

PUBLICATIONS.

The only publication issued during the year was the Annual Progress Report of the Geological Survey for the year 1937.

The following Bulletin is in the hands of the Printer:—

Bulletin 97:

The Geology of the Yilgarn Goldfield South of the Great Eastern Railway, by H. A. Ellis, B.Sc., A.O.S.M., with an Appendix by Dorothy Carroll, Ph.D., D.I.C., on Sand-Plain Soils from the Yilgarn Goldfield.

The following Bulletins are prepared and are awaiting authority to print:—

Bulletin 98:

The Mining Groups of the Yilgarn Goldfield South of the Great Eastern Railway, Part I., From Southern Cross Southwards to Marvel Loch, by R. S. Matheson, B.Sc., and R. A. Hobson, B.Sc. (Hons.).

Bulletin 99:

The Mining Groups of the Yilgarn Goldfield South of the Great Eastern Railway, Part II., South of Marvel Loch, by R. A. Hobson, B.Sc. (Hons.), and R. S. Matheson, B.Sc.

The information contained in these Bulletins is of the greatest value when it can be made available to the mining community as soon as possible after it is compiled, and it is to be hoped that all three Bulletins will be published during the coming year.

SERVICE TO THE GENERAL PUBLIC.

During the course of a year many hundreds of inquiries, both personal and written, for information on geological matters, are attended to by the Government Geologist and other members of the staff who happen to be in the office at the time. Petrological determinations are made on specimens submitted, and information is freely given to intending prospectors. It is satisfactory to be able to record that these services are much appreciated by those receiving them.

It should also be placed on record that mine-owners, leaseholders, and prospectors generally show an appreciation of the advice and general help offered them by the field officers in the course of their mine examinations and general field work in the areas in which they are operating.

Not infrequently, the field officers are able to offer to those new to the arts of prospecting and mining of small ore deposits, suggestions which save them much useless work, and in the course of the examination of numerous mines it becomes obvious how much this service is needed.

Keeness in field work, engendered by a desire to satisfactorily solve the many problems of geological structure met with in the course of their field investigations, has been manifested by the field officers during the year, and under the somewhat arduous conditions attached to camp life in the Eastern Goldfields, it is not easy to maintain this state of efficiency. I desire to record my appreciation of the quality of the work done by the field officers and also to state that the office staff have given good service.

Mr. I. F. Outtrim, junior clerk, who has had some training in geology, has attended to many inquiries

of a technical nature since the office has been without the services of a trained technical assistant.

The reports which follow place on record the results of the work done by the various members of the staff, except that carried out for purely Departmental purposes.

H. A. ELLIS,

Acting Government Geologist.

30th December, 1938.

ARTESIAN AND SUB-ARTESIAN WATER
POSSIBILITIES ON CARDABIA STATION,
NORTH-WEST DIVISION.

(By F. G. Forman, B.Sc., Government Geologist.)

Cardabia Station is situated about 125 miles north of Carnarvon adjacent to the coast. The homestead is situated close to the Indian Ocean about one mile from the landing near Point Maud.

Except for a coastal strip about six miles wide which is occupied by sandhills of Sub-Recent and Recent origin, the whole of Cardabia Station is underlain by rocks of Cretaceous age. Over the greater part of the area occupied by the Cretaceous rocks the geological succession and structure is clearly revealed by frequent outcrops, but the sandhills in the coastal zone effectively mask the underlying bed-rock, which is presumably a westward extension of the outcropping Cretaceous rocks to the east and make it impossible to elucidate the structure of the coastal strip by surface examination.

A study of the Cretaceous outcrops and the logs of the various bores which have been put down from time to time reveals the following generalised succession:—

TOP.	THICKNESS.
Red clays or shales and limestone ...	105 feet in No. 5 bore.
Yellow calcareous clays with limestone bands and hard white polyzoal limestones with bands of yellow clay. (The red beds mentioned above may be a local variation of these beds. See logs of Nos. 2, 7 and 33 bores.)	About 200 feet as measured in the section between Nos. 10 and 33 bores.
Green glauconite clay, sandy clay or sandstones with Ammonites and coprolites. (Absent in No. 10 bore where this bed is reported as replaced by light coloured clay with limestone rubble.) Bores 8 and 9 in the same vicinity have, however, cut the green clays, in their normal position	10 feet as measured in bores Nos. 8 and 9. Also seen outcropping at House's mound east of No. 18 bore.
Light coloured clays and marls or light grey shales carrying <i>Inoceramus</i> . Reported in some bore logs as fawn coloured clays carrying <i>Inoceramus</i>	100 feet in No. 10 bore. 140 feet in bores on eastern side of Cardabia Range near Winning Station Boundary.
Blue puggy shales	150 feet thick in bores on east side of Cardabia Range. Increasing in thickness westwards to 800 feet in the Government bore.
Mainly black shales with a Belemnite zone near the top and sand or sandstone at base	1,000 feet and increasing in thickness westwards.

A detailed study of the various outcrops would enable the Cretaceous rocks to be divided up into a greater number of stages with distinct lithological characters and fossil contents, but the subdivision given above is sufficient for the purpose of discussing the water problems of the area and it is considered that further subdivision in a report of this nature would be an unnecessary complication.

The Cretaceous rocks everywhere exhibit low dips and on the eastern side of Cardabia Station they have been thrown into a broad anticlinal fold. The axis of this fold strikes in a N.N.E.-S.S.W. direction and passes close to the site of No. 2 deep bore. The denuded western limb of the anticline is well exposed in the long line of hills known as the Cardabia Range, and in the vicinity of Remarkable Hill a very complete section of the strata from near the base of the *Inoceramus* beds to and including the greater part of the polyzoal limestone beds can be seen. The rocks of the eastern limb of the fold form a belt of high country made up of a series of disconnected low hills close to the eastern boundary of Cardabia Station. The outcrops on the eastern limb are discontinuous and scattered but are sufficiently frequent with the help of information available from bore logs in this locality to indicate that the geological section is broadly identical with that exposed in the Cardabia Range. The central or axial portion of the fold has been deeply eroded, so that, in the bed of Cardabia Creek the blue and black shales of the lower part of the Cretaceous Series are extensively exposed and elsewhere are met with at very shallow depths in bore holes and wells.

To the west of the Cardabia Range, the rocks continue to dip to the westward wherever they are exposed to view. Unfortunately, the sandhill country, which occupies the whole of the coastal strip, masks from view the structure of the underlying rocks on the western portion of the property, and it is, therefore, impossible to say definitely how the rocks behave in the coastal area. Cross sections drawn between bores which have been put down on the western side of the Cardabia Range indicate, however, that the dip of the rocks does not increase beyond that observed in the Cardabia Range. It is possible that the rocks may continue to the westward with a uniform dip so that the depth to any particular horizon will steadily increase towards the west in the coastal strip. The dip may flatten out and the strata eventually become horizontal, in which case the depth to any particular horizon will remain uniform as the coast is approached. There may be a reversal of dip of which there is some evidence in at least one place (the vicinity of Nos. 2, 3 and 4 bores). In this case the depth to a particular horizon would decrease towards the west. What the actual conditions are can only be determined by putting down several trial bores in the coastal section, after the sinking of which, fairly accurate predictions of the depth to a particular bed could be made.

From a study of the logs of the bores which have already been put down it appears that the principal shallow water bearing horizons lie in the clays and marls which constitute the *Inoceramus* zone. Poor supplies of good quality water have been met with in this zone in Bores Nos. 8 and 9 and Nos. 22 and 23. These supplies were found near the top of the zone. Good supplies of good quality water have been met with lower in the same zone, in Bores Nos. 5, 6 and 7.

The water obtained in Bores Nos. 14 and 17 on the eastern limb of the Cardabia anticline also comes from the *Inoceramus* zone, but the succession in the locality is abnormal as a band of glauconitic green-sand which carries the water occurs near the base of the *Inoceramus* zone.

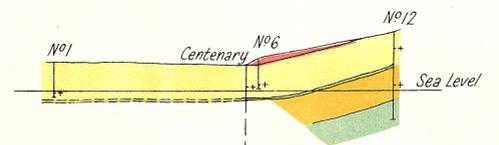
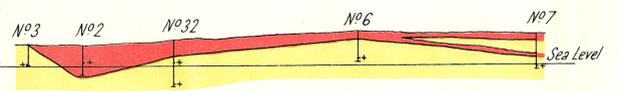
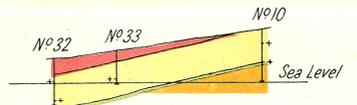
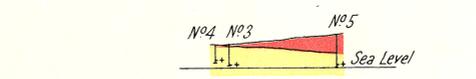
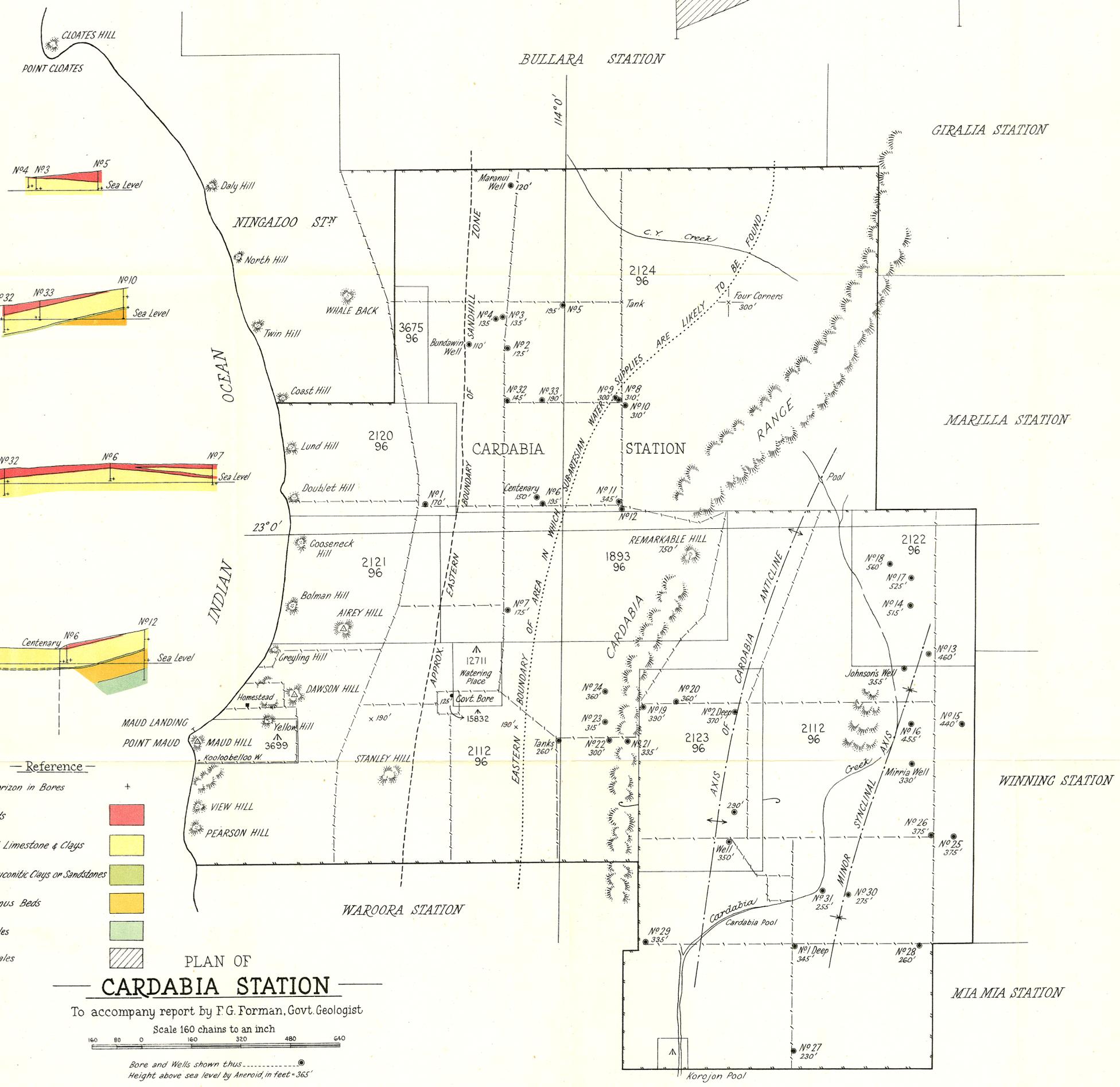
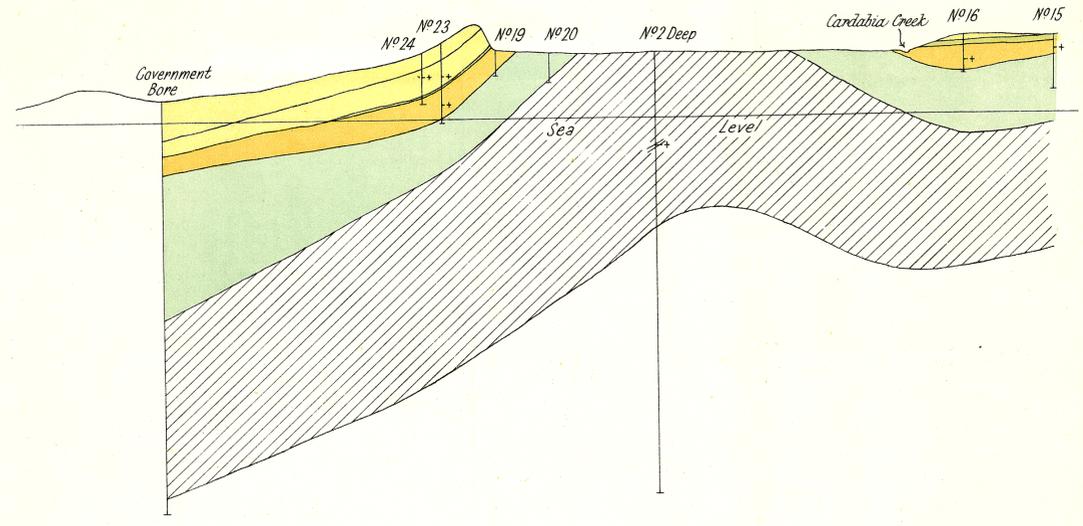
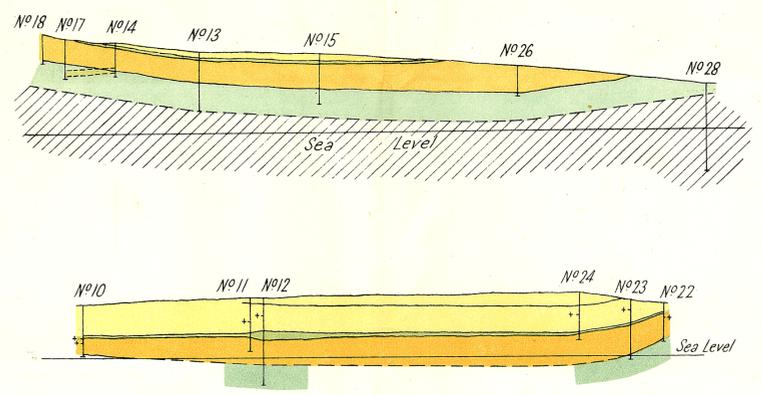
A sandy zone at the base of the blue and black shales of the lower part of the Cretaceous Series constitutes an important artesian water horizon. It is in fact, the most important artesian water horizon throughout the North-west Artesian Basin and has been tapped in scores of artesian and sub-artesian wells throughout the pastoral country north of Hamelin Pool. The flow from the Government Bore, that which was originally struck in the Centenary Bore and which has since failed, and the sub-artesian supplies obtained in the Cardabia No. 1 and No. 2 deep bores all come from the deep artesian zone at the base of the Cretaceous Series. The depth of this horizon is over 1,000 feet everywhere on Cardabia Station, its closest approach to the surface being along the axis of the Cardabia anticline where it has been tapped by the Nos. 1 and 2 deep bores at a depth of a little over 1,000 feet. At both these sites only sub-artesian supplies have been obtained, as the surface of the ground at the bores is well above the rest level of the artesian supply. The depth to the artesian water horizon in the Government Bore and the Centenary Bore is respectively 2,275 feet and 2,374 feet. This marked increase in depth as compared with the Nos. 1 and 2 deep bores is due partly to the thickening towards the west of the lower part of the Cretaceous Series, but principally to the westerly dip of the beds on the western limb of the Cardabia anticline.

Artesian water could be obtained by sinking bores to the base of the Cretaceous Series anywhere along the coastal strip, as the surface elevations over the whole of the western section of Cardabia Station is below the rest level of the water in the artesian horizon. It would, however, be necessary to sink to greater and greater depths as the coast is approached, owing to the thickening of the strata and the westerly dips.

The sub-artesian horizons of the *Inoceramus* zone lie at comparatively shallow depths throughout the central and western portion of Cardabia. They are almost everywhere at a depth of less than 500 feet below the surface and it seems likely that they will be found at much the same depths throughout the coastal strip. As explained earlier, however, this will depend on the structural behaviour of the rocks and no definite information can be given until several exploratory test bores have been put down.

A number of bores which have already been sunk, mainly those along the western slope of the Cardabia Range and those close to the eastern boundary of Cardabia Station have either failed entirely to strike water, or obtained only seepages of good water or moderate supplies of water unsuitable for stock. In all cases, the failure is due to the bores being located too close to the outcrop of the water-bearing beds in the Cardabia Range or to the outcrop of the same beds in the eastern limb of the Cardabia anticline.

A line has been drawn on the accompanying map showing what I consider to be the eastern boundary of the area from which useful supplies of water can confidently be expected. The whole of the country



Reference

- Water Horizon in Bores +
- Red Beds
- Polyzoal Limestone & Clays
- Green Glauconitic Clays or Sandstones
- Inoceramus Beds
- Blue Shales
- Black Shales

PLAN OF
CARDABIA STATION

To accompany report by F.G. Forman, Govt. Geologist

Scale 160 chains to an inch



Bore and Wells shown thus
Height above sea level by Aneroid, in feet = 365'

Vertical Scale: 500 feet = 1 inch

east of this line is not worth the expense of boring owing to the water-bearing beds being too close to the outcrop and consequently carrying only small supplies of good water or moderate supplies of bad water. On the eastern side of the line the volume of water circulating in the beds is insufficient to flush out any salt which was an original constituent of the sediments making up the Cretaceous Series.

An examination of the map will show that No. 10 Bore which yields a good supply of good water lies on the eastern side of the boundary line. The most likely explanation of the finding of good water in this bore is that it was sunk close to the bed of a fairly large creek which runs to the westward from the Cardabia Range and consequently the water-bearing horizon which has been tapped in No. 10 Bore has been well fed by soakage from the creek bed at its outcrop somewhere to the east.

No doubt a number of successful bores could be obtained on the eastern side of the line and close to it by choosing favourable sites for sinking a bore close to a creek bed which cuts throughout the water-bearing horizons at their outcrop to the eastward.

It would, however, be a very uncertain matter and it is not considered advisable to go to the expense of putting down bores on the eastern side of the line indicated.

The selected site for a bore at the Four Corners east of No. 5 Bore is also on the eastern side of the boundary line. There is, therefore, doubt as to whether suitable water would be met with at this site. In this case, I have considered that the sinking of a bore is justified because of the peculiar suitability of the site for watering four paddocks from the one point. It cannot be said that the site is particularly favourable but there is some chance of obtaining useful supplies. If the Four Corners site fails to obtain good water, the next best alternative is to sink a bore about 2½ miles north, close to the bed of C.Y. Creek, where water will probably be obtained owing to the water-bearing beds probably being well supplied at their outcrop in the upper reaches of the creek. The second alternative would be a bore put down about 2½ miles west of the Four Corners which lies westward of the line marking the boundary of good sub-artesian supplies.

Any site to the south of the Government bore should strike good supplies of water, and this remark applies equally to the whole of the coastal strip. It might be objected that shallow sub-artesian water was not reported in the log of the Government Artesian Bore, but it seems probable that the drillers who had as a definite objective the artesian horizon at the base of the Cretaceous Series, did not bother to mention any shallow water horizon lying within three or four hundred feet of the surface.

On the meagre evidence available it seems probable that the depth to the main sub-artesian horizons in the *Inoceramus* zone should be met with in bores throughout the coastal country on Cardabia Station at depths of probably less than 500 feet. (In all cases of exploratory boring the work should not be abandoned until it is certain that the blue shales underlying the *Inoceramus* zone have been penetrated, as until this occurs there is always a possibility of cutting a useful water-bearing bed.)

A study of the bores already put down indicates that the water horizons cut do not always lie in the same position in the *Inoceramus* zone. Sometimes

the water occurs near the top of this zone, sometimes near the bottom. A probable explanation of this fact is that the water-bearing beds are lenticular and do not extend uniformly over the whole area. For this reason no statement has been made as to the depth of water-bearing beds below the top of the *Inoceramus* zone. The safest rule to follow would appear to be to bore for the *Inoceramus* zone which is usually easily identified by the numerous shell fragments which are scattered throughout, and to continue boring until the main body of the underlying blue shales is penetrated before abandoning a bore-site as hopeless. Until the blue shales are penetrated, there is always a chance of cutting a useful water-bearing bed.

REPORT ON THE VULCAN TIN MINE, GREENBUSHES.

(By H. A. Ellis, B.Sc., A.O.S.M., Geologist.)

Introduction.

The Vulcan Tin Mine is situated in the north-eastern corner of Mineral Claim No. 4, known as the "New Caledonian" Lease, situated on a flatly undulating spur between Bunbury and Westralian Gullies on the south side of the main Greenbushes-Bridgetown road, some two miles south-east by south from Greenbushes Townsite.

The mine is operated by a Perth company known as Vulcan Tin Mines, Limited, mining operations being carried out by the hydraulic sluicing of a weathered, kaolinised tin-oxide and tourmaline-impregnated zone of granitised schist and associated pegmatite dykes. The maximum dimensions of the working cut are approximately 260 feet in length, 195 feet in width and 35 feet in depth. The disintegrated tin-bearing material is elevated from the bottom of the open-cut as a pulp by a gravel pump and passed through sluice boxes in which the tin-oxide concentrate is recovered by the normal sluice-box process.

Since the commencement of production by the present company on February 4th, 1937, approximately 41 tons of tin concentrates, of an average metallic tin content of nearly 57 per cent. valued at £5,707 10s., have been won up to the end of January, 1938. The approximate volume of the ore treated for this return is 16,900 cubic yards, giving an average value of 5.39 lbs. of concentrates, containing 57 per cent. of metallic tin per cubic yard. Operations are at present (January, 1938) suspended owing to a shortage of water, and the necessity for additional equipment to enable sluicing to be carried out under a higher nozzle pressure than is at present in use.

The limits of the tin bearing formation at present being worked are known definitely at one point only, namely, in a tunnel driven through the eastern wall of the open cut in a north-easterly direction.

As a result of an inspection of the mine workings and leases made by the writer during the period January 18th-26th, 1938, it was found that the only practical means of determining the extent of the payable tin-bearing formation was by a series of boreholes sunk with a percussion drilling plant in which the shoe of the casing can be kept in advance of the face of the drilling bit.

Topography and Geology.

The area in which the company's holdings are situated is one of gentle slopes of general low relief, and