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THE HYDROGEOLOGY OF THE MOUNT GAMBIER AREA,
SOUTH-EASTERN SOUTH AUSTRALIA

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THE HYDROGEOLOGY OF THE MOUNT GAMBIER AREA, SOUTH-EASTERN SOUTH AUSTRALIA

by

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ABSTRACT

The Mount Gambier area of south-eastern South Australia is totally dependant upon groundwater for its water supplies. Water of low salinity is extracted from unconfined aquifers (Oligo-Miocene calcarenites) and to a much lesser extent, confined aquifers (Eocene sands). Both systems are likely to contribute to the Blue Lake, which occupies a recent volcanic cratera, and from which the city of Mount Gambier derives its municipal supplies.

A winter precipitation surplus of 300 mm over the potential evapotranspiration allows recharge to the unconfined aquifer through most of the area. The amount varies considerably with soil type and land use, with extremes shown by pine forests (little or no recharge) and karstic pavements (recharge estimated at 100-200 mm). Water balance determinations suggest that current recharge estimates need to be increased by 25% or more to balance the estimated discharge of 6.6 cumecs from the system. The confined aquifer derives much of its recharge to the north of the area studied, but some is expected north of Mount Gambier, where leakage downwards through the confining beds is likely to occur.

Most of the discharge from the unconfined system is controlled by a solution-enlarged fracture system which localizes major spring discharges at the coast, and has a hydraulic conductivity of 100-300 $m^3 day^{-1} m^{-2}$, compared with 10-30 $m^3 day^{-1} m^{-2}$ for porous medium flow in unfractured aquifer material.

The hydrochemistry of the unconfined aquifers can be explained in terms of cyclic salt and dissolution of impure limestone.

The cavernous nature of the limestone underlying most of the area has facilitated subsurface waste disposal. In turn a serious pollution problem has developed, particularly in the Mount Gambier city area. The main indicator of pollution is the nitrate ion, derived from the breakdown of organic wastes. Nitrate concentrations range from immeasurably low to 490 mg/l, considerably in excess of the safe limit for infants, and dramatic when compared with natural concentrations of 0-25 mg/l. Localized contamination is a problem in rural areas, with dairies, houses and stockyards all contributing, particularly where they coincide with karst features such as solution enlarged fractures.

Although pollution of the unconfined aquifer is serious at Mount Gambier, there remains a valuable resource elsewhere in the area, and it merits more detailed study. The confined system is also unpolluted, and its development will require careful management to ensure that its present hydraulic relationship with the unconfined aquifers is preserved.

1. INTRODUCTION

The Mount Gambier region (The Gambier Plain) depends upon groundwater supplies for urban, industrial and domestic purposes. In particular Mount Gambier city's supply is taken from Blue Lake, an expression of the water table revealed by a volcanic crater. Water suitable for most purposes is withdrawn from the unconfined, Gambier Limestone aquifer, with a small, but growing contribution from the underlying, confined, Knight Group aquifer system.

The most recent summary of the hydrogeology was made by O'Driscoll (1960), where the author stated that there was little danger of over-exploitation of the groundwater resource, but that the possibility of its contamination should be regarded seriously.

In recent years the problems associated with development in an area underlain by an aquifer with local, widespread recharge have become very apparent, with numerous examples of individual boreholes yielding obviously polluted water (Ide, 1971). It became essential to investigate the hydrogeology in detail, and assess the pollution hazard, identifying the sources where possible. To this end the Tertiary stratigraphy was investigated, 8 stratigraphic boreholes being drilled with cable tool rigs. Appendix A outlines the method of sampling and the problems of interpretation. The configuration of the water table was determined with a grid of about 250 observation boreholes (Map 1), many of them drilled for that purpose. The observation bore grid was then systematically sampled to obtain reliable data for hydrochemical and pollution studies. Details of the investigations outlined above may be found in Appendix B, with a detailed description of water sampling techniques in Appendix C, and a glossary of terms in Appendix D.

Lack of quantitative data still makes it difficult to determine the safe yield of the aquifers in the area, but the pollution problem can be assessed.

At present the water resources of the area are administered under the Underground Waters Preservation Act, 1973 (Boucaut and Waterhouse, 1973), and control of effluent disposal is possible. Subsurface disposal, one major source of pollution, will decrease in importance in future years as resource management policies will require alternative methods of disposal of wastes.

2. DESCRIPTION OF AREA

The Mount Gambier area comprises 1 400 km^2 in the extreme south-eastern corner of South Australia (Figure 1). The study area comprised the Hundreds of Blanche, Gambier, Caroline and MacDonnell, and parts of Mingbool and Young. Relief is generally low, and occasionally moderate, with north-westerly trending ridges rising to a maximum of 50 metres above their flanking plains. Mount Gambier and Mount Schank dominate, rising to 190 and 120 metres above sea level respectively. Both are volcanic in origin, Mount Schank being a well-preserved, dry-floored cone (Plate 1). The Mount Gambier complex (Fenner, 1921) contains four lakes, one of which, the well known Blue Lake (Plate 2) is about 80 metres deep, whilst the others are smaller and shallower.

The City of Mount Gambier, with a population approaching 20 000, is the only sizeable town in the area. Local industries are based mainly on extensive pine forests and dairy products.

The region has been cleared of most natural vegetation, and put to conventional farming or forestry. The lower South-East proved difficult to develop in the early days of settlement because of extensive swampy conditions. This problem was overcome (not without the introduction of others) by the construction of a network of artificial drains, as there is no natural well-defined drainage pattern. To the north of the Mount Gambier area Dismal Swamp remains largely undrained to the present day. It is a series of disconnected, shallow, often circular swamps forming a belt extending north-west from the Victorian border. Different geological conditions and a deeper water table prevented swamp formation further south. At the coast the water table is again shallow and swamps occur. These also have been made suitable for agriculture by drainage channels.

The locations of points of interest may be found on Figure 1, and all sample points are labelled on Map 1.

3. GEOLOGY

A. GENERAL

The Mount Gambier area forms part of the Gambier Embayment of the Otway Basin, described in Wopfner and Douglas (1971). Surface geology is shown on Figure 2. The sequence of sediments was deposited intermittently from Jurassic through to Recent times. The Tertiary sediments of the Knight Group and the Gambier Limestone are of particular interest as they form the dominant aquifers. Figure 3 shows the locations of boreholes used for stratigraphic information. Table 1 summarizes ages, lithologies, and aquifer characteristics of the stratigraphic units relevant to the Tertiary - Recent period. The subsurface relationships between the main Tertiary units is illustrated by Figures 4 and 5, north-south cross-sections.

The Gambier Limestone and Knight Group sediments predominate, occurring through most of the area, with much smaller and irregular occurrences of the other units.

The Knight Group sediments are paralic, with a poorly preserved marine fauna (Ludbrook, 1961). An increasing marine influence was felt during the deposition of the Kongorong Sand and the Lacepede Formation, climaxing with a major marine transgression in the Oligocene. The Gambier Limestone was then deposited with minor terrigenous influence. Pleistocene aeolianites of the Bridgewater Formation overlie the older sediments, some in well-defined bands marking old shores lines (Sprigg, 1952). Recent coastal and fluviatile sands cover some of the area (Firman, 1973).

Recent volcanic activity is revealed by Mount Gambier and the smaller cone of Mount Schank to the south.

TABLE I - Stratigraphy (after Parkin, 1969)

AGE	UNIT	LITHOLOGY	AQUIFER CHARACTERISTICS
Quaternary	Undifferentiated volcanics	Mainly ash showers, with minor basalt lava flows at the base.	Undeveloped, very restricted areal distribution.
Quaternary	Bridgewater Formation	Largely aeolianite with some shelly beds.	Little developed, restricted areal distribution.
Miocene - Oligocene	Gambier Limestone	Calcilutite - calcarenite, bryozoal and flinty.	Poor to very good, widely developed throughout area. Unconfined and semi-confined.
Late Oligocene(?)	Compton Conglomerate	Ferruginous, rubbly conglomerate - reworked Knight sediments.	Not an aquifer - very limited occurrence.
Upper to Middle Eocene	Kongorong Sand	Poorly sorted ferruginous quartz arenite.	Saline, undeveloped, very restricted occurrence.
Upper to Middle Eocene	Lacepede Formation	Variable. Glauconitic, silty limestone with polished brown ironstone grains grading to brown glauconitic silts.	Forms part of the confining layer between confined and unconfined aquifers.
Eocene	Knight Group sediments	Interbedded black/brown lignitic clays and quartz arenites.	Good aquifer where developed. Widespread, but often at uneconomic depths. Confined in most of the area.

B. KNIGHT GROUP

The Tartwaup Formation (Parkin, 1969), also named Knight Formation (Harris, 1966) is the upper Formation within the Knight Group sediments (Sprigg, 1952). They are a paralic sequence of interbedded sands and carbonaceous clays of Eocene age. Sediments characteristically contain polished, rounded quartz arenite, fine mica flakes and some irregular pyrite grains and rock fragments. By virtue of the ubiquitous black clay and often coarse, rounded quartz grains, the Knight Group is readily distinguished from the overlying Gambier Limestone, and can usually be recognized from even the poorest geological log. The upper portion is often black clay with varying proportions of silt and well rounded quartz arenite, and has been named the "Burrungule Member" (Harris, 1966).

The only South Australian exposure (Plate 3) in Allen's Quarry, Section 715, Hundred of Blanche reveals coarse grained, poorly sorted quartz sands (Ludbrook, 1961). The overlying clays are leached and oxidised (grey and red-yellow brown) compared with subsurface occurrences, where they are dark brown to black.

C. KONGORONG SAND, LACEPEDE FORMATION, COMPTON CONGLOMERATE

Two thin formations of Middle and Upper Eocene age have been recognised at the base of the Gambier Limestone (Parkin, 1969).

A dark, glauconitic silt believed to be the Lacepede Formation was recognised in samples from a few bores in the area; it is not discussed in detail.

The Kongorong Sand (a limonitic quartz arenite - rudite) was described from ODNL Mount Salt Structure Hole No. 3 (Parkin, 1969) in the southern part of the area. Quartz arenite resembling the Kongorong Sand was recognised in borehole CAR 11 in the extreme south-east of the area but not in any other bores. This is interpreted as being the result of sedimentation on an undulating surface, with possible subsequent erosion.

D. GAMBIER LIMESTONE

The Gambier Limestone is a transgressive Oligo-Miocene unit (Parkin, 1969), with a considerable diversity of sediment types within the calcarenite-marl framework.

Sediments range from richly fossiliferous calcirudites through calcarenites and calcisiltites to glauconitic marls, some apparently 100% fossil fragments, others apparently unfossiliferous. Black to dark brown flint occurs commonly, and in the hand specimen sometimes grades directly to a grey silicified calcarenite with readily recognisable fossil fragments. Quartz arenite occurs commonly as a minor constituent and rarely as a major constituent, reflecting a terrestrial influence on the predominantly marine sequence.

The limestone is jointed where exposed, with a dominant NW-SE trend (Sprigg, 1952). Cave formation has often been controlled by jointing (Plate 4), and linear caves some hundreds of metres long have been mapped by members of the Cave Exploration Group of South Australia (F. Aslin, S. Aust. Dept. Mines, pers. comm.).

Dolines and cenotes are common, and their concentration near Barnoolut, south-west of Mount Gambier, probably indicates more intense fracturing in that area.

The formation thins considerably from 300 metres at the coast to a few metres in the north of the Mount Gambier area (Figure 4). Logs of existing bores suggest that the limestone is thin and sometimes absent in the Hundred of Young, and it can be seen to be absent in part of Allen's Quarry in the north of the Hundred of Blanche.

Detailed lithological correlations are difficult because of the repetitive nature of the sequence. Irregular flint formation, dolomitization and recrystallization complicate the situation.

Lindsay (1967) recognised three zones within the Gambier Limestone sequence from bores drilled 45 km to the north-west near Millicent, an "Upper grey cherty limestone", a "Cream limestone" and a "Lower grey limestone". Ludbrook, in Wopfner and Douglas (1971), recognised a "thin marl member" at the base of the formation. McGowran (1973) described a three fold succession similar to Lindsay's in a borehole drilled near Robe, 120 km to the north-west of Mount Gambier.

The three-fold sequence can be recognised wholly or in part from boreholes in the Mount Gambier area and is represented on the Fence Diagram (Figure 6) and the Geological Section (Figure 4). It is often difficult to determine a boundary between the "Upper grey cherty" zone and the underlying "Cream" zone because cream, flint-free layers are commonly found within the upper zone. Generally a thickness of some tens of metres of consistent cream limestone could, however, be recognised. The "Lower grey" zone was easily recognised to the south of Mount Gambier, but appears to be absent in many cases to the north. A detailed examination of the stratigraphy is being undertaken by J.M. Lindsay, a micropalaeontologist with the South Australian Department of Mines.

The sequence is reflected in the soils of the area (Blackburn, 1959), with flinty soils in the area where the "Upper grey cherty" zone outcrops, and a lack of reported flint in soils where the "Cream" zone outcrops.

The main quarries from which building stone is derived, and the type section for the Gambier Limestone (Ludbrook (1961) and Tenison Woods (1860, p. 256 and 1862, p. 75)) also lie in the area of outcrop of the middle zone. This has resulted in the widely accepted, but erroneous view that the Gambier Limestone is essentially a bryozoal calcarenite.

The occurrence of the middle zone at depth in the sequence south of the outcrop area has been substantiated by a local water boring contractor, Mr. Jack Sims, who has used it to provide larger or less polluted supplies than can be obtained from the overlying material.

The upper part of the sequence has sometimes been removed by erosion (the upper zone is often absent), particularly in the northern part of the area. Proximity to the Pleistocene upwarp axis proposed by Sprigg (1952) may be a contributing factor.

Selected geological logs are included in Appendix E.

E. BRIDGEWATER FORMATION

Part of the series of sub-parallel dune ranges for which the south-east of the State is well known rest unconformably on the Gambier Limestone. Well developed ridges occur south of Mount Gambier whilst to the east and north dune complexes are found.

Drilling results revealed the cross-section of a well-developed dune 5 km south of Mount Gambier (Figure 5). The base of the dune was found to rest on the plain of Gambier Limestone exposed on the interdunal flat. The geological section on Figure 4 reveals that the base of some dunes may be several metres above the level of the interdunal flat, giving some measure of the removal of material that has taken place since formation. Detailed field work to investigate the dune bases has not been undertaken.

Bores penetrating the dunes revealed highly variable sequences of yellow/brown quartzose calcarenites with occasionally shelly fossils, and differing degrees of cementation.

F. VOLCANICS

Mount Gambier is a complex maar (Ollier, 1967), although it has been considered by some (Fenner, 1921 and Williams, 1941) to be a collapse caldera. However, modern interpretation suggests that explosive phreatic activity was responsible for the formation of the craters. Two radiocarbon dates have been determined for the eruption(s), 1410 years B.P. (Blackburn, 1966) and 4 800 years B.P. (Fergusson and Rafter, 1957). Both dates were obtained from good material, and infer two periods of activity. A soil profile has been recognised in the ash (G. Blackburn, C.S.I.R.O. Division of Soils, pers. comm., 1975), providing supporting evidence.

Mount Schank is a well-preserved scoria cone, with a small subsidiary vent on its flank. Although abundant groundwater is available there, as it is at Mount Gambier, a maar did not form, and the cone is dry floored. No carbon date is available, but its youthful appearance suggests that it is of recent origin, and it is reasonable to assign an age similar to Mount Gambier.

4. HYDROGEOLOGY

A. GENERAL

Confined aquifers are found within the Knight Group and essentially unconfined aquifers within the Gambier Limestone and Bridgewater Formations. The Bridgewater Formation is usually above the water table in the Mount Gambier area, but where the base of a dune is below the water table, hydraulic continuity is likely.

Most of the development of groundwater has utilised the relatively shallow Gambier Limestone aquifer, as it is simple and cheap to obtain supplies. The Knight Group aquifer has only been penetrated by a few bores, and only the one supplying the Wattie-Pict Factory at Mount Gambier (Hundred of Blanche, Section 364, Bore 03) is currently withdrawing significant quantities of water from it. It will probably be used more in the future to obtain pollution free supplies.

The Kongorong Sand need not be considered a potentially useful aquifer in the area as it has only been penetrated in relatively deep bores and contained saline water (6 500 mg/l) when sampled at 298 m in borehole CAR 11. The Lacepede Formation (where encountered) forms part of the confining layers between the Gambier Limestone and Knight Group aquifers.

B. CLIMATE AND SURFACE HYDROLOGY

Average annual rainfall for the area ranges from 700 mm to 800 mm for the measuring stations at Cape Northumberland and Mount Gambier P.O. respectively. (Director of Meteorology, 1966). Most rain falls in the winter months, with average monthly totals exceeding 75 mm from May to September, and exceeding 90-100 mm from June to August.

Potential evapotranspiration for grassland has been estimated (Holmes and Colville, 1970) and is shown graphically on Figure 7, together with average monthly rainfall data for the two stations. It can be seen that precipitation exceeds potential evapotranspiration from early April to late September, with a maximum difference of 2.75 mm day^{-1} in June-July. The total rainfall excess for the winter months is close to 300 mm at both rainfall stations, and is probably fairly uniform (for grassland) throughout the area. The maximum amount available for recharge, considering soil moisture deficit, will therefore be somewhat less than 300 mm.

Despite the excess precipitation in winter, the only significant surface flows in the area are seen in channelled discharges from swamps and the aquifer near the coast, and a loop of the tidal reach of the Glenelg River. The headwaters of the Glenelg River are in the Grampians, a mountain range in western Victoria, and it becomes an effluent stream in its lower reaches. This is evidenced by progressively lower tritium concentrations in a downstream direction (J.W. Holmes, pers. comm.) and the discrete groundwater discharges which can be observed (Plate 4). The base flow of the river has been conservatively estimated at 2.5 cumecs (J.W. Holmes, pers.comm.), with a 1 cumec contribution along the tidal reach to Moleside Creek in Victoria.

A few minor inland flows occur during heavy rain, running down short, blind valleys with swallow-holes at their extremities.

C. CONFINED AQUIFERS

At Mount Gambier thinner overlying sediments and the prospect of obtaining a pollution free supply makes the confined aquifers economically accessible, and to the north of the area investigated the small supplies obtained from the overlying unconfined aquifers often makes their development essential.

In the area south of Mount Gambier the confined aquifers have never been penetrated by water well drilling, and the limited data available is that which has accrued from petroleum exploration drilling.

Recharge probably takes place over a large area some tens of kilometres to the north of Mount Gambier, where the confining layers (and in some cases the Gambier Limestone) are thin or absent (Floegel, 1972). Colville and Holmes (1972) discovered a sink in the unconfined aquifer near Nangwarry, 30 km to the north of Mount Gambier, and it is likely that others, as yet undiscovered, also exist. Until that area has been investigated in some detail, it will not be possible to arrive at a quantitative estimate of recharge.

Both salinity and hydrochemistry are similar to the unconfined aquifer, providing supporting evidence for a significant vertical leakage component of recharge. The differences that have been shown to exist are the presence of iron in significant concentrations in the confined aquifer, and the low level of dissolved oxygen. Both these differences are to be expected when the pyrite content and the reducing environment of the sediments are considered.

The top of the Knight Group is 300 m below sea level at the coast, and discharge presumably takes place under the sea, with a component of vertical leakage where the hydraulic conditions are suitable. To the north of Mount Gambier drilling has shown that the potentiometric level in the confined system is several metres below that in the unconfined aquifer, which suggests a net inflow to the confined aquifers. At Mount Gambier the heads have reversed, partly due to the steep gradient exhibited by the unconfined aquifer north of the city (Figure 8). The potentiometric level of the confined aquifer at the Wattie-Pict bore is 7 metres above that in the unconfined aquifers. This has two important implications.

(1) Pollution of the confined aquifers is not possible at Mount Gambier by direct leakage from the overlying polluted aquifer, unless future withdrawals from the confined aquifers reverse the head difference.

(2) It is likely that a proportion of the water in the Blue Lake is derived from the confined aquifer. The bottom of the lake is within a few tens of metres of the inferred top of the Knight Group, and an effective seal in the recently formed volcanic conduit is unlikely. However, this has not been proved by interpretation of the known chemistry of the waters because the two aquifers are not sufficiently different. Tritium, ^{14}C and stable isotope analyses could be utilized to quantify the situation. Substantial withdrawals from the confined aquifers could prevent upward movement of water, and allow an influx of polluted water to the lake from the unconfined system.

The hydraulic relationship between the aquifer systems south of Mount Gambier is not known, however it is expected that upward leakage will occur.

Aquifer parameters have been determined for the uppermost sand aquifer at Mount Gambier (Valentine and Waterhouse, 1974). During the aquifer tests a marked hydrogeological boundary was encountered, reducing the transmissivity from 1 600 $m^3day^{-1}m^{-1}$ near the borehole to 180 $m^3day^{-1}m^{-1}$ at some distance from it. The storage coefficient was calculated to be 10^{-4}. The sedimentary environment in which the aquifer material was deposited is likely to have resulted in marked lateral facies changes, and wide variations in hydraulic properties will be common.

The low value of storage coefficient is characteristic of confined aquifers, and will result in much greater drawdown effects than would occur in the Gambier Limestone when exploitation takes place.

D. UNCONFINED AQUIFERS

(i) GENERAL

Groundwater with a salinity often less than 500 mg/l is found throughout the area at depths ranging from 2 to 30 metres below the ground surface. The upper two zones of the Gambier Limestone appear from sparse data to form two separate sub-aquifers, with slight hydraulic separation.

Due to the irregular incidence of solution features and the inhomogeneity of the sediments, individual bore yields vary considerably from 0.5 litres/sec and (1/sec) or less, to 50 l/sec. One bore in the Dismal Swamp area is reputed to yield 200 l/sec.

Despite widespread development there have been few determinations of aquifer parameters. The available aquifer data are summarized in Table II.

(ii) WATER TABLE CONFIGURATION

The observation bore network was established in 1971 and 1972. Water level measurements provided the basis for the water table contours shown on Figure 8.

The hydraulic gradients are moderate to low generally, due to low relief and the high transmissivity of the Gambier Limestone. They suggest that movement of the groundwater is in a southerly direction throughout the area.

There is a groundwater divide at the north of the Dismal Swamp in the hundreds of Mingbool and Young (S. Aust. Dept. Mines unpublished data of Cobb, 1972). To the north of the divide groundwater flow is in a northerly direction; to the south flow is in a southerly direction. Therefore most groundwater moving through the area studied must be derived from <u>within the area</u>, with a small component moving south-west from Victoria.

The area seems to divide itself naturally into hydrogeological zones exhibiting particular characteristics (see Figure 8).

<u>Steep Gradient Zone</u>: The most obvious feature of the contour plan is the abrupt steepening of gradient north and west of Mount Gambier in the Hundreds of Blanche and Gambier. Local gradients are as steep as 1 in 40, compared with 1 in 1 300 between Mount Gambier and the coast. Several observation bores were drilled in the area northwest of Mount Gambier to investigate this feature, and as can be seen on the fence diagram (Figure 6) and the cross section (Figure 4) there is a marked thinning of the Gambier Limestone in the area of the steep gradient north-west of the city. Examination of bore logs and results obtained from test pumping of observation bores suggest that there may be lower permeabilities in the area of steepest gradient, but thinning of the aquifer probably is more significant in leading to lower transmissivity. The steepening of the hydraulic gradient can be seen in areas both with and without pine forest development and can therefore be regarded as largely independent of land use.

Recharge is reasonably constant as a first approximation and the aquifer therefore must transmit greater amounts of water further to the south, inconsistent with the observed steeper gradient to the north. (Darcy's Law requires that a steeper gradient must occur where the transmissivity of the aquifer is lesser, if a constant volume of water is transmitted.)

Isolated Zones of Steep Gradient - "Dune Highs": A pronounced ridge in the water table contours occurs about 10 km south-east of Mt. Gambier. The feature corresponds with the position of a large Pleistocene dune, and borehole BLA 22 (see Map 1) was drilled through the dune to investigate the possibility of a perched water table. It revealed that the base of that dune corresponds well with the levels of the interdunal flat (Figure 5), and showed that the high water level under the dune is probably related to topography.

Other similar, irregular water table highs probably exist, but their recognition depends upon precise observation bore locations as the water levels drop to "normal" close to the flanks of the dune. The slight dome near the western end of the Steep Gradient Zone is probably related to a similar topographic feature.

Ewens Ponds - Mount Schank Trough: A well developed trough extends in a NNW direction from Ewens Ponds, through Mount Schank to the edge of the Steep Gradient Zone about 5 km west of Mount Gambier. It is aligned with the main direction of regional jointing (Sprigg, 1952), and corresponds approximately with the occurrence of the greatest local density of large solution features (Edwards, 1973), particularly those occurring on the property Barnoolut. Mount Schank lies near the centre of the trough, probably controlled by the same fracture system, and the largest individual spring discharge (Eight Mile Creek) is found in the centre of the trough at the coast.

These factors all suggest that the trough represents a zone of increased fracture solution cavity permeability, and by inference it is a preferred flow path for groundwater.

Mount Gambier Plain: A zone approximately 5 km by 15 km centred on Mount Gambier exhibits an extremely low gradient. Many water levels measured in the area differ by less than 0.1 m. The zone is aligned with its long axis orientated in a NW-SE direction - similar to the regional jointing in that area (Sprigg, 1952).

The northern and western boundaries are formed by the Steep Gradient Zone, whilst gentle gradients characterise those to the south and east, with the exception of the local "Dune High".

Despite large annual withdrawals from the Blue Lake (at the centre of the zone) there is little evidence for a surrounding cone of depression. To the north-east of the Lake a slight trough is apparent in the extention towards the lake from the Steep Gradient Zone. The trough is small and affects only one contour line however, and further interpretation is not possible without more observation points.

The zone is interpreted as one of high fracture permeability, partially due to solution enlargement of those fractures localizing the volcanic activity, and is probably the northern extension of the Ewens Ponds - Mount Schank Trough.

Dismal Swamp Area: Swampy conditions prevail to the north of the Steep Gradient Zone, with near-surface groundwater. Recharge to the Knight Group aquifers has long been postulated for this area, but recent drilling in the Hundred of Mingbool has revealed a thick Gambier Limestone sequence with confining beds at the base. Significant recharge to the confined aquifers is unlikely in the east of the Dismal Swamp Area, therefore, but may occur in the west, where bore logs suggest that the Knight Group is close to the surface.

Hydraulic gradients are low in the area, and a detailed study of its hydrogeology and hydrology has yet to be made.

5. WATER BALANCE

There is not sufficient data available to determine the detailed water balance, but reasonable approximations can be made to give a preliminary interpretation.

It must be assumed that there is no major change in storage taking place, and at present there is no evidence to suggest otherwise, except at the Blue Lake and at Eight Mile Creek. The Swamps at Eight Mile Creek and adjacent areas were drained after World War II to allow agriculture to be practised, and that hydrologic system has probably reached its new equilibrium. The only long term water level measurements that have been made are those of the Blue Lake, which has been correlated with the mass rainfall curve (Ward, 1941) and local land-use (Anonymous, 1972). On this basis there has been a decrease in storage in recent years in the Mount Gambier Plain, but as there are no comparable water level measurements elsewhere in that area there is no way of reliably estimating its magnitude.

The balance can therefore be expressed in the form "INFLOW = OUTFLOW", and the various components are discussed below:

A. INFLOW

Most recharge occurs by direct infiltration through the soil, and varies considerably with soil types and land use. Several recent determinations have been made using lysimeters or environmental tritium (Holmes and Colville, 1970a and b; Colville and Holmes, 1972; Allison and Holmes, 1973, and Allison and Hughes, 1972) with varying, though relatively consistent results.

In summary, recharge in pine forests (20% of the area studied) is considerably less than in grassland areas, although the estimates of the magnitude of this difference vary. Recharge estimates for grassland range from 40 mm to 140 mm per annum, as a function of soil type and depth to the water table.

Some of the interdune flats have extensive exposures of limestone. No estimates of recharge have been made in these areas.

In addition to percolation through porous soil and rock there is a component of point recharge via solution features and drainage bores. This component is hard to estimate, but is probably insignificant when compared with the volumes of conventional percolation. Vertical leakage from the underlying confined aquifer is also expected where the head difference is appropriate.

(i) Soil Infiltration Component (A)

The rate of recharge can be obtained from the estimate of 120 mm/year and 60 mm/year for two parts of the area, made by Allison and Holmes (1973). The 120 mm estimate applies to the area from the coast to about 20 km inland, and the 60 mm estimate to the remaining area south of the groundwater divide.

The volume of infiltrating rainwater recharging the aquifer can thus be calculated to be 3.83 cumecs. This compares well with the figure of 3.76 cumecs which can be calculated from the overall estimate of 85 mm/year recharge in sub-region 2 of Holmes and Colville (1970a).

A value of 4 cumecs is taken as a recharge estimate for this component.

(ii) Increased Recharge from City Area Runoff (B)

Recharge in the Mount Gambier city area has been enhanced by paved areas and house roofs étc. (although this water is probably contaminated to some extent) as all city runoff is drained down sinkholes and several hundred boreholes (Plate 5).

This component can be estimated using a figure of 36% hard surface area contributing to runoff from an urban area, and reducing daily rainfalls by about 1 mm to allow for evaporation (D. Kingston, Hydrologist, S.A. Engineering and Water Supply Dept. pers. comm.).

The paved city area can only be measured to about 20% accuracy, as irregular growth has made the urban boundary somewhat diffuse, and a figure of 10 km^2 has been adopted.

Appendix F gives average daily rainfalls for Mount Gambier Aerodrome (data from the Commonwealth Bureau of Metereology). The calculated annual rainfall with 1 mm subtracted for each rain day is 409 mm.

The annual volume available for recharge is 36% of $10 \times 10^6 \times 0.409$ m^3, with an additional 85 mm for 64% of 10 km^2, that is 2.0 m^3 yr^{-1} (0.064 cumecs). The amount of recharge in a comparable area of grassland (85 mm $year^{-1}$) would be 8.5×10^5 m^3 $year^{-1}$ (0.027 cumecs). The paved city areas have therefore increased intake by 0.04 cumecs, which is not a significant contribution to the total.

(iii) Point Recharge Component (C)

The component of recharge from runoff into solution features is virtually impossible to quantify, and overlaps both components discussed above. It is unlikely to contribute significantly to the total inflow.

(iv) Leakage From Confined Aquifer (D)

At Mount Gambier the potentiometric level of the confined aquifer is 7 metres above that in the unconfined aquifers. To the north the head difference reverses, unconfined water levels being 3 metres higher than those in the confined aquifer at borehole BLA 66, near Allen's Quarry. Borehole data shows that the confining beds vary in thickness and composition. It is impossible to estimate the leakage from the confined aquifer at this stage, but it is possible that it takes place throughout the area south of Mount Gambier.

Upward leakage through the bed of the Blue Lake may be very important locally.

(v) Discussion of inflow estimate

Inhomogeneities of land use and geology make the estimate of 4 cumecs inexact, although the effects sometimes tend to cancel each other. The combined error from these causes is unlikely to exceed 30% of the estimate. The principal sources of error are listed below.

(1) Pine forests cover about 20% of the area, and are known (Holmes and Colville, 1970b) to markedly <u>decrease</u> recharge.

(2) There are large interdunal areas south of Mount Gambier with exposed Gambier Limestone pavements (see Figure 2, and Plate 6). No recharge determinations have been made in these areas, but it is considered that it could exceed 100-150 mm, <u>increasing</u> overall recharge significantly.

(3) Infiltration in parts of the Hundreds of Mingbool, Young and Blanche (for example at Allen's Quarry where the Gambier Limestone is in the unsaturated zone) recharges the Knight Group aquifer, <u>decreasing</u> recharge to the unconfined aquifer by a small amount.

B. OUTFLOW

The loss of water from the system falls into two distinct categories, natural discharge and withdrawals, of which the former is by far the larger.

(i) Natural Discharge

A number of readily measured springs and drainage channels, (Plates 7 and 8), discharge to the sea between Cape Northumberland and the mouth of the Glenelg River. These clearly are a major natural outflow from the aquifer, (E), and have a combined discharge of 5.2 cumecs (Clisby, 1972).

The remaining natural discharge from the system has not been directly measured, and is difficult to estimate, comprising evapotranspiration (F) in areas of shallow groundwater (Dismal Swamp and coastal areas) and porous medium flow into the sea, (G) at and beyond the coast, and leakage through the confining beds into the confined aquifer north of Mount Gambier (H).

A major proportion of the base flow of the Glenelg River is unlikely to be derived from the study area, because the streamlines, deduced from the water table contour plan, suggest a groundwater divide to the east of the Ewens Ponds - Mount Schank Trough. Only some infiltration in the south east of the Hundred of Caroline flows to the Glenelg River.

(ii) Municipal, Industrial and Private Water Supplies (I)

Water was abstracted from the Blue Lake (and therefore possibly from both aquifer systems) at a rate of 0.14 cumecs in 1972, (D. Ide, Regional Engineer, E. & W.S. Dept., Mt. Gambier). Until early 1971 five boreholes provided part of this supply from the unconfined aquifer but these were withdrawn from service when pollution loadings reached the limit of safety (Ide, 1971). A large proportion of Mount Gambier has now been connected to a sewerage system, but prior to 1963 all wastes drained underground, and water was probably lost from the system only by increased evapotranspiration in gardens and vegetable plots. When the sewerage system is completed a significant proportion of the Blue Lake withdrawals will be discharged into the sea.

Industries and private individuals extract groundwater, and although it is also lost via the sewerage system and evapotranspiration, the total volume involved is relatively small. Total sewerage discharge averages about 0.05 cumecs, of which a little more than half can be attributed to industrial use (P.D. Harvey, Chemist, E. & W.S. Dept. Mt. Gambier, pers. comm., 1975).

(iii) Agricultural Use (J)

Farmers use water mainly for stock and crop watering. As borehole data are incomplete, and use of irrigation bores varies considerably from year to year (depending on the prevailing agricultural conditions, both climatic and economic) no estimate of the amount being withdrawn can be made. Less than 10% of the total area is being irrigated, which is well within the 25% limit suggested by Holmes and Colville (1970a). Evaporative loss of irrigation water will thus be a small proportion of the total outflow from the system.

(iv) Pine Forests (K)

The forests are an extreme example of land use affecting the water budget by reducing recharge. They intercept and transpire large volumes, but probably do not represent a net water loss (J.W. Holmes, pers. comm.).

(v) Discussion of outflow estimate

The discharges E and much of I have been measured. E is known to be reasonably constant, but I will increase with time, and may become less representative of unconfined aquifer discharges if more use is made of the confined aquifer (The Wattie-Pict factory discharges accounted for about half the <u>total</u> sewerage system capacity in 1972).

The error of spring discharge determination is $\pm$ 7½% (Clisby, 1972), that is $\pm$ 0.39 cumecs. The total discharge is therefore probably best estimated to 1 significant figure at this stage, i.e. 5 cumecs, and the minor components lose most of their significance in the discussion.

C. AQUIFER PARAMETERS

The measured spring discharge allows the calculation of a Transmissivity (T) for the aquifer, representing the value appropriate for the transmission through the aquifer of 5 cumecs to the coast for discharge to the sea.

Darcy's Law can be stated Q = T i L, where

Q = Discharge (5.2 cumecs)

T = Transmissivity (Hydraulic Conductivity x Aquifer Thickness)

i = Hydraulic Gradient (From Mt. Gambier to the coast $\frac{15.5}{21 \times 10^3}$)

L = Length of Aquifer Discharging (27 km from Cape Northumberland to the Victorian Border)

$$T = \frac{Q}{i\,L} + \frac{5.2 \times 86\,400 \times 21 \times 10^3}{27 \times 10^3 \times 15.5}\ m^3\ day^{-1}\ m^{-1}$$

$$= 22.5 \times 10^3\ m^3\ day^{-1}\ m^{-1}, \text{ best stated as } 2 \times 10^4\ m^3\ day^{-1}\ m^{-1}$$

This large value of transmissivity corresponds to a hydraulic conductivity of 100 m^3 day^{-1} m^{-2} for a thickness of aquifer estimated to be, on average, 200 m.

Most of the discharge occurs across a much narrower strip (10 km) of coast near Eight Mile Creek, and flowlines can be seen to converge upon the Piccaninnie Ponds and Eight Mile Creek areas. Local hydraulic conductivities must therefore be greater than the value calculated. If the length of coast across which most discharge takes place is taken to be 10 km, a value of 270 m^3 day^{-1} m^{-2} is appropriate.

Aquifer parameters that have been determined in or near the area are listed in Table II, and it can be seen that there is a marked variation between values.

In summary the overall aquifer hydraulic conductivity is of the order 10 to 30 m^3 day^{-1} m^{-2}, with a value of at least 100 m^3 day^{-1} day^{-2} applicable in zones where fracture/solution cavity permeability dominates.

Templer (1972) found that intergranular permeability of Gambier Limestone was highest in the NW-SE direction. This probably reflects ordered deposition of the sediments in the structurally controlled basin.

The specific yield of the bryozoal calcarenite facies of the aquifer material is of the order of 0.4 (Templer, 1972) with a lower value, of the order 0.1 - 0.2 (Bowering, 1973), probably applicable for the bulk aquifer.

TABLE II - AQUIFER PARAMETERS - GAMBIER LIMESTONE

HYDRAULIC CONDUCTIVITY ($m^3 day^{-1} m^{-2}$)	SPECIFIC YIELD	LOCATION OF TEST, SAMPLE, OR DETERMINATION	COMMENTS	REFERENCE
7	-	Mt. Gambier Aerodrome	Bore test (8 hours) (no observation points)	Read and Waterhouse, 1974
8-12	0.09	Snuggery, 45 km NE of Mt. Gambier	Aquifer Test (72 hours)	Bowering, 1973
30	-	Nangwarry, 40 km N of Mount Gambier	Several pumping tests. Value adopted by Allison and Holmes, 1973	Bleys and Warner, 1963
60	-	"Gambier Plain"	Figure adopted from Bleys and Warner for their area study	Allison and Holmes, 1973
110	-	Bulk aquifer along (1) Coastal section	Calculated by Darcy's Law	Herein
270		(2) Ewens Ponds Trough		
150	-	Borehole test at Wattie-Pict	Limestone known to be cavernous	Harris, 1970
-	0.4	Compton Quarry	Laboratory measurement (Typical building stone-bryozoal calcarenite)	Templer, 1972
13.0	-		Vertical permeability	
19.0	-		NW-SE direction	
10.4			SW-NE direction	
-	0.054	Hd. Mingbool	Neutron moisture meter, reworked Gambier Limestone and base of soil profile.	Colville and Holmes, 1972

D. WATER BALANCE

The equation INFLOW = OUTFLOW can now be written in the form:

Inflow		Outflow
Soil Infiltration Component, A		Spring Discharges, E
City Area Runoff, B		Evapotranspiration, F
Point Recharge Component, C	=	Porous Medium Flow, G
Leakage from Confined Aquifer, D		Leakage into Confined Aquifer, H
		Municipal etc. Supplies, I
		Agricultural Use, J
		Pine Forests, K

or

A + B + C + D = E + F + G + H + I + J + K.................................(1)

With numerical values for (A + B) and E, equation (1) becomes:

4 + C + D = 5.2 + F + G + H + I + J + K ....(2)

The components C, D, F, G, H, I, J and K have not been evaluated at this stage, but each is likely to be of a much smaller magnitude than the estimated recharge or the measured discharge, with the possible exception of G, the porous medium discharge component. The equation (2) therefore becomes: 4 = 5.2 + G..................(3)

This shows that the recharge estimate is inadequate, by at least 25%, depending upon the magnitude of G, providing that the assumption of a steady state is correct.

Using the known hydraulic gradient from Mount Gambier to the coast, it is possible to calculate minimum and maximum values for the porous medium discharge, using appropriate values of hydraulic conductivity from Table II. Darcy's Law can be stated Q = TiL, where

Q = Discharge

i = Hydraulic Gradient, $\frac{15.5}{21 \times 10^3}$

L = Length of Discharge Strip, 27×10^3 m

$T_{max} = 30 \times 200 \ m^3 \ day^{-1} m^{-1}$

$T_{min} = 10 \times 200 \ m^3 \ day^{-1} m^{-1}$

On this basis the maximum expected porous medium flow is 1.4 cumecs, 27% of the gauged surface discharge, and the minimum expected is 0.5 cumecs, 9% of the gauged discharge.

The maximum total discharge to the sea can therefore be estimated at 5.2 + 1.4 = 6.6 cumecs, which requires an average recharge of 150 mm per year throughout the area, or an even higher recharge over some portion of the area.

The Ewens Ponds - Mount Schank Trough is bounded to the west by a poorly defined groundwater divide (observation bores are spaced at 5 km intervals in that area) and to the east by a more clearly defined groundwater divide. Both divides are shown on Figure 8. The area from which water drains through the Trough is approximately 1 040 km^2, and the measured discharge at the coast is 4.2 cumecs. Porous medium flow across the 10 km strip can be calculated to be a maximum of 0.5 cumecs, giving a total discharge of 4.7 cumecs. This would require a recharge of 140 mm within the catchment defined by the groundwater divide, a similar value to that estimated for the entire area.

The Piccaninnie Pond discharge drains 225 km^2 of the area, with a coastal strip of 10 km suggested by the groundwater divide, and may derive some of its water from western Victoria. The measured discharge is 1 cumec, and porous medium flow across the coastal strip can be calculated to be a maximum of 0.5 cumecs. This would require a recharge of 210 mm within the catchment. As there is unlikely to be significantly more recharge within the Piccaninnie Pond catchment than elsewhere in the area south of Mount Gambier two possibilities exist. Either the porous medium discharge estimate is too large, or there is a component of groundwater movement from the east, in Victoria. The latter explanation seems more likely.

In summary it seems likely that the springs constitute about 75 to 80% of the discharge from the system, the remainder being by porous medium flow. The bulk transmissivity which has been calculated for the aquifer suggests that most of the water movement takes place along a fracture/solution cavity system which extends inland for some distance from the Ewens Ponds area and suppresses the large seasonal fluctuations which might be expected with such a system. The current estimates of recharge are too low for the area south of Mount Gambier, where thin sandy soils and karstic pavements probably allow infiltration to reach 100 to 200 mm per year.

6. HYDROCHEMISTRY OF UNCONFINED AQUIFERS

A. GENERAL

The analytical data accumulated from sampling the observation bore grid is listed in Appendix G. Examination of the data revealed that the nitrate ion was commonly present in significant or even dominant proportions. As it is an unwelcome addition to the natural system,the natural hydrochemistry of the unconfined aquifers can only be studied using samples suggested by low nitrate concentrations to be uncontaminated.

Historical data are unreliable or unavailable. Nitrate concentration was either determined only as ammonia (not now considered a reliable technique) or not determined by analyses at all, and the sampling methods were rarely documented. Old data invariably could not therefore be used to improve the reliability of the interpretation, or to establish any trends in water quality.

The current hydrologic model for the area suggests that surplus precipitation is removed by groundwater of local origin. Studies of the chemistry of the dissolved salts in the groundwater were made to check this hypothesis. Several whole rock analyses are presented in Appendix H, revealing $CaCO_3$ dominant in most cases.

In this context analyses were examined where the nitrate concentrations was below 10 mg/l (arbitrarily regarded as uncontaminated) and where the sample was obtained using pumping windmills or the portable pumping unit to ensure representative samples.

The chemistry of the groundwater is controlled by several factors apart from extreme contamination. These are:

(1) Soil type (less important where the soil is thin and sandy),

(2) Ion exchange with clays in the soil and the aquifer material,

(3) The proportion of dolomite in the limestone through which the water has moved.

(4) Residence time of water in the aquifer in the area sampled, and

(5) Agricultural practice resulting in minor alterations to chemistry from fertilizers.

B. IONIC BALANCE

The low salinities and large values of hydraulic conductivity demonstrate that connate water does not need to be considered when examining the composition of the water.

The aquifer is dominantly a calcarenite, with dolomitic and flinty zones. Water samples generally had pH values in the range 6.5 to 8.5, and the dominant carbonate special expected is therefore the bicarbonate ion, HCO_3^- (Garrels and Christ, 1965), in conjunction with Ca^{++} and generally lower concentrations of Mg^{++}.

Other constituents for which analyses were made, such as Na^+, K^+, Cl^-, $SO_4^=$ were considered most likely to be derived from cyclic salt.

The data were analysed to test the hypothesis that the chemical composition of the groundwater could be explained as a first approximation in terms of dissolution of calcarenite and addition of cyclic salt.

(i) Cyclic Salt Contribution

The main constituents of sea water (from Krauskopf, 1967) are listed in Table III.

TABLE III - MAIN IONIC CONSTITUENTS OF SEA WATER

COMPONENT	CONCENTRATION		MOLAR RATIO
	mg/l	millimoles/litre	with respect to Cl^-
Cl^-	18 980	535	1.00
$SO_4^=$	2 649	27.6	0.052
Na^+	10 556	459	0.858
Mg^{++}	1 272	52.3	0.098
Ca^{++}	400	10.0	0.019
K^+	380	9.72	0.018

The ratios of $SO_4^{=}/Cl^-$ tabulated below (Table IV), correspond reasonably well with the ratio for sea water. In particular, the overall average of 0.066 compares well with 0.052 for sea-water, and indicates only a slight excess of $SO_4^{=}$.

Similarly the ratios of K^+/Cl^- and Na^+/Cl^- listed in Table IV correspond well with the sea-water value, but again with a slight K^+ and Na^+ excess.

Both sulphate and potassium concentrations in the samples were low (e.g. 0-35 mg/l for sulphate), and percentage errors in analytical determinations would have been maximized.

TABLE IV - MOLAR RATIOS - $SO_4^{=}/Cl$, K^+/Cl^- and Na^+/Cl^-

HUNDRED	AVERAGE $SO_4^{=}/Cl^-$	AVERAGE K^+/Cl^-	AVERAGE Na^+/Cl^-
Blanche	0.062	0.030	1.05
Caroline	0.059	0.014	0.95
Gambier	0.050	0.008	0.96
MacDonnell	0.155	0.017	0.96
Mingbool	0.031	0.024	1.00
Young	0.084	0.025	1.13
Overall	0.066	0.021	1.02
SEAWATER	0.052	0.018	0.86

Thus $SO_4^{=}/Cl^-$ and K^+/Cl^- show good agreement with the sea water ratios, with a slight, but consistent excess.

The obviously large contribution of Mg and Ca (in widely varying proportions) from dissolution of limestone and dolomite made it unrealistic to compare their chloride ratios with those of sea water.

(ii) Mass Balance

The aim of the examination of the analysis results was to balance the molar concentrations of the dissolved constituents by combination of ions based on their probable origin. Thus Ca^{++} and Mg^{++} were combined with HCO_3^- to form dolomite, the remaining Ca^{++} and HCO_3^- to form calcite, and the remaining ions subtracted in the proportions of seawater (Table III), based on Cl^-, the dominant anion.

Appendix I is an example showing a reasonable balance.

Generally the calcite/dolomite balance was good, however significant excesses of Na^+ or Cl^- were common. This suggests additional components for which analyses were not performed, such as silica (SiO_2), and flint, quartz arenite and sponge spicules would all contribute it to the groundwater. Minor excesses or deficiencies can be attributed to analytical errors, processes such as ion exchange in the soil layer and the arbitrary assumption that a sample was uncontaminated, which was based on the samples nitrate concentration alone.

C. CONCLUSIONS

The examination of the water analyses supports the view that the groundwater chemistry can be explained mainly in terms of cyclic salt and dissolution of dolomitic limestone. More detailed analyses (such as SiO_2) could be used to advantage, although the problems of contamination are hard to overcome.

7. GROUNDWATER CONTAMINATION

A. GENERAL

The Gambier Limestone is particularly suitable for subsurface waste disposal. It allows rapid passage of liquids from the surface to the water table by way of features such as swallowholes and vertical (often infilled) solution tubes and may permit rapid horizontal migration of pollutants.

Waste liquids, both industrial and domestic, have been discharged for more than one hundred years into wells, boreholes, caves and sinkholes (Plates 5 and 9). The result is introduction of various pollutants directly to the aquifer without dilution or filtration, particularly in and near Mount Gambier.

The problem is compounded by runoff from the city of Mount Gambier being drained down boreholes and sinkholes (Plate 6).

B. INDICATORS OF CONTAMINATION

(i) Nitrate

To date one of the most significant pollutants in groundwater at Mount Gambier has been the nitrate ion, NO_3^-, for which concentrations of up to 490 mg/l have been recorded. The generally accepted safe limit for NO_3^- concentration in water for human consumption has been 45 mg/l (U.S. Dept. of Health, 1962), although Hart (1974) recommends 10 mg/l, as there is the possibility of infants contracting the disease methemoglobinaemia when concentrations exceed this limit.

Nitrogen is not a major constituent of the Gambier Limestone, so any nitrogen compounds in the groundwater must have been introduced by infiltration or drainage.

It is possible to estimate the contribution of nitrogen to the groundwater from two pollution sources, Mount Gambier city effluent and cattle excrement, and to express each as a concentration of nitrate ion in a perfectly mixed aquifer.

Mount Gambier city effluent can be estimated on the basis of a population of 20 000, with each person contributing 11 lbs (5 kg) of nitrogen per year (Task Group Report, 1967). The volume of water in the aquifer can be estimated on the basis of a saturated thickness of 100 m beneath the city, with an aquifer porosity of 0.3. The approximate area of the city is 10 km^2.

This effluent load would raise the nitrate concentration of the water in the aquifer beneath the city by 1.5 mg/l per year, and groundwater movement of a few metres per year is unlikely to significantly reduce this concentration in the short time.

The irregular input of effluent, slow rate of mixing and inhomogeneity of the aquifer will all tend to prevent a uniform increase in nitrate concentration, and an uneven distribution of high nitrates in the upper part of the aquifer could be expected. At least 50% of all effluent is now safely removed by the sewerage system, but the cumulative effects of at least 100 years of effluent disposal can be expected to have increased nitrate concentrations by 25 to 100 mg/l within the city area.

The contribution of nitrogen from the waste products of cattle can be estimated in a similar way. Stocking rates vary considerably with time and from place to place, but local Department of Agriculture representatives gave an estimate of 1 to 1.5 cows per acre as an optimum for rural areas. The maximum of 1.5 cows per acre is used here, that is, 3.7 cows/hectare (ha).

The waste products from 1 cow are equivalent to those from about 16.4 humans, each person contributing on average 11 lbs. of nitrogen (N) per year (Task Group Report, 1967). About 1300 kg NO_3/ha/y can therefore be expected from bovine sources as a maximum estimate.

Recharge to groundwater in grassland near Mount Gambier has been estimated at 85 mm/year (Holmes and Colville, 1970a), from which the concentration of nitrate in the infiltrating water can be calculated to be 1 500 mg/l in an average paddock, stocked with cattle.

Such a nitrate concentration could be expected in the infiltrating water if the excrement were evenly distributed over the area of intake (with 3.7 cows per hectare), with 85 mm of recharge and no loss of nitrogen from the infiltrating water. The possibility of the high nitrate concentrations in local groundwater being caused by animal husbandry is thus demonstrated.

The actual nitrate concentration of recharge water in areas stocked with cattle has never been measured but will vary from the estimate because of interaction between the following processes.

1. Cattle tend to congregate and defecate near stock troughs, and increased nitrate concentrations are to be expected there as a result.
2. Local cones of depression around windmills (usually adjacent to stock troughs) may tend to reduce dispersion of pollutants, accelerating the rate of increase of nitrate concentration.
3. During summer months nitrogen in the ammonia form may be lost in significant quantities whilst on the surface, and up to 30% may be volatilized from the soil (Bartholomew and Clark, 1965). Conditions favouring water loss also favour ammonia loss, and ammonia may be carried by upward moving soil-water to a zone from which it can volatilize.

4. During the period of active growth, uptake by plants is likely to reduce the amount of nitrogen available for recharge.
5. Although the nitrate ion is extremely mobile, ammonium is readily absorbed by clay in soils (Bartholomew and Clark, 1965). The thin and sandy soils found south of Mount Gambier allow the greatest possibility of ammonia movement.
6. Dung forms an essential food supply during the life-cycle of some insects. Unknown amounts of nitrogen will be withheld from infiltrating water in this way.
7. Recharge exceeds 85 mm in some areas, and nitrate concentrations in recharge water may be correspondingly reduced.

If the aquifer beneath a cattle paddock were 100 m thick, with a porosity of 0.3, the nitrate concentration of the groundwater could increase by about 1.5 mg/l per year. In practise the concentrations beneath the city area could be expected to be much greater than beneath an area stocked with cattle because of the variability of stocking rates and the mechanisms for nitrogen loss or fixation, which are effectively by-passed by the use of soakage pits and boreholes.

(ii) Bacteria

Bacteria are readily removed by passage of water through porous media, but are a problem in karstic zones where rapid flow along solution cavities may occur.

High (and unacceptable) bacteriological counts in water supplies have forced the Engineering and Water Supply Department to stop using certain water supply bores. Many private bores have also been sampled by the local Department of Agriculture and E. & W.S. Department representatives and have been found contaminated. Extremely high counts were reported in the old production bore of the Wattie-Pict Ltd. frozen food factory and investigations by E. & W.S. officers in 1972 failed to trace positively the source of pollution. Significantly, the bore penetrated two cavities during drilling and these presumably allowed ready transmittal of pollutants from nearby factory drainage bores.

(iii) Phosphate

Phosphates are found in animal waste products, and may also be derived from phosphate-based detergents. As background phosphate levels in groundwater in the area are very low (a large number of sample analyses contained less than 0.01 mg/l) it was hoped initially that phosphates might be a better indicator of pollution than nitrates.

Superphosphate fertilizer is used locally, and could be a source of pollution in rural areas. The amount infiltrating beyond the root zone will vary considerably, controlled by intensity of fertilizer use, soil type, plant type and karst features.

(iv) Phenols

Spillage and drip of creosote from impregnated timber treated at the State Sawmill (Figure 1) infiltrated the soil and was carried into a nearby sinkhole with runoff water, before a new treatment area was constructed. Very low concentrations of phenol in water may be detected by taste, although opinions vary on the actual detection limit. The U.S. Public Health Service (1962) limit and that of Hart, 1974 is 0.001 mg/l for human consumption.

Chlorophenols may be detected in water in much smaller concentrations than phenols. As the Mount Gambier town water supply is chlorinated, formation of chlorophenols from any phenols present in the water of the Blue Lake would be very serious.

(v) Metals

Pine Timber is "salt treated" at the State Sawmill by impregnation with a solution of copper, chromium and arsenic salts. Wastes from this process may reach the aquifer in the same ways as creosote wastes.

Maximum allowable limits are:

Cu: 1 mg/l (Hart, 1974)

Cr: 0.05 mg/l (U.S. Public Health Service, 1962 and Hart, 1974_.

As: 0.5 mg/l (Hart, 1974).

Observation bores were drilled near the sawmill to test for pollution by phenols or metals.

(vi) Dissolved Oxygen (D.O.)

Organic wastes typically deplete the oxygen dissolved in water. Organic contamination of bores should be indicated by low D.O. readings (possibly in association with the other analyses such as bacteriological counts and Chemical Oxygen Demand discussed below).

(vii) Chemical Oxygen Demand (COD)

COD was determined as a measure of the pollution load. The biological oxygen demand (BOD) is a more commonly used indicator of pollution, but is a slow determination and posed problems in this study because of the time involved transporting samples to the laboratories in Adelaide.

Table V shows the analyses performed to detect specific pollutants in the groundwater.

TABLE V - Analyses for Specific Pollutants

POLLUTION SOURCE	POLLUTANTS	ANALYSES
Domestic	Sewage and other wastes giving rise to nitrogen compounds and phosphate.	Full*, NO_3, PO_4, COD, Total N in some cases, Bacteriological.
Dairies and Piggeries	Wastes rich in nitrogen compounds.	Full NO_3, PO_4, COD. Total N, Bacteriological.
Cheese Factories	Whey and wastes rich in nitrogen compounds.	Full NO_3, PO_4, COD. Total N, Bacteriological.
Woods & Forests Department	Creosote, copper-chromium-arsenic salts.	Full NO_3, PO_4, COD. Phenol, Cu, Cr, As.
Others	Various, including pea wastes, glue, sawdust, oil etc.	Full, NO_3, PO_4, COD.

* Full analysis is taken here to include Na^+, K^+, Ca^{++}, Mg^{++}, Cl^-, $SO_4^=$, HCO_3^- .

8. DISCUSSION AND INTERPRETATION OF RESULTS OF POLLUTION SAMPLING

A. NITRATE

All samples were analysed for nitrate. In addition, waters from bores near Mount Gambier were analysed to determine the form in which the nitrogen was present in the groundwater (Total N in Table V). Results of these special analyses are included in Appendix G.

"Free and saline" nitrogen is a measure of nitrogen present as ammonia, and "albuminoid" nitrogen is nitrogen contained in organic molecules. The nitrogen in reduced forms oxidises to nitrite and then to nitrate with time, given suitable conditions. Where anaerobic pools are used for effluent storage, nitrogen will remain in the ammonia form (Schmidt, 1972). These conditions might be expected in a stagnant, disused bore column, but not in the majority of waters sampled.

Most of the analyses were low in all nitrogen compounds except nitrate, although concentrations of other compounds were measurable in a few samples and indicate contamination by animal wastes or septic tanks. The ammonia in water from borehole BLA 28 related to a putrid sample from a disused bore - an obvious case of contamination of water in the bore column itself.

If nitrogen compounds such as ammonia were originally present as pollutants they have oxidised almost completely to nitrate by the time they reach the water table (during their passage through the unsaturated zone). Consequently, the treatment of spatial distribution and sources of nitrogen compounds in groundwater was restricted to examination of nitrates.

(i) Sampling Methods

As samples were collected in three different ways, it was important to test for bias in each of the different sampling methods, as they represent sampling from the aquifer at three pumping rates with consequent different chance of measuring contamination of the bore column. The portable pump has a capacity of about 2.5 l/sec, windmills about 0.5 l/sec, and a bailer removes a negligible amount of water from storage within the bore column. Figure 9 shows the correspondence between analysis results for samples and windmill, pumped and bailed sources in each area.

Water was withdrawn from the bores at varying depths in the aquifer, usually within the top 20 m. A plot of nitrate content of sample versus depth below the water table for samples obtained with the portable pump (Figure 10) demonstrates the lack of any relationship between composition and depth of sampling within the range of depths from which samples were taken in the pollution survey.

Samples taken from springs and sinkholes although few in number also conform with the distributions of the main three sampling methods.

It appears that sampling method is not a controlling factor for the nitrate concentration of groundwater samples in this instance.

(ii) Nitrates in Stratigraphic Bores

Representative water samples were taken at various depths during the drilling of each stratigraphic bore. The nitrate profiles are shown on Figure 11, revealing a slight or marked decrease in nitrate concentration at depth, or uniformly low concentrations at all depths.

This is consistent with nitrate derived relatively recently from surface sources, with the lower, less active zones of the aquifer not yet having mixed sufficiently with the upper nitrate rich zones.

Bore BLA 76 appears anomalous, but only on the basis of one analysis. Bore KON 1 shows a fluctuating pattern of low nitrate concentrations, but as they are in the range 10-20 mg/l this is likely to be a natural pattern.

(iii) Statistical Treatment of Data

It was thought that bores in the Mount Gambier area might have higher nitrates than bores in the surrounding areas, as a result of the higher population density and greater intensity of waste disposal, but this was not obvious by inspection of analytical results. Figure 12 shows the contoured distribution of nitrate concentration and the very significant effects of point sources.

In an attempt to discover the role of the city of Mount Gambier and near environment in the regional nitrate distribution, the results were separated into two groups; one (Area A) of samples taken within a radius of 5 km of the city centre and the other (Area B) to include all other samples.

To check the possibility of high nitrate concentration resulting from essentially local effects, boreholes were divided into two categories on the basis of the adjacent surface environment.

(1) Bores not likely to be directly polluted from adjacent surface features, and

(2) Bores considered to be located such that surface features (houses, stock-troughs, dairies etc.) could directly contaminate the aquifer in the area adjacent to the bore. A distance of 100 m was arbitrarily chosen as the limiting distance between bore and pollution source, although most were much closer.

A fifth group was formed from samples taken from those bores situated within the Mount Gambier metropolitan area.

Statistical techniques were applied to the data to estimate the probability of independence between the different sample groups. Table VI shows the calculated probabilities of independence between the different groups, including the total population.

The log normal distribution was chosen because the data can be shown to fit that form closely. There were no values of nitrate concentration zero, or less, and the curve had a long positive tail. An analysis result of zero mg/l means that the nitrate concentration of the sample was too low to measure, not that nitrate was absent from the samples. The independence probabilities were determined by independence areas under the calculated normal curves for the logarithm to the base 10 of sample nitrate concentration. The measure obtained will always under-rate the independence between the groups, as there must be overlap between sample groups even if they are quite independent.

TABLE VI - Independence probabilities for Different Sample Groups

SAMPLE GROUPS COMPARED	INDEPENDENCE PROBABILITY
Bores Likely to be Polluted - Total	6%
Bores Not Likely to be Polluted - Total	14%
Bores Likely to be Polluted - Bores Not Likely to be Polluted	20%
Area A - Total	31%
Area B - Total	5%
Area A - Area B	37%
Mount Gambier Metropolitan - Total	58%
Mount Gambier Metropolitan - Area A	30%

<u>Borehole Environment</u> The probabilities of independence between the sample groups selected on the basis of nearby surface features likely to cause contamination are low when compared with the total population. The two groups have a 20% probability of being independent of one another, which, while low, is still significant. The surface environment near the borehole cannot be said to exert a controlling influence on the sample nitrate concentration, or by implication, to be a major source of pollution. The local environment may still be very important in individual cases, however.

<u>Spatial Distribution</u> Samples from Area B have only a 5% probability of being independent of the total population (82% of all boreholes sampled are in AreaB), but samples from Area A have a 31% probability of being independent of the total population, and a 37% probability of being independent of samples from Area B.

This moderate probability of independence between the samples from Areas A and B is believed to result from the effects of waste disposal in Area A. Figure 13 shows sample histograms with 10 mg/l and 25 mg/l class intervals for those samples from bores in the two areas, with a shift in the peaks from a low 0-10 mg/l in Area B to 30-40 mg/l in Area A. Natural nitrate concentrations are expected to be of the order 0-25 mg/l.

The most significant departure from the total population is provided by samples from the Mount Gambier metropolitan area. They have a 30% probability of being independent from Area A (and comprise 20% of the population from that area) and a 58% probability of being independent from the total population.

Figure 14 presents the calculated normal distributions for the logarithms of sample nitrate concentration for the groups discussed. The departure of the distributions for samples from both Area A and the Mount Gambier metropolitan area from the other distributions is clearly illustrated.

There are not significantly greater stock populations in Area A than Area B, and the most important difference is the high human population and the intensive subsurface waste disposal. Samples from Mount Gambier metropolitan area ranged from 45 mg/l to 300 mg/l nitrate, consistent with the predicted order of magnitude (see page 30).

(iv) Change in Ionic Constituents with Increasing Nitrate

In an attempt to determine which constituents were added to groundwater with the nitrogen compounds, the dependence of Na^+, K^+, Ca^{++}, Mg^{++}, Cl^-, HCO_3^-, $SO_4^=$ and $PO_4^{\equiv}$ upon nitrate concentration was tested.

There is a tendency for samples with high nitrate concentrations to show corresponding higher than usual concentrations of other components, but good correlations between individual components were not exhibited.

Correspondence between Cl^- and NO_3^- ions can indicate contamination by septic tank effluent (Schmidt, 1972). Na and Ca appeared to be the main balancing cations, with a smaller proportion of Mg.

The compositions of samples were plotted on Piper diagrams, on Figures 15, 16 and 17. The plot of the relatively uncontaminated samples is shown in Figure 15. Samples from Hundreds of Gambier and Blanche with nitrate concentrations greater than 50 mg/l are plotted on Fig. 16 and those from Caroline, MacDonnell, Mingbool and Young on Figure 17. The resultant distributions show the obvious effects of the increasing nitrate (as an increase in its percentage of total anions) by a shift of points towards the $SO_4^=$ + NO_3^- corner (effectively the NO_3^- corner) and away from the HCO_3^- corner.

Cation distribution shows a slight shift away from the Na^+ corner, without much increase in the amount of Mg^{++} suggesting that more Ca^{++} has gone into solution with the NO_3^- and Na^+ and Mg^{++}.

(v) Blue Lake Nitrates

The variation of nitrate content of Blue Lake water (with time) is shown on Figure 18. The recent high nitrates are not a unique occurrence, the highest recorded level being in 1944. Records start in 1924, some 80 years after European settlement.

Analyses of water samples from the Blue Lake (from records kept by the E. & W.S. Department) show that nitrate concentration does not vary with depth, and was about 12 mg/l when sampled in 1972.

This shows that nitrates have not entered the lake in sufficient quantity to significantly affect water composition.

Some more rapid transmittal of pollutants is possible along solution cavities, but explored caves in the area which extend to the water table rarely exhibit flowing water (F. Aslin, S.A. Dept. Mines, pers. comm., 1972). This mechanism is unlikely to contribute to any pollution of the lake.

A continued rise in nitrate concentration in the lake is probable in the long term, even if all underground discharge is halted immediately, unless there is a major contribution of water from the underlying Knight Group aquifer.

B. PHOSPHATES

Concentrations of phosphates are usually less than 1 mg/l and frequently less than 0.01 mg/l. The highest concentration (12.3 mg/l) is associated with a bailed sample of putrid water from bore BLA 28.

Fig. 19 shows sample histograms of phosphates showing a distribution with very few concentrations greater than 0.2 mg/l, and most less than 0.01 mg/l, in both areas A and B. Samples with high phosphate concentrations correlate with high nitrate in a few cases - suggesting contamination by animal wastes. The other samples with high phosphate concentration fall into a distinct group with low nitrate concentrations. Table VII shows the 11 samples with greater than 0.2 mg/l PO_4.

All samples in Table VII except GAM 12 and GAM 58 have obvious local sources of contamination.

Bore BLA 61 was sampled immediately after a windmill was started (Sample BLA 61A) and again after 15 minutes (Sample BLA 61). In that time phosphate dropped from 0.73 to less than 0.01 mg/l, indicating that the high phosphate was associated with water in the upper part of the bore column, i.e. not associated with aquifer contamination.

Bore GAM 58 is immediately south of the State Sawmill, with no obvious features likely to cause phosphate contamination. Bore GAM 12 has no obvious local source of PO_4 and both may be the result of superphosphate use.

TABLE VII - SAMPLES WITH GREATER THAN 0.2 mg/l PHOSPHATE

BORE NO.	mg/l PO_4	mg/l NO_3	SAMPLING METHOD	AREA	COMMENTS
BLA 4	0.45	490	Bailed	A	Bailed sample from W/M adj. house.
BLA 32	0.20	265	Bailed	B	Disused, in house yard adjacent to dairy.
GAM 57	0.92	495	Bailed	B	Clean sample, W/M adjacent to house.
MIN 14	1.75	105	W/M	B	Clean sample, W/M started for sample (adjacent troughs and stockyards).
BLA 28	12.3	27	Bailed	A	Disused bore, completed at ground level, putrid sample.
BLA 29	0.25	20	Bailed	A	Moderately bailed sample, D of M bore on roadside - no adjacent features to contaminate.
BLA 50	0.2	14	Bailed	B	Open bore in shed - small dead animal. Bird droppings in profusion.
BLA 92	1.0	30	W/M	B	Windmill with adjacent trough.
GAM 12	1.35	55	Pumped	A	Dept. Mines observation bore, clean sample
GAM 58	0.85	13	Pumped	A	Dept. Mines observation bore, clean sample. On railway line adj. State sawmill.
CAR 23	1.2	12	Pumped	B	Pumped well - dirty water - dead birds in water, dead sheep 1 year before.

In summary phosphate concentrations are not sufficiently high to allow assessment of regional pollution. Sampling method appears to be the main controlling influence.

C. DISSOLVED OXYGEN, CHEMICAL OXYGEN DEMAND

Dissolved oxygen concentrations cover a wide range (expressed in mg/l, in Appendix G), from less than 1 mg/l to greater than 10 mg/l. Ranges and averages for separate hundreds, areas A and B, and the total area are shown in Table VIII. Generally the values are similar except for noticeably lower dissolved oxygen concentration in the Hundreds of Mingbool and Young, where less permeable soils overlie thin Gambier Limestone, depth to the water table is small (swampy conditions are common), and infiltration rates lower.

Figure 20 shows histograms of dissolved oxygen concentration. Both distributions are bimodal, and both peaks show a shift to the lower dissolved oxygen values for boreholes likely to be polluted compared with those not likely to be polluted.

Samples from bores in the Hundreds of Mingbool and Young fall in the lower dissolved oxygen classes in both histograms reflecting lower oxygen concentrations in groundwater in those Hundreds. The dotted line showing the histograms for the four Hundreds, Blanche, Caroline, Gambier and MacDonnell lacks the bimodal character, showing the influence that the low values in Mingbool and Young have on the overall distribution.

Table VIII shows the ranges and averages of COD and DO in the area sampled. COD values cover the range from less than 5 mg/l to 80 mg/l, although all but two are below 50 mg/l. At these low values a dilute dichromate solution is used for the determination, and the error in determination may be up to 20 mg/l (N. Blesing, Amdel, pers. comm.). Differences of less than 20 mg/l cannot therefore be interpreted as having significance in terms of pollution load in the samples analysed. The COD averages are all in the 15-20 mg/l interval, and their differences are regarded as insignificant.

TABLE VIII - DO and COD (in Hundreds)

	MIN(mg/l)	MAX(mg/l)	AVERAGE(mg/l)	HUNDRED
DO COD	1.8 5	10 70	8.3 17.9	BLANCHE
DO COD	0.5 5	9.8 50	6.6 16.7	CAROLINE
DO COD	1.1 5	10.6 30	7.0 15.2	GAMBIER
DO COD	2.0 5	10 35	6.3 16.5	MACDONNELL
DO COD	1.3 10	4.5 30	2.7 18.1	MINGBOOL
DO COD	1.5 10	10.0 80	4.8 20	YOUNG
DO COD	5.4 5	10.6 70	8.4 16.5	AREA A
DO COD	0.5 5	10 80	6.4 17.1	AREA B
DO COD	0.5 5	10.6 80	6.8 17.0	TOTAL AREA

The low values indicate that contamination with oxidisable substances such as organic compounds has not had a measurable impact on the groundwater to date. This reflects the aerobic conditions expected in the unsaturated zone, where oxidisable materials will be oxidized before reaching the water table, and in the upper zone of the aquifer where DO is high.

Only two bores with a COD greater than 50 mg/l were encountered. Both samples were putrid water, collected by bailing, and indicate contamination of the bore water column itself.

The plot of COD vs DO on Figure 21 shows that samples with low COD cover complete range of DO values. The two higher COD samples have low DO values, suggesting depletion of oxygen in the bore, as would be expected. The range of lower DO values with low COD are likely to reflect two factors:

(1) Depletion of oxygen by a limited pollution load,

(2) Depletion of oxygen due to other factors - e.g. respiration by plant roots.

Some samples known to be contaminated (e.g. dead sheep in well) did not have a correspondingly high COD - throwing more doubt on the usefulness of the method as an indicator of pollution in this situation.

D. SPECIAL ANALYSES (Appendix K)

(i) Phenol

All but three analyses were below the detection limit (1 mg/l) and indicate a lack of creosote contamination in the aquifer in the vicinity of the State Sawmill - where the creosote wastes are likely to reach the water table.

Water from bore BLA 28 in the Mount Gambier metropolitan area (a bailed, putrid sample) was first recorded by Amdel as 80 mg/l phenol, and re-analysed at 3 mg/l. The results have no significance when the condition of the water sample is considered.

Samples from bores BLA 39 and bore BLA 82 contain 1 mg/l phenol, however there is no obvious source for phenol.

Analysis for phenol at low concentrations in a laboratory is a difficult task, and a single analysis result of 1 mg/l phenol is not a reliable figure on which to base any conclusions.

(ii) Copper-Chromium-Arsenic

Copper - All but two samples were below the detection limit.

Bore BLA 39 was found to contain 0.06 mg/l Cu, and Bore GAM 12, 0.26 mg/l Cu. As $CuSO_4$ was used as a preservative (see Appendix C) in samples taken at the same time, the most likely explanation of the Cu analysis results is contamination during sampling, as no obvious sources of Cu are evident near the bores.

Chromium - All samples were below the detection limit.

Arsenic - All samples were either below the detection limit, or at that limit (0.005 mg/l). This is not an unrealistic natural concentration, and is not regarded as indicative of contamination.

In summary no significant concentrations of copper, chromium or arsenic were detected in the areas around the State Sawmill and the Softwood Holdings factory. If significant pollution has taken place, it has not yet migrated as far as the sampling points.

E. BACTERIOLOGICAL ANALYSES (Appendix L)

Samples were taken from bores using the portable pump where possible, as it was believed that the risk of contamination was too great with other sampling methods. All bores had been drilled at least two months prior to sampling, and some were over 1 year old, reducing the chance of contamination introduced during the drilling process giving misleading indications.

Bolivar Laboratories of the E. & W.S. Department, in which the analyses were performed, commented that those bores with three indicator organisms present could be considered polluted. GAM 56 is omitted from their list, presumably due to the small amounts of the indicator organisms present, although three were detected.

The results are presented in Appendix K, with comments about the location of bores, whether local contamination is expected, and the sampling methods used.

Samples with three indicator organisms fall into three groups, with only one exception (Bore BLA 30).

(1) Bores considered likely to be contaminated (10 samples)

(2) Bores sampled by bailing (3 samples)

(3) Bores sampled with the portable pump, but where the low bore yield drastically reduced pumping time because the bore column was rapidly pumped dry (4 samples).

Groups (2) and (3) represent poor sampling techniques. This was realised in the field, but where the E. & W.S. Department personnel were on site it was considered worthwhile to sample the bore. Not all bailed samples had high bacterial counts (e.g. bore GAM 67), but a high count from a sample obtained by bailing or short term pumping cannot be considered to indicate contamination of the aquifer.

The high levels of bacterial contamination in sampled bores can be ascribed to local borehole contamination or improper sampling.

No useful relationships between bacterial counts and either COD or DO were disclosed by the survey.

F. CONFINED AQUIFERS

Boreholes BLA 66 and BLA 88 were the only pumped sampling points for the confined aquifers.

There was no indication of contamination of the aquifer on the basis of nitrate or phosphate. Dissolved oxygen was found to be low in both, and consistent with the reducing environment (black, pyritic clays).

The production bore at the Wattie-Pict Factory has been tested repeatedly for bacteriological quality by officers of the Engineering and Water Supply Department since 1972, with consistently negative results (P.D. Harvey, pers. comm., 1975).

G. CONCLUSIONS

The nitrate ion is the only component for which analyses were made that is a useful indicator of pollution of the Gambier Limestone aquifer. Other constituents or analyses (phosphate, dissolved oxygen, chemical oxygen demand, bacteriological tests, copper, chromium, arsenic and phenol) are useful for detection of extreme borehole contamination in a restricted area. The subdivision of the sample nitrate population on the basis of sampling method, local borehole environment and location has allowed certain conclusions to be drawn.

(i) There is no overall control of nitrate concentration by the method of sampling.

(ii) When samples were divided into groups on the basis of pollution sources adjacent to the borehole, the resultant distributions had a 20% probability of being independent. This suggests that the division is valid, but that the local environment does not exert sole control over the nitrate concentration of a sample.

(iii) Samples taken from the Mount Gambier metropolitan area form a statistically independent group (at a 58% level of probability) from the total sample population. Thus it can be stated that the top 20 m of the aquifer in that area shows significantly higher nitrate concentrations that elsewhere, probably caused by subsurface effluent disposal over a prolonged period.

Nitrate concentrations in the groundwater have not yet significantly affected water in the Blue Lake, because of the slow rate of movement of the groundwater, low nitrate concentrations at depth in the aquifer, and a possible contribution of water to the lake from the underlying confined aquifer. A long term rise is likely unless there is a major contribution of water from the confined aquifer to the lake.

There is no evidence of pollution of the confined aquifer underlying the Gambier Limestone.

9. RECOMMENDATIONS

A. GENERAL

It is concluded that water suitable for human consumption is unlikely to be available from unconfined aquifers in the Mount Gambier city area because of the problems of pollution. Investigations to determine the extent of good quality water elsewhere in the deeper sub-aquifer of the Gambier Limestone are strongly recommended with a programme of testing both sub-aquifers and the vertical leakage that development of the lower would induce.

A further study to determine the proportion of Blue Lake water derived from the confined aquifers is essential if its long-term viability as a town water supply is to be assessed.

A detailed investigation of agricultural sources of nitrogen in the area was discussed in 1973, but lack of funds and staff in the Department of Agriculture has prevented further action. This is an important project, as the suitability of agricultural practices on various soil types in the area should be assessed in the context of groundwater pollution and recharge.

The unresolved components of the water balance for both aquifers need study, with initial concentration on recharge in the area south of Mount Gambier, and to the confined aquifer north of Mount Gambier.

Determination of aquifer parameters and characteristics of the confined aquifers is essential to ensure that their development is properly managed. A study of their area of recharge is particularly relevant in the context of forest hydrology.

B. MANAGEMENT PROPOSALS

Action to control and monitor the effects of man's activities on the groundwater resource is essential for its long term preservation. Some aspects will be dependent upon future studies of, for example, agricultural pollution and reduction of recharge by forests, but others can be stated.

Relatively polluted water supplies have been proved in as yet undefined areas from the middle zone of the Gambier Limestone. Protection of this water from contamination by correct borehole construction is essential.

Localized contamination from stockyards, dairies etc. can be difficult to control, but correct siting of supply bores as far as possible from pollution sources may provide acceptable quality water. Pumping water to stock troughs at least 100 metres from supply bores is an example worthy of adoption.

Although legislation gives the power to control waste disposal, there are still many outstanding examples of pollution hazards, and abuses of authorized drainage bores are inevitable unless their use is actively policed.

Economic considerations fortunately limited development of the confined aquifers to a minimum prior to the enactment of protective legislation. Proper construction methods are now mandatory for any bore penetrating them.

The main requirement of management at this stage is to ensure that bores exploiting the confined aquifers are properly constructed, and sited suitably to minimise interference effects. Digital or analogue modelling techniques could well be used in the future when more aquifer parameters have been determined. Maintenance of the hydraulic head above that in the unconfined aquifers is desirable, to ensure that downward leakage of polluted water cannot occur. This may prove essential to control water quality in the Blue Lake, if it is proved that a major proportion of its water comes from the confined aquifers.

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REFERENCES

Allison, G.B. and Holmes, J.W., 1973. The Environmental Tritium Concentration of Underground Water and its Hydrological Interpretation. J. Hydrol., 19: 131-143.

Allison, G.B. and Hughes, M.W., 1972. Comparison of Recharge to Groundwater under Pasture and Forest using Environmental Tritium. J. Hydrol. 17: 81-95.

Anonymous, 1972. Land Use and Water Tables. Rural Research 78.

Bartholomew, M.V. and Clark, F.E., (Ed.), 1965. Soil Nitrogen. Monograph 10, American Society of Agronomy.

Blackburn, G., 1959. Soils of County Grey, South Australia. Soils and Land Use Series No. 33, C.S.I.R.O., Australia.

Blackburn, G., 1966. Radiocarbon Dates Relating to Soil Development, Coast-line Changes, and Volcanic Ash Deposition in South-east South Australia. Aust. J. Sci., Vol. 29, No. 2, pp. 50-52.

Blackburn, G., 1966. Carbon date of Mount Gambier, Radiocarbon 8, p. 61.

Bleys, C. and Warner, K.R., 1963. Results of Pump Tests of C.S.I.R.O. Bores, Nangwarry. S. Aust. Dept. Mines unpublished report, R.B. 56/91.

Boucaut, W.R.P. and Waterhouse, J.D., 1973. The South-East Defined Areas - Their Hydrogeology and the Reasons for their Proclamation Under the Underground Waters Preservation Act. S. Aust. Dept. Mines unpublished report R.B.73/210.

Bowering, O.J.W., 1973. Pumping Test Results on Water Bore MI-1 at Snuggery - Report No. 1. S. Aust. Dept. Mines unpublished Report R.B. 73/166.

Clisby, R.L., 1972. Spring Discharges, Hundreds MacDonnell and Caroline, South-East Region, South Australia. S. Aust. Eng. and Water Supply Dept. unpub. rept. PD 96.

Cobb, M.A., 1972. South East Water Resources Regional Bore Network. Water Table Contours, March, 1972. S. Aust. Dept. Mines unpublished Plan, Number 72-1093.

Cobb, M.A. and Waterhouse, J.D., 1974. Two Model Hydrogeological Environments in South Eastern South Australia. S. Aust. Dept. Mines unpub. rept. R.B. 74/116.

Colville, J.S., and Holmes, J.W., 1972. Water Table Fluctuations under Forest and Pasture in a Karstic Region of Southern Australia. J. Hydrol. 17: 61-80.

Director of Meteorology, November, 1966. Rainfall Statistics South Australia. Commonwealth of Australia Bureau of Meteorology.

Edwards, N.H., 1973. South East Water Resources Investigation. Location and Levelling of Selected Observation Sink Holes and Springs in the Mount Gambier Area. Survey Report No. 1, Part County Grey. S. Aust. Dept. Mines unpub. (confidential) rept. R.B. 775.

Floegel, H., 1972. The Position of the Lower Tertiary Artesian Aquifer Within the Hydrogeology and Hydrochemistry of the Gambier Embayment Area (South Australia/Victoria). Unpublished Ph.D. Thesis, Breslau University, Germany.

Fenner, C., 1921. The Craters and Lakes of Mount Gambier, South Australia. Trans. R. Soc. S. Aust. 45.

Fergusson, G.T. and Rafter, T.A., 1957. New Zealand C-14 age measurement - No. 3 N.Z. Jl. Sci. Technol. 38B: 732-733.

Firman, J.B., 1973. Regional Stratigraphy of Surficial Deposits in the Murray Basin and Gambier Embayment. Rep. Invest. Geol. Surv. S. Aust., 39: 68 pp.

Garrels, R.M. and Christ, C.L., 1965. Solutions, Minerals and Equilibria. Harper and Row, and John Weatherill, Inc.

Harris, B.M., 1970. Results of a Pumping Test on the Water Supply Bore for the South West Frozen Food Producers, Mt. Gambier. S. Aust. Dept. Mines unpub. rept. R.B. 70/137.

Harris, B.M., 1971. South East Water Resources Investigation Proposed Activities in the Period from July 1971 to June 1976. S. Aust. Dept. Mines unpub. rept. R.B. 71/149.

Harris, W.K., 1966. New and Redefined Names in South Australian Lower Tertiary Stratigraphy. Quart. Geol. Notes, Geol. Surv. S. Aust. 20.

Hart, B.T., 1974. A Compilation of Australian Water Quality Criteria. Australian Water Resources Council Technical Paper Number 7.

Holmes, J.W. and Colville, J.S., 1970a. Grassland Hydrology in a Karstic Region of South Australia. J. Hydrol. 10: 38-58.

Holmes, J.W. and Colville, J.S., 1970b. Forest Hydrology in a Karstic Region of Southern Australia. J. Hydrol. 10: 59-74.

Ide, D., 1971. Preliminary Survey of Potential Pollution of Underground Water in and around Mount Gambier. S. Aust. Eng. and Water Supply Dept. unpub. rept. in E.W.S. docket 3591/71.

Jennings, J.N., 1972. An Introduction to Systematic Geomorphology, Volume Seven. Karst. (A.N.U. Press, Canberra).

Krauskopf, K.B., 1967. Introduction to Geochemistry (McGraw-Hill Inc.).

Lindsay, J.M., 1967. E. & W.S. Dept. Millicent Bores 2 and 5, Micropalaeontological examination of Gambier Limestone Sections. S. Aust. Dept. Mines unpub. rept. R.B.64/116.

Ludbrook, N.H., 1961. Stratigraphy of the Murray Basin in South Australia. Bull. Geol. Surv. S. Aust. 36.

McGowran, B., 1973. Observation Bore No. 2, Gambier Embayment of the Otway Basin. Tertiary Micropalaeontology and Stratigraphy. Min. Res. Rev., S. Aust., 135: 43-55.

Ollier, C.D., 1967. Maars-Their characteristics, varieties and definition. Bulletin Volcanologique, Tome XXXI, pp. 45-73.

O'Driscoll, E.P., 1960. The Hydrology of the Murray Basin Province in South Australia. Bull. Geol. Surv. S. Aust., 35: 300 pp.

Parkin, L.W. (Ed.), 1969. Handbook of South Australian Geology. Geol. Surv. S. Aust.

Pilkington, G., 1971. Port MacDonnell Resistivity Survey, August 1971. Northumberland 1 Mile Sheet. S. Aust. Dept. Mines unpub. Rept., R.B. 71/171.

Read, R.E. and Waterhouse, J.D., 1974. A pump Test of the Mount Gambier Aerodrome Bore Number 2 - Section 593, Hd. Young. S. Aust. Dept. Mines unpub. rept. R.B.74/101.

Schmidt, K.D., 1972. Nitrate in Groundwater of the Fresno-Clovis Metropolitan Area, California. Groundwater 10: 50-61.

Sprigg, R.C., 1952. The Geology of the South-East Province, South Australia, with Special Reference to Quaternary Coastline Migrations and Modern Beach Developments. Bull. Geol. Surv. S. Aust. 29.

Task Group Report, 1967. Sources of Nitrogen and Phosphorus in Water Supplies. AWWA 59: 344-366.

Templer, G.J., 1972. The Laboratory Measurement of Storage Coefficient and Specific Yield for Compton Quarry Limestone. S. Aust. Eng. and Water Supply Dept. unpub. rept. PD 102.

U.S. Dept. of Health, Education and Welfare, 1962. Public Health Service Drinking Water Standards. US Public Health Service Publication 956.

Valentine, J.T. and Waterhouse,J.D., 1974. Production Tests of the Upper Knight Group Aquifer at Mount Gambier. S. Aust. Dept. Mines unpub. rept. R.B. 74/81.

Ward, L.K., 1941. The Underground Water of the South-Eastern Part of South Australia. Bull. Geol. Survey S. Aust. 19.

Waterhouse, J.D., 1973. Operating Procedures for the Portable Submersible Pump Unit, and Suggestions for Modifications. S. Aust. Dept. Mines unpub. rept. R.B. 73/65.

Williams, H., 1941. Calderas and their origin. Bull. Dept. Geol. Univ. Calif. 25: 239-346.

Woods, J.E. Tenison, 1860. On some Tertiary Rocks in the Colony of South Australia. Quart. Journ. Geol. Soc. Lond. 16 pp. 253-260.

Woods, J.E. Tenison, 1862. Geological Observations in South Australia. London; Melbourne.

Wopfner, H. and Douglas, J.D., 1971. The Otway Basin of South-eastern Australia. Special Bulletin, Geol. Surv. S. Aust. and Victoria. 464 pp.

APPENDIX A

Discussion of Cable-tool Drill Sampling and Interpretation

Methods of Drilling and Geological Sampling

All bores were drilled with cable-tool rigs by the percussion method. This entails the regular lifting and dropping of a drill string consisting of a bit, sinker bar (for additional weight) and jars (used to free jammed bits). Using water poured down the hole or that occurring naturally in the formation this method crushes the rock material to form a sludge, which is periodically withdrawn from the hole (and sampled) with a bailer (an open tube, with a flap valve at its base).

Sludge samples were taken every 2 m, with the casing driven (in most cases) close behind the bit at all times to minimize contamination of water and sludge samples from higher levels.

Several factors therefore complicate interpretation of the geological log.

(1) Grain size

The observed grain size of a sample will depend upon the time elapsed before the bailer is run into the hole, the proportion of fines cushioning the friable grains such as bryozoal fragments from the action of the bit, and the original grain size of the sediment.

Sorting of grains will take place within the borehole, the bailer and the sludge trench and bucket from which the sample is taken for bagging.

(2) Layering

Any sedimentary layering will be totally obliterated except for example in the case of a layered clay/sand, where layering may be preserved in small lumps (2 to 3 cm) brought up on the bailer.

Any major lithological variations accompanying layering, but thinner than the 2 m sampling interval, will tend to be masked by other material to a degree controlled by the thickness of the layer and the skill of the driller in recognising the change and sampling accordingly.

Thin marls and flint layers which can be observed in sinkhole exposures are good examples.

These problems can be overcome to some degree by taking tube samples - a method involving the driving of a tube vertically into the material at the bottom of a hole. This is only satisfactory for softer layers when using a cable tool rig.

APPENDIX B

Summary of Investigations

SUMMARY OF INVESTIGATIONS

Investigations carried out can be divided into three categories:

1. <u>Stratigraphic investigations</u>

Eight stratigraphic bores were drilled, with a combined depth of approximately 1 700 m. Their purpose was to investigate the Gambier Limestone aquifer in terms of its permeability fabric and thickness, in order to provide a geological framework for the observed hydrogeological features.

Table (page IX) shows the hydrogeological environment for each of the stratigraphic bores, partly as proposed by Harris (1971).

TABLE IX - Stratigraphic Bore Sites

BORE NUMBER	DEPTH (m)	REMARKS
BLA 76	171	Located in the zone of steep water table gradient north of Mt. Gambier.
BLA 77	132	Located in the extremely "flat" water table zone surrounding the Blue Lake.
CAR 9	226	Located to the east of the possible flow path suggested by water table contours.
CAR 10	300	Drilled at the coast to examine the salt-water interface near the above mentioned flow path.
CAR 11	298	Drilled at the coast to examine the saltwater interface near Piccaninnie Ponds.
GAM 72	185	Drilled in an area of moderate hydraulic gradient east of Mt. Gambier to examine the upper Knight Formation aquifer(s).
MAC 35	218	Located in the possible flow path south of Mt. Gambier.
KON 1	191	Located to the west of the possible flow path.

The bore locations are shown on Figure 3 and Map 1. Sludge, bit and tube samples were taken for geological and palaeontological examinations, and the geological logs are compiled in Appendix B.

All bores were geophysically logged, but their interpretation is not within the scope of this thesis.

Several of the grid observation bores also penetrated the full Gambier Limestone sequence and where appropriate they have been used for their stratigraphic information.

All stratigraphic bores except CAR 9, KON 1 and MAC 35 fully penetrated the Gambier Limestone, the remaining three being halted when it was considered that the markedly permeable zones of the Gambier Limestone had been penetrated. The decision to stop drilling was probably unfortunate, in retrospect, as the bores are in an area where data is scarce. All were completed as observation bores in the unconfined aquifer.

2. Observation Bores

The initial "1 mile grid" of observation bores at Mount Gambier was laid out in 1971 by hydrogeologist M.A. Cobb, with sites in and near the Mount Gambier city area (pegged for drilling where private bores were unavailable) at a spacing of about 1.5 km.

Drilling of the observation bores commenced in mid 1971, and by late 1972, a total of 63 bores had been completed. Bores were usually drilled to penetrate about 10 m of the aquifer to allow sufficient available drawdown for sampling with the portable pump unit, with exceptions where bores were deepened to obtain stratigraphic information. Bores were completed with 6 inch casing and fitted with a locked cap and an identification marker.

The original grid was extended during 1972, particularly to the northwest, to examine interesting features in the water table contour plans revealed by the early water level measurements.

The grid, measured and sampled in late 1972, contained a total of 258 bores, including 3-mile grid bores which form a network covering most of the South East of the State.

3. Pollution Study

Samples were taken systematically from the observation bores and some springs and sinkholes (Map 1) to obtain a controlled, regional set of data. These data were then available for assessment of the degree of contamination of the aquifer in such terms as spatial distribution of pollutants, with particular reference to the Mount Gambier city area.

APPENDIX C

Water Sampling and Analysis Methods

Water Sampling and Analysis Methods

A. GENERAL

The sampling programme commenced in late October, 1972 and was completed in early December, 1972. Water samples were tested in the field for pH, temperature and dissolved oxygen content.

Three parameters were expected to vary significantly after sampling, and measurements made some time later would therefore have been useless.

pH was measured with a PYE Model 293 Meter with manual temperature compensation. Dissolved oxygen (D.O.) was measured with an E.I.L. Model 1520 portable Dissolved Oxygen Meter with automatic temperature compensation. Conductivity was measured with an Electric Switchgear Electrolytic Conductivity Measuring Set, Model MC-1, mark V. Temperature was measured with a mercury thermometer, or the temperature scale on the D.O. meter, (which was calibrated with the mercury thermometer).

It was considered feasible to take samples for bacteriological analysis from those bores pumped with the portable pump unit. For this purpose the pump unit was sterilised every morning during the pumping programme, with a solution of Sodium Hypochlorite. One teaspoonful to 44 gallons gave a solution of approximately 20 ppm free chlorine, which, circulated for 15-20 minutes was adequate to sterilise the unit. The concentration was decided after consultation with Mr. Robert Tucker of the E. & W.S. Department. The flushing action of 30 minutes pumping from a bore, prior to sampling, was considered sufficient to prevent contamination (from bores already pumped) of water from bores sampled later.

Samples were analysed at Amdel for the following constituents:
Na^+, K^+, Ca^{++}, Mg^{++}, Cl^-, HCO_3^- , $SO_4^=$, NO_3^-, $PO_4^{\equiv}$, Chemical Oxygen Demand (COD).
As samples were forwarded promptly to Amdel, Mr. Neville Blesing, a Group Leader in the Chemical Metallurgy Section, did not consider that significant change in constituents such as bicarbonate would take place if the sample bottles were completely filled and tightly sealed.

All samples for bacteriological examination at the Bolivar Laboratories of the E. & W.S. Department were collected during the sampling programme by Mr. David Maloney of the Mount Gambier Regional Branch of that Department.

Three additional types of analysis were made on certain samples, two of which required addition of reagents in the field as preservatives.

1. Total Nitrogen Analysis - addition of 0.8 ml of concentrated sulphuric acid per sample.
2. Phenol Analysis - Phosphoric acid to lower pH (about 5 ml/sample) and 1 g copper sulphate per sample.
3. Copper-chromium-arsenic analysis - no reagents added.

All samples were collected in 1 litre,plastic, screwtop bottles. Samples for Total Nitrogen and Phenol analysis were air freighted to Adelaide daily for prompt analysis.

B. SAMPLING METHODS

A. Pumped Bores (77 samples)

Wherever possible bores were sampled using the Mines Department portable pump unit (see Waterhouse (1973), for details of operation), as this was believed to give the best sample of water from the aquifer by virtue of its capacity (about 2.5 l/s, much greater than a windmill pump). Bores were pumped for a minimum of 30 minutes where possible (to pump out the entire bore water column) the water being continuously run through a 44 gallon drum to provide a contingency sample. Some bores pumped dry in a matter of minutes, justifying the precaution.

The water hose was curled horizontally for a minimum of two turns in the base of the drum to minimize the vertical velocity component of the water. This reduced circulation of water within the drum in order to keep errors in D.O. measurements to a minimum, as measurements showed a gradual increase in dissolved oxygen with time when extreme turbulence of drum water occurred.

D.O. was measured with the electrode near the bottom of the drum to minimise dissolution of oxygen by sample water in contact with the atmosphere.

Temperature and pH were also measured in the flowing water, and were found to stabilise early in the pumping period.

Samples were taken as near as possible to the end of the pumping period to obtain as representative a sample as possible.

B. Windmill Samples (119 samples)

Most windmill samples were taken from the outlet pipe (generally above a storage tank) and field measurements made as soon as was practicable. Some windmills were not rotating (swung out of the wind by tank float, or visited during calm conditions) and were started and/or operated manually. Most samples were clear but some were rusty.

C. Bailed Samples (58 samples)

Some unequipped bores were either inaccessible to the portable pump or of small diameter. These and sinkholes, springs, and inoperative windmills were sampled with a bailer. Field measurements were made as soon as possible after sampling.

APPENDIX D

Glossary of Terms

Glossary of Terms
(After Cobb and Waterhouse (1974))

Aquifer: A formation, group of formations, or part of a formation that contains sufficient saturated permeable material to yield significant quantities of water to wells and springs.

Confined Groundwater: Confined groundwater is under pressure, significantly greater than atmospheric, and its upper limit is the bottom of a bed of distinctly lower hydraulic conductivity than that of the material in which the confined water occurs.

Cyclic Sodium Chloride: That proportion of the dissolved NaCl which is derived directly from the oceans as spray and incorporated in droplets within clouds to fall as rain.

Groundwater: That part of subsurface water in completely saturated interstices.

Hydraulic Conductivity: If a porous medium is isotropic and the fluid is homogeneous, the hydraulic conductivity of the medium is the volume of water at the existing kinematic viscosity that will move in unit time under a unit hydraulic gradient through a unit area measured at right angles to the direction of flow. Units $L^3T^{-1}L^{-2}$.

Specific Yield: The ratio of the volume of water which the rock or soil, after being saturated, will yield by gravity to the volume of the rock or soil. The definition implies that gravity drainage is complete. (Dimensionless).

Transmissivity: The rate at which water of the prevailing kinematic viscosity is transmitted through a unit width of the aquifer under a unit hydraulic gradient. Units $L^3T^{-1}L^{-1}$.

Water table: The water surface in an unconfined groundwater body at which the pressure is atmospheric. It is defined by the levels at which water stands in wells that just penetrate the water body. In wells which penetrate to greater depths, the water level will stand above or below the water table if an upward or downward component of groundwater flow exists.

Water Table Contour: A line joining points on the water table which have the same static head, or height above a standard datum. Units L.

Unconfined Groundwater: Water in an aquifer that has a water table as its upper surface.

APPENDIX E

Selected Geological Logs

DEPARTMENT OF MINES — SOUTH AUSTRALIA

SHEET 1 OF 2

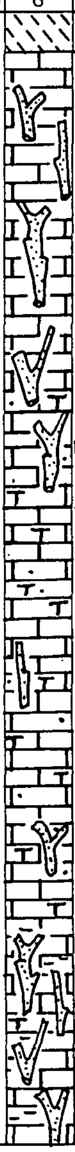
BORE LOG · HYDROGEOLOGY

Purpose of Bore	Observation			State No.	246071502
Hundred	Blanche	Section	715	Bore Serial No.	125/72
Owner	Dept. of Mines	Address	Adelaide	Project No.	BLA.66
Driller	R.B. Toohey			Docket No.	231/69
Commenced	27/3/72	Completed	8/4/72	R.L. Collar (M.S.L.)	
				Depth	35m
Drill type	Cable Tool	Circulation	Water	R.L. Surface	
				Co-ords E	
Logged by	J.D.Waterhouse	Date	27/2/73	Casing	4" 13.5m
				A.M.G. Zone	N

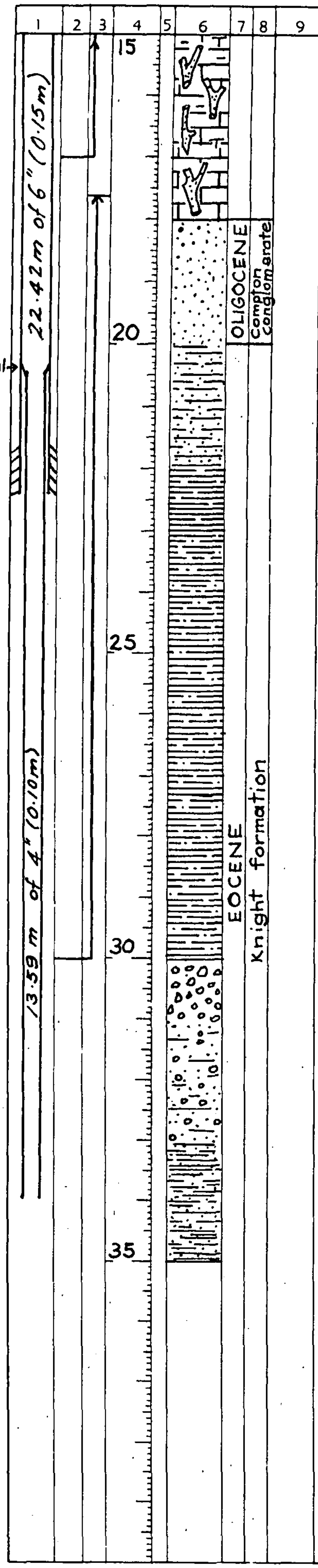
WATERS CUT

DEPTH (m)	WATER LEVEL (m)	SUPPLY- l/sec	HOW TESTED	TOTAL SALTS mg/l	ANALYSIS No.
17	14.06			415	W.1770/72
30	17.65	1	Bailer		
				470	W.1771/72
				500	W.1772/72

REMARKS. Completed to observe water levels in the Knight formation aquifer. 6" casing cemented by dump bailing

CASING 1	WATERS CUT 2	WATER LEVEL 3	DEPTH (m) 4	CORE 5	GRAPHIC LOG 6	AGE 7	UNIT 8	PENETRATION RATE 9	DESCRIPTION
22.42m of 6" (0.15m)			5, 10, 15			OLIGOCENE - MIOCENE	Gambier limestone		0-0.5m SOIL Dark brown silty clay with 30-50% quartz arenite to 0.2mm, fawn, some well cemented, white calcarenite fragments. 0.5-6m CALCARENITE At least 50% bryozoal fragments, max. 1-2mm. The rest calcareous grains, subangular, max. 1-2mm. rarely stained yellow. Minor silt and marl. Buff. 6-12m CALCARENITE Well cemented, angular, brown fragments to 5mm. Minor bryozoal fragments to 2mm, minor subangular quartz to 0.2 mm. 20% Marl. Overall light brown. 12-17m CALCARENITE Well cemented, angular, brown fragments to 5mm. 50% bryozoal fragments to 6mm. Minor silt and marl. Light brown.

State No. 246071502 Bore Serial No. 125/72 SHEET 2 OF 2



CALCARENITE 30% bryozoal and other fossil fragments to 5mm. The remainder angular calcarenite fragments of two types.

17-18 m A. white bryozoal calcarenite.
B. grey/white/brown colours, massive, minor black specks.

18-20 m ARENITE 75% quartz grains- colourless, milky and brown (stained) 0.1 - 3mm. Subangular to rounded. 25% Dark brown, ferruginous grains to 4mm.
Minor bryozoal fragments.

20-22m LUTITE Dark brown. 50% arenite as above

22-23m LUTITE Dark brown. Plentiful fine mica. Less than 5% silt size colourless quartz. Minor black subangular grains 1-2mm.

23-30m LUTITE Contains minor rounded to sub- rounded colourless quartz, silt size to 2 mm. Up to 5% fine mica and rare angular rock fragments and corroded pyrite grains. Carbonaceous.

30-31m ARENITE Pebbly. Sand size 50%. Rudite size 50%. Some binding black clay. Well rounded quartz pebbles to 2cm. (Milky - colourless)

31-32m ARENITE Coarse grained rounded - sub- rounded quartz. Up to 2.5mm, pale blue-colourless. 10% Carbonaceous clay binding.

32-33m ARENITE Even grained, well rounded quartz average grain size 1mm, in black clay. Quartz colourless and milky.

33-35 LUTITE Black, with common fine mica flakes. 50% poorly sorted quartz arenite. Angular to subrounded, 0.3-5.0m.

END.

DEPARTMENT OF MINES — SOUTH AUSTRALIA

BORE LOG · HYDROGEOLOGY

Purpose of Bore	Observation	State No.	246058801
Hundred	Blanche	Section	Rd side adj.sect.588
Bore Serial No.	149/72	Owner	Dept. of Mines
Address	Adelaide	Project No.	BLA.72
Driller	Fred Farrow	Docket No.	231/69
Commenced	30.5.72	Completed	6.6.72
R.L. Collar (M.S.L.)		Depth	45 m
Drill type	Cable Tool	Circulation	Water
R.L. Surface		Co-ords E	
Logged by	F. Aslin	Date	2-3/8/72
Casing	5.92 m of 6"	A.M.G. Zone	
N			

WATERS CUT

DEPTH (m)	WATER LEVEL (m)	SUPPLY-	HOW TESTED	TOTAL SALTS mg/ℓ	ANALYSIS No.
28.20	26.07			470	W.2545/72
				500	W.2546/72

REMARKS

CASING 1	WATERS CUT 2	WATER LEVEL 3	DEPTH (m) 4	CORE 5	GRAPHIC LOG 6	AGE 7	UNIT 8	PENETRATION RATE 9	DESCRIPTION
5.92 m of 6" Casing			0 – 15			OLIGOCENE - MIOCENE	GAMBIER LIMESTONE		

0.0 - 4.0 m Dolomitic calcarenite,pink; 30% angular to well rounded quartz arenite, 0.2-0.4 mm (occasionally to 1 mm); up to 10% of fragments strongly effervescent in 10% HCL; 5% of material ferruginous cement (dark red-brown; minor marl.

4.0 - 6.0 m Dolomitic calcarenite, pink; 30% angular to well rounded quartz arenite 0.1 - 0.2 mm; up to 10% of fragments strongly effervescent in 10% HCL: Minor marl.

6.0 - 8.0 m Dolomitic calcarenite,pink; & fossiliferous calcarenite off white, in approx. equal proportions; minor quartz arenite & marl.

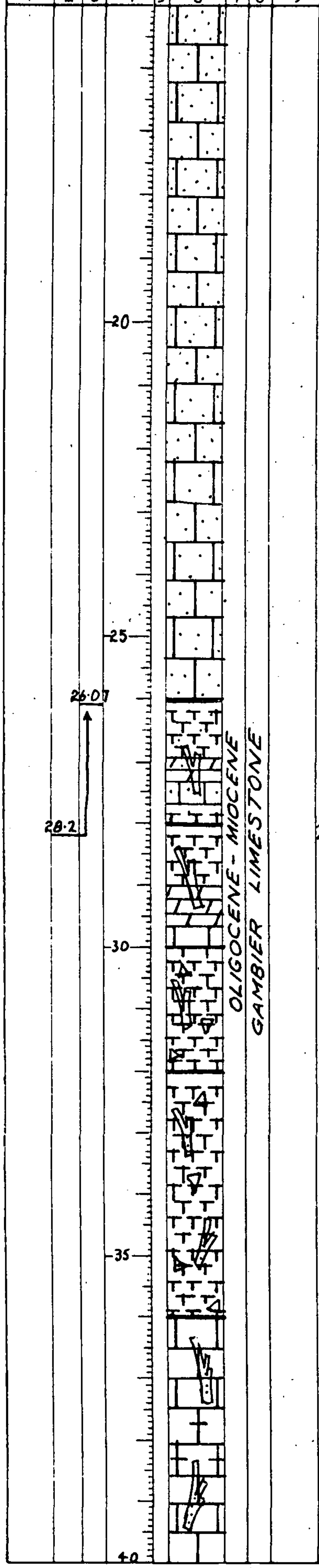
8.0 - 10.0m fossiliferous calcarenite, off white, fossil fragments to 3 mm, minor pink dolomitic calcarenite, quartz arenite & marl

10.0 - 12.0 m Approx. equal proportions of dolomitic calcarenite, pink; & fossiliferous calcarenite, off white, fossil fragments to 2mm. Minor quartz arenite (0.1 - 0.2m) & marl.

12.0 - 14.0 No sample

14.0 - 26.0 m Arenaceous calcarenite,pink, marly. Grains 0.2mm Proportion quartz arrenite indeterminable.

1	2	3	4	5	6	7	8	9	State No. 246058801 Bore Serial No. 149/72 SHEET 2 OF 3



26.0 - 28.0 m Marl, buff; 20% fossiliferous calcarenite, off white, fossil fragments to 2 mm; 20% arenaceous calcarenite, pink.

28.0 - 30.0 m Approx. 40% Marl, buff, 40% dolomitic calcarenite, pink, moderately to strongly cemented; 20% fossiliferous calcarenite, off white, fossil fragments to 7mm.

30.0 - 32.0m Marl, grey; 20% massive, slightly calcareous, grey fragments to 1 cm. Minor fossil fragments to 2 mm.

32.0 - 36.0 Marl, grey, stiff. Minor, massive, slightly calcareous fragments to 5 mm; trace of fossil fragments to < 2 mm.

36.0 - 40.0m Fossiliferous calcarenite, off white, fossil fragments to 4 mm; Marly; 4 mm diam. lumps of blue-grey calcisiltite, moderately cemented; minor massive slightly calcareous fragments.

1	2	3	4	5	6	7	8	9	State No. 246058801 Bore Serial No. 149/72 SHEET 3 OF 3

40.0 - 42.0 m MARL. Grey, stiff. Minor massive slightly Calcareous fragments to 5 mm.

42.0-44.0 m BLACK CLAY with 30% quartz (< 0.1mm to 5mm) sub angular to rounded, coloured & colourless, clear grains.

44.0-45.0 m Black clay with 40-50% quartz (< 0.1mm to 5mm) sub angular to rounded, clear & coloured, small amount of fine mica.

EOCENE

KNIGHT FORMATION

End of hole 45m.

45

50

55

60

65

DEPARTMENT OF MINES — SOUTH AUSTRALIA

BORE LOG · HYDROGEOLOGY

Purpose of Bore: Stratigraphic Observation
State No. 246066801

Hundred: Blanche
Section: Adj. 668
Bore Serial No. 5/72

Owner: Dept. of Mines
Address: Adelaide
Project No. M.G. 1 BLA 76

Driller: Harry James
Docket No. DM 223/1/69

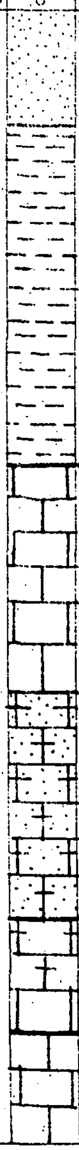
Commenced: 30/7/71
Completed: 25/9/71
R.L. Collar (M.S.L.)
Depth: 171 m

Drill type: Percussion
Circulation
R.L. Surface
Co-ords E

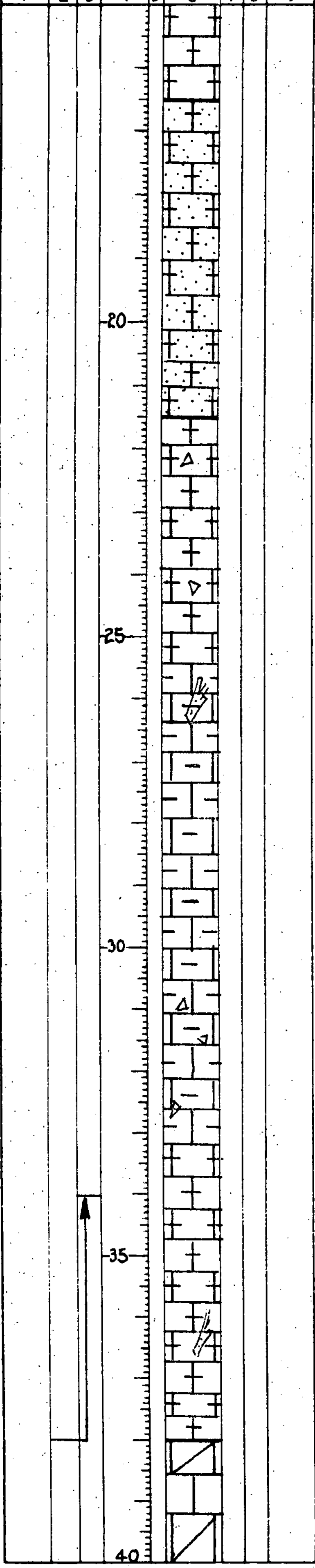
Logged by: M.A. Cobb
Date: 5/11/71
Casing: 6m of 0.152m
Zone
N

WATERS CUT: DEPTH (m)	WATER LEVEL (m)	SUPPLY-	HOW TESTED	TOTAL SALTS mg/l	ANALYSIS No
38-140	34			500	3359/71
145-157	35			555	3367/71

REMARKS: CEMENT GROUT (25 GALLONS - ?ORE) BETWEEN GAMBIER AND KNIGHT GROUP SEDIMENTS. COMPLETED AS AN OBSERVATION BORE ?40 ch. AIR PHOTO NO. 5 1475.

CASING 1	WATERS CUT 2	WATER LEVEL 3	DEPTH (m) 4	CORE 5	GRAPHIC LOG 6	AGE 7	UNIT 8	PENETRATION RATE 9	DESCRIPTION
6m of 152 casing			5, 10, 15					0-1.5	QUARTZ SAND. 0-0.5 dark brown, well rounded quartz. Grain avergae size 0.4 mm about 10-20% organic matter and silt. 0.5-1.5 orange, average grain size 0.2 mm. Angular - well rounded. Odd organic material
								1.5-6	QUARTZ SILT. Pale orange brown. Average grain size 0.1-0.2 mm. Calcareous up to 20% clay. 3-4.5 some flint chips and pale grey brown cemented calcarenite fragments. 4.5-6 lighter colour and about 30% sand size grains. Odd small cemented calcarenite fragments.
								6 -9	CALCARENITE. Pale brown buff. 6-7.5 average grain size 0.2-0.4 mm generally well rounded. Up to 10% silt. 7.5-9 average grain size 0.5-0.6 mm generally sub-angular some 3-4 mm strongly cemented calcarenite fragments. Odd bryozoa spicule?
								9 -12	CALCISILTITE. Pale brown-buff. Average grain size 0.1 mm. About 10-20% sand size grains and large (1-2 cm) moderately well rounded calcareous sandstone fragments, 9-12 . Up to 20% clay and 10-20% quartz, only a few large fragments.
								12-13.5	CALCISILTITE/CALCARENITE. Buff. About 40% sand size. Odd quartz well rounded. About 10% clay.
								13.5-15	CALCARENITE. Buff-cream. Average grain size 0.3-0.5 mm. About 20% silt-clay. Odd calcareous sandstone chips (pale grey-white, up to 5-6 mm). Odd bryozoa fragment?

1	2	3	4	5	6	7	8	9	State No. 246066801 Bore Serial No. SHEET 2 OF 8

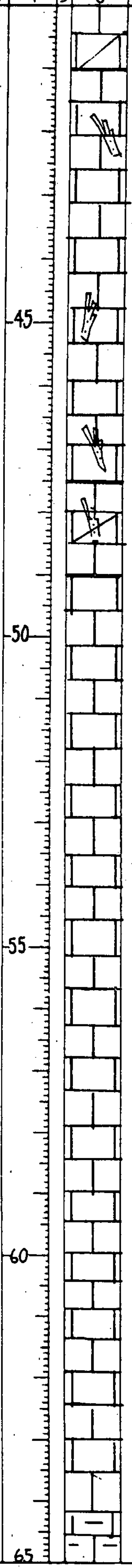


15-16.5 CALCISILTITE. Pale grey-brown. About 20% sand and up to 10-20% quartz and black flint chips and larger (1 cm) nodules of strongly cemented (siliceous) calcarenite.

16.5-21.5 SANDY CALCISILTITE. Off white-grey. 16.5-18 Flint fragments common and bryozoa fragments somewhat siliceous and odd shell fragments 18-20 somewhat clayey (pale grey-brown) and odd flint chip up to 1 cm. 20-21.5 somewhat clayey and odd bryozoa and flat chips. Some quite strongly cemented nodules of calcarenite.

21.5-38 CLAYEY CALCISILTITE. Off white-cream. Few sand size grains, flint common. 23-24.5 bryozoa moderately common, flint up to 5 mm common. 24.5-26 Flint very common up to 1.5 cm. 26-27.5 little flint. 27.5-29 flint moderately common, about 30% clay somewhat sticky when wet. 29-30.5 few bryozoa and odd pale brown chert. 32-33.5 large flint fragments average size 5 mm and bryozoa fragments moderately common. 33.5-38 Pale grey/buff, flint and chert fragments very common (often 60%) size range 0.2-1cm (larger in 36.5-38). Very sharp and angular. Odd bryozoa and towards base somewhat rounded fragments of strongly cemented bryozoal calcarenite.

38-41 CALCIRUDITE. Essentially flint and fossil fragments. Flint about 20% and up to 1 cm in size. Rest bryozoa tubes and colonial fragments, coral fragments and echinoid spines (cidaris)



41-47.5 CALCARENITE. Off white pale brown. Essentially fossil fragments - bryozoa tubes and colonies, coral tubes somewhat orange stained (limonite?). Few flint chips. 42.5-46 finer grained somewhat and more even grained.

47.5-49 CALCIRUDITE. Off-white - pale brown. Essentially fossils - bryozoa, echinoid spines. Contains fragments of recrystallised calcarenite.

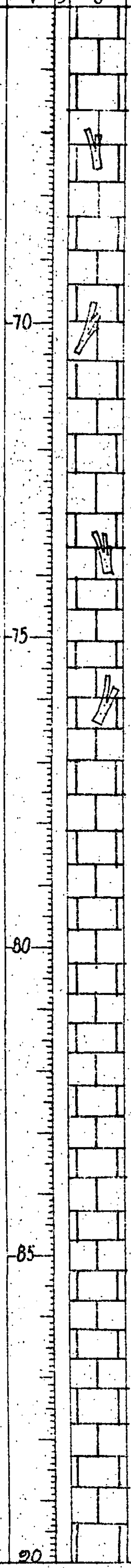
49-101 CALCARENITE. Off-white - pale brown. 49-50.5 Mixture of sand size fossils and fragments of a greyish very hard recrystallised (dolomotised?) calcarenite 50.5-53.5 Fossils more than 80% mostly bryozoa. Rest smaller fragments of recrystallised calcarenite. Some flint 52-53.5.
53.5-61 Pale grey-brown. Recrystallised fragments common, bryozoa mdoerately common - rest calcareous chips. Flint fragments up to 1 cm common.
Recrystallised fragments about ½ of sample, rest fossil and calcareous chips. Chert and flint fragments common - large fragments (1-3 cm) of recrystallised calcarenite.

61-62.5 Off-white fossils and flint dominant few recrystallised fragments.

62.5-64 Off-white cream essentially bryozoa tubes and fragments.

64-67 Pale grey-brown essentially bryozoa tubes with clayey calcarenite nodules. Nodules contain about 50% Clay.

1	2	3	4	5	6	7	8	9	State No. 246066801	Bore Serial No.	SHEET 4 OF 8



67-70 White, essentially fossil and chert fragments up to 1 cm (grey-brown)
Odd orange stained quartz grain.

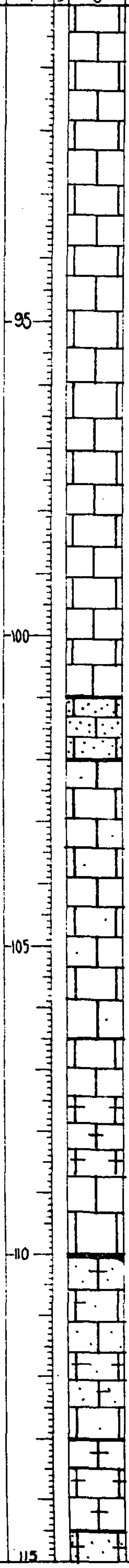
68.5 Much recrystallised material.

Odd small recrystallised fragments.

Fawn, average grain size 0.5 mm. Bryozoal and calcareous chips.

Odd larger recrystallised fragments becoming paler.

Some orange stained chips.



Cream average grain size less than 1 mm. Orange staining of bryozoal and calcareous chips moderately common.

Strong orange, staining. Average grain size 1 mm.

Orange some strongly cemented nodules (2-3 cm) some smooth. Appears somewhat siliceous.

101-102 QUARTZOSE CALCARENITE. Up to 30% quartz + very hard angular fragments of calcarenite. Fawn-grey.

102-106.5 CALCARENITE Some orange staining + dark red brown ferruginous chips. Little quartz.
Off-white-cream, little orange staining.
Odd well rounded quartz grain. Average grain size approx. 1 mm.
Slightly finer grained.

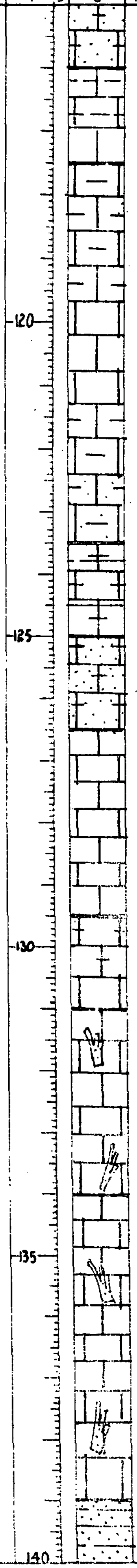
106.5-110 SILTY CALCARENITE Off white-cream. Average grain size 0.1-0.2 mm. Some hard fragments (recrystallised) Clay fraction, but lot of silt size grains.

110-113 SANDY CALCISILTITE Pale grey. Fair proportion of sand and clay plus hard fragments.

Some large fragments of a fawn calcarenite.

113-114.5 CALCISILTITE Fawn-pale grey. High proportion of clay plus some sand size grains plus odd hard fragment.

1	2	3	4	5	6	7	8	9	State No. 246066801 Bore Serial No.	SHEET 6 OF 8



114.5-116 SANDY CALCISILTITE Pale grey. About 30% sand size. Significant clay fraction.

116-117.5 SILTY CALCARENITE Pale grey. Some clay- Up to 5-10% well rounded quartz.

117.5-123.5 CALCISILTITE/CALCILUTITE (MARL) Medium grey About 10% sand size, rest equal proportions. Odd larger hard fragment. Some quite large very hard fine grained cemented fragments - angular.

Blue grey, some sand, fragments rare

About 10% fine quartz sand. Medium grey, Very sticky.

123.5-125 CLAYEY CALCISILTITE Medium grey. About 20% sand size. Plastic

125-126.5 SANDY CALCISILTITE Buff-pale grey. About 30-40% sand size (bryozoa etc.) Some clay.

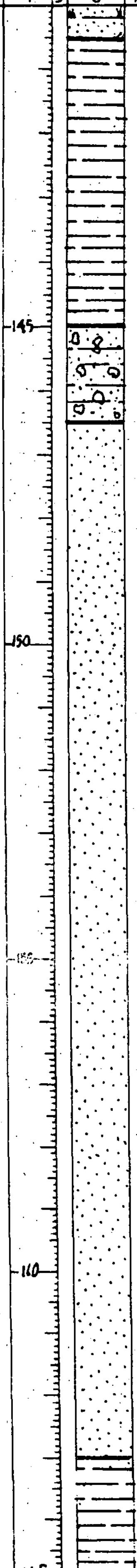
126.5-129.5 CALCARENITE Buff-pale grey. Average grain size 0.6-1 mm. Essentially calcareous chips and bryozoa - Some well rounded quartz.

129.5-131 SILTY CALCARENITE Average grain size 0.2-0.4 mm. Odd larger well rounded quartz (1½ mm)

131-134 CALCARENITE Average grain size 0.5-0.8 mm Buff. Essentially bryozoa fragments + chips. Some quartz.
More silty and finer grained.

134-139 CALCARENITE Coarse grained, Average grain size 1.3-1.6 mm. Buff. Essentially calcareous chips and bryozoa. Some large (3 mm) fossils. Odd well rounded quartz grains.

139-140.5 CLAYEY SAND (grit) Black. Quartz grains 0.2-2.4 mm well rounded, some angular. In a



Depth	Description
	black clay. Some calcareous material Gives H2S in acid
140.5-145	CLAY Black, plastic. Odd sand-gravel size grain
	Less than 5% well rounded quartz sand/gravel
	Brownish-black, tight, some silt.
145-146.5	CLAYEY GRAVEL Black. About 50-60% well rounded quartz sand-gravel in a clay matrix sulph[illegible]ated.
146.5-163	SAND Essentially quartz (more than 95%) Moderate to well rounded mostly clear, rest milky average 1.5 mm.
	Coarse sand to grit, up to 3.5 mm, grey, minor clay.
	Coarse sand pale grey
	Sub rounded grains approx. 1 mm diameter minor fine sand fraction.
	Fine sand approx. 0.1-0.2 mm diameter, grey 60-70% sand, 30-40% black clay.
	Average grain size 1 mm non calcareous. H2S with acid.
	80-90% angular quartz, 10-20% black clay. Sand about 0.5 mm diameter.
163-171	CLAY Black, plastic. Minor fine sand and silt fraction. Non calcareous. Gives off H2S with acid.

1	2	3	4	5	6	7	8	9	State No 246066801 Bore Serial No. SHEET 8 OF 8

170

End of Hole

175

180

185

190

DEPARTMENT OF MINES — SOUTH AUSTRALIA

BORE LOG · HYDROGEOLOGY

Purpose of Bore: Stratigraphic/Observation
State No. 246036501
Hundred: Blanche
Section: 365
Bore Serial No. 104/72
Owner: Mines
Address: Adelaide
Project No. MG2 BLA77
Driller: W.H. James
Docket No. 224/1/69
Commenced: 27/9/71
Completed: 13/11/71
R.L. Collar (M.S.L.)
Depth: 132.5 m
Drill type: Percussion
Circulation
R.L. Surface
Co-ords E
Logged by: M.A. Cobb, E. Aslin, J.D. Waterhouse
Date: 1/6/72
Casing: 11.4 m of 0.152 m
A.M.G. Zone
N

WATERS CUT

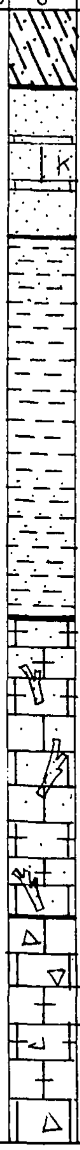
DEPTH (m)	WATER LEVEL (m)	SUPPLY-	HOW TESTED	TOTAL SALTS mg/l	ANALYSIS No.
26.8	25.9				
108.2	17.3				

REMARKS: Cement plug at 90.5 m.

CASING 1	WATERS CUT 2	WATER LEVEL 3	DEPTH (m) 4	CORE 5	GRAPHIC LOG 6	AGE 7	UNIT 8	PENETRATION RATE 9	DESCRIPTION

11.38 m of 152 m Casing

Depth (m): 5, 10, 15



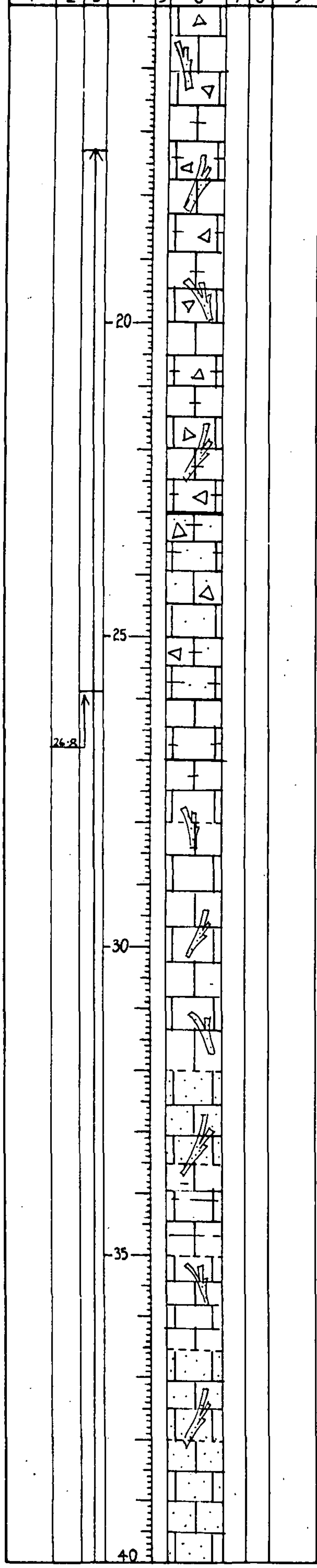
0-1 SOIL - dark brown sand, organic.

1-3 SAND Dark brown-grey. Silty - some hard fragments of dolomitised limestone?

3-8 SILT Grey brown, sandy, weakly calcareous. Hard fragments of silicified clay.
Between 5-6 m.
Pale brown - fawn, some clay, calcareous.
Between 6-7.5 m. Pale grey brown, some hard silicified sand fragments. Sandy.

8-12 CALCISILTITE Buff-pale grey. Some sand and clay. Essentially bryozoa and calcareous chips and some quartz and ironstone chips (dark red-black).
Between 9-10.5 m.
Slightly darker, sandy.
Between 10.5-12 m.
Buff pale orange. Some clay. Sandy

12-23 SILTY CALCARENITE Buff. Fine grained (average grain size 0-5 mm) Some clay. Many small black chips (flint.)



13.5-16.5 m.
Buff-cream. Some large (2-3 cm) angular chert fragments (bands in ground). Very small flint chips.

23-26 <u>SANDY CALCISILTITE</u> Buff. Some small flint fragments + chert + fragments of strongly cemented calcarenite/calcisiltite.

26-27 <u>SILTY CALCARENITE</u> Fragments of cream, strongly cemented calcarenite. Some chert.

27-51.5 <u>CALCARENITE</u> Cream, average grain size 0.5-1 mm. Calcareous chips + bryozoa tubules. Some brown chert fragments.
Between 29-32 m.
Cream - off white.

32-33.5 Some grey brown fine grained quartz sand.

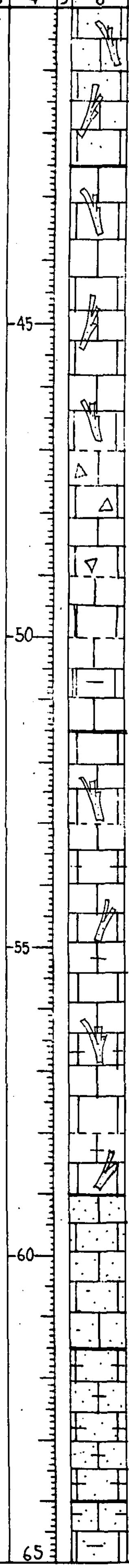
33.5-35 Pale grey brown. 1-2 mm fragments of black clay - silt.

35-36.5 Somewhat finer grained, pale brown-grey. (0.5 mm)

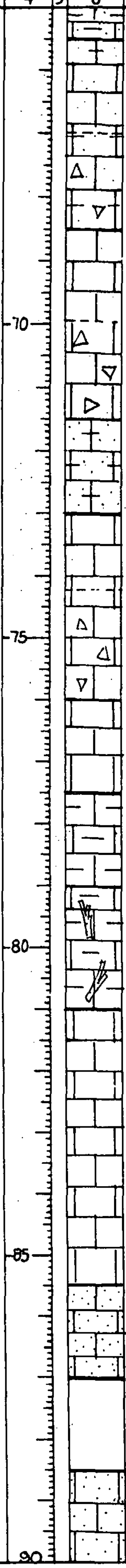
36.5-38 Average grain size 0.8-1 mm. Some fine quartz.

38-42.5 Again quartz (contamination from above.)

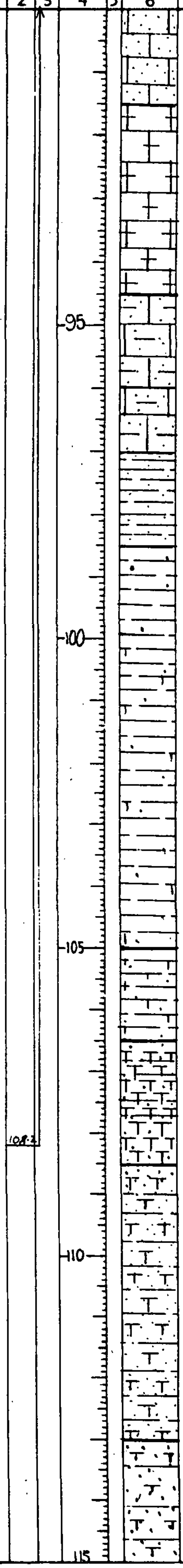
1	2	3	4	5	6	7	8	9	State No. 246036501	Bore Serial No.	SHEET 3 OF 6



42.5-47	Buff wide size range 0.2-1 mm. Some large bryozoa tubes (4 mm x 2 mm). Some strongly cemented fragments.
47-49	Off-white - buff. Some flint fragments (black).
49-50	Fine grained - Average grain size 0.3-0.6 mm.
50-51.5	Some clay + cemented fragments.
51.5-59	<u>SILTY CALCARENITE</u> Pale greenish - buff. Average grain size 0.1-0.4 mm. Glassy calcite + calcareous chips + bryozoa. Between 53-58 mm. Granular grains Buff - off white, greenish tinge. Between 58-59 mm. <u>Orange</u>. Hard cemented fragments, some quite porous.
59-61.5	<u>CALCARENITE</u> Buff-pale orange. Some dark orange staining. (Much quartz.)
61.5-64	<u>CALCISILTITE</u> Pale green-grey, nodules of hard, yellow quartzose calcarenite.
64-65.5	<u>SANDY CALCILUTITE</u> Some sand size grains (quartz.)



65.5-68.5	SILTY CALCARENITE Pale grey-green. 60-70% sand size. Harder nodule of cream - pale orange quartzose calcareni Between 67-68.5. 80% sand size. Flint chips up to 1 cm.
68.5-71.5	CALCARENITE Buff - some clay. Some pale grey-green clay nodules. Some 5 mm nodules of quartzose calcarenite (hard). From 70-71.5 large amounts of flint and chert.
71.5-73	SANDY CALCISILTITE Medium grey. Some non-calcareous clay.
73-76	CALCARENITE Pale yellow brown. Average grain size 0.2-0.4 mm. Between 74.5-76.m. Browner. Chert chips 2-3 mm.
76-77.5	CALCARENITE Grey, 0.2-1 mm.
77.5-79	CALCICUTITE Silty, grey.
79-81	CALCILUTITE Silty, grey with 10% fossiliferous calcarenite.
81-85.5	CALCILUTITE Silty, light grey with <5% fossiliferous calcarenite
85.5-87	CALCARENITE Grey, with quartz grains (0.2-1 mm, subangular to subrounded) and minor glauconite.
87-88.5	No Sample.
88.5-91.5	CALCISILTITE Dark brown, with quartz grains. (0.2-2.0 mm, subangular to subrounded).



91.5-94.5 CALCISILTITE Dark brown, quartz grains, now 0.1 to 3 mm, subangular to subrounded.

94.5-96 CALCILUTITE Silty. Quartz grains (0.2-3 mm, subangular to rounded) with corroded pyrite grains to 3 mm. Dark brown.

96-97 CALCILUTITE Silty, dark brown. Quartz grains (0.2-5 mm, subangular to rounded, some cemented with pyrite giving fragments to 1 cm).

97-98.5 CLAY Dark brown, with 50% quartz grains (0.3-4.5 mm, subangular to rounded).

98.5-105 CLAY Brown, with common fine mica flakes and minor white calcareous blebs.
5% Arenite - quartz grains to 3 mm, rounded, polished. Av. 1-2 mm.

Quartz fraction increases from 5% (85.5 m) to 50% (98.5 m) over this interval.

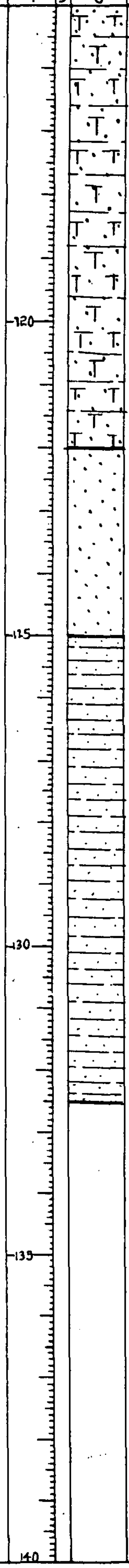
105-106.5 CLAY As above.
10% Arenite as above.

106.5-108.5 ARENITE Round, polished quartz grains from silt size to 3 mm. 25% clay, brown.

108.5-113 As above. Clay 10-15%

113-122 ARENITE Quartz grains mostly 0.5-1 mm, Some 1-1.5 cm. All rounded, polished grains. Minor fawn clay.

1	2	3	4	5	6	7	8	9	State No. 246036501	Bore Serial No.	SHEET 6 OF 6



122-125 As above, without fawn clay.

Rare mica flakes to 1 mm in the 106.5-125 interval.

125-132.5 CLAY Black/brown, H25 apparent. Finely laminated (grey brown/dark black brown laminations). Fine mica flakes common. 50% Arenite - rounded, polished quartz from silt size to 3-4 mm.

132.5 END OF HOLE.

DEPARTMENT OF MINES — SOUTH AUSTRALIA

SHEET 1 OF 1

BORE LOG · HYDROGEOLOGY

Purpose of Bore	Observation			State No.	246022701
Hundred	BLANCHE	Section	227	Bore Serial No.	102/73
Owner	Dept. of Mines	Address	Adelaide	Project No.	BLA80
Driller	W.H. James			Docket No.	231/69
Commenced	26.7.72	Completed	27.7.72	R.L. Collar (M.S.L.)	
				Depth	14 m
Drill type	Cable Tool	Circulation	Water	R.L. Surface	
				Co-ords E	
Logged by	J.D. Waterhouse	Date	20.9.72	Casing	12.27m of 15 m
				A.M.G. Zone	
				N	

WATERS CUT

DEPTH (m)	WATER LEVEL (m)	SUPPLY-	HOW TESTED	TOTAL SALTS mg/l	ANALYSIS No.
6.00	5.13			290	W2972/72
				290	W2973/72

REMARKS. Poor Water supply.

1 CASING	2 WATERS CUT	3 WATER LEVEL	4 DEPTH (m)	5 CORE	6 GRAPHIC LOG	7 AGE	8 UNIT	9 PENETRATION RATE
12.27m of 0.15m casing			5, 10, 14			OLIGOCENE - MIOCENE; EOCENE	Gambier limestone; Knight formation	

DESCRIPTION

0-1.5m	ARENITE Quartz, angular to subangular, silt size to 0.3mm, mainly 0.1-0.3mm. Rarely to 1mm, subrounded, colourless, brown and black grains. Some organic matter.
1.5-2.5m	SILTY CLAY Contains fragments (to 6mm) of rounded, well cemented (limonitic) sandstone pebbles. Minor quartz as above. Orange/brown.
2.5-4m	ARENITE Quartz, subangular, 0.1-0.3mm, colourless. Contains 20% silty clay and minor bryozoa fragments to 2mm. Orange brown.
4-6m	CALCARENITE At least 50% bryozoal fragmen to 3mm, with other calcareous grains from silt size to 2mm. Off white with up to 30 light brown silty marl.
6-8m	CALCARENITE Bryozoal and calcareous fragments to 1-2mm with minor shell fragments to 5mm. Well cemented with some silt and marl. Off white.
8-10m	CALCARENITE Well cemented almost massive with white red and brown patches. Common black grains to 0.3mm.
10-12m	As above with 10% rounded colourless quart grains from silt size to 4mm.
12-14m	ARENITE Quartz, well rounded, from silt size to 4mm, colourless and white grains. 10% Black clay.
14m	END

DEPARTMENT OF MINES — SOUTH AUSTRALIA

SHEET 1 OF 3

BORE LOG · HYDROGEOLOGY

Purpose of Bore: Observation

State No. 246021903

Hundred: Blanche

Section: Adj 219

Bore Serial No. 111/73

Owner: D. of Mines

Address: Adelaide

Project No. BLA 84

Driller: Harry James

Docket No. 231/69

Commenced: 14/8/72

Completed: 23.8.72

R.L. Collar (M.S.L.)

Depth: 64m

Drill type: Cable Tool

Circulation: Water

R.L. Surface

Co-ords E

Logged by: F.W. Aslin

Date: 7.3.73

Casing: 5.66m of 6"

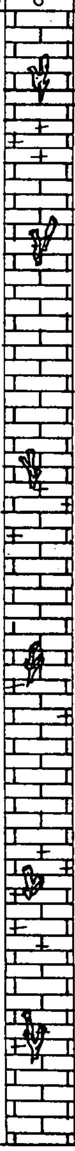
A.M.G. Zone

N

WATERS CUT

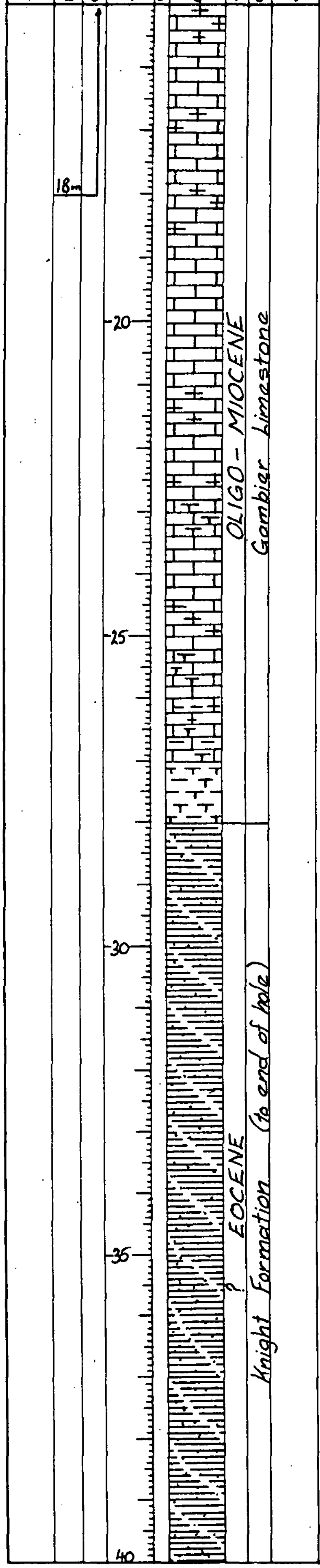
DEPTH (m)	WATER LEVEL (m)	SUPPLY-	HOW TESTED	TOTAL SALTS mg/l	ANALYSIS No.
18.00	14.40			345	W3039/72
				345	W3040/72
				345	W3041/72

REMARKS: Bit samples from 30, 34, 44 & 48-50m. Tooth washed from 30-32m sludge.

CASING 1	WATERS CUT 2	WATER LEVEL 3	DEPTH (m) 4	CORE 5	GRAPHIC LOG 6	AGE 7	UNIT 8	PENETRATION RATE 9	DESCRIPTION
5.66m of 6" casing.						OLIGO – MIOCENE	Gambier Limestone		0-6.0m FOSSILIFEROUS CALCARENITE Off white-cream essentially bryozoal fragments (to 5m.m.) Silty, weakly cemented.
			5						6.0-27.0m CALCARENITE Partially fossiliferous. (fossil fragments weakly cemented.) partially strongly cemented. Cream. Cream calcisiltite from minor to 40%.
									6-10m, calcisiltite 20%.
			10						10-12m " 5%.
									12-14m " 40%.
		14.40	15						14-16m " 30%.

State No. 246021903 Bore Serial No. 111/73 SHEET 2 OF 3

1	2	3	4	5	6	7	8	9



16-18m Calcisiltite 10%

18-22m " 5%

22-27m " 10-20% Marly

27-28m SILTY MARL. Mid brown, minor black clay 20-15% calcareous fragments.
Minor quartz arenite, clear, less than 0.1 - 2.0 mm. (Av. 0.2mm), subangular to subrounded.
Trace of dark brown-black grains, non calcareous, subrounded - rounded, 0.2-2.5mm.

28-40m CLAY, Dark brown-black, silty, sticky below 34m.
28-30m. 15-20% quartz arenite, less than 0.1 - 3mm. (Av. 0.5mm) clear and opaque, subangular to subrounded.
Minor strongly cemented fragments of quartz grains in grey-green ? glauconite cement. Trace fine calcareous matter.
30-34m. 30-40% quartz arenite, less than 0.1 - 6.0mm (Av. 0.6mm) as above. Rare coloured grains. Part tooth in 30-32m sludge. Trace pyrite on some quartz grains in 30-32m.
34-36m Approx. 20% quartz arenite as above, minor fragments with ? pyrite and ? glauconite encrustation.
36-38m As above with rare opaque quartz grains to 1 cm.

38-40m. Less than 5% quartz arenite from less than 0.1 to 3.0mm.

40-48m CLAY Grey-brown, slightly silty, sticky. Trace quartz arenite at 40m. decreasing to absence at 48m.
40-44m Trace ? pyrite and ? glauconite.

45

48-52m CLAY Grey-brown with minor cream mottling sticky. Rare quartz grains to 6mm. (Av. 1.5mm)
48-50m Minor lignite.

50

52-58m CLAY Dark grey, dark brown mottling, sticky. Less than 5% quartz arenite to 6mm. (Av.1.5mm)
52-54m Minor ? pyrite and ? glauconite.
56-58m Trace ? glauconite

55

58-64m CLAY, Dark grey with minor brown and cream mottling and rare quartz grains.

60

END OF HOLE 64m.

65

DEPARTMENT OF MINES — SOUTH AUSTRALIA

BORE LOG · HYDROGEOLOGY

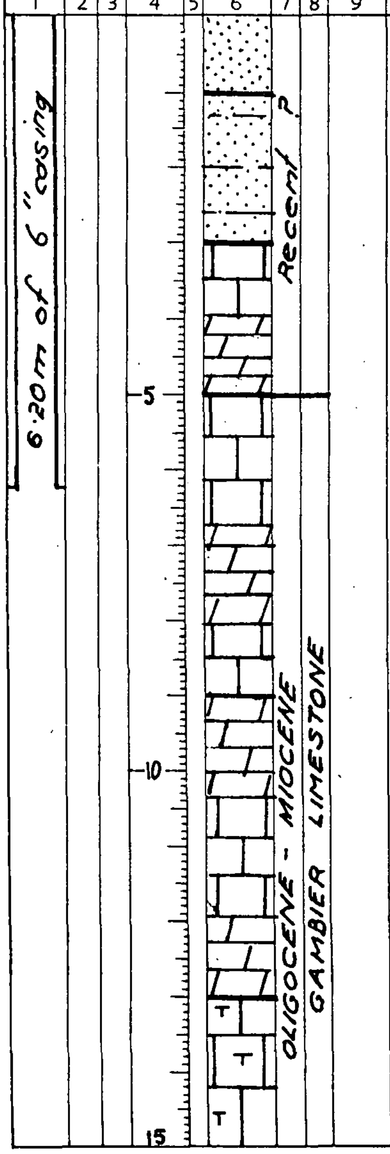
Purpose of Bore	OBSERVATION			State No.	246018301
Hundred	BLANCHE	Section	Adj.183	Bore Serial No.	113/73
Owner	DEPT. OF MINES	Address		Project No.	BLA.86
Driller	H. JAMES			Docket No.	231/69
Commenced	25.8.72	Completed	29.8.72	R.L. Collar (M.S.L.)	
Depth	47 m				
Drill type	Cable Tool	Circulation	Water	R.L. Surface	
Co-ords E					
Logged by	J.D. Waterhouse	Date	19.9.72	Casing	
A.M.G. Zone		N			

WATERS CUT

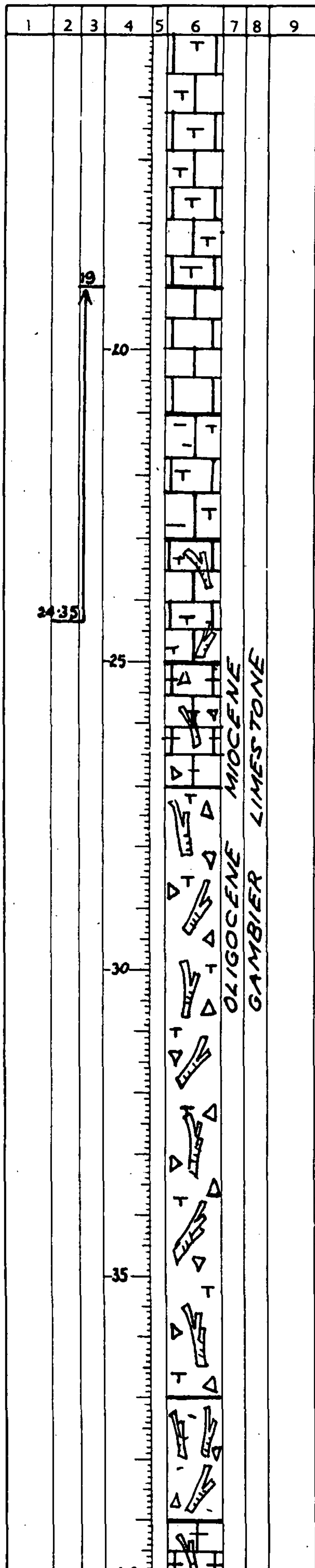
DEPTH (m)	WATER LEVEL (m)	SUPPLY-	HOW TESTED	TOTAL SALTS mg/ℓ	ANALYSIS No.
	24.35			W.3058/72	670
				W.3059/72	645

REMARKS Pinkish calcarenite appeared to be dolomitic in upper 13 m of hole. Bore has insufficient water to be pumped.

CASING 1	WATERS CUT 2	WATER LEVEL 3	DEPTH (m) 4	CORE 5	GRAPHIC LOG 6	AGE 7	UNIT 8	PENETRATION RATE 9



	DESCRIPTION
0 - 1 m	ARENITE. Quartz, angular to subangular, colourless, white, pink grains, silt size to 1 mm, most appr. 0.2 mm. Minor organic matter.
1 - 3 m	ARENITE. As above, with 10% orange/brown clay and rare calcareous grains. Orange brown.
3 - 5 m	As above, grading to well cemented fragments of pink and white massive calcarenite.
5 - 9 m	CALCARENITE. Moderately cemented. White, pink and brown grains to 3 mm, subangular - angular, with minor clay and subrounded to rounded quartz (colourless to 1 mm). Pink/brown. Rare bryozoal fragments to 2 mm.
9 - 13 m	CALCARENITE. Moderately cemented. White and pink grains to 5 mm with approx. 10% quartz grains 0.1 - 0.2 mm, subangular. Pink/white.
13 - 19 m	CALCARENITE. Angular white grains/fragments to 4 mm. 13 - 15 m Up to 25% Marl and silt 15 - 19 m Up to 50% Marl and silt. Cream, with rare pink grains.



19 - 21m	CALCARENITE. White, angular, massive fragments to 5 mm, with yellow and rare pink grains. Rare bryozoal fragments to 2 mm. Minor silt.
21 - 23 m	As above, with 25% silty marl. Cream/brown.
23 - 25 m	CALCARENITE - MARL. White and yellow calcareous fragments with common bryozoal fragments to 3 mm, with an appr. equal amount of grey marl.
25 - 27 m	CALCISILTITE. Weakly cemented with 5% bryozoal fragments. Up to 20% angular flint fragments and silicified limestone. Grey.
27 - 37 m	CALCARENITE. Essentially bryozoal fragments to 5 mm with minor white and red angular calcareous fragments to 2 mm. Minor dark brown round grains to 2 mm. Marly. Grey.
	From 27 - 35 50% Angular flint fragments (dark brown) to 5 mm.
	From 35 - 37 30% Flint fragments.
37 - 39 m	CALCARENITE. Entirely bryozoal fragments to 5 mm. Minor silt, marl and angular flint fragments. Grey.
39 - 43 m	CALCISILTITE. Marly, with 20% bryozoal fragments to 2 mm.
	39 - 41 Offwhite

Eocene

Knight Formation

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41 - 43 Grey.

43 - 45 m CALCARENITE. Well cemented, with minor shell fragments and bryozoal fragments. Minor subangular to angular quartz grains to 0.5 mm. Minor black grains to 1-2 mm. White and yellow calcareous grains.

45 - 47 m ARENITE. Mainly colourless and white rounded quartz from silt size to 5 mm. Minor rock fragments 10-20%. Black clay.

47 m END.

DEPARTMENT OF MINES — SOUTH AUSTRALIA

BORE LOG · HYDROGEOLOGY

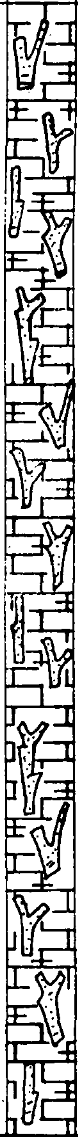
Purpose of Bore: Water Observation
Hundred: Caroline | Section: Adj. 152
Owner: Dept. of Mines | Address: Mt. Gambier
Driller: L. Hausler
Commenced: 7.12.71 | Completed: 10.2.72
Drill type: Cable Tool | Circulation: —
Logged by: P.C. Smith | Date: 27/3/73

State No. 286015201
Bore Serial No. 106/72
Project No. M.G.5 CAR9
Docket No. 224/1/69
Depth 225.6 m
R.L. Collar (M.S.L.)
R.L. Surface
Casing 6 inch
A.M.G. Zone
Co-ords E
N

WATERS CUT

DEPTH (m)	WATER LEVEL (m)	SUPPLY-	HOW TESTED	TOTAL SALTS mg/ℓ	ANALYSIS No.
22.86	19.81				

REMARKS: Completed Water Observation CAR 9

CASING 1	WATERS CUT 2	WATER LEVEL 3	DEPTH (m) 4	CORE 5	GRAPHIC LOG 6	AGE 7	UNIT 8	PENETRATION RATE 9	DESCRIPTION
6.27 m of 6"			0 – 15						0 - 25.9 m **Calcarenite** - white to orange in colour. Bryozoal fragments varying from 0.5 - 1 mm diameter. Some secondary carbonate - silicified in part. Silt content variable - 10 to 20%.

1	2	3	4	5	6	7	8	9

State No. 286015201 Bore Serial No. 106/72 SHEET 2 OF 10

15

20

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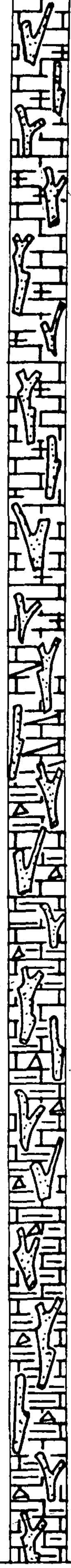
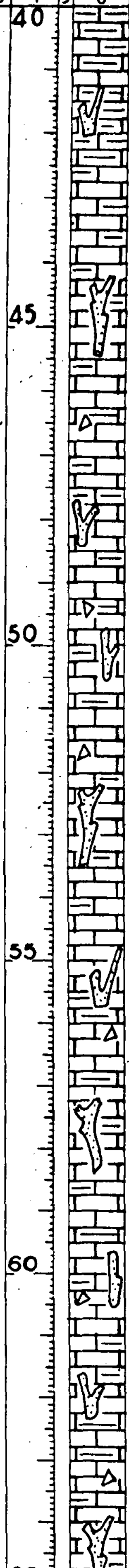


0 - 25.9 m	As above
25.9 - 27.4 m	**Calcirudite** (calcarenite) - mixture of bryozoal fragments (to 2 mm) and hard secondary dolomite (orange) - shell fragments (to 5 mm).
27.4 - 42.7 m	**Arenaceous Calcilutite** - offwhite in colour - varying proportions of sand sized fraction. Bryozoal, echinoid spine fragments. Variable proportions of flint fragments. Minor iron staining Sand fraction varies from 10-40% with grain size approx. 0.1 mm diam.

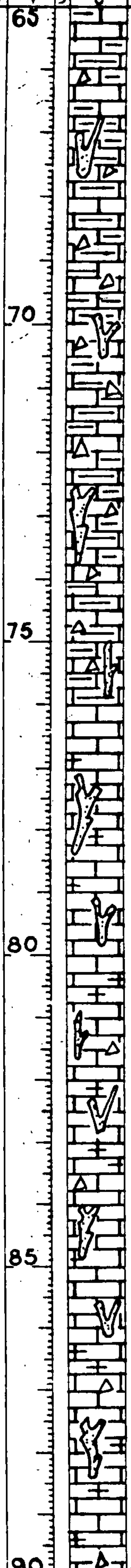
1	2	3	4	5	6	7	8	9	State No 286015201 Bore Serial No. 106/72 SHEET 3 OF 10



27.4 - 42.7 m As above

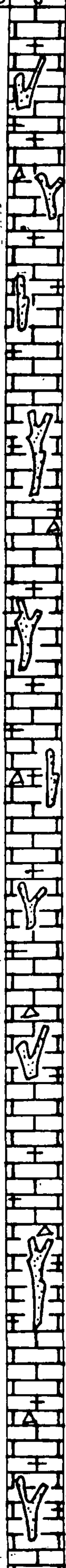
42.7 - 65.5 m <u>Lutitic Calcarenite</u> - light grey in colour. 50-60% calcarenite, numerous bryozoal fragments. Minor flint. Calcilutitic fraction variable.

1	2	3	4	5	6	7	8	9	



Interval	Description
42.7 - 65.5 m	As above
65.5 - 76.2 m	<u>Arenaceous Calcilutite</u> - mid grey in colour. Similar lithology to 27.4 - 42.7 m samples but with a larger percentage of flint fragments (up to 80%)
76.2 -115.8 m	<u>Bryozoal Calcarenite</u> - offwhite to buff in colour - Dominantly calcarenite sized particles (<2 mm diam) with numerous bryozoal fragments. Varying proportions of calcilutitic material - samples with greater calcilutite fraction appear darker grey in colour. Most samples contain up to 20% calcisiltite fraction. Degree of induration also varies from sample to sample.

1	2	3	4	5	6	7	8	9	State No. 286015201 Bore Serial No. 106/72 SHEET 5 OF 10



90

95

100

105

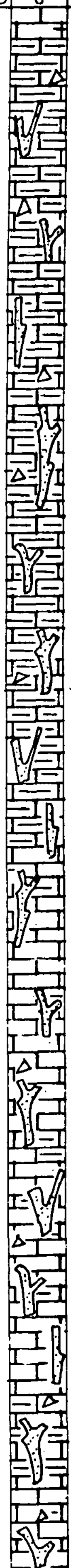
110

115

76.2 - 115.8 m As above

1	2	3	4	5	6	7	8	9	State No. 286015201 Bore Serial No. 106/72 SHEET 6 OF 10

115



76.2 - 115.8 m As above

120

115.8 - 128.0 m **Bryozoal Calcilutite** - light to mid grey in colour. 30% bryozoal fragments plus dark grey flint fragments from 2-5 mm diam. Some evidence of iron staining. Varying degrees of induration. No flint in the last 1.5 m

125

130

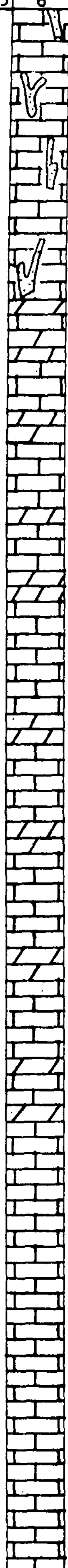
128.0 - 144.8 m **Bryozoal Calcarenite** - buff in colour. Large proportion of bryozoal fragments. Minor calcilutite fraction. Grain size of arenite fraction 0.2 - 0.3 mm. Minor flint fragments.

135

140

1	2	3	4	5	6	7	8	9	State No. 280015201 Bore Serial No. 106/72 SHEET 7 OF 10

140



145

150

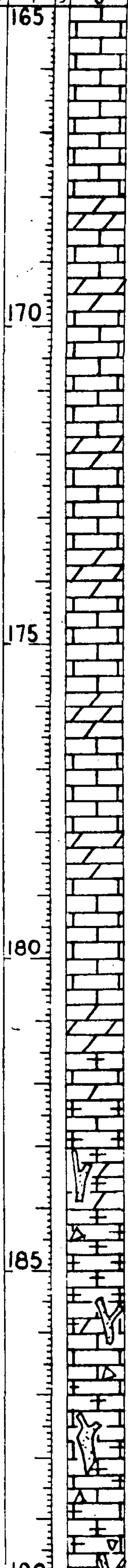
155

160

165

128.0 - 144.8 m As above

144.8 - 181.4 m Calcarenite - buff to pink in colour. Large angular fragments of well indurated limestone. No bryozoal fragments. Grain size ≈ 0.3 mm. Dolomitic - a number of samples show a small red - pink nucleus enclosed by off white dolomite (g.s. approx. 0.5 mm diam) Flint absent. From 157.5 m - 168 m - no dolomitisation sample offwhite in colour - calcarenite grains approx. 0.5 mm diam. large fraction of calcite rhombs approx. 0.3 - 0.5 mm diam.



144.8 - 181.4 m As above.

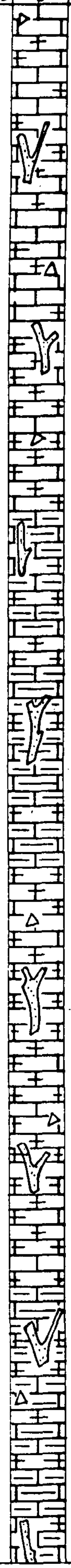
181.4 - 182.9 m <u>Silty calcarenite</u> - off-white to pink in colour. Finer grained than above. Grain size 0.2-0.5 mm. Dolomite 10-20%. Silt fraction 40%.

182.9 - 185.9 m <u>Arenaceous Calcisiltite</u> - pale grey in colour. Sand fraction 20-30%, dolomitic. Bryozoal fragments and calcite chips. Some grey-green flint.

185.9 - 195.1 m <u>Silty Calcarenite</u> - pale grey in colour. Silt 30-40% - bryozoal fragments and calcite chips & minor flint.

1	2	3	4	5	6	7	8	9

190



195

200

205

210

215

185.9 - 195.1 m As above.

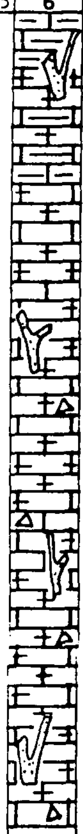
195.1 - 198.1 m Calcisiltite - grey in colour About 10-20% sand size fraction. Bryozoa with cemented fragments of same. Flint.

198.1 - 204.2 m Silty Calcisiltite - grey in colour. Some sand sized grains. Bryozoal fragments up to 1 mm diam. Some well indurated fragments.

204.2 - 210.3 m Arenaceous Calcisiltite - sand fraction 20-30%. Bryozoal fragments to 1 mm. Calcilutite fraction. Minor flint and calcite chips 0.5-1 mm diam.

210.8 - 216.4 m Silty Calcilutite - grey in colour. Silt and sand sized fraction 10%. Bryozoal fragments up to 0.4 mm.

215



220

216.4 - 225.6 m <u>Arenaceous Calcisiltite</u> - grey in colour. Sand fraction approx. 30% bryozoal fragments, calcite chips, flint. Cemented calcisiltite to 3 mm. Some samples very well indurated.

225

225.6 m END OF HOLE

230

DEPARTMENT OF MINES SOUTH AUSTRALIA

HYDROGEOLOGY SECTION

BORE LOG

HIRER DEPT. OF MINES.

Drill type Cable Tool
Circulation Water — Logged by M.A. COBB
Driller L.A. Hausler — Date logged 31.5.72
Start 11.2.72 — Bore Diameter
Finish 3.5.72 — DEPTH 300m (m)

A.M.G. Zone
Coords. E
" N
Datum Elev.
Ref. Pt. Elev.
Surface Elev.

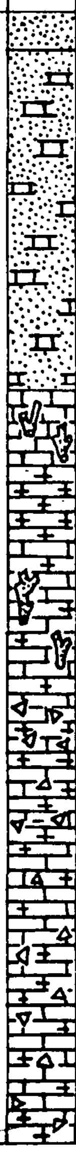
HUNDRED CAROLINE
SECTION 636
STATE No. 286063602
Project No. M.G.6(CAR 10).
Docket No. 224/1/69
Bore Serial No. 231/69

Depth to Water cut (m)	Depth to standing water (m)	SUPPLY litres/sec.	SUPPLY Method of test	TOTAL DISSOLVED SOLIDS Milligrammes/litre	TOTAL DISSOLVED SOLIDS Analysis W. No.
3	1.60			See summary sheets.	

REMARKS
Mt. Gambier test area Stratigraphic Bore M.G. 6 (Observation Bore CAR 10).

CASING | WATERS CUT | WATER LEVEL | DEPTH (m) | CORE | GRAPHIC LOG | AGE | UNIT

DEPTH (m) 0, 5, 10, 15

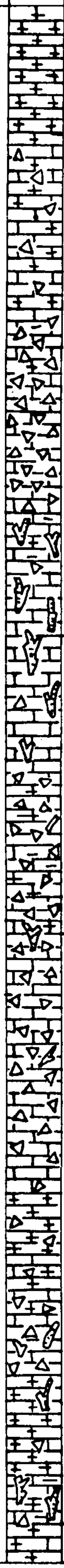


DEPTH (m) from – to	DESCRIPTION
0 – 0.25	<u>QUARTZ SAND</u>. Clean, white, rootlets, etc.
0.25–0.5	<u>QUARTZ SAND</u>. Black, organic.
0.5 – 5.0	<u>CALCAREOUS QUARTZ SAND</u>. Pale grey. Mixture of fine grained quartz (0.1-0.3mm), calcareous chips (up to 40%) and shell fragments and shells. Between 3 - 4m some cemented quartz 'sandstone' and well rounded chert and flint "pebbles" plus large shell fragments.
5 – 6	<u>CALCARENITE</u>. Offwhite - pale grey. Dominantly bryozoal and calcareous chips with coral fragments.
6 – 7	<u>SILTY CALCARENITE</u>. About 30% silt size grains.
7 – 11	<u>CALCARENITE</u>. Off white. Grain size range 0.2 - 1.4mm average 0.5mm - bryozoa, calcareous chips. Some fossil fragments up to 10mm. Flint below 9m. Silt content increases with depth.
11 – 12	<u>SANDY CALCISILTITE</u>. Off white - pale grey. About 30% sand size (0.4-0.8mm). Some Flint.
12 – 15	<u>SILTY CALCARENITE</u>. About 40% silt size. Becoming darker with depth. Flint moderately common.

Drn: — Sheet 1 of 13
Date: — Bore Folder No. 351

PF Nº S10537 MH

DEPARTMENT OF MINES — SOUTH AUSTRALIA

CASING	WATERS CUT	WATER LEVEL	DEPTH (m)	CORE	GRAPHIC LOG	AGE	UNIT	DEPTH (m) from – to	DESCRIPTION
			15					15 - 17	SANDY CALCISILTITE. Medium grey. 30-40% sand size grains.
								17 - 20	SILTY CALCARENITE. Medium dark grey. About 30% silt size. Flint moderately common.
			20					20 - 23	SILTY CALCARENITE/FLINT. As above but flint fragments make from 50 - 90% of samples (up to 8 cm in size).
								23 - 27	CALCARENITE. Off white, coarse grained (average 0.8 - 1mm). Flint about 5% of samples. Dominantly bryozoal fragments and calcite chips. Between 26 - 27m very hard lithology - drilling gives rudite, size hard fragments. Calcite rhombs common. Flint common.
			25						
								27 - 30	FLINT/SILTY CALCARENITE. Medium - dark grey. Again flint makes up most of sample (up to 90%). Rest a silty calcarenite.
			30					30 - 34	FLINT/CALCARENITE. Off white. About 80% of samples flint chips. Rest bryozoa, coral fragments plus echinoid - spines. Near base silicified calcarenite/siltite fragments common.
								34 - 36	SANDY CALCISILTITE/FLINT. Medium grey. Flint decreases from about 70% to 30% of samples.
			35					36 - 37	SILTY CALCARENITE/FLINT. Pale - medium grey 10 - 20% silt. Chert/flint 50% of samples. Rest bryozoal etc.
								37 - 40	SANDY CALCISILTITE. Pale-medium grey. About 30% sand size, rest silt and clay size (sticky when wet). Some Flint Chips. Sand content increases with depth.
			40						

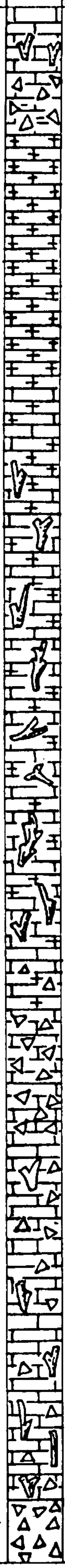
Borehole State No. 286063602

Drn: Sheet 2 of 13

Date: Bore Folder No. 351

PF Nº S10537a MH

DEPARTMENT OF MINES — SOUTH AUSTRALIA

CASING	WATERS CUT	WATER LEVEL	DEPTH (m)	CORE	GRAPHIC LOG	AGE	UNIT
			40, 45, 50, 55, 60, 65				

DEPTH (m) from	to	DESCRIPTION
40	41	CALCARENITE. Medium grey. About 10% silt. Rest bryozoa and calcareous chips. Flint chips small.
41	42	FLINT/SANDY CALCISILTITE. Medium grey. Flint about 70% of sample.
42	46	CALCISILTITE. Medium grey, sticky, (moderate clay content). Little sand or flint. Between 44 - 45m sand content about 10%.
46	47	CALCISILTITE/CALCARENITE. Pale-medium grey. About equal proportions sand and silt sizes. Some flint.
47	55	SANDY CALCISILTITE. Pale-medium grey. Some flint. About 30% sand size. Dominantly calcareous chips and bryozoal fragments.
55	56	SILTY CALCARENITE. Pale grey. About 30% silt and clay. Flint chips common.
56	58	FLINT/CALCARENITE. Pale grey. Flint up to 80% of sample. Rest bryozoal fragments and calcareous chips. Some silt.
58	60	CALCARENITE. Off white. Characterised by very hard cemented bryozoal and spicules etc. Some orange staining of fragments. Some quartz grains. Flint. Moderately common.
60	64	CALCARENITE. White-cream. Dominantly loose bryozoal but some hard cemented fragments indicating hard bars. Average grain size 0.2-0.5mm. Flint about 30% of sample.
64	66	FLINT. Flint fragments occupy nearly all of sample. Some calcarenite grains plus silt ..

Borehole State No. 286063602

Drn:

Date:

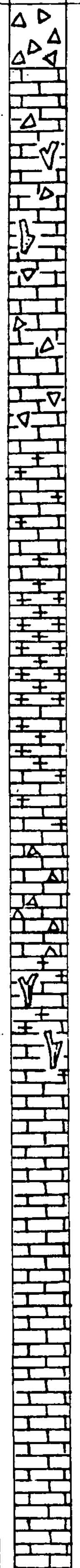
Sheet 3 of 13

Bore Folder No. 351-

PF Nº S10537a MH

DEPARTMENT OF MINES — SOUTH AUSTRALIA

CASING	WATERS CUT	WATER LEVEL	DEPTH (m)	CORE	GRAPHIC LOG	AGE	UNIT
			65				
			70				
			75				
			80				
			85				
			90				



DEPTH (m) from – to	DESCRIPTION
66 - 70	CALCARENITE. Off white. Samples characterised by very hard well cemeted fragments - extremely hard layers in situ. Flint moderately common.
70 - 72	CALCARENITE. White-cream, clean. Even grained average grain size 0.4-0.5m. (bryozoal and calcareous chips, odd one orange stained). Some flint chips.
72 - 74	SANDY CALCISILTITE. Pale grey. About 40% sand size. Some flint.
74 - 76	CALCISILTITE. Pale grey. Odd sand size grain.
76 - 78	SANDY CALCISILTITE. Sand grains. About 40% of sample.
78 - 80	CALCARENITE. Cream, clean. Average grain size 0.5 - 0.8 mm. Chert and flint chips common.
80 - 82	SANDY CALCISILTITE. Pale-medium grey. About 30% sand size grains. Dominantly bryozoal fragments etc.
82 - 98	CALCARENITE. Cream. Average grain size range 0.2-0.5mm. Between 84 - 86m calcareous chips dominant not bryozoal fragments. Some orange staining and ironstone fragments (around 89m and 93m). Between 86 - 88m some chalcopyrite grains. Hard, recrystallised layers between 90 - 92m and 94 - 96m.

Borehole State No. 286063602

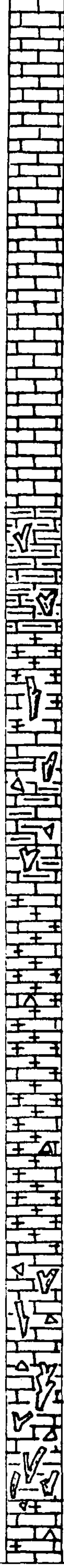
Drn: Date:

Sheet 4 of 13

Bore Folder No. 35[illegible]

PF Nº S10537a MH

DEPARTMENT OF MINES — SOUTH AUSTRALIA

CASING	WATERS CUT	WATER LEVEL	DEPTH (m)	CORE	GRAPHIC LOG	AGE	UNIT	DEPTH (m) from – to	DESCRIPTION
			90–115					98 - 100	SANDY CALCILUTITE. Pale grey, plastic. About 20% sand size, buff to white (bryozoa plus harder fragments).
								100 -102	SANDY CALCISILTITE. Pale grey. Dominantly calcareous chips and bryozoal fragments. A clay size fraction.
								102–104	CLAYEY CALCARENITE. Medium - dark grey. Bryozoal and calcareous chips plus flint fragments.
								104–110	SANDY CALCISILTITE. Pale grey. Small to moderate sand size fraction. Minor flint chips. Silt content increases with depth.
								110–114	CALCARENITE. Offwhite - pale grey. About [illegible] bryozoal fragments. Numerous small flint chips. Small clay fraction. Grain size decreases with depth.

Borehole State No. 286063602

Drn:

Date:

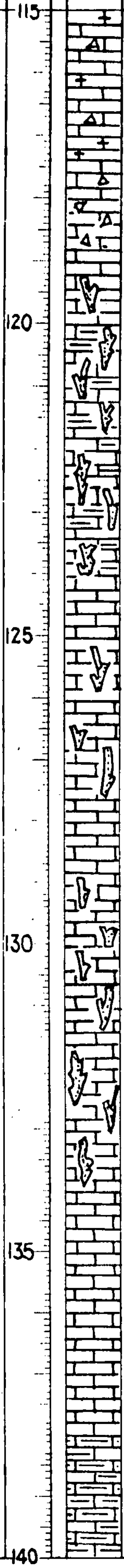
Sheet 5 of 13

Bore Folder No. 351

PF Nº S10537a MH

DEPARTMENT OF MINES — SOUTH AUSTRALIA

CASING | WATERS CUT | WATER LEVEL | DEPTH (m) | CORE | GRAPHIC LOG | AGE | UNIT



DEPTH (m) from to	DESCRIPTION
114–118	SILTY CALCARENITE. Buff-pale grey. Moderate silt size fraction. Small flint chips common.
118–134	CALCARENITE. Off white-buff. Clean. Dominantly bryozoal fragments. Numerous small flint fragments at top but soon disappears with depth. Clay content moderate between 120-124m.
	Between 124-128m average grain size 0.5mm. Bryozoal content decreasing.
	Between 128-134m grain size averages 1.0-2mm. Some pinkish coral fragments. Bryozoal content increases to 40-50% near base.
134–138	CALCARENITE. Large fragments (to 0.5cm) of hard cemented calcarenite - A hard band in situ.
138–142	SANDY CALCILUTITE. Cream with a greenish tinge. Clay size fraction about 80%. Rest silt and sand size, amount increasing with depth.

Borehole State No. 286063602

Drn:

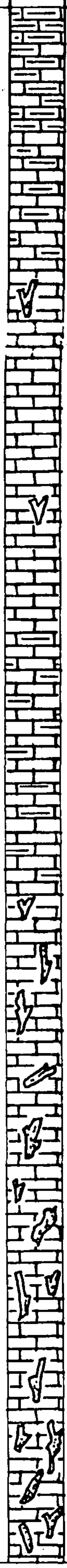
Date:

Sheet 6 of 13

Bore Folder No. 351

PF Nº S10537a MH

DEPARTMENT OF MINES — SOUTH AUSTRALIA

CASING	WATERS CUT	WATER LEVEL	DEPTH (m)	CORE	GRAPHIC LOG	AGE	UNIT	DEPTH (m) from to	DESCRIPTION
			140–165					142–144	CLAYEY CALCARENITE. Cream with greenish tinge. Sand size fraction 60-70%.
								144–150	CALCARENITE. Average grain size 1mm but grain size decreases with depth. About 10% silt/clay size fraction.
								150–154	CLAYEY CALCARENITE. Sand size average grain size 0.3 - 1mm. Dominantly calcareous chips. Up to 30% clay size fraction.
								154–178	CALCARENITE. Dominantly calcareous chips and bryozoal fragments. Up to 10% clay/silt size fraction. Grain size increases with depth up to 1-2mm.

Depth scale: 140, 145, 150, 155, 160, 165

Borehole State No. 286063602

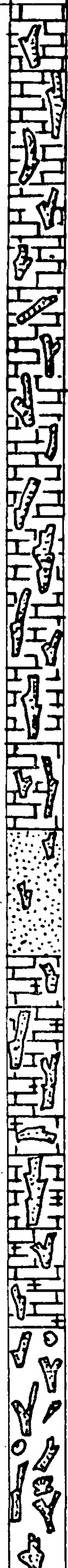
Drn:

Date:

Sheet 7 of 13

Bore Folder No. 35

PF Nº S10537a MH

CASING	WATERS CUT	WATER LEVEL	DEPTH (m)	CORE	GRAPHIC LOG	AGE	UNIT	DEPTH (m) from to	DESCRIPTION
			165						
			170						
			175						
								178–180	QUARTZ SAND. 80% quartz sand, pinkish in colour with an average grain size 0.2mm. Rest clay, greenish coloured calcarenite (inc. bryozoal fragments).
			180					180–186	SANDY CALCISILTITE. Pale grey, plastic - small to moderate clay/sand fraction. No flint. Up to 10% pinkish angular quartz grains. Dominantly bryozoal fragments.
			185						
								186–192	CALCARENITE. Grading from almost a calcirudite near the top down to a calcarenite. Off white-buff. Entirely bryozoal fragments plus small molluscs.
			190						

Borehole State No. 286063602

Drn:

Date:

Sheet 8 of 13

Bore Folder No. 351-

PF Nº S10537a MH

DEPARTMENT OF MINES — SOUTH AUSTRALIA

CASING | WATERS CUT | WATER LEVEL | DEPTH (m) | CORE | GRAPHIC LOG | AGE | UNIT

190 195 200 205 210 215

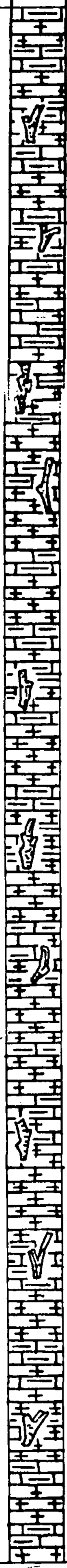
DEPTH (m) from to	DESCRIPTION
192–196	SANDY CALCILUTITE. Grey. Small to moderate silt/sand size fractions dominantly bryozoal fragments.
196–200	CALCARENITE. Off white-buff. Average grain size 0.5–1mm. Dominantly bryozoal fragments.
200–202	CALCISILTITE. Pale grey. Rounded silty material and bryozoal fragments bound by a clay fraction.
202–204	CLACARENITE. Pale grey. Large fragments of bryozoal up to 2mm about 80% of sample. Rest a grey coloured clay.
204–246	SANDY CALCISILTITE. Grey coloured, plastic, with high silt fraction together with clay and minor sand fraction (calcareous chips and bryozoal fragments).

Borehole State No. 286063602 | Drn: | Sheet 9 of 13
Date: | Bore Folder No. 351

PF Nº S10537a MH

DEPARTMENT OF MINES — SOUTH AUSTRALIA

CASING	WATERS CUT	WATER LEVEL	DEPTH (m)	CORE	GRAPHIC LOG	AGE	UNIT	DEPTH (m) from	to	DESCRIPTION
			215							
			220							
			225							
			230							
			235							
			240							



Borehole State No. 286063602

Drn:

Date:

Sheet 10 of 13

Bore Folder No. 35

PF Nº S10537a MH

CASING	WATERS CUT	WATER LEVEL	DEPTH (m)	CORE	GRAPHIC LOG	AGE	UNIT	DEPTH (m) from to	DESCRIPTION
			240						
			245						
								246-298	SANDY CALCILUTITE. Clay fraction about 70%. Medium grey becoming darker with depth. Remainder made up to sand and silt size fractions (calcareous chips and bryozoal fragments). Some bands of harder (well indurated) calcisiltite chips (chert).
			250						
			255						
			260						
			265						

DEPARTMENT OF MINES — SOUTH AUSTRALIA

Borehole State No. 286063602

Drn:

Date:

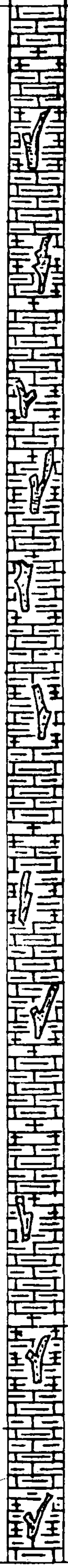
Sheet 11 of 13

Bore Folder No. 35

PF Nº S10537a MH

DEPARTMENT OF MINES — SOUTH AUSTRALIA

CASING	WATERS CUT	WATER LEVEL	DEPTH (m)	CORE	GRAPHIC LOG	AGE	UNIT	DEPTH (m) from	to	DESCRIPTION
			265							
			270							
			275							
			280							
			285							
			290							



Borehole State No. 286063602

Drn:

Date:

Sheet 12 of 13

Bore Folder No. 351-

PF Nº S10537a MH

DEPARTMENT OF MINES — SOUTH AUSTRALIA

CASING	WATERS CUT	WATER LEVEL	DEPTH (m)	CORE	GRAPHIC LOG	AGE	UNIT	DEPTH (m) from to	DESCRIPTION
			290						
			295						
								298–300	CLAY. Dark grey - green, sticky. Some small (about 1mm) dark material.
			300						END OF HOLE 300m.

Borehole State No.	286063602	Drn:	Sheet 13 of 13
		Date:	Bore Folder No. 35-

PF Nº S10537a MH

DEPARTMENT OF MINES SOUTH AUSTRALIA

HYDROGEOLOGY SECTION

BORE LOG

HIRER DEPT. OF MINES

Drill type Cable Tool	A.M.G. Zone	HUNDRED CAROLINE
Circulation Water	Logged by J.D. WATERHOUSE	SECTION 310
Driller L. Hausler	Date logged Feb. 1973 " N	STATE No. 286031001
Start 4.5.72	Bore Diameter	Datum Elev.	Project No CAR 11
Finish 6.10.72	DEPTH 298m. (m) Ref. Pt. Elev.	Docket No. 224/1/69
	Surface Elev.	Bore Serial No. 142/72

Depth to Water cut (m)	Depth to standing water (m)	SUPPLY litres/sec.	SUPPLY Method of test	TOTAL DISSOLVED SOLIDS Milligrammes/litre	TOTAL DISSOLVED SOLIDS Analysis W. No.
	SEE ATTACHED SHEET.				

REMARKS Completed as observation bore in Gambier Limestone aquifer. Cement plug at top of Kongorong Sand.

CASING	WATERS CUT	WATER LEVEL	DEPTH (m)	CORE	GRAPHIC LOG	AGE	UNIT	DEPTH (m) from – to	DESCRIPTION
6.23m of 6" Casing			0–15			OLIGO-MIOCENE	Gambier limestone	0 – 0.5	SOIL. Mainly subangular calcareous grains to 1mm. Minor dark brown clay and fragments of bryozoal calcaronite to 1.5cm. Minore quartz arenite.
								0.5 – 32	CALCARENITE. More than 50% bryozoal and other fossil fragments to 4mm. Subangular quartz grains to 1-2mm. Minor marl. Some red and yellow staining. Rare subrounded quartz to 0.5mm to 2.5mm. Minor moderately cemented calcarenite fragments. Pale pink brown, grading to pale fawn by 20m.

Drn:	Sheet 1 of 13
Date:	Bore Folder No. 47/

PF Nº S10537 MH

DEPARTMENT OF MINES — SOUTH AUSTRALIA

CASING	WATERS CUT	WATER LEVEL	DEPTH (m)	CORE	GRAPHIC LOG	AGE	UNIT	DEPTH (m) from to	DESCRIPTION
			20						
			25						
			30					32 - 40	As above with 5% marl, grading to grey brown.
			35						
			40						

Borehole State No. 286031001

Drn:

Date:

Sheet 2 of 13

Bore Folder No. 47/-

PF Nº S10537a MH

CASING | WATERS CUT | WATER LEVEL | DEPTH (m) | CORE | GRAPHIC LOG | AGE | UNIT

DEPTH (m): 45, 50, 55, 60, 65

AGE: OLIGO - MIOCENE

UNIT: Gambier Limestone

DEPTH (m) from, to	DESCRIPTION
40 - 54	MARL. With 25-50% bryozoal fragments to 3mm. Minor calcisiltite. Grey.
	42-46m 5% dark brown angular flint fragments to 3mm. Rare grey silicified marl.
	46-48m 20% dark brown angular flint fragments to 1cm.
	48-54m 5% dark brown angular flint fragments to 3mm.
54 - 64	CALCARENITE. Silt size to 3mm. Mainly bryozoal fragments, with minor fossiliferous and calcareous grains. Minor marl and angular flint fragments to 5mm. Grey-brown.
	60-64m 10-20% marl.
64 - 72	FLINT. see overleaf.

Borehole State No. 286031001

Drn: | Date:

Bore Folder No. 47/-

PF Nº S10537a MH

DEPARTMENT OF MINES — SOUTH AUSTRALIA

CASING | WATERS CUT | WATER LEVEL | DEPTH (m) | CORE | GRAPHIC LOG | AGE | UNIT

DEPTH (m) 298m

Age: OLIGO-MIOCENE

Unit: Gambier Limestone

Depth scale: 70, 75, 80, 85, 90

DEPTH (m) from – to	DESCRIPTION
	FLINT. Grey-brown angular fragments from silt size to greater than 1 cm. Minor grey marl and bryozoal fragments to 3mm. 68-72m 10% bryozoa fragments.
72 – 76	CALCARENITE. Mainly bryozoal fragments to 3mm. 10% Silty marl. 5% dark brown angular flint fragments to 3mm.
76 – 78	FLINT. Dark brown-black fragments to 2cm with grey silicified calcarenite. 20% calcarenite as above.
78 – 80	CALCARENITE. Mainly bryozoal fragments to 3mm. Up to 50% dark brown angular flint fragments to 3mm. Minor silt and marl.
80 – 86	FLINT. Dark brown-black fragments to 2cm with grey silicified calcarenite. 20% calcarenite as above.
86 – 96	CALCARENITE. Mainly bryozoal fragments to 3mm. 50% dark brown angular flint fragments, decreasing to 25% by 92m.

Borehole State No. 286031001

Drn:

Date:

Sheet 4 of 13

Bore Folder No. 47/–

PF Nº S10537a MH

DEPARTMENT OF MINES — SOUTH AUSTRALIA

CASING	WATERS CUT	WATER LEVEL	DEPTH (m)	CORE	GRAPHIC LOG	AGE	UNIT	DEPTH (m, 298m) from to	DESCRIPTION
			95						
			100					96 - 100	CALCARENITE. At least 50% bryozoal fragments, with fossiliferous and calcareous grains also, to 3mm. 10% Calcisiltite. Minor brown angular flint fragments to 3mm.
						OLIGO-MIOCENE	Gambier Limestone	100-106	CALCARENITE. At least 75% bryozoal fragments from silt size to 2mm. 5-10% calcisiltite, minor marl. Minor grey-brown angular flint fragments to 3mm.
			105					106-108	CALCARENITE. 50% bryozoal and minor fossil fragments to 3mm. 50% grey angular flint fragments to 7mm. Minor grey marl.
			110					108-120	CALCARENITE. At least 50% bryozoal wit[h] minor fossil fragments to 2mm. Most off-white, some brown to pale yellow. Minor marl, calcisiltite. From 108-110m 20% grey to dark brown angular flint fragments to 3mm. Fawn overall.
			115						

Borehole State No. 286031001

Drn: | Sheet 5 of 13
Date: | Bore Folder No. 47/-

PF Nº S10537a MH

CASING	WATERS CUT	WATER LEVEL	DEPTH (m)	CORE	GRAPHIC LOG	AGE	UNIT
			120–140			OLIGO-MIOCENE	Gambier Limestone

DEPTH (m) from to	298m DESCRIPTION
120-128	CALCARENITE. Well cemented, cream. At least 50% bryozoal fragments 0.5-3mm Minor shell fragments. Slightly silty. Rare red-brown staining.
128-130	CALCARENITE. Mainly bryozoal fragments 0.5-5mm with some calcareous grains and fossil fragments. 50% brown-black angular flint fragments to 7mm. Minor grey marl.
130-132	CALCARENITE. Moderately cemented. Mainly bryozoal fragments, off white. 5% angular flint fragments to 5mm.
132-136	SILTY MARL. Contains 20% bryozoal fragments to 1.5mm. Minor angular flint fragments to 3mm. Grey.
136-138	FLINT. Angular fragments to 5mm. Dark brown. Minor grey marl and bryozoal fragments to 1.5mm.
138-140	CALCARENITE. Grains 0.5-3mm. Some bryozoal fragments, off white to yellow brown. Minor grey, well cemented fragments to 2mm. 20% grey silty marl.

Borehole State No. 286031001 | Drn: | Date: | Sheet 6 of 13 | Bore Folder No. 47/-

PF Nº S10537a MH

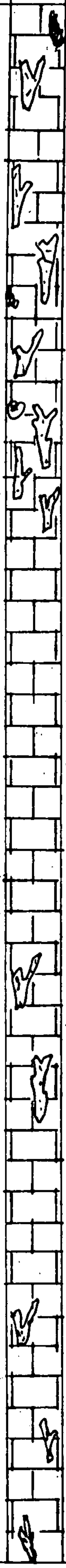
DEPARTMENT OF MINES — SOUTH AUSTRALIA

Casing: 147m of 5"

Age: OLIGO-MIOCENE

Unit: Gambier Limestone

Depth (m) scale: 145, 150, 155, 160, 165



DEPTH (m) from – to	DESCRIPTION
140–146	CALCARENITE. From silt size to 4mm. 25% bryozoa and minor fossil fragments. Off white.
146–148	CALCARENITE. Well cemented. Grains mainly 0.1-1.5mm, rarely to 3mm. Up to 50% bryozoal fragmemts, minor fossil fragments. Fawn.
148–154	CALCARENITE. Moderately cemented. Yellow brown and white grains 1-3mm.
154–158	CALCARENITE. Well cemented fragments 0.1 to 7mm. Cream, with minor bryozoal fragments.
158–160	CALCARENITE. Well cemented pale brown massive fragments to 3cm.
160–164	CALCARENITE. Well cemented white fragments. Rare bryozoal fragments 0.1 to 2mm. White, brown and red (dolomitic) grains. (10%).
164–166	CALCARENITE. White and brown grains to 1mm. Rare bryozoal fragments.

Borehole State No. 286031001

Drn:

Date:

Bore Folder No. 47/–

PE Nº S10537a MH

DEPARTMENT OF MINES — SOUTH AUSTRALIA

CASING	WATERS CUT	WATER LEVEL	DEPTH (m)	CORE	GRAPHIC LOG	AGE	UNIT	DEPTH (m) from to 298m	DESCRIPTION
147m of 5"			170, 175, 180, 185, 190			OLIGO-MIOCENE	Gambier Limestone	166-172	CALCARENITE. White and pale brown grains to 1.5mm. Minor silty marl, rare greenish grains to 2mm.
								172-182	CALCARENITE. Pale brown to orange-red (dolomitic) grains 0.1-1mm, rarely to 1.5mm. 25-50% dolomitic grains.
								182-184	CALCISILTITE-CALCARENITE. 90% colourless calcareous grains, subangular, 0.1-0.3mm 5-10% white bryozoal fragments to 1mm.
								184-186	MARL. 25% angular flint fragments, dark brown, and grey silicified marl (?) to 5mm. Minor orange/red dolomitic grains to 3mm. Rare bryozoal fragments to 1mm, fossil fragments to 4mm. Grey.
								186-188	MARL. 5% bryozoal and calcareous fragments to 3mm 10% grey silicified Limestone grading to flint. 20% colourless subangular quartz arenite, 0.1 to 0.3mm.
								188-198	CALCARENITE. Essentially bryozoal fragments to 2mm. White, well cemented. 30% quartz arenite, 0.1-0.3mm, subangular 20% Grey silty marl.

Borehole State No. 286031001 | Drn: | Sheet 8 of 13 | Date: | Bore Folder No. 47/-

PF Nº S10537a MH

DEPARTMENT OF MINES — SOUTH AUSTRALIA

CASING	WATERS CUT	WATER LEVEL	DEPTH (m)	CORE	GRAPHIC LOG	AGE	UNIT	DEPTH (m) 298m from to	DESCRIPTION
147m of 5"			195 200 205 210 215			OLIGO-MIOCENE	Gambier Limestone		190-192m Also 10% grey silicified limestone - brown flint angular fragments. 192-198m Quartz arenite decreases to less than 10%.
								198-214	CALCARENITE. Essentially bryozoal fragments to 2mm. 5% silicified Limestone fragments to 5mm. 20% silty marl. Less than 5% colourless, subangular to rounded quartz arenite 0.1-0.3mm. 204-206m 10% silicified Limestone. 206-210m 20% Calcisiltite, minor marl no silicified calcarenite. 210-214m 5% Marl.
								214-220	As above with marl increasing to greater than 50%.

Borehole State No. 286031001

Drn:

Date:

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Bore Folder No. 47/-

PF Nº S10537a MH

CASING	WATERS CUT	WATER LEVEL	DEPTH (m)	CORE	GRAPHIC LOG	AGE	UNIT	DEPTH (m) from to 298m	DESCRIPTION
147m of 5"			220			OLIGO-MIOCENE	Gambier Limestone	220–254	MARL. Contains approx. 25% bryozoal fragments, minor quartz arenite 0.1-0.3mm.
			225						Bryozoal fragments decreasing as proportion of total.
			230						
			235						
			240						

DEPARTMENT OF MINES — SOUTH AUSTRALIA

CASING	WATERS CUT	WATER LEVEL	DEPTH (m)	CORE	GRAPHIC LOG	AGE	UNIT	DEPTH (m) from to 298m	DESCRIPTION
147m of 5"			245			OLIGO-MIOCENE	Gambier Limestone		
									250m Bryozoal fragments rare Rare Glauconite grains appearing.
			250						
								254-256	MARL. Some calcareous grains and glauconite grains to 1mm. 10% sub-angular quartz arenite - 0.1 to 0.3mm rarely rounded to 1.5mm - colourless and milky.
			255					256- 298	ARENITE. Quartz, subrounded to rounded colourless-milky with brown and black staining. 256-258m 10-20% light brown clay, less than 5% black opaques. Quartz silt size to 5mm. 258-262m Minor clay, quartz silt size to 5mm.
Cement plug at top of Kongorong Sand			260			EOCENE	Kongorong Sand		
									262-272m Quartz-most less than 1.5mm rarely greater than 2mm, max. 3mm.
			265						

Borehole State No. 286031001

Drn:

Date:

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Bore Folder No. 47/-

PF Nº S10537a MH

DEPARTMENT OF MINES — SOUTH AUSTRALIA

CASING	WATERS CUT	WATER LEVEL	DEPTH (m)	CORE	GRAPHIC LOG	AGE	UNIT	DEPTH (m) 298m from to	DESCRIPTION
147m of 5"			270			EOCENE	Kongorong Sand		270-272m 5% Clay.
									272-274m Quartz 0.1 to 1mm, most less than 0.5mm.
			275						274-276m Rare rock fragments. Quartz 0.1 to 3mm, most less than 1.5mm.
									276-284m Quartz up to 5mm.
			280						
									282-284m Minor clay
			285						284-286m Quartz mainly less than 2mm, max. 4mm.
									286-286m Quartz maximum 2mm.
			290						288-290m Quartz to 2mm, rarely up to 4mm.

Borehole State No. 286031001

Drn: Date:

Bore Folder No. 47/-

RF Nº SJ0537 MH

CASING	WATERS CUT	WATER LEVEL	DEPTH (m)	CORE	GRAPHIC LOG	AGE	UNIT	DEPTH (m) from to 298m	DESCRIPTION
147m of 5"						EOCENE	Kongorong sand		290-294m Quartz mostly less than 3mm, rarely to 5mm. 292-294m Rare weakly cemented sandstone fragments. 294-296m 5% greenish brown clay. Quartz from silt size to 1.5mm, most less than 0.5mm, most colourless.
						EOCENE	Knight Formation	298	<u>CLAY</u>. Black, verystiff, with minor, fine colourless quartz. END. 298m.

Borehole State No. 286031001

Drn:

Date:

Sheet 13 of 13

Bore Folder No. 47

PF Nº S10537a MH

DEPARTMENT OF MINES — SOUTH AUSTRALIA

BORE LOG · HYDROGEOLOGY

Purpose of Bore	STRATIGRAPHIC			State No.	362049801
Hundred	Gambier	Section	Adj. 498	Bore Serial No.	115/73
Owner	Department of Mines	Address	Adelaide	Project No.	GAM 72
Driller	Hausler			Docket No.	224/1/69
Commenced	23/10/72	Completed	30/6/73	R.L. Collar (M.S.L.)	
Depth	185 m	Drill type	Cable Tool	Circulation	Water
R.L. Surface		Co-ords E		Logged by	Waterhouse, Valentine
Date	Aug.73	Casing	10" casing to 11.28m	A.M.G. Zone	
N					

WATERS CUT

DEPTH (m)	WATER LEVEL (m)	SUPPLY-	HOW TESTED	TOTAL SALTS mg/l	ANALYSIS No.
9.0	7.21				
174.0	8.90				

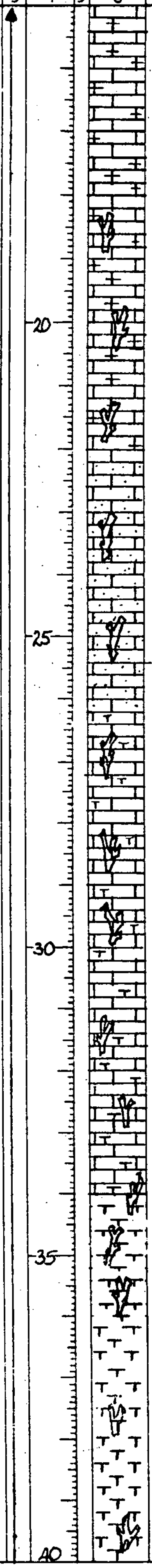
REMARKS Final "MG" bore Penetrates 67 m of Knight Formation, and completed as an observation bore in Gambier Limestone.

CASING 1	WATERS CUT 2	WATER LEVEL 3	DEPTH (m) 4	CORE 5	GRAPHIC LOG 6	AGE 7	UNIT 8	PENETRATION RATE 9
11.28m of 10" casing	9.0	7.21, 8.9	5, 10, 15			Pliestocene; Oligo-Miocene	Bridgewater Fm.; Gambier Limestone	

DESCRIPTION

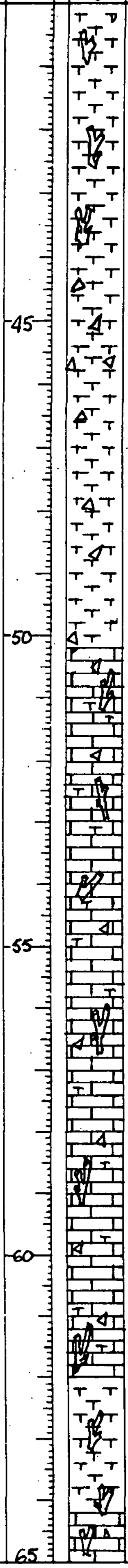
Surface:	ARENITE-SILT Quartz grains, most colourless, some pink. Subangular-angular <0.1-0.3 mm, most 0.2 mm. Some organic matter, grey overall.
0-1 m	ARENITE. Quartz, colourless to brown, subangular to subrounded, <0.1-0.5 mm, most 0.2-0.3 mm. Larger grains rounded. <5% black opaques 0.1 mm. Ironstone (brown) nodules to 1-2 cm. Brown
1-2 m	ARENITE. As above with some red and yellow grains. No ironstone nodules, minor brown clay.
2-4 m	ARENITE. As above with 30% brown clay.
4-6 m	CALCARENITE. Fragments of well cemented, fawn quartzose calcarenite, with some quartz as above. Minor clay.
6-8 m	CALCARENITE. Fragments of well cemented fawn calcarenite.
8-10 m	CALCARENITE. Well cemented fawn fragments composed of fawn angular calcareous grains 0.2-3 mm. Minor quartz to 0.2 mm
10-12 m	CALCARENITE. Well cemented fawn fragments composed of angular calcareous grains 0.1-2 mm Rare spicules and bryozoal fragments. Minor colourless quartz, subangular to rounded, 0.1-1 mm. Minor clay.
12-14 m	As above, fragments white, fawn and grey. Silty.
14-18 m	As above, mainly grey.

1	2	3	4	5	6	7	8	9	State No. 362049801. Bore Serial No. 115/73. SHEET 2 OF 8.



Depth	Description
18-22 m	As above, grey and brown. Bryozoal fragments 2-3 mm Rare quartz grains to 2 mm.
22-26 m	CALCARENITE. As above with well cemented white fragments. Minor white clay, 25% fawn quartz arenite 0.2-0.3 m Bryozoal fragments becoming more common, to 4 mm
26-30 m	CALCARENITE. 75% bryozoal fragments, white with grey/green marl. Minor well cemented brown fragments.
30-34 m	CALCARENITE. Well cemented, massive brown calcarenite fragments to 1 cm. Minor white bryozoal fragments to 2 mm. Minor black opaques 0.1 mm. 25% marl - green and grey.
34-36 m	CALCARENITE. 50% white bryozoal and fossil fragments. 40% grey/green marl. Rare glauconite grains to 2 mm
36-44 m	MARL Dark grey/green. 5% white bryozoal fragments to 1.5 mm. Green colour grading to entirely grey by 44 m.

1	2	3	4	5	6	7	8	9	State No. 362049801 Bore Serial No. 115/73 SHEET 3 OF 8



44-46 m — MARL. Grey with minor bryozoal fragments. Contains 30-50% black angular flint fragments

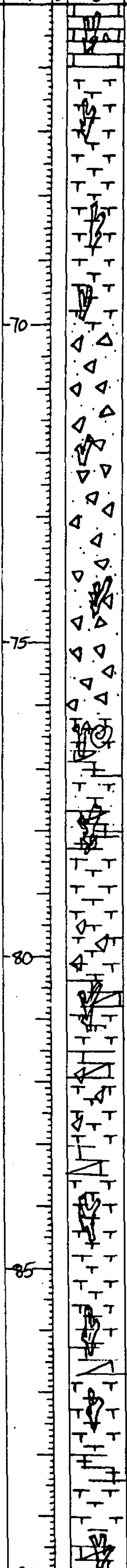
46-50 m — MARL. Grey with minor bryozoal fragments. Contains 5-10% flint as above.

50-62 m — CALCARENITE. Well cemented white fragments, essentially bryozoal fragments to 4 mm. 5% grey marl, 5% black angular flint fragments

62-64 m — MARL. Dark grey, silty. 5% Bryozoal fragments and rare dark grey well cemented calcareous fragments to 1 cm

64-66 m — CALCARENITE. Essentially white bryozoal fragments to 3 mm. Minor grey marl, angular black flint fragments.

1	2	3	4	5	6	7	8	9	State No. 362049801	Bore Serial No. 115/73	SHEET 4 OF 8



66-68 m

MARL. Dark grey, silty. 5% Bryozoal fragments and rare dark grey, well cemented calcareous fragments to 1 cm.

68-70 m

MARL. Grey, silty. 30% white bryozoal fragments to 1.5 mm

70-76 m

FLINT 75% Angular black fragments to 2 cm.
5% Bryozoal fragments to 2 cm.
10% Quartz arenite, colourless to fawn, 0.2-0.3 mm

76-82 m

LIMY MARL. Light to dark grey. Moderately plastic. Minor quartz arenite to 0.15 mm, grains transparent, subrounded. Elongate fragments in conc. Hcl residue, up to 6 mm long x 0.3 mm diam. ? silicified plant roots. Trace of glauconite.

76-80 m 15% calcirudaceous calcarenite (uncemented bryozoal remains to 3 mm)
20% calcisiltite
15% dark grey angular flint fragments to 3 mm decreasing to 5% at 78m-80m Bit sample 76 m

80-82 m 40% calcirudaceous calcarenite (bryozoal remains to 8 mm including fragments black calcareous echinoid spines)
5% grey angular fragments to 3 mm with moderately well cemented fragments of flinty calcarenite
5-10% calcisiltite.

82-94 m

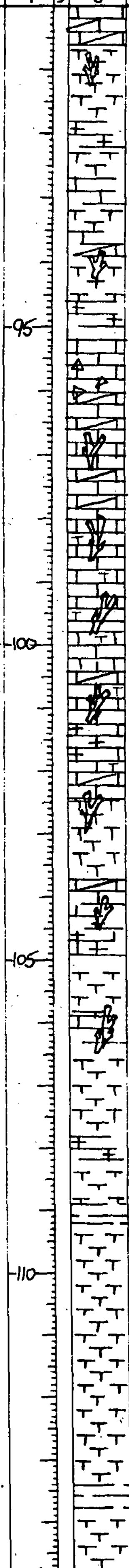
CALCIRUDACEOUS CALCARENITE. Buff 10% weakly to moderately well cemented fragments to 1 cm + bryozoal and echinoid remains to 5 mm
10% calcisiltite
trace to 1% glauconite
Minor black flint fragments to 2 mm + minor fine quartz arenite

82-86 m 20% Marl Buff

86-94 m 10% Marl Buff

92-94 m uncemented calcarenite

1	2	3	4	5	6	7	8	9	State No. 362049801	Bore Serial No. 115/73	SHEET 5 OF 8



94-102 m

CALCIRUDACEOUS CALCARENITE. Off white to brown to grey. Predominantly uncemented polyzoal remains to 1 cm with 5-10% weakly cemented calcarenite fragments to 7 mm. 5-10% black angular calc. siltstone & flint fragments to 5 mm

94-98 m — 30% clear calcite fragments, ave. 0.3 mm diam. ?recrystallized. 10% calcisiltite. A few fragments iron oxide to 3 mm diam.

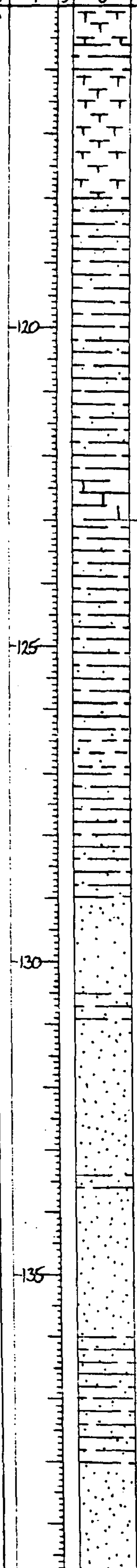
98-102 m — 20% calcisiltite. 5% white marl. Contains the odd fragment of glauconite to 1 mm diam.

102-116 m

MARL. Plastic, clayey & silty. Grey with minor calcisiltite. Calcarenitic but decreasingly so with depth. Clay content increases with depth as does plasticity. A few calc. siltstone fragments are present.

102-104 m — 40% Calcirudaceous calcarenite. Fossil fragments to 5 mm with weak to well cemented calcarenite fragments to 1 cm. Rare glauconite to 1 mm diam.

104-108 m — 10% calcarenite (uncemented polyzoal fragments to 2 mm)



116-118 m — CLAYEY MARL. Grey, plastic & silty. Bit samples at 116 & 118 m

118-126 m — CLAY. Brown, silty, arenaceous

- 118-120 m — 20% quartz arenite, grains transparent & subangular to subrounded 0.1-0.5 mm diam. (ave. 0.1 mm) minor bryozoal calcarenite (? contam. from above)
- 120-122 m — 30% quartz arenite as above.
- 122-124 m — 10% " " " " 10% nodules dark green & black plastic clay and off white marl. Minor lignite + 5% calcarenite (contam.)
- 124-126 m — 20% quartz arenite as above

126-128 m — CLAY. Dark greenish grey, plastic 10% brown silty clay containing quartz arenite as for 118-120 m. Minor nodules white clayey marl.

128-136 m — QUARTZ ARENITE. Light brown-grey, silty. Grains transparent, subangular and moderately well sorted (0.1 mm - 0.5 mm diam., ave. 0.15 mm) Minor bryozoa to 2 mm (?contam.)

- 128-130 m — 25% greenish grey clay of moderate plasticity.
- 130-132 m — 10% plastic clay as above. Bit sample 132 m contained no clay
- 132-136 m — Less than 5% clay as above A few transparent mica flakes, 0.5 mm - 2.0 mm diam.

136-138 m — CLAY. Very dark chocolate brown, almost black. Plasticity low, slightly arenaceous (qtz.) & silty (less than 5%). Bit sample 138 m - minor subrounded quartz to 2.5 mm, 15% silty quartz arenite.

138-144 m — QUARTZ ARENITE. Brown. Poorly sorted, transparent & subrounded grains, 0.1 mm - 2.5 mm diam. (ave. 0.8 mm)

- 138-140 m — Rare ? pyrite grains 1 mm diam.

145 — 150 — 155 — 160 — 165

138-144 m (cont.)

140-142 m — 50% dark brown and light greenish grey plastic clay. Bit Sample 142 m dark chocolate brown plastic clay.

142-144 m — As above but much less clay (less than 5%, brown & light grey, plastic)

144-150 m — QUARTZ ARENITE. Brown, silty 5% fragments black (lignitic) clay to 10 mm

144-148 m — Grains transparent, subrounded, moderately well sorted (0.1 mm - 1.5 mm diam., ave. 0.2 mm)

146-148 m — Lighter in colour + only slightly silty.

148-150 m — Grains transparent, subrounded & poorly sorted (0.2 - 2.0 mm, ave. 0.5 mm) 20% grey-green & black plastic clay.

150-152 m — CLAY. Greenish grey & brown, silty & plastic in part. 10% quartz arenite as for 148-150 m. A few frosted, rounded quartz grains 2-5 mm diam. Bit sample 150 m - Black plastic clay

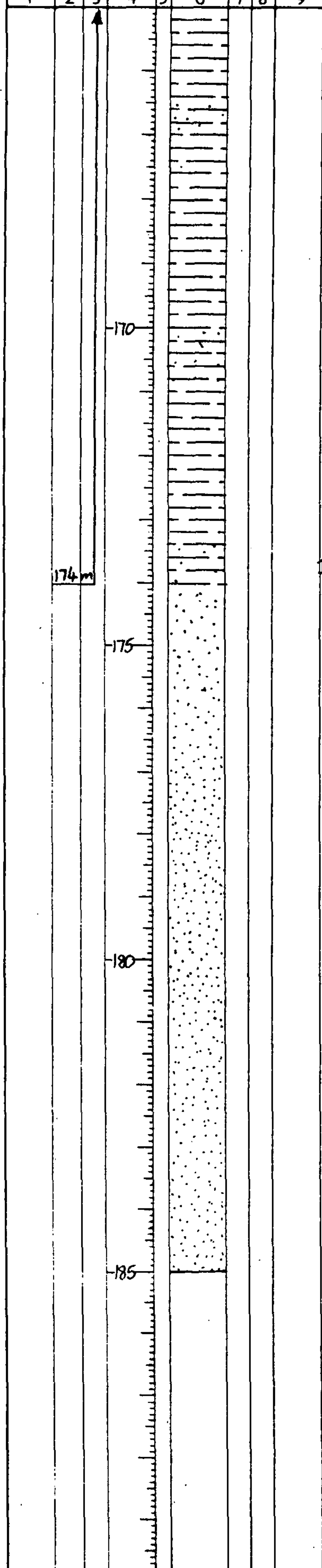
152-154 m — CLAY. Brown, of low plasticity. Less than 5% quartz arenite, ave. 0.1 mm diam.

154-156 m — QUARTZ ARENITE. Silty, transparent, subrounded to subangular, well sorted, equidimensional to elongate quartz grains 0.1-0.9 mm diam. (ave. 0.1 mm) 20% grey-green & black plastic clay.

156-174 m — CLAY. Dark chocolate brown, lignitic & plastic in part, but generally silty & of low plasticity

160-162 m — Some grey-green plastic clay.

1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | State No. 362049801 | Bore Serial No. 115/73. | SHEET 8 OF 8



156-174 m (cont.)

166-168 m — Streaks of mid-brown clay, with 5% quartz arenite - grains transparent, subangular & well sorted (0.2 - 0.5 mm ave. 0.2 mm)

169 m — Bit sample - Black plastic clay with light brown streaks

170-174 m — 20% quartz arenite. Grains transparent, subrounded & poorly sorted (0.1 - 2 mm diam. ave. 0.5 mm)

174-185 m — ARENITE. Quartz sands with black clays. No samples bagged for examination.

END OF HOLE 185m

DEPARTMENT OF MINES — SOUTH AUSTRALIA

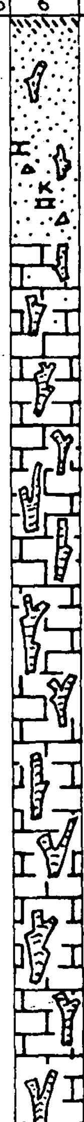
BORE LOG · HYDROGEOLOGY

Purpose of Bore STRATIGRAPHIC. State No. 439043901
Hundred KONGORONG Section ADJ. SEC. 439 Bore Serial No. 103/72.
Owner S.A. DEPT. OF MINES. Address ADELAIDE Project No. KON 1 (M.G.3)
Driller R.B. TOOHEY Docket No. 224/1/69
Commenced 22/9/71 Completed 15/1/72 R.L. Collar (M.S.L.) 18.870 Depth 190.5 m
Drill type CABLE TOOL Circulation Water R.L. Surface 18.712 Co-ords E
Logged by J.D. WATERHOUSE Date FEB. 1972 Casing N/L A.M.G. Zone N

WATERS CUT

DEPTH (m)	WATER LEVEL (m)	SUPPLY-	HOW TESTED	TOTAL SALTS mg/l	ANALYSIS No.
6.1	3.7			See summary sheets 10 of 10.	

REMARKS MT. GAMBIER AREA STRATIGRAPHIC BORE MG3. (OBSERVATION BORE KON 1)

CASING 1	WATERS CUT 2	WATER LEVEL 3	DEPTH (m) 4	CORE 5	GRAPHIC LOG 6	AGE 7	UNIT 8	PENETRATION RATE 9	DESCRIPTION
			0, 5, 10, 15						

0 - 0.15 m. SOIL. Slightly calcareous. Angular to subangular quartz with organic material. Dark brown/black.

0.15 - 1.5 m ARENITE. Quartz, 0.3-0.4 mm, subrounded. Light brown.

1.5 - 3.0 m ARENITE. Quartz, av. 0.3-0.4 mm, subrounded. Silty, with calcrete fragments, spicules, bryozoal and flint fragments. Light brown.

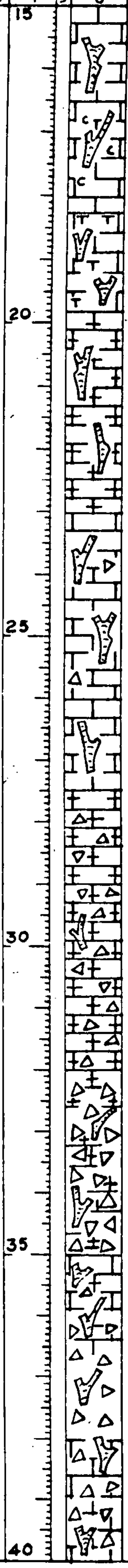
3.0 - 4.5 m ARENITE. Calcareous. 50% quartz grain, 0.2-0.4 mm, rounded, spicules to 1.5 mm. Ironstone fragments to 0.4 mm. Flint fragments to 2 cm. Light brown.

4.5 - 9.0 m CALCARENITE. Mainly bryozoal fragments to 5 mm. Off white 10% quartz most <0.2mm, max. 0.3 mm, fawn grains, rounded.

Minor flint fragments to 5 mm.

9.0 - 20 m. CALCARENITE. Bryozoa with calcareous fragments 0.1-0.3 mm. Off white. Well cemented.

12.0 - 14.0 m. Contains white to light brown/green calcareous fragments.

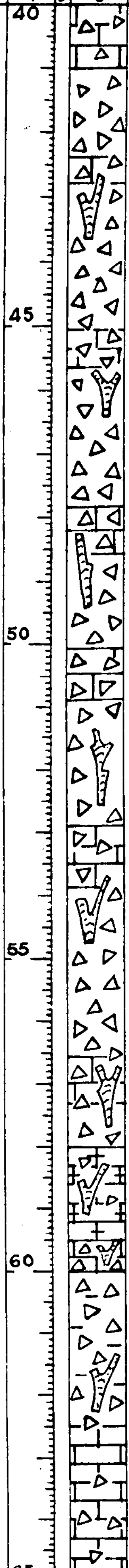


16.5-18 m. Contains grey recrystallized calcareous fragments to 8 mm.

18 - 20 m. Contains 20% marl.

20 - 23 m.	CALCISILTITE. 20-30%. Bryozoal and calcareous fragments to 3 mm. Dark flint fragments to 7 mm. Pale grey.
23 - 26 m.	CALCARENITE. Silty Bryozoal and calc. fragments to 5 mm. Flint fragments to 5 mm.
26 - 27.5 m	As above, No flint, but some silicified limestone.
27.5 - 32 m	CALCISILTITE. 5% Bryozoal fragments to 5 mm. 50% Dark flint to 1 cm.
32 - 33.5 m	FLINT. Grey black angular fragments to 2 cm. <5% calcisiltite, minor bryozoa to 1 cm.
33.5 - 35 m	FLINT. As above, bryozoal fragments 10%.
35 - 36.5 m	CALCARENITE. Silty bryozoal fragments and echinoid spines to 5 mm. 5% flint fragments to 1 cm. Cream.
36.5 - 38 m	FLINT. Grey fragments to 2 cm. 20-30% fossil fragments to 6 cm.
38 - 41 m	CALCARENITE. Bryozoal, echinoid fragments to 5 mm. 40% flint fragments to 1 cm. Cream.

1	2	3	4	5	6	7	8	9	State No. 439043901 Bore Serial No. 103/72. SHEET 3 OF 10



41 - 58 m. FLINT. Dark grey fragments to 3 cm. 10-20% Bryozoa and calcareous fragments to 3 mm.

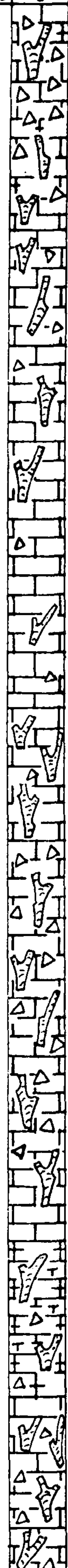
58 - 59.5 m CALCISILTITE. Marly. Minor bryozoa and calcareous fragments to 8 mm. Minor red/brown ironstone fragments to 3 mm. 20% flint fragments to 1 cm.

59.5 - 62.5 m FLINT. Fragments to 2 cm. Minor bryozoa and calcareous fragments to 3 mm. Silty.

62.5 - 67 m CALCARENITE. Bryozoa and calcareous fragments to 4 mm. 40% flint fragments to 2 cm.

1	2	3	4	5	6	7	8	9	State No. 439043901	Bore Serial No. 103/72	SHEET 4 OF 10

65



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67 - 68.5 m	CALCARENITE. 30% Flint.
68.5 - 70 m	CALCARENITE. Bryozoa and calcareous fragments to 5 mm, slighly silty. Minor flint to 1 cm. Cream.
70 - 73 m	CALCARENITE. Bryozoa and calcareous fragments to 3 mm, most 0.5 mm. Minor flint to 1 cm. Cream.
73 - 76 m	CALCARENITE. Mainly calcareous fragments to 2 mm, average <0.5 mm. Rare bryozoal fragments to 3 mm. Minor flint <1 mm. Silty. Cream.
76 - 77.5 m	CALCARENITE. Mainly bryozoal fragments to 3 mm, minor calcareous fragments to 1 cm; 5% flint fragments to 1 cm. Cream.
77.5 - 84 m	CALCARENITE. Bryozoa and fossiliferous fragments to 1 cm, most 1-3 mm. 20% grey flint fragments to 1 cm. Silty. Cream.
84 - 87 m	CALCISILTITE. Marly. 5-10% bryozoal fragments to 3 mm. 5-10%. Flint fragments to 1 cm. Off white.
87 - 92.5 m	CALCARENITE. Silty. Mainly bryozoal fragments to 3 mm. 40-50%. Flint fragments to 1 cm. Offwhite.

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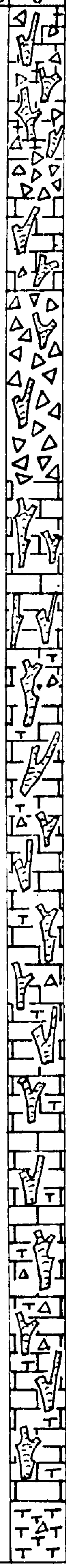
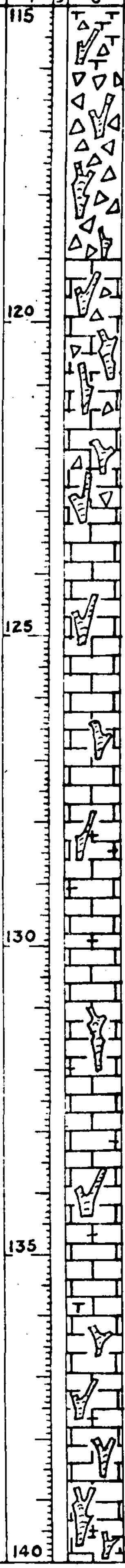


92.5 - 93 m	FLINT. Angular fragments to 1 cm. 30% fossiliferous calcarenite (bryozoa, shell fragments, echinoderm spines to 5 mm. Minor silt. Dark.
93 - 94.5 m	CALCARENITE. Fossiliferous as above. 5% angular flint fragments.
94.5 - 97.5 m	FLINT. Angular fragments to 5 mm. 10% fossiliferous calcarenite as above.
97.5 - 108 m	CALCARENITE. Mainly bryozoal fragments to 3 mm with calcisiltite. Cream. 5% angular flint fragments to 2 cm.
	At 107-108 m. 15% angular flint fragments, and grey marl blebs to 2 cm.
108 - 114 m	CALCARENITE. Mainly bryozoal fragments av. 2 mm rarely to 1cm. 20-30% Marl. Grey. 110-111 m 20% angular flint. fragments, Marl <10%. 113-114 m Minor red/brown staining on some calcareous fragments.
114 - 116 m	MARL. Grey. 20% Angular flint fragments to 4 mm. 20% fossiliferous calcarenite, mainly bryozoa to 3 mm.

1	2	3	4	5	6	7	8	9

State No. 439043901 Bore Serial No. 103/72 SHEET 6 OF 10



116 - 119 m FLINT. Angular fragments including silicified fossiliferous calcarenite. 30-40% calcarenite (mainly bryozoal fragments to 3 mm).

119 - 123.5 m CALCARENITE. As above.
119-120 m 40% angular flint fragments.
120-123.5 m 20% " "

123.4 - 128 m CALCARENITE. Minor bryozoal fragments to 3 mm, av. 2 mm. Cream.

128 - 129.5 m CALCARENITE. As above with 20-30%. Calcisiltite. Marly. Fawn.

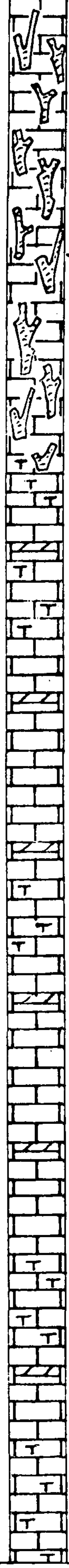
129.5 - 137 m CALCARENITE. As above with 5% Calcisiltite

136-137 m Minor marly blebs.

137 - 148 m CALCARENITE. Essentially bryozoal fragments to 2 mm. Minor calcisiltite. Well cemented. Fawn.

1	2	3	4	5	6	7	8	9	State No. 439043901 Bore Serial No. 103/72. SHEET 7 OF 10

140



145

147-148 Marly.

148 - 187.5 m CALCARENITE. Dolomitic in places. Cream.

149-150 Marly

150

154-155.5 Marly

155

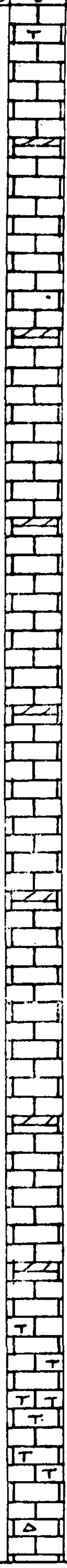
160

160-161.5 Marly

163-166 Marly.

165

1	2	3	4	5	6	7	8	9	State No. 439043901 Bore Serial No. 103/72 SHEET 8 OF 10



165

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185

186 - 187 m Marly

187.5 - 189 m 50% Marl

189 - 190.5 m 10% angular flint fragments to 4 cm.

190

1	2	3	4	5	6	7	8	9	State No. 439043901 Bore Serial No. 103/72 SHEET 9 OF 10
			190						
			190·5						190.5 END.

DEPARTMENT OF MINES SOUTH AUSTRALIA

HYDROGEOLOGY SECTION

BORE LOG

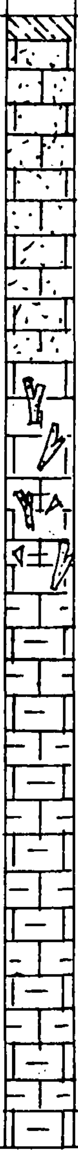
HIRER DEPT. OF MINES

Drill type	Cable Tool			A.M.G. Zone	HUNDRED MacDONNELL
Circulation	Water	Logged by	M.A. COBB	Coords. E	SECTION Adj. 44.
Driller	L.A. Hausler	Date logged	10.3.72	" N	STATE No. 463004401
Start	27.10.71	Bore Diameter		Datum Elev.	Project No. MAC 35
Finish	5.12.71	DEPTH	218m	(m) Ref. Pt. Elev.	Docket No. 224/1/69
				Surface Elev.	Bore Serial No. 105/72

Depth to Water cut (m)	Depth to standing water (m)	SUPPLY litres/sec.	SUPPLY Method of test	TOTAL DISSOLVED SOLIDS Milligrammes/litre	TOTAL DISSOLVED SOLIDS Analysis W. No.
6.1	5.5			SEE SUMMARY SHEET.	

REMARKS
Mt. Gambier Area, Deep Bore Series (M.G. Numbers) MAC 35. M.G.4

CASING: 6.6m of 0.152m Casing



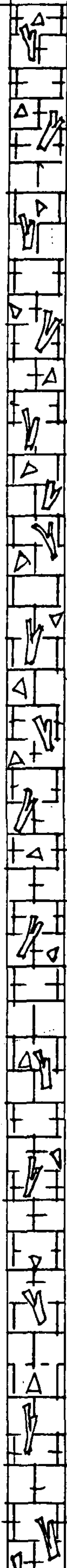
DEPTH (m) from – to	DESCRIPTION
0 – 0.3	SOIL. Dark brown, some calcrete fragments.
0.3–4.5	QUARTZOSE CALCARENITE. Pale-medium brown. Average grain size 0.3mm. About 40% quartz silt and sand. Rest bryozoa tubes, calcareous chips, spicules. Decrease in quartz with depth.
4.5 – 6	CALCARENITE. Off white-pale grey. About 20% silt size. Average grain size 0.5–1mm. Dominantly bryozoal tubes rest calcareous chips. Some cemented fragments.
6.0–7.5	SANDY CALCISILTITE. Pale grey. About 60% silt size, average grain size less than 0.2mm. Dominantly bryozoal tubes. Some large flint chips.
7.5 – 15	CALCILUTITE. Medium grey. Sticky – between 9–10.5m small flint chips common. Becomes more silty with depth.

Drn:		Sheet 1 of 10	
Date:		Bore Folder No. 66/–	

PF Nº S10537 MH

DEPARTMENT OF MINES — SOUTH AUSTRALIA

CASING	WATERS CUT	WATER LEVEL	DEPTH (m)	CORE	GRAPHIC LOG	AGE	UNIT	DEPTH (m) 218m from to	DESCRIPTION
								15-23	SANDY CALCISILTITE. Medium grey. About 40% sand size grains dominantly bryozoa tubules. Much Flint. Becomes somewhate paler with depth. Some well cemented fragments.
			20					23 - 26	CALCARENITE. Off white. Average grain size 1-1.5mm. Dominantly bryozoal tubes and calcareous chips. Flint chips make up about 20% of sample.
			25					26 -45.5	SANDY CALCISILTITE. Pale-medium grey. About 30% sand size. Essentially bryozoa tubes and calcareous chips. Much flint. Slightly darker in colour and with a moderate clay content (20%) between 36.5-41m and 42.5-45.5m
			30						
			35						
			40						



Borehole State No. 463004401

Drn: Date:

Sheet 2 of 10

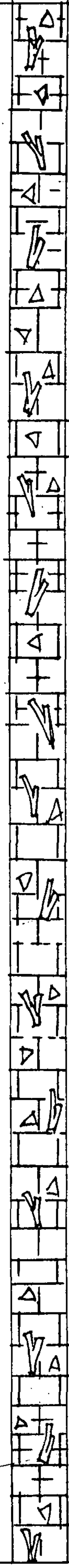
Bore Folder No. 66/—

DEPARTMENT OF MINES — SOUTH AUSTRALIA

CASING | WATERS CUT | WATER LEVEL | DEPTH (m) | CORE | GRAPHIC LOG | AGE | UNIT

DEPTH/(m) from to 218m

DESCRIPTION



Depth scale: 45, 50, 55, 60, 65

DEPTH (m) from – to	DESCRIPTION
45.5–47.3	CALCARENITE. Buff-pale grey. Average grain size 0.4-0.6 mm. Essentially bryozoal tubes and calcareous chips. Flint chips common.
47.3-52	SILTY CALCARENITE. Pale grey to off white with depth. About 30% silt size grains. Bryozoa and calcareous chips. Flint chips common.
52 - 61	CALCARENITE. Off white-cream. Clean calcarenite essentially bryozoal tubes and calcareous chips some flint but very common between 55-56.5m. Average grain size 0.5-1mm.
61 - 79	SILTY CALCARENITE. Pale-medium grey. About 30% silt size grains. Flint dominant at top grading down to about 30% of sample by 72m then only a small amount of flint. Rest bryozoa tubes and calcareous chips.

Borehole State No. 463004401

Drn: Date: -

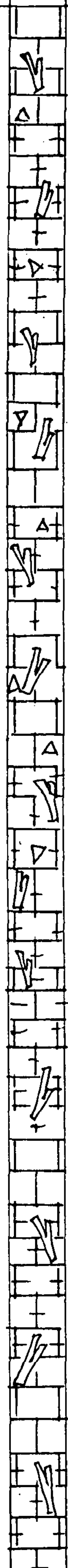
Sheet 3 of 10

Bore Folder No. 66/-

PF Nº S10537a MH

DEPARTMENT OF MINES — SOUTH AUSTRALIA

CASING	WATERS CUT	WATER LEVEL	DEPTH (m)	CORE	GRAPHIC LOG	AGE	UNIT	DEPTH (m) from to	218m DESCRIPTION
			70						
			75						
								79.2-80.9	<u>CLAYEY CALCISILTITE</u>. Pale grey-off white. About 40% clay, rest bryozoal tubes. Average grain size less than 0.1mm.
			80					80.9-90	<u>SANDY CALCISILTITE</u>. Pale-medium grey, darkening with depth. About 40% sand size grains. Essentially bryozoal tubes and calcareous chips. Some flint.
			85						
			90						



Borehole State No. 463004401

Drn:

Date:

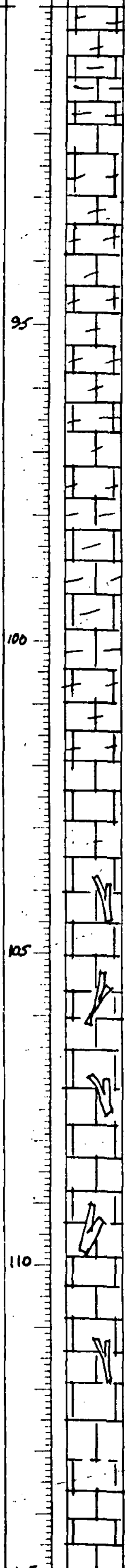
Sheet 4 of 10

Bore Folder No. 667-

PF Nº S10537a MH

DEPARTMENT OF MINES — SOUTH AUSTRALIA

CASING	WATERS CUT	WATER LEVEL	DEPTH (m)	CORE	GRAPHIC LOG	AGE	UNIT	DEPTH (m) from to 218m	DESCRIPTION



DEPTH (m)	DESCRIPTION
90-91.5	CLAYEY CALCISILTITE. Medium grey. About 30% clay and 20% sand size. Bryozoa and calcareous chips. Some flint.
91.5-93	SANDY CALCISILTITE. Medium-dark grey. About 30% sand size grain.
93-100.5	CLAYEY CALCISILTITE. Medium grey becoming pale with depth. Clay content increasing to about 50% towards base.
100.5-103.5	SANDY CALCISILTITE. Pale grey-buff. About 30-40% sand size. No flint.
103.5-128	CALCARENITE. Off white-cream. Average grain size 0.3-0.5mm. Essentially bryozoal tubes and calcareous chips. No flint. Increase in silt content with depth.
	Between 114.5-120.5 few if any fossils essentially calcite grains. Grains size less than 0.5mm.

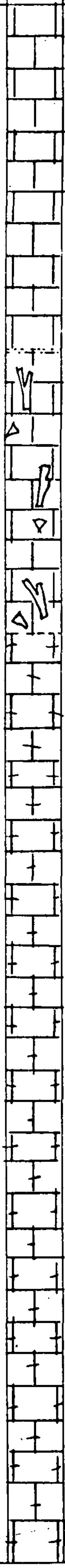
Borehole State No. 463004401

Drn: | Sheet 5 of 10

Date: – | Bore Folder No. 66/–

PF Nº S10537a MH

CASING	WATERS CUT	WATER LEVEL	DEPTH (m)	CORE	GRAPHIC LOG	AGE	UNIT	DEPTH (m) from to	DESCRIPTION
								218m	
			120						
									Between 120.5 and 125m flint chips appear and fossil spines become dominant. Becoming silty some harder cemented fragments.
			125						
									Below 125m grades to a calcisiltite.
								128–140	CALCISILTITE. Off white to buff. Minor calcarenite (up to 10%). No observable fossils.
			130						
			135						
			140						



DEPARTMENT OF MINES — SOUTH AUSTRALIA

Borehole State No. 463004401

Drn:

Date:

Sheet 6 of 10

Bore Folder No. 66/–

PF Nº S10537a MH

DEPARTMENT OF MINES — SOUTH AUSTRALIA

CASING	WATERS CUT	WATER LEVEL	DEPTH (m)	CORE	GRAPHIC LOG	AGE	UNIT	DEPTH (m) from to 218m	DESCRIPTION
								140-143.5	CALCARENITE. Buff. Average grain size 0.2-0.4mm. About 10% finer material.
								143.5-158.5	CALCISILTITE. Buff grading to orange with depth. Clay content increases with depth (quite plastic at 158m).
			145						
			150						
			155						
								158.5-218	CALCILUTITE. Buff to light grey. Silt fraction say 10%. Becomes darker grey with depth below 161.5m
			160						
			165						

Borehole State No. 463004401

Drn:

Date:

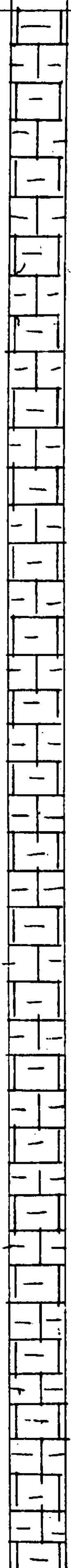
Sheet 7 of 10

Bore Folder No 66/-

PF Nº S10537a MH

DEPARTMENT OF MINES — SOUTH AUSTRALIA

CASING	WATERS CUT	WATER LEVEL	DEPTH (m)	CORE	GRAPHIC LOG	AGE	UNIT	DEPTH (m) from to	DESCRIPTION
			170						
			175						
			180						
			185						
			180						



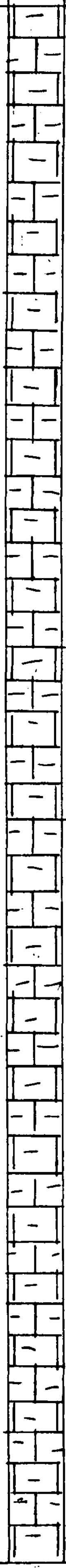
Borehole State No. 463004401

Drn:	Sheet 8 of 10
Date:	Bore Folder No. 66/–

PF Nº S10537a MH

DEPARTMENT OF MINES — SOUTH AUSTRALIA

CASING	WATERS CUT	WATER LEVEL	DEPTH (m)	CORE	GRAPHIC LOG	AGE	UNIT	DEPTH (m) from to	DESCRIPTION
			195						
			200						
			205						
			210						
			215						



Borehole State No. 463004401

Drn:
Date:

Sheet 9 of 10
Bore Folder No 667

PF Nº S10537a MH

CASING	WATERS CUT	WATER LEVEL	DEPTH (m)	CORE	GRAPHIC LOG	AGE	UNIT	DEPARTMENT OF MINES — SOUTH AUSTRALIA DEPTH (m) from to 218m	DESCRIPTION
			220						END OF BORE. 281m.

Borehole State No.

Drn:

Date:

Sheet 10 of 10

Bore Folder No. 66/-

PF Nº S10537a MH

DEPARTMENT OF MINES — SOUTH AUSTRALIA

BORE LOG · HYDROGEOLOGY

Purpose of Bore: OBSERVATION | State No. 731001601
Hundred: YOUNG | Section: 16 | Bore Serial No. 141/72
Owner: D.M. | Address: ADELAIDE | Project No. You2
Driller: R.B. TOOHEY | Docket No. 231/69
Commenced: 6.5.72 | Completed: 20.5.72 | R.L. Collar (M.S.L.) | Depth: 25 m
Drill type: CABLE TOOL | Circulation: Water | R.L. Surface 10·53m of 5" (Slotted) | Co-ords
Logged by: FRED W. ASLIN | Date: 6.10.72 | Casing 13.87m of 6" | A.M.G. Zone | N

WATERS CUT

DEPTH (m)	WATER LEVEL (m)	SUPPLY-	HOW TESTED	TOTAL SALTS mg/ℓ	ANALYSIS No.
13.5	13.15			415	W2257/72
				345	W2358/72

REMARKS. Bit samples but no tube core. Bit samples 6.0, 12.0 m.

1 CASING	2 WATERS CUT	3 WATER LEVEL	4 DEPTH (m)	5 CORE	6 GRAPHIC LOG	7 AGE	8 UNIT	9 PENETRATION RATE	DESCRIPTION	
13.87 m of 6" Casing						RECENT			0.0-0.18m	Quartz arenite, grey, grains 0.1-1.0mm (Av 0.2mm) sub angular-subrounded, organic matter.
									0.18-1.00m	Quartz arenite, buff, as above, slightly silty, minor organic matter.
						OLIGO-MIOCENE	GAMBIER LIMESTONE		1.0-3.0 m	50% Quartz arenite, colourless, 0.1-1.5mm (Av. 0.2 mm) subangular to rounded. 50% Clay, light brown.
			5						3.0-8.0 m	50% fossiliferous calcarenite, off white with some red stain, fossil fragments to 3mm. 50% marl, buff. Minor smears of dull red-brown clay.
									8.0-10.0 m	Fossiliferous calcarenite, off white, fossil fragments to 4 mm. Approx. 15-20% marl, cream.
			10						10.0-12.0 m	Clay, brown, with finely disseminated fossil fragments in it. 10% fossiliferous calcarenite in lumps up to 2.5 cm off white, fossil fragments to 3 mm. organic matter.
			15						12.0-18.0 m	Quartz arenite, 0.1-3.0 mm (Av 0.35 mm) predominantly colourless, some milky and odd black. subangular-subrounded. 13.0-14.0 Trace of marl. 16.0-18.0 Trace of brown clay.

1	2	3	4	5	6	7	8	9	State No. 7310016 01 Bore Serial No. 141/72 SHEET 2 OF 2

10.53 m of 5" slotted casing

EOCENE

KNIGHT FORMATION

18.0-19.0 m	Quartz arenite, <0.1mm-0.4mm (Av 0.15) angular to subrounded. Minor fine mica.
19.0-21.0m	Quartz arenite, <0.1mm-1.0mm (Av 0.15) angular to subrounded. Approx. 10% black clay.
21.0-24.0 m	60% quartz arentie as above. 40% black clay. 23.0-24.0 m clay grey-black and well mixed with arenite.
24.0-25.0 m	60% clay, grey-black. 40% Quartz arenite, 0.1-0.4 mm (Av 0.15 mm) Minor fine mica

End of hole 25.0 m.

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DEPARTMENT OF MINES SOUTH AUSTRALIA

HYDROGEOLOGY SECTION

BORE LOG

HIRER DEPT. OF MINES.

Drill type	Cable Tool			A.M.G. Zone	HUNDRED YOUNG
Circulation	Water	Logged by	F.W. ASLIN	Coords. E	SECTION Adj. 829
Driller	R.B. Toohey	Date logged	10.10.72	" N	STATE No. 731082901
Start	20.5.72	Bore Diameter		Datum Elev.	Project No. YOU, 3
Finish	24.5.72	DEPTH	16m	(m) Ref. Pt. Elev.	Docket No. 231/69
				Surface Elev.	Bore Serial No. 145/72

Depth to Water cut (m)	Depth to standing water (m)	SUPPLY litres/sec.	SUPPLY Method of test	TOTAL DISSOLVED SOLIDS Milligrammes/litre	TOTAL DISSOLVED SOLIDS Analysis W. No.
12	7.77			3.45 3.45	W2359/72 W2360/72

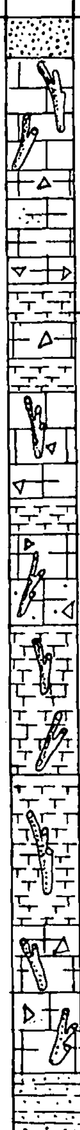
REMARKS

Bit sample 16.0. No tube core.

CASING: 5.80m of 6" casing

AGE: Oligo-Miocene; Eocene

UNIT: Gambier Limestone; Knight Fmn.



DEPTH (m) from – to	DESCRIPTION
0.0 -0.5	QUARTZ ARENITE. < 0.1-0.5mm (Av. 0.2mm) rose and colourless. Minor red-brown clay Minor ferruginous lumps to 1cm. Minor fossil fragments to 2mm.
0.5-2.0	FOSSILIFEROUS CALCARENITE, marly, silty, off white with minor green patches. Fossil fragments to 2mm.
2.0-4.0	SILTY Marl, light chocolate brown, Approx. 30% angular, massive, slight-moderately calcareous fragments to 1cm cream with black flecks. Approx. 5% quartz arenite < 0.1-0.2mm colourless.
4.0-8.0	SILTY Marl and minor clay, all light chocolate brown. Approx. 10% angular, massive, slightly calcareous fragments to 1 cm. Grey with black flecks. Approx. 10% Calcarenite and fossil fragments. Approx. 10% quartz arenite, 0.1-0.2mm, subangular - subrounded, colourless.
8.0-10.0	MARL, off white- grey, Approx 25% fossil fragments to 3mm, off white.
10.0-12.0	CLAYEY Marl, grey blue-grey mottle, Approx. 10-20% fossil fragments to 2mm.
12.0-14.0	CALCISILTITE, grey, Approx. 10-20% fossil fragments to 2mm. Minor angular, massive slightly calcareous fragments to 3mm, grey with black flecks.

Drn: Sheet 1 of 2

Date: Bore Folder No. 381

PF Nº S10537 MH

CASING	WATERS CUT	WATER LEVEL	DEPTH (m)	CORE	GRAPHIC LOG	AGE	UNIT	DEPTH (m) from to	DESCRIPTION
			15					14.0-16.0 END	Approx. 60% Black Clay. 40% Quartz Arenite 0.1-5.0mm (Av. 0.4mm) subangular - subrounded colourless, milky and greenish. Minor fine mica Bit sample 16.0m END OF HOLE 16.0m
			20						

DEPARTMENT OF MINES — SOUTH AUSTRALIA

16m

Borehole State No. 731082901

Drn:

Date:

Sheet 2 of 2

Bore Folder No. 381-

PF Nº S10537a MH

APPENDIX F

Daily Rainfall Figures, Mt. Gambier Aerodrome

(data from the Bureau of Meterology, Adelaide, S.A.)

1972

(in points, with values in mm in parentheses)

Daily Rain gaugings for Mt. Gambier Airport for 1972

DAY	JAN	FEB	MARCH	APR	MAY	JUNE
1	1 (0.25)	-	-	-	-	-
2	1 (0.25)	-	10 (2.54)	-	-	-
3	-	-	1 (0.25)	-	-	1 (0.25)
4	-	-	1 (0.25)	-	1 (0.25)	7 (1.78)
5	-	-	-	5 (1.27)	-	-
6	7 (1.78)	-	-	-	-	-
7	41 (10.41)	-	-	-	-	-
8	12 (3.05)	-	-	-	-	-
9	55 (13.97)	-	-	76 (19.30)	-	-
10	-	-	-	16 (4.06)	-	8 (2.03)
11	2 (0.51)	-	-	-	-	3 (0.76)
12	71 (18.03)	-	1 (0.25)	1 (0.25)	-	-
13	-	-	-	-	-	-
14	-	9 (2.29)	3 (0.76)	2 (0.51)	-	-
15	-	31 (7.87)	-	-	-	-
16	-	13 (3.30)	3 (0.76)	-	31 (7.87)	-
17	-	1 (0.25)	-	-	13 (3.30)	-
18	-	4 (1.02)	-	-	4 (1.02)	-
19	-	6 (1.52)	-	-	12 (3.05)	-
20	-	1 (0.03)	-	-	2 (0.51)	-
21	-	29 (7.37)	-	-	4 (1.02)	8 (2.03)
22	-	3 (0.76)	-	35 (8.89)	-	-
23	1 (0.25)	2 (0.51)	5 (1.27)	70 (17.78)	6 (1.52)	-
24	-	-	-	67 (17.02)	3 (0.76)	-
25	-	-	-	4 (1.02)	-	-
26	-	-	-	-	1 (0.25)	-
27	-	-	-	34 (8.64)	-	5 (1.27)
28	-	-	-	-	-	58 (14.73)
29	-	1 (0.25)	3 (0.76)	-	-	50 (12.70)
30	1 (0.25)	-	-	-	-	43 (10.92)
31	1 (0.25)	-	2 (0.51)	-	-	-
TOTAL	193	100	42	310	77	183

Daily rain gaugings for Mt. Gambier Airport for <u>1972</u>

DAY	JULY	AUG	SEPT	OCT	NOV	DEC
1	18 (4.57)	-	-	-	-	-
2	5 (1.27)	18 (4.57)	-	-	5 (1.27)	1 (0.25)
3	-	33 (8.38)	-	6 (1.52)	-	-
4	20 (5.08)	7 (1.78)	-	3 (0.76)	-	-
5	37 (9.40)	3 (0.76)	-	25 (6.35)	-	-
6	16 (4.06)	22 (5.59)	2 (0.51)	16 (4.06)	-	-
7	30 (7.62)	15 (3.81)	23 (5.84)	-	7 (1.78)	3 (0.76)
8	14 (3.56)	69 (17.53)	13 (3.30)	1 (0.25)	-	-
9	4 (1.02)	26 (6.60)	6 (1.52)	2 (0.51)	2 (0.51)	-
10	6 (1.52)	51 (12.95)	-	6 (1.52)	55 (13.97)	-
11	2 (0.51)	29 (7.37)	-	24 (6.10)	16 (4.06)	-
12	25 (6.35)	8 (2.03)	14 (3.56)	37 (9.40)	24 (6.10)	-
13	48 (12.19)	4 (1.02)	47 (11.94)	1 (0.25)	5 (1.27)	-
14	25 (6.35)	2 (0.51)	-	1 (0.25)	2 (0.51)	-
15	23 (5.84)	1 (0.25)	2 (0.51)	5 (1.27)	-	-
16	24 (6.10)	3 (0.76)	-	-	-	-
17	6 (1.52)	-	1 (0.25)	-	-	-
18	7 (1.78)	-	9 (2.29)	-	15 (3.81)	12 (3.05)
19	16 (4.06)	41 (10.41)	4 (1.02)	-	-	-
20	23 (5.84)	11 (2.79)	3 (0.76)	-	1 (0.25)	-
21	4 (1.02)	-	-	-	-	-
22	7 (1.78)	6 (1.52)	12 (3.05)	-	-	-
23	-	-	-	-	-	3 (0.76)
24	-	-	-	-	-	3 (0.76)
25	11 (2.79)	6 (1.52)	6 (1.52)	-	1 (0.25)	2 (0.51)
26	19 (4.83)	-	-	2 (0.51)	-	1 (0.28)
27	-	-	1 (0.25)	-	-	2 (0.51)
28	-	-	1 (0.25)	-	-	-
29	-	9 (2.29)	-	-	-	-
30	-	2 (0.51)	1 (0.25)	-	-	-
31	8 (2.03)	5 (1.27)	-	-	-	-
TOTAL	523	371	147	129	129	27

Total, less 1 mm for each rain day = <u>409.22 mm</u>

APPENDIX G

Water Analyses

WATER ANALYSIS RESULTS

HUNDRED BLANCHE

Bore	Date	Sampling Method	Temp.	Cond.	pH	Dissolved Oxygen	COD	Salinity	Ca (mg/l)	Mg (mg/l)	Na (mg/l)	K (mg/l)	HCO3 (mg/l)	SO4 (mg/l)	Cl (mg/l)	NO3 (mg/l)	PO4 (mg/l)	Ca (meq/l)	Mg (meq/l)	Na (meq/l)	K (meq/l)	HCO3 (meq/l)	SO4 (meq/l)	Cl (meq/l)	NO3 (meq/l)	PO4 (meq/l)	Red Salinity
BLA 1	17/11/72	W/M	18	710	7.3	4.6	10	395	92	19	35	<1	346	15	46	16	<.01	4.6	1.6	1.5	-	5.7	0.3	1.4	0.3	-	379
2	17/11/72	B	18	720	7.4	9.9	10	385	82	11	45	<1	262	10	64	44	<.01	4.1	0.9	2.0	-	4.3	0.2	1.8	0.7	-	341
3	17/11/72	B	17	2950	7.1	3.4	5	588	133	6	70	3	365	10	91	95	<.01	6.6	0.5	3.0	0.1	6.0	0.2	2.6	1.5	-	493
4	17/11/72	P	17	1060	7.2	8.0	25	1684	297	54	183	8	369	10	460	490	0.45	14.8	4.4	8.0	0.2	6.1	0.2	13.0	7.9	-	1196
5	10/11/72	P	15	860	7.2	9.3	10	474	81	15	65	5	265	10	88	80	.01	4.0	1.2	2.8	0.1	4.4	0.2	2.5	1.3	-	394
6	10/11/72	P	15	900	7.4	10	15	468	72	24	65	5	310	15	86	50	.02	3.6	2.0	2.8	0.1	5.1	0.3	2.4	0.8	-	416
7	8/12/72	W/M	16	670	7.2	9.9	20	340	80	9	42	<1	255	10	65	11	<.01	4.0	0.7	1.8	<0.1	4.2	0.2	1.8	0.2	-	329
8	7/11/72	P	15	880	7.2	10	20	389	41	30	67	<1	275	5	87	16	<.01	2.0	2.5	2.9	0.2	4.5	0.1	2.5	0.3	-	373
9	8/12/72	W/M	17	580	7.0	9.2	15	290	80	5	26	<1	210	5	43	30	<.01	4.0	0.4	1.1	<0.1	3.4	0.1	1.3	0.5	-	260
11	2/11/72	W/M	16	445	7.1	9.6	20	586	125	11	50	1	225	15	95	180	<.01	6.2	0.9	2.2	-	3.7	0.3	2.7	2.9	-	406
12	28/11/72	W/M	21	600	7.5	7.0	5	312	75	9	29	1	231	5	49	30	<.01	3.7	0.7	1.3	-	3.8	0.1	1.4	0.5	-	282
13	28/11/72	W/M	23	810	7.6	6.3	10	377	86	11	40	<1	259	10	56	47	<.01	4.3	0.9	1.7	-	4.2	0.2	1.6	0.8	-	330
14	1/12/72	W/M	22	830	7.3	8.8	15	417	95	11	43	1	255	5	67	70	<.01	4.7	0.9	1.9	<.1	4.2	0.1	1.9	1.1	-	347
15	30/11/72	W/M	23	900	7.4	5.5	25	462	69	28	66	<1	315	5	89	50	<.01	3.4	2.3	2.9	<.1	5.2	0.1	2.5	0.8	-	412
16	10/11/72	P	15	710	7.2	9.8	10	391	62	8	74	3	255	20	54	45	.02	3.1	0.7	3.2	0.1	4.2	0.4	1.5	0.7	-	346
17	9/11/72	P	15	910	7.3	-	15	487	60	24	82	6	255	15	110	65	<.01	3.0	2.0	3.6	0.2	4.2	0.3	3.1	1.0	-	422
18	30/10/72	P	16	1130	7.1	-	20	828	109	44	85	20	255	10	135	300	<.01	5.4	3.6	3.7	0.5	4.2	0.2	3.8	4.9	-	524
19	30/10/72	B	16	1160	7.1	-	35	855	103	55	135	23	425	50	280	<5	<.01	5.1	4.5	5.9	0.6	7.0	1.0	7.9	-	-	855
20	3/11/72	P	15	380	7.3	9.2	15	400	58	20	57	9	275	15	65	41	<.01	2.9	1.6	2.5	0.2	4.5	0.3	1.8	0.6	-	359
21	3/11/72	P	15	380	7.2	9.2	15	516	89	22	55	7	300	25	70	100	<.01	4.4	1.8	2.4	0.2	4.9	0.5	2.0	1.6	-	416
22	16/11/72	P	15	685	7.0	10	45	399	90	7	86	<1	185	10	60	105	<.01	4.5	0.6	1.6	-	3.0	0.2	1.7	1.7	-	294
23	28/11/72	W/M	17	680	7.4	7.8	5	350	83	11	34	1	256	10	50	35	<.01	4.1	0.9	1.5	-	4.2	0.2	1.4	0.6	-	315
24	28/11/72	B	18	690	7.4	10	15	340	82	8	35	1	259	10	52	25	<.01	4.1	0.7	1.5	-	4.2	0.2	1.5	0.4	-	315
25	28/11/72	W/M	21	700	7.5	8.6	10	344	78	11	38	4	242	5	62	31	<.01	3.9	0.9	1.7	-	4.0	0.1	1.7	0.5	-	313
26	28/11/72	W/M	17	500	7.8	6.3	15	253	40	11	35	1	95	5	60	54	<.01	2.0	0.9	1.5	-	1.6	0.1	1.7	0.9	-	199
27	6/11/72	P	15	490	7.3	-	20	382	64	18	48	1	240	5	83	45	<.01	3.2	1.5	2.1	-	3.9	0.1	2.3	0.7	-	337
28	6/11/72	B	15	2600	7.0	-	70	1247	159	82	165	21	925	<5	326	27	12.3	7.9	6.7	7.2	0.5	15.1	-	9.4	0.4	0.3	1220
29	6/11/72	B	15	1000	7.5	-	10	550	47	27	120	11	359	45	103	20	0.25	2.3	2.2	5.2	0.3	5.9	0.9	2.9	0.3	-	530
30	2/11/72	P	15	230	7.2	8.5	15	474	52	28	75	8	320	25	65	65	<.01	2.6	2.3	3.3	0.2	5.2	0.5	1.8	1.1	-	409
31	2/11/72	P	15	250	7.9	9.6	25	998	111	40	175	7	280	60	255	225	<.01	5.5	3.3	7.6	0.1	4.6	1.2	7.2	3.6	-	773
32	2/11/72	B	14.5	560	6.9	9.4	25	870	120	39	94	19	290	50	140	265	0.20	6.0	3.2	4.1	0.5	4.8	1.0	3.9	4.3	-	605
33	2/11/72	W/M	15	400	6.9	9.4	25	408	83	12	43	3	230	15	75	65	<.01	4.1	1.0	1.9	0.1	3.8	0.3	2.1	1.0	-	343
34	17/11/72	B	18	440	7.5	2.2	10	232	39	10	37	1	134	5	72	2	<.01	1.9	0.8	1.6	-	2.2	0.1	2.0	-	-	230
36	1/12/72	W/M	21	740	7.7	8.4	10	394	69	34	30	<1	312	10	44	54	.01	3.4	2.8	1.3	<.1	5.1	0.2	1.2	0.9	-	340
37	20/11/72	W/M	16	670	7.3	10	10	372	79	15	38	1	255	10	64	40	<.01	3.9	1.2	1.7	-	4.2	0.2	1.8	0.6	-	332
38	6/11/72	P	15	400	7.1	-	15	455	104	9	40	3	231	<5	75	110	<.01	5.2	0.7	1.7	0.1	3.8	-	2.1	1.8	-	345
39	6/11/72	P	15	90	7.3	5.4	10	690	113	18	81	3	75	<5	124	265	.01	5.7	1.5	3.5	0.1	2.9	-	3.5	1.3	-	425
40	2/11/72	P	15	250	6.8	7.6	20	423	57	31	581	4	325	15	68	30	<.01	2.8	2.5	2.5	0.1	5.3	0.3	1.9	0.5	-	393
41	2/11/72	P	15	380	7.0	8.2	30	841	104	31	110	15	265	25	145	275	<.01	5.2	2.8	4.8	0.4	4.4	0.5	4.1	4.4	-	566
42	8/11/72	P	15.5	950	7.0	8.5	15	498	88	26	55	7	330	15	80	65	.03	4.4	2.1	2.4	0.2	5.4	0.3	2.3	1.0	-	433
43	8/12/72	W/M	16	1230	7.3	8.8	20	715	124	19	83	5	215	10	140	230	<.01	6.2	1.6	3.5	0.1	3.5	0.1	3.9	3.7	-	465
44	22/11/72	W/M	14	610	7.3	7.3	15	340	74	10	38	2	189	5	70	48	<.01	3.7	0.8	1.7	-	3.1	0.1	2.0	0.8	-	292
45	17/11/72	W/M	18	710	7.3	7.4	5	371	82	12	40	<1	278	20	51	29	<.01	4.1	1.0	1.7	-	4.6	0.4	1.4	0.5	-	342
47	20/11/72	W/M	16	600	7.5	8.6	10	321	65	18	27	<1	234	10	46	40	<.01	3.2	1.5	1.2	-	3.8	0.2	1.3	0.6	-	281
48	31/10/72	P	16	740	7.6	9.0	20	435	93	21	32	1	300	20	55	65	<.01	4.6	1.8	1.4	-	4.9	0.4	1.6	1.0	-	370
49	31/10/73	B	16	670	6.8	8.2	20	456	85	19	60	2	285	15	85	50	<.01	4.2	1.6	2.6	<.1	4.7	0.3	2.4	0.8	-	406
50	1/11/72	B	15.5	430	7.7	2.4	20	332	55	18	44	3	240	10	70	14	0.2	2.8	1.4	1.9	0.1	3.9	0.2	2.0	0.2	-	318
52	1/11/72	P	15	540	7.3	8.6	15	478	87	13	34	1	265	5	58	50	<.01	4.4	1.0	1.5	-	4.4	0.1	1.6	0.8	-	428
53	1/11/72	B	17	560	7.9	3.4	15	281	36	14	57	2	173	10	84	<.5	<.01	1.8	1.1	2.5	-	2.8	0.2	2.4	-	-	281
54	8/12/72	W/M	20	780	7.3	7.6	15	410	78	19	51	1	300	10	80	20	<.01	3.9	1.6	2.3	<.1	4.9	0.2	2.3	0.3	-	390
56	30/10/72	B	18	475	7.7	9.1	25	225	49	12	41	1	90	10	55	13	<.01	2.4	1.0	1.8	-	3.1	0.2	1.6	0.2	-	212
59	20/11/72	W/M	17	730	7.4	9.4	5	386	70	35	22	4	320	10	37	55	<.01	3.5	2.9	1.0	-	5.3	0.2	1.0	0.9	-	331
89-60	31/10/72	B	16	270	7.8	7.5	15	388	68	34	29	2	325	10	50	35	<.01	3.4	2.8	1.2	<.1	5.3	0.2	1.4	0.6	-	353
61A	7/12/72	W/M	15	765	7.1	1.8	10	390	74	21	500	1	285	10	80	15	0.73	3.7	1.7	2.2	<0.1	4.7	0.2	2.3	0.2	-	375
62	8/12/72	W/M	16	810	7.1	7.4	15	430	75	25	550	11	330	15	80	15	<.01	3.7	2.1	2.6	<0.1	5.4	0.3	2.3	0.2	-	415
61B	7/12/72	W/M	16	780	7.1	6.6	15	390	79	20	445	11	285	10	75	25	.01	3.9	1.6	2.0	<0.1	4.7	0.2	2.1	0.4	-	365
63	7/12/72	P	19	810	7.2	9.8	20	380	74	20	48	11	295	15	75	3	<.01	3.7	1.6	2.1	<0.1	4.8	0.3	2.1	0.1	-	377
64	8/12/72	W/M	20	890	7.4	5.4	20	425	60	7	103	<11	315	25	80	2	<.01	3.0	0.6	4.5	<0.1	5.2	0.5	2.3	<0.1	-	423
65	1/11/72	P	15	330	7.1	8.5	15	340	89	7	31	<1	260	10	42	25	<.01	4.5	0.6	1.3	-	4.6	0.2	1.2	0.4	-	315
66	17/11/72	B	18	620	7.3	2.6	10	292	53	10	47	2	119	15	72	<0.5	<.01	2.6	0.8	2.0	0.1	3.1	0.3	2.0	-	-	292
67	3/11/72	P	15	255	7.3	7.6	20	368	63	23	40	4	250	10	70	35	<.01	3.1	1.9	1.7	0.1	4.1	0.2	2.0	0.6	-	333
68	3/11/72	B	16	230	8.3	3.2	15	321	29	26	66	3	165	25	95	1.5	.03	1.4	1.6	2.9	0.1	2.7	0.5	2.7	-	-	320
69	31/10/72	P	16	236	7.6	5.8	25	278	73	10	24	<1	245	10	35	5	<.01	3.6	0.8	1.0	-	4.0	0.2	1.0	0.1	-	273
71	31/10/72	P	16	310	7.1	9.2	30	602	122	40	59	<1	405	10	170	6	<.01	6.1	3.3	2.6	-	6.6	0.2	4.8	0.1	-	596
72	1/11/72	P	16	240	7.3	8.5	5	408	69	33	40	1	320	15	170	22	<.01	3.5	2.6	1.7	-	5.2	0.3	2.0	0.1	-	456
73	7/12/72	W/M	16	1380	6.9	7.2	10	735	81	34	158	4	500	25	185	<1	<.01	4.0	2.8	6.9	0.1	8.2	0.5	5.2	<0.1	-	735
74	7/12/72	W/M	17	750	7.1	9.9	15	385	66	26	18	1	315	15	60	13	<.01	3.3	2.1	2.1	<.1	5.2	0.3	1.7	0.2	-	372
75	8/12/72	W/M	16	830	7.1	7.4	15	440	88	13	68	<1	305	15	105	<1	<.01	4.4	1.1	3.0	<.1	5.0	0.3	3.0	<.1	-	440
76	10/11/72	P	15	760	7.2	8.6	10	393	83	11	50	2	265	10	67	40	.02	4.1	0.9	2.2	-	4.4	0.2	1.9	0.6	-	353
77	6/11/72	P	15	540	7.1	-	15	447	64	22	68	3	312	5	96	75	<.01	3.2	1.8	3.0	0.1	5.1	0.1	2.7	0.5	-	372
78	30/10/72	P	16	710	7.1	10+	15	407	93	20	24	<1	285	15	45	70	<.01	4.6	1.6	1.0	-	4.7	0.3	1.3	1.1	-	337
79	28/11/72	W/M	21	720	7.4	7.5	10	427	80	16	49	1	267	10	60	80	<.01	4.0	1.3	2.1	-	4.4	0.2	1.7	1.3	-	347
80	31/10/72	P	15	208	7.1	6.6	10	304	76	9	30	<1	260	15	35	11	<.01	3.8	0.7	1.3	-	4.3	0.3	1.0	0.2	-	293
81	1/11/72	P	15	590	7.2	9.2	15	380	87	13	41	1	275	10	82	16	<.01	4.4	1.0	1.8	-	4.5	2.2	2.3	0.2	-	364
82	6/11/72	P	15	1260	7.1	-	10	580	108	40	98	12	<5	5	157	160	.07	5.4	3.3	4.3	0.3	0	18.0	4.4	2.6	-	420
83	1/12/72	P	17	770	7.0	7.7	10	420	104	9	38	<1	265	10	69	60	<.01	5.2	0.7	1.7	<.1	4.3	0.2	1.9	1.0	-	360
84	30/10/72	P	16	700	7.1	-	15	385	82	15	40	<1	280	15	60	35	<.01	4.1	1.2	1.7	-	4.6	0.3	1.7	0.6	-	350
85	30/10/72	P	15	950	7.0	6.5	15	504	99	20	72	1	340	20	120	5	<.01	4.9	1.6	3.1	-	5.6	0.4	3.4	0.1	-	200
86	31/10/72	P	16	900	7.0	8.9	25	628	110	42	72	<1	390	25	175	12	<.01	5.5	3.5	3.1	-	6.4	0.5	4.9	0.2	-	616
87	1/11/72	P	16	290	7.0	8.5	15	467	105	12	63	1	350	10	105	<5	<.01	5.2	1.0	2.7	-	5.7	2.0	3.0	-	-	467
88	7/12/72	P	18	1140	7.1	2.0	15	580	95	27	97	5	405	15	145	<1	.03	4.7	2.2	4.2	0.1	6.6	0.3	4.1	<.1	-	550
89	31/10/72	B	16	270	7.8	7.5		SAME AS BLA 60																			
90	20/11/72	W/M	16	790	7.3	7.8	15	436	86	23	35	1	305	10	51	80	<.01	4.3	1.9	1.5	-	5.0	0.2	1.4	1.3	-	356
91	20/11/72	W/M	15.5	890	7.0	3.4	20	470	93	17	68	1	380	10	90	4	<.01	4.6	1.4	3.0	-	6.2	0.2	2.5	0.1	-	466
92	1/12/72	W/M	18	730	7.4	8.0	15	381	89	6	43	1	290	5	61	30	1.0	4.4	0.7	1.9	<0.1	4.8	0.1	1.7	0.5	-	351
93	1/12/72	W/M	18	1330	7.3	8.2	10	747	99	27	155	2	445	40	185	20	.08	4.9	2.2	6.7	<0.1	7.3	0.8	5.2	0.3	-	727
96	22/11/72	W/M	16	1460	7.2	10+	25	816	167	23	80	1	325	<5	170	215	<.01	8.3	1.9	3.5	-	5.3	-	4.8	3.5	-	600

WATER ANALYSIS RESULTS

Hd. CAROLINE

Milligrammes per Litre — Milli-equivalents per Litre

BORE	DATE	Sampling Method	Temp.	Cond.	pH	Dissolved Oxygen	COD	SALINITY	Ca	Mg	Na	K	HCO_3	SO_4	Cl	NO_3	PO_4	Ca	Mg	Na	K	HCO_3	SO_4	Cl	NO_3	PO_4	Red Salinity
CAR 1	21/11/72	B	17	980	7.1	7.6	5	532	121	18	51	1	273	20	143	41	.02	6.0	1.5	2.3	-	4.5	0.4	4.0	0.7	-	491
2	21/11/72	W/M	16	800	7.1	7.5	5	442	87	16	50	2	251	15	84	65	<.01	4.3	1.3	2.2	-	4.1	0.3	2.4	1.1	-	387
3	21/11/72	W/M	18	610	7.1	8.7	15	308	70	8	33	1	220	10	60	18	.01	3.5	0.7	1.4	-	3.6	0.2	1.7	0.3	-	290
4	21/11/72	W/M	18	810	7.2	7.6	15	417	77	20	54	2	300	15	84	17	<.01	3.8	1.6	2.3	<0.1	4.9	0.3	2.4	0.3	-	400
5	21/11/72	W/M	18	930	7.0	6.0	10	537	119	10	49	5	245	25	98	110	<.01	5.9	0.8	2.1	0.1	4.0	0.5	2.8	1.8	-	427
7	21/11/72	B	16	1380	7.0	2.8	20	706	77	29	153	5	345	10	260	2	.11	3.8	2.4	6.7	0.1	5.7	0.2	7.3	-	-	704
8	21/11/72	W/M	18	970	7.0	4.5	30	553	45	11	162	1	390	25	103	11	<.01	2.2	0.9	7.0	-	6.4	0.5	2.9	0.2	-	540
9	15/11/72	P	16	820	7.2	6.8	10	420	75	27	49	2	335	15	79	8	-	3.7	2.2	2.1	0.1	5.5	0.3	2.2	0.1	-	412
10	15/11/72	P	19	11000	7.1	5.7	35	7212	140	270	2140	82	305	570	3860	<0.5	.02	7.0	22.3	93.1	2.1	5.0	11.7	108.9	-	-	7212
11	15/11/72	P	17	10000	7.2	3.8	50	5906	149	223	1720	60	315	430	3165	4	-	7.4	18.3	74.8	1.5	5.2	8.9	0.1	-	-	5902
12	29/11/72	W/M	18	770	7.4	7.4	15	375	78	9	45	<1	230	10	65	50	.03	3.9	0.7	2.0	<0.1	3.8	0.2	1.8	0.8	-	325
13	29/11/72	W/M	21	560	7.7	6.2	15	255	55	6	29	<1	135	5	50	45	.01	2.7	0.5	1.3	<0.1	2.2	0.1	1.4	0.7	-	210
14	29/11/72	W/M	17	650	7.4	8.1	15	400	93	7	30	<1	185	5	50	125	<.01	4.6	0.6	1.3	0.1	3.0	0.1	1.4	2.0	-	275
15	29/11/72	W/M	18	710	7.3	8.2	15	365	92	8	36	<1	260	10	65	28	<.01	4.6	0.7	1.6	<0.1	4.3	0.2	1.8	0.5	-	337
16	23/11/72	W/M	15	610	7.1	6.0	15	324	78	10	30	<1	250	5	52	26	<.01	3.9	0.8	1.3	-	4.1	0.1	1.5	0.4	-	298
17	16/11/72	B	17	1030	7.4	8.9	10	519	85	9	108	<1	253	20	170	2	<.01	4.2	0.7	4.7	-	4.2	0.4	4.8	0.1	-	517
18	16/11/72	B	16	730	7.4	5.5	10	387	73	23	48	2	325	5	71	5	<.01	3.6	1.9	2.1	0.1	5.3	0.1	2.0	0.1	-	382
19	15/11/72	B	15	540	7.0	9.8	5	303	89	7	19	<1	300	10	30	0.5	.01	4.4	0.6	0.8	-	4.9	0.2	0.8	-	-	303
20	16/11/72	B	16	655	7.3	9.0	10	357	78	6	31	8	160	10	69	70	.01	3.9	0.5	1.3	0.2	2.6	0.2	2.0	1.1	-	281
21	16/11/72	B	14	880	7.2	4.2	15	472	87	19	74	<1	340	15	110	<0.5	<.01	4.3	1.6	3.2	-	5.6	0.3	3.1	-	-	472
22	15/11/72	B	15	560	7.1	8.8	10	297	63	13	32	1	225	15	54	8	-	3.1	1.1	1.4	-	3.7	0.3	1.5	0.1	-	291
23	15/11/72	P	13.5	1050	7.4	0.5	40	551	107	14	83	5	365	20	130	12	1.2	5.3	1.2	3.6	0.1	6.0	0.4	3.7	0.2	0.1	540
24	16/11/72	W/M	17	740	7.2	7.6	15	401	94	8	47	3	265	15	86	18	.01	4.7	0.7	2.0	0.1	4.3	0.3	2.4	0.3	-	383

HUNDRED MACDONNELL

Milligrammes per litre — Milli-equivalents per litre

Bore	Date	Sampling Method	Temp.	Cond.	pH	Dissolved Oxygen	COD	Salinity	Ca	Mg	Na	K	HCO3	SO4	Cl	NO3	PO4	Ca	Mg	Na	K	HCO3	SO4	Cl	NO3	PO4	Red Salinity
MAC 2	30/11/72	W/M	19	810	7.4	8.7	15	396	86	15	42	<1	255	<5	83	15	<.01	4.3	1.2	1.8	<.1	4.2	<.1	2.3	0.7	-	351
3	30/11/72	B	15	1090	6.9	5.5	15	638	125	12	43	35	300	10	73	190	<.01	6.2	1.0	1.9	0.9	4.9	0.2	2.9	3.0	-	446
4	30/11/72	P	18	640	7.4	9.4	15	315	71	10	36	<1	215	<5	67	30	<.01	3.5	0.8	1.6	<.1	3.6	<0.1	1.8	0.5	-	285
5	30/11/72	W/M	19	840	7.4	6.2	10	435	100	10	44	1	255	10	75	70	.01	5.0	0.8	1.9	<0.1	4.2	0.2	2.1	1.1	-	365
6	22/11/72	W/M	15	810	7.4	7.8	10	477	90	10	48	11	184	5	70	153	<.01	4.5	0.8	2.1	0.3	3.0	0.1	2.0	2.5	-	325
7	30/11/72	W/M	19	860	7.4	8.0	10	450	96	11	38	<1	150	5	70	110	<.02	4.8	0.9	1.7	<.1	3.0	0.1	2.0	2.2	-	410
8	30/11/72	W/M	15	720	7.2	7.6	10	413	80	12	40	<1	180	5	62	125	.01	4.0	1.0	1.7	0.1	2.9	0.1	1.8	2.0	-	256
9	29/11/72	W/M	18	810	7.3	7.9	20	460	92	14	45	1	215	10	82	110	.01	4.6	1.2	2.0	<0.1	3.6	0.2	2.3	1.7	-	350
10	30/11/72	W/M	17	630	7.3	5.8	20	325	64	13	28	1	160	10	55	75	.02	3.2	1.1	1.2	<0.1	2.6	0.2	1.6	1.2	-	250
11	30/11/72	W/M	18	920	7.2	2.7	20	469	65	19	87	2	315	15	96	30	<.01	3.2	1.6	3.8	<0.1	5.2	0.3	2.7	0.5	-	439
12	30/11/72	P	15	1300	7.0	4.1	20	684	74	31	138	12	355	20	216	16	.01	3.7	2.5	6.0	0.3	5.8	0.4	6.2	0.3	-	665
13	22/11/72	W/M	17	710	7.3	4.4	10	366	81	12	38	<1	245	10	65	40	<.01	4.0	1.0	1.7	-	4.0	0.2	1.8	0.6	-	326
14	30/11/72	W/M	24	820	7.5	4.9	15	430	92	12	40	3	235	10	75	60	.15	4.6	1.0	1.7	0.1	3.9	0.2	2.1	1.3	-	350
15	22/11/72	B	17	750	7.4	8.3	15	376	83	10	46	2	260	<5	77	30	.01	4.1	0.8	2.1	0.1	4.3	-	2.2	0.5	-	346
16	30/11/72	P	19	680	7.5	6.4	25	335	65	19	36	1	265	10	65	10	.01	3.2	1.6	1.6	<0.1	4.3	0.2	1.8	0.1	-	325
17	22/11/72	P	17	1320	7.0	8.0	15	762	156	23	73	2	340	15	146	180	<.01	7.8	1.9	3.2	-	5.6	0.3	4.1	2.9	-	582
19	30/11/72	W/M	18	1300	7.2	8.4	25	767	132	16	56	50	275	10	106	260	<.01	6.6	1.3	2.5	1.3	4.5	0.2	3.0	4.2	-	507
20	30/11/72	W/M	23	810	7.4	10	15	375	71	14	52	1	275	10	70	20	.01	3.5	1.2	2.3	<.1	4.5	0.2	2.0	0.3	-	355
21	30/11/72	W/M	19	780	7.4	7.3	20	395	81	13	45	1	265	10	72	10	.01	4.0	1.1	2.0	0.1	4.4	0.2	2.0	0.7	-	355
22	30/11/72	P	20	800	7.4	8.8	15	430	92	11	60	1	345	15	70	9	.05	4.6	0.9	2.6	<0.1	5.6	0.3	2.0	0.2	-	420
23	22/11/72	W/M	17	595	7.7	7.5	10	302	68	6	36	1	173	15	67	21	<.01	3.4	0.5	1.6	-	2.8	0.3	2.9	0.4	-	278
24	21/11/72	W/M	16	1060	7.1	8.3	10	583	140	13	60	<1	384	20	111	17	<.01	7.0	1.1	2.6	-	6.3	0.4	3.2	0.8	-	536
25	15/11/72	P	14	780	7.3	0.8	15	381	62	18	60	2	255	5	107	1.5	<.01	3.1	1.5	2.6	0.1	4.2	1.0	3.0	-	-	360
26	21/11/72	W/M	16	1010	7.6	7.8	15	541	75	18	94	3	212	25	182	30	<.01	3.7	1.5	4.1	0.3	3.5	0.5	5.1	0.5	-	511
27	21/11/72	W/M	16	1780	7.1	2.0	25	1000	108	44	205	3	468	130	279	1	<.01	5.4	3.6	8.9	0.1	7.7	2.7	7.9	-	-	1000
MAC 28	21/11/72	B	17	1220	7.2	3.8	15	625	92	37	92	5	395	35	156	17	.01	4.6	3.0	4.0	0.1	6.5	0.7	4.4	0.3	-	611
29	21/11/72	B	16	1370	7.3	7.0	15	721	108	38	100	3	356	55	192	50	.01	5.4	3.1	4.4	0.1	5.8	1.1	5.4	0.8	-	671
30	21/11/72	W/M	17	1360	7.0	6.6	10	706	109	32	114	2	365	45	207	17	<.01	5.4	2.6	5.0	<0.1	6.0	1.0	5.8	0.3	-	691
31	22/11/72	W/M	17	3100	7.3	2.4	15	1661	110	70	420	11	334	105	780	1.0	<.01	5.5	5.8	18.3	0.3	5.5	2.2	22.0	-	-	1660
32	22/11/72	W/M	16	1540	7.1	2.5	35	689	133	43	136	3	390	155	220	<.01	0.15	6.6	3.5	5.9	0.2	6.4	3.3	6.2	-	-	659
33	22/11/72	W/M	17	1120	7.2	2.5	30	598	102	32	61	4	395	55	130	<.01	<.01	5.1	2.6	3.5	0.1	6.5	1.1	3.7	-	-	598
34	29/11/72	W/M	17	900	7.3	7.9	20	480	97	17	58	<1	285	<5	118	50	<.01	4.8	1.4	2.5	<0.1	4.7	<0.1	3.3	0.8	-	430
35	16/11/72	P	15	825	7.2	5.0	20	436	70	27	62	2	295	10	110	10	.02	3.5	2.2	2.7	0.1	4.8	0.2	3.1	0.2	-	426
38	22/11/72	W/M	17	900	7.7	6.9	10	450	97	9	63	1	295	10	90	30	<.01	4.8	0.7	2.7	-	4.8	0.2	2.5	0.6	-	115
36	29/11/72	W/M	17	780	7.3	7.7	15	385	75	8	53	1	205	15	80	35	.02	3.7	0.7	2.3	<0.1	3.3	0.3	2.2	0.9	-	330
40	22/11/72	B	17	1100	7.1	8.7	15	589	101	16	99	2	284	25	151	55	<.01	5.0	1.3	4.3	-	4.7	0.5	4.3	0.9	-	534
41	22/11/72	W/M	17	635	7.2	8.5	10	341	78	8	32	2	217	15	56	13	<.01	3.9	0.7	1.4	-	3.6	0.3	1.6	0.7	-	298
42	21/11/72	W/M	13	690	7.6	8.0	5	361	67	13	46	1	273	15	70	10	<.01	3.3	1.5	2.0	-	4.5	0.3	2.0	0.2	-	351
44	22/11/72	W/M	18	2350	7.1	4.6	15	1154	130	5	300	3	340	55	479	15	<.01	6.5	0.4	13.1	0.1	5.6	1.1	13.5	0.2	-	1140
45	21/11/72	B	16	1130	7.3	3.8	35	535	49	45	94	5	239	20	204	<0.5	.04	2.4	3.7	4.1	0.1	3.9	0.4	5.8	-	-	535

HUNDRED MINGBOOL

Milligrammes per Litre — Milli-equivalents per litre

Bore	Date	Sampling Method	Temp.	Cond.	pH	Dissolved Oxygen	COD	Salinity	Ca	Mg	Na	K	HCO3	SO4	Cl	NO3	PO4	Ca	Mg	Na	K	HCO3	SO4	Cl	NO3	PO4	Red Salinity
MIN 1	27/11/72	W/M	15	1800	7.1	3.0	10	869	142	23	164	2	381	40	311	0.5	<.01	7.1	1.9	7.1	-	6.2	0.8	8.8	-	-	869
2	27/11/72	W/M	17	750	7.3	1.5	20	394	82	9	57	9	276	10	91	0.5	<.01	4.1	0.7	2.5	0.2	4.5	0.2	2.6	-	-	394
3	28/11/72	W/M	14	1320	6.9	1.3	20	686	137	15	113	1	434	5	188	14	<.01	6.8	1.2	4.9	-	7.1	0.1	5.3	0.2	-	672
4	27/11/72	B	17	880	7.1	3.4	25	454	88	11	72	2	309	15	97	17	.01	4.4	0.9	3.1	-	5.1	0.3	2.7	0.3	-	437
5	27/11/72	W/M	17	980	7.2	1.3	15	508	113	9	79	1	376	5	116	<1	.01	5.6	0.7	3.4	-	6.2	0.1	3.3	-	-	508
6	14/11/72	P	14	1460	7.0	3.9	15	727	124	18	133	1	435	25	203	9	-	6.2	1.5	5.6	-	7.1	0.5	5.7	0.1	-	718
7	14/11/72	B		395	8.7	3.3	15	196	17	6	48	4	134	5	50	<1	-	0.8	0.5	2.1	0.1	2.2	0.1	1.4	-	-	196
8		NOT ALLOCATED																									
9		"																									
10	27/11/72	W/M	18	2100	7.1	3.2	25	1081	176	29	205	1	440	20	434	<0.5	<.01	8.8	2.4	6.9	-	7.2	0.4	12.2	-	-	1081
11	23/11/72	B	15	1430	7.3	2.3	15	752	69	22	187	11	295	5	295	18	<.01	3.4	1.8	8.1	0.3	4.8	0.1	8.3	0.3	-	734
12	23/11/72	B	15	1800	7.0	2.8	15	843	88	19	215	2	323	10	350	0.5	<.01	4.4	1.6	9.4	-	5.3	0.2	9.9	-	-	843
13	27/11/72	B	17	1650	7.9	2.2	20	825	52	23	205	8	339	5	312	53	.01	2.6	1.9	8.9	0.2	5.5	0.1	8.8	0.9	-	872
14	27/11/72	W/M	15	1200	7.3	4.5	30	691	93	13	83	79	329	40	115	105	1.74	4.6	1.1	3.6	2.0	5.4	0.8	3.2	1.7	-	586
15	23/11/72	W/M	15½	1240	7.2	2.4	10	646	108	13	130	1	345	20	204	0.5	<.01	5.4	1.1	5.7	-	5.7	0.4	5.8	-	-	646

HUNDRED YOUNG

Milligrams per litre

Bore	Date	Sampling Method	Temp.	Cond.	pH	Dissolved Oxygen	COD	Salinity	Ca	Mg	Na	K	HCO3	SO4	Cl	NO3	PO4	Ca	Mg	Na	K	HCO3	SO4	Cl	NO3	PO4	Red Salinity
YOU 1	20/11/72	B	16°	730	7.3	9.0	15	415	96	13	40	1	285	<5	60	6.5	<.01	4.7	1.1	1.7	-	4.7	-	1.7	1.0	-	409
2	30/10/72	P	17°	375	7.1	-	15	239	56	7	26	1	210	15	30	0.5	<.01	2.8	0.6	1.1	-	3.4	0.3	0.9	-	-	239
3	30/10/72	P	16°	425	7.2	-	10	265	60	15	22	4	245	10	30	7.5	<.01	3.0	1.2	0.9	-	4.0	0.2	0.8	0.1	-	257
4	28/11/72	W/M	17°	910	7.5	6.8	15	445	101	13	50	1	264	15	105	30	<.01	5.0	1.1	2.2	-	4.3	0.3	3.0	0.5	-	415
5	28/11/72	W/M	16°	1080	7.3	2.5	15	532	100	25	77	2	395	<5	129	5	.01	5.0	2.1	3.3	-	6.5	-	3.6	0.1	-	527
6	28/11/72	W/M	16°	760	7.4	7.8	10	398	83	15	39	2	256	10	59	64	<.01	4.1	1.2	1.7	-	4.2	0.2	1.7	1.0	-	334
7	28/11/72	B	15°	760	7.0	3.5	10	384	98	10	32	4	301	<5	60	32	.01	4.9	0.8	1.4	0.1	4.9	-	1.7	0.5	-	352
8		8U sampled instead																									
9		NOT TO BE SAMPLED																									
15	20/11/72	W/M	18°	850	7.9	10.0	10	451	96	12	57	1	295	20	88	32	<.01	4.8	1.0	2.5	-	4.8	0.4	2.5	0.5	-	418
16	20/11/72	B	17°	790	6.4	3.2	80	428	50	16	92	2	285	50	78	<0.5	.02	2.5	1.2	4.0	0.1	4.7	1.0	2.2	-	-	428
17	27/11/72	W/M	16°	1100	7.3	2.8	10	634	98	29	93	<1	326	70	119	65	<.01	4.9	2.-	4.0	-	5.3	1.4	3.4	1.0	-	569
18	27/11/72	W/M	17°	1150	7.2	1.5	25	671	100	17	133	1	429	55	154	<0.5	.02	5.0	1.4	5.8	-	7.0	1.1	4.3	-	-	671
19	20/11/72	W/M	15°	1600	6.9	-	25	924	116	32	195	1	380	40	347	6.5	<.01	5.8	2.6	8.5	-	6.2	0.8	9.8	0.1	-	917
20	20/11/72	W/M	15°	1580	6.8	-	30	795	177	25	89	1	335	15	315	7.5	<.01	8.8	2.1	3.9	-	5.5	0.3	8.9	0.1	-	787
21	20/11/72	W/M	17°	870	7.1	3.4	15	436	90	17	60	1	375	15	68	<0.5	<.01	4.5	1.4	2.6	-	6.2	0.3	1.9	-	-	436
22	27/11/72	W/M	17°	1060	7.2	1.9	15	533	117	11	78	2	376	5	125	10	<.01	5.8	0.9	3.4	-	6.2	0.1	3.5	0.2	-	523

WATER ANALYSIS RESULTS

[illegible] GAMBIER

Bore	Date	Sampling Method	Temp.	Cond.	pH	Dissolved Oxygen	COD	Salinity	Milligrams per litre									Milli-equivalents Per Litre									Red Salinity
									Ca	Mg	Na	K	HCO3	SO4	Cl	NO3	PO4	Ca	Mg	Na	K	HCO3	SO4	Cl	NO3	PO4	
GAM 1	27/11/72	W/M	14.5	1240	7.1	5.1	15	677	132	19	102	4	373	25	194	18	<.01	6.6	1.6	4.4	0.1	6.1	0.5	5.5	0.3	-	659
2	27/11/72	W/M	15	780	7.1	4.3	15	411	90	11	52	<1	292	10	83	24	.01	4.5	0.9	2.3	-	4.8	0.2	2.3	0.4	-	390
3	24/11/72	W/M	14	590	7.4	6.3	5	330	69	9	33	<1	178	10	46	75	<.01	3.4	0.7	1.4	-	2.9	0.2	1.3	1.2	-	255
4	24/11/72	W/M	14	730	7.0	8.7	5	383	71	15	51	1	251	10	76	36	<.01	3.5	1.2	2.2	-	4.1	0.2	2.1	0.6	-	347
5	24/11/72	W/M	16	720	7.7	8.0	15	389	78	10	52	1	255	10	66	47	.06	3.9	0.8	2.3	-	4.2	0.2	1.9	0.8	-	342
6	30/10/72	B	16	1550	7.1	-	30	1173	229	24	109	1	265	15	215	450	<.01	11.4	2.0	4.7	-	4.3	0.3	6.1	7.2	-	725
7	8/11/72	B	15	600	7.0	9.0	10	310	61	18	31	3	285	10	35	7.5	<.01	3.0	1.5	1.5	0.1	4.7	0.2	1.0	0.1	-	303
8	7/11/72	P	15	750	7.2	10.0	10	381	62	31	37	3	298	<5	58	43	<.01	3.1	2.6	1.6	0.1	4.9	-	1.6	0.7	-	335
9	7/11/72	P	15	1070	7.0	9.0	10	494	78	33	58	1	225	<5	129	70	<.01	3.9	2.7	2.5	-	3.2	-	3.6	1.1	-	424
10	29/11/72	W/M	19	755	7.4	3.4	15	365	79	17	40	<1	280	10	65	20	<.01	3.9	1.4	1.7	<0.1	4.6	0.2	1.8	0.3	-	345
11	29/11/72	W/M	23	740	7.6	7.5	20	375	82	9	38	<1	200	5	60	65	<.01	4.1	0.7	1.7	<0.1	3.3	0.1	1.7	1.4	-	290
12	7/11/72	P	15	710	7.2	9.5	15	370	69	19	40	3	253	<5	56	55	1.35	3.4	1.6	1.7	0.1	4.2	-	1.6	0.9	-	315
13	24/11/72	W/M	14.5	640	7.5	6.5	5	338	74	9	38	2	184	15	78	32	<.01	3.7	0.7	1.7	-	3.0	0.3	2.2	0.5	-	306
14	24/11/72	P	15	1000	7.1	3.4	10	524	102	14	80	3	362	10	127	10	<.01	5.1	1.2	3.5	0.1	5.9	0.2	3.6	0.2	-	514
15	24/11/72	W/M	15.5	790	7.5	8.3	15	438	84	11	55	1	280	20	81	42	<.01	4.2	1.2	2.5	-	4.6	0.4	2.3	0.7	-	396
16	24/11/72	W/M	15	720	7.5	3.8	15	386	75	10	57	1	228	5	89	37	.04	3.7	0.8	2.5	-	3.7	0.1	2.5	0.6	-	349
17	24/11/72	W/M	15	740	7.4	7.5	20	390	83	12	47	1	267	<5	76	30	.06	4.1	1.0	2.0	-	4.4	-	2.1	0.6	-	350
18	9/11/72	P	16	720	7.2	10.6	15	358	77	10	18	<1	250	10	65	25	<.01	3.8	0.8	2.1	-	4.1	0.2	1.8	0.4	-	333
19	7/11/72	P	15	1010	6.9	9.6	20	482	60	31	66	6	270	10	94	80	<.01	3.0	2.5	2.9	0.2	4.4	0.2	2.7	1.3	-	402
20	9/11/72	P	15	710	7.1	9.9	10	241	95	13	41	<1	-	5	60	27	.03	4.7	1.1	1.8	-	-	0.2	1.7	0.4	-	214
21	9/11/72	P	15	890	6.9	8.9	10	466	111	14	48	<1	325	15	90	28	<.01	5.5	1.2	2.1	-	5.3	0.3	2.5	0.5	-	442
22	9/11/72	P	15	620	7.1	10.4	10	329	72	15	30	<1	230	10	50	39	<.01	3.6	1.2	1.3	-	3.8	0.2	1.4	0.6	-	290
23	7/11/72	P	15	900	7.2	-	15	448	48	13	54	5	309	5	81	60	.01	2.4	3.5	2.4	0.1	5.1	0.1	2.3	1.0	-	355
24	NOT TO BE SAMPLED																										
25	24/11/72	W/M	15	960	7.5	6.5	25	538	89	23	80	1	267	30	134	50	.01	4.4	1.9	3.5	-	4.4	0.6	3.8	0.8	-	455
26	24/11/72	W/M	16	750	7.0	5.6	15	408	81	11	55	1	280	20	81	18	<.01	4.2	0.9	2.4	-	4.6	0.4	2.3	0.3	-	390
27	24/11/72	W/M	16	615	7.4	6.7	15	333	69	8	44	1	235	10	52	33	.01	3.4	0.7	1.9	-	3.9	0.2	1.5	0.5	-	300
28	13/11/72	P	15	590	7.1	10.0	15	322	72	7	36	<1	225	10	52	34	-	3.6	0.6	1.6	-	3.7	0.2	1.5	0.5	-	255
29	13/11/72	P	15	660	7.1	9.4	10	353	83	8	37	<1	260	10	53	34	-	4.1	0.7	1.6	-	4.3	0.2	1.5	0.5	-	319
30	13/11/72	P	15	610	7.0	9.4	15	324	75	9	34	<1	240	10	53	25	-	3.7	0.7	1.5	-	3.9	0.2	1.5	0.4	-	299
31	29/11/72	W/M	16	810	7.3	7.9	15	450	95	13	55	1	290	10	70	60	<.01	4.7	1.1	2.4	-	4.8	0.2	2.0	1.0	-	390
32	29/11/72	B	17	610	7.3	7.0	15	320	64	7	46	<1	195	10	65	30	<.01	3.2	0.6	2.0	-	3.2	0.2	1.8	0.5	-	290
33	29/11/72	B	18	630	7.4	6.7	10	325	83	8	28	3	250	5	45	30	.01	4.1	0.7	1.2	0.1	4.1	0.1	1.3	0.5	-	295
34	27/11/72	W/M	15	970	7.3	2.4	20	496	77	11	100	<1	228	40	156	<0.5	<.01	3.8	0.9	4.4	-	3.7	0.8	4.4	-	-	496
35	24/11/72	P	14	1260	7.1	1.5	20	687	112	23	120	4	384	35	197	7	<.01	5.6	1.9	5.2	0.1	6.3	0.7	5.6	0.1	-	650
36	24/11/72	W/M	15	690	7.4	2.3	15	376	86	9	42	2	290	20	54	17	.01	4.3	0.7	2.0	0.1	4.8	0.4	1.5	0.3	-	359
37	14/11/72	P	15	580	7.4	4.0	15	315	71	8	38	1	225	15	60	11	-	3.5	0.7	1.7	-	3.7	0.3	1.7	0.2	-	301
38	24/11/72	W/M	16	680	7.4	4.6	15	352	83	9	42	<1	267	5	69	13	<.01	4.1	0.7	1.8	-	4.4	0.1	1.9	0.2	-	339
39	23/11/72	P	16.5	740	7.3	6.2	15	397	93	9	44	<1	267	5	69	16	<.01	4.6	0.7	1.9	-	4.4	0.1	1.9	0.2	-	351
40	23/11/72	W/M	16	720	7.4	8.5	15	395	90	9	41	<1	228	5	73	65	.01	4.5	0.7	1.8	-	3.7	0.1	2.1	1.1	-	330
41	23/11/72	P	14	725	7.1	8.0	10	419	90	10	48	1	267	10	69	60	.01	4.5	0.8	2.1	-	4.4	0.2	1.9	1.0	-	359
42	29/11/72	W/M	17	660	7.5	7.8	20	350	77	10	42	<1	255	5	60	30	<.01	3.8	0.8	1.8	-	4.2	0.1	1.7	0.5	-	320
43	29/11/72	P	17	710	7.3	8.0	15	360	85	12	32	<1	310	5	60	4	<.01	4.0	1.0	1.5	-	5.1	0.1	1.7	0.1	-	358
44	29/11/72	W/M	17	630	7.6	9.5	15	325	83	5	30	3	220	5	50	40	0.11	4.1	0.4	1.3	0.1	3.6	0.1	1.4	0.7	-	255
45	24/11/72	W/M	14	820	7.3	4.5	20	438	86	9	67	1	245	25	113	17	<.01	4.3	0.7	2.9	-	4.0	0.5	3.2	0.3	-	421
46	14/11/72	B	16	580	7.7	2.8	10	311	60	6	51	<1	205	20	73	<1	-	3.0	0.5	2.2	-	3.4	0.4	2.1	-	-	311
47	14/11/72	P	16	660	7.3	2.9	10	357	83	8	40	1	250	25	69	5	-	4.1	0.7	1.7	-	4.1	0.5	1.9	0.1	-	349
48	14/11/72	B	16	600	8.2	6.0	30	346	43	9	80	1	160	<5	134	0.5	.01	2.1	0.7	3.5	-	2.6	-	3.8	-	-	346
49	23/11/72	W/M	16	880	7.3	6.0	10	461	108	9	62	1	334	<5	108	9	.01	5.4	0.7	2.7	-	5.5	-	3.0	0.1	-	452
50	23/11/72	W/M	16	590	7.6	8.5	10	300	72	6	33	<1	206	5	49	34	.01	3.6	0.5	1.4	-	3.4	0.1	1.4	0.5	-	266
51	23/11/72	W/M	16	660	7.6	8.0	10	350	78	11	38	<1	245	5	45	41	<.01	3.9	0.9	1.7	-	4.0	0.1	1.5	0.7	-	306
52	13/11/72	P	16	750	6.9	6.5	15	392	89	13	43	1	300	10	75	13	-	4.4	1.1	1.9	-	4.9	0.2	2.9	0.2	-	379
53	23/11/72	P	15	860	7.2	8.0	15	461	102	14	50	1	295	15	84	70	<.01	5.1	1.2	2.2	-	4.8	0.3	2.4	1.1	-	411
54	23/11/72	W/M	15	550	7.2	8.6	10	283	77	5	25	<1	211	5	53	14	<.01	3.8	0.4	1.1	-	3.5	0.1	1.5	0.2	-	269
55	23/11/72	W/M	15	700	6.8	6.0	10	390	103	8	40	1	340	5	60	6	.03	5.1	0.7	1.7	-	5.6	0.1	1.7	0.1	-	394
56	8/11/72	P	15	750	7.0	9.2	10	391	77	21	41	2	295	10	55	40	<.01	3.8	1.7	1.8	-	4.8	0.2	1.6	0.6	-	351
57	29/11/72	B	14	2180	6.9	7.0	30	1270	202	64	102	6	260	10	280	480	0.92	10.1	5.3	4.4	0.2	4.3	0.2	7.9	7.7	-	790
58	8/11/72	P	15	730	7.2	8.0	10	375	64	21	48	3	290	15	65	13	0.65	3.2	2.0	2.1	0.1	4.8	0.3	1.8	0.2	-	362
59	8/11/72	P	16	900	7.2	6.4	15	465	88	21	62	2	345	15	85	22	<.01	4.4	1.7	2.7	-	5.7	0.3	2.4	0.4	-	443
60	9/11/72	P	15	680	7.0	9.9	10	336	78	9	35	1	225	5	60	37	<.01	3.9	0.7	1.5	-	3.7	0.1	1.7	0.6	-	299
61	10/11/72	P	15	560	7.0	-	10	315	69	10	36	2	215	5	52	35	.02	3.4	0.8	1.6	-	3.5	0.1	1.5	0.6	-	240
62	24/11/72	W/M	15	910	7.3	2.8	25	478	110	8	66	1	345	10	113	<0.5	<.01	5.5	0.7	2.9	-	5.7	0.2	3.2	-	-	476
63	23/11/72	W/M	15	1380	7.2	1.1	25	726	138	15	125	1	390	25	230	<0.5	<.01	6.9	1.2	5.4	-	6.4	0.5	6.5	-	-	726
64	13/11/72	B	15	760	7.5	9.6	15	327	82	7	32	3	260	10	40	25	-	4.1	0.6	1.4	0.1	4.3	0.2	1.1	0.4	-	302
[illegible]	23/11/72	W/M	16	660	7.3	3.5	15	348	87	6	40	3	278	<5	53	22	<.01	4.3	0.5	1.7	0.1	4.6	-	1.5	0.4	-	326

Bore	Date	Sampling Method	Temp.	Cond.	pH	Dissolved Oxygen	COD	Salinity	Milligrams per litre																		Red Salinity
									Ca	Mg	Na	K	HCO3	SO4	Cl	NO3	PO4	Ca	Mg	Na	K	HCO3	SO4	Cl	NO3	PO4	
Allendale Sinkhole	22/11/72	B	17.5°	810	7.4	45	10	429	80	21	57	2	317	15	86	12	<.01	4.0	1.7	2.5	-	5.2	0.3	2.4	0.2	-	417
Ewens Ponds	21/11/72	B	17.5°	760	7.4	8.8	5	367	73	20	46	2	290	15	73	13	<.01	3.6	1.6	2.0	-	4.8	0.3	2.1	0.2	-	372
Clarke Park Spring	22/11/72	B	17°	980	6.7	4.9	15	478	73	25	76	2	295	15	128	14	<.01	3.6	2.1	3.3	-	4.8	0.3	3.6	0.2	-	464
Allen's Quarry	17/11/72	B	15°	720	7.3	10.0	10	401	83	19	41	<1	306	10	60	37	<.01	4.1	1.6	1.8	-	5.0	0.2	1.7	0.6	-	364
Beach Spring	15/11/72	B	17°	1140	7.3	4.0	20	730	84	34	144	5	350	35	250	6	<.01	4.2	2.8	6.3	0.1	5.7	0.7	7.1	0.1	-	724
Spring Sect 159 BLA	20/11/72	B	14°	970	7.0	8.8	15	513	98	11	81	1	295	20	125	32	<.01	4.9	0.9	3.5	<0.1	4.8	0.4	3.5	0.5	-	491
BLN 12	1/12/72	W/M	22°	800	7.7	10	20	452	105	7	50	1	285	5	74	70	.06	5.2	0.6	2.2	<0.1	4.7	0.1	2.1	1.1	-	362
Little Blue Lake	12/12/72	B	19°	520	8.0	10	10	230	40	11	35	2	155	5	60	1	.01	2.0	0.9	1.5	<0.1	2.5	0.1	1.7	<0.1	-	229
Bullock Hole	12/12/72	B	16°	740	7.2	7.4	15	370	80	15	45	1	290	10	75	2	[illegible]	4.0	1.2	2.0	-	4.8	0.2	2.1	0.1	-	365
Umpherstones Cave	12/12/72	B	15°	2475	7.8	-	40	1520	208	45	230	9	110	605	320	45	0.13	10.4	3.7	10.0	0.2	1.8	12.6	9.0	0.9	-	1475
Showgrds. Shale	12/12/72	B	15°	915	7.1	6.3	15	460	90	18	62	2	315	30	95	7	1.24	4.5	1.5	2.7	0.1	5.2	0.6	2.7	0.1	-	453
8 Mile Creek	12/12/72	B	18°	1000	7.5	10	15	465	70	24	78	2	290	15	130	3	.01	3.5	2.0	3.4	0.1	4.8	0.3	3.7	0.1	-	462
Piccanninie Ponds Jetty	12/12/72	B	18°	3900	7.1	7.5	40	2045	94	83	560	19	335	130	995	<1	.01	4.7	6.8	24.4	0.5	5.5	2.7	26.1	-	-	2045
Pine Ponds Outlet	12/12/72	B	18°	3000	7.8	10	40	1500	94	65	380	13	320	95	700	<1	.01	4.7	5.3	16.5	0.3	5.2	2.0	19.7	-	-	1500

APPENDIX H

Whole Rock Analyses

(Gambier Limestone)

EXAMPLES OF WHOLE ROCK ANALYSES (24 March, 1955)

HD. BLANCHE SEC. UNKNOWN

$CaCO_3$	$MgCO_3$	SiO_2(5)	Fe_2O_3(F)	Al_2O_3(A)	S+F+A
96.79	1.73	0.50	0.17	0.69	1.36
97.59	1.50	0.52	0.19	0.33	1.04
96.79	1.83	0.34	0.15	0.49	0.98
69.71	1.11	24.48	0.84	2.90	28.22
93.97	0.76	2.22	0.50	1.14	3.86
91.43	5.72	0.50	0.12	0.16	0.78
98.05	1.04	0.44	0.24	0.24	0.92
96.98	1.22	0.40	0.42	0.30	1.12

(Expressed as weight percentage)

Samples identified as "Mount Gambier Limestone"

APPENDIX I

Sample Mass Balance Determination

BOREHOLE MIN 5

REACTION	CONSTITUENTS (millimoles/litre)						
Composition of Dissolved Salts	Na^+	K^+	Ca^{++}	Mg^{++}	Cl^-	$SO_4^=$	HCO_3^-
	3.43	0.03	2.82	0.37	3.27	0.05	6.16
1. Dissolution of Dolomite							
$Ca^{++} + Mg^{++} + 4HCO_3^- = CaMg(CO_3)_2 + 2CO_2 + 2H_2O$	3.43	0.03	2.45	0	3.27	0.05	4.68
2. Dissolution of Calcite							
$Ca^{++} + 2HCO_3^- = CaCO_3 + CO_2 + H_2O$	3.43	0.03	0.11	0	3.27	0.05	0
3. Addition of Cyclic Salt							
$0.86\ Na^+ + 0.02K^+ + 0.02\ Ca^{++} + 0.10Mg^{++} + Cl^- + 0.05\ SO_4^=$	0.62	-0.03	0.04	0	0	-0.09	0

APPENDIX J

Special Analyses

(Cu, Cr, As, Nitrogen analyses, all concentrations in mg/l)

Bore	Nitrogen Free & saline	Nitrogen	Nitrite	Nitrate
BLA 5	0.005	0.6	0.01	70
BLA 6	<T 0.005	0.05	0.01	50
BLA 8	0.005	0.08	<T 0.01	15
BLA 16	<T 0.005	0.045	0.01	45
BLA 17	0.025	0.05	0.01	55
BLA 18	0.005	0.09	0.01	285
BLA 20	0.005	0.04	0.01	50
BLA 21	0.02	0.05	0.01	10
BLA 22	0.02	0.035	<T 0.01	110
BLA 27	0.045	0.02	0.01	41
BLA 28	102	19	0.4	17
BLA 29	0.065	0.05	0.01	25
BLA 30	0.005	0.09	0.01	70
BLA 31	0.005	0.135	0.01	225
BLA 38	0.005	0.02	<T 0.01	41
BLA 49	0.025	0.08	0.01	110
BLA 40	0.005	0.065	0.01	27
BLA 41	0.005	0.11	0.02	250
BLA 42	0.025	0.05	0.01	65
BLA 52	0.01	0.045	0.01	45
BLA 50	2.25	0.56	0.05	3
BLA 53	0.06	0.025	0.01	0.5
BLA 67	0.065	0.04	0.22	38
BLA 76	0.005	0.02	<T 0.01	42
BLA 77	0.01	0.04	<T 0.01	33
BLA 81	0.04	0.025	0.01	17
BLA 82	0.005	0.045	0.01	143

Bore	Nitrogen Free & saline	Nitrogen Albuminoid	Nitrite	Nitrate
CAR 9	0.01	0.05	0.02	9
CAR 10	0.01	0.035	0.01	1
CAR 11	0.02	0.065	0.01	5
GAM 7	0.02	0.08	0.02	7
GAM 8	0.005	0.085	<T 0.01	41
GAM 9	0101	0.05	0.01	65
GAM 12	0.005	0.15	0.02	50
GAM 18	0.01	0.02	<T 0.01	27
GAM 19	0.005	0.025	<T 0.01	80
GAM 20	0.005	0.035	0.01	27
GAM 21	0.005	0.035	<T 0.01	32
GAM 22	0.01	0.02	<T 0.01	43
GAM 23	0.015	0.045	<T 0.01	60
GAM 28	0.035	0.09	0.01	30
GAM 29	0.055	0.085	0.12	35
GAM 30	0.025	0.075	0.02	30
GAM 56	0.02	0.05	0.01	40
GAM 58	0.025	0.045	0.02	15
GAM 59	0.005	0.03	<T 0.01	25
GAM 60	0.01	0.02	<T 0.01	37
GAM 61	0.015	0.05	0.05	26
MAC 25	0.05	0.105	0.02	1
MAC 35	0.01	0.05	<T 0.01	10

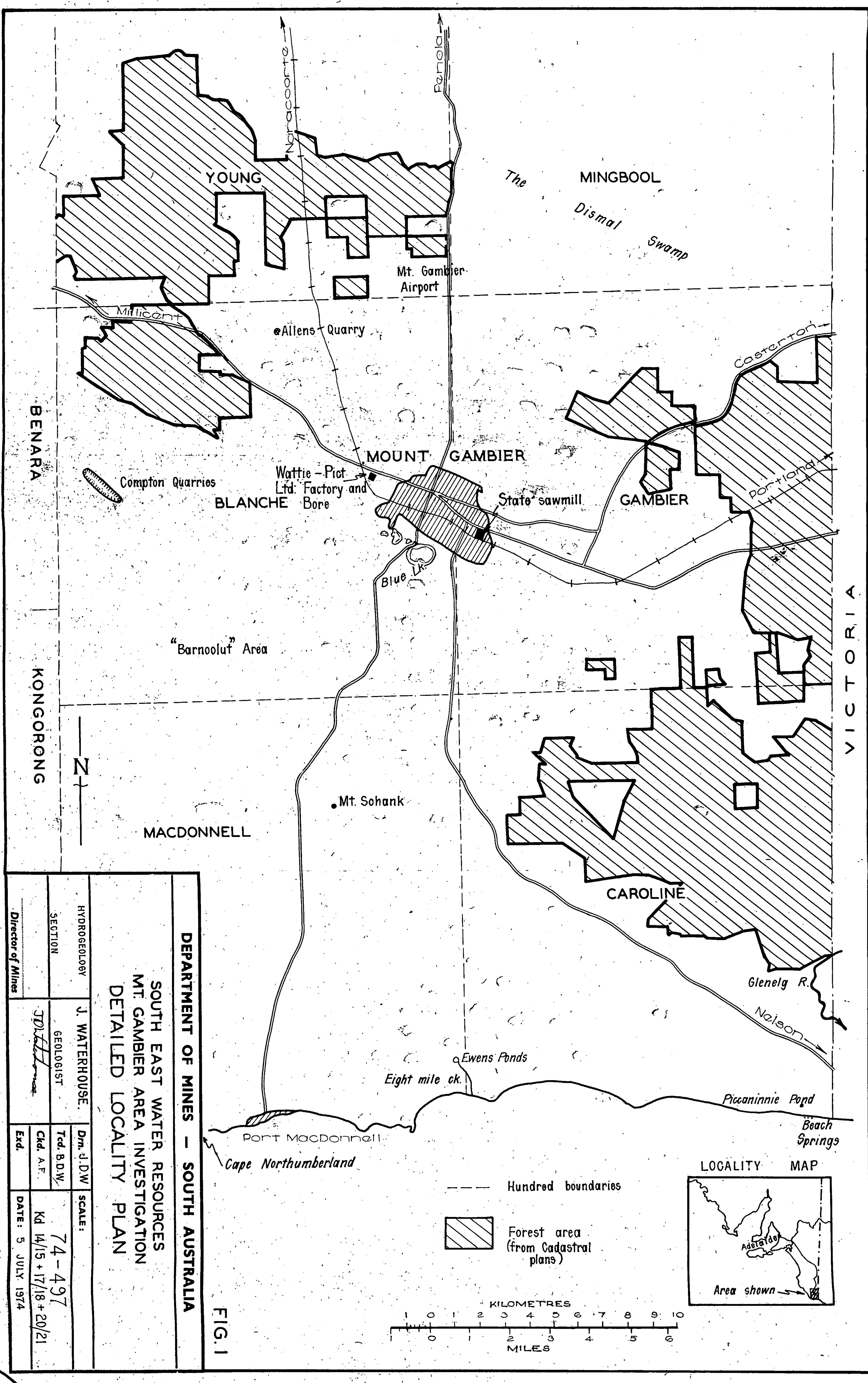
CONSTITUENTS IN mg/l

Bore No.	Phenol	Copper	Chromium	Arsenic
BLA 8	<T 1	<T 0.02	<T 0.02	<T 0.005
BLA 27	<T 1	<T 0.02	<T 0.02	<T 0.005
BLA 28	80,3	<T 0.02	<T 0.02	0.005
BLA 38	<T 1	<T 0.02	<T 0.02	<T 0.005
BLA 39	<T 1	0.06	<T 0.02	0.005
BLA 42	<T 1	<T 0.02	<T 0.02	<T 0.005
BLA 77	<T 1	<T 0.02	<T 0.02	0.005
BLA 82	<T 1	<T 0.02	<T 0.02	<T 0.005
GAM 7	<T 1	<T 0.02	<T 0.02	<T 0.005
GAM 8	<T 1	<T 0.02	<T 0.02	<T 0.005
GAM 9	<T 1	<T 0.02	<T 0.02	0.005
GAM 12	<T 1	0.26	<T 0.02	0.005
GAM 19	<T 1	<T 0.02	<T 0.02	<T 0.005
GAM 23	<T 1	<T 0.02	<T 0.02	T 0.005
GAM 56	<T 1	<T 0.02	<T 0.02	<T 0.005
GAM 58	<T 1	-	-	-
GAM 59	<T 1	<T 0.02	<T 0.02	<T 0.005

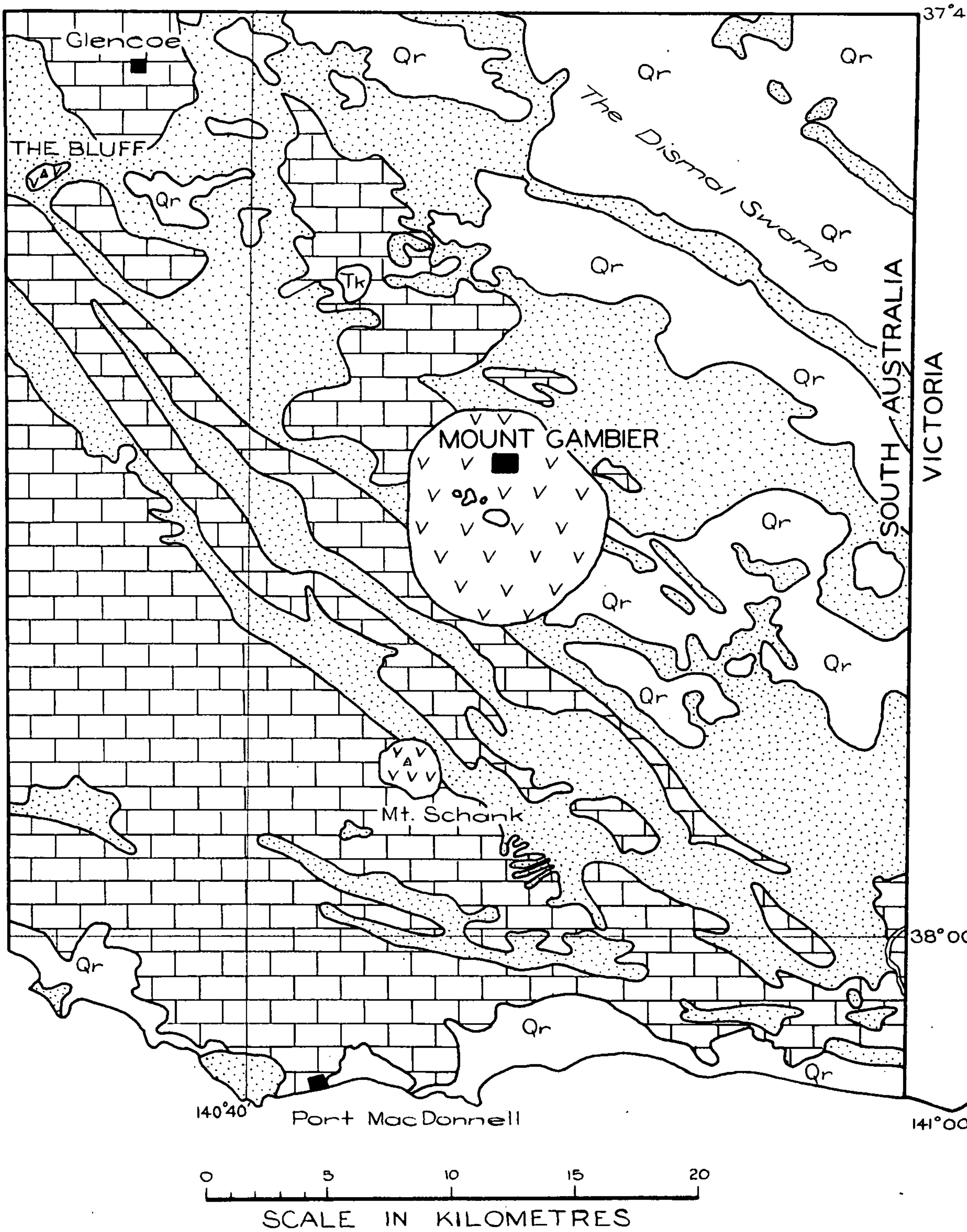
APPENDIX K

Bacteriological Analyses

DATE	DESCRIPTION	THE MOST PROBABLE NUMBER OF ORGANISMS PER 100 ML OF WATER		THE NUMBER OF FAECAL STREPTOCOCCI PER 100 ML OF WATER	DO mg/l	COD mg/l	POLLUTION EXPECTED	COMMENTS	SAMPLING METHOD
		COLIFORMS	E. COLI						
2/11/72	BLA 11	absent	absent	2	9.6	20	Yes	Windmill and trough.	W/M
30/10/72	BLA 18	4	2	4	-	20	Metrop.	Surrounded by houses.	P - mod. clean.
30/10/72	BLA 19	275	absent	none	-	35	No	Adjacent Leg of Mutton Lake.	Bailed.
3/11/72	BLA 20	absent	absent	none	9.2	15	Yes	Adjacent new houses and paddocks.	P
3/11/72	BLA 21	2	2	none	9.2	15	Yes	Adjacent paddocks.	P
2/11/72	BLA 30	8	2	2	8.6	15	Yes	Adjacent paddocks and brickyards.	P
2/11/72	BLA 31	absent	absent	none	9.6	25	Yes	Adjacent paddocks.	P
* 2/11/72	BLA 32	225	8	80	9.4	25	Yes	Bore in house yard near dairy.	B
2/11/72	BLA 33	17	absent	20	9.4	25	Yes	Bore near recently occupied shack.	W/M
2/11/72	BLA 40	absent	absent	10	7.6	20	No	Adjacent paddocks.	P
2/11/72	BLA 41	absent	absent	2	8.2	30	Yes	Adjacent paddocks.	P - slightly silty.
*31/10/72	BLA 48	30	8	60	9.0	20	Yes	Windmill and trough.	P - Well.
*31/10/72	BLA 49	1 600	13	400	8.2	20	Yes	Between house and dairy.	B
1/11/72	BLA 52	absent	absent	none	8.6	15	No	Adjacent paddocks.	P
30/10/72	BLA 56	900	absent	none	9.1	25	No	Adjacent paddocks.	B
* 3/11/72	BLA 62	30	30	30	7.4	15	Yes	Adjacent house and dairy.	P - mod. clean.
* 1/11/72	BLA 65	11	2	68	8.5	15	No	Adjacent paddocks.	P - 2 mins.only.
31/10/72	BLA 69	20	absent	none	5.8	25	No	Adjacent paddocks.	P - short time.
31/10/72	BLA 71	absent	absent	none	9.2	30	No	Adjacent pines.	P
1/11/72	BLA 72	absent	absent	none	8.5	5	No.	Adjacent pines and paddocks.	P - short time.
*30/11/72	BLA 78	75	8	20	10	15	Yes	Unequipped, uncased,near ?disused stockyards.	P - 2½ min. only
31/10/72	BLA 80	absent	absent	none	6.6	10	Yes	Adjacent paddocks, house 50 m to south.	P - short time.
1/11/72	BLA 81	2	absent	none	9.2	15	No	Adjacent paddocks, house 20 m to east.	P
30/10/72	BLA 84	14	11	none	-	15	No	Adjacent paddocks.	P
30/10/72	BLA 85	absent	absent	2	6.5	15	No	Surrounded by pines.	P
*31/10/72	BLA 86	35	35	10	8.9	25	No	Surrounded by pines.	P - short time.
1/11/72	BLA 87	absent	absent	none	8.5	15	No	Adjacent paddocks.	P - short time.
31/10/72	BLA 89	17	absent	none	7.5	15	Yes	Windmill and trough.	B
15/11/72	CAR 9	absent	absent	4	6.8	10	No	D of M stratigraphic bore.	P
15/11/72	CAR 10	absent	absent	none	5.7	35	No	D of M stratigraphic bore.	P
15/11/72	CAR 11	absent	absent	2	3.8	50	No	D of M stratigraphic bore.	P
*16/11/72	CAR 17	4	4	1 100	8.9	10	No	In pines, adjacent ruin.	B
*16/11/72	CAR 18	50	50	890	5.5	10	Yes	Adjacent Carba Treatment Plant and pines.	B
15/11/72	CAR 19	absent	absent	20	9.8	5	No	Adjacent pines, paddocks.	B
16/11/72	CAR 20	absent	absent	none	9.0	10	Yes	Adjacent trough, windmill.	B
*16/11/72	CAR 21	70	70	72	4.2	15	Yes	Caroline Sinkhole.	B
15/11/72	CAR 22	absent	absent	none	8.8	10	No	Adjacent paddocks.	P
16/11/72	CAR 23	900	550	270	0.5	40	Yes	Adjacent ruin and paddocks.	P - Well - dead sheep last year
16/11/72	CAR 24	2	absent	6	7.6	15	Yes	Windmill trough, shearing shed.	B
30/10/72	GAM 6	4	absent	20	-	30	Yes	Windmill and trough adjacent old house,dairy.	B
8/11/72	GAM 7	13	absent	150	9.0	10	No	Adjacent paddocks.	B
7/11/72	GAM 8	absent	absent	8	10.0	10	No	Adjacent paddocks, houses to south.	P
7/11/72	GAM 9	absent	absent	8	9.0	10	Yes	Surrounded by stockyards.	P
7/11/72	GAM 12	absent	absent	14	9.5	15	No	Adjacent paddocks.	P
8/11/72	GAM 17	absent	absent	none	7.5	20	Yes	Windmill and trough.	W/M - pumping strongly.
9/11/72	GAM 18	absent	absent	10	10.6	15	No	Adjacent paddocks.	P - short time.
7/11/72	GAM 19	absent	absent	44	9.6	20	Metrop.	On reserve, surrounded by houses.	P
9/11/72	GAM 20	absent	absent	none	9.9	10	No	Adjacent paddocks.	P - minor silt.
9/11/72	GAM 21	absent	absent	none	8.9	10	No	Adjacent paddocks.	P - minor silt.
9/11/72	GAM 22	absent	absent	none	10.4	10	No	Adjacent paddocks.	P
7/11/72	GAM 23	absent	absent	24	-	15	No	Adjacent paddocks.	P - poor sample.
*13/11/72	GAM 28	8	5	190	10.0	15	No	Adjacent paddocks.	P - short time.
*13/11/72	GAM 29	1 800+	5	3 400	9.4	10	No	Adjacent paddocks.	P - short time.
*13/11/72	GAM 30	130	13	60	9.4	15	No	On racecourse.	P
14/11/72	GAM 37	40	absent	8	4.0	15	No	Adjacent paddocks.	P
8/11/72	GAM 42	absent	absent	none	7.8	20	Yes	Windmill and trough.	W/M
14/11/72	GAM 46	absent	absent	120	2.8	10	No	Adjacent paddocks.	B
*14/11/72	GAM 47	225	20	46	2.9	10	Yes	Windmill and trough.	P
*14/11/72	GAM 48	350	11	46	6.0	30	No	Adjacent paddocks.	B
13/11/72	GAM 52	absent	absent	12	6.5	15	No	Adjacent paddocks.	P
8/11/72	GAM 56	5	5	6	9.2	10	Yes	Adjacent state sawmill.	P
8/11/72	GAM 58	absent	absent	none	8.4	10	Yes	Adjacent state sawmill.	P
8/11/72	GAM 59	absent	absent	70	6.4	15	Yes	Adjacent state sawmill.	P - mediocre sample.
9/11/72	GAM 60	absent	absent	none	9.9	10	No	Adjacent paddocks.	P
10/11/72	GAM 61	Absent	absent	500	-	10	No	Adjacent paddocks.	P - short time.
13/11/72	GAM 67	absent	absent	6	9.6	15	No	Adjacent paddocks.	B
*15/11/72	MAC 25	35	35	36	0.8	15	Yes	Earl's Cave.	P - discoloured water.
16/11/72	MAC 35	absent	absent	2	5.0	20	No	Paddocks adjacent.	P
14/11/72	MIN 6	absent	absent	none	3.9	15	No	Unequipped bore in potato paddock.	P
*14/11/72	MIN 7	7	2	30	3.3	15	No	Adjacent paddocks.	B
30/10/72	YOU 2	35	absent	none	-	10	No	Surrounded by pines.	B
30/10/72	YOU 3	2	absent	none	-	10	No	Adjacent pines, paddocks.	P - short time.



Naracoorte
Penola
YOUNG
MINGBOOL
The Dismal Swamp
Mt. Gambier Airport
Millicent
Allens Quarry
Casterton
BENARA
Compton Quarries
MOUNT GAMBIER
Wattie - Pict Ltd. Factory and Bore
BLANCHE
State sawmill
GAMBIER
Portland
Blue Lk.
"Barnoolut" Area
KONGORONG
VICTORIA
N
Mt. Sohank
MACDONNELL
CAROLINE
Glenelg R.
Nelson
Ewens Ponds
Eight mile ck.
Piccaninnie Pond
Beach Springs
Port MacDonnell
Cape Northumberland
Hundred boundaries
Forest area (from Cadastral plans)
LOCALITY MAP
Adelaide
Area shown
KILOMETRES
1 0 1 2 3 4 5 6 7 8 9 10
1 0 1 2 3 4 5 6
MILES
DEPARTMENT OF MINES — SOUTH AUSTRALIA
SOUTH EAST WATER RESOURCES
MT. GAMBIER AREA INVESTIGATION
DETAILED LOCALITY PLAN
HYDROGEOLOGY SECTION
J. WATERHOUSE. GEOLOGIST
Director of Mines
Drn. J.D.W
Tcd. B.D.W.
Ckd. A.F.
Exd.
SCALE:
74-497
Kd 14/15 + 17/18 + 20/21
DATE: 5 JULY 1974
FIG. 1



LEGEND

Qr	*Recent undifferentiated deposits.*		*Tertiary - Gambier Limestone.*
	Quaternary aeolianites - Bridgwater Formation.	Tk	*Tertiary - Knight Group.*
	Quaternary volcanics.		

FIG. 2

(GEOLOGY after Sprigg et al, 1951)

DEPARTMENT OF MINES — SOUTH AUSTRALIA

HYDROGEOLOGY SECTION	Drn. J.W.	SOUTH EAST WATER RESOURCES	SCALE: 1:250,000
	Tcd. J.W.	MOUNT GAMBIER AREA INVESTIGATION	S10898
GEOLOGIST J. D. WATERHOUSE	Ckd.	GEOLOGICAL PLAN	Kd 14/15+17/18+20/21
	Exd.		DATE: 6th June 1974

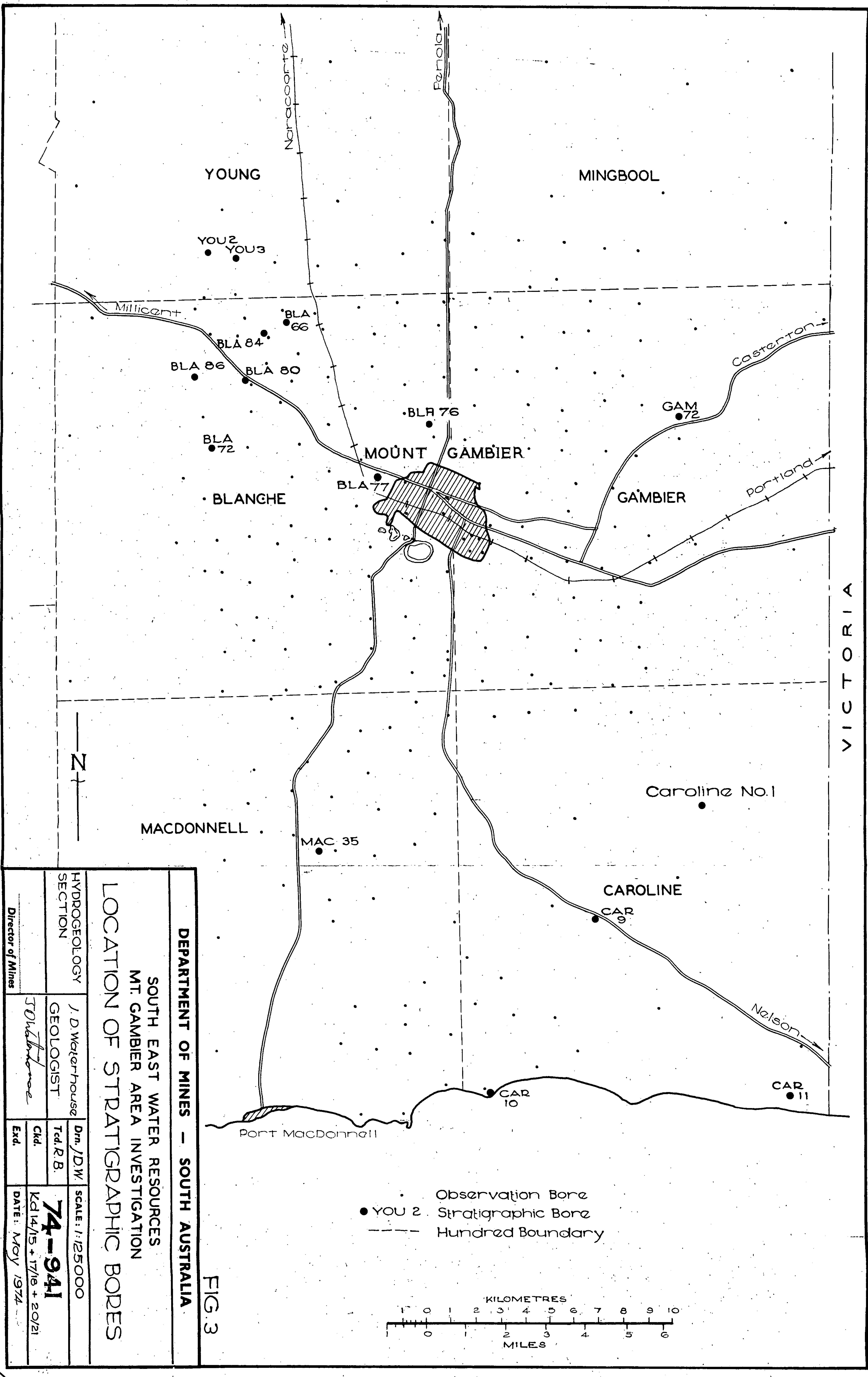


FIG. 3

DEPARTMENT OF MINES — SOUTH AUSTRALIA

SOUTH EAST WATER RESOURCES
MT. GAMBIER AREA INVESTIGATION

LOCATION OF STRATIGRAPHIC BORES

HYDROGEOLOGY SECTION

J. D. Waterhouse
GEOLOGIST

J D Waterhouse

Director of Mines

Drn. J.D.W.
Tcd. R.B.
Ckd.
Exd.

SCALE: 1:125000

74-941

Kd 14/15 + 17/18 + 20/21

DATE: May 1974

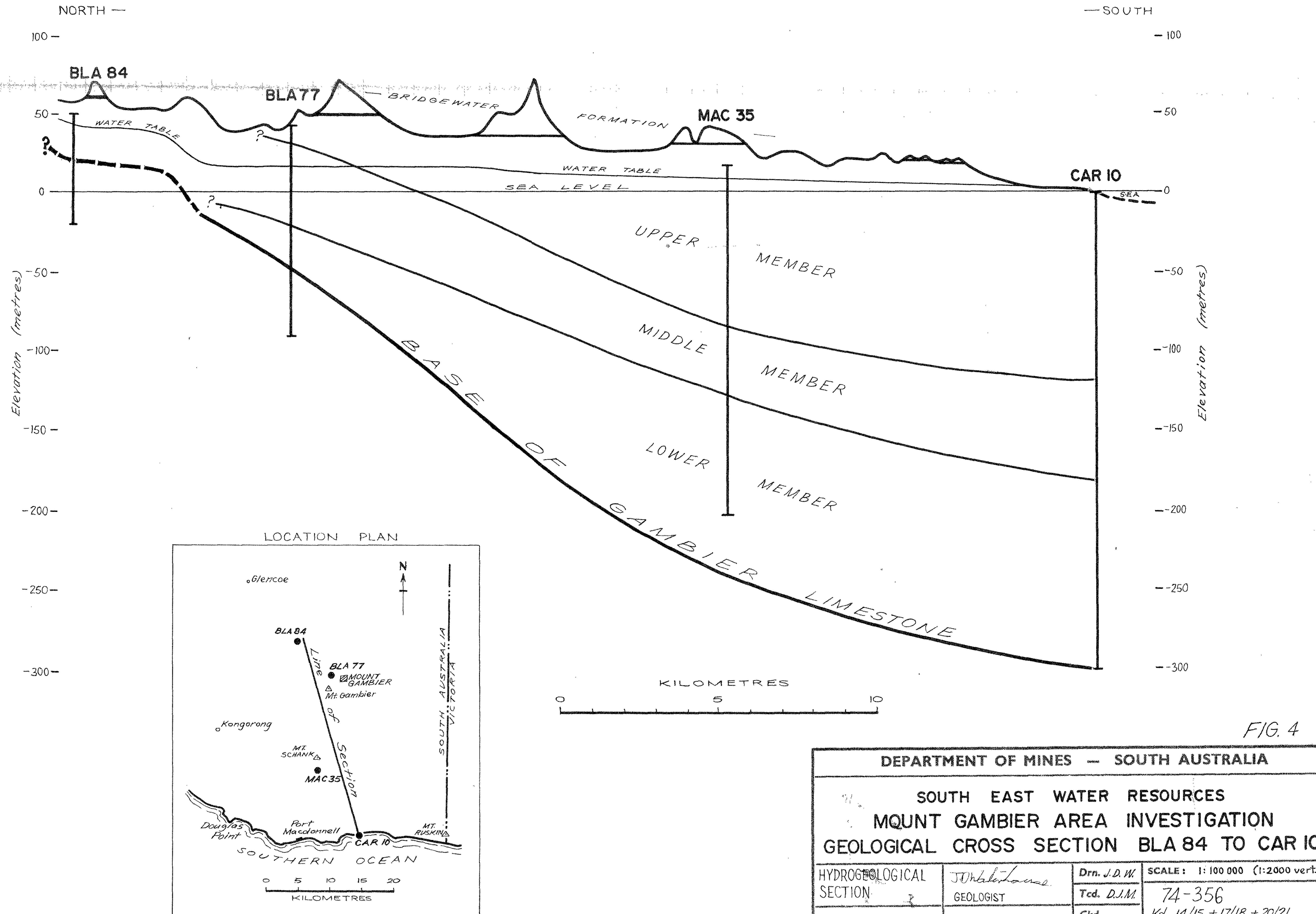


FIG. 4

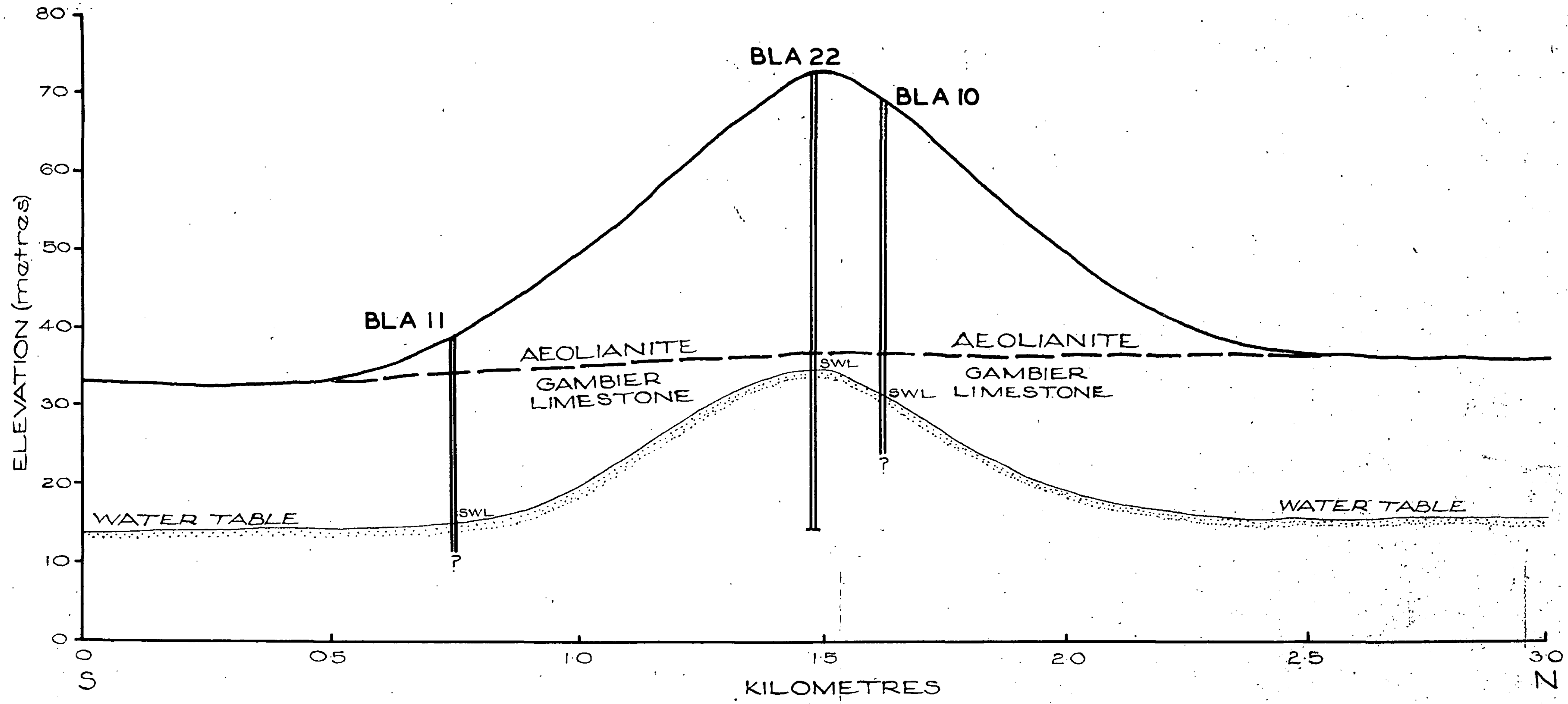
DEPARTMENT OF MINES — SOUTH AUSTRALIA

SOUTH EAST WATER RESOURCES

MOUNT GAMBIER AREA INVESTIGATION

GEOLOGICAL CROSS SECTION BLA 84 TO CAR 10

HYDROGEOLOGICAL SECTION	J. Waterhouse GEOLOGIST	Drn. J.D.W.	SCALE: 1:100 000 (1:2000 vert.)
		Tcd. D.J.M.	74-356 Kd 14/15 + 17/18 + 20/21
		Ckd.	
Director of Mines	SENIOR GEOLOGIST	Exd.	DATE: 17 MAY 1974



LEGEND

BLA22 SWL — Bore, with Obs. no. and measured static water level

Ground surface

Inferred boundary between dune Aeolianite and Gambier Limestone

Water table

FIG. 5

DEPARTMENT OF MINES — SOUTH AUSTRALIA

SOUTH EAST WATER RESOURCES
MT. GAMBIER AREA INVESTIGATION
DIAGRAMMATIC CROSS-SECTION THROUGH DUNE

HYDROGEOLOGY SECTION	J.D. Waterhouse GEOLOGIST	Drn. J.W	SCALE : 1:1000 (Horizontal)
		Tcd. R.B	74-22
		Ckd. A.F.	Kd 17/18
Director of Mines		Exd.	DATE : 7 JAN 1974

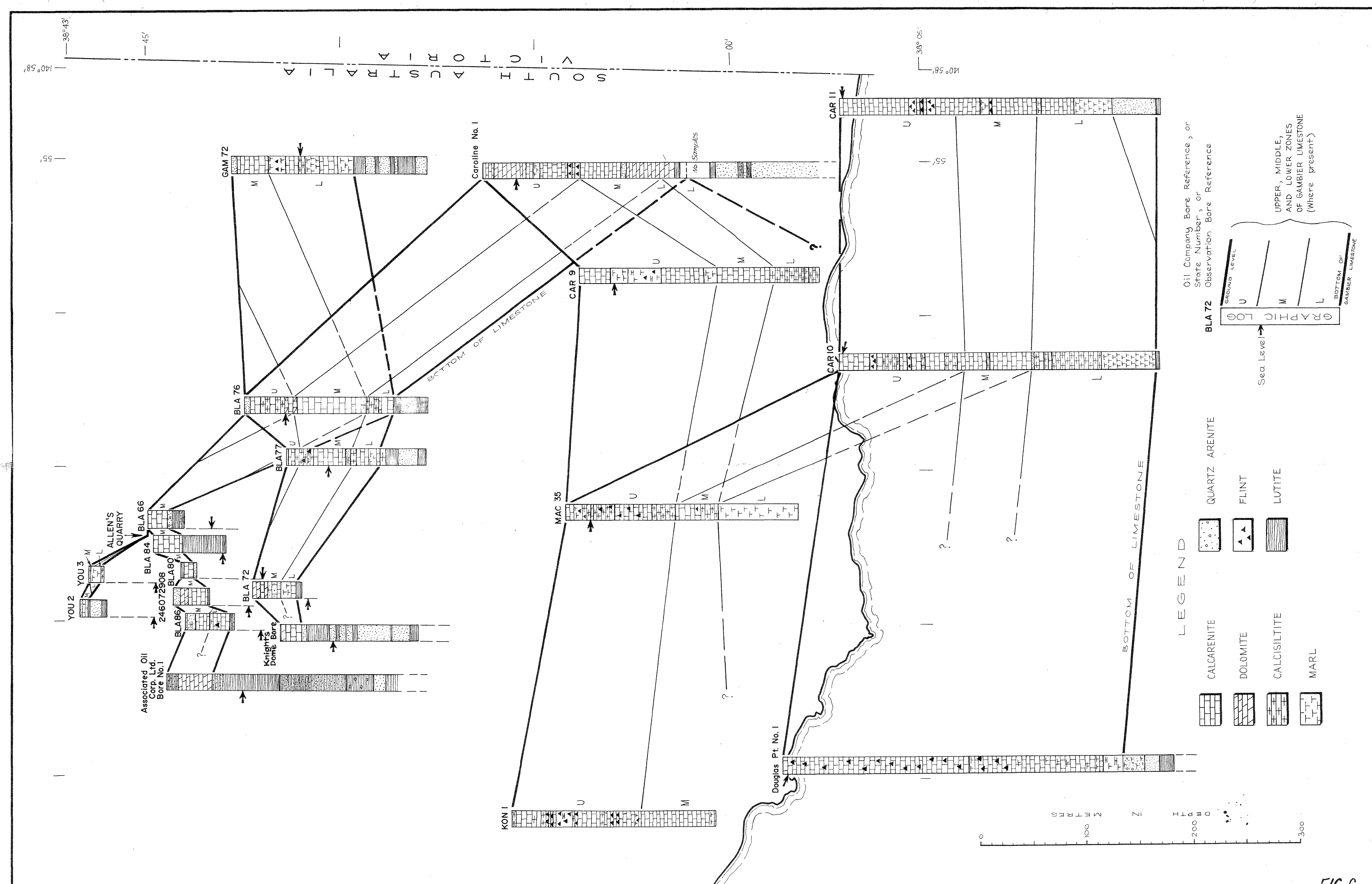
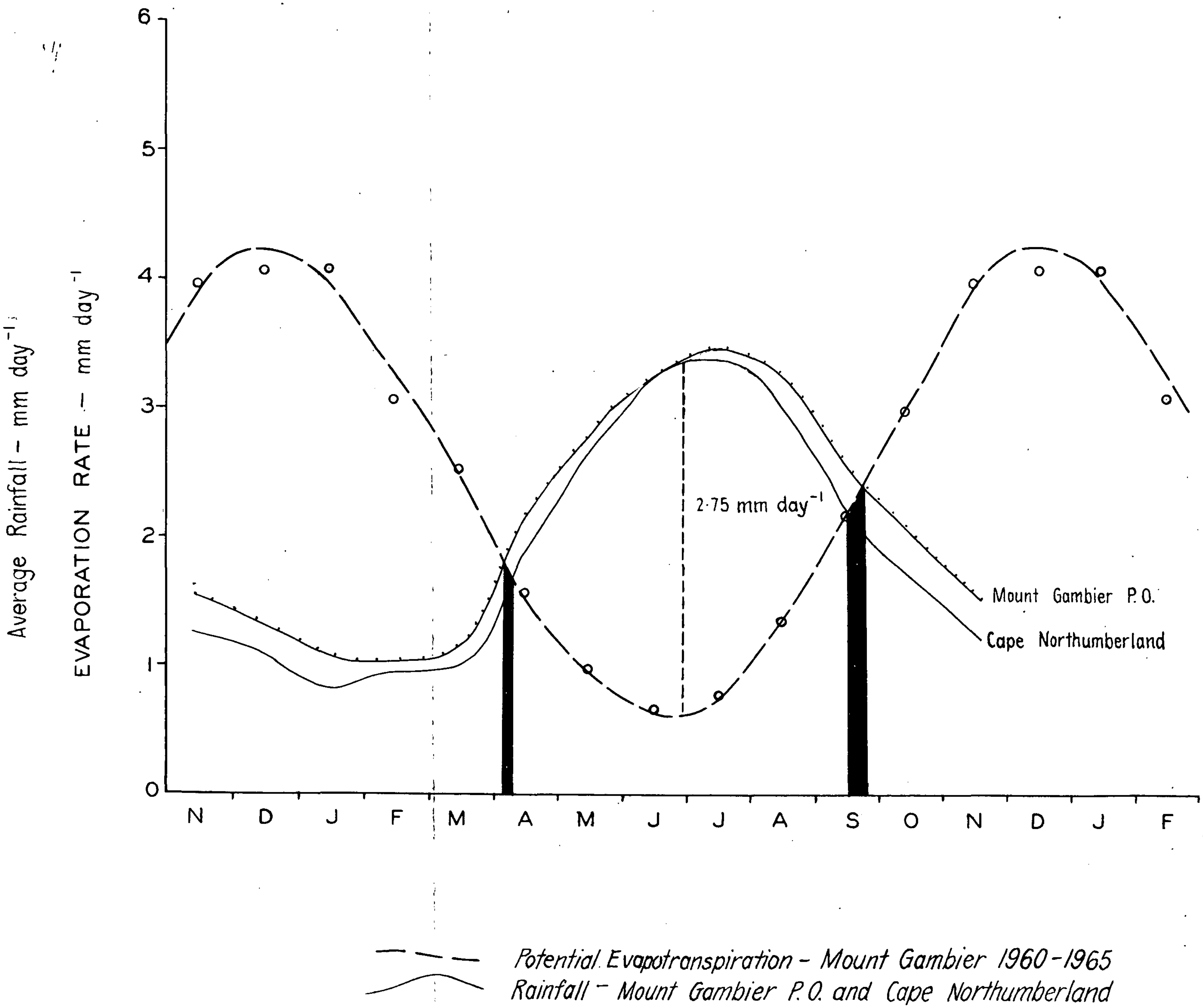


FIG. 6

DEPARTMENT OF MINES — SOUTH AUSTRALIA

SOUTH EAST WATER RESOURCES
MOUNT GAMBIER AREA INVESTIGATION
FENCE DIAGRAM

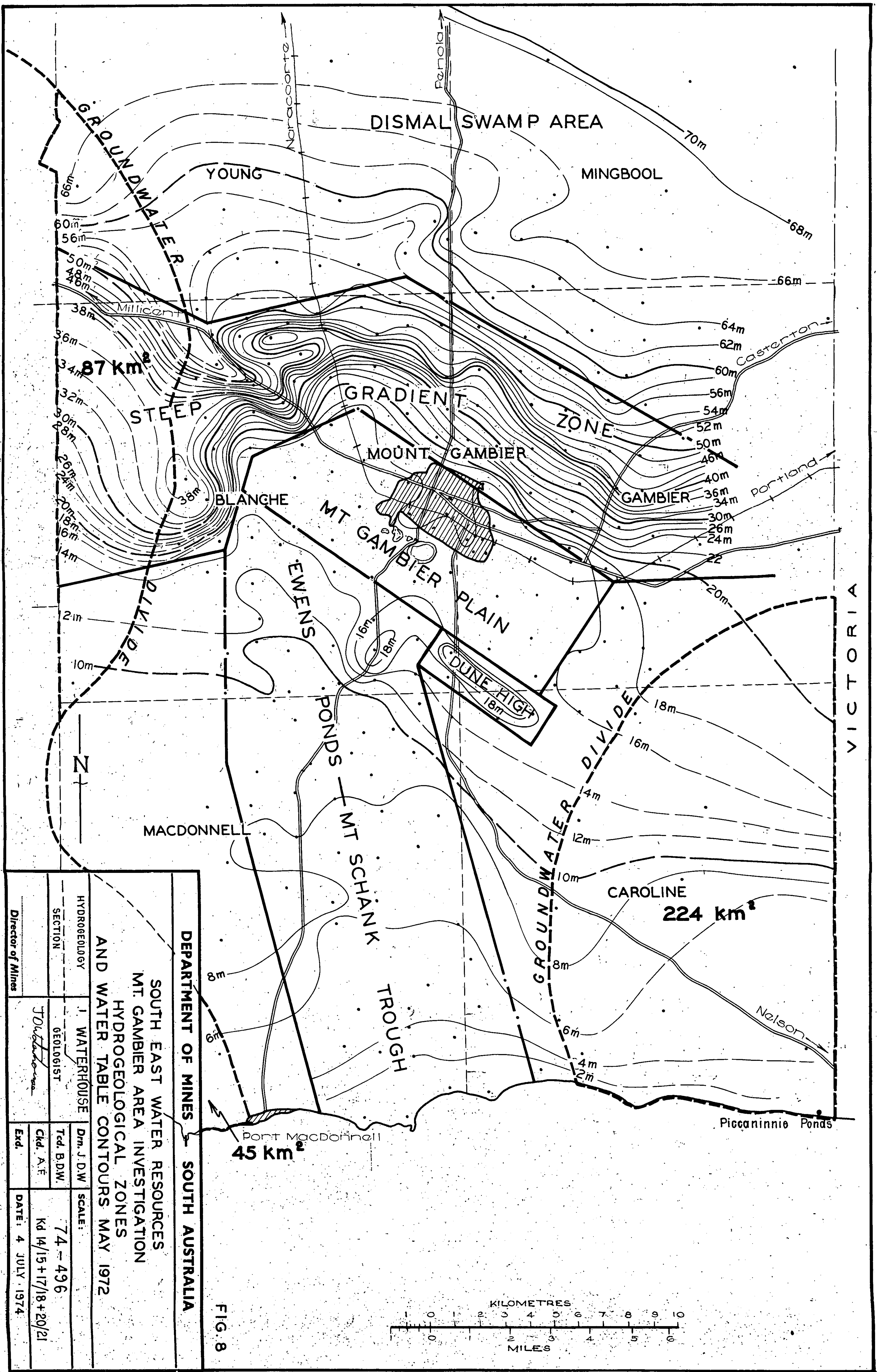
HYDROGEOLOGY SECTION	J D Waterhouse GEOLOGIST	Compiled J. D. Waterhouse	Scale: 1:100 000 (1:2000 vert)
			Date: 17 MAY 1974
		Drn. DJM	Drg. No. 74-357 Kd 14/15 + 17/18 + 20/21
Director of Mines	SENIOR GEOLOGIST	Chd. A.F.	



Potential Evapotranspiration from grassland (after Holmes and Colville, 1970) FIG. 7

HYDROGEOLOGY SECTION		DEPARTMENT OF MINES — SOUTH AUSTRALIA	Scale: Diagram
Compiled: J. D. W.		SOUTH EAST WATER RESOURCES MOUNT GAMBIER AREA INVESTIGATION	Date: 4 Feb. 1975
Drn. TJE	Ckd.	POTENTIAL EVAPOTRANSPIRATION FROM GRASSLAND AND AVERAGE MONTHLY RAINFALLS	Drg. No. 75-98
J. D. Waterhouse			

7022


DISMAL SWAMP AREA
YOUNG
MINGBOOL
GROUNDWATER DIVIDE
Naracoorte
Penola
Millicent
Casterton
Portland
Nelson
87 km²
STEEP GRADIENT ZONE
MOUNT GAMBIER
GAMBIER
BLANCHE
MT GAMBIER PLAIN
EWENS PONDS — MT SCHANK TROUGH
DUNE HIGH
MACDONNELL
CAROLINE
224 km²
VICTORIA
Port MacDonnell
45 km²
Piccaninnie Ponds
N
70m
68m
66m
64m
62m
60m
56m
54m
52m
50m
48m
46m
40m
38m
36m
34m
32m
30m
28m
26m
24m
22
20m
18m
16m
14m
12m
10m
8m
6m
4m
2m
KILOMETRES
1 0 1 2 3 4 5 6 7 8 9 10
MILES
1 0 1 2 3 4 5 6
DEPARTMENT OF MINES — SOUTH AUSTRALIA
SOUTH EAST WATER RESOURCES
MT. GAMBIER AREA INVESTIGATION
HYDROGEOLOGICAL ZONES
AND WATER TABLE CONTOURS MAY 1972
HYDROGEOLOGY SECTION
J. WATERHOUSE GEOLOGIST
Director of Mines
Drn. J.D.W
Trd. B.DW.
Ckd. A.F
Exd.
SCALE:
74-496
Kd 14/15+17/18+20/21
DATE: 4 JULY 1974
FIG. 8

NB. All histograms have a class interval of 25 mg/ℓ

FIG 9

HYDROGEOLOGY SECTION	DEPARTMENT OF MINES – SOUTH AUSTRALIA		Scale: Diagram
Compiled: J.D. Waterhouse	SOUTH EAST WATER RESOURCES MOUNT GAMBIER AREA INVESTIGATION		Date: 3 Feb. 1975
Drn. T.J.E.	Ckd. A.F.		Drg. No. 75-101
J.D. Waterhouse	NITRATE CONCENTRATIONS FOR DIFFERENT SAMPLING METHODS		

7027 1M–2.70 A1811

NB. All histograms have a class interval of 25 mg/ℓ

FIG. 9.

HYDROGEOLOGY SECTION	DEPARTMENT OF MINES – SOUTH AUSTRALIA	Scale: Diagram
Compiled: J.D. Waterhouse	SOUTH EAST WATER RESOURCES	Date: 3 Feb. 1975
Drn. T.J.E. Ckd. A.F.	MOUNT GAMBIER AREA INVESTIGATION	Drg. No.
J.D. Waterhouse	NITRATE CONCENTRATIONS FOR DIFFERENT SAMPLING METHODS	75-101

7022 1M-2.70 A1831

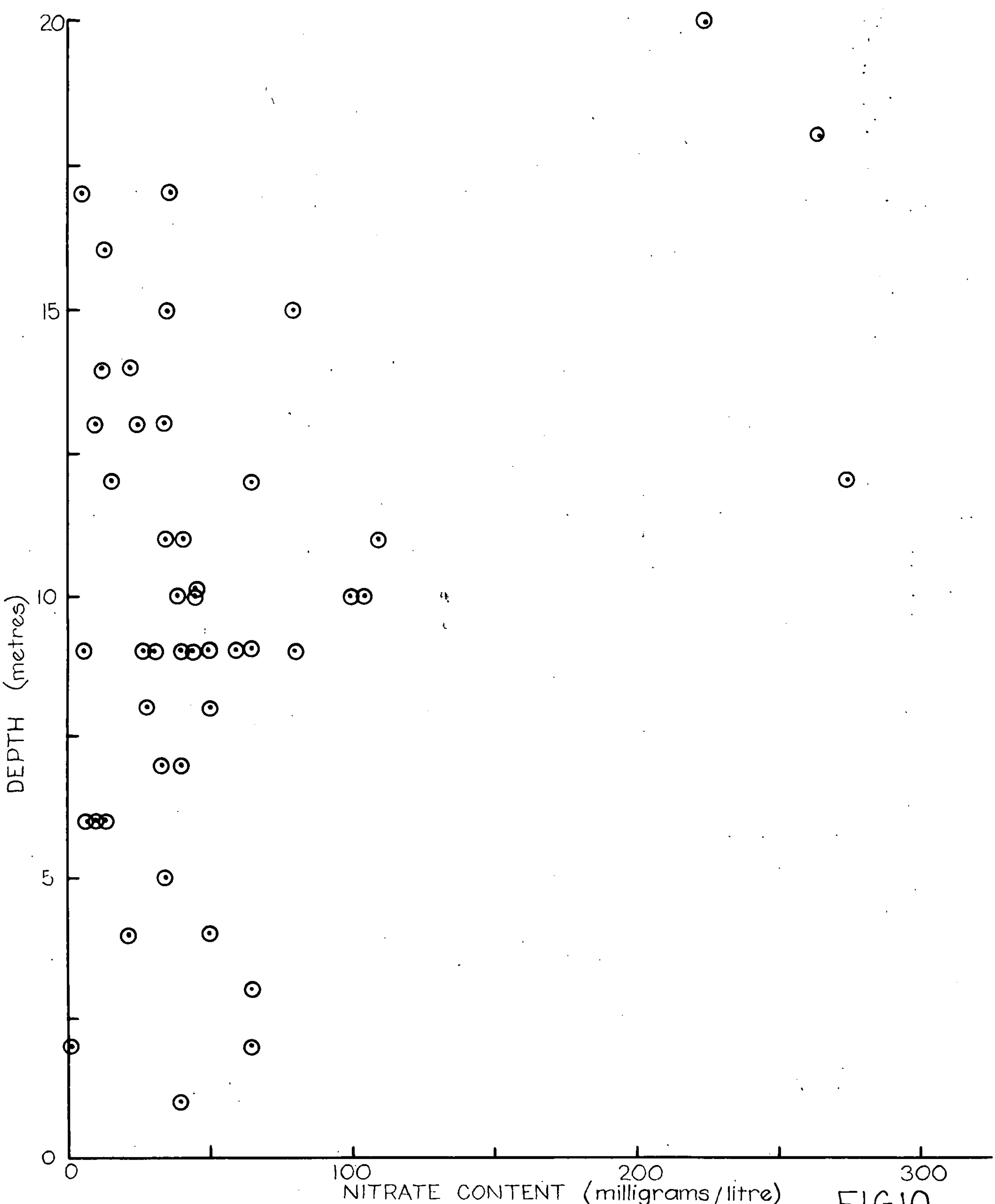
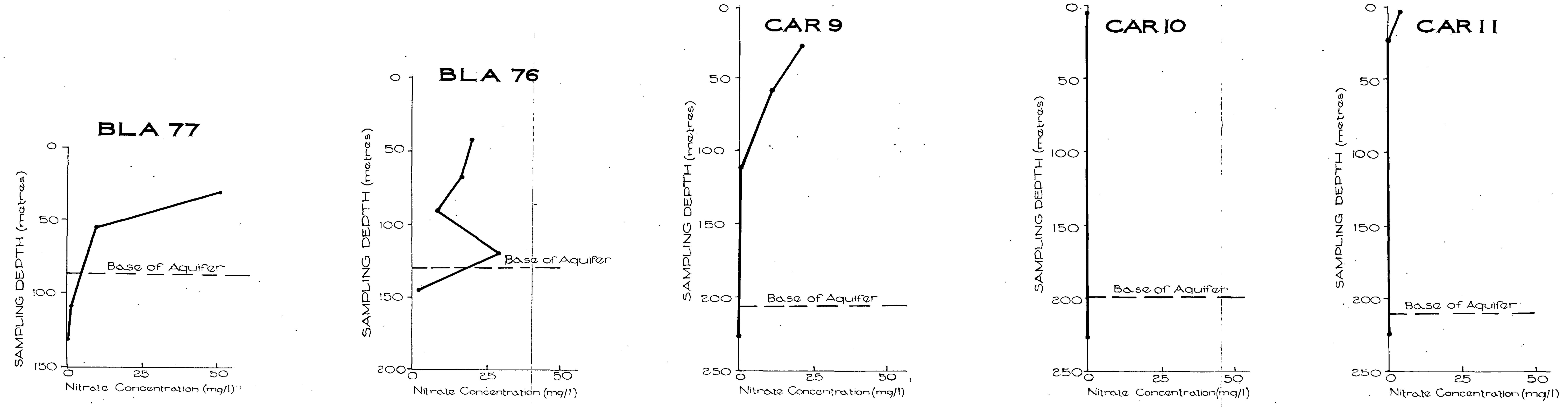


FIG.10

DEPARTMENT OF MINES — SOUTH AUSTRALIA		Scale: AS SHOWN
Compiled: J. D. W	SOUTH EAST WATER RESOURCES	Date: 16 APRIL 1973
Drn. S.J.C. Ckd. A.F.	MOUNT GAMBIER AREA INVESTIGATION	Drg. No.
J D Waterhouse	PLOT OF DEPTH OF SAMPLING BELOW WATER TABLE VS NITRATE CONTENT	S11342

300–6.72 C5552 7021,22



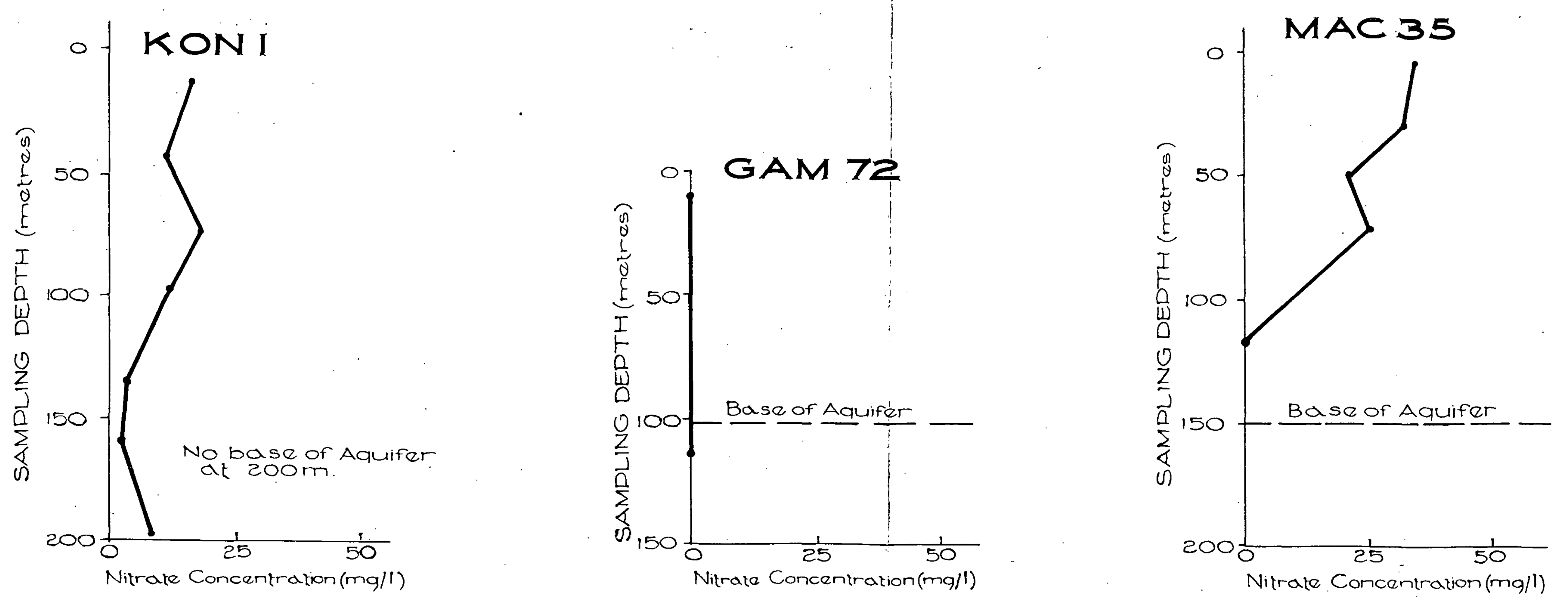


FIG. 11

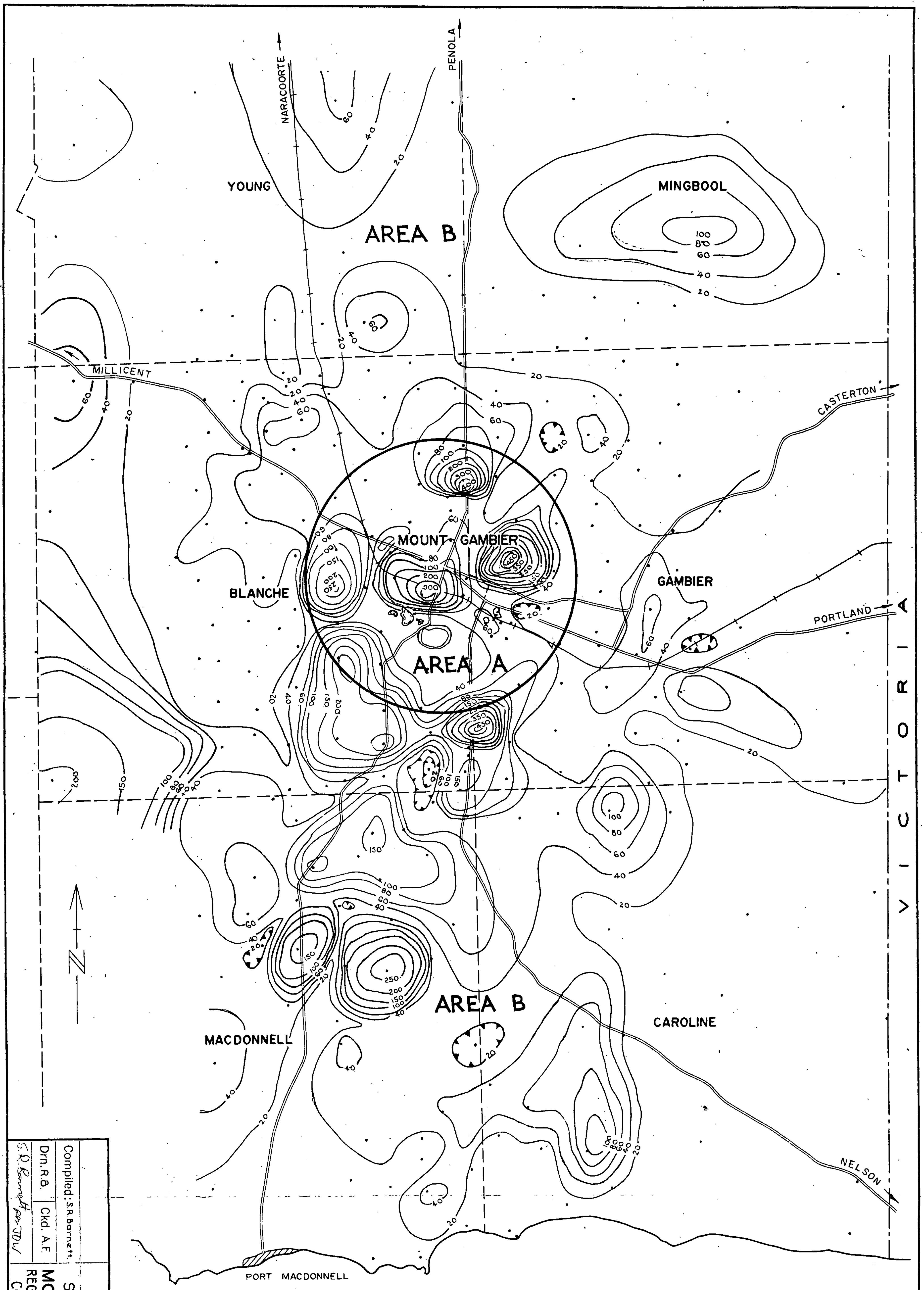
DEPARTMENT OF MINES — SOUTH AUSTRALIA

SOUTH EAST WATER RESOURCES
MT. GAMBIER AREA INVESTIGATION

STRATIGRAPHIC BORES
NITRATE CONCENTRATION vs SAMPLING DEPTH

HYDROGEOLOGY SECTION	J. Dubbelhouse GEOLOGIST	Compiled J.D.W.	Scale: Graphical
			Date: 5 June 1974
Director of Mines		Drn. R.B. / Ckd. A.F.	Drg. No. 74-417

7021,22



KILOMETRES
1 0 1 2 3 4 5 6 7 8 9 10
1 0 1 2 3 4 5 6
MILES

FIG 12

DEPARTMENT OF MINES – SOUTH AUSTRALIA

SOUTH EAST WATER RESOURCES

MOUNT GAMBIER AREA INVESTIGATION

REGIONAL DISTRIBUTION OF SAMPLE NITRATE CONCENTRATIONS, LOCATIONS OF AREAS A & B

Compiled: S.R. Barnett		Scale: 1:125,000
Drn. R.B.	Ckd. A.F.	Date: 11 May 1973
S.R. Barnett per JDW		Drg. No. 75-146

Kd

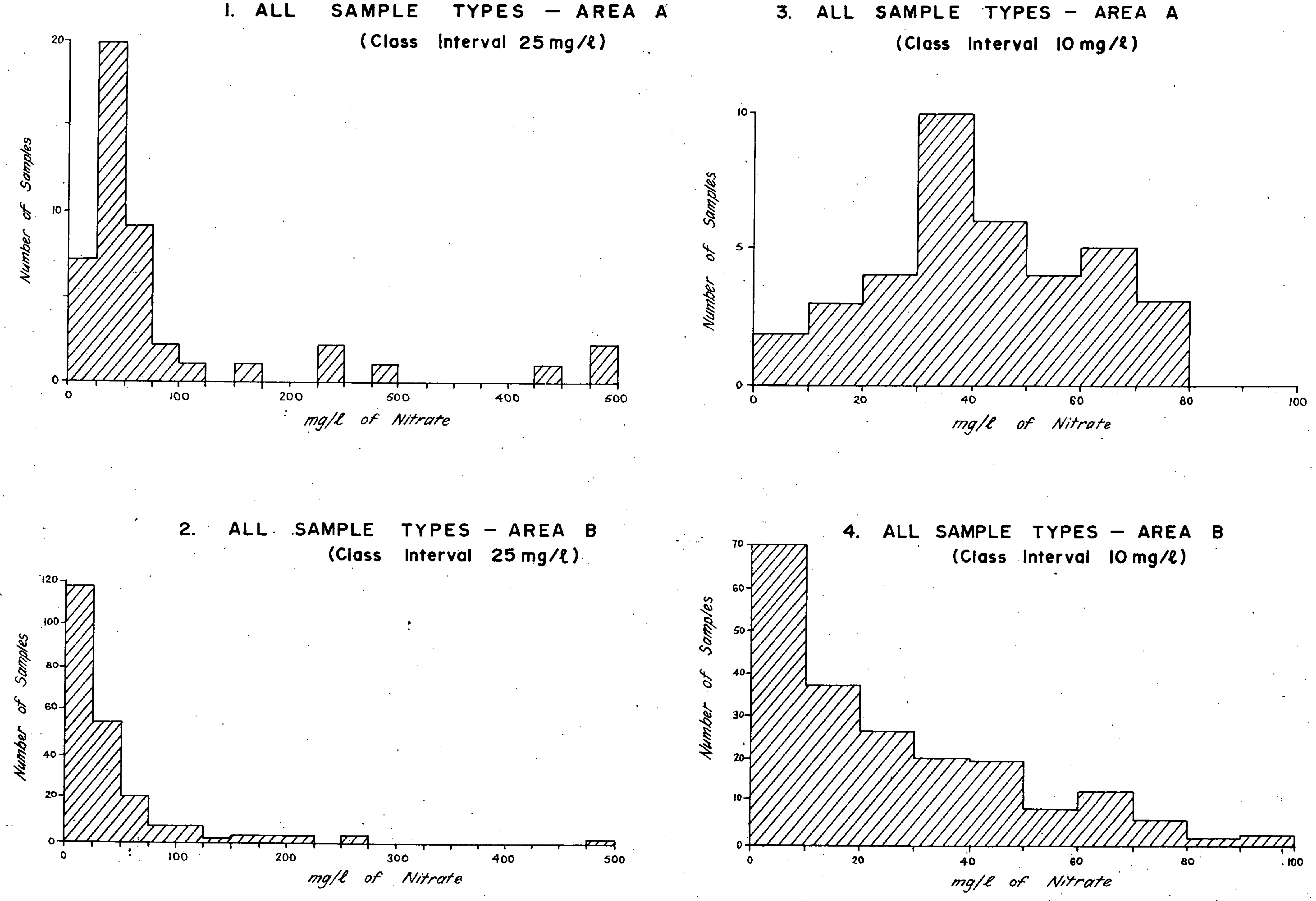
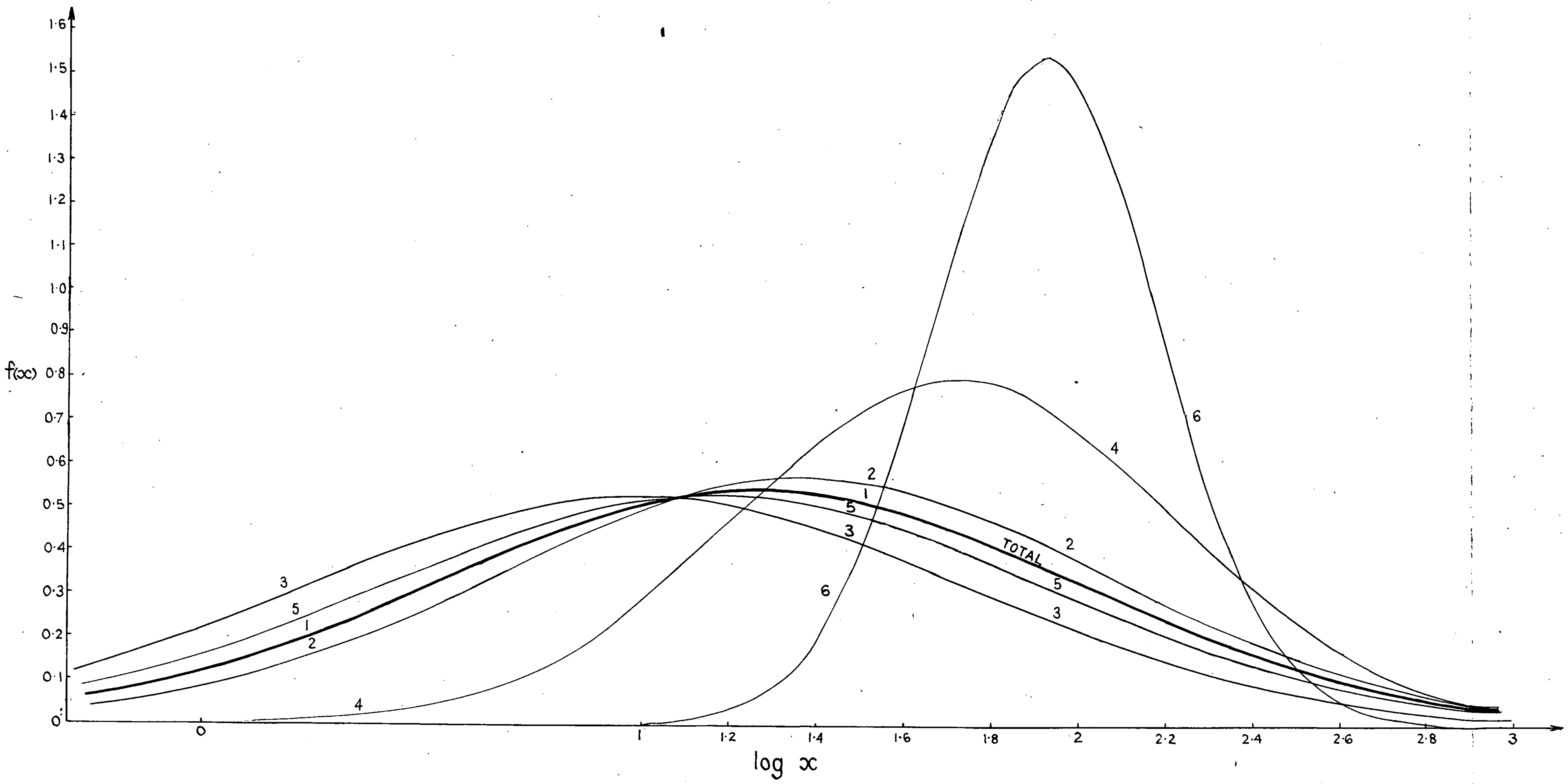


FIG. 13.

HYDROGEOLOGY SECTION		DEPARTMENT OF MINES – SOUTH AUSTRALIA	Scale: Diagram
Compiled: J.D. Waterhouse		SOUTH EAST WATER RESOURCES MOUNT GAMBIER AREA INVESTIGATION	Date: 4 Feb. 1975
Drn. T.J.E.	Ckd. A.F.		Drg. No.
J.D. Waterhouse		HISTOGRAMS OF NITRATE CONCENTRATIONS, AREAS A&B	75-100

7022 1M–2,70 A1811



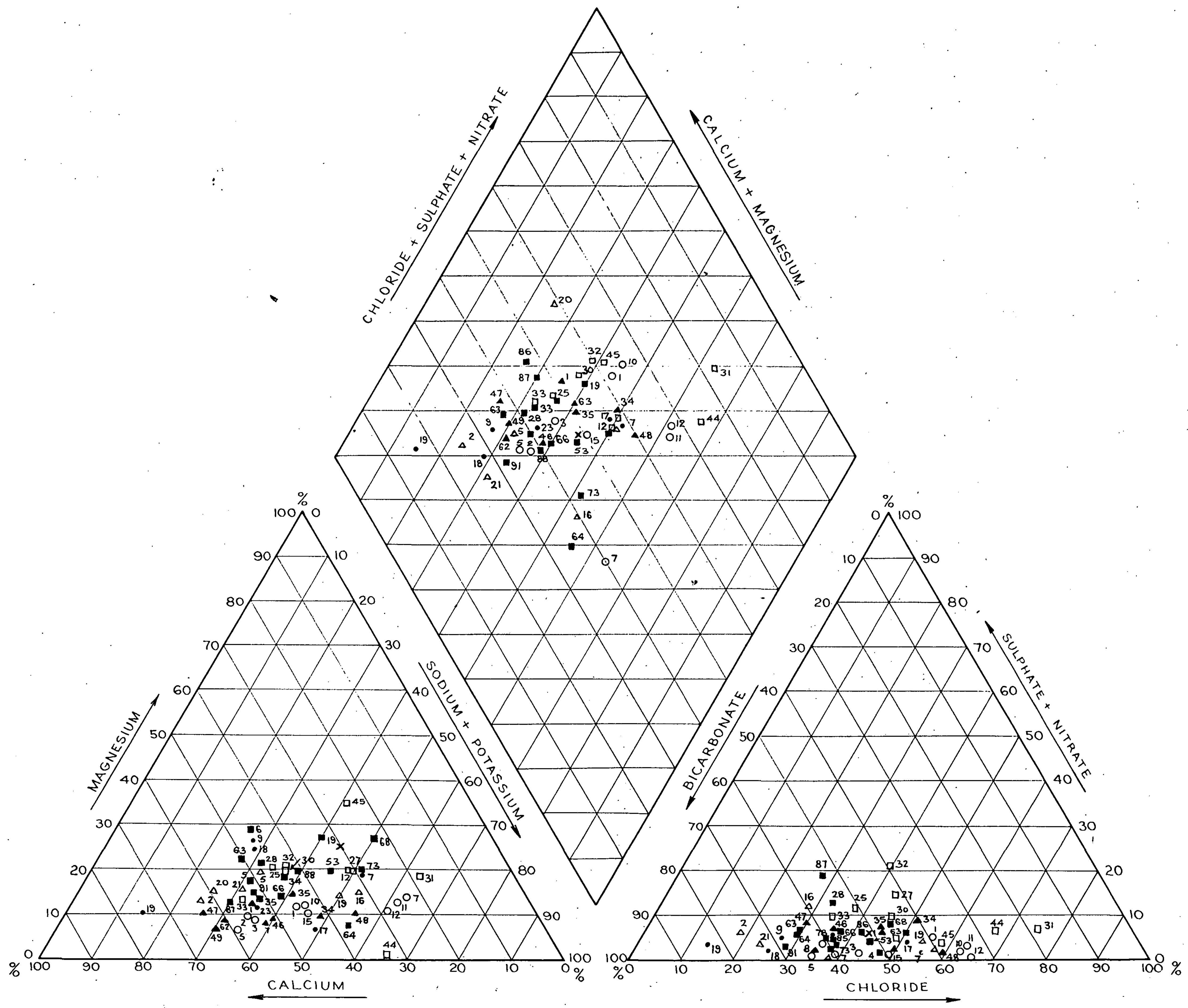
LEGEND

Curve No.	Population
1	Population, Total
2	Samples from bores likely to be polluted
3	Samples from bores not likely to be polluted
4	Samples from Area A
5	Samples from Area B
6	Samples from Mount Gambier Metropolitan Area

FIG. 14

HYDROGEOLOGY SECTION	DEPARTMENT OF MINES – SOUTH AUSTRALIA	Scale: Diagram
Compiled: J. D. W.	SOUTH EAST WATER RESOURCES MOUNT GAMBIER AREA INVESTIGATION	Date: 4 Feb. 1975
Drn. TJE | Ckd.	NORMALIZED DISTRIBUTIONS OF SAMPLE NITRATE CONCENTRATIONS	Drg. No. 75-99
J.D. Waterhouse		

7022 1M–2,70 A1811



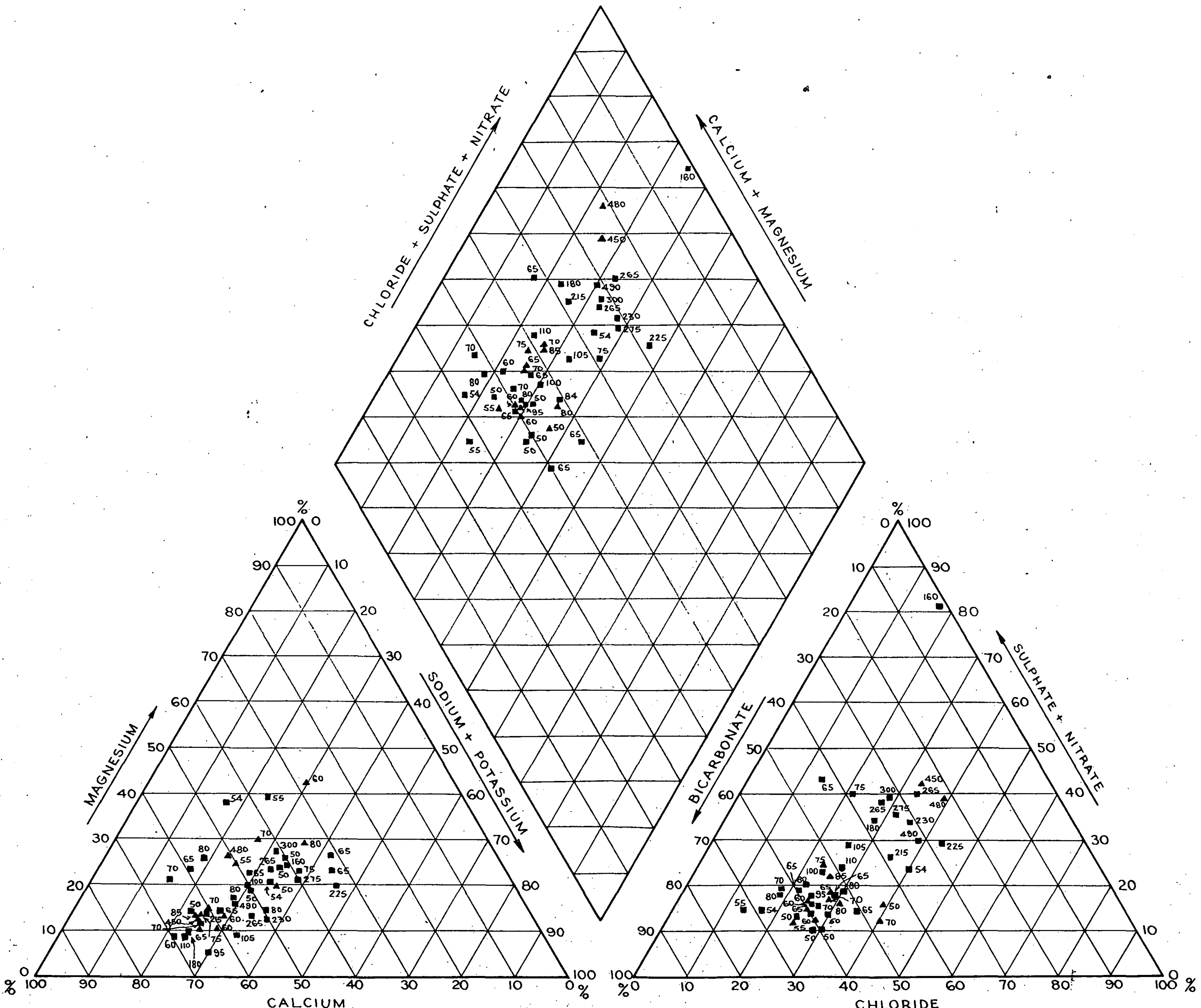
▲63 Observation bore number
Index to Hundreds

■ BLANCHE	• CAROLINE	▲ GAMBIER
□ MACDONNELL	○ MINGBOOL	△ YOUNG
× BLUE LAKE		

FIG. 15

	DEPARTMENT OF MINES – SOUTH AUSTRALIA	Scale:
Compiled: J.D. Waterhouse	SOUTH EAST WATER RESOURCES MOUNT GAMBIER AREA INVESTIGATION PIPER DIAGRAM	Date: 3 April 1973
Drn. D.I.M. Ckd. A.F.		Drg. No.
J.D. Waterhouse	– SAMPLES WITH LESS THAN 50mg/l NITRATE	75-148

7021,22



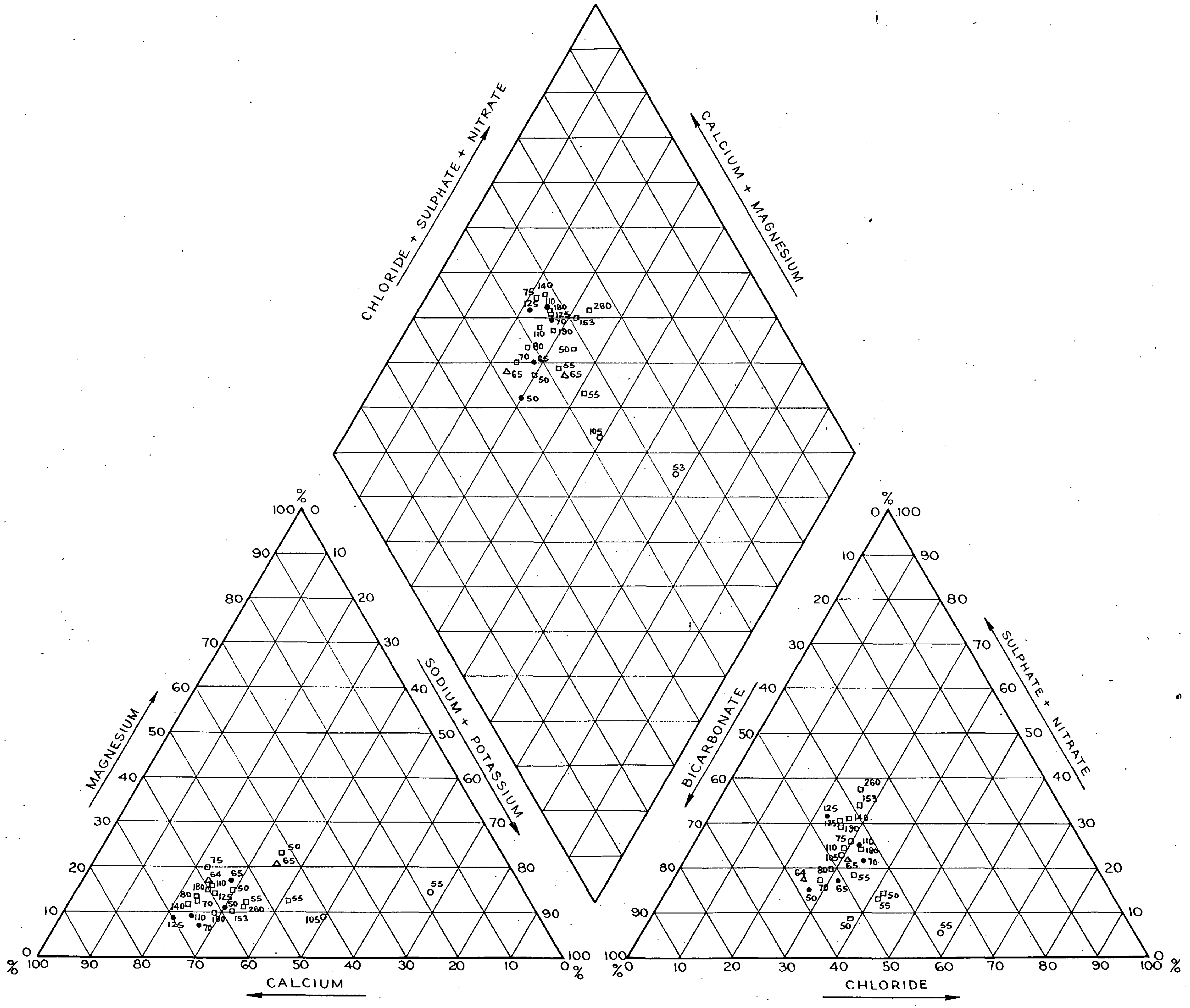
■95 Composition : number refers to nitrate in mg/ℓ

■ Hd. of Blanche sample ▲ Hd. of Gambier sample

FIG. 16

	DEPARTMENT OF MINES – SOUTH AUSTRALIA	Scale:
Compiled: J.D. Waterhouse	SOUTH EAST WATER RESOURCES MOUNT GAMBIER AREA INVESTIGATION	Date: 3 April 1973
Drn. D.J.M. Ckd. A.F.	HUNDREDS OF BLANCHE AND GAMBIER SAMPLES WITH GREATER THAN 50 mg/ℓ OF NITRATE	Drg. No.
J.D. Waterhouse	PIPER DIAGRAM	75-149

7022,21 1M-2,70 A1811



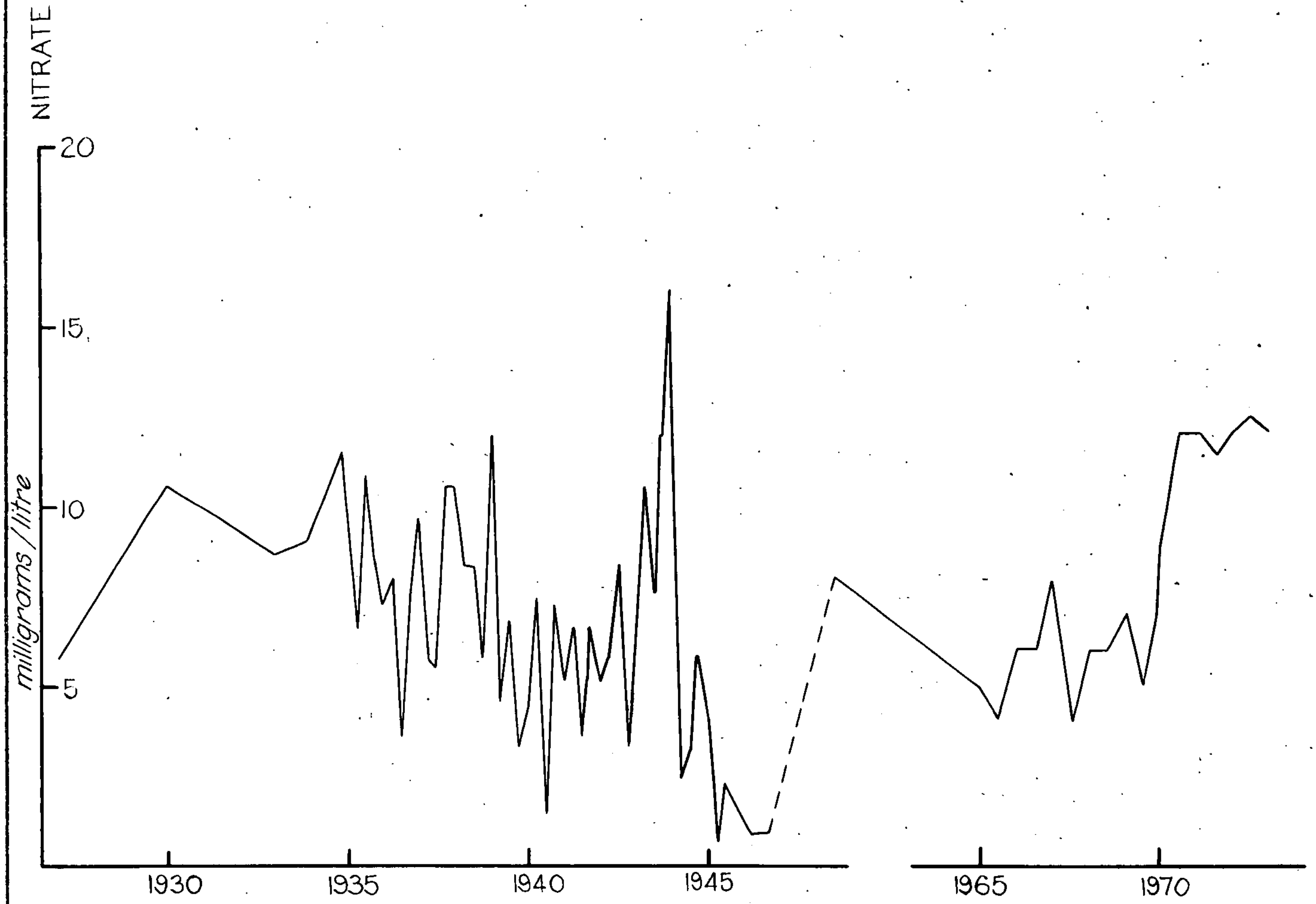
△[65] Composition : number refers to nitrate in mg/ℓ
Index to Hundreds

• Caroline ▫ MacDonnell ○ Mingbool △ Young

FIG. 17

	DEPARTMENT OF MINES – SOUTH AUSTRALIA	Scale:
Compiled: J.D. Waterhouse	SOUTH EAST WATER RESOURCES MOUNT GAMBIER AREA INVESTIGATION	Date: 3 April 1973
Drn. D.J.M. Ckd. A.F.	HDS. OF CAROLINE, MACDONNELL, MINGBOOL, & YOUNG SAMPLES WITH GREATER THAN 50 mg/ℓ OF NITRATE PIPER DIAGRAM	Drg. No. 75-150

7021,22 1M–2.70 A1811



Note: Up to 1945 values were reported as ammonia, but have been recalculated as nitrate using the formula below.

$$NO_3 = \frac{62}{17} NH_3 \quad \text{(in milligrams/ litre)}$$

FIG. 18

	DEPARTMENT OF MINES – SOUTH AUSTRALIA	Scale: AS SHOWN
Compiled: J. D.W.	SOUTH EAST WATER RESOURCES	Date: 16 APRIL 1973
Drn. S.J.C. Ckd. A.F.	MOUNT GAMBIER AREA INVESTIGATION	Drg. No.
JDWaterhouse	NITRATE CONCENTRATION IN BLUE LAKE WATER	S11343

300–6.72 C5552 7021,22

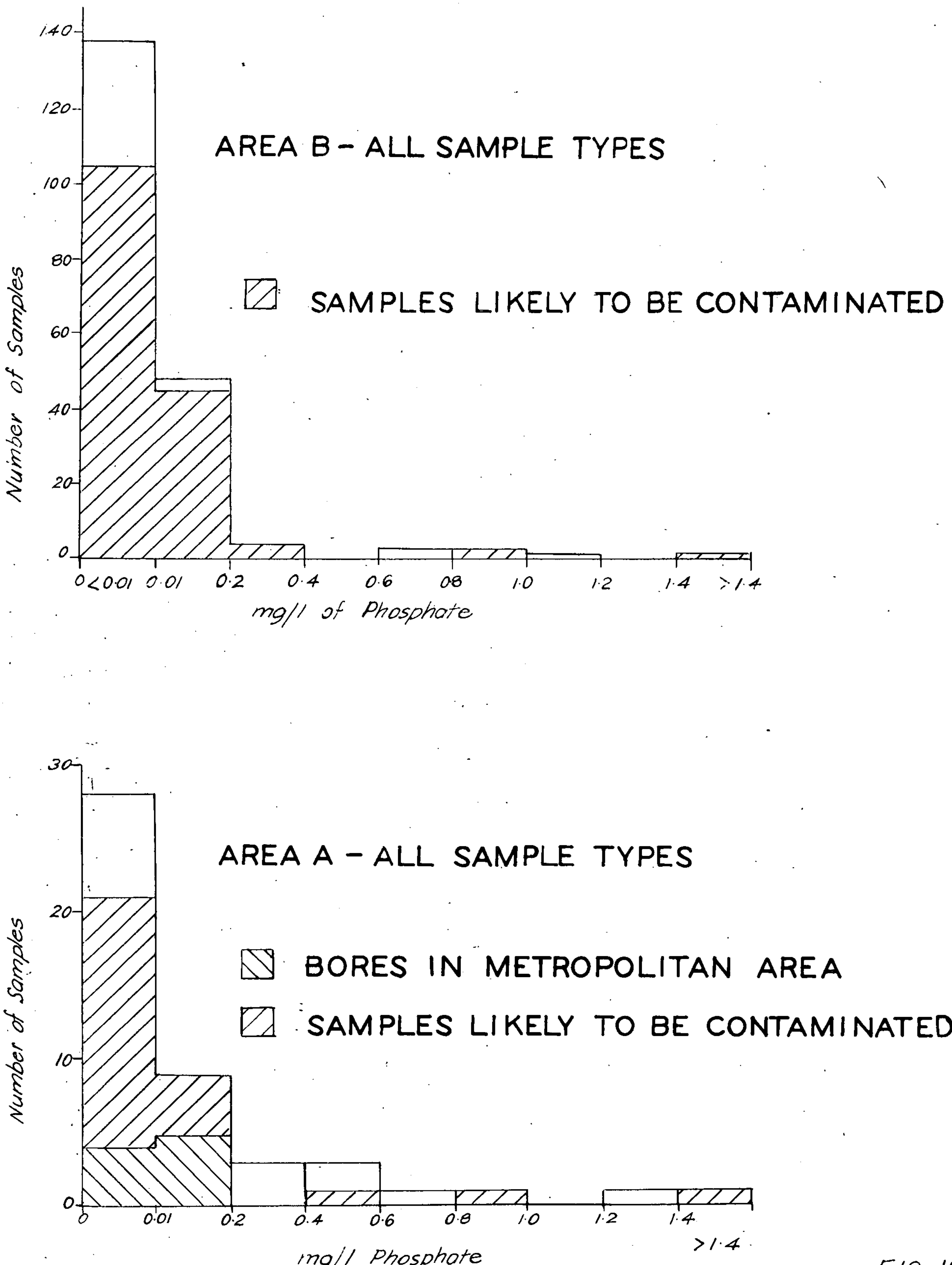
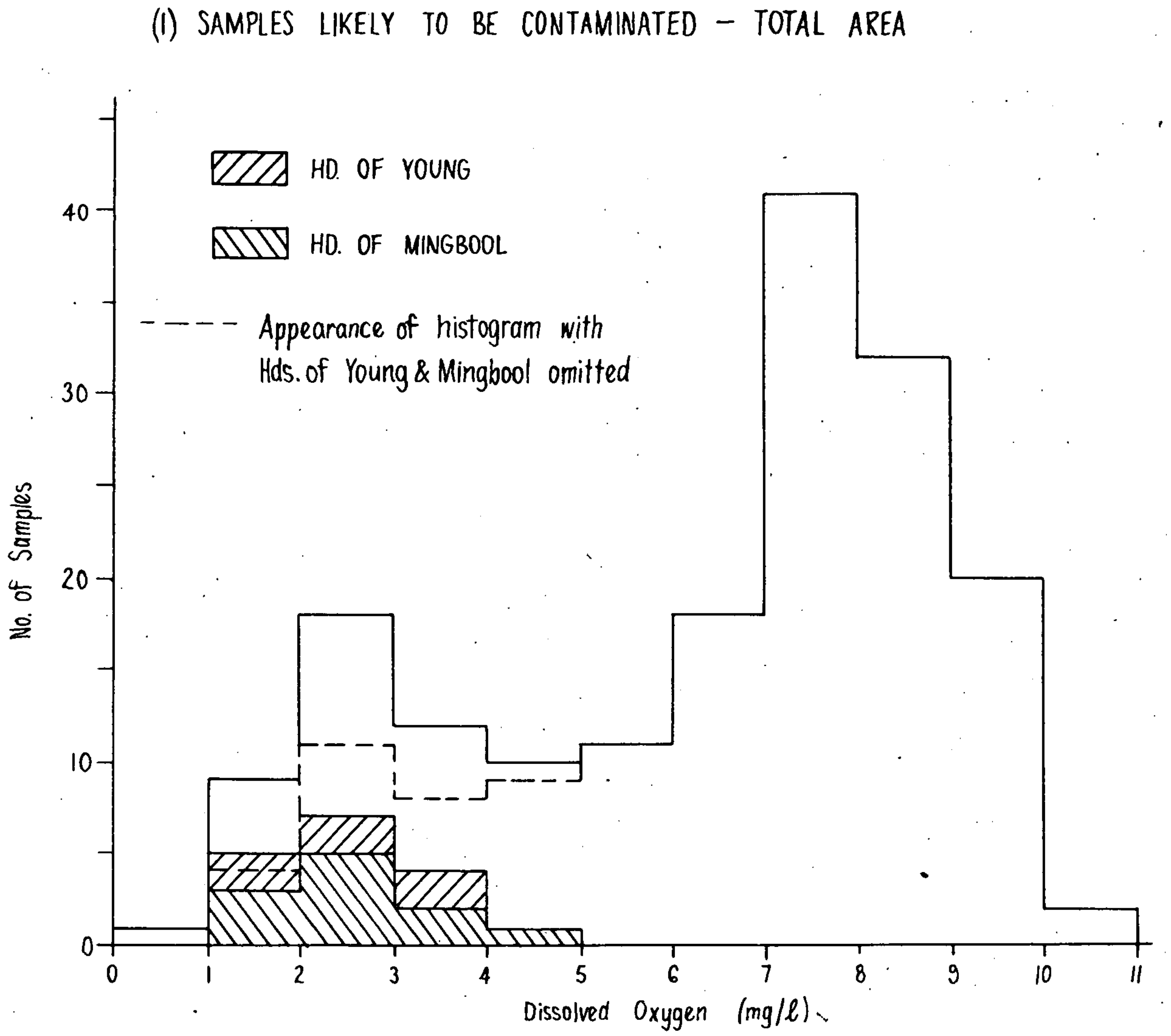


FIG. 19

HYDROLOGY SECTION	DEPARTMENT OF MINES – SOUTH AUSTRALIA	Scale. Diagram
Compiled: J.D. Waterhouse	SOUTH EAST WATER RESOURCES	Date: 13 Mar. 1973
Drn. DWW. Ckd. A.F.	MOUNT GAMBIER AREA INVESTIGATION	Drg. No.
J.D. Waterhouse	PHOSPHATE CONTENT OF SAMPLED WATER	S11345

7021,22



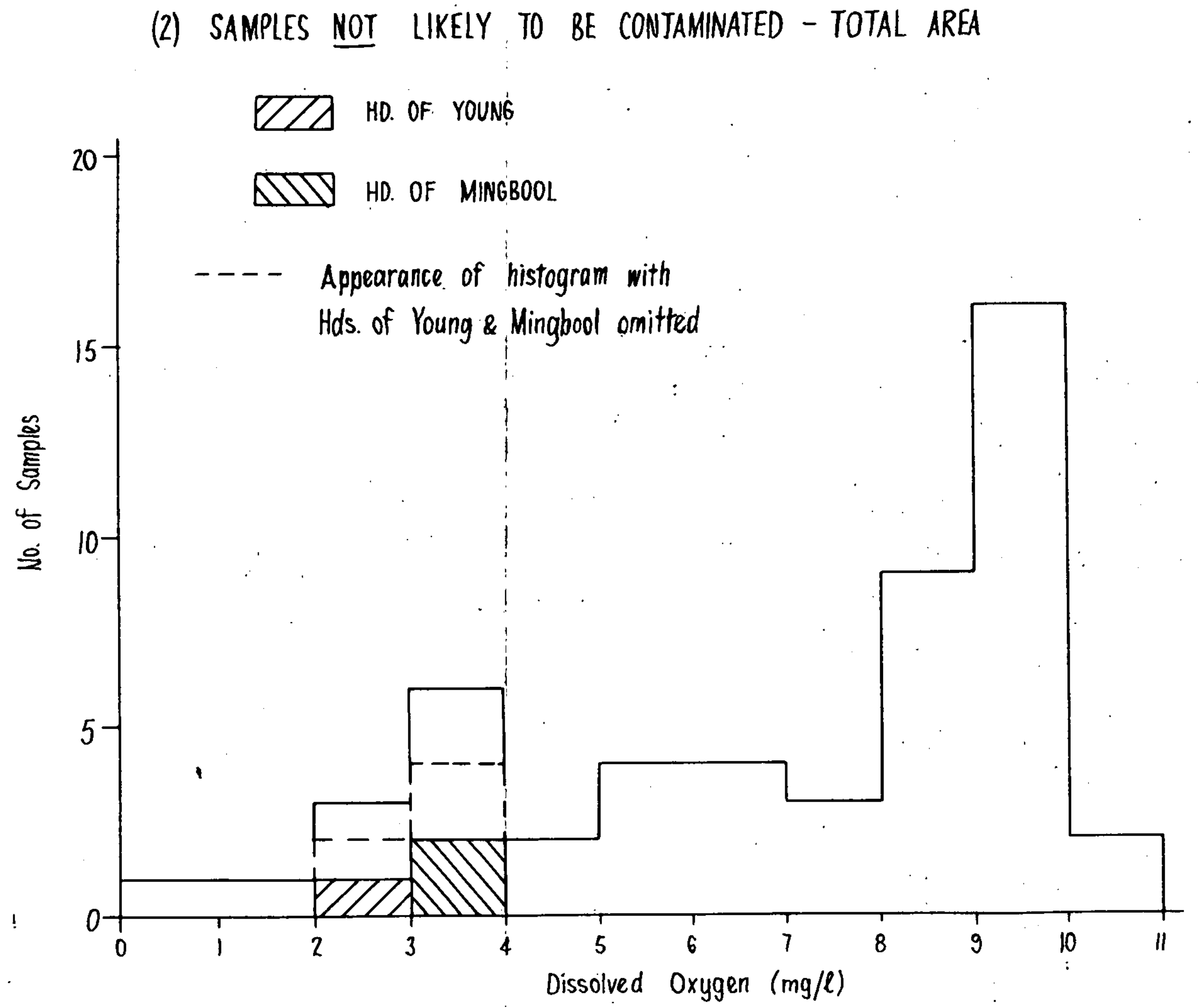


FIG. 20

HYDROGEOLOGY SECTION	DEPARTMENT OF MINES – SOUTH AUSTRALIA	Scale:
Compiled J.D. Waterhouse	SOUTH EAST WATER RESOURCES MT. GAMBIER AREA INVESTIGATION	Date: 30 APRIL '73
Drn. D.J.M. Ckd A.F.	DISSOLVED OXYGEN CONTENT OF SAMPLED WATER	Drg. No. 75-147
J.D. Waterhouse		

7021,22 1M–2.70 A1811

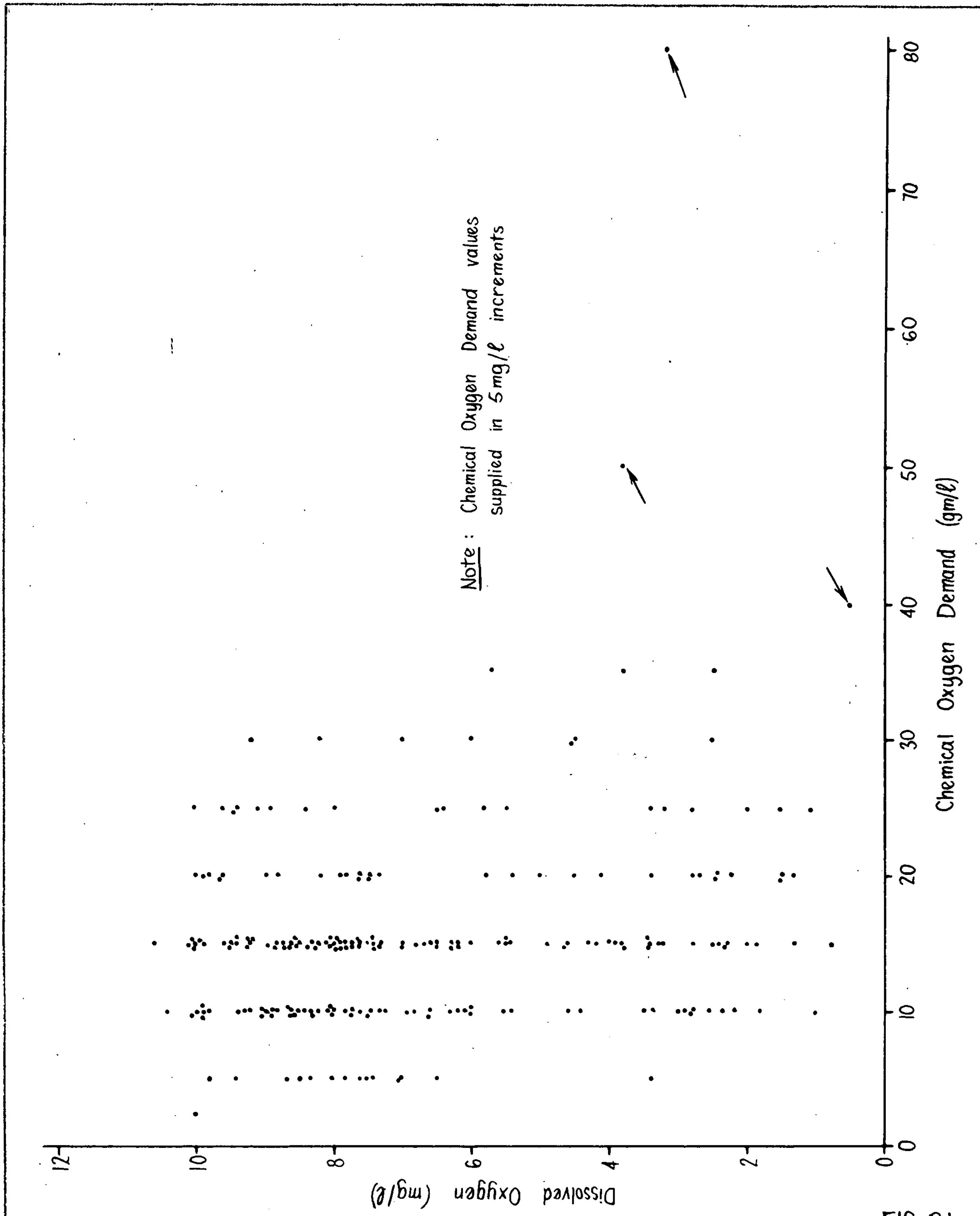


FIG. 21

HYDROGEOLOGY SECTION

DEPARTMENT OF MINES — SOUTH AUSTRALIA

Scale:

Compiled: J.D. Waterhouse

SOUTH EAST WATER RESOURCES
MT. GAMBIER AREA INVESTIGATION

Date: 30 APRIL '73

Drn. D.J.M. | Ckd. A.F.

Drg. No S11344

J D Waterhouse

DISSOLVED OXYGEN v CHEMICAL OXYGEN DEMAND

300- 6 72 05552 7021,22


MINGBOOL
GAMBIER
CAROLINE
AREA "A"
AREA "B"
AREA "B"
CITY OF MT. GAMBIER
YOUNG
BLANCHE
MAC DONNELL
BENARA
UMPHERSTONE'S CAVE
STATE SAWMILL
GAMBIER TOWN
PICT LTD. PEA FACTORY
ALLEN'S QUARRY SPRING
BURRUNGULE SPRING
LITTLE BLUE LAKE
ALLENDALE SINKHOLE
EWENS PONDS
EIGHT MILE CREEK
CAVETON
CLARKE PARK SPRING
PICCANINNIE PONDS
BEACH SPRING
PORT MAC DONNELL
DISCOVERY BAY
RAILWAY
LOCAL NETWORK OBS. BORE
D&M DRILLED BORE
REGIONAL NETWORK OBS. BORE
19 BORE & NUMBER
6·7 R.L. OF S.W.L. IN METRES
—8— S.W.L. CONTOUR
DATUM = MEAN SEA LEVEL, PT. ADELAIDE
NOTE: TO OBTAIN THE PROGRAM NUMBER OF A BORE, PREFIX THE NUMBER WITHIN EACH HUNDRED WITH THE ABBREVIATION BELOW.
YOUNG.... YOU MINGBOOL ..MIN
BLANCHE.BLA GAMBIER.... GAM
MACDONNELL.MAC CAROLINE.CAR
BENARA... BEN
SCALE
0 1 2 3 4 5 KILOMETRES
0 1 2 3 MILES
MAP I
DEPARTMENT OF MINES — SOUTH AUSTRALIA
SOUTH EAST WATER RESOURCES
MOUNT GAMBIER AREA INVESTIGATION
POLLUTION SURVEY AREAS AND SAMPLE POINTS
HYDROGEOLOGY SECTION
J. D. WATERHOUSE GEOLOGIST
COMPILED J.D.W.
DRN. TJE
CKD.
DIRECTOR OF MINES
SCALE: 1:50000
DATE: 6 JUNE 1973
DRG. NO. 73-436
Kd 14/15+17/18+20/21

72-317