277-315	Blue sandy clay.
315-342	Blue clay.
342-345	Blue sand-rock. (Needle Well bed.)
345-360	Blue sandy clay.

Waters cut at 83ft., 249ft., and 342ft.

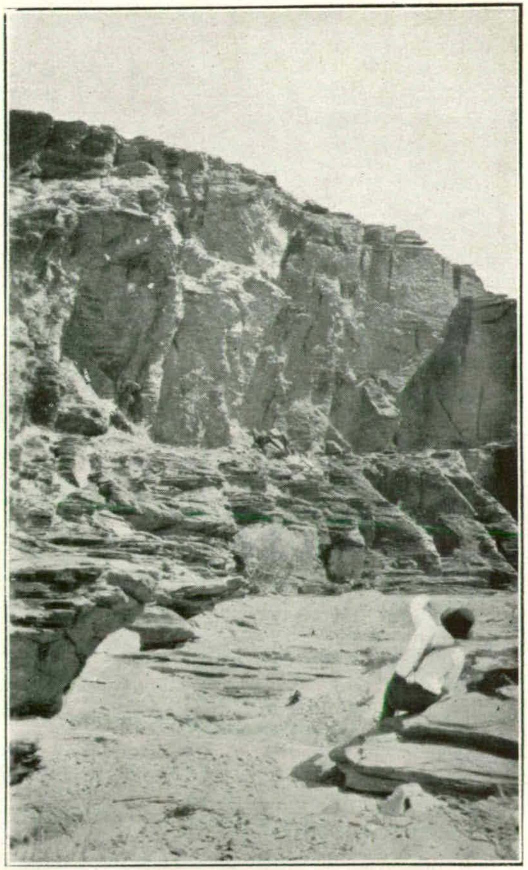
Deepest water, 840galls. per hour of 0.49oz. water, rises to 80ft.

Main Bed should be about 590ft.

To face page 24.]



Siliceous Crust of Desert Sandstone near Needle Hill Bore, Cordillo.



Spring in Calcareous Slate, and Slate E. of Jones' Hill (suggested Well Site), North Flinders Range.

Peetana Bore.

Height above sea level, 190ft.

Upper Cretaceous—

Feet.	
0-6	Red loam and boulders.
6-18	Conglomerate (?)
18-38	Pink gypsum (sandstone).
38-48	White gypsum (sandstone).
48-68	Pink gypsum (sandstone).
68-95	White clay.
95-100	Red sand and rock.
100-110	White gypsum (sandstone).
110-130	Pink clay.
130-190	Yellow clay.

Middle Cretaceous—

190-260	Blue sticky clay.
260-261	White rock.
261-281	Green sand rock and lignite.
281-470	Blue clay.
470-480	Blue sandy clay.
480-645	Blue sticky clay.
645-655	Blue sandy clay.
655-732	Hard blue shale.
732-736	Hard sand rock.
736-754	Hard blue shale.
754-763	Light sandy clay.
763-765	White rock.
765-770	Sandy clay.
770-775	Blue shale.
(Needle	Well water-bed, dry (?))
775-793	Dark sandy clay.
793-806	Light blue shale.
806-807	Blue rock.
807-887	Hard blue shale.
887-897	Hard blue rock.
897-902	Sandy clay.
902-932	Hard, blue shale.
932-935	Blue rock.
935-998	Hard blue shale.
998-1,008	Sand rock (water-bearing). (Main bed.)
1,008-1,010	Blue rock.
1,010-1,030	Hard blue shale.
1,030-1,033	Blue rock.
1,033-1,043	Hard blue shale.
1,043-1,048	Blue rock.
1,048-1,076	Hard blue shale.

Final water, with 1.48oz. of salt per gallon, cut 1,000ft.-1,010ft. Tested to 1,000galls. per hour.

Pillathilparie Bore.

Height above sea level, 368ft.

Upper Cretaceous—

Middle Third—

Feet.	
0-8	Gravel and clay.
8-13	Boulders.
13-16	White rock.
16-39	Hard yellow rock.
39-80	Pipeclay. Soakage at "".
80-109	Yellow sandy clay.

PILLATHILPARIE BORE—*continued.*

Lower Third—

109-133	Sandstone (small supply, fresh).
133-145	White pipeclay.
145-150	Sandstone streak and hard brown rock.
150-197	Grey clay.
197-261	Blue clay.
261-264	White rock.

Middle Cretaceous—

264-284	Sandy clay.
284-345	Brown clay.
345-480	Blue clay.
480-484	Rock.
484-491	Sandstone (water, Needle bed).
491-510	Blue clay.

Water with 0.15oz. salts cut at 484ft. and rises to 75ft.; good supply.

PINIEWIRRIE BORE.

Height above sea level, 150ft.

Upper Cretaceous—

Middle Third—

Feet.	
0-7	Red clay.
7-20	Clay and ironstone boulders
20-42	White rock.

Lower Third—

42-56	White sandstone.
56-80	Yellow clay.
80-100	White and yellow clay.
100-175	White and yellow clay (soapy heads).
175-200	Yellow clay.

Middle Cretaceous—

200-235	Green sandy clay.
235-255	Blue sandy clay (includes Needle bed).
255-300	Brown clay.
300-350	Green sandy clay.
350-406	Brown clay with rock.
406-425	Blue sandy clay.
425-443	Brown clay.
443-446	Blue slate (shale).
446-450	Soft brown clay.
450-465	Blue sand (Main bed).
465-495	Blue sandy clay.
495-567	Blue clay.

Waters cut:—23ft., soakage only; 235ft., a little water; 450ft.-465ft., fair supply of .96oz. water.

TURLIE TUDDA BORE.

No log.

380ft. Water, 1.84oz.

Union Bore.

Height above sea level, 196ft.

Upper Cretaceous—

Middle Third—

Feet.	
0-7	Clay and pebbles.
7-13	Boulders.
13-33	White rock.
33-41	Yellow sandstone.
41-54	Pink clay.
54-71	Yellow clay.
71-102	White clay.

Lower Third—

102-110	Yellow sandstone.
110-111	Sand.
111-121	Brown clay.
121-145	Red sand rock.
145-160	White clay.
160-171	Yellow clay.
171-198	Grey sandy clay.
198-204	Sandstone.

Middle Cretaceous—

204-277	Changeable blue clay.
277-341	——

At 102ft. cut 700galls. per hour of 0.24oz. water, rising to 84ft.

Needle Well bed should be about 550ft.

Wongyarra Bore.

Height above sea level, 175ft.

Feet.	
0-8	Gravel and clay.
8-41	Rock and boulders.
41-44	Rock.
44-90	Yellow clay.
90-111	Sandstone (small supply).

Middle Cretaceous—

111-125	Clay.
125-153	Sandstone (water) (Main bed.)
153-400	Blue clay.
400-405	Sandstone.
405-488	Blue clay.
488-493	Rock.
493-608	Sandy clay.
608-621	Sandy rock (water).
621-747	Sandy clay.
747-772	Sandstone (water).
772-789	Blue clay.
789-800	Sandstone (water).
800-822	Clay.
822-825	Rock.
825-883	Clay.

Waters cut at:—

90ft.-111ft., small.
125ft.-153ft., water.
608ft.-621ft., water.
747ft.-772ft., water.
789ft.-800ft. water.
} Tested to 1,020galls. per hour; 1.49oz. of salts.

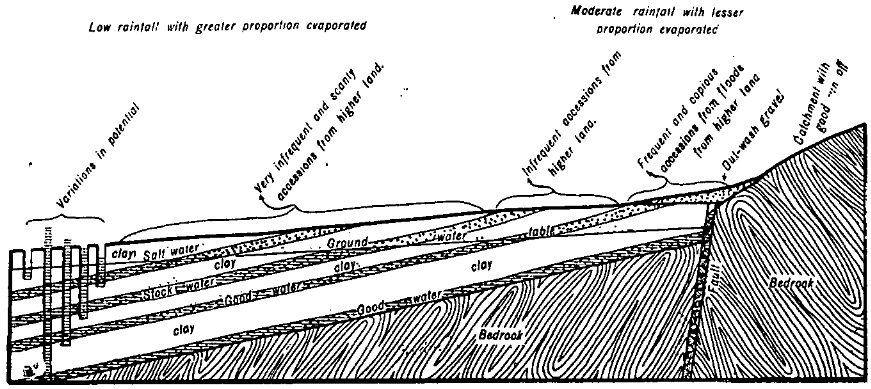
THE AREA EAST AND SOUTH-EAST OF LAKE FROME.

The Border Basin.

An extensive plain commences a little to the north of Cockburn, on the Broken Hill Railway, and occupies an embayment bounded on the east by the Barrier Ranges and on the west and south by the ranges of Boolcoomatta and their isolated outliers.

For a considerable distance out this plain is essentially argillaceous, and carries a saltbush vegetation. Beyond this, to the north and north-west, are sand-drifted ridges, now fixed by vegetation. The soil becomes lighter, and the saltbush, to a very considerable extent, is replaced by grasses and a more abundant growth of mulga, black oak, and similar vegetation.

The Mingary Creek is the principal watercourse in this area, and runs to the northwards, and then is deflected to the north-west by the slightly warped configuration of the plain. It does not appear as if it has much effect on the ground water, but it is utilised as much as possible to fill a series of dams (or tanks) along its course. The high ground of the Barrier Range is the source of several creeks, which, by the time they cross the border into South Australia, have degenerated into watercourses, or



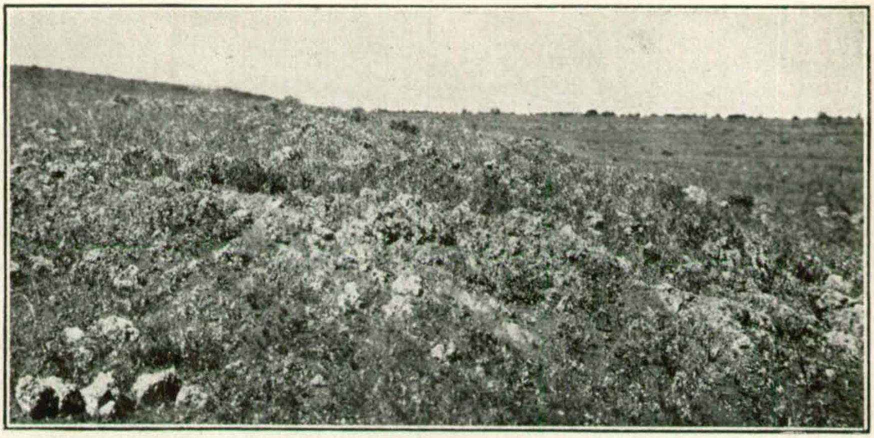
Illustrating the Influence of Distance of Intake from the Effective Catchment Area on the Quality of the Water.

flood flats. There is no doubt but that these creeks are the source of supply for the several shallow water-bearing beds that have been tapped by boring in New South Wales and South Australia. The deepest beds, outcropping near this range, and so being in a position to receive the most frequent and copious additions of water, contain the freshest water, while the progressively ascending beds outcropping at correspondingly greater distances from the range, receive less and less supply, and contain progressively worse water.

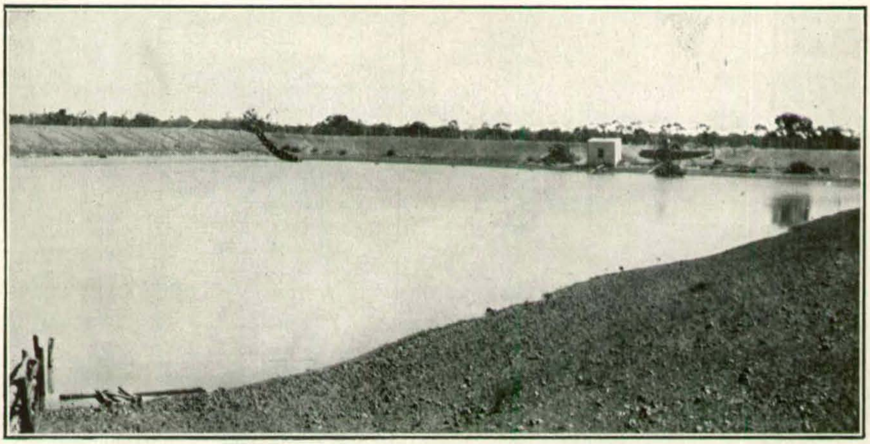
The country between the Mingary Creek and the New South Wales border is characterised by a complete absence of rock, so much so that the crystal aggregates of gypsum that occur in great profusion in the clay excavated from dams (see plate on opposite page) are utilised as the aggregate in the concrete work of the intake aprons of the dams.

In 1890 and 1891 Mulyungarie Bores Nos. 1 and 2 were sunk in this area. They passed through Recent to Tertiary material, the Winton (or upper portion of the Lower Cretaceous) beds, and into the slate and calcareous slate bedrock in search of water.

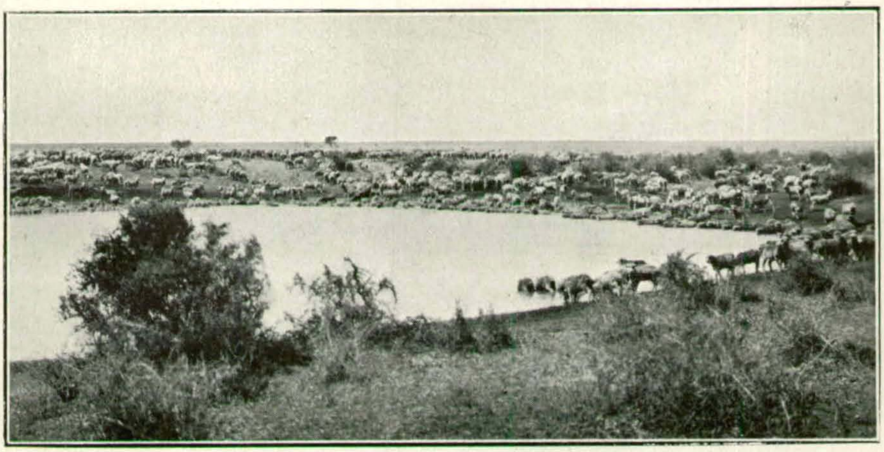
Very salt water was recorded in No. 1 Bore at a depth of 148ft., but in No. 2, although a large proportion of sandy material was recorded between



Gypsum Crystal Masses from Clay of Relief Dam, Mulyungarie Station.



Watson's Dam, a Large Excavated Reservoir on Mulyungarie Station
(depth 26ft., capacity 48,000 cub. yds.).



Sheep Watering on Moriarty Dam.

150ft. and 311ft., there is no mention of water till salt water was cut in several joints in the bedrock. In view of the history of later bores, it would be strange if these sands were dry. Probably the upper waters were ignored when the bores were being sunk, as the objective was flowing artesian water. It was, however, stated to the writer when in the district that an attempt was made to cut the casing opposite a shallow water-bearing stratum. In the light of present information it appears to the writer that it would be a reasonable risk to prospect the locality again with a hole not more than 320ft. in depth.

These two bores gave the impression that useful water was not obtainable, and the development of the country proceeded by the excavation of large dams, and the capture of the waters of Mingary Creek and of the watercourses from the east by extensive surface drains. The largest private dams sunk on one station are 53,000 and 48,000 cubic yards respectively.

Recent developments in well-sinking and bores between the Barrier Range and the South Australian border, north of Cockburn, gave evidence of useful sub-artesian water in New South Wales. The creeks from the Barrier Range gradually die out on the plains, but before doing so cross and feed the intake of some thin sand beds.

The success of the bores in New South Wales induced the Mutooroo Pastoral Company to try a series of bores on Mulyungarie Station, close to the New South Wales border, in the hope of getting the extension of these waters, and so having a more reliable supply than from the surface waters alone.

Relief, the first bore sunk, got 3.54oz. water at 180ft., salt water at 388ft., and was abandoned at 400ft. in clay that was gradually "becoming harder."

Wallace Bore cut 4.52oz. water at 150ft. and 0.93oz. water at a depth of 370ft. in fine sand. The water rises to 140ft. from the surface.

Furlough Bore cut 4.09oz. water at 160ft., 2.61oz. water at 201 ft., 1.66oz. water at 280ft., and 0.70oz. water at 355ft., in exceedingly fine sand.

Corona Bore, the last bore completed, cut 2.24oz. water at 140ft., 2.00oz. at 189ft., and 0.93oz. at 254ft.

In all cases the waters occur in beds of fine siliceous sand.

When the writer was in the district *Relief* and *Wallace* had been sunk. It appeared safer at the time to assume that the good water occurred down grade from the intersections of the intake beds by the watercourses, and *Corona* and *Furlough* were sunk on watercourses to get the benefit of any water taken in higher up the watercourse. The results, however, indicate that this precaution was unnecessary, and that there is every probability of a widespread sheet of useful water under the north-east portion of Mulyungarie Station. The extension westward is uncertain, as Mulyungarie Bore No. 1 was a failure (1) by cutting bedrock at a shallow depth, and (2) by only getting salt water. Mulyungarie No. 2 had enough depth of unconsolidated material to contain the water-bearing beds before it reached bedrock, but there is some doubt as to quality. No water was recorded, in the log, above the bedrock, though it is hardly likely that sands to a depth of 310ft. were waterless. As a matter of fact, it was stated locally that an attempt was made to slot the casing opposite a shallow water. In view of the doubt, the writer considers that the western limit of usable water may be regarded as being in the vicinity of Mulyungarie No. 2.

The arear marked on the accompanying plan (Plate II.) should yield supplies where desired.

In view of the importance of these results the logs of bores sunk farther to the northward by the Government and others were re-examined. These bores have been sunk to get the main artesian supply of the Great Australian Basin, and the waters passed through above the marine blue shale (Lower Cretaceous) do not appear to have been in all cases tested, or even recorded as fully as is now seen to be desirable.

This basin, as drawn from the information available, appears to have an area of at least 2,600 square miles in South Australia and a very considerable extension into New South Wales.

The deepest water above the blue shale of which there is a record is only 383ft. below the surface, and the blue shale in the bores in the district in no case is deeper than 557ft. from the surface.

The water, therefore, can be cheaply developed, compared with the deeper artesian water, but on the other hand pumping equipment is required, and the quality of the sub-artesian water is inferior to that of the artesian.

The greatest value of this shallow basin is that it will provide water over about 750 square miles of the State that has hitherto been solely dependent on surface supplies. The extension into New South Wales will be equally valuable, as this portion of the country is also beyond the limits of the Great Basin.

The following bores tap the Great Basin water, and the features of interest are given in condensed form from their logs:—

Dewdney Bore (the southernmost) cut salt water at 140ft., but sandy shale occurs at 203ft., and for the most part from 305ft. to 508ft., in which there is no mention of water of any sort. The bore passed from blue shale into hard micaceous rock and sandstone at 735ft., without passing through the water-bearing sands, and continued to 972ft. in the bedrock. At 960ft. ¾oz. water was struck in a quartz-filled crevice, and rose to 140ft. from the surface.

Glenmanyie, the next bore to the north-west, cut 9oz. water at 40ft., and 1½oz. water (*i.e.,* suitable for sheep) at 234ft., the water rising to 40ft from the surface. The better water occurred in 3ft. of coarse siliceous sand and gravel resting on the blue shale. At 811ft. the artesian sands yielded an artesian flow of 10,800galls. per day of ⅝oz. water. The bore finished in reddish-brown sandstone bedrock at 890ft.

Culberta, a private bore to the north-west of Glenmanyie, got salt water at 188ft. and 274ft., above the main supply, and so is beyond the western limit of the area. This bore at 629ft. passed from the blue shale into a reddish dense conglomerate grit (called "red granite" in bore log), and continued in it to 648ft.

Water was got in a crevice at 637ft. flowing to the extent of 2,000galls. per day, and after clearing out the sand, the flow increased to 15,000galls.

Thurlooka, like *Culberta,* is a private bore on Lake Elder Station, and lies to the north-east of Dewdney Bore. From the logs supplied by the Lake Elder Pastoral Company it cut a little salt water at 154ft.; brackish water, which rose 40ft., at 177ft.; salt water, rising 80ft., at 234ft.; water at 260ft.; and at 383ft. good water, rising 180ft. All these waters were in beds of white sand. The Great Basin water was cut at 1,067ft., and flowed over the surface at the rate of 4,800 galls. per day. Evidently the top of the bore was just above the isopotential, and the flow is reported (1924) to have ceased (De Villa).

Curraworra, north of Dewdney, had salt water at 126ft.; 2½oz. water at 155ft.; and 1⅛oz. water in sands at 254ft. At 1,140ft. the main water was flowing at the rate of 230,000galls per day, and the bore was stopped at 1,156ft.

Arboola cut salt ground water at 115ft., and there is no mention of any waters in the sands that occur to a depth of 422ft. above the blue shale. Below the blue shale the main water was struck in sand at 1,015ft. The bore is 1,060ft. deep, still in sand, and yielded, in August, 1913, 230,400galls. per day.

Coonee Creek passed through a large proportion of sands in the first 370ft. above the blue shale, but there is no mention of any water in these sands. The bore is 1,325ft. deep, and, when sunk, yielded 1,250,000galls. a day from a hard sandstone.

Coonanna cut fresh water at 238ft. in sand, with lignite. Sands persist to 396ft., but no more water is recorded until the artesian water was cut at a depth of 1,803ft. The bore was sunk to 2,030ft., yielding 64,000galls. per day at 1,833ft., and 500,000galls. per day at 2,025ft.

Yandama cut several sand beds in the first 575ft., but no water of any sort is recorded. The artesian supply was cut at 1,566ft., and the bore was continued to 1,642ft. The flow was 432,000galls. per day.

It thus appears that there is a probability of shallow water fit for sheep in the vicinity of Mulyungarie No. 2, and to the eastward of a line from that point to between Glenmanyie and Culberta; thence between Culberta and Curraworra; between Arboola and Curraworra; and thence to a point west of Coonanna. There is no positive information in the logs of Arboola and Yandama to show that useful water does not occur above the blue shale as far west as these bores. Coonee Creek Bore, within the probable area of useful water, has no record of the presence or absence of the upper waters.

Flowing water can be got to the north of the Glenmanyie Bore from the main bed of the Great Basin. This water is of better quality than that above the blue shale, but the average depth as far north as Coonanna is 1,170ft.

The recorded overlapping useful water lies between 383ft. and 238ft. from the surface, but does not rise to the surface, and it may, in deeper portions of the area, be preferable to develop this water rather than incur the expense of deep boring. The latter would be justifiable where it is possible to cut drains that would enable the flow to be properly distributed and utilised, but in much of this sandy country drains would be expensive to maintain, and there is no advantage in obtaining a very large supply of water unless it can be distributed over a sufficient area of pasturage to enable it to be utilised.

Logs of Bores in the Area East and South-East of Lake Frome.

Arboola.—Height above sea level estimated 170ft.

Feet.	
0-30	Red sand and clay.
30-100	Sandy clay.
100-129	Blue sandy clay. Salt water at 115ft.
129-137	Drift sand.
137-147	Sand and lignite.
147-172	Blue sandy clay.
172-220	Yellow clay.
220-250	Fine sand.
250-264	Clay.
264-368	Sandstone.
368-422	Dark sand and quartz. (Pebbles?—R.L.J.)
422-1,015	Blue shale with some bands of calcareous rock.
1,015-1,060	Sand and quartz.

Struck water at 1,015ft. and at 1,045ft. Flow 230,400galls. per day.
Completed by Engineer-in-Chief, August, 1913.

Coonanna.—Height above sea level estimated 200ft.

Feet.	
0-5	Red sandy loam.
5-45	Soft white sandstone.
45-50	White clay.
50-78	Grey clay.
78-89	Yellow clay.
89-238	Light-colored clays with thin bands of sand.
238-246	Grey sand with lignite. (238ft. fresh water struck, rising 38ft.)
246-384	Brown and grey siliceous sand and lignite.
384-396	Coarse sand, gravel, and lignite.
396-636	Grey sandy clay.
636-970	Blue marine shale with thin beds of limestone.
970-985	Soft sandstone containing fresh water, which rose to 160ft. from surface.
985-1,803	Blue shale with marine fossils and thin beds of limestone.
1,803-1,808	Calcareous rock and coarse quartz gravel.
1,808-1,830	Sandstone with seams of light-colored shale.
1,830-1,833	Slaty rock with coarse quartz pebbles.
1,833-1,860	Hard sandstone with bands of clay.
	(Water cut at 1,803ft. At 1,833ft. supply 64,000galls. per day.)
1,860-1,882	Bluish and white clayey sands.
1,882-1,887	Coarse drift sand.
1,887-1,889	Hard sandstone rock.
1,889-2,015	Grey shale.
2,015-2,025	Soft sandstone and slate (?).
2,025-2,030	Coarse gravel, pebbles, and lignite.

Water cut at 2,025ft. flowing at the rate of 500,000galls. per day. Total solids 0.36oz. per gallon.

Completed by Engineer-in-Chief in 1904.

Coonce Creek.—Height above sea level, 200ft.

Feet.	
0-76	No samples.
76-106	Sandy clay.
106-122	Sand.
122-156	Grey sandy shale.
156-157	Iron pyrites (nodular).
157-290	Black carbonaceous fine-grained sand and lignite.
290-370	Medium-grained sand.
370-1,290	Blue shale.
1,290-1,325	Hard sandstone.

Artesian flow from 1,325ft., rising 4ft. 9in. over surface; 1,250,000galls. per day; ⅜oz. solids per gallon.

Completed November, 1912, by Engineer-in-Chief.

Corona (Mutooroo Pastoral Company).

Feet.	
0-13	Red sand.
13-22	Red and white fairly coarse sand.
22-70	Brownish-red clay.
70-91	White and yellow sandy clay.
91-122	Fawn-colored fine-grained clay.
122-140	Cream-colored fine-grained siliceous sand.
140-141	Yellow sandy clay; 2.24oz. water at 140ft.
141-147	Greenish-grey clay. Trace of lignite.
147-170	Yellowish-grey strong clay.
170-189	White very plastic clay.; 2.00oz. water at 189ft.
189-200	Clay with lignite.
200-228	Fawn-yellowish brown and grey clays.
228-238	Calcareous clays.
238-247	Brownish-grey clay.
247-254	Greenish-grey clay.
254-270	Very fine siliceous sand with a small proportion of coarser sand. Yields large supply of 0.93oz. water, rising to 130ft. from surface.
270	Blue clay.

Feet.	*Culberta* (Lake Elder Pastoral Company).
0-22	Dark clay.
22-119	Yellow clay with hard bands.
119-177	Dark clay.
177-188	Black clay.
188-208	Sandy pipeclay with small supply of salt water.
208-218	Light clay.
218-251	Pipeclay and sand.
251-259	Pipeclay and sand.
259-274	Blue clay.
274-276	Gravel with salt water.
276-310	White drift (sand).
310-328	Gravel.
328-394	Blue clay.
394-567	Blue clay with thin black rock beds. (Probably the blue shale and thin limestone beds—R. L. J.)
567-571	Grey rock.
571-629	Blue shale.
629-648	? Red granite. (Spec. shows red siliceous grit conglomerate.—R. L. J.)

Water got in crevice at 637ft.; after clearing sand in crevice by pumping, got 15,000galls. per day.

Feet.	*Curraworra.*
0-20	Red sandy clay.
20-98	Light sandy clay.
98-115	Dark clay.
115-120	Light-blue clay.
120-129	Sand with salt water at 126ft.
129-208	Blue slatey clay with 2½oz. water, rising to 125ft. at 155ft. depth.
208-254	Sandy clay with thin layers of rock. (254ft., 1⅛oz. water cut, rising to 150ft.)
254-305	Sand.
305-327	Lignitic sand and clay.
327-363	Brown sandy clay.
363-409	Sand and quartz pebbles.
409-860	Blue slatey clay with thin layers of hard rock; 1¼oz. water at 640ft., rising to 567ft.
860-1,065	Blue shale.
1,065-1,075	Sand.
1,075-1,088	Blue shale.
1,088-1,156	Sandy clay with hard bands.
1,140	230,000galls. per day flow of water containing 0.28oz. per gallon.

Completed by Engineer-in-Chief, May, 1913.

Feet.	*Dewdney.*
0-30	Soil, sand and sandy clay.
30-203	Clay. Salt water cut at 140ft.
203-212	Sandy clay.
212-305	Light colored clay.
305-325	Grey sand.
325-345	Clay.
345-375	White sandy clay.
375-391	Clay and lignite.
391-488	Black sand and lignite.
488-508	Sand, and quartz with mica.
508-735	Blue shale with thin layers of rock.
735-740	Hard micaceous rock.
740-744	Blue shale.
744-746	Grey micaceous rock.
746-762	Clay.
762-793	Sandstone with layers of hard rock.
793-880	Hard micaceous sandstone.
880-922	Hard and soft sandstone.
922-972	Micaceous sandstone.

At 960ft. water cut in joint rises to 140ft. from surface. Solids, ¾oz. per gallon. Completed by Engineer-in-Chief in May, 1915.

Furlough (Mutooroo Pastoral Company).

Feet.	
0-14	Yellow and parti-colored clay with gypsum.
14-76	Yellowish-pink clay.
76-101	Yellowish-brown clay with some white clay.
101-160	Whitish clay with iron stains and streaks.
160-170	Very fine white siliceous sand, carrying 4.09oz. water, rising to 140ft.
170-201	Light-grey very fine textured clay.
201-202	Yellow iron-stained clay. At 201ft. 2.61oz. water, rising to 141ft.
202-204	Very fine white sand.
204-237	Grey clay.
237-242	Fine siliceous sand, reported moist only.
242-279	Whitish clay with traces of lignite particles.
279-283	Fine-grained clean siliceous sand with 1.66oz. water, rising to 140ft.
283-325	Grey clay with a little carbonaceous clay.
325-333	Light-grey clay.
333-355	Greenish-grey clay.
355-358	Med. grain siliceous sand with 0.70oz. water, rising to 145ft.

Glenmanyie.

Feet.	
0-2	Red sand.
2-8	Calcareous sandstone.
8-17	Iron-stained clay.
17-19	Clay.
19-50	White calcareous clay. At 40ft. 9oz. water, rising to 28ft.
50-100	Fine-grained white argillaceous sandstone.
100-106	Sub-angular white sand.
106-140	Dark clay.
140-165	Pale calcareous sandstone.
165-220	White fine-grained calcareous sandstone.
220-234	Grey siliceous sand and fine gravel. (At 234ft. 1½oz. water struck, rising to 40ft. from surface.)
234-237	Coarse siliceous gravel and siliceous sand.

237-658	Blue shale.
658-660	Coarse siliceous sand and gravel. First small artesian flow struck at 660ft.
660-720	Blue shale.
720-722	Grey argillaceous limestone.
722-760	Blue shale.
760-771	Fine white siliceous sand. Flow 7,000galls. per day.
771-800	Plastic white clay.
800-807	Pale calcareous clay with dolomitic limestone.
807-820	Siliceous sand and gravel. At 811ft. flow is 10,800galls. per day. Total solids 0.37oz. per gallon.
820-826	Grey limestone.
826-890	Reddish brown sandstone.

Completed in 1921 by Engineer-in-Chief.

Lake Mulyungarie, No. 1.

Feet.	
0-20	Dark-brown clay.
20-45	Clay and sand.
45-95	Blue clay.
95-100	Clay and gravel.
100-148	Yellow and white sandy clay. Very salt water at 148ft.
148-180	Brown clay.
180-180½	Quartzite boulders.

180½-320	Light-grey pipeclay. (Probably decomposed slate.—R. L. J.).
320-502½	Soft blue rock. (Slate.—R. L. J.)
502½-1,031	Hard blue and brown rock. (Slate.—R. L. J.)

3½oz. water cut at 610ft.
Completed by Engineer-in-Chief prior to 1891.

Lake Mulyungarie, No. 2.

Feet.	
0-30	Sand and clay.
30-33	Gravel and clay.
33-150	Dark clay.
150-250	Quartzose sand.
250-255	Pipeclay.
255-283	Coarse sand.
283-285	Lignite.
285-290	Coarse water-worn gravel.
290-293	Lignite.
293-302	Coarse sand.
302-305	Lignite.
305-312	Sand and gravel.
312-535	Clay with sand and pebbles.

535-545	Soft calcareous rock.
545-550	Soft clay rock.
550-706	Hard dark calcareous rock. Salt water at 690ft., rising to 125ft.
706-820	Grey and pink calcareous rock.
820-1,616	Dark clay rock. (Slate.—R. L. J.). Salt water at 1,030ft. and 1,120ft., rising to 125ft. from surface.
1,616-1,655	Light grey crystalline limestone.
1,655-1,710	Brown calcareous rock. Salt water at 1,692ft. and 1,710ft., rising to 125ft. from surface.
1,710-1909¾	Hard dark calcareous rock.

Abandoned by Engineer-in-Chief, as no prospect of good water, in March, 1891.

Relief. (Mutooroo Pastoral Company.)

Feet.	
0-210	At 180ft. water struck containing 3.54oz. per gallon.
210-220	Very fine siliceous sand.
220-260	Brownish-grey clay.
260-290	Fine-grained very pale-grey clay.
290-300	Fine-grained white and purple clay.
300-330	Fine-grained yellow clay and white clay.
330-370	Fine-grained flaky greenish French-grey clay with purple traces.
370-380	Fine-grained greenish-grey clay.
380-385	Fine-grained greenish-grey clay, with purple traces.
385-400	Shale, becoming harder.

At 388ft. cut 3.44oz. water, rising to 238ft.
Bore abandoned, as the last sample was probably bedrock.

Thurlooka. (Lake Elder Pastoral Company).

Feet.	
0-20	—.
20-35	Red clay.
35-42	Red sand.
42-46	Grey clay.
46-102	Blue clay.
102-154	Blue and yellow clay.
154-158	White sand. A little salt water.
158-166	Sandy clay.
166-177	White clay.
177-186	White drift (sand). Brackish water, rose 40ft.
186-189	Yellow clay.
189-191	Grey sand.
191-202	Yellow and blue clay.
202-234	Dark clay.
234-239	White drift (sand). Salt water rises 80ft.
239-260	Sandy clay.
260-317	White sand, with water.
317-347	White sand and clay.
347-383	Blue and yellow clay.
383-398	Coarse and fine white sand. Good water, rises 180ft.
398-430	Brown clay and lignite and some sand.
430-446	Fine silty black sand.

Thurlooka—continued.

446-467	Light clay and sand.
467-477	Brown clay and lignite.
477-492	Coarse sand.
492-494	Brown clay.
494-526	Coarse sand, with mica, lignite, pebbles, and stones.
526-545	Blue clay.
545-547	Black rock.
547-562	Green silty sand. Good water rises to 200ft. from surface.
562-564	Black rock.
564-582	Pyritic sandy clay.
582-584	Black rock.
584-650	Sandy clay.
650-842	Blue clay.
842-844	Black rock.
844-910	Blue clay.
910-982	Sticky clay.
982-984	Black rock.
984-1,002	Blue shale.
1,002-1,005	Grey rock and pebbles.
1,005-1,020	Blue clay.
1,020-1,022	Grey rock.
1,022-1,033	Sandy clay and stones.
1,033-1,039	Hard grey sand.
1,039-1,041	Grey rock.
1,041-1,048	Sticky clay.
1,048-1,050	Grey rock.
1,050-1,067	Red-stained sandrock. Good water, rising in bore.
1,067-1,079	Red soft sandrock.
1,079-1,092	Sandrock and clay.
1,092-1,104	White sandrock and lignite. Water.

Bottom. Light clay.

Wallace. (Mutooroo Pastoral Co.).

Feet.	
0-15	Siliceous iron-cemented grit.
15-30	Fairly coarse siliceous sand.
30-70	Buff-colored clay and sand.
70-110	Parti-colored clays (red, buff, and yellowish-brown).
110-150	Chocolate and grey clay. At 145ft. 4.52oz. water cut.
150-160	White fine siliceous sand.
160-190	Very fine slightly clayey yellowish quartz sand.
190-216	Buff colored clays.
216-230	Grey clay, with dark green bands. ((?) carbonaceous and glauconitic).
230-240	Grey clay with glauconite.
240-260	Greyish-brown clay.
260-270	Greyish and reddish brown clay, with harder particles of shale.
270-300	Light grey clay.
300-350	Dark grey waxy clay.
350-370	—.
370	Fine sand. Water containing 0.93oz. per gallon, rises to 153ft. from surface.

Yandama.

Feet.	
0-12	Brown siliceous sand.
12-30	Gypseous clay.
30-38	Yellow clay.
38-60	Blue clay.
60-106	Sandy clay.
106-160	Fine siliceous sand.
160-164	Greyish blue shale.
164-192	Yellow to greyish clay.
192-220	Indurated yellow sand.
220-228	White calcareous clay.
228-270	Siliceous sand.
270-290	Brown sand, with bands of clay. Carbonaceous color.
290-330	Sand and well-developed lignite.
330-432	Medium to coarse siliceous sand.
432-444	Very coarse siliceous sand and pyrite.

Yandama—continued.

444-475	Grey shale.
475-515	Fine-grained sandy-blue shale with pyrite.
515-828	Blue shale with limestone bed at 631-633ft.
828-849	Soft sandstone.
849-852	Gravel and sand.
852-936	Blue shale.
936-1,094	Blue sandy shale.
1,094-1,097	Blue shale with thin veins of rock gypsum.
1,097-1,208	Blue shale with gypsum and pyrite.
1,208-1,310	Blue slightly sandy shale.
1,310-1,314	Blue limestone.
1,314-1,566	Blue shale with L.S. band at 1,438-1,442ft., with some water.
1,566-1,582	Fine sand. Flowing water struck.
1,582-1,598	Blue shale.
1,598-1,600	Fine sand.
1,600-1,625	Ferruginous calcareous sand.
1,625-1,642	Sand and shale.

Completed by Engineer-in-Chief 1901.
Supply, 432,000galls. per day at 1,620ft.

THE AREA SOUTH OF LAKE FROME.

THE "SICCUS BASIN."

This area is separated from that to the east and south-east of Lake Frome by shallow slate bedrock, which is exposed in the Mooleulooloo Hills, and in an old filled-in well at Lake Benadgerie. There is also a low hill some miles south of the latter. South-west of Lake Benadgerie sub-angular quartz and quartzite fragments on the surface suggest the presence of bedrock at no great depth. These stones were also noted to the westward as far as Benadgerie Station west boundary.

The only successful well that was seen on this area was at Ethelmere Dam on P.L. 968A. This dam is in a swamp that does not hold up water, though it is fed by a good water-course. Water occurs in sand a couple of feet below the bottom of the dam, and is drawn on by a windmill. A well beside the dam taps the same water in sand on gypseous clay.

The writer was informed that the flat had been tested by hand-boring and the fresh water was found to extend for about a quarter of a mile round the well to a depth of 3 or 4ft. on the clay. The supply is stated to be 5,000galls. a day for about nine months, and then the well fails till it is replenished by rains. The water is slightly acrid, and contains 1¼oz. of total solids.

This well has been mentioned in some detail, as it is a type that should be looked for when the conditions are as follows:—

(1) A good feeding watercourse.

(2) Pervious ground, capable of absorbing water rapidly, and characterised by a non-saline vegetation.

The third condition, an impervious bottom to retain the water, can only be found by shallow borings.

Somewhat similar conditions give rise to the shallow wells at Rushy Swamp, where the Billeroo Station and Napier wells tap shallow water. These wells appear to be in the bed of an extinct lake, in which gypsum and carbonate of lime have been deposited over blue clay, and which have been covered by about 10ft. of clay alluvium.

The Billeroo Wells are close to a watercourse and dam. The latter cut through the clay into the gypseous bed, and acts not as a dam, but as an inlet for water to the porous beds.

The two Billeroo Wells contain water of ½oz. to ¾oz. quality at a depth of 23ft., and each has been drawn on at the rate of 3,500galls. per day for six months, with no sign of failure.

A quarter of a mile west of these wells is a small well that formerly gave useful water, but became salt after it was cleaned out. It appears that there is salt water beneath the blue clay, and that this water must have broken in from below. Borings have also cut this salt water.

The two *Napier Wells*, about half a mile north-west of Billeroo, are about 100 yards apart, 20ft. and 22ft. deep, with 100ft. of drives each, and the bottoms are in gypsum and carbonate of lime. The deeper well contains about ¾oz. and the shallower about ⅝oz. of solids per gallon. The two wells can now water about 10,000 sheep.

All these wells are reported to have had a gradual rise in their ground water level since they were first sunk, and to yield more copious supplies.

The *Amphitheatre Well*, on Wirrealpa, is a third locality where shallow soakage wells occur. The well is 20ft. deep, with 6ft. of fresh water in sands. It can water about 1,200 sheep. The well is sited in a hollow, in which a catchpit had been sunk as a preliminary to a dam, but the occurrence of pervious material led to the abandonment of dam-sinking, and the catchpit now acts as a feeder to the underlying sand.

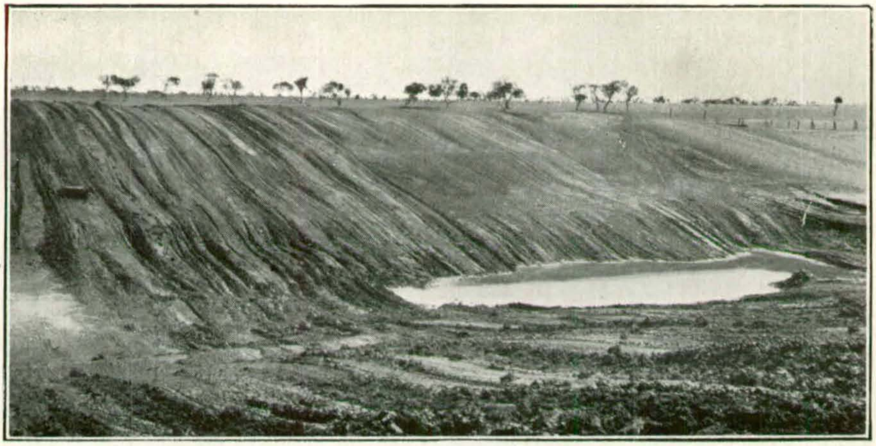
A short distance to the westward wells that were sunk to a greater depth were spoilt by the underlying salt water.

The phenomenon of the rise of the ground water in the older pastoral holdings appears to be fairly well established for a number of wells beside creeks or watercourses. The writer suggests that the possible explanation is that a greater proportion of the rainfall now reaches the watercourses than when the wells in them were first sunk, and that the pervious beds are, in consequence, replenished more frequently and copiously than hitherto. There is no doubt but that vegetation has been thinned by stock, and the originally somewhat pervious and puffy surface compacted, and tracks cut by the same agency. The effect of such changes is that the water runs more freely to the watercourses, instead of being held by the uncompacted soil, to be evaporated where it fell. The matter is not without importance, as it emphasises the advisability of seeking well sites on watercourses, in strata capable of absorbing water from the watercourses.

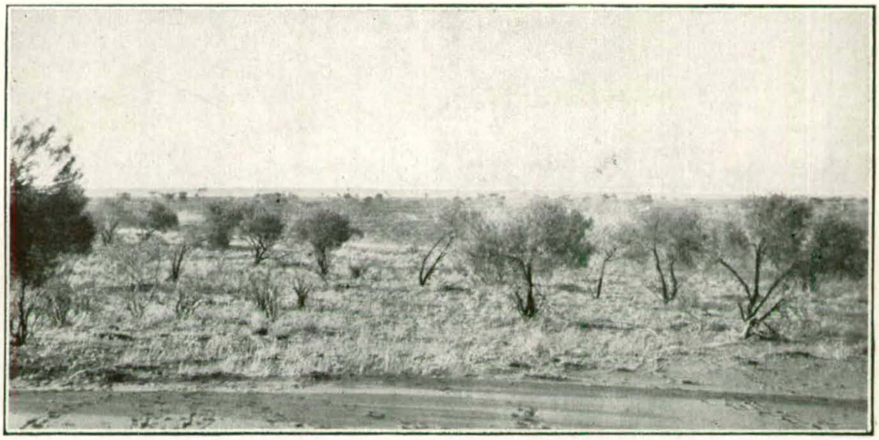
Furthermore, wells in such sites in newly stocked country that are barely usable should become better as the country becomes compacted, and, therefore, should be re-examined from time to time. The complement is that wells on the watershed (catchment area) and not on the watercourse should deteriorate in quality and supply.

West of the Benadgerie-Mooleulooloo bedrock area there is no further outcrop of bedrock until the foothills of the Flinders Range are reached. There are, however, the remnants of a very young bed of massive conglomerate that formerly covered a considerable extent of the area of the Siccus Valley, and overlies the deeper filling. These remnants were noted by the writer at McLean's Nob, Amphitheatre Well, and Bayes Dam (on Erudina). Terrell's Well, also on Erudina, is reported to have passed through 18ft. of this material into sand and gravel.

All the evidence available goes to show that there is a deep alluvial-filled embayment to the south of Lake Frome, and extending to a little south of Curnamona, that should provide a sub-artesian basin. East of the present Siccus River, wells to ground-water have been unsatisfactory owing to the salinity of the water, but to the west, on the piedmont plain, the ground-water, fed by the floods from the Flinders Range, has provided useful water of good to indifferent quality.



Cleaning Out a Dam (with mudscoops).



Looking N. to Lake Frome. Typical pastoral vegetation of the sandy country.

The Old Cup of the Mound of Coombs Spring.

To face page 38.]

The following information was supplied to the writer concerning wells on Erudina Station on or west of the Siccus:—

Two Gums Wells (4) are 40ft. deep in the bed of the Siccus. The water is good to good stock water in quality, and occurs in sand under clay, and on a bed of clay about 20ft. deep, beneath which is salt water. A bore in one of these wells penetrated to 270ft., and got no useful water. In view of the information now available, it appears as if this bore was not deep enough.

Two Mile Well, in bed of Wilpena Creek, on right bank. The water is now stated to be 20ft. from the surface, but was formerly at a deeper level. The supply is large, and the quality very good.

Erudina H.S. Well, on left bank of Wilpena Creek, has not a great supply, and the quality is not equal to that of the Two Mile Well. It appears to the writer that as the valley filled with alluvium, the Wilpena Creek was diverted more to the north-westward, and that now the tendency of water percolating into the present bed is to work into older gravels and drifts under the right bank rather than under the left bank. A better quality and supply should exist on the right bank perhaps a quarter of a mile distant from the present well, which is probably not getting much benefit from the flood flows of the creek.

Terrell's Well, 80ft. to 90ft. deep, on an old flood plain, has a supply equal to watering 2,000 sheep.

North Well is 116ft. deep in red clay, with a large supply of 2½oz. water.

Well Near North Dam, 40ft. deep. The water is salt.

Mulga Well. Reported to contain very bad water.

6-Mile Well, 108ft. deep, in clay; has a very good supply of 1¾oz. water.

Gum Well, in Wilpena Creek, has a small soakage supply at 14ft., with salt water at a greater depth.

It is apparent that the wells on and west of the Siccus have been sunk to ground water only, and that there has been no occasion to seek deeper supplies. East of the Siccus, however, the water difficulty has been much more pronounced, a large proportion of failures resulting from test bores to ground water.

To the south, in the head of the embayment, the bores on Curnamona Station got water in sand drift, as follows:—Curnamona, 456ft.; Dusthole, 150½ft.; Mulga, 490ft.; Sandyoota, 185½ft.; and Woolshed, 394ft. In all cases the water rose when struck. Further north are the old Government bores, Frome Downs No. 4, and Frome Downs No. 3, or Canegrass. (See logs on page 40). No. 4 was a failure, getting salt water at 110ft. and 180ft., and reaching bedrock probably at 250ft., thus indicating that it was beyond the Siccus basin to the east. No. 3 Bore passed through clays to 250ft., and thence to bedrock at 412ft.; sands predominate. Salt water is recorded at 68ft. and 330ft. Mr. Neales, the Manager of Erudina, stated that he worked on the drill, and that the 330ft. water was "good enough stock water." This bore is evidently very near to the useful water, and the site may be worthy of further testing.

To the north, near the south-east corner of Lake Frome, is Coomb's Spring. The spring was developed by a 10ft. pit, with a 26ft. bore in the bottom. The water was trickling over the surface, but before the pipe decayed, was reported to yield 3,000galls. per day. The spring is in the centre of a flat, about 50 yards across, which probably represents the cup of a mound spring, as it is on the top of a mound 3ft. to 4ft. high, with a quaquaversal siliceous crust surrounding it. Other similar springs are stated to exist. The water, as it issued from the pit, was sampled by the writer, and its analysis is given on page 61. Though it contains 2.31oz. of salt per gallon, the water was used for sheep. Possibly, when the pipe was in order, the quality may have been a little better. The analysis shows that the water is not of the Great Basin type, nor does it resemble the waters of the sub-artesian basin near the New South Wales border. The probability is that the water is from more than one bed of the Siccus basin, possibly better water from below mingling with the upper or ground water.

On the foregoing data, the writer has drawn an approximate eastern boundary to the Siccus basin on Plate II., and has suggested the advisability of boring to the west of it for deeper supplies.

In consequence, Loveday Bore has been sunk on Frome Downs Station, and got 0.44oz. water in fine sand at a depth of 427ft. (See page 61).

With this confirmation there should be no difficulty in getting useful supplies between the Lake and the Curnamona bores, to the west of the line set down. At the same time, in view of the uncertainty of the exact position of this line, it would be advisable to develop the western portion of any desired area first. West of the Siccus there is no deep bore, as far as the writer is aware, but one or more would seem to be justified to see if better quality water than that cut by the shallow wells exists. In this area the Siccus Basin probably merges with, or is overlapped by, the area west of Lake Frome.

Bore Logs in Siccus Basin.

Frome Downs, No. 3 Bore (Cane Grass Dam).

Feet.	
0-1	Red sand.
1-26	Red sandy clay.
26-76	Variegated clay.
68	Salt water cut, rising to 60ft.
76-104	Limestone alternating with beds of marly clay.
104-260	Grey clay.
260-280	Yellow clay and sand.
280-298	Fine white quartzose sand.
298-330	Grey clay.
330-356	White sand.
330	Salt water cut, rising to 30ft. from surface. (Stated locally to be "stock water." R. L. J.).
356-361	White pipe-clay.
361-415	Sand, with thin layers of clay and lignite.
415-450	Red clay. (Probably top of bedrock. R. L. J.).
450-476	Soft argillaceous rock with bands of blue limestone.
476-495	Red and blue argillaceous rock.
495-554	Indurated red clay.
554-592	Blue argillaceous rock with bands of blue limestone.
592-635	Indurated red clay.
635-679	Blue argillaceous rock with bands of blue clay.
679-1,412	Hard blue and red calcareous rock.

Abandoned by Engineer-in-Chief, 1892.

Frome Downs, No. 4 Bore.

Feet.	
0-10	Clayey loam.
10-20	Yellow clay with gypsum.
20-60	Red clay.
60-90	Blue clay.
90-91	Indurated gravel.
91-120	Yellow clay. Salt water at 110ft.
120-135	Blue clay.
135-160	Yellow clay.
160-245	Blue clay. Salt water at 180ft.
245-250	Yellow sandy clay.
250-276	Blue clay.
276-305	Brown clay.
305-390	Red and yellow clay. Salt water at 330ft., rising to 145ft. from the surface.
390-691	Blue and brown calcareous rock.

Bore abandoned by Engineer-in-Chief August, 1892.

THE AREA WEST OF LAKE FROME AND EAST OF THE FLINDERS' RANGE.

Between the eastern slopes of the Flinders Range and Lake Frome lies an extensive plain built up of outwash debris, which is utilised as sheep country.

The northern portion overlies the Great Artesian Basin, while the southernmost merges into the Siccus basin, as described on page 40. It appears that water, either ground water or sub-artesian, is to be found throughout the greater portion of this area.

On the north portion are Petermorra, Lake Crossing. Poontana, Woolatchi, and the Muloowurtina Bores, sunk for the main artesian supply. Waters above the main artesian water were cut by the following bores:—

Petermorra cut ⅝oz. water at about 140ft. in slightly sandy shale.

Lake Crossing Bore hardly comes within the definition of a shallow upper water, but, on the other hand, the analysis (page 43) shows very clearly that the water cut is not of the type normal to the Great Basin at this point, but that it has a south-western source. The bore cut salt water at 427ft., rising to 20ft. from the surface; brackish water at 740ft., which overflowed; and at 1,351ft. 130,000galls. per day of stock water (735 grains per gallon). The bore was stopped (in 1898) at 1,703ft. in blue shale, without reaching the better quality Great Basin water, which at this point should not contain more than 80 grains of salts per gallon.

Poontana Bore, which proved the Lower Cretaceous blue shale to rest directly on the bedrock, the Jurassic water-bearing sands being absent, cut fresh water, which rose to 108ft. at 121ft. Fresh water was also reported in gravels, near the base of the Winton beds, between 800ft. and 845ft. in depth. This water rose to within 100ft. of the surface. Sunk in 1906, the value of non-flowing sub-artesian water does not appear to have been realised, and the bore was abandoned.

Woolatchi cut 300galls. per hour of stock water at 110ft. and 600galls. per hour at 243ft., which rose to 143ft. from the surface. The quality was not mentioned in the log, but as a test of quantity was made it was probably fit for stock. The Great Basin water, carrying 141.2 grains per gallon, was cut at 1,821ft., and overflowed.

To the north of Lake Frome are the two Muloowurtina Bores. No. 2 Bore cut a flow (in 1905) of 314,000galls. per day at 1,400ft. from the main water bed. No mention is made in the logs of shallow waters, but the writer was recently informed that the boring contractors used a shallow water from the holes for steam raising while sinking for the main supply.

The eastward extension shown by these bores, the presence of useful shallow water in Coonanna, despite the fact that no shallow water is recorded in Yandama, though the strata are favorable aquifers, suggest that it is possible that there is a merging of the shallow waters of the area west of Lake Frome into the area east of Lake Frome. Culberta suggests a southern division of the useful water, but to the north of it, should sub-artesian water be desired, the risk of a shallow bore would be well justified.

South of the bores mentioned, and to the west of Lake Frome, the type of water flowing from Paralana Springs indicates the possibility of the Great Basin water extending as far as this point, while Dewdney Bore, to the east of the Lake, indicates its southernmost extension in this direction.

The useful water south of Paralana is very shallow, and has its origin in the outflow from the creeks of the Flinders Range, which is largely absorbed by the outwash plain.

The lessees of P.L. 1,082 and 1,161 (Wooltana Station) have carried out an extensive campaign of development of these waters, some 38 bores in all, totalling over 4,800ft., having been sunk, with a large percentage of success. The lessees supplied the following information and samples, the analyses of which, by W. S. Chapman, have been incorporated in the table by the writer:—

Locality.	No. of Bore.	Depth feet.	Water cut feet.	Water stands feet.	Salts ounces per gall.	Remarks.
P.L. 1,082	1	120	100	90	0.15	300 g.p.h.
P.L. 1,082	2	165	145	130	0.46	Unlimited*
P.L. 1,082	3	195	145	140	0.29	350 g.p.h.
P.L. 1,082	4	—	200	—	salt	Unlimited*
P.L. 1,082	5	72	51	55	0.85	300 g.p.h.
P.L. 1,161	6	210	190	150	0.30	Unlimited*
P.L. 1,161	7	120	—	—	—	On hard rock.
P.L. 1,082	8	220	180	170	fresh	280 g.p.h.
P.L. 1,082	9	152	132	115	0.29	Unlimited*
P.L. 1,082	10	108	100	70	0.21	Unlimited*
P.L. 1,082	11	118	70	60	0.33	Unlimited*
P.L. 1,082	12	117	90	70	0.14	Unlimited*
P.L. 1,082	13	145	125	90	0.12	Unlimited*
P.L. 1,161	14	64	—	—	—	Failure, boulders struck.
P.L. 1,161	15	23	—	—	—	Failure, boulders struck.
P.L. 1,161	16	195	150	140	0.58	240 g.p.h.
P.L. 1,082	17	87	80	50	1.29	Unlimited*
P.L. 1,082	18	206	50	40	—	100 g.p.h.
P.L. 1,082	19	156	140	130	salt	Unlimited*
P.L. 1,082	20	162	140	110	1.21	Unlimited*
P.L. 1,082 / P.L. 1,161 ..	21	139	130	100	0.24	Unlimited*
P.L. 1,161	21	288	200 / 250	150	0.22	Unlimited*
P.L. 1,082	23	178	140	130	3.24 / 2.24	Unlimited*
P.L. 1,082	24	144	136	126	3.66	Unlimited*
P.L. 1,161	25	284	85 / 270	85	0.59	Unlimited*
P.L. 1,161	26	179	154	147	0.18	200 g.p.h.
P.L. 1,161	27	177	150	142	0.12	Unlimited*
P.L. 1,161	28	122	90	80	0.13	400 g.p.h.
P.L. 1,161	29	96	70	60	0.53	540 g.p.h.
P.L. 1,082 / P.L. 1,161 ..	30	51	40	30	2.03	Unlimited*
P.L. 1,161	31	51	46	44	salt	Unlimited*
P.L. 1,161	32	60	50	46	2.95	Unlimited (salt).
P.L. 1,161	33	101	50	35	1.68	60 g.p.h.
P.L. 1,082	34	192	50	50	1.66	212 g.p.h.
P.L. 1,082	35	48	12 / 20	10	salt	Unlimited*
P.L. 1,161	36	65	28 / 35	28	7.98	Unlimited*
P.L. 1,082	37	177	160	147	0.11	Unlimited*
P.L. 1161	38	270	250	—	fresh	Very fine sand.

*Unlimited may be taken to indicate that the supply is greater than the stock carrying capacity of the accessible country calls for.

Other bores recording shallow water in the area west of Lake Frome are:—

Locality.	Depth feet.	Water Cut feet.	Water stands feet.	Salts ounces per gall.	Remarks.
Muloowurtina . . .	—	A shallow water.			Used in boiler while boring to main supply.
Petermorra	—	140	—	$\frac{5}{8}$	
Poontana.	1692	121	108	"fresh"	
		800	100	"fresh"	
		841	100	"fresh"	
Woolatchi	1872	110	?		300 g.p.h. stock water.
		243	143		600 g.p.h.
		1821	Flowing	141.2 grains salt	Main water.
Lake Crossing . .	1703	427	20		
		740	Flowing	brackish	
		1351	Flowing	1.67	

There is every reason to expect that this zone of useful water will be proved to extend as far south as Tooth's Nob. and out from the Flinders Ranges as far as Lake Frome, and to a line south from the south-west corner of the Lake. The analyses show that the best quality water is found opposite the debouchures of the most efficient feeders or creeks from the ranges, and, as a general principle, it is advisable to develop similar sites before extending the work of boring to the country lying between the feeders.

The most efficient feeders are Bolla-Bollana and Big John Creeks, and the Poontana Creek. The waters deteriorate as they are developed farther from the Flinders Range. The eastern bores near the lake margin develop shallow water of poor to useless quality.

It appears to the writer that there are probably at least two beds carrying water, and that only the upper one has been touched near the lake. No. 34 Bore, though it went to 192ft., got water between 50ft. and 60ft., and the hole was in clay below 60ft. This or one of the neighboring holes could well be carried considerably deeper as it is probable that the better waters of the western bores underlie the inferior top water. One prospecting hole, carried down until it cut bedrock or a water of satisfactory quality, is certainly justified by the structural features of the basin.

In the southernmost portion a number of wells have been mentioned when discussing the adjoining area to the south of Lake Frome. Some of them contain distinctly poor water, but, in view of the very considerable areas of high catchments in the Flinders Range and the depth of young sediments proved by Loveday and Frome Downs No. 3 Bores, and some of the Curnamona bores, it appears more than likely that there is more than one water-bearing horizon, and that the deeper water will be of better quality. There should be little hesitation in carrying on in the younger sediments, if necessary, until bedrock is struck, in the hope of getting good quality water, even though the upper waters are too saline to be of use; but as soon as bedrock is struck beneath these sediments boring should cease. The bedrock that will probably be struck in the central and southern portion is bluish and dense slate, but limestone or quartzite may be got.

A good deal of successful boring and sinking for water has been done in the Flinders Ranges in these rocks; but only when they can be examined on the surface, and the possibilities of water occurring in them can be duly considered and weighed, is the expense of boring or sinking in them justified. If they are covered by deep clayey sediments, continuing to sink in them is trusting to blind chance.

THE LAKE TORRENS AREA.

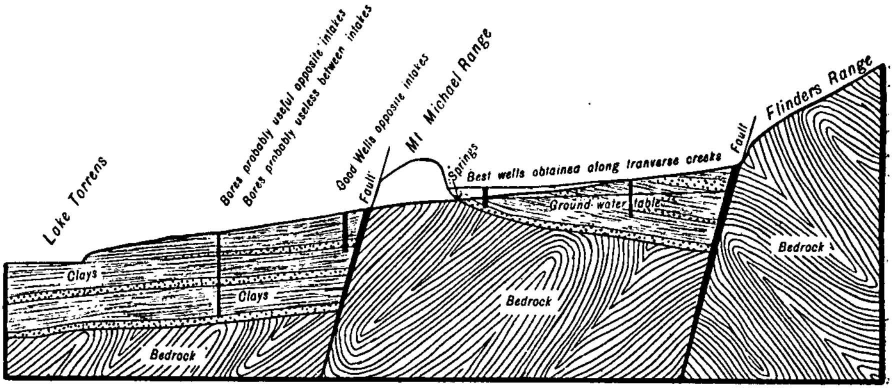
The area lying to the west of the Flinders Range was, during Pliocene time (W. Howchin), traversed by a series of step faults that resulted in the great rift valleys now occupied by St. Vincent's and Spencer's Gulfs, and by Lake Torrens.

The faults on the west of the Lake Torrens-Spencer Gulf valley need not now be considered. To the east of the Gulf an area known as the Port Pirie Basin yields flowing and sub-artesian water that, at the best, is used for the irrigation of lucerne, and ranges through stock water to water unfit for use.

Recently, however, information has become available as to portion of the area east of Lake Torrens, and a visit was made to it.

There are two main faults recognisable in the area. The eastern shows as a fault scarp running to the westward of Mount Deception Range, Beltana Hill, the Red Range, and thence probably in a south-south-east direction. To the east are the Cambrian rocks of the Flinders Range series, but on the west, or downthrow side, the shelf has been covered by a deposit of outwash material from the Ranges.

This shelf is some miles wide, and is bounded on the west by a low continuous range of bedrock, of which the salient points are "Survey Point," Mount James, Ediacara, Randell's Lookout, Mount Michael, and the extension south-south-east, across Breakfast-time Creek, of the range. This range may be regarded as the hinge round which the shelf to the eastward sank.



Generalized Section showing the Occurrence of Water in the Pirie-Torrens Area.

The western side of this range is marked by a similar fault-scarp dropping the bedrock some hundreds of feet on the west side. The drainage from the east passes to the north of the James Range by Nankabunyana Creek, and through notches in the range by Warrioota and Breakfast-time Creeks. There are also small creeks rising in this range, and flowing to the westward. These have filled the western or lowest shelf with sediments, and Lake Torrens lies upon these sediments a few miles to the westward, and receives water in exceptional floods. A good deal of red sand has accumulated as dunes to the east of Lake Torrens, but, together with the firmer loam, yields good pasturage. On the shore for a distance of nearly a mile there are stated to be low rises of gypsum and gypseous earths. These are probably analogous to those seen round the salt lakes of Yorke Peninsula.

and at Snowtown, and which were formed by the blowing of seed and flour gypsum on to the lee bank from the bed of the lake, where it has been deposited from solution.

It is thus apparent that there must be two water horizons, one on each shelf and separated by the Mount Michael-Mount James ridge. The eastern shelf is crossed by several important creeks rising in the Flinders Range, or in its outliers. The chief streams are Depot, or Aroona Creek, with tributaries, Nankabunya, Warrioota, Breakfast-time, and Blackfellow's Creeks.

It is to the percolation of the flood flows of these creeks that one must look for the source of useful water in these basins.

To take the southern end first, the last three-named creeks cross the alluvium-covered shelf, and lose a proportion of their waters into the beds along their courses. The alluvial filling has been held up by the Mount Michael ridge, and was at one time about 30ft. higher than the bottom of the present gaps. These gaps, or notches in the bedrock, have been cut down, and some of the alluvium has been cut into tabular plateaus or terraces by the rejuvenated streams.

The Mount Michael ridge, composed of tilted slates, quartzites, and a little limestone, acted not only as a bar for the alluvium, but holds up water in the latter. The excess water from this escapes as springs over the bedrock. It thus follows that there should be an extensive area of underground water where the alluvium is deep enough. As, however, there are definite inlets (the creek beds) and definite outlets for the water, the tendency will be for the underground water to travel from one to the other by the shortest practicable path. That is to say, that the most active travel of the water will be approximately under the creek beds, and the areas between the creeks will contain relatively stagnant water. Such stagnant waters are generally saline in a region of low rainfall, so that wells should be sunk close to the creeks for the sake of both quality and quantity.

Comparatively shallow wells tap this water just above the notch in the bedrock at Nilpena and Winnowie Stations. The quality is rather variable in the different wells. Others considerably deeper occur farther to the eastward.

The prospects of getting useful water at the following sites were discussed with the lessees of the area, who are carrying out an extensive search for additional waters:—

Right bank of Deadman's Creek, four miles east-south-east of Nilpena Station, on flood channel of Blackfellow's Creek.

One mile below the old collapsed Blackfellow's Creek Well, and a point on Breakfast-time Creek, one to two miles below the old Red Range Well.

On Beltana the Warrioota Creek, west of the Mount Deception Range, should have similar conditions. The water is held up by a bedrock bar at Winnowie, and shallow wells are obtained above the bar.

Millya-Millyana Bore and Well, situated six miles to the east of the bar near Winnowie, gets this water at various horizons between 33ft. and 68ft.

On the western side of the Mount Michael ridge is the Doubtful Well, to the south of Winnowie.

Still farther to the north is the Ettenna Bore. This bore has been sunk to a depth of 360ft in Post-Pliocene sediments, and obtained useful water, the composition of which is given on page 63. It has the section shown on page 48, and is probably quite close to the eastern fault scarp.

About nine miles west of Ettenna is the Pinery Bore, sunk to a total depth of 661ft., where it stopped in red slate. It probably entered bedrock at 605ft., after passing through unconsolidated sediments. It cut water containing 1.71oz. of salts per gallon at 159ft., water of unspecified quality at 337ft. (rising to 58ft. from the surface), and 1.67oz. water at 425-473ft. The water is probably derived from Aroona Creek. (See pages 49 and 63).

Boondi Well, on the left bank of Depot, or Aroona Creek, formerly had a good supply of good quality water, but after the well had been out of commission for some years it was found that the water had a content of 2.85oz. per gallon, and a bore had to be sunk to recover the useful water. This only contains about ⅞oz. per gallon. (See pages 48 and 63).

The Gap Well is situated on a small creek less than a quarter of a mile distant from the exposed bedrock, and has a depth of about 200ft. in alluvial. The water is of good quality, and is derived from a small catchment area of old rocks, whence it is led to a point where it sinks into the made ground to the west of the scarp fault. The supply entering the porous material at such a site can only be small, and it would be inadvisable to try and get water from such a small catchment very far from the point of absorption.

Possibly there are other similar sites to be found.

Warrioota Well is just such another site, but here the Warrioota Creek has been much more powerful, and threw out a considerable alluvial fan in building up the area west of the fault scarp, and there would be more latitude in the choice of a site.

Some 12 miles west-north-westerly from Warrioota (on P.L. 1,062 (?)) a bore has been drilled in sandhill country to a depth of 315ft. through clays, getting salt water only. As there does not seem to be a reasonably possible feeder to these beds from the eastward owing to the intervention of the Mount James ridge, the bore was abandoned, on the advice of the writer.

A second bore was sunk about three miles to the west of Mount Michael to a depth of 515ft., and apparently finished in bedrock after passing through clays for the most part. It is located on a flood plain, but the only waters obtained, at 150ft. and below, were salt. On following this creek up to its debouchure from the Mount Michael ridge, it (Pigeon Creek) was found to be a stream of some magnitude, flowing over west dipping slate and calcareous slate. The bedrock is cut off by faulting on the western side, and the conditions obtaining at the Gap Well are duplicated here. There is a well a mile or so west of the fault line that was said to have been sunk to a depth of 100ft., and to have been a failure, either by reason of salinity or lack of supply of useful water. In its position it seems unlikely to have been salt, and may have been a failure by reason of getting a small supply only on a bed of clay, possibly overlying other porous strata. A well or bore about a quarter of a mile distant from the slate, and opposite the outlet of Pigeon Creek, should get useful water at a depth of probably less than 150ft. Subsequent boring got a very small supply of 0.79oz. water at 180ft. in argillaceous strata. The bore passed through a very hard bar of silica or cemented sand at 92ft., which, however, had the appearance of a silicified Recent sediment rather than of a bedrock quartzite.

Breakfast-time Creek, after passing through the Mount Michael ridge, formed an alluvial fan of which the approximate limits are the present main branch on the south and the old channel to the north. There is every prospect of useful water occurring between these branches, but the strong spring that is forced up by the bedrock ridge runs water so far along the south branch that the question of additional water is not urgent.

There is the possibility of shallow water occurring along the margin of Lake Torrens under two conditions. One possibility was mentioned as an intermittent lagoon or swamp, occasionally filled by the floods of Pigeon

Creek, and which dries off without concentration of salt or the growth of salt-swamp vegetation. This would indicate a somewhat porous bottom, and percolation of the stored surface water. Such conditions should result, along the margin of the Lake in ground water at such shallow depths that testing by an auger would be rapid and effective. In boring such localities the quality of the water should be tested as soon as it is reached, and if the quality is satisfactory the hole should be deepened very cautiously, with frequent testing for quality, for the reason that in many localities the fresh water occurs as a shallow layer resting on salt water.

The other possibility is in the low gypseous undulations that are stated to fringe the lake margin. On Eyre Peninsula, which, however, has a better rainfall, shallow wells of useful water have been developed in the lower portions of such gypseous localities adjacent to salt lakes. They depend upon the local rainfall for their supply, the water running off the slopes into the depressions, and there soaking into the gypsite. The quality is not good, as a general rule, only being fit for sheep, and no great supplies can be expected; but the water, if present, is very shallow and easily prospected for with an auger, and easily developed.

These two types of soakages, if there is reason to suppose that they rest on salt water, should not be sunk into farther than is absolutely essential, the necessary storage being provided by driving or trenching.

For the major waters such as would be sought by bores or deep wells, it may be generally stated for the Torrens basin that first consideration should be given to the possible intake of the water. In other words, the points at which creeks from the ranges leave bedrock and cross on to the alluvial should be located as the probable points of intake, and from these points the probable course of the underground water should be estimated. This, in practice, will generally be along the course of the streams, and sites along such streams should be chosen whenever available, as there is the possibility of other porous strata being fed from their beds.

It would be unwise, until the possibilities along stream channels are exhausted, to bore away from the creeks unless there is no choice of positions. Such bores would probably find the uppermost water of very poor quality, and would have to be continued in the hope of getting deeper water-bearing beds above the bedrock. The deeper beds are more likely to receive frequent and copious supplies from near the edge of the basin, and so the fresh water, if present, should be less localised.

Quality of Water.

In common with most of the drier portions of the State there is a strong tendency to salinity in the waters. Indeed, it may be postulated that, in arid areas in which the accession to the ground water comes entirely from rainfall falling immediately overhead, and without the addition of surface water accumulated from some adjacent gathering ground, the ground water will be salt. There are exceptions, such as the pure sand areas, resting on an impervious bottom, into which even a low rainfall can percolate so freely as to yield sand-soak supplies. Ooldea is a case in point, to say nothing of the numerous coastal sand-soak wells along the coast of South Australia.

The fresher and more useful ground waters should be found along watercourses draining from the hills, and which, by percolation, have fed the ground water beneath their course relatively abundantly.

The deeper beds, if the structure is that of an artesian basin (pervious beds intercalated with clays) may contain salt water, or water of useful quality. Which condition obtains depends on whether the deeper beds outcrop or not, or whether the outcrop is in such a position relative to the surface drainage lines of the country as to constitute an effective intake.

Should the bed not outcrop, or outcrop in a position where it can receive only a very scanty accession of ground water, then the quality is likely to be bad. This is probably the cause of the bad water in the Warrioota and West Paddock bores. Should, however, the outcrop be at the foot of elevated ground, affording a free run off, the bed receives numerous and abundant supplies, and so contains water of good quality. (See diagram on page 28).

The diagram illustrates how it is that the lower beds in this type of sub-artesian area in so many cases yield water of better quality than the overlying beds.

Analyses of a number of bore waters are recorded on page 63.

Boondi Well was formerly good quality, but an irruption of saline water reduced the quality to that given in the analysis. On sinking a bore to the original depth the bad water was cased out, and the original supply of under 1oz. water was recovered.

The following bore logs have been supplied to the writer by the Beltana Pastoral Company, and are put on record :—

Boondi Bore.

Feet.	
0-8	Red clay with bands of gravel.
8-19	Red clay.
19-24	Stones (conglomerated) and clay.
24-60	Red clay with stones and gravel.
60-68	Stones and boulders.
68-81	Yellow clay.
81-96	Red clay.
96-101	Red sand.

Water struck at 96ft. rises to 77ft. from surface.

Ettenna Bore.

Feet.	
0-18	Red clay.
18-20	Stones.
20-40	Red clay and stones.
40-49	Red clay.
49-53	Stones (conglomerated) and gravel.
53-83	Red clay with gravel.
83-101	Stones, boulders, and gravel, and some red clay.
101-103	Red sandy clay.
103-106	Stones, gravel, and boulders.
106-110	Clay and stone.
110-181	Red clay with layers of stones.
168	A very little water.
181-204	Red clay with layer of white clay.
204-245	White clay with layers of red.
245-255	Red clay.
255-257	Yellow fine sand. Good stock water struck, rising 105ft. in bore (*i.e.*, to 150ft. from surface).
257-335	Red, white, and yellow clays.
335-341	White sand and clay. Water cut here rises to 200ft. from surface.
341-360	Red and white clay.

Milla Millyana Bore.

Feet.	
1-16	Dry sand and stones.
16-38	Conglomerated stones (probably boulder or gravel wash).
33	Water struck.
38-58	Red clay.
58-61	White sandy clay (with water).
61-70	Yellow clay, with a little water between 65ft. and 68ft.

Pinery Bore.

Feet.	
0-15	Sandy clay.
15-43	Sandstone and red and yellow clay.
43-67	Yellow clay.
67-71	Gravel.
71-159	Light red clay.
159-239	White drift sand, with small supply of water at 165ft.
239-260	Pink clay.
260-286	White clay.
286-290	Drift sand.
290-337	Yellow, brown, and pink clays.
337-342	Drift sand, with water which rises to 58ft. from the surface.
342-410	Pipe, yellow, and grey clays.
410-425	Light blue clay.
425-473	Gravel, with salt water. (*Note*—The casing is slotted to admit this water).
473-477	Sand and gravel.
477-531	Chocolate clay.
531-555	Dark brown and dark sand.
555-567	Soft sand rock.
567-605	Blue clay.
605-646	Pink rock. } Bedrock.
646-661	Red slate. } Bedrock.

THE AREA BETWEEN FARINA AND THE NORTHERN EXTREMITY OF THE FLINDERS RANGE.

THE "LYNDHURST AREA."

A portion of this area was traversed by the writer in making an examination of the possibility of increasing the number of wells over an area of about 40 miles in a north and south direction, and for about 50 miles east and west. Although the district is a limited one, it is of interest, as it is situated in the driest portion of the Flinders Range, and the conditions governing the occurrence of useful waters in the somewhat similar geological and topographical features of the rest of the Flinders Range to the southward should be at least equally favorable. The country seen is largely stocked with sheep, and so water is required at fairly close intervals, as it is undesirable to force sheep to travel more than four miles from pasturage to the water.

Map references are taken from the four-mile Pastoral Plans, sheets 11 and 12, but Plate II. shows the chief localities.

The highest country is to the south-east and east of Mount Lyndhurst Station, in the spurs and backbone of the Flinders Range. From this high country gum creeks trend in a general north-north-west direction over the Upper Pre-Cambrian bedrock of the region towards the lower and newer country of the Great Artesian Basin and its margin. The newer sediments lie to the north of Wilkowie Well, Smart's Bluff, Village Well, and the new silver-lead discovery a little to the north of Mount Distance. The conditions under which water occurs differ in the older and newer rocks.

THE OLDER ROCKS.

The Upper Pre-Cambrian, in the main, consists of thick and thin-bedded slates, with fairly numerous intercalated beds of calcareous slate and limestone. Quartzite is fairly scarce. As a whole, in this district this series has been folded along east-west axes, although there are many local divergencies in strike. The result of this folding (and of erosion) has been that there are outcrops of the calcareous beds exposed, and that there are numerous intersections of these outcrops by the creek system.

The topography of this area is such that, although the rainfall is sparse (from 6in. to 10in.) there is a good run-off through the creeks, and, consequently, these calcareous outcrops have opportunities to absorb water of useful quality at these intersections.

It may be stated at this point that almost all the existing wells have water of useful quality, and a reasonable explanation for the bad quality water could be found in the case of the poor quality wells that were visited, and which were badly located. As the good quality water enters the joints and bedding planes of the bedrock from the creek bottoms due consideration should be given to the dip of the bedrock in selecting a well site. For example, if a creek runs along the strike of rocks dipping under the right bank, the well site should be so chosen on the right bank as to get water entering a permeable bed outcropping in the creek. There might be an equally permeable bed outcropping beside the creek and dipping under it, but if its outcrop is not fed by the flood-flows of the creek, it cannot be expected to collect and retain water equal in supply and quality to that held by a bed of which the outcrop is periodically flooded. Thus it is obvious that, in the location of a bedrock well, the relation of the site to the dip of the rocks and their probable intake of water must be considered.

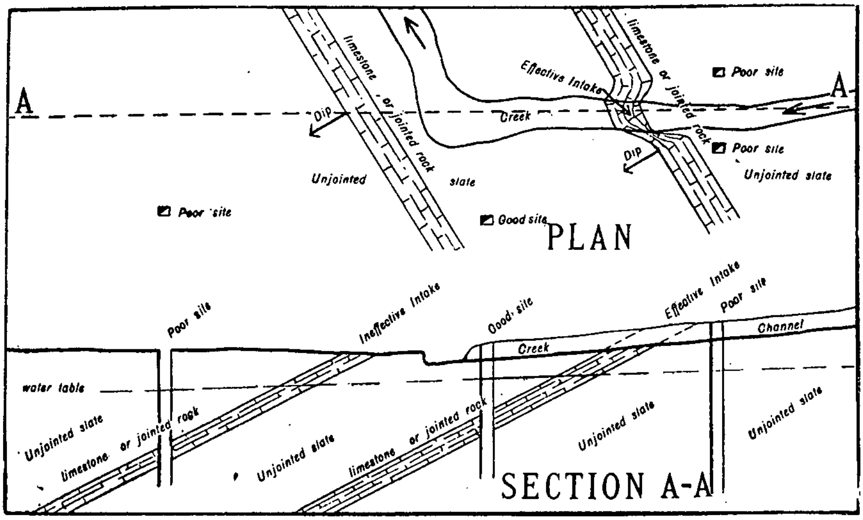


Diagram Illustrating the Location of Good and Bad Well Sites in Arid Bed Rock Areas.

As mentioned above, the chief rocks of the bedrock area are slates, and limestones or calcareous slates. The folding that has taken place must have caused a good deal of jointing in both rocks, but less in the slates, which are more deformable than in the brittle limestone. With the weathering that has subsequently taken place the conversion of the slate to clay causes an increase in volume, so that there is a tendency for joints in slate to be so filled and pugged with clay as to render the circulation of the ground-water very difficult. This is probably one of the reasons for the poor supply in the Twin's Well, the other being that the well is situated badly with respect to the dip of the slate.

Limestones, on the other hand, are brittle, and are well jointed by the folding of the rocks. These joints are enlarged by solution of the limestone by circulating ground-water. In extreme cases this solution process results in large caves. A bed of limestone enclosed by slate may thus be regarded as being relatively full of joints and crevices of such size as to permit of the storage of a considerable quantity of water. It may also be regarded as being an easily permeable channel traversing the slate and tapping a large number of small joints in the slate, which act as further storages. The crossing of such a bed by a creek ensures that the supply is replenished from time to time. A well sunk to cut such a bed below water level thus taps the equivalent of a collecting and storage drive of indefinite length.

It is noticeable that the bedrock wells on Mount Lyndhurst Station have for the most part been located in accordance with these conditions, and the most successful wells are in or near considerable developments of limestone. Tower Gap, The Head Station, Gill's Bluff, Yerelina, and Village Wells may be cited.

It may be laid down as a rule for this area that, where possible, a well site should be chosen:—

(*a*) Where a creek crosses a prominent limestone bed, or at least, a calcareous slate.

(*b*) On the side of the creek down the dip from the point of intersection of the creek and limestone bed.

(*c*) So as to cut the probable water-bearing bed below the estimated level of ground-water.

In suggesting sites, these conditions were sought as far as possible. Provisional sites submitted to the writer for confirmation or otherwise had generally been chosen in accordance with these principles.

The Newer Sediments.

The country north of Wilkowie Well, Smart's Bluff, Village Well, and Ooloo Dam has different conditions; the bedrock is concealed beneath newer sediments. At some distance north, on Murnpeowie Station, bores show that the water-bearing artesian sand of Jurassic age lies upon the bedrock and thins out against its slope. This sand is overlain by the Lower Cretaceous marine "blue shale," which extends to the south of the edge of the sand, and in its turn overlaps on to the bedrock. It effectively seals off the water of the underlying sand, and prevents its extension to the south. Above the blue shale is the Upper Cretaceous "Desert Sandstone," composed of white and yellowish clays and somewhat siliceous beds. It is characterised by the formation of flat-topped hills and "table-lands," and its surface is covered by a great development of quartzite stones or "gibbers," formed under arid conditions by silicification of surface material. This desert sandstone extends far to the south of the blue shale, and has filled the valleys of the Pre-Cambrian bedrock for some distance. There has been, since its deposition, a good deal of erosion, so that fragments, or "table hills," are left isolated. This erosion has resulted in the formation of channels on the north portion of Mount Lyndhurst Station, which have become filled with alluvium, and which are now little more than flooded flats.

These flooded flats receive, and doubtless absorb, much of the floodwater from the creeks that reach them, and may either hold it or give it an opportunity to find and enter the more porous members of the desert sandstone extending to the north. The blue shale is normally too watertight to contain water-bearing beds, but, given a good flood plain to the south to absorb water, there is a chance of water either in the alluvium of the flood plain, or in the desert sandstone above the blue shale.

The bores (Pearl Hill, Gill's Gums, Nursery, Junction, Four Corners, and Woodgate) that have been sunk in these Jurassic sediments subsequent to the writer's visit indicate the presence of a fringing basin of sub-artesian to artesian type, on a higher horizon than the great Artesian Basin water.

Mookawarrina Bore, to the north of Junction Bore, cut 400galls. per hour of 1½oz. water at a depth of 778ft. in the blue shale. The water rose to 48ft. from the surface, and can probably be correlated with that of the Junction Bore.

Murnpeowie Bore reported fresh water at 314ft., rising to 63ft. from the surface. It, however, gets a flowing supply from the Great Basin water.

Lake Crossing and Yerilla Bores, well to the eastward, are definitely on the upper water only, although they get their supply at considerable depths; while Cat and Mulligan Springs, from their analyses, probably derive their waters from the upper and the upper and main waters respectively.

It thus appears that there is a considerable area (the Lyndhurst Basin) between the old rocks of the Flinders Range and the southern limits of the main artesian water bed, which contains useful water. It enters from the streams flowing off the Flinders Range, and in the light of experience elsewhere, it is probable that the best water will be found to occur opposite the most efficient feeders.

Notes on Existing Wells and Suggested Sites.

The following notes refer to wells visited and possible sites for other wells. Footnotes are appended showing the developments since the writer's visit early in 1924:—

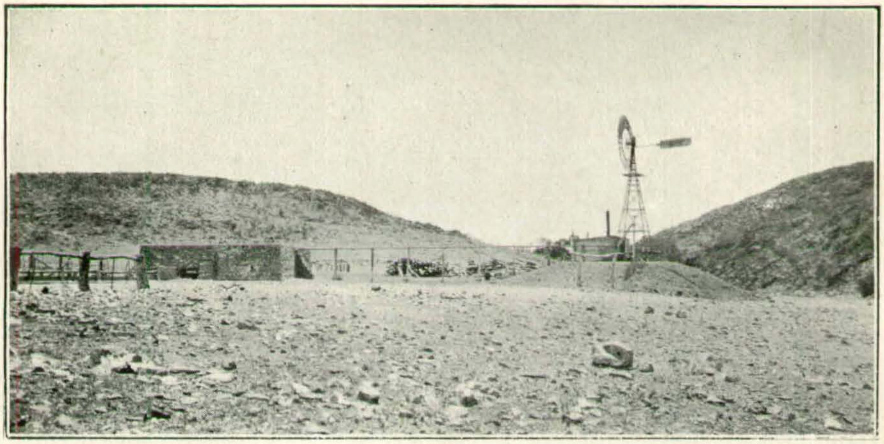
Last Chance Mine, about eight miles west of Mount Lyndhurst Head Station, and just south of telephone line from Lyndhurst Siding. The shaft is in semi-decomposed slate in hilly country, near a divide. Water level is at 30ft. The quality is good, but the quantity is only sufficient to water teams on the road.

Tower Hill Well (36ft.) is about a mile east of Avondale Mine, on a small creek, which crosses the strike of a north-dipping calcareous slate. The quality of the water is "good stock," and the well waters 1,000 sheep. While the supply is probably sufficient, there is a better site for a large supply about a quarter of a mile to the south, where an outcrop of limestone two chains wide is crossed by the same creek.

Old Tower Hill Well is east of Tower Hill, and is 80ft. deep. The water is barely good enough for sheep. Here a creek flows along the strike of a south dipping bed of calcareous slate. The well is situated on the north side, and consequently, the beds it penetrates cannot be freely fed from the creek.

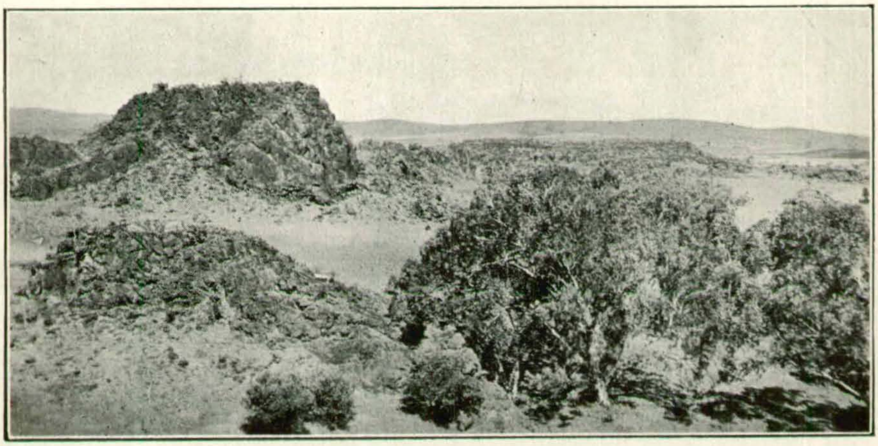
Tower Gap Well (120ft.) waters 3,500 sheep. The quality of the water is good. The well is situated beside a magnesian limestone bed, through which a large creek from hilly country has cut a gorge a quarter of a mile in length. The bottom of the well appears to be in slate. The well might have yielded a larger supply if placed one chain upstream, or if the limestone was driven to. However, the supply is ample as it is.

This bed of limestone can be traced to the south-west of Tower Gap Well, and about four miles distant it is crossed by a similar though smaller creek. This creek flows along the eastern edge of the limestone for a little distance before it breaks through the limestone hill by a gap, which a road follows, and which shows about 150yds. thickness of limestone. Sinking in the limestone on the right (or north) bank of the creek, about 25 to 50yds. upstream



Tower Gap Well, Mount Lyndhurst, at the Intersection of a creek and a bed (the hill) of Limestone.

Village Well and Creek, below beds of Dolomitic Limestone.



Looking up creek near Village Well. A very good well site would be under the big gum tree.

To face page 52.]

from the contact of the limestone and slate, should give a well similar to Tower Gap. The water may be slightly shallower, but it would be advisable to count on the same depth, viz., 120ft.

Wilkowie Well (70ft.) is eight miles north-north-east of Mount Lyndhurst Head Station, on the left bank of the Frome, and yields stock water in quantity sufficient to water 1,200 sheep. It is apparently sunk in much decomposed bedrock, as a short distance downstream the dump of an old well consists of material that is probably very much decomposed thin-bedded arenaceous slate. The surrounding country is strewn with "gibbers" of desert sandstone type.

A short distance north of Wilkowie Well a channel leads from the Frome towards the mapped head of Watson's Creek. This channel is reported to carry water whenever the Frome does, and is regarded by those who are familiar with it as a former bed of the Frome. As this channel appears to have cut its way through "gibber" country, it is very probable that it is an old channel, and as the flood-flows down this anabranch are stated to lose themselves about four to five miles out, it is a reasonable risk to bore in the northern portion of the flooded area. This is approximately three miles west of Debney's Hole on the Frome. (*a*).

(*a*) Pearl Hill Bore was sunk here to 318ft., and furnished the following section:—

Feet.	
0-7	Red clay.
7-14	Stones and gravel.
14-20	Conglomerate.
20-22	Stones and gravel.
22-32	Yellow clay with stones.
32-76	Alternating beds of red and light clay.
76-80	Compressed sand.
80-88	Limestone and sand.
88-97	Yellow clay and sand. (Very small supply of water).
97-103	Pipe clay.
103-135	Small supply of ¾oz. water rose 45ft. in bore.
135-153	Yellow clay.
153-175	Red clay.
175-186	Yellow clay.
186-202	Greenish-yellow clay.
202-230	Blue clay.
230-318	Blue slate.

The bore yielded, on testing, at the rate of 150galls. per hour.

Debney's Hole was a 12ft. hole (now silted up) in alluvium, and probably reached bedrock, as argillaceous rock dipping 20° south-south-west is exposed within a few yards in the bank of the Frome. The slate here is capped by a crust of ironstone (limonite). A similar crust occurs about two miles downstream, and may indicate the presence of slate. To the north of this ironstone is alluvium, with table-land country to the west. A site on the left bank of the Frome about four miles upstream from Apollinaris Well was suggested as a useful one. The upper portion at least will be in alluvium, and water should be got in the alluvium, or, failing that, at no great depth in the underlying bedrock. (*b*)

(*b*) The bore (Gill's Gums) subsequently sunk here passed through:—

Feet.	
0-12	Red clay.
12-15	Sand and stones.
15-35	Conglomerate.
35-42	Red and light clay.
42-47	Yellow clay.
47-49	Yellow sandy clay.
49-57	Fine white and coarse sands, with quartzite grit.
57-59	Limestone.
59-70	Dry, yellow sand, with hard bands.

70-84	Light yellow clay.
84-88	White sand, with small supply of good water.
88-102	Yellow clay.
102-175	Yellow sandy clay, with about 150galls. per hour of water.*
175-193	Blue clay (probably slate).
193-357	Soft blue slate (bedrock).

* The quality of the water is shown by the analysis on page 63.

Apollinaris Well is 140ft. deep, and waters 8,000 sheep. Quality good. It is said to have passed through a "conglomerate" at 30ft., and thence through white clay, with reddish stains, and possibly traces of lignite. It is stated to have bottomed on bluish clay, which may be the "blue shale." There is no apparent reason why similar wells should not be got beside the Frome until its junction with Yerelina Creek. Just below the junction would be an excellent site. (*c*)

(*c*) Nursery Bore sunk after Gill's Gums at a point on the Frome four miles downstream from Apollinaris Well, got 700galls. per hour of 1.37oz. (see page 63) water at a depth of 95-100ft. The bore log is as follows:—

Feet.	
0-5	Gravel.
5-10	Conglomerate.
10-18	Light clay.
18-33	Red and white clay.
33-67	Bluish clay.
67-95	White clay, with bands of limestone.
95-105	White sandy clay, with water rising to 75ft. from surface.

The site below the junction of the Frome and the Yerelina was also bored. The log is given below, and the quality of the water is shown on page 63.

Contrary to the writer's expectation, no useful water was got at shallow depths corresponding to those of the bores along the Frome to the southward, and it was not until a depth of 625ft. was reached that an unsuspected water-bearing zone in the blue shale was cut.

The bore was continued to bedrock at 723ft., but only a little additional water appeared to be present in the thin seam of sand overlying the bedrock.

The water just flows over the surface, but pumping, with the pump at 250ft., gave a supply of 360galls. per hour.

Junction Bore.

Feet.	
1-15	Red clay.
15-17	Red sand.
17-58	Light clay.
58-77	Yellow sandy clay. Small supply salt water at 60ft.
77-526	Blue clay, lighter in places.
526-570	Dark-blue clay.
570	Water (1¾oz.) cut, rising to 420ft.
570-580	Silty-greenish clay.
580-581	Flinty rock.
581-612	Sticky blue clay with stones.
612-613	Flinty rock.
613-625	Light clay.
625-627	White sand rock. Water (1.36oz.) cut, rising to surface.
627-656	Sticky blue clay.
656-661	White sand rock.
661-697	Blue clay.
697-703	Light clay, with stones.
703-716	Bands of stones, a little sand, and white clay.
716-719	Greenish slate.
719-723	Hard slate and quartz.

Yerelina Creek and the Frome, for some miles above and below this junction, show as wide flooded box-flats between table-land country. These flats take the drainage from a very large area, and give it an opportunity to percolate. Mulga Well gets fair water at 120ft. in quantity sufficient to water 4,000 sheep.

It is situated beside a small local creek, but it appears more probable that it derives its water from the larger flood-flows that come down Yerelina Creek, which is only a short distance to the south. The dump shows the well to have passed through chocolate and dark clays, with very fine sands.

Mookawarrina Well is reported to be about 200ft. deep, and to have a supply of useful water. It, therefore, appears probable that between these two wells and the north side of the flooded box-flats, bores could be sunk with reasonable confidence (*d*).

(*d*) Four Corners Bore was sunk subsequently near the Yerelina flood-flat, with the following results:—

Four Corners Bore.

Feet.	
0-8	Red clay.
8-15	Sand, gravel, and stones.
15-31	Conglomerate.
31-75	Red clay.
75-130	Red clay, with bands of white.
130-138	Red clay.
138-185	Yellow clay, with bands of red.
185-193	White sandy clay.
193	Boulders.

500galls. per hour cut at 187ft., rising to 144ft. (Quality 1.27oz.). (See analysis, page 63.

Walter's Well (Government W.R. 218) is situated on the south bank of a creek, in slate dipping south. It is shallow, and the supply is small and of good quality.

Taylor's Limestone Well, on the left bank of Taylor's Creek, is 25ft. deep (12ft. to water), and waters 1,500 sheep. The quality is good stock water. The well is sunk in limestone and calcareous slate, which strikes across Taylor's Creek, and dips west-south-west towards the well. Slate underlies the limestone, and probably acts as a dam in raising the level of the ground-water upstream from it. Deepening would increase the supply, if desired.

Taylor's Well, an old well sunk half a mile down Taylor's Creek, on the right bank. It is not equipped and the water is reported to be bad. This well is sunk in slate two or three chains back from the creek. The slate dips towards the creek, so that the beds the well penetrates are here not fed by the creek, but by the scanty seepage from the country to the north-east and east. It may be remarked that the country between this well and the Nob Well—mostly slate—is, for some reason, particularly saline.

Sawmill Well (50ft.), sunk in alluvium and bottoming in sand, on the left bank of Taylor's Creek, yields fresh water, and is capable of watering 4,000 sheep. The alluvial plain extends for over a mile to the west to a slate ridge, which continues to two miles north-west of the well. On the right side of the creek is Smart's Bluff table-land, probably part of the Desert Sandstone.

Taylor's Creek joins Yerelina Creek, to the north of Sawmill Well, and forms extensive flooded flats, with "gibber" country to the north.

A site, on a fence that runs north to Christmas Dam, in the middle of this flooded plain, appears to be well worthy of testing, as the plain is fed with water from a very large and effective catchment area. It is possible that a bore would have to go as deep as Apollinaris Well, say, to 150ft.

Twin's Creek Well (W.R. 108) on Tindelpina Creek, was not seen. It is reported to have a small supply of good water.

Pelican Creek was crossed between Wade's Tank and Village Well. It is a considerable gum creek, cutting into the desert sandstone table-land, which probably rests upon the bedrock. Probably a well site at the fence which crosses the creek just south of the track would give water. No estimate as to quantity could be attempted in the absence of rock exposures, except the generalisation that the creek must carry a considerable volume of water, which should have a reasonable opportunity of percolating into its bed (*a*).

(*a*) Woodgate Bore was subsequently sunk on Pelican Creek, about four miles to the northward of this fence, near its junction with Tindelpina Creek. No top water was reported but water was cut between 644ft. and 670ft., in silty clay and sand rock, and rose to 200ft. from the surface. When the bore was deepened to 700ft. the water rose to 80ft. from the surface. The analysis on page 63 shows it contains 0.88oz. of total salts per gallon. The log is given below:—

Feet.	
0-11	Gravel and stones.
11-42	Red and white clay.
42-85	White clay.
85-96	Brown clay and gravel.
96-115	White sandy clay.
115-138	Yellowish clay, with gravel.
138-197	White compressed sand, or very soft sandstone.
197-205	Yellow clay.
205-212	Light clay.
212-644	Blue clay.
644-658	Green silty clay, with some water.
658-664	Sand rock.
664	Clay.
670	Sand rock.
700	Big supply, rising to 80ft.

Village Well (80ft.), waters 3,000 sheep, and yields good quality water. It is sunk in (?) decomposed slate, on the left bank of Village Creek, about 100yds. below where the creek passes over a very large development of limestone. This limestone is weathered into large, irregular masses, the aggregate receiving the name of "Devil's Village." The well would probably have had an even better supply if it had been sunk in the limestone, which must constitute an immense storage reservoir.

Pelican Well (35ft.) waters 4,000 sheep; quality, "poor stock water." The following analysis by W. S. Chapman shows the contained salts:—

	Grains per Gallon.
Chlorine, Cl	196.12
Sulphuric acid (radicle), SO_4	220.12
Carbonic acid (radicle), CO_3	20.10
Sodium, Na / Potassium, K	156.30
Calcium, Ca	25.80
Magnesium, Mg	32.48
Silica, SiO_2	1.20
Total saline matter, Grains per gallon	652.75
Total saline matter, Ounces per gallon	1.49
Suspended matter	—
Organic matter	—

Assumed Composition of Salts.

	Grains per gallon
Calcium carbonate	33.50
Calcium sulphate	42.16
Calcium chloride	—
Magnesium carbonate	—
Magnesium sulphate	162.40
Magnesium chloride	—
Sodium carbonate	—
Sodium sulphate	90.33
Sodium chloride	323.16
Potassium chloride	—
Silica	1.20

Hardness. Degrees (English).

Hardness, total	200.07
Hardness, temporary	33.50
Hardness, permanent	166.57
Hardness, due to calcium	64.50
Hardness, due to magnesium	135.57

The analysis shows a very abnormal proportion of aperient salts, no less than 38.4 per cent. of the total consisting of Epsom and Glauber's salts, and makes it quite obvious why it has proved to be a "poor stock water."

The well is sunk on the right bank of Pelican Creek in slates dipping to the north, on the upstream end of a small gorge.

Twin's Well (120ft.). The water is of fair quality, but is only sufficient to water 300 sheep. A slate bar crosses the creek diagonally at this point, and dips upstream. The clay slate in which the well is sunk is too tight a rock to yield a large supply, and, furthermore, the well is situated on a bed which it is difficult for the creek to feed. It would have been better if the well had been located on the right bank about 300yds. above the present well, as a long gravel-filled reach of the creek would retain water so long as to give it an opportunity to saturate the underlying bedrock. There is no opportunity of seeing the bedrock here, and unless a layer of limestone or a joint larger than is normal is cut, the supply may not be much bigger than in the present well. A good supply here would be very useful, and this consideration may justify boring to a depth of say 150ft. to test the site.

Yerelina Well (35ft.), on the left or south bank of Yerelina Creek (a large gum creek) yields a very large supply of good quality water. The well is sunk through a little alluvium into calcareous slate, dipping to the south. On the right bank of the creek limestone is well developed, and small beds are present in the calcareous slate.

Springs East of Jones's Hill.—The head waters of Tindelpina Creek rise in rough slate ranges, through which the creek has cut very pronounced gorges. Lavinia Well, in the bed of a tributary near the Great Gladstone Mine, is a 12ft. pit sunk in thick, flaggy slate, which dips at a very low angle to the south-south-west, or with the creek. Water is flush with the surface, and, indeed, overflows for a few yards. The slate here, however, appears to be very dense and sparsely jointed, and in consequence may not yield a large supply.

About a mile down the main creek is a spring ("brackish" on map). At this point the slates are dipping north about 10° to 20°. In places they are slightly calcareous. Just downstream from the top spring the slate is very dense and thick-bedded, and forms the subterranean dam which has caused the spring. On the right bank of the creek upstream from the spring there is a fairly calcareous bed that must underlie the dense slate and form the reservoir rock. This should be sunk into by a well located at the first appearance of water in the creek bed, and should, on the experience of Gill's Bluff Well, give an ample supply of good water.

Gill's Bluff Well (30ft.). The quality of the water is good, and the well is capable of watering 7,000 sheep. The site of the well is an almost exact parallel, both geologically and topographically, to the site suggested above. Flatly dipping calcareous slate and limestone is crossed by a creek in rugged country. Overlying the calcareous slate is thin-bedded slate, which appears to act as the subterranean dam to hold the water in the calcareous formations.

Hogan's Well (40ft.) can water 4,000 sheep, and is sunk on the right bank of Lyndhurst Creek through alluvial and calcareous rock. The outcrop of the latter and its enclosed limestone layers is crossed by the creek.

Mount Lyndhurst (*H.S.*) *Well*, on the same creek, is similarly placed, and the supply of fresh water from the 40ft. well is stated to be "unlimited."

Some four or five miles below the Lyndhurst Well the creek spreads on to a wide alluvial flooded flat, which also receives floodwaters from the south. The bulk of the water flows north through a narrow alluvial-filled gap between two small slate rises (the Doughboy). The slate dips about 30° to the south, and is underlain by about 20ft. of calcareous slate and limestone. The outcrop of the latter is covered by the alluvial in the gap, and should be readily absorbent. A well about 80ft. to 90ft. south of the limestone, say, on the north-east corner of the western slate rise, should cut the calcareous slate at 40ft. to 60ft., and get a large volume of good stock water in it.*

Tardlapinna Well is a 16ft. hole on the left or west bank of McDonnell Creek in the high country within a few miles of its head. It is sunk in calcareous slate, dipping 40° west. The supply is small, and the quality good. A spring a few hundred yards higher up the creek is in similar material. Sinking and driving would improve the supply, but perhaps not sufficiently, and the well is cramped in a gorge.

A much better site occurs about a mile downstream, where the creek turns to the west through a gorge off an alluvial flat. Here the limestone bands, dipping one in three downstream, pass beneath the creek and the alluvium, and should give good storage. A site in the alluvium on the left bank, laid out to cut the limestone at a depth of 50ft., should give an ample water supply, if developed. (*a*)

(*a*) A well subsequently sunk here cut fresh water at 31ft., 200galls. per hour, and is being continued.

Willows Paddock lies to the south-south-west of the Head Station. A considerable gum creek crosses this paddock, and dies out near the Doughboy. After passing south over the axis of an anticline in the slate a quartzite bar was noted dipping 20° upstream. Above this was a long gravel-filled stretch of creek bottom, with exceptionally large and flourishing gums that gave evidence of frequent soakage. There was no exposure of other bedrock close enough to enable an opinion to be formed as to what lay beneath the gravel at any definite spot. Slate is visible on the right bank some distance out, and must underlie the gravel at a shallow depth, but it was impossible to locate any calcareous zones in the creek bed, though limestone debris in the wash indicates its presence upstream. It appears probable that the anticline and the quartzite bar form a dam, and that above it useful water will be got in the bedrock beneath the gravel, and at no great depth. The writer suggests a site on the right bank of the creek about 300 yards above the quartzite bar. The doubt here is as to size of supply, as there is no permeable bed visible on which to locate a well site.

Mount Freeling Police Well.—This well is situated on the right bank of a creek, and has been located on the axis of a sharp anticline that has caused fractures in the slate. The axis of the anticline is crossed in three places by the creek, so that the fractures have every opportunity to be fed by floodwaters. Water is about 20ft. below the surface, and the well yields 1,000galls. to 1,500galls. per day of potable water.

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* This well has since been sunk, and, after passing through 20ft. of alluvium, entered calcareous slate and limestone, in which water was cut. The well has a total depth of 31½ft., and yields 4,800galls. per day. The quality is described as being "as good as rain water."

Bore or Well—	Sundry.		CORDILLO DOWNS AREA. Un-placed.	Main Bed.			Wongyarra Bed.					Bull's Hole Bed.				
	Patchawarra Bore, 4,000ft.	Chidlee Well, Strzelecki.	Needle Hill Bore, 241ft.	Indranie Bore, 360ft.	Peetana Bore, 998ft.	Piniewirrie Bore.	Dooncoonarra Bore.	Wongyarra Bore.	Wongyarra Bore.	Turlie Tudda Bore, 380ft.	Bull's Hole Bore, 1,625ft.	Bull's Hole Bore, 1,625ft.	Bull's Hole Bore, 1,625ft. After pumping.	Bull's Hole Bore, 1,625ft. After pumping.	Needle Hill Bore, 1,650ft.	Needle Hill Bore. After pumping with slotted casing.
Date of Analysis—	31.10.23	3.7.24	19.12.16	5.4.18	24.12.23	19.9.18	8.1.19	20.11.19	19.7.24	20.9.21	19.7.24	20.10.24	27.7.23	15.1.25	20.10.24	15.1.25
Analyst—	W.S.C.	W.S.C.	C.M.H.	C.M.H.	C.M.H.	C.M.H.	C.M.H.	C.M.H.	T.W.D.	C.M.H.	T.W.D.	W.S.C.	W.S.C.	W.S.C.	W.S.C.	W.S.C.
Chlorine, Cl.	87·10	77·00	—	—	—	—	—	—	191·10	—	41·58	42·14	189·83	197·11	230·79	234·02
Sulphuric acid (radicle), SO_4	0·33	23·23	—	—	—	—	—	—	65·05	—	21·92	25·33	55·70	49·40	11·32	12·32
Carbonic acid (radicle), Co_3	29·40	20·10	*—	*—	*—	*—	*—	*—	7·95	*—	5·85	10·80	5·25	4·95	1·65	1·20
Sodium, Na } Potassium, K }	77·77	69·63	—	—	—	—	—	—	113·25	—	36·65	35·05	115·11	120·72	137·37	133·33
Calcium, Ca	0·64	2·43	—	—	—	—	—	—	25·73	—	1·07	5·50	26·16	24·01	15·15	19·80
Magnesium, Mg	·32	2·09	—	—	—	—	—	—	9·50	—	2·11	3·30	4·43	3·56	0·73	1·21
Silica, SiO_2	2·50	3·40	—	—	—	—	—	—	0·80	—	0·10	3·20	1·10	1·50	0·80	1·40
Oxide of iron and alumina, Fe_2O_3 and Al_2O_3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Grains per gallon	198·06	197·88	898·4	742·8	—	418·8	614·7	651·6	413·38	804·1	109·28	125·32	397·58	401·25	397·81	403·28
Ounces per gallon	0·45	·45	2·05	1·70	1·48	0·96	1·40	1·49	0·94	1·84	0·25	0·28	0·91	0·92	0·91	0·92
Assumed Composition of Salts, grains per Gallon.																
Calcium carbonate	1·60	0·07	42·9	4·0	7·3	14·6	13·8	85·0	13·25	6·1	2·67	15·75	8·75	8·25	2·75	2·00
Calcium sulphate	—	—	118·7	117·8	116·0	34·6	120·4	55·1	69·46	72·1	—	—	77·04	69·98	16·03	17·45
Calcium chloride	—	—	—	102·9	43·0	12·2	—	—	—	—	—	—	—	0·36	25·91	38·49
Magnesium carbonate	1·12	7·31	—	—	—	—	—	—	—	—	5·95	3·57	—	—	—	—
Magnesium sulphate	—	—	124·5	—	—	—	27·0	55·5	20·02	38·9	2·05	11·40	1·65	—	—	—
Magnesium chloride	—	—	—	77·6	17·4	22·2	27·0	—	21·77	24·6	—	—	16·23	14·09	2·89	4·79
Sodium carbonate	48·83	19·86	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Sodium sulphate	0·49	34·36	—	—	—	—	—	14·2	—	—	30·00	23·97	—	—	—	—
Sodium and potassium chloride	143·52	126·88	612·3	440·5	463·7	335·2	426·5	441·8	288·08	662·4	68·51	69·43	292·81	307·07	349·4	339·15
Silica	2·50	3·40	—	—	—	—	—	—	0·80	—	0·10	3·20	1·10	1·50	0·80	1·40
Oxides of iron and alumina	—	—		—	—	—	—	—	—	—	—	—	—	—	—	—
Hardness (English Degrees).																
Total	2·93	14·79	—	—	—	—	—	—	103·97	—	11·47	27·51	83·89	74·88	40·91	54·55
Temporary	2·93	14·79	—	—	—	—	—	—	13·25	—	9·76	18·00	8·75	8·25	2·75	2·00
Permanent	Nil	Nil	—	—	—	—	—	—	90·72	—	1·71	9·51	75·14	66·63	38·16	52·55
Due to calcium	1·60	6·07	—	—	—	—	—	—	64·32	—	2·67	13·75	65·40	60·02	37·87	49·50
Due to magnesium	1·33	8·72	—	—	—	—	—	—	39·65	—	8 80	13·76	18·49	14·86	3·04	5·05

Analysts—C. M. Hallett, W. S. Chapman, T. W. Dalwood.

* NOTE.—In C. M. Hallett's analyses, for carbonate read bicarbonate.

CORDILLO DOWNS AREA.

	Needle Well Bed.				Upper Cretaceous Waters.										
					Upper Third.							Lower Third.			
Bore or Well—	Mirakoonda Bore, 557ft.	Needle Well Bore.	Pillathilparie Bore, 470ft.	Do., but casing slotted opp. top water.	Pillathilparie Well. 117ft.	Nada Well, 56ft.	Cooroondoona Well. 70ft.	Durrembinnie Well, 60ft.	Durrembinnie Well, 60ft.	Horseshoe Well.	Koora Well.	McCormac's Well, 122ft.	Cordillo Bore, 130ft.–147ft.	Cordillo Bore, 130ft.–147ft.	Union Bore.
Date of Analysis—	15.1.25	19.7.24	12.2.20	19.7.24	19.7.24	19.7.24	19.7.24	9.11.14	19.7.24	19.7.24	19.7.24	19.7.24	7.3.23	19.7.24	19.7.24
Analyst—	W.S.C.	T.W.D.	C.M.H.	T.W.D.	T.W.D.	T.W.D.	T.W.D.	C.M.H.	T.W.D.	T.W.D.	T.W.D.	T.W.D.	C.M.H.	T.W.D.	T.W.D.
Chlorine, Cl.	267·11	66·88	—	22·26	25·76	2·10	71·96	—	156·10	65·94	208·60	9·94	—	56·98	37·80
Sulphuric acid (radicle), SO_4	14·99	38·44	—	7·08	5·40	7·91	66·08	—	50·55	37·49	33·99	·1·77	—	27·89	18·08
Carbonic acid (radicle), CO_3	2·55	25·35	*—	11·70	15·00	5·10	12·45	*	5·85	11·85	6·90	18·90	*	17·40	11·10
Sodium, Na } Potassium, K }	138·28	66·30	—	19·82	21·38	2·96	67·27	—	82·64	53·18	107·49	12·81	—	50·34	29·50
Calcium, Ca	25·01	7·15	—	3·50	4·43	3·36	8·65	—	26·16	7·72	27·87	5·00	—	6·00	6·43
Magnesium, Mg	7·90	4·15	—	1·53	2·24	1·16	5·53	—	8·92	4·02	8·96	1·68	—	3·32	2·48
Silica, SiO_2	0·60	3·90	—	4·60	4·60	5·90	4·50	—	4·40	5·80	2·40	3·40	—	3·60	2·00
Oxide of iron and alumina. Fe_2O_3 and Al_2O_3	—	—	—	—	—	—	—	—	—	—	1·70		—	1·70	—
Grains per gallon	456·44	214·17	58·3	70·49	78·81	28·49	236·44	358·6	334·62	186·00	397·91	53·50	247·9	167·23	107·39
Ounces per gallon	1·04	0·49	0·13	0·16	0·18	0·06	0·54	0·82	0·76	0·42	0·91	0·12	0·57	0·38	0·24
							Assumed Composition of Salts, grains per gallon.								
Calcium carbonate	4·25	17·87	5·6	8·75	11·07	8·40	20·75	20·7	9·75	19·30	11·50	12·50	30·0	15·00	16·07
Calcium sulphate	21·24	—	—	—	—	—	1·19	73·4	71·61	—	48·15	—	—	—	—
Calcium chloride	47·34	—	—	—	—	—	—	·8	3·33	—	25·28	—	—	—	—
Magnesium carbonate	—	14·52	Tr.	5·35	7·84	0·08	—	—	—	0·38	—	5·88	3·6	11·62	2·04
Magnesium sulphate	—	—	—	—	—	5·70	27·65	—	—	19·55	—	—	24·5	—	9·50
Magnesium chloride	31·27	—	—	—	—	—	—	39·6	35·31	—	35·46	—	—	—	—
Sodium carbonate	—	7·52	29·4	4·64	4·87	—	—	—	—	—	—	12·72	—	0·17	—
Sodium sulphate	—	56·86	5·5	10·47	7·99	4·95	63·78	—	—	32·32	—	2·62	28·3	41·25	15·50
Sodium and potassium chloride	351·74	113·50	17·8	36·68	42·44	3·46	118·57	224·1	210·22	108·65	273·42	16·38	161·5	93·89	62·28
Silica	0·60	3·90	—	4·60	4·60	5·90	4·50	—	4·40	5·80	2·40	3·40	—	3·60	2·00
Oxides of iron and alumina	—	—	—	—	—	—	—	—	—	—	1·70	—	—	1·70	—
								Hardness (English Degrees).							
Total	95·49	35·19	—	15·13	20·42	13·24	44·70	—	102·63	36·08	107·07	19·51	—	28·86	26·42
Temporary	4·25	35·19	—	15·13	20·42	8·48	20·75	—	9·75	19·76	11·50	19·51	—	28·86	18·49
Permanent	91·24	Nil	—	Nil	Nil	4·76	23·95	—	92·88	16·32	95·57	Nil	—	Nil	7·93
Due to calcium	62·52	17·87	—	8·75	11·07	8·40	21·62	—	65·40	19·30	69·67	12·50	—	15·00	16·07
Due to magnesium	32·97	17·32	—	6·38	9·35	4·84	23·08	—	37·23	16·78	37·40	7·01	—	13·86	10·35

* Note.—In C. M. Hallett's analyses, for carbonate read bicarbonate.

	S.E. OF LAKE FROME. BORDER BASIN.				S. OF LAKE FROME. SICCUS BASIN.		(3) WEST OF LAKE FROME. WOOLTANA STATION.									
Bore or Well—	Relief Bore, 180ft.	Wallace Bore, 370ft.	Furlough, 280ft.	Furlough, 355ft.	Billy Coombs Sp.	Loveday Bore, Frome Downs, 427ft.	No. 1.	No. 2.	No. 3.	No. 5.	No. 6.	No. 8.	No. 9.	No. 10.	No. 11.	No. 12.
Date of Analysis—	2·8·23	2·11·23	20·3·24	9·4·24	30·10·23	27·10·24	18.8.23	18.8.23	18.8.23	18.8.23	18.8.23	18.8.23	18.8.23	18.8.23	18.8.23	18.8.23
Analyst—	W.S.C.	W.S.C.	W.S.C.	W.S.C.	W.S.C.	W.S.C.	W.S.C.	W.S.C.	W.S.C.	W.S.C.	W.S.C.	W.S.C.	W.S.C.	W.S.C.	W.S.C.	W.S.C.
Chlorine, Cl.	743·82	180·28	319·07	132·74	517·80	87·27	22·61	90·03	38·73	144·81	54·09	45·36	40·83	39·08	49·39	21·19
Sulphuric acid (radicle), SO_4	236·98	74·74	144·24	53·81	77·82	26·13	8·49	31·86	21·05	73·79	16·77	32·42	29·62	13·68	25·54	11·39
Carbonic acid (radicle), CO_3	7·80	9·00	9·45	10·50	31·80	8·19	9·75	12·75	22·80	20·25	11·85	21·90	14·40	7·05	17·10	9·24
Sodium, Na.	472·87	112·95	194·79	89·78	361·05	63·24	12·15	42·47	30·76	107·05	36·27	36·50	26·72	22·69	41·98	16·03
Potassium, K																
Calcium, Ca.	43·74	16·79	33·95	11·29	9·00	3·50	4·57	8·72	5·50	7·15	5·86	4·57	5·50	3·42	5·21	4·20
Magnesium, Mg.	40·80	14·21	25·68	8·90	13·41	4·20	4·50	16·09	8·12	15·36	5·29	10·41	9·72	5·55	4·88	2·80
Silica, SiO_2	3·60	1·00	·50	·60	1·20	1·12	2·00	1·70	2·00	1·80	1·80	N.D.	1·30	1·90	1·60	—
Oxide of iron and alumina, Fe_2O_3 and Al_2O_3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Grains per gallon	1549·61	408·97	727·68	307·62	1012·08	193·65	64·15	203·56	128·96	370·21	130·93	151·16	128·09	93·38	145·70	64·85
Ounces per gallon	3·54	0·93	1·66	·70	2·31	·44	·15	·46	·29	·85	·30	·35	·29	·21	·33	·14
Assumed Composition of Salts, Grains per gallon.																
Calcium carbonate	13·00	15·00	15·75	17·50	22·50	8·75	11·42	21·25	13·75	17·87	14·65	11·42	13·75	8·57	13·02	10·50
Calcium sulphate	131·03	36·68	94·01	14·58	—	—	—	0·75	—	—	—	—	—	—	—	—
Calcium chloride	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Magnesium carbonate	—	—	—	—	25·62	4·11	4·06	—	20·37	13·34	4·28	21·07	8·61	2·67	13·00	4·12
Magnesium sulphate	180·61	61·06	97·35	44·50	30·45	15·15	10·61	39·09	11·50	57·75	20·35	21·95	36·30	17·10	5·85	8·10
Magnesium chloride	18·53	7·91	24·58	—	—	—	5·15	32·74	—	—	—	—	—	5·42	—	—
Sodium carbonate	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Sodium sulphate	—	—	—	11·71	79·08	20·72	—	—	17·52	40·83	·72	21·98	0·85	—	30·85	7·22
Sodium and Potassium chloride	1202·84	287·32	495·49	218·73	853·23	143·80	30·91	108·03	63·82	238·62	89·13	74·74	67·28	57·72	81·38	34·91
Silica	3·60	1·00	·50	·60	1·20	1·12	2·00	1·70	2·00	1·80	1·80	N.D.	1·30	1·90	1·60	—
Oxide of Iron and Alumina	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Hardness (English Degrees).																
Total	279·65	101·28	192·06	65·37	78·47	26·27	30·53	88·96	47·64	81·98	36·73	54·87	54·32	31·73	33·38	22·18
Temporary	13·00	15·00	15·75	17·50	53·05	13·63	16·26	21·25	38·04	33·77	19·74	36·55	24·02	11·74	28·50	15·42
Permanent	266·65	86·28	176·31	47·87	25·42	12·64	14·27	67·71	9·60	48·21	16·99	18·32	30·30	19·99	4·88	6·76
Due to calcium	109·35	41·97	84·87	28·22	22·50	8·75	11·42	21·80	13·75	17·87	14·65	11·42	13·75	8·57	13·02	10·50
Due to magnesium	170·30 *	59·31 †	107·19 ‡	37·15	55·97	17·52	19·11	67·16	33·89	64·11	22·08	43·45	40·57	23·16	20·36	11·68

* Also at 388ft., 3.44ozs. † Also at 145ft., 4·52ozs. ‡ Also at 160ft., 4·09ozs. at 201ft., 2·61ozs.,

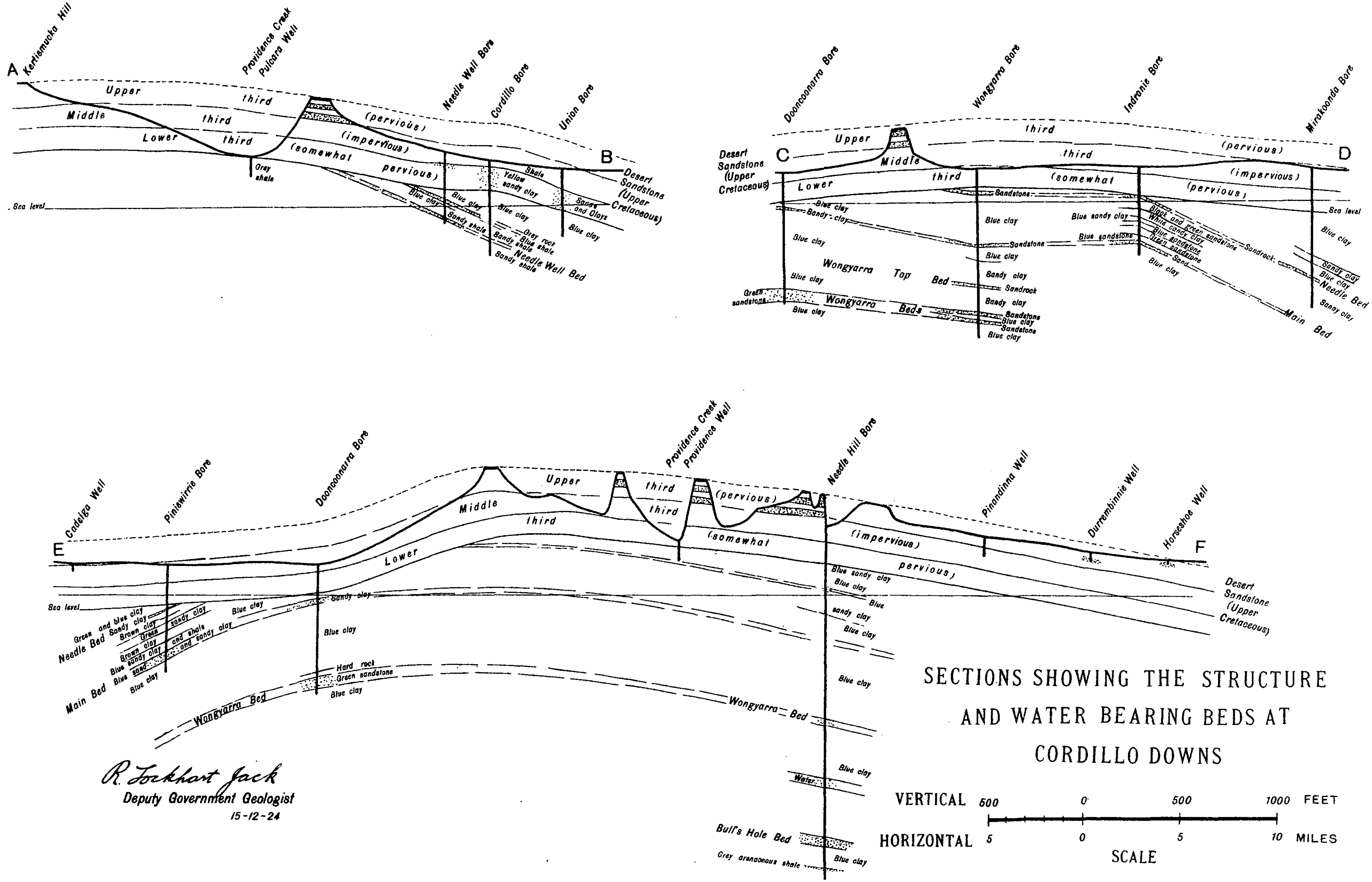
(3) WEST OF LAKE FROME.

WOOLTANA STATION.

Bore or Well—	No. 13.	No. 16 Bore.	No. 17 Bore.	No. 20 Bore.	No. 21 Bore.	No. 22 Bore.	No. 23 Bore. Top water 140ft.	No. 23 Bore. Bottom water 150ft.	No. 24 Bore.	No. 25 Bore.	No. 26 Bore.	No. 27 Bore.	No. 28 Bore.	No. 29 Bore.	No. 30.	No. 32.
Date of Analysis—	18.8.23	5.1.25	5.1.25	5.1.25	5.1.25	5.1.25	5.1.25	5.1.25	5.1.25	15.1.25	15.1.25	15.1.25	15.1.25	15.1.25	16.5.24	16.5.24
Analyst—	W.S.C.	W.S.C.	W.S.C.	W.S.C.	W.S.C.	W.S.C.	W.S.C.	W.S.C.	W.S.C.	W.S.C.	W.S.C.	W.S.C.	W.S.C.	W.S.C.	W.S.C.	W.S.C.
Chlorine, Cl.	15·62	117·56	207·20	31·55	43·17	25·90	452·22	669·31	720·27	114·92	25·77	15·32	15·32	105·17	235·39	554·14
Sulphuric acid (radicle), SO_4	7·45	35·43	152·39	12·15	10·71	19·36	168·83	226·47	301·74	33·78	11·70	5·27	1·11	29·13	340·31	268·80
Carbonic acid (radicle), CO_3	10·50	9·60	8·55	13·80	10·20	15·15	4·95	12·15	8·70	14·40	13·20	11·40	15·60	10·80	6·60	4·50
Sodium, Na } Potassium, K }	14·51	67·20	168·26	23·21	32·38	22·86	297·46	407·77	448·58	69·73	20·46	16·07	17·95	66·08	220·16	387·00
Calcium, Ca	5·07	16·86	12·59	7·86	6·50	7·28	30·94	67·60	83·54	12·72	4·29	2·36	1·93	13·36	51·21	51·63
Magnesium, Mg	·73	7·25	16·15	2·07	0·71	3·34	23·26	34·71	38·28	9·03	3·69	1·25	1·37	4·66	21·64	23·40
Silica, SiO_2	·50	0·80	1·10	1·10	1·10	1·90	2·20	1·00	2·30	3·60	1·40	2·30	2·90	2·30	1·12	1·12
Oxide of iron and alumina, Fe_2O_3 and Al_2O_3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Grains per gallon	54·38	254·70	566·24	91·74	104·77	95·79	979·86	1419·01	1603·41	258·18	80·51	53·97	55·98	231·50	876·33	1290·59
Ounces per gallon	·12	0·58	1·29	0·21	0·24	0·22	2·24	3·24	3·66	0·59	0·18	0·12	0·13	0·53	2·03	2·95
Assumed Composition of Salts. Grains per gallon.																
Calcium carbonate	12·67	16·00	14·25	19·65	16·25	18·20	8·25	20·25	14·50	24·00	10·72	5·90	4·82	18·00	11·00	7·50
Calcium sulphate	—	35·56	23·42	—	—	—	93·97	202·30	264·31	10·61	—	—	—	20·94	159·15	165·34
Calcium chloride	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Magnesium carbonate	2·55	—	—	2·81	0·63	5·91	—	—	—	—	9·48	4·37	4·09	—	—	—
Magnesium sulphate	—	12·91	80·75	7·62	2·65	8·30	116·30	104·58	143·96	32·86	4·90	—	—	17·94	108 20	117·00
Magnesium chloride	—	18·49	—	—	—	—	—	53·64	37·28	9·73	—	—	—	4·23	—	—
Sodium carbonate	1·91	—	—	—	—	—	—	—	—	—	—	8·37	17·29	—	—	—
Sodium sulphate	11·02	—	105·40	8·58	12·70	18·81	13·98	—	—	—	11·55	7·79	1·64	—	209·16	86·52
Sodium and potassium chloride	25·73	170·94	341·32	51·98	71·44	42·67	745·16	1037·24	1141·06	177·38	42·46	25·24	25·24	168·09	387·70	913·11
Silica	·50	0·80	1·10	1·10	1·10	1·90	2·20	1·00	2·30	3·60	1·40	2·30	2·90	2·30	1·12	1·12
Oxides of iron and alumina	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Hardness (English degrees.)																
Total	15·71	72·41	98·88	28·26	19·20	32·12	174·43	313·37	368·63	69·49	26·12	11·11	9·70	52·85	218·34	226·74
Temporary	15·71	16·00	14·25	22·96	16·99	25·20	8·25	20·25	14·50	24·00	22·03	11·11	9·70	18·00	11·00	7·50
Permanent	Nil	56·41	84·63	5·30	2·21	6·92	166·18	295·62	354·13	45·49	4·09	Nil	Nil	34·85	207·34	219·24
Due to calcium	12·67	42·15	31·47	19·65	16·25	18·20	77·35	169·00	208·85	31·80	10·72	5·90	4·82	33·40	128·02	129·07
Due to magnesium	3·04	30·26	67·41	8·81	2·95	13·92	97·08	144·87	159·78	37·69	15·40	5·21	4·88	19·45	90·32	97·67

Bore or Well—	(3) WEST OF LAKE FROME. WOOLTANA STATION.				EAST OF LAKE TORRENS. PIRIE–TORRENS BASIN.								LYNDHURST AREA.				
	No. 33.	No. 34.	No. 36 Bore.	No. 37 Bore.	Boondi, 96ft.	Ettenna, 256ft.	Ettenna, 335ft.	Millya Millyana, 58ft.	Pinery, 159ft.	Pinery, 467ft.	Winnowie, 134ft.	Winnowie, 160ft.	Four Corners Bore.	Gill's Gums Bore.	Junction Bore.	Nursery Bore.	Woodgate Bore.
Date of Analysis—	16.5.24	16.5.24	15.1.25	15.1.25	5·5·22	5·1·24	27·7·23	27·11·23	20·7·20	25·11·20	27·9·23	27·9·23	15.11.24	25.9.24	27.10.24	28.10.24	15.1.25
Analyst—	W.S.C.	W.S.C.	W.S.C.	W.S.C.	C.M.H.	W.S.C.	W.S.C.	W.S.C.	C.M.H.	C.M.H.	W.S.C.	W.S.C.	W.S.C.	W.S.C.	W.S.C.	W.S.C.	W.S.C.
Chlorine, Cl.	278·08	301·95	1806·85	14·07	For carbonate read bicarbonate	224·83	229·61	126·97	For carbonate read bicarbonate	For carbonate read bicarbonate	147·76	366·64	235·76	19·60	295·51	241·33	156·57
Sulphuric acid (radicle), SO_4	193·57	168·07	400·42	6·22		70·20	73·09	39·43			39·84	66·17	116·47	14·62	84·46	140·49	82·93
Carbonic acid (radicle), CO_3.	5·25	7·05	10·65	11·10		12·00	12·60	8·55			18·90	11·55	8·70	12·90	4·65	13·20	9·30
Sodium, Na; Potassium, K.	225·39	176·46	1087·88	7·85		138·46	146·27	59·41			119·21	233·16	149·36	14·73	189·53	152·92	104·96
Calcium, Ca	18·61	32·82	89·98	5·36		17·87	19·01	16·79			4·36	21·30	25·58	4·57	24·22	21·08	21·44
Magnesium, Mg	15·72	35.13	93·48	3·43		15·38	13·20	15·12			2·65	10·65	19·01	5·01	9·43	29·53	9·74
Silica, SiO_2	0·84	3·36	1·50	2·10		1·10	0·90	0·90			2·25	1·85	1·10	0·90	1·70	0·90	1·70
Oxide of iron and alumina, Fe_2O_3 and Al_2O_3	—	—	—	—		—	—	—			—	—	—	—	—	—	—
Grains per gallon	737·46	724·84	3490·76	50·13	1249·5	479·84	494·68	267·17	749·7	732·6	334·97	711·32	555·98	72·33	609·50	599·45	386·64
Ounces per gallon	1·68	1·66	7·98	0·11	2·85	1·09	1·13	0·61	1·71	1·67	0·76	1·62	1·27	0·16	1·39	1·37	0·88
Assumed Composition of Salts, Grains per Gallon.																	
Calcium carbonate	8·75	11·75	17·75	13·40	22·3	20·00	21·00	14·25	25·5	29·6	10·90	19·25	14·50	11·42	7·75	22·00	15·50
Calcium sulphate	51·37	95·60	281·79	—	213·5	33·56	36·07	37·70	49·3	49·0	—	46·24	67·25	—	71·80	41·75	51·81
Calcium chloride	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Magnesium carbonate	—	—	—	4·28	—	—	—	—	—	—	9·27	—	—	8·47	—	—	—
Magnesium sulphate	78·60	125·74	251·89	7·77	38·9	58·14	59·54	16·02	93·5	78·0	—	41·91	86·25	12·95	42·22	138·77	48·70
Magnesium chloride	—	39·52	170·60	2·61	344·2	14·84	5·10	47·18	11·1	17·4	—	8·98	6·96	—	3·92	7·05	—
Sodium carbonate	—	—	—	—	—	—	—	—	—	—	10·14	—	—	—	—	—	—
Sodium sulphate	139·68	—	—	—	—	—	—	—	—	—	58·93	—	—	6·30	—	—	10·94
Sodium & potassium chloride	458·22	448·87	2767·23	19·97	630·6	352·20	372·07	151·12	570·3	558·6	243·48	593·09	379·92	32·29	482·11	388·98	257·99
Silica	0·84	3·36	1·50	2·10	—	1·10	0·90	0·90	—	—	2·25	1·85	1·10	0·90	1·70	0·90	1·70
Oxides of iron and alumina	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Hardness (English Degrees).																	
Total	112·13	228·68	615·13	27·71	—	108·86	102·62	105·08	—	—	21·96	97·70	143·29	32·33	95·59	175·96	94·25
Temporary	8·75	11·75	17·75	18·49	—	20·00	21·00	14·25	—	—	21·96	19·25	14·50	21·52	7·75	22·00	15·50
Permanent	103·38	216·93	595·38	9·22	—	88·86	81·62	90·83	—	—	Nil	78·45	128·79	10·81	87·84	153·96	78·75
Due to calcium	46·52	82·05	224·95	13·40	—	44·67	47·52	41·97	—	—	10·90	53·25	63·95	11·42	56·23	52·70	53·60
Due to magnesium	65·61	146·63	390·18	14·31	—	64·19	55·10	63·11	—	—	11·06	44·45	79·34	20·91	39·36	123·26	40·65

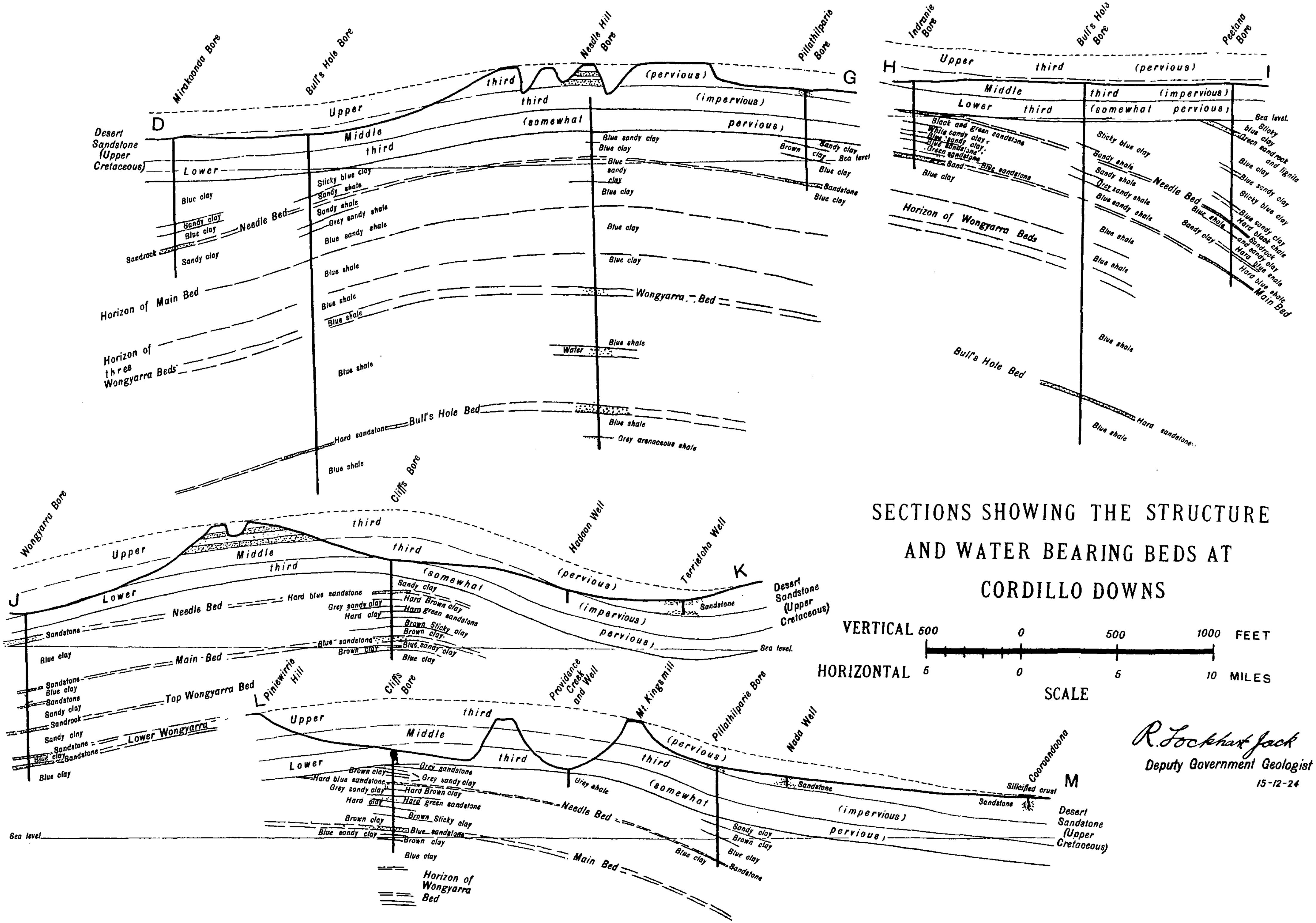
PLATES.



SECTIONS SHOWING THE STRUCTURE AND WATER BEARING BEDS AT CORDILLO DOWNS

R. Lockhart Jack
Deputy Government Geologist
15-12-24

H. E. POWELL, GOVERNMENT PHOTOLITHOGRAPHER, ADELAIDE.



SECTIONS SHOWING THE STRUCTURE AND WATER BEARING BEDS AT CORDILLO DOWNS

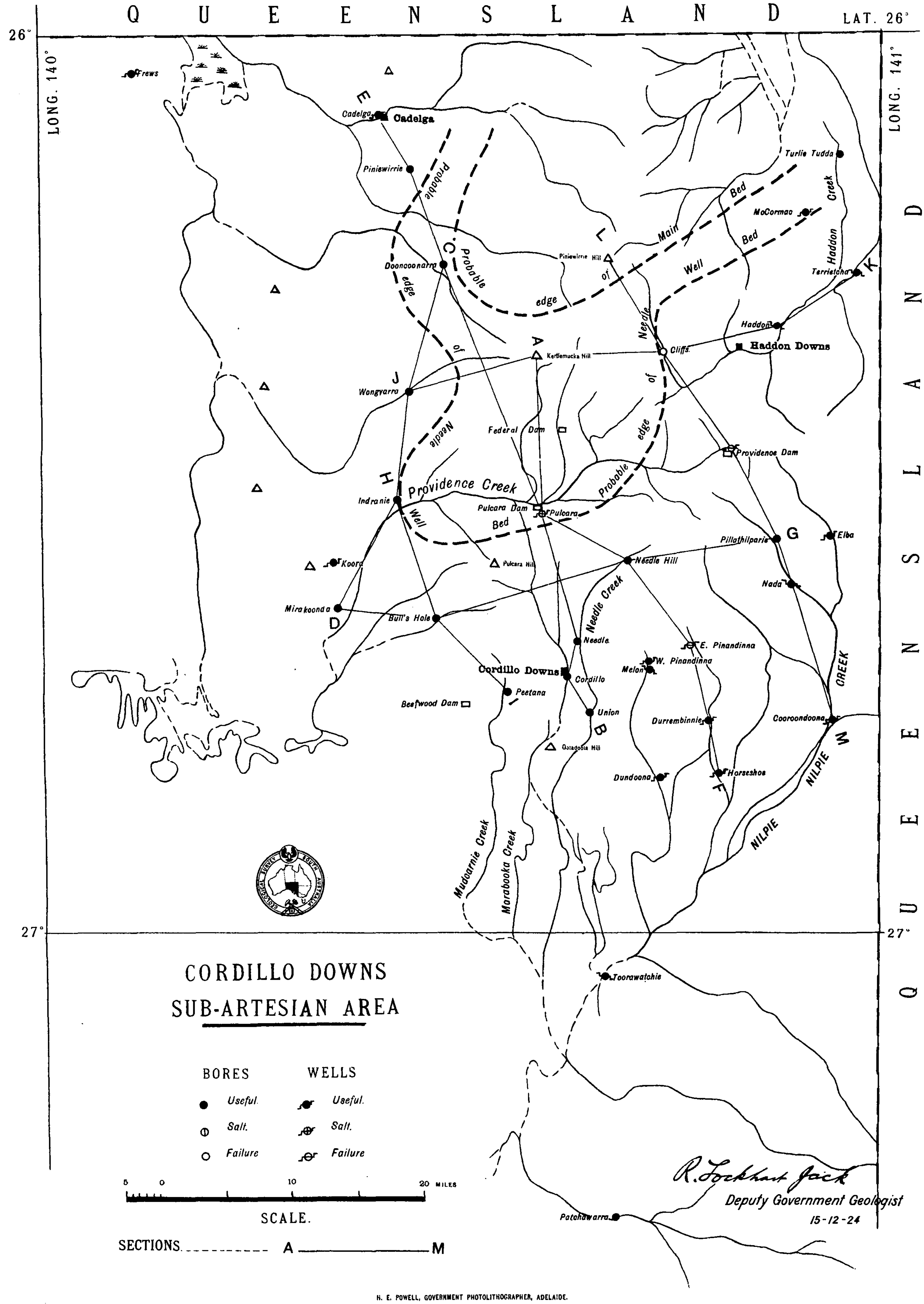
VERTICAL	500	0	500	1000	FEET
HORIZONTAL	5	0	5	10	MILES

SCALE

R. Lockhart Jack
Deputy Government Geologist
15-12-24

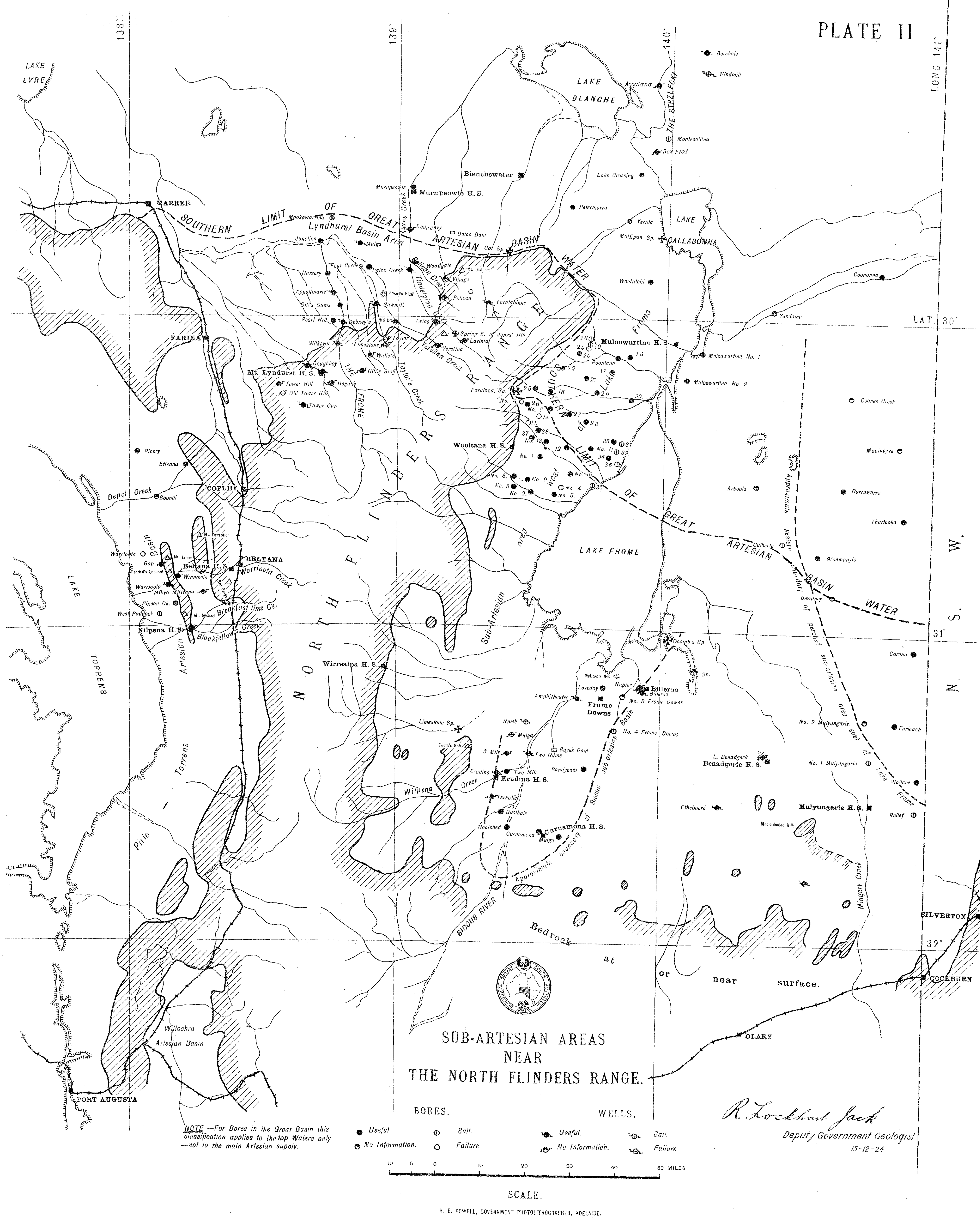
H. E. POWELL, GOVERNMENT PHOTOLITHOGRAPHER, ADELAIDE.

PLATE I



H. E. POWELL, GOVERNMENT PHOTOLITHOGRAPHER, ADELAIDE.

PLATE II



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