DEPARTMENT OF MINES
SOUTH AUSTRALIA

GEOLOGICAL SURVEY
ENGINEERING DIVISION

DISPOSAL OF EFFLUENT AT KRAFT CHEESE FACTORY, MIL-LEL, MT. GAMBIER

Progress Report No. 1 - to June, 1976

by

S.R. BARNETT
GEOLOGIST, MT. GAMBIER

D.W. ARMSTRONG
SENIOR RESEARCH OFFICER
DEPT. OF AGRICULTURE & FISHERIES, NARACOORTE

W. EMMETT
CHEMIST
E. & W.S. DEPT., MT. GAMBIER

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ABSTRACT

A monitoring programme has been established, in a paddock immediately north of the factory, to ascertain the effect of sprinkler disposal of partly treated factory effluent on soil, herbage and groundwater composition. The aim of the investigation is to determine management techniques for the safe disposal of whey.

Representative sites have been selected for regular soil and herbage sampling and sampling of groundwater will be achieved through a network of 47 observation wells. These samples will be mainly analyzed for nitrogen, chloride and total salt content.

Results of groundwater sampling so far have shown background nitrate values of up to 42 mg/l before any effluent has been applied to the area.

It is recommended that sampling continue at regular intervals for a minimum period of two years to determine long term effects of this method of effluent disposal.

INTRODUCTION

The disposal of industrial wastes is a general problem in the South East of South Australia (Fig. 1). Good quality groundwater occurs at shallow depths in an often cavernous limestone aquifer, and is very susceptible to contamination. To protect this important water resources, legislation has been passed prohibiting the disposal of untreated wastes directly underground as from 31st December, 1977.

The management of Kraft Foods Ltd. has taken a positive step at their Mil-Lel cheese factory in changing their disposal practice from direct discharge underground to land application. They are spray irrigating about 20 to 40 hectares of perennial pasture with a travelling irrigator, the fodder being cut and removed from the paddock, with some areas grazed by cattle (Fig. 2).

Owing to complicating factors at Mil-Lel of high winter rainfall, permeable soils and good quality groundwaters at shallow depths, an investigation was initiated with the co-operation of Kraft, to monitor the results of this disposal method. The participants in this project are the Department of Agriculture and Fisheries, Department of Mines and the Engineering and Water Supply Department. As a result of this investigation, modifications of this disposal method may be suggested for this and other sites in the South East where irrigation with effluent is to be practised.

The aim of this report is to detail all work carried out before commencement of effluent spraying, to establish normal background data.

PROJECT AIM

The fundamental aim of this investigation is to enable guidelines for safe disposal of whey to be formulated. To achieve this, it is proposed to monitor the composition of herbage, soil and groundwater before effluent is applied and during application for two years. Recommendations can then be made on application rates and dilution of the effluent on the basis of these analyses to ensure maximum protection of the groundwater regime.

It is considered that the application of effluent will lead to an increase in concentration of particular salts (especially nitrate, Total Kjeldahl Nitrogen, chloride, Total Organic Carbon and total salt level) in the soil, herbage and groundwater.

If a water table mound does form due to the increase in infiltration above normal precipitation, it will be detected by accurate water level measurements.

PROJECT METHODS

In general, the field work consists of regular sampling of the soil, herbage and groundwater at specific sites within the disposal area. Analysis of the samples should reveal changes in composition during the period under study. Similarly, regular measurements of the groundwater level will indicate the effect of effluent disposal on groundwater levels.

Sampling for a short period before effluent application will assist interpretation of the analytical results.

A network of observation bores within 1.5 km of the site will be used to determine the regional water table configuration at three-monthly intervals with a closer grid inside the spray area for detailed water level measurements every 3 weeks and sampling at monthly intervals. Seven holes were drilled by a cable tool rig to ensure sampling by portable pump with the remainder drilled by an auger rig with sampling by bailer.

Representative sites will be selected for regular soil sampling. An annual sampling at 0.5 m increments down to the water table will indicate the nitrogen profile of the soil above the water table.

A more intensive sampling at the same sites will be carried out every three months to sample the root zone at 0.5 m increments to a depth of 2.0 m. At each site, 4 holes will be sampled with samples being bulked from the same depth.

Routine herbage samples will be collected from selected sites at regular intervals for analysis.

SITE PREPARATION

The disposal site lies 8 km northeast of Mount Gambier and consists of parts of sections 59 and 61, hundred of Gambier (see Locality Plan, Fig. 1).

It consists of two paddocks totalling 40 ha immediately north of the factory with a gravel road along the western boundary (Fig. 2).

The topography is undulating in the southern half and flat or nearly so in the northern part. Apart from pines along part of the western boundary and one or two in the middle, it supports only pasture plants with small areas of bracken.

The southern paddock contains perennial and annual pasture species including perennial rye-grass, lucerne, sub clover and sorrel, while annual species predominate in the northern paddock.

The average annual rainfall for the area is about 80 m with an A Class pan evaporation of approximately 1 520 mm.

Well Grid for Groundwater Observations

A field survey was carried out to locate all existing wells within 1.5 km of the irrigation site and from these, a grid of 33 wells was selected for monitoring the regional water-table configuration (Figs. 7 and 8).

In addition to this grid 47 observation wells were drilled in or adjacent to the proposed irrigation area (Fig. 2). Seven holes were drilled with a cable tool rig - four inside the area and three outside. Where possible, the holes were continuously cored to the water table below which sludge samples were taken at one metre intervals to the final depth of 15 m below water table. This enabled accurate assessment of the underlying geology. The wells were cased to the water table with 152 mm diameter steel casing with the exception of two wells which were fully cased with slotted 76 mm PVC casing (due to very difficult drilling conditions in unconsolidated sediments). The 152 mm casing allows groundwater sampling with a portable submersible pump and also the measurement of temperature and dissolved oxygen profiles when desired.

The remaining 40 wells were drilled with a Department of Agriculture and Fisheries Proline auger rig using 102 mm diameter flights and cased with 76 mm slotted PVC casing. Some problems were encountered with unconsolidated sediments collapsing back into the hole whilst the auger flights were being removed and before the PVC casing could be inserted in the hole. These holes were located on a grid inside the area (Fig. 2).

Hydrogeology

The geology and hydrogeology of the site is summarized in Table 1. Detailed geological logs of the cable tool holes are presented in Appendix 1 and geological cross-sections shown in Fig. 3.

The area under investigation can be subdivided into two regions. The southern half exhibits an undulating topography resulting from a blanket of unconsolidated sands of variable thickness over the stranded dune complex of the Bridgewater Formation. This unit overlies the Gambier Limestone with an almost horizontal unconformity.

The northern portion however, is almost flat-lying with the Bridgewater Formation absent. Here, the sandy clays and silty sands of the Malanganee Formation (which were probably deposited in inter-dunal lagoons during the Pleistocene shoreline retreat) directly overlie the Gambier Limestone.

TABLE 1

HYDROGEOLOGY

Age	Unit and Lithology	Thickness	Hydrogeology
Pleistocene-Recent	Malanganee Formation-unconsolidated wind-blown quartz sand derived from winnowing of aeolianite dunes (Crocker, 1946). Also includes sandy clays and silty sands deposited in back-shore lagoonal environments.	1-12 m	Poor aquifer of limited areal extent where water table is close to ground surface. Often contains perched water tables. Stock supplies only of very low salinity water (less than 300 mg/l).
Pleistocene	Bridgewater Formation- orange-brown quartzose calcarenite (aeolianite), fossiliferous. Unconformably overlies Gambier Limestone.	0-10 m	Variable aquifer of limited areal extent. Generally not widely developed. Hydraulically continuous with Gambier Limestone aquifer.
Oligo-Miocene	Gambier Limestone-typically an offwhite to grey bryozoal calcarenite containing black flint and traces of green glauconite. Very small calcite rhombs often present.	90 m	An extremely important water resource for domestic, industrial and irrigation purposes. Contains good quality groundwater (less than 500 mg/l) at shallow depth. Easily contaminated due to its cavernous nature.

Soil Survey

A soil survey of the disposal area was conducted in August, 1975. The aim was to describe and map the soil to permit better understanding of the results and assist extrapolation of the results to other situations.

The site was surveyed by description of soil profiles on a 61 m square grid with auger holes (33 mm in diameter and 1 200 mm deep) drilled by a Proline auger to allow inspection of the profile. At all sites depth, texture, type and amount of stone were recorded, and at about 25% of the sites, soil colour (Munsell) fabric, reaction to 1 N Hydrochloric acid and pH were recorded.

As a result of this field work the area has been divided into four quite distinct units described as follows with detailed profiles presented in Appendix 1.1.

SOIL UNIT 1. Sand over shallow stone soils, area 8.0 ha.

This unit slopes gently away from the factory to the north, with very gentle undulations. The soils all have a sandy loam surface texture (Malanganee Formation), with the sand predominating down the profile generally to about 0.6 m.

Below the sand there is usually a layer of red to orange medium clay, usually less than 0.6 m thick, although the clay was not encountered on a slight rise.

Generally coarse textured calcareous stone (Bridgewater Formation) occurs within 1.2 m of the soil surface with nodular ironstone gravel occasionally found in the sand immediately above the clay or stone.

The clay in this unit was well drained. No*gleying was observed. Generally it is weakly pedal with clay skins apparent at most sites.

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*gleying - a bluish-grey compact soil horizon developed under the influence of excessive moisture.

Soils of this unit should be well drained allowing rapid infiltration of rainfall and effluent. The clay should not be a significant barrier to infiltration because it occurs as a thin layer and has some structure.

SOIL UNIT 2. Deep sand-dune soils, area 10.5 ha.

This unit is essentially the dune area with the sand being deep, (up to 10 m) and extending to the base of the dune. Topography is gently to steeply undulating.

The sand is part of the Malanganee Formation, and deep drilling during construction of the observation bores indicated that it overlies Bridgewater Formation. Infiltration of rainfall and effluent in this unit would be extremely rapid.

SOIL UNIT 3. Red clayey soils with shallow stone, area 2.0 ha.

A gently to steeply sloping unit with a considerable amount of clay in the surface soil layer. Surface textures range from fine sandy loam to sandy clay loam overlying fine sandy loam to clay loam.

Coarse calcareous stone (Bridgewater Formation) always occurs within 0.7 m of the soil surface.

In most cases the profiles in this unit contained very little sand and therefore represent an area where aeolian sand of the Malanganee Formation was either not deposited or has been removed. The resulting soil has developed from and in the Bridgewater Formation.

Many of the soil profiles were of uniform texture (Northcote, 1971) and can be classified as Terra Rossa soils according to the Great Soil Group classification.

The soils of this unit have a medium infiltration capacity and are well drained. However, run-off is likely during heavy rain or when effluent is applied at heavy rates (at say greater than 8.0 mm per hour).

SOIL UNIT 4. Sandy soils of the flat, area 20.8 ha.

The soils of this unit consist of sand extending to 1 m over most of the area. Surface texture is generally a sandy loam becoming more sandy with depth.

In two small low lying areas the surface soil was darker coloured with paler lower layers than on the main better drained area.

Within this unit the topography is nearly flat with undulations of only 1-2 m. The north east corner is inundated during the winter, and a water table occurs over most of the unit at 1-2 m. Deeper drilling during construction of the groundwater observation wells revealed a bluish grey impermeable clay at 3-4 m.

The inherent infiltration capacity of the soil is very high. However, infiltration may be prevented by a high water table likely to develop during winter and if effluent applications exceed evapo-transpiration.

INITIAL RESULTS IF MONITORING

Groundwater

The depth to the water table beneath the irrigation site varies between one and twelve metres, and is shown in Fig. 5. These contours are of course, mainly a reflection of the topography. The regional water table configuration (Figs. 7 & 8) shows that groundwater flow (which is perpendicular to the water table contours) is towards the southwest. The gradient of the water table is also steepening in this direction and represents the northern margin of the "Steep Gradient Zone" (Waterhouse, 1975).

Water table contour plans of the site (Figs. 9 & 10) also show the southwesterly trend but with a topographic effect from the dune forming the highest point on the area of interest. As can be seen in the geological cross-section (Fig. 4), the water table is continuous across geological boundaries. Water level measurements taken at three-weekly intervals indicate that the highest point of the water table occurred in January with the lowest level in late July. The range is 0.6 to 0.8 metres.

The approximate annual recharge has been calculated to be about 200 mm on the basis of tritium work carried out by the CSIRO.

The chemical composition of the groundwater is of the calcium bicarbonate-sodium chloride type which can be explained mainly in terms of dissolution of dolomitic limestone and cyclic salt (Waterhouse, 1975).

Analyses of pumped samples from the cable tool drilled wells shqw that these salts predominate (Appendix 2.2). Observation wells GAM 112, 124, 147 and 149 were sampled after 30 mins.pumping with a portable submersible pump and GAM 131 and 160 similarly with a Finsbury centrifugal pump. Sampling was carried out on most bores at approximate monthly intervals with the analyses included in Appendix 2.2 covering the period only up until straying of effluent commenced in early June, 1976.

It is interesting to note the reasonably high nitrate values (up to 42 mg/l) present before any effluent had been applied to the area. The nitrate ion is derived from the breakdown of organic wastes and its presence in this area is thought to be mainly the result of agricultural practices, e.g. stock wastes and fertilizers.

As expected, the initial pollution indicator levels and bacteria counts are fairly low. The presence of bacteria in wells where the water table is very shallow (GAM 131, 149, 160) is possibly due to soil bacteria and contamination from grazing cattle.

The remaining observation wells were well bailed before sampling (sufficient to empty well column) on an approximate monthly basis, and analysed for chloride, nitrate and conductivity with results tabulated in Appendix 2.3. Values from each well appear reasonably consistent, even though they differ from samples obtained by pumping from the same well. Differing quantities of groundwater removed from the well before sampling could account for these discrepancies.

Fig. 6 shows salinity and nitrate contours of bailed samples for April, 1976. The salinity values of less than 300 mg/l are associated with bores completed in the interbedded sands and clays of the Malanganee Formation present in the northern portion of the area. Here, the water table is also shallow (1-3 m).

Salinity levels of over 400 mg/l are restricted to the area close to the factory and down gradient from it and could possibly be the result of the previous practice of sub-surface waste disposal. Two observation wells, GAM 113 and GAM 168 show obvious signs of contamination with very high salinity values and a surprisingly low nitrate content. This trend compares well with the effluent analysis in Appendix 2.4.

In fact, polluted groundwater was intersected during the drilling of GAM 113. The water was milky, noticeably warm and possessed a strong pungent whey odour. This well should be included in the monthly sampling to gain an indication of the composition of groundwater polluted by whey and also to detect any improvement in water quality with the cessation of underground disposal.

Soil Analyses

Nine representative sampling sites have been selected with their locations shown on Fig. 4. Although a large number of soil samples have been taken for analysis by the Department of Agriculture and Fisheries, most analyses have not yet been completed.

Soil samples were taken at the following dates:-

Oct. 1975 During drilling of the deep observation wells by Department of Mines cable tool rig.

Frozen samples to be analysed for nitrate and chloride.

Dried samples to be analysed for total nitrogen, organic carbon, carbonate, bicarbonate, ammonia, total salts and pH.

Results from GAM 147 are shown in Appendix 3.3.

Oct. 1975 Deep drilling at 3 sites by CSIRO.

Frozen samples for nitrate and chloride determinations.

These analyses have been completed and results are presented in Appendix 3.1 (the sampling sites are indicated as C1 to C3 on Fig. 3).

Dec. 1975 First routine soil sampling, 9 sites, 50 cm increments to 2 m.

Frozen and dried samples for same analyses as for Department of Mines wells.

April, 1976 Second routine sampling as above.

June, 1976 Third routine sampling.

Results of nitrate and chloride analyses for the above routine samplings shown in Appendix 3.2.

Herbage Analyses

Herbage sampling was started in September, 1975 by taking a single sample of herbage from each of the 9 soil sampling sites. Bulking the samples from sites 1, 2 and 9 and sites 3 to 8 produces samples A and B respectively.

These samples are being analysed for nitrate, nitrate, total nitrogen and magnesium.

To date, only sample B has been obtained i.e. pasture within the main effluent disposal area adjacent to the factory.

Sample Date	Analysis (%)							
	N	P	S	Cl	K	Ca	Mg	Na
2/12/75	1.08	0.16	0.15	0.81	1.10	0.41	0.19	0.28

THE EFFLUENT

Effluent produced by the factory consists chiefly of whey, together with small quantities of detergents and sodium hydroxide, and wastewater produced from spillages and washing down.

As much whey as possible is sold to pig farmers for use as feed, and it is the whey surplus to this requirement which is disposed of by spray irrigation.

Effluent is pumped to the treatment plant at the southwest corner of the factory site. Whey is treated in a flotation cell to remove as many solids as possible which are disposed of by dumping on the ground. The whey liquid waste is then diluted with well water and mixed with the remainder of the effluent before spray irrigation. The dilution factor being used in approximately 1 part whey to 3 parts of water. The water used for dilution is from a Gambier Limestone well which had been used as the main Kraft production bore before the aquifer became polluted by the previous discharge of effluent underground. A well drilled to the Knight Group confined aquifer is now used as a production well (Barnett, 1976).

Spray irrigation trials to determine the optimum water-whey ratio commenced in May, 1976. It was desired to irrigate with the highest possible whey concentration to reduce the volume of effluent to be applied. The upper limit of whey concentration was that which caused pasture burn (approximately 3 000 mg/l).

The tests were completed early in June, and spray irrigation on a daily basis commenced June 8th. Spraying was to be carried out for approximately 14 hours per day, 7 days per week.

There are 13 hydrants in the irrigation area to which the travelling irrigator will be attached in turn (Fig. 2). Use of hydrant 1 would result in effluent being sprayed onto the factory car park and onto two houses adjacent to the factory. Hydrants beyond No. 10 will only be used to dispose of surplus effluent. Complete rotation of hydrants is expected to take approximately 2 weeks, during which time effluent equivalent to 50-75 mm of rainfall will have been sprayed onto each section of pasture. Approximate spraying rate is 50 kl per hour.

Grazing of approximately 40 cows for 2 hours per day, in the area between gate 1 and hydrant 8 (Fig. 2) commenced on June 27th and will continue until the end of August. Pasture would then be slashed, and cut for hay between September and November, depending on seasonal conditions. The remainder of the main irrigation area, up to hydrant 8 will be forage harvested during July and cut for hay later in the year.

The area beyond hydrant 8 is used for uncontrolled grazing.

The utilisation of areas described above will probably apply until the end of 1976.

Sampling and Analysis

Effluent is to be monitored daily by Kraft for suspended solids, pH and Chemical Oxygen Demand, and conductivity.

Kraft plans to install an automatic effluent sampling device before the end of 1976, which will enable daily composite samples to be taken. Refrigeration of samples will also be incorporated. At this stage it is not thought that effluent composition varies greatly throughout the day.

Analyses of "grab" samples of (i) effluent as applied to the pasture, (ii) undiluted whey after flotation, and (iii) bore water used for dilution are given in Appendix 2.4.

CONCLUSIONS AND RECOMMENDATIONS

A monitoring programme has been instigated to determine if spray irrigation of effluent can be a successful disposal method with recommendations on application rates and effluent concentration provided on the basis of analysing soil, herbage and groundwater composition.

It is thought that nitrogen, chloride and total salt content are suitable parameters for analysis, but these may be modified as the project progresses. Although background nitrate values are as high as 42 mg/l, the nitrate ion may not be a critical parameter in determining contamination by effluent.

Regular sampling should continue at regular intervals for at least two years. In particular, groundwater sampling should be carried out at monthly intervals until the end of 1976 to monitor any rapid changes in groundwater chemistry.

ACKNOWLEDGEMENTS

The interest, assistance and encouragement of the management and staff of Kraft Foods Ltd., Mil Lel factory, particularly Mr. David Robb and Mr. Colin Stone are gratefully acknowledged.

11/2/77

S.R. BARNETT
GEOLOGIST

D.W. ARMSTRONG
SENIOR RESEARCH OFFICER

W. EMMETT
CHEMIST

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APPENDIX I

GEOLOGICAL LOGS

1.1 Soil Profiles

DEPARTMENT OF MINES SOUTH AUSTRALIA

HYDROGEOLOGY SECTION

BORE LOG

HIRER **DEPT. OF MINES**

Drill type CABLE TOOL
Circulation Water, mud
Driller A. Anderson
Start 10·9·75
Finish 17·9·75

Logged by S. BARNETT
Date logged 26·9·75
Bore Diameter 152 mm
DEPTH 20·00 m

A.M.G. Zone
Coords. E
" N
Datum Elev. MSL Pt. Adel.
(m) Ref. Pt. Elev. 11·605 m. T.O.C.
Surface Elev.

HUNDRED GAMBIER
SECTION 61
STATE No. 70222700W00170
Project No. GAM 147
Docket No. 238/75
Bore Serial No. 113/76

Depth to Water cut (m)	Depth to standing water (m)	SUPPLY		TOTAL DISSOLVED SOLIDS	
		litres/sec.	Method of test	Milligrammes/litre	Analysis W. No.
12·25	11·94		depth 12·0 m 20·0 m	402 495	E&WS analysis

REMARKS KRAFT SPRAY EFFLUENT SCHEME INVESTIGATION, MIL-LEL. TEMP. Nº VA 54, PERMIT B 429. BORE CORED FROM SURFACE TO 14·75 WITH SLUDGE TO 20·0m

CASING	WATERS CUT	WATER LEVEL	DEPTH (m)	CORE	GRAPHIC LOG	AGE	UNIT	DEPTH (m) from	DEPTH (m) to	DESCRIPTION
14·34 m of 152 mm steel casing cemented to surface			0			Pleistocene – Recent	Malanganee Formation	0	12·0	**ARENITE** dark chocolate brown in colour with abundant plant roots etc. Quartz grains avge. 0·2–0·3 mm diam, mainly translucent subangular to rounded, well sorted & equant. Occasional rounded opaque grains 0·1 mm (heavy mins (?)) Quartz grains frosted. 5% dark brown silt **0·25–0·50m** as above, dark orange brown colour, fewer plant roots **0·50–1·25** light brown arenite, roots absent **1·25–1·50m** as above, fawn coloured arenite

Drn: G.M | Sheet 1 of 3
Date: 18·5·76 | Bore Folder No.

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
14.34 m of 152m steel casing cemented to surface			1.5			Pleistocene - Recent	Malanganee Formation		**1.50 - 1.80 m** mainly off-white clean arenite with light & dark brown mottling.
									1.80 - 2.00 m clean offwhite arenite, av. size as above.
			2.0						**2.00 - 2.75 m** as for 1.50 - 1.80 m
			2.5						**2.75 - 3.15 m** fawn, light orange & dark brown mottling
			3.0						**3.15 - 3.75 m** dark orange arenite with dark brown mottling. Soil moderately consolidated 5% dk brown silt
			3.5						**3.75 - 4.00 m** as above 10% dk brown silt
			4.0						**4.00 - 4.75 m** dk orange arenite with dk brn mottling & minor silt
			4.5						**4.75 - 5.00 m** buff coloured arenite with light brown mottling
			5.0						**5.00 - 5.75 m** as above with light & dark brown mottling
			5.5						**5.75 - 6.00 m** mostly dk brown arenite with black mottling
			6.0						**6.00 - 7.50 m** as for 5.00 - 5.75m
			6.5						

Borehole State No. 70222700W00170

Drn: G.M | Sheet 2 of 3

Date: 19.5.76 | Bore Folder No.

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
14.34m of 152mm steel casing cemented to surface			6.5			Pleistocene - Recent	Malarganee Formation		**7.50 - 8.00 m** dk brown & fawn arenite, av. size 0.3 - 0.4 mm **8.00 - 9.30 m.** clean fawn arenite ave. size 0.2 - 0.3 mm. **9.30 - 12.00 m** fawn coloured arenite a.a mottled light & dark brown
			12.0					12.00 20.0	**CALCARENITE** orange brown, moderately consolidated with 25% orange calcilutite. Mainly bryozoal frags up to 2mm with minor well cemented frags. up to 1cm, stained orange **12.20 - 12.25 m** off-white bryozoal calcarenite, av. 0.5 - 1.0 mm, 20% calcilutite **12.25 - 12.75 m** pale orange with bryoz. frags < 3mm **12.75 - 13.00 m** as for 12.20 - 12.25 m **13.00 - 14.15 m** pale orange calcarenite with bryozoal frags < 3mm with up to 40% orange WCF & 20% calcisiltite
7.37m of slotted 127mm steel casing			14.0			Pleistocene	Bridgewater Formation		**14.15 - 14.30 m** v. pale orange bryozoal calcarenite, fossil frags < 2mm blebs of whitish calcisiltite 10%, minor WCF **14.30 - 14.50 m** as for 12.20 - 12.25 m **14.50 - 14.70 m** as for 13.0 - 14.15 m **14.70 - 14.75 m** as for 12.20 - 12.25 m **14.75 - 16.00 m** pale orange bryoz calcar, bryoz frags < 3mm, 25% calcisiltite, 10% blebs of calcilutite
			16.0						**16.00 - 20.00 m** v. pale orange in colour, bryoz. frags 0.3 - 0.5 mm 20% WCF, 10% blebs of lutite
			18.0						
			20						**END OF HOLE 20.00 m**

Borehole State No. 70222700W00170

Drn: G.M | Sheet 3 of 3

Date: 18.5.76 | Bore Folder No.

PF No S10537a MH

DEPARTMENT OF MINES SOUTH AUSTRALIA

HYDROGEOLOGY SECTION

BORE LOG

HIRER DEPARTMENT OF MINES.

Drill type CABLE TOOL
Circulation Water
Driller A. Anderson
Start 18.9.75
Finish 23.9.75

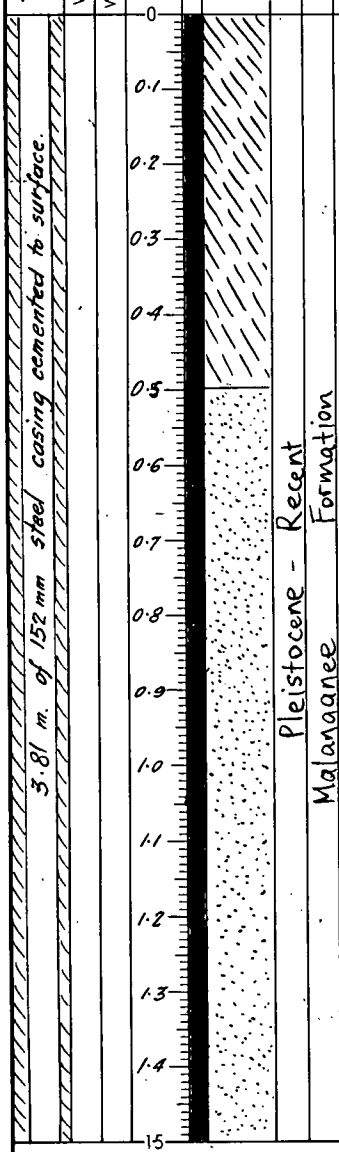
Logged by M. A. Cobb
Date logged 21.10.75
Bore Diameter 152 mm.
DEPTH 18 m.

A.M.G. Zone
Coords. E
" N
Datum Elev. M.S.L. Pt. Adel.
(m) Ref. Pt. Elev. 62.145 T.O.C.
Surface Elev.

HUNDRED GAMBIER
SECTION 61
STATE No. 702227OOWOO172
Project No. GAM 149
Docket No. 238/75
Bore Serial No. 115/76.

Depth to Water cut (m)	Depth to standing water (m)	SUPPLY		TOTAL DISSOLVED SOLIDS	
		litres/sec.	Method of test	Milligrammes/litre	Analysis W. No.
3.00	2.20		depth 3.0 m	358	E & W.S. analyses
			8.0 m	530	
			13.0 m	525	
			18.0 m	460	

REMARKS KRAFT MIL-LEL SPRAY EFFLUENT SCHEME INVESTIGATION BORE TEMPORARY Nº Y.A.55. BORE TUBED FROM SURFACE TO 3.25 m THEN 1m SLUDGE SAMPLES TO BASE PERMIT B.429.



DEPTH (m) from	to	DESCRIPTION
0	0.50	QUARTZ ARENITE Dark brown. Quartz silt size to 0.2 mm, angular to well rounded, sub-spherical, dominantly brown stained, some clear (transparent); frosted. Minor black Fe oxides (nodular), organic fragments. Becomes paler (orange-brown) to base and more even grained (0.1 – 0.2 mm), grains white to orange stained, some with small black inclusions. Proportion of clear grains increases with depth.
0.50	0.60	QUARTZ ARENITE Pale brown-fawn. Generally as above, even grained 0.1 – 0.2 mm., quartz clear, frosted, some orange-brown stained, angular to sub-angular, some well rounded, spherical to platy. Minor Fe oxides / sulphides.
0.60	2.05	QUARTZ ARENITE Pale fawn., clear, even grained average 0.2 mm. Only minor orange staining of quartz grains, frosting common, some pale pink. Minor green-brown mica and black nodular Fe oxides below 1m. Slightly clayey to base.

Drn: B.S.G. | Sheet 1 of 3
Date: 20.5.76 | Bore Folder No.

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
		Pleistocene - Recent
		Malanganee Formation
2.05	2.25	QUARTZOSE LUTITE Pale grey (green fringe) 30-40% quartz arenite at top decreasing to 5-10% at base. Non calcareous, plastic. Quartz grains as above.
2.25	2.37	LUTITIC QUARTZ ARENITE Pale grey. Generally as above with 20% lutite binding a quartz arenite Odd calcareous grain.
2.37	2.75	LUTITE Generally as above with 10-20% clear quartz. Increase in content of calcareous grains and cemented nodules of calcareous grains to base.
		Pleistocene
		Bridgewater Formation
2.75	3.15	LUTITIC CALCARENITE off-white, fine grained. Dominantly calcareous chips 0.1-0.2 mm., bryozoal and spicular fragments, up to 10% clear quartz. Some orange staining. Some grains to 1mm.
3.15	3.25	CALCARENITE, minor lutite matrix, average grain size 0.5-0.8 mm. dominantly calcareous chips, bryozoal fragments (plate, tubes, branching colonies), foraminifera, minor quartz. Some orange staining.
3.25	4.0	CALCARENITE/CALCIRUDITE Generally as above, average grain size 1-1.5 mm. dominantly calcareous chips, bryozoal fragments etc. Minor clear quartz. Some orange staining.
4.0	10.0	CALCARENITE. off-white - pale fawn. Grain size range 0.1-2 mm, average 0.4-0.5 mm becoming slightly finer and more even grained with depth. Dominantly calcareous chips, bryozoal fragments (elongate-tubular, platy), foraminifera - Minor quartz. Slightly clayey below 7m. Translucent calcareous grains common below 8m. and minor Fe oxide 9-10 m.

3.81m x 152 mm steel cemented to surface.

Change in Scale.

Borehole State No. 70222700W00172

Drn: B. S. G. | Sheet 2 of 3

Date: 20.5.76 | Bore Folder No.

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
			8			Pleistocene	Bridgewater	10	12	CALCIRUDITE Essentially fragments of shells, bryozoa, travertine, flint(chert) & well cemented (siliceous) (recrystallised) grey-red-brown calcisiltite/calcarenite to 1cm. Finer grained fraction (0·2-0·4 mm) similar. Average grain size towards base 2-3mm plus achinoid spines, minor clear rounded quartz. Glauconitic
			9							
			10							
			11							
			12					12	13	CALCISILTITE/CALCARENITE. Pale grey. Generally as shown but finer grained. Several larger (1cm) complete shells(mollusca?). Minor clear brown stained quartz, minor glauconite.
			13			Oligo-Miocene	Gambier Limestone	13	16	CALCARENITE/CALCIRUDITE Pale grey. Dominantly fossil fragments, shells(helical, valves etc), bryozoa (plate, branching tubes), spicules, foraminifera - Silicified fragments, flint, chert common. Minor well rounded quartz. Glauconitic.
			14							
			15							
			16					16	17	CALCARENITE Generally as above. Grain size range 0·2-2mm. Some well polished brown quartz travertine, glauconite.
			17							
			18					17	18	CALCARENITE/CALCISILTITE. Strongly silicified fragments of grey calcisiltite with brown flint (chert) dominate sample. Rest calcareous chips, fossil fragments as above.
										End of hole 18·0 m.

Borehole State No. 7022700W00172

Drn: B.S.G. | Sheet 3 of 3

Date: 20·5·76 | Bore Folder No.

PF Nº S10537a MH

DEPARTMENT OF MINES SOUTH AUSTRALIA

HYDROGEOLOGY SECTION

BORE LOG

HIRER DEPT. OF MINES

Drill type CABLE TOOL
Circulation WATER
Driller A. ANDERSON
Start 23·9·75
Finish 2·10·75

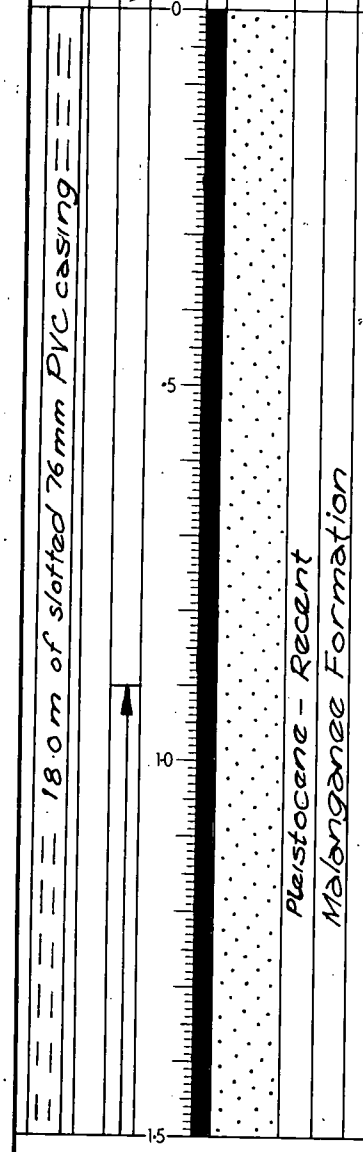
Logged by S. BARNETT
Date logged 20·10·75
Bore Diameter 254, 203mm
DEPTH 18·0m

A.M.G. Zone
Coords. E
" N
Datum Elev. M.S.L
(m) Ref. Pt. Elev. Pt Adel. 63·131m TOC
Surface Elev.

HUNDRED GAMBIER
SECTION 61
STATE No. 70222700W00184
Project No. GAM 160
Docket No. 238/75
Bore Serial No. 117/76

Depth to Water cut (m)	Depth to standing water (m)	SUPPLY		TOTAL DISSOLVED SOLIDS	
		litres/sec.	Method of test	Milligrammes/litre	Analysis W. No.
5.00m (seepage) 11.00m	0·90m		depth 5·0m 11·0m 15·0m 18·0m	392 585 580 580	E&W.S Analyses

REMARKS KRAFT MIL-LEL SPRAY EFFLUENT SCHEME INVESTIGATION. TEMP. No. VA 56 BORE TUBED FROM SURFACE TO 1·75 & 4·50–5·00m WITH SLUDGE TO 18·0m PERMIT B 429

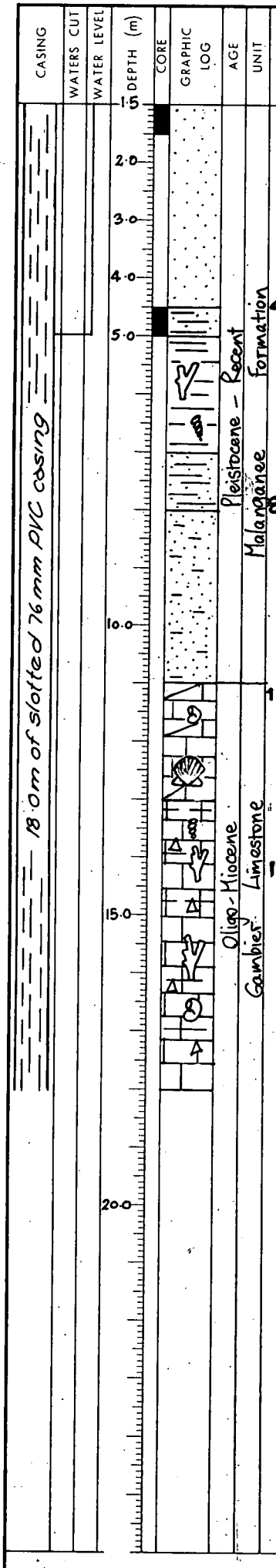


DEPTH (m) from	to	DESCRIPTION
0	4·5	**QUARTZ ARENITE 0–0.3m** very dark brown, abundant organic matter (plant root(s). Quartz grains 0·2–0·3mm diam., mainly translucent with brown staining, equant, subrounded to rounded. Grains well sorted & frosted. 10% dark brown silt with minor rounded opaque grains 0·1mm (Fe oxide) **0·3–0.5m** arenite as above grading to paler brown cleaner sand portions mottled dark brown moist and finer grained (0·1mm) **0·5–0·75m** dark brown mottled arenite as above grading to clean pale orange & off-white arenite 0·2–0·3 mm grains frosted & well sorted **0·75–1·00m** off white to pale orange arenite as above. Rare black opaque heavy mineral grains 0·1mm still present **1·0–1·3m** moist off-white arenite (clean) as above **1·3–4·5m** pale grey moist arenite as above with 10% silt

Drn: G.M | Sheet 1 of 2
Date: 19.5.76 | Bore Folder No.

PF Nº S10537 MH

DEPARTMENT OF MINES — SOUTH AUSTRALIA



DEPTH (m) from	to	DESCRIPTION
4·5	8·0	**LUTITE 4·5-5·0m** very stiff plastic pale blue-grey lutite with 30% rounded translucent quartz grains (0·1-0·2mm) disseminated throughout. Small bands of dark brown arenite 0·2-0·3 within lutite. **5·0-7·0 m** very dark grey plastic lutite with 40% shell & bryozoal fragments up to 2mm 10% quartz grains as above **7·0-8·0m** grey-black plastic lutite with 30% translucent subrounded quartz grains av. 0·2mm. No fossils
8·0	11·0	**ARENITE** well sorted, equant, mostly translucent grains, subrounded to rounded 0·2-0·3 mm 20% dark brown silt. **9·0-11·0m** as above with grey well cemented fragments up to 4cm containing 10% rounded, platy, reworked shell fragments concentrated in layers showing preferred orientation. Also unconsolidated shell fragments (10%) up to 1·5 with large forams and rare rare minute specks of dk green glauconite.
11·0	13·0	**CALCIRUDITE** Mostly complete shells & fragments - bivalves, gastropods, echinoid stems & bryozoal fragments up to 1·5cm with 20% clear quartz grains 0·1-0·2mm, subangular to subround. 10% grey calcisiltite. specks of glauconite **12·0-13m** 30% grey well cemented frags 1cm, 20% flint 1cm, 20% shell fragments as above, 20% grey calcisiltite, 10% arenite
13·0	18·0	**CALCARENITE** 60% grey well cemented fragments. 20% grey calcisiltite, 10% flint, 10% bryozoal fragments to 1 cm & 10% arenite asabove. Abundant minute calcite rhombs & specks of glauconite. **15·0-16m** 30% grey WCF, 30% bryozoal fragments (some tubes 2cm long, 5mm.diam) 30% calcisiltite. 5% flint **16·0-17·0m** essentially grey bryozoal fragments to 3mm, abundant traces of glauconitic & some forams present **17·0-18·0m** 60% grey WCF, 20% bryozoal frags. as above 10% flint & 10% calcisiltite END OF HOLE 18m

Borehole State No. 702227OOW00184

Drn: G.M. | Sheet 2 of 2

Date: 20·5·76 | Bore Folder No.

PF Nº S10537a MH

DEPARTMENT OF MINES SOUTH AUSTRALIA

HYDROGEOLOGY SECTION

BORE LOG

HIRER **DEPT. OF MINES**

Drill type Cable tool
Circulation Water
Driller W.E.Kahl
Start 3·10·75
Finish 15·10·75

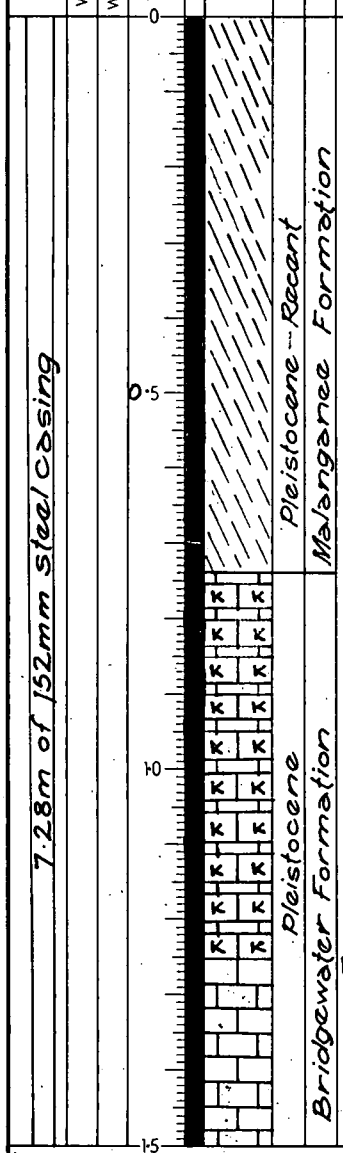
Logged by S.R.Barnett
Date logged 3·2·76
Bore Diameter 152mm
DEPTH 22·0m.

A.M.G. Zone
Coords. E
" N
Datum Elev. M.S.L. PtAd.
(m) Ref. Pt. Elev. 65·073m TOC
Surface Elev.

HUNDRED GAMBIER
SECTION 59
STATE No. 70222700W00148
Project No. GAM 124
Docket No. 238/75
Bore Serial No. 119/76

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.
7·00	6·61		depth 7m	350	E&WS analyses
			12m	520	
			17m	520	
			22m	520	

REMARKS KRAFT SPRAY EFFLUENT SCHEME INVESTIGATION, MIL-LEL. TEMP. Nº VA57 PERMIT B429. BORE CORED FROM SURFACE 7·00m WITH SLUDGE TO 22·0m.



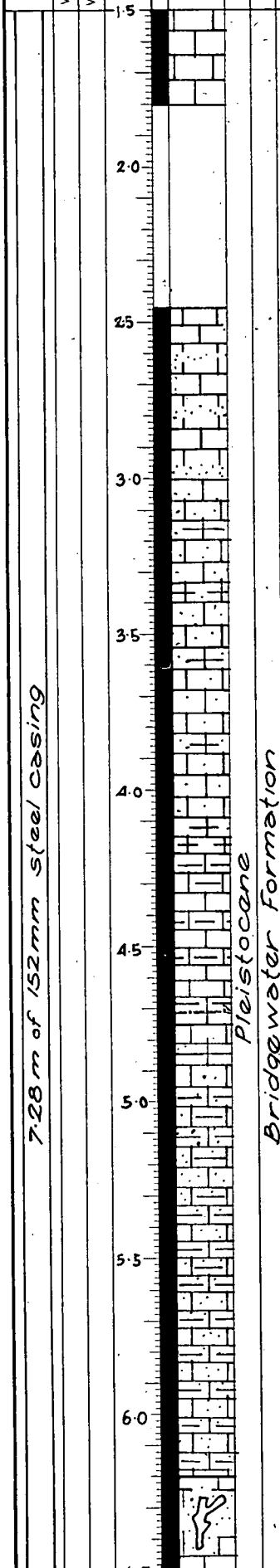
DEPTH (m) from	to	DESCRIPTION
0	0·75	**QUARTZ ARENITE** dark chocolate brown & friable, semi-consolidated with occasional plant roots. Non-calcareous. Quartz grains, well sorted, av. 0·2–0·3mm. in diam. Mainly clear with some translucent, rounded to subrounded, mainly equant. Some minor black rounded grains 0·1mm diam (heavy mins?), 30–40% dk. brn. silt.
		0·25 – 0·50m as above, light to dark brown in colour, less roots.
		0·50 – 0·75m dark orange brown arenite semi-consolidated a.a. grading to off-white calcareous grains with hard cemented fragments
0·75	1·25	**CALCRETE** offwhite & very hard generally, with some soft unconsolidated calcareous material 30%. Some recrystallised fragments in matrix of unconsolidated calcareous material and quartz arenite a.a (contamination?)
1·25	22·0	**CALCARENITE** pale orange in colour, very hard with minor unconsolidated calcareous grains & quartz grains a.a.

Drn: GM | Sheet 1 of 3
Date: 18·5·76. | Bore Folder No.

PF Nº S10537 MH

DEPARTMENT OF MINES — SOUTH AUSTRALIA

CASING | WATERS CUT | WATER LEVEL | DEPTH (m) | CORE | GRAPHIC LOG | AGI | UNIT | DEPTH in from to | DESCRIPTION



1·70 – 2·45 m CAVITY.

2·45 – 2·50 m. dk orange calcarenite with calc. grains av. 0·2 mm, semiconsolidated, friable with 10% quartz grains.

2·50 – 2·75 m hard cemented calcarenite as orange-yellow in matrix of unconsol. calc. grns & 10% quartz. Some black staining present

2·75 – 3·00 m as above 25% – 30% quartz grains translucent, milky, subrounded to rounded av. 0·2 mm diam. cemented in calcarenite with occasional bryozoal fragment & foram: 25% light brown calcisiltite

3·00 – 3·50 m as above dark orange brown staining. Black absent

3·50 – 4·25 m cemented brown offwhite & orange calcaranite with 10% brown calcisiltite in matrix of unconsolidated quartz & calc. grains

4·25 – 4·75 m cemented calcarenite as in matrix of 40% dark orange calcilutite with small well cemented frags < 1 cm

4·75 – 5·25 m as for 2·75 – 3·00 m

5·25 – 6·25 m well cemented calcarenite frags as above only 2–3 cm diam, 20% calcilutite and matrix as for 3·50 – 4·25 m

6·25 – 6·75 m mostly unconsolidated calcareous & fossil frags < 1 mm with 15–20% quartz grains 20% orange stained cemented frags & 20% calcisiltite

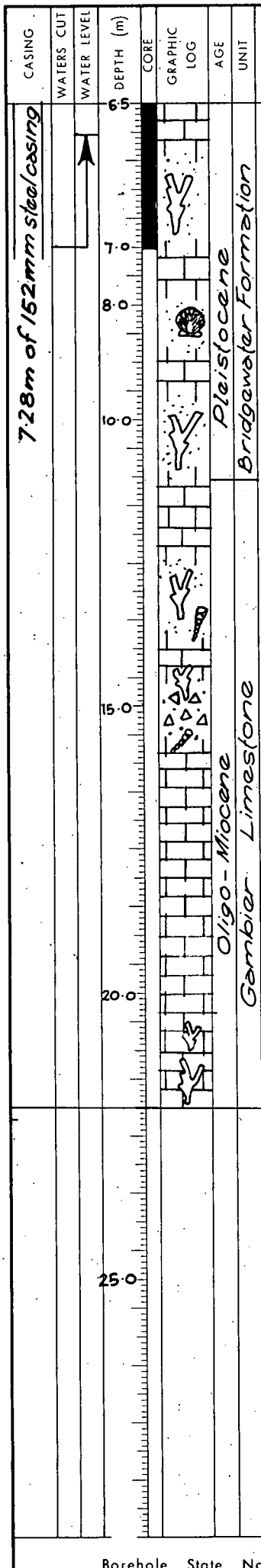
Borehole State No. 70222700W00148

Drn: GM | Sheet 2 of 3

Date: 18·5·76 | Bore Folder No.

PF Nº S10537a MH

DEPARTMENT OF MINES — SOUTH AUSTRALIA



DEPTH (m) from to

DESCRIPTION

6·75–7·00m as above with 60% cemented fragments.

7·00–8·00m 60% orange cemented frags <1cm with 20% unconsol. fossil frags <1·5cm, 10% pale orange calcisiltite 10% quartz

8·00–10·00m mostly white & orange bryozoal foram shell frags <2mm with 10% quartz & 10% calcisiltite. Cemented frags absent

10·00m–11·00m as above but fawn colour, 2% orange stained fossil frags.

11·00–14·00m 40% grey cemented fossil frags. with traces of green glauconite & specks of black opaque mineral. 30% orange stained fossil-cemented fragments <5mm

14·00–16·00m 30% grey & white fossil & cemented fragments as above with 10% orange stained. 30% angular black flint frags. and grey siliceous, calcarenite 10% grey calcisiltite and minor quartz 0·1mm drain, subrounded, clear.

16·00–18·00m mostly grey bryozoal frags. <3mm with 40% grey calcisiltite & abundant specks of glauconite & rare quartz

18·00–19·00m mostly grey cemented frags <1·5cm, fossil frags. <1cm 20%, with 20% flint 10% grey calcisiltite

19·00–20·00m as above but finer grained—WCF <7mm, fossils <5mm, 10% flint. White shell fragments 1cm diam

20·00–21·00m as above, grey silicified calcarenite <1·5cm 20%

21·00–22·00m as above 5% silicified calc. <5mm, 20% flint

END OF HOLE 22·0 m

Borehole State No. 7022270OW00148

Drn: GM | Sheet 3 of 3

Date: 18·5·76 | Bore Folder No.

PF Nº S10537a MH

DEPARTMENT OF MINES SOUTH AUSTRALIA

HYDROGEOLOGY SECTION

BORE LOG

HIRER *DEPT OF MINES*

Drill type *CABLE TOOL*
Circulation *WATER*
Driller *A. ANDERSON*
Start *16·10·75*
Finish *27.10.75*

Logged by *S. BARNETT*
Date logged *20.11.75*
Bore Diameter *152mm*
DEPTH *18·0m* (m)

A.M.G. Zone
Coords. E
" N
Datum Elev *M.S.L. PT Adel.*
Ref. Pt. Elev. *61·664m T.O.C.*
Surface Elev.

HUNDRED *GAMBIER*
SECTION *59*
STATE No. *70222700W00152*
Project No. *GAM 131*
Docket No. *238/75*
Bore Serial No. *120/76*

Depth to Water cut (m)	Depth to standing water (m)	SUPPLY		TOTAL DISSOLVED SOLIDS	
		litres/sec.	Method of test	Milligrammes/litre	Analysis W. No.
3·00m	*2·45m*		*depth 3·0m*	*416*	*E&WS analysis*
			8·0m	*540*	
			13·0m	*565*	
			18·0m	*620*	

REMARKS *KRAFT SPRAY EFFLUENT SCHEME INVESTIGATION. TEMP. Nº VA 583 Permit B429 BORE CORED FROM SURFACE TO 3·00m WITH SLUDGE TO 18·00 m.*

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

18·0m of 76mm PVC casing.

0 — 0·5 — 10 — 15

Pleistocene - Recent

Mabangonee Formation

DEPTH (m) from	to	DESCRIPTION
0·0	*2·70*	*ARENITE dark brown with abundant organic matter (plant roots). Quartz grains 0·2-0·3mm av. Translucent but mostly stained. Subangular to rounded grains which are well sorted and equant. 20% dk. brown silt & minor lutite.*
		0·25-0·50m as above, colour grading to dk. orange brown, grains mostly frosted. Minor white calcareous nodules to 1cm less plant roots.
		0·50-0·65m as above with colour dk. orange brown with minor dk. brown mottling. 10% silt. Rare plant roots.
		0·65-0·75m fawn coloured arenite av. 0·2-0·3mm with minor small black rounded grains 0·1 mm diam. (heavy minerals?).
		0·75-1·00m as above with minor dark brown mottling.
		1·00-1·50m off-white clean arenite as above.

Drn: | Sheet 1 of 3
Date: | Bore Folder No.

PF Nº S10537 MH

DEPARTMENT OF MINES — SOUTH AUSTRALIA

CASING	WATERS CUT	WATER LEVEL	DEPTH (m)	CORE	GRAPHIC LOG	AGE	UNIT	DEPTH m from	DEPTH m to	DESCRIPTION
18.0m of 16mm P.V.C. casing			1.5			Pleistocene - Recent	Malanganee Formation			1.50 - 2.50m fawn arenite with 30% lutitic, partly calcareous arenite. (25% orange lutite.
			2.0							
			2.5							2.50 - 2.70m arenite as above - some grains up to 0.4mm with calcareous & bryozoal fragments 10%, up to 1mm, off white in colour. 25% dk. brown silt and minor lutite.
								2.70	2.80	LUTITIC ARENITE quartz grains as above with 40% light orange-brown plastic lutite with 10% calcareous & bryozoal fragments.
						Pleistocene	Bridgewater Formation	2.80	3.00	LUTITE orange-brown with 40% arenite as above and 10% bryozoal & calcareous fragments.
			3.0					3.0	18.00	CALCARENITE pale orange (Fe stained?) 20% bryozoal fragments av. 2mm with 10% calcisiltite & well cemented fragments up to 2cm. 30% quartz grains av. 0.1 - 0.2mm transparent & translucent. Rare calcite crystals.
			4.0							6.0 - 7.0m bryozoal fragments finer grained, av. 1.0mm, paler orange in colour.
			5.0							7.0 - 9.0m as above, 10% off-white calcisiltite, 10% quartz, occasional orange well cemented frags. up to 3mm. Calcite rhombs present.
						Oligo-Miocene	Gambier Limestone			9.0 - 10.0m off-white calcarenite, bryoz. frags. up to 2mm with well cemented frags. to 5% quartz as above with traces of dk. green glauconite.
			10.0							10.0 - 11.0m as above with 10% blebs of grey calcilutite and minor black flint. 10% fawn minute calcite rhombs to 0.1mm. 20% bryoz. frags.
										11.0 - 12.0m light grey calcisiltite 20% mainly bryoz. frags. up to 5mm with abundant specks of glauconite. 5% quartz.
										12.0 - 13.0m 30% black angular flint 30% grey W.C.F. < 1.5cm. 20% calcisiltite plus 10% bryoz. frags.

Borehole State No. 70222700W00152

Drn: | Sheet 2 of 3

Date: , | Bore Folder No.

PF Nº S10537a MH

DEPARTMENT OF MINES — SOUTH AUSTRALIA

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

= 18.0m of 76mm PVC

13.0
15.0
20.0

Oligo - Miocene

Gambier Limestone

DEPTH (m) from	to	DESCRIPTION
		13.0 - 14.0m as for 11-12m but quartz absent.
		14.0 - 15.0m as above with 2% flint frags up to 3m.
		15.0 - 17.0m as for 12-13m but 30% echinoidal, shell & bryozoal fragments up to 2cm with 20% well-cemented frags. Quartz absent.
		17.0 - 18.0m 50% well cemented fragments to 1cm, 40% black flint and 10% fossil fragments as above up to 5mm.
		END OF HOLE 18.0m.

Borehole State No. 70222700W00152

Drn:

Date:

Sheet 3 of 3

Bore Folder No.

PF Nº S10537a MH

DEPARTMENT OF MINES SOUTH AUSTRALIA

HYDROGEOLOGY SECTION

BORE LOG

HIRER DEPT of Mines

Drill type Cable Tool
Circulation Water
Driller A. Anderson
Start 28·10·75
Finish 3·11·75

Logged by S Barnett
Date logged 6-1-76
Bore Diameter 152mm
DEPTH 27·0m (m)

A.M.G. Zone
Coords. E
" N
Datum Elev. M.S.L. Pt Adl.
Ref. Pt. Elev. 70·343m T.O.C.
Surface Elev. 70·343m

HUNDRED Gambier
SECTION Adj. 324
STATE No. 70222700W00142
Project No. GAM 112
Docket No. 748/74
Bore Serial No. 121/76

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.
11·50	11·30		depth 11·5m	341	E&WS
			17·0 "	540	Analyses
			22·0 "	465	
			27·0 "	515	

REMARKS Kraft spray effluent scheme investigation; Permit B276; Temp No. VA 59, Sludge from surface to 27m.

CASING: 11·73m of 152mm steel casing

DEPTH (m) from	to	DESCRIPTION	AGE	UNIT
0·0	3·0	ARENITE dark brown, abundant plant roots. Qtz grains ave. 0·2 – 0·3 mm, sub-rounded to rounded, frosted although clear & translucent. Grains mod. well sorted, mainly equant although some platy & elongated. Some stained brown. 10% Silt. Calcareous.	PLEIST.–RECENT	MALANGANEE FM
0·1	3·0	aa light brown, well sorted & mostly clear grains Non calcareous. Small black rounded grains, or 0·1mm diameter (heavy min) present. 20% Silt.		
3·0	27·0	CALCARENITE pale orange, bryoz. & foram. frags <2mm, 30% quartz aa with 25% calcisiltite	PLEISTOCENE	BRIDGEWATER FORMATION
4·0	8·0m	aa with 25% well cemented frags. <1cm, stained orange		
8·0	11·0m	60% pale orange bryozoal frags, 20% qtz aa.		
11·0	12·0m	a.a. with echinoid fragments <3mm with 10% calcisiltite & 10% quartz		
12·0	13·0m	colour darker orange		
13·0	14·0m	pale orange colour		
14·0	15·0m	fawn calcarenite as above, minor well cemented frags. to 1cm.		

Drn: R.B | Sheet 1 of 1
Date: 12·5·76 | Bore Folder No.

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			PLEIST.	BRIDGE.			15-16·0m as above, fossil frags ave. 1·0-1·5mm, 10-15% quartz 16·0-17·0m fawn calcarenite a.a. 10% white calcisiltite 17·0-18·0m a.a. some grey WCF < 1cm, 1% black flint with traces of green glauconite & minute black opaque grains (heavy mins), 30% clear qtz grains. 18·0-21·0m 30-45% pale grey calcisiltite, off white to grey fossil frags as above, ave. 1-2mm, abundant specks of glauconite, 10-15% qtz.
			20			OLIGO-MIOCENE	GAMBIER LIMESTONE			21·0-23·0m as above, 40% fossil frags < 1cm, 20% flint, 5% qtz. Some bryozoal stems up to 1cm. 23·0-25·0m 40% grey WCF < 2cm, 30% calcisiltite, 20% fossil fragments < 3mm & 10% black flint. 25·0-26·0m shell & bryozoal frags. up to 1·5cm 20%, 5% calcisiltite. Traces of glauconite & qtz. a.a. 50% W.C.F. 26·0-27·0m as above, W.C.F. only 5%, fossil frags 60% ave. 5mm diam. with 20% calcisiltite.
			25							
			30							END of HOLE 27·00m

Borehole State No. 70222700W00142

Drn: R.B | Sheet 2 of 2

Date: 12·5·76 | Bore Folder No.

PF Nº S10537a MH

DEPARTMENT OF MINES SOUTH AUSTRALIA

HYDROGEOLOGY SECTION

BORE LOG

HIRER *DEPT. OF MINES*

Drill type *CABLE TOOL*
Circulation *WATER*
Driller *A. ANDERSON*
Start *4·11·75*
Finish *12·11·75*

Logged by *S. BARNETT*
Date logged *24·11·75*
Bore Diameter *152mm*
DEPTH *20·0m* (m)

A.M.G. Zone
Coords. E
" N
Datum Elev. *M.S.L. (Pt Adel.)*
Ref. Pt. Elev. *61·877m T.O.C.*
Surface Elev. *61·656m*

HUNDRED *GAMBIER*
SECTION *ADJ 304*
STATE No. *7022270OW00143*
Project No. *GAM. 113*
Docket No. *748/74*
Bore Serial No. *123/76*

Depth to Water cut (m)	Depth to standing water (m)	SUPPLY		TOTAL DISSOLVED SOLIDS	
		litres/sec.	Method of test	Milligrammes/litre	Analysis W. No.
4·50	*3·92*		*depth 4·5m*	*1015*	*E & WS*
			10·0m	*3500*	*analyses*
			15·0m	*2480*	
			20·0m	*1095*	

REMARKS *TEMP Nº VA60. PERMIT B276. KRAFT SPRAY EFFLUENT SCHEME INVESTIGATION MIL-LEL. BORE TUBED FROM SURFACE TO 3·50m WITH SLUDGE TO 20·0m.*

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

3·39m of 152mm steel casing.

Pleistocene - Recent

Malanganee Formation

DEPTH (m) from	to	DESCRIPTION
0·0	*3·50*	*QUARTZ ARENITE v. dark brown, abundant organic matter (plant roots etc). Friable & calcareous. Occasional small snails to 1cm. Quartz grains frosted, well sorted, equant. Mostly translucent, some stained light brown 0·2-0·3mm average, subrounded to rounded with 20% dark brown silt.*
		0·35-0·50m consolidated arenite, v. dark brown - dark orange quartz grains as above with 30% silt.
		0·50-1·00m arenite unconsolidated, light to dark brown, non-calcareous. Quartz grains as above, mainly clear, translucent grains. Minor black rounded grains to 0·1mm (heavy min?)
		1·00-1·25m pale khaki to off-white clean quartz arenite as above. Grains translucent and transparent, with minor staining.
		1·25-2·00m arenite as above, off-white to pale orange in colour.

Drn: | Sheet *1* of *3*
Date: | Bore Folder No.

PF Nº S10537 MH

DEPARTMENT OF MINES — SOUTH AUSTRALIA

CASING	WATERS CUT	WATER LEVEL	DEPTH (m)	CORE	GRAPHIC LOG	AGE	UNIT	DEPTH (m) from	DEPTH (m) to	DESCRIPTION
5.39m of 152mm steel casing			1.5			Pleistocene - Recent	Malangonee Formation			
			2.0							2.00 - 2.30m pale orange arenite with dark orange stained semi-consolidated aggregates with 10% silt. Minor well cemented aggregates up to 1cm.
										2.30 - 2.50m off-white arenite with minor pale orange mottling and dark orange-brown well consolidated fragments up to 1.5cm.
			2.5							2.50 - 2.60m off-white with mostly brown staining and mottling with some semi-consolidated aggregates.
										2.60 - 3.00m off-white grading to fawn arenite.
			3.0							3.00 - 3.50m arenite as above with 40% light brown lutitic silt.
			3.5					3.5	4.0	LUTITE pale brown & silty with 10% blebs of very plastic dark orange lutite. 30% quartz arenite as above.
			4.0			Pleistocene	Bridgewater Formation	4.0	20.0	CALCARENITE orange, essentially calcareous chips, forams shell & bryozoal fragments up to 2mm (40% well cemented fragments). 25% quartz grains, clear & translucent, subangular to subrounded, av. 0.2 - 0.3mm. 20% calcisiltite pale orange. Quartz content decreases to 15% @ 10m.
			5.0							
			6.0							
			7.0							7.0 - 8.0m mostly layered well cemented fragments.
			8.0							8.0 - 9.0m 50% well cemented orange coloured frags. with 20% off-white calcisiltite and 20% quartz as above.
			9.0							

Borehole State No. 7022700W00143

Drn: 2 | Sheet 2 of 3

Date: | Bore Folder No.

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
			9.0			Pleistocene	Bridgewater Fm.			9.0 - 10.0m fawn calcarenite as above - strong odour of whey.
			10.0							10.0 - 11.0m fawn & pale orange, occasional white bryozoal fragments and a large foram 5mm diam. Traces of dark green glauconite.
										11.0 - 14.0m 30% fawn well cemented calcarenite as above with 30% - 40% black flint and grey silicified calcarenite, 20% white shell and bryozoal fragments up to 1cm occasional forams, 10% calcisiltite and rare quartz as above.
										14.0 - 15.0m essentially bryozoal & shell fragments av. 2-3mm diam. minor grey silicified fragments, abundant specks of glauconite.
			15.0			Oligo - Miocene	Gambier Limestone			15.0 - 17.0m as above with 20% calcisiltite.
										17.0 - 19.0m as above with 5% orange-stained fragments.
										19.0 - 20.0m as above av. size bryozoal fragments 1 - 2mm.
			20.0							END OF HOLE 20.0m.

Borehole State No. 70222700W00143

Drn:

Date:

Sheet 3 of 3

Bore Folder No.

PF No S10537a MH

APPENDIX 1.1

Soil Profiles

Site	Depth (m)	Texture*	Munsell Colour (moist)	Calcium	pH
SOIL UNIT 1					
121	0-0.17	Sandy Loam	5.0YR3/2 (Dk. reddish brown)	Nil	6.0
	0.17-0.50	Loamy sand	5.0YR4/4 (reddish brown)	Nil	6.5
	0.50-0.80	Medium clay	10.0YR5/4 (Yellowish brown)	Nil	8.0
	0.80-1.00**	Clay sand	5.0YR8/1 (White)	High	9.0
		**75-100% stone in this layer			
109	0-0.20	Sandy loam	5.0YR3/2 (Dk. reddish brown)	Nil	6.5
	0.20-0.55	Loamy sand	5.0YR4/4 (Reddish brown)	Nil	6.5
	0.55-0.85	Sand	7.5YR5/6 (Strong brown)	Nil	7.0
	0.85-1.10	Medium clay	10.0YR5/6 (Yellowish brown)	Nil	8.0
SOIL UNIT 2					
67	0-0.25	Sandy loam	5.0YR3/2 (Dk. reddish brown)	Nil	6.5
	0.25-0.65	Loamy sand	5.0YR3/4 (Dk. reddish brown)	Nil	6.5
	0.65-1.10	Sand	7.5YR5/6 (strong brown)	Nil	7.0
SOIL UNIT 3					
47	0-0.15	Sandy clay loam	5.0YR3/3 (Dk. reddish brown)	Nil	6.0
	0.15-0.40	Clay loam	5.0YR4/6 (Yellowish red)	Nil	6.5
	0.40-1.00	75-100% stone, high calcium			
52	0-0.15	Fine sandy loam	5.0YR3/4 (Dk. reddish brown)	Nil	6.0
	0.15-0.70	Sandy clay loam	2.5YR3/6 (Dark red)	Nil	6.0
	0.70-1.00	75-100% stone, high calcium			
SOIL UNIT 4					
1	0-0.10	Sandy loam	7.5YR3/1 (very dark grey)	Nil	7.0
	0.10-0.21	Loamy sand	7.5YR3/2 (Dark brown)	Nil	6.5
	0.21-0.39	Loamy sand	7.5YR4/4 (Dark brown)	Nil	6.0
	0.39-0.64	Loamy sand	10.0YR6/6 (Brownish yellow)	Nil	6.0
	0.64-0.77	Loamy sand	7.5YR5/6 (strong brown)	Nil	8.5
	0.77-1.00	Sand	2.5Y 7/2 (Light grey)	Nil	9.0

*Texture as described by Northcote (1971)

APPENDIX 2

Chemical Analyses

2.1 Groundwater samples obtained during drilling.

2.2 Observation wells - pumped samples (a) Chemical Analysis

(b) Bacteriological Results

2.3 Observation Wells - bailed samples.

2.4 Effluent analysis.

Analyses carried out by the Engineering and Water Supply Department.

APPENDIX 2.1

Chemical Analyses of samples taken during drilling of Mines Dept. observation bores

	DEPTH (m)	COND (µs/cm)	ATS (mg/l)	NO_3 (mg/l)
GAM 147 (VA 54)	12	774	402	52.3
	20	914	495	14.6
GAM 149 (VA 55)	3	690	358	31.0
	8	975	530	6.2
	13	958	525	12.0
	18	858	460	14.6
GAM 160 (VA 56)	5	752	392	0.4
	11	1 074	585	0.4
	15	1 064	580	0.4
	18	1 064	580	0.4
GAM 124 (VA 57)	7	673	350	53.2
	12	952	520	19.5
	17	947	520	32.8
	22	950	520	19.5
GAM 131 (VA 58)	3	801	416	53.2
	8	984	540	20.8
	13	1 033	565	0.1
	18	1 132	620	0.1
GAM 112 (VA 59)	11.5	656	341	29.2
	17	989	540	0.9
	22	857	465	30.6
	27	940	515	4.4
GAM 113 (VA 60)	4.5	1 812	1 015	121.8
	10	5 773	3 500	0.1
	15	4 248	2 480	0.1
	20	1 939	1 095	0.1

APPENDIX 2.2

Observation Wells - Pumped Samples

(a) Chemical Analysis

WELL NO. - GAM 147 (VA 54)

Date	7.1.76	18.3.76	2.6.76	
Cond (25°C)	900	875	840	
T.D.S. (Calc)	506	495	474	
T.D.S. by Cond	490	470	450	
pH	-	7.1	7.2	
Ca	96	96	98	
Mg	17	11	10	
Na *	77	77	72	
K	-	-	-	
CO_3	NIL	NIL	NIL	
HCO_3	336	332	320	
SO_4	12	12	9	
Cl	128	112	114	
F	-	-	0.18	
NO_3	11.1	10.8	14.3	
PO_4	-	0.17	0.06	
SiO_2	-	13	-	
Fe	0.5	1.2	0.1	
Free CO_2	-	42	32	
Alkalinity	275	272	263	
Total Hardness	310	285	284	
Total PO_4 as P	-	0.057	0.020	
Soluble PO_4 as P	-	0.006	0.006	
NO_3 as N	2.50	2.45	3.24	
NO_2 as N	-	-	<0.01	
NH_3 as N	-	0.01	0.03	
Total Kjeldahl Nitrogen	-	0.27	0.10	
Total Organic Carbon.	-	17	5	

All concentrations in milligrams/ litre.

* (NA+K) BY DIFFERENCE EXPRESSED AS Na

WELL NO - GAM 149 (VA 55).

Date	7.1.76	18.3.76	2.6.76	
Cond (25°C)	880	870	870	
T.D.S. (Calc)	495	488	495	
T.D.S. by Cond	480	470	470	
pH	-	7.2	7.2	
Ca	94	94	96	
Mg	13	14	15	
Na *	77	70	74	
K	-	-	-	
CO_3	NIL	NIL	NIL	
HCO_3	320	326	326	
SO_4	17	17	21	
Cl	123	107	116	
F	-	-	0.20	
NO_3	13.3	11.0	13.9	
PO_4	-	0.03	0.01	
SiO_2	-	15	-	
Fe	< 0.1	0.4	0.1	
Free CO_2	-	33	33	
Alkalinity	263	267	268	
Total Hardness	290	293	300	
Total PO_4 as P	-	0.013	0.004	
Soluble PO_4 as P	-	0.006	0.003	
NO_3 as N	3.00	2.50	3.13	
NO_2 as N	-	-	< 0.01	
NH_3 as N	-	0.06	0.03	
Total Kjeldahl Nitrogen	-	0.34	0.18	
Total Organic Carbon.	-	19	4	

All concentrations in milligrams/ litre.

* (Na+K) by difference, expressed as Na

WELL NO - GAM 124 (VA 57)

Date	7.1.76	18.3.76	2.6.76	
Cond (25°C)	707	676	660	
T.D.S. (Calc)	407	377	384	
T.D.S. by Cond	370	350	340	
p^H	-	7.5	7.5	
Ca	83	79	79	
Mg	9	9	10	
Na *	58	45	49	
K	-	-	-	
CO_3	NIL	NIL	NIL	
HCO_3	256	238	235	
SO_4	5	13	9	
Cl	88	68	75	
F	-	-	0.18	
NO_3	38.6	33.1	42.5	
PO_4	-	0.06	0.02	
SiO_2	-	13	-	
Fe	< 0.1	0.1	< 0.1	
Free CO_2	-	12	12	
Alkalinity	210	195	193	
Total Hardness	243	234	237	
Total PO_4 as P	-	0.021	0.008	
Soluble PO_4 as P	-	0.003	0.006	
NO_3 as N	8.70	7.50	9.61	
NO_2 as N	-	-	0.01	
NH_3 as N	-	0.01	0.07	
Total Kjeldahl Nitrogen	-	0.21	0.18	
Total Organic Carbon.	-	9	3	

All concentrations in milligrams/ litre.

* (Na+K) by difference, expressed as Na

WELL NO - GAM 112 (VA 59).

Date	7.1.76	18.3.76	2.6.76	
Cond (25°C)	772	652	610	
T.D.S. (Calc)	506	370	345	
T.D.S. by Cond	400	340	320	
$_pH$	-	7.4	7.3	
Ca	87	72	73	
Mg	9	9	8	
Na *	98	54	48	
K	-	-	-	
CO_3	NIL	NIL	NIL	
HCO_3	293	247	229	
SO_4	5	16	12	
Cl	153	74	77	
F	-	-	0.17	
NO_3	10.2	13.0	16.7	
PO_4	-	0.17	0.03	
SiO_2	-	11	-	
Fe	< 0.1	0.3	< 0.1	
Free CO_2	-	16	12	
Alkalinity	240	203	188	
Total Hardness	256	217	216	
Total PO_4 as P	-	0.057	0.012	
Soluble PO_4 as P	-	0.003	0.006	
NO_3 as N	2.30	2.95	3.78	
NO_2 as N	-	-	0.18	
NH_3 as N	-	0.03	0.04	
Total Kjeldahl Nitrogen	-	0.10	0.39	
Total Organic Carbon.	-	2	2	

All concentrations in milligrams/ litre.

* (Na+K) by difference, expressed as Na

WELL NO - GAM 160 (VA 56) GAM 131 (VA 58)

Date	2.6.76		2.6.76	
Cond (25°C)	590		940	
T.D.S. (Calc)	-		-	
T.D.S. by Cond	310		500	
pH	7.4		7.1	
Ca	-		-	
Mg	-		-	
Na	-		-	
K	-		-	
CO_3	-		-	
HCO_3	-		-	
SO_4	13		10	
Cl	73		125	
F	0.16		0.20	
NO_3	7.0		16.0	
PO_4	0.41		0.41	
SiO_2	-		-	
Fe	0.8		0.5	
Free CO_2	-		-	
Alkalinity	-		-	
Total Hardness	-		-	
Total PO_4 as P	0.135		0.135	
Soluble PO_4 as P	0.006		0.006	
NO_3 as N	1.57		3.62	
NO_2 as N	0.03		0.03	
NH_3 as N	0.01		0.07	
Total Kjeldahl Nitrogen	0.45		0.27	
Total Organic Carbon.	5		3	

All concentrations in milligrams/ litre.

(b) Bacteriological Results

DATE	WELL	*Number of Organisms present per 100ml water		Faecal Streptococci per 100 ml of water
		Total coliforms	E.coli I	(Membrane filter)
7.1.76	Gam 147 (VA 54)	Absent	Absent	None
18.3.76		"	"	"
2.6.76		"	"	2
7.1.76	Gam 149 (VA 55)	160	160	None
18.3.76		25	Absent	"
2.6.76		2	2	"
2.6.76	Gam 160 (VA 56)	5	Absent	None
7.1.76	Gam 124 (VA 57)	Absent	Absent	None
18.3.76		"	"	"
2.6.76		"	"	"
2.6.76	Gam 131 (VA 58)	13	Absent	8

* by Multiple Tube Dilution technique (Most Probable Number of organisms present)

DATE	WELL	*Number of Organisms present per 100ml water		Faecal Streptococci per 100 ml of water
		Total coliforms	E.coli I	(Membrane filter)
7.1.76	Gam 112 (VA 59)	Absent	Absent	None
18.3.76		2	"	"
2.6.76		5	"	"

* by Multiple Tube Dilution technique (Most Probable Number of organisms present)

APPENDIX 2.3

Observation Wells - Bailed Samples

WELL		TDS by conductivity (mg/ℓ)		Cℓ (mg/ℓ)		Total Oxidised N as NO_3 (mg/ℓ)	
		28.4.76	2.6.76	28.4.76	2.6.76	28.4.76	2.6.76
GAM 123	(PVC 1)	280	320	62	61	49.6	46.9
125	2	480	420	62	72	34.1	48.7
126	3	480	480	68	71	15.1	42.1
127	4	400	370	77	78	39.9	41.2
128	5	310	290	52	56	62.0	44.3
129	6	330	300	62	63	29.7	22.1
130	7	330	340	73	76	41.6	37.6
132	8	360	370	83	85	41.2	40.7
136	9	310	340	64	74	54.9	40.7
137	10	290	290	60	60	59.8	61.5
138	11	300	310	60	61	62.0	62.5
139	12	310	350	71	67	59.8	58.9
140	13	330	360	73	87	41.6	31.9
141	14	380	390	77	82	42.5	48.7
142	15	330	320	69	70	48.7	44.3
143	16	360	370	83	82	19.5	16.4
145	17	270	260	52	54	18.2	16.0
146	18	340	330	79	70	16.4	28.6
148	19	340	340	68	69	24.8	24.4
150	20	380	390	88	99	28.8	24.8
151	21	220	230	43	46	20.8	17.9
152	22	240	220	34	38	<0.1	2.5
153	23	340	380	77	94	11.1	7.1
154	24	-	330	-	61	-	29.0
155	25	270	270	50	50	19.0	24.6
156	26	220	170	30	29	6.2	12.6
157	27	280	240	45	42	16.4	24.4
158	28	280	280	56	58	27.5	25.9
159	29	-	-	-	-	-	-
161	30	310	240	83	58	17.7	26.4
162	31	240	230	41	41	32.3	30.2
165	32	340	330	71	67	20.4	18.4
164	33	340	320	73	70	6.2	12.6
144	34	380	400	77	77	86.4	99.6
163	35	240	230	41	40	29.2	25.3
166	36	290	280	60	56	53.2	55.8

WELL	TDS by conductivity (mg/ℓ)		Cℓ (mg/ℓ)		Total Oxidised N as NO_3 (mg/ℓ)	
	28.4.76	2.6.76	28.4.76	2.6.76	28.4.76	2.6.76
GAM 133 (PVC 37)	330	350	74	76	42.1	41.6
134 38	360	360	79	80	45.2	39.9
168 39	1050	1130	173	197	2.2	9.9
167 40	440	470	98	101	27.5	23.0
111 -	360	380	86	88	21.7	21.0
113 VA 60	3800	3170	850	800	1.2	3.8
	18.3.76	28.4.76	18.3.76	28.4.76	18.3.76	28.4.76
GAM 147 VA 54	-	330	-	82	-	9.3
149 55	-	320	-	79	-	5.8
160 56	370	240	-	41	4.7	13.3
124 57	-	330	-	68	-	55.4
131 58	510	460	-	107	16.2	33.7
112 59	-	260	-	52	-	32.3

APPENDIX 2.4

Effluent Analysis

	Dilution Water	Whey	Water-Whey Mixture
Conductivity (µs/cm at 25°C)	2 750	5 150	3 550
TDS by Cond.	1 570	3 070	2 050
pH	6.7	4.1 4.2	4.8 5.1
Biochemical Oxygen Demand	-	23 600	25 500
Suspended Solids	-	2 790	1 600
Total Phosphorus as P	2.8	360	240
Soluble Phosphorus as P	0.44	133	58
NO_3 as N	0.29	0.04	0.58
NO_2 as N	<0.01	<0.01	<0.01
NH_3 as N	58	118	87
Total Kjeldahl Nitrogen	91	984	524
Ca	130		
Mg	24		
Na	220		
K	70		
HCO_3	903		
SO_4	10		
Cl	350		
NO_3	1.3		
PO_4	8.6		
Fe	0.5		
Alkalinity	740		

All concentrations in (mg/l)

APPENDIX 3

Soil Analyses

3.1 CSIRO Gemco drilling

3.2 Intensive sampling

3.3 Annual sampling

All soil analyses carried out by the Dept. of Agriculture and Fisheries.

APPENDIX 3.1

C.S.I.R.O. Gemco Drilling - 21/10/75

SITE C 1.

Sample No.	Depth (m)	Nitrate-N, mg/l Dry Soil	Nitrate-N, mg/l Soil Soln	Chloride, mg/l Dry Soil	Chloride, mg/l Soil Soln
101	0- 0.76	0.16	1.7	1.95	20.2
102	0.76- 1.52	0.62	11.2	1.54	28.0
103	1.52- 2.29	1.02	16.7	1.16	19.1
104	2.29- 3.05	1.06	15.7	2.36	34.8
105	3.05- 3.81	1.67	19.9	2.74	32.6
106	3.81- 4.58	1.51	16.1	1.86	19.8
107	4.58- 5.33	2.46	23.9	1.72	16.7
108	5.33- 6.10	2.43	24.8	1.72	17.5
109	6.10- 6.86	3.07	29.8	1.84	17.9
110	6.86- 7.63	2.57	17.5	3.02	20.5
111	7.63- 8.39	2.90	10.6	4.35	15.8
112	8.39- 9.15	3.29	12.3	6.94	25.9
113	9.15- 9.88	3.48	17.9	4.76	24.5
114	9.88-10.68	3.34	28.3	2.81	23.9
115	10.68-10.98	2.97	23.4	3.63	28.6
116	10.98-11.44	3.27	19.7	3.64	21.9
117	11.44-12.20	3.93	10.9	7.87	21.9
118*	13.72		10.3		24.5
119*	16.74		7.11		43.6

*Water Samples

Nitrates	NO_2-N mg/l	Dry Soil	Soil Soln
112		0.37	1.37
119		0.39	1.47

SITE C 2.

Sample No.	Depth (m)	Nitrate-N, mg/l Dry Soil	Nitrate-N, mg/l Soil Soln	Chloride, mg/l Dry Soil	Chloride, mg/l Soil Soln
210	0-0.76	2.05	18.2	1.32	13.0
211	0.76-1.52	1.59	18.3	0.63	7.8
212	1.52-2.29	1.88	16.8	1.70	16.8
213	2.29-3.05	2.08	17.1	0.99	9.1
214	3.05-3.81	2.15	19.9	2.67	27.4
215	3.81-4.58	6.28	16.3	3.97	14.3
216	4.58-5.33	5.23	31.9	4.49	31.9
217	5.33-5.87	4.95	32.4	3.94	29.7
218	6.10-6.86	6.80	26.2	4.13	20.0
219	6.86-7.63	5.97	13.4	8.27	26.9
220	7.63-8.38	4.44	13.7	12.9	52.8
221	8.38-9.14	4.46	15.3	6.9	30.5
222*	9.14		10.7		20.9
223*	9.14		5.06		55.3

*Water Samples

Nitrates	NO_2-N mg/l	Dry Soil	Soil Soln
	214	0.54	4.98
	223	0.10	0.92

SITE C 3.

Sample No.	Depth (m)	Nitrate-N, mg/l Dry Soil	Nitrate-N, mg/l Soil Soln	Chloride, mg/l Dry Soil	Chloride, mg/l Soil Soln
301	0.0.76	0.31	2.33	1.66	14.0
302	0.76-1.20	0.68	5.71	0.73	6.85
303	1.20-1.52	3.76	13.2	8.10	36.6
304	1.52-1.90	2.33	5.82	6.65	23.3
305	1.90-2.29	3.61	7.90	7.29	23.3
306	2.29-2.59	3.64	5.90	7.41	19.4
307	2.59-3.05	3.85	7.30	7.68	22.3
308	3.05-3.81	3.34	6.71	4.73	14.2
309*	4.57		5.02		17.8
310*	6.10		8.76		27.8
311*	7.62		10.4		54.1
312*	9.14		5.46		59.4

*Water Samples

Nitrates	NO_2-N mg/l	Dry Soil	Soil Soln
304		0.72	1.79
308		0.78	1.58

APPENDIX 3.2

Chloride content of air dried soil

mg/1 000 gm (ppm)

SITE		3/12/75	6/4/76	3/6/76
1	0 - 0.50	4.90	4.51	5.60
	0.50 - 1.00	2.69	1.50	1.54
	1.00 - 1.50	1.74	1.71	1.87
	1.50 - 2.00	2.20	0.82	1.35
2	0 - 0.50	6.07	5.75	8.04
	0.50 - 1.00	2.41	0.86	1.36
	1.00 - 1.50	1.70	0.58	0.66
	1.50 - 2.00	3.23	2.01	2.32
3	0 - 0.50	4.21	36.74	47.70
	0.50 - 1.00	1.41	2.74	26.02
	1.00 - 1.50	1.91	0.93	2.28
	1.50 - 2.00	7.55	2.92	2.92
4	0 - 0.50	7.99	47.46	41.95
	0.50 - 1.00	3.72	6.11	9.89
	1.00 - 1.50	8.13	2.06	6.37
	1.50 - 2.00	10.23	0.95	NR*
5	0 - 0.50	5.74	31.08	45.33
	0.50 - 1.00	2.12	7.41	1.73
	1.00 - 1.50	5.13	3.33	0.42
	1.50 - 2.00	19.76	7.41	1.59
6	0 - 0.50	2.20	30.43	36.51
	0.50 - 1.00	1.24	10.86	23.40
	1.00 - 1.50	1.48	4.82	6.97
	1.50 - 2.00	1.43	3.13	3.82
7	0 - 0.50	3.93	30.23	25.12
	0.50 - 1.00	1.71	5.89	13.61
	1.00 - 1.50	2.92	2.55	1.26
	1.50 - 2.00	3.40	3.73	2.84
8	0 - 0.50	4.33	38.03	47.77
	0.50 - 1.00	1.26	1.63	3.00
	1.00 - 1.50	1.03	0.39	2.14
	1.50 - 2.00	1.41	1.38	1.02
9	0 - 0.50	3.33	7.15	6.42
	0.50 - 1.00	2.66	1.56	1.23
	1.00 - 1.50	4.70	2.77	1.47
	1.50 - 2.00	7.90	3.42	3.18

* No Record

Nitrate content of air dried soil

mg/1 000 gm (ppm)

SITE	DEPTH (m)	3/12/75	6/4/76	3/6/76
1	0 - 0.50	2.23	9.26	5.20
	0.50 - 1.00	0.96	2.46	1.32
	1.00 - 1.50	0.87	0.43	1.15
	1.50 - 2.00	0.77	0.72	0.45
2	0 - 0.50	1.69	12.58	9.83
	0.50 - 1.00	0.67	1.08	0.57
	1.00 - 1.50	0.85	0.00	0.11
	1.50 - 2.00	1.08	0.88	0.12
3	0 - 0.50	3.51	1.47	0.31
	0.50 - 1.00	0.82	0.23	0.00
	1.00 - 1.50	0.96	0.12	0.10
	1.50 - 2.00	2.36	0.56	0.84
4	0 - 0.50	2.62	3.11	0.56
	0.50 - 1.00	0.58	0.12	0.00
	1.00 - 1.50	0.85	0.00	0.15
	1.50 - 2.00	0.76	0.12	NR
5	0 - 0.50	1.37	1.05	0.15
	0.50 - 1.00	0.42	0.37	0.22
	1.00 - 1.50	0.51	0.22	0.21
	1.50 - 2.00	1.03	0.77	0.00
6	0 - 0.50	0.61	1.77	0.13
	0.50 - 1.00	0.41	0.31	0.11
	1.00 - 1.50	0.74	0.46	0.22
	1.50 - 2.00	0.72	0.24	0.42
7	0 - 0.50	3.00	4.48	0.14
	0.50 - 1.00	0.64	1.05	0.21
	1.00 - 1.50	1.04	0.23	0.11
	1.50 - 2.00	0.74	0.44	0.66
8	0 - 0.50	1.93	3.85	0.54
	0.50 - 1.00	0.21	0.23	0.00
	1.00 - 1.50	0.21	0.00	0.12
	1.50 - 2.00	0.50	0.11	0.10
9	0 - 0.50	1.11	4.17	2.57
	0.50 - 1.00	0.44	0.39	0.72
	1.00 - 1.50	1.28	0.21	0.42
	1.50 - 2.00	0.89	0.20	0.11

APPENDIX 3.3

Annual Sampling - GAM 147, September, 1975

Depth (m)	Conductivity Micro µ/cm	pH	Total Soil Nitrate (%)	PO_4 (mg/l)	NH_4 - N (mg/l)	Organic Carbon (%)	Bicarbonate (mg/l)
0 - 0.25	183	6.1	0.145	11.0	23.0	1.72	0.305
0.25 - 0.50	89	6.4	0.030	7.5	11.3	0.37	0.110
0.50 - 0.75	53	6.4	0.013	3.5	6.0	0.18	0.020
0.75 - 1.00	99	7.2	0.006	2.5	4.7	0.07	0.225
1.00 - 1.25	74	7.3	0.005	2.0	6.3	0.05	0.100
1.25 - 1.50	50	7.0	0.005	2.0	4.7	0.05	0.010
1.50 - 1.75	49	7.0	0.006	2.5	4.0	0.07	0.010
1.75 - 2.00	64	7.6	0.005	1.0	2.3	0.09	0.085
2.00 - 2.25	64	8.1	0.002	1.0	1.0	0.01	0.145
2.25 - 2.50	54	7.6	0.003	1.0	2.0	0.04	0.030
2.50 - 2.75	55	7.4	0.004	1.5	2.0	0.05	0.035
2.75 - 3.00	57	7.2	0.012	1.0	7.3	0.24	0.035
3.0 - 3.25	87	6.6	0.036	2.0	12.3	0.56	0.065
3.25 - 3.50	92	6.8	0.016	1.5	9.0	0.36	0.120
3.50 - 3.75	114	6.5	0.008	1.5	5.3	0.27	0.240
3.75 - 4.00	54	6.5	0.010	2.5	5.7	0.34	0.035
4.00 - 4.25	62	6.7	0.008	1.0	6.0	0.32	0.025
4.25 - 4.50	55	6.7	0.005	1.5	4.7	0.19	0.050
4.50 - 4.75	50	6.6	0.006	0.5	4.7	0.20	0.020
4.75 - 5.00	71	6.7	0.003	0.0	3.3	0.12	0.085
5.00 - 5.25	159	6.5	0.008	0.5	5.7	0.28	0.095
5.25 - 5.50	52	6.4	0.003	0.5	6.3	0.15	0.020
5.50 - 5.75	60	7.3	0.002	0.0	5.3	0.09	0.120
5.75 - 6.00	55	7.0	0.004	0.0	5.7	0.09	0.050
6.00 - 6.25	116	7.9	0.005	2.5	6.3	0.13	0.035
6.25 - 6.50	52	7.0	0.005	1.5	5.0	0.15	0.025
6.50 - 6.75	52	6.9	0.006	0.0	4.3	0.17	0.020
6.75 - 7.00	73	6.9	0.002	0.0	3.3	0.06	0.060
7.00 - 7.25	75	7.2	0.002	0.0	3.0	0.16	0.115
7.25 - 7.50	63	7.0	0.005	1.0	4.7	0.14	0.060
7.50 - 7.75	58	6.8	0.005	2.0	5.0	0.14	0.015
7.75 - 8.00	60	6.8	0.004	0.0	7.0	0.06	0.020

8.00 - 8.25	58	6.7	0.005	1.0	6.0	0.17	0.045
8.25 - 8.50	81	7.3	0.005	1.0	5.7	0.12	0.085
8.50 - 8.75	66	7.1	0.004	1.0	3.7	0.09	0.055
8.75 - 9.00	117	7.9	0.004	2.0	3.7	0.12	0.305
9.00 - 9.25	87	7.7	0.004	0.0	4.0	0.06	0.130
9.25 - 9.50	88	7.4	0.005	1.0	7.0	0.17	0.115
9.50 - 9.75	71	7.2	0.002	0.0	4.0	0.10	0.065
9.75 - 10.00	65	7.1	0.003	0.0	4.0	0.15	0.035
10.00 - 11.0	75	7.1	0.005	0.0	5.0	0.33	0.050
11.00 - 12.00	128	7.9	0.005	1.0	4.0	0.22	0.315
12.00 - 12.50	117	8.8	0.003	2.0	2.0	0.35	0.305
12.50 - 12.75	140	8.8	0.005	3.0	2.0	0.40	0.330
12.75 - 13.00	132	8.9	0.005	2.5	1.3	0.14	0.290
13.00 - 13.25	132	9.0	0.003	2.0	3.0	0.25	0.325
13.25 - 13.50	132	9.0	0.003	2.0	1.7	0.27	0.310
13.50 - 13.75	129	9.0	0.003	3.0	1.7	0.31	0.275
13.75 - 14.00	127	9.1	0.003	3.0	1.3	0.23	0.265
14.75 - 16.00	682	9.7	0.005	3.0	4.7	0.27	0.825
16.00 - 18.00	629	9.6	0.006	3.0	3.3	0.37	1.160

APPENDIX 4

Details of Observation Wells

OBS.NO.	TEMP.NO.	DEPTH (m)	S.W.L.* (m)	CASING	
Cable tool drilled (September-October, 1975)					
GAM 147	VA 54	20.0	11.95	steel 152 mm,127 mm	slotted 14-20 m
149	55	18.0	2.20	steel 152 mm	cased to 3.80 m
160	56	18.0	0.90	PVC 76 mm	slotted to 18 m
124	57	22.0	6.60	steel 152 mm	cased to 7.30 m
131	58	18.0	2.45	PVC 76 m	slotted 3-18 m
112	59	27.0	11.30	steel 152 mm	cased to 11.73 m
113	60	20.0	3.92	steel 152 mm	cased to 5.40 m
Auger drilled (August and November, 1975)					
GAM 123	PVC 1	**11.0	6.70	All PVC 76 mm	bottom 3 m slotted
125	2	9.2	7.32		"
126	3	8.4	5.50		"
127	4	8.9	5.74		"
128	5	8.0	6.40		"
129	6	8.7	6.55		"
130	7	6.8	3.51		"
132	8	6.0	3.51		"
136	9	11.2	6.32		bottom 6 m slotted
137	10	13.5	8.09		"
138	11	15.0	10.19		"
139	12	11.0	6.71		"
140	13	8.4	2.92		"
141	14	14.2	7.74		"
142	15	10.8	5.13		bottom 7.5 m slotted
143	16	7.2	2.20		slotted to surface
145	17	7.2	3.57		bottom 6 m slotted
146	18	14.0	10.36		bottom 7.5 m slotted
148	19	11.6	7.62		"
150	20	6.8	1.68		slotted to surface
151	21	8.1	3.40		bottom 7.4 m slotted
152	22	6.3	3.10		slotted to surface
153	23	7.8	2.29		bottom 7.3 slotted
154	24	9.0	7.14		bottom 6 m slotted
155	25	4.6	1.36		slotted to surface
156	26	4.4	1.94		slotted to surface
157	27	5.6	2.35		"
158	28	4.9	1.63		"
159	29	4.9	0.77		"
161	30	5.0	1.61		"
162	31	5.3	1.38		"
165	32	7.8	1.36		bottom 7.5 m slotted
164	33	5.4	2.86		slotted to surface
144	34	10.3	7.63		"
163	35	8.0	2.86		"
166	36	6.0	3.81		"
133	37	7.8	4.06		"
134	38	6.9	4.61		bottom 6 m slotted
168	39	7.8	5.66		slotted to surface
167	40	7.5	5.57		"

* Standing water level at time of drilling.

** Depths of the auger drilled holes are only approximate and are taken to be equal to the length of casing able to be inserted in the hole. In several cases soft unconsolidated sediments collapsed back into the hole and up inside the casing as it was inserted.

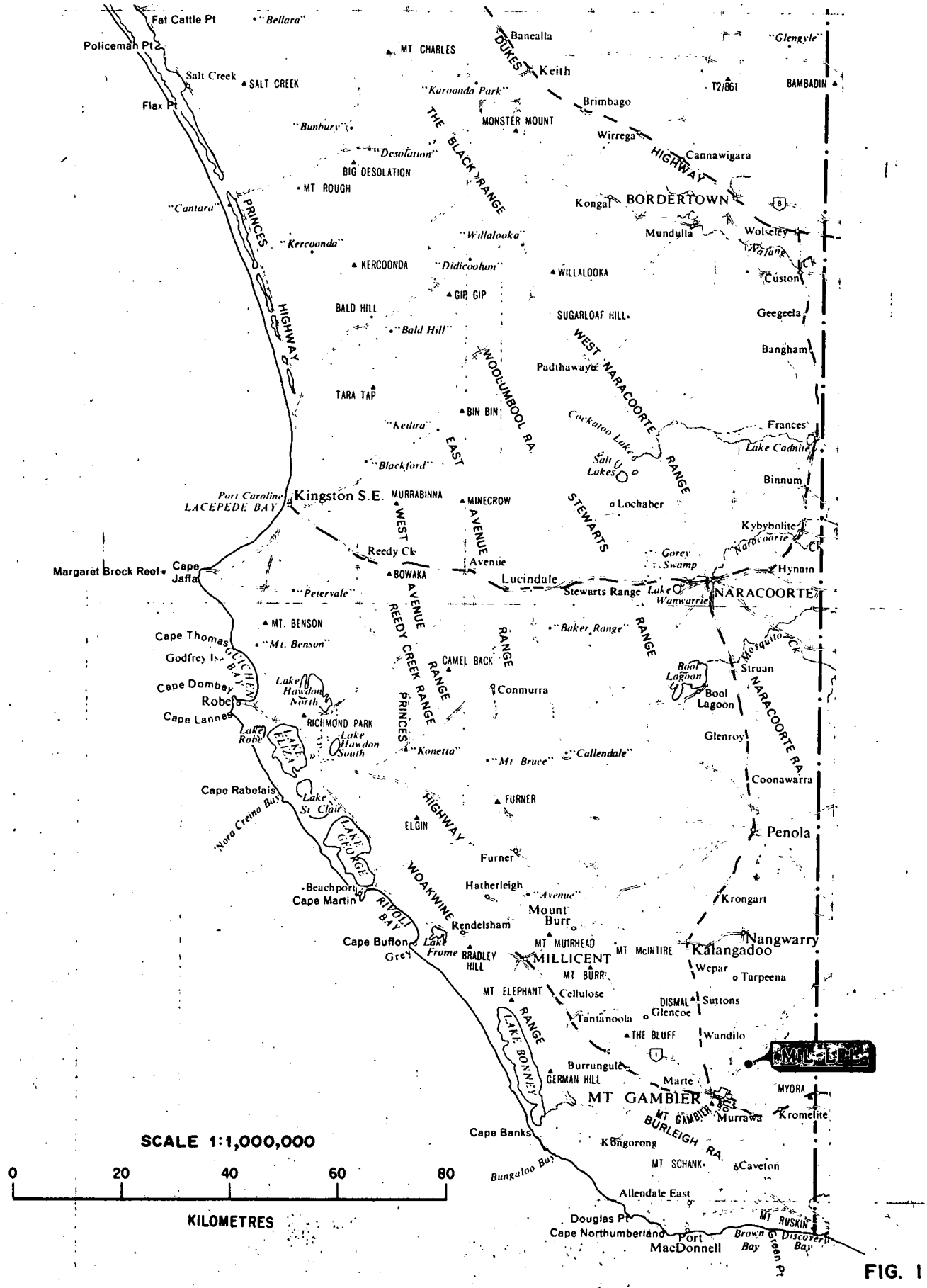


FIG. 1

	DEPARTMENT OF MINES – SOUTH AUSTRALIA	SCALE 1:1,000,000
COMPILED S. Barnett	KRAFT MIL-LEL SPRAY EFFLUENT SCHEME	DATE 28th Sept. 1976
DRN T.E. CKD R.H.	LOCALITY PLAN	PLAN NUMBER S 12377

7022-11

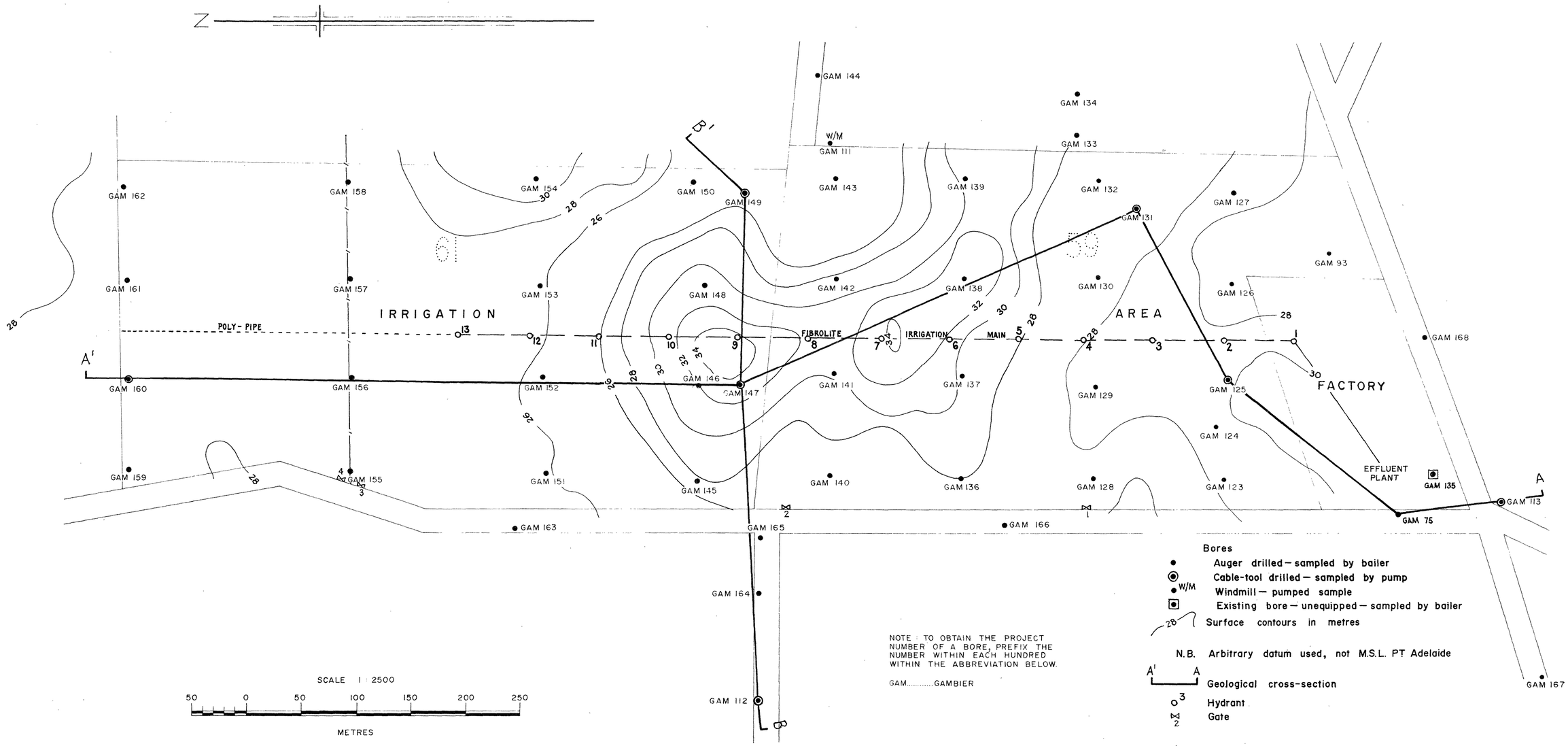
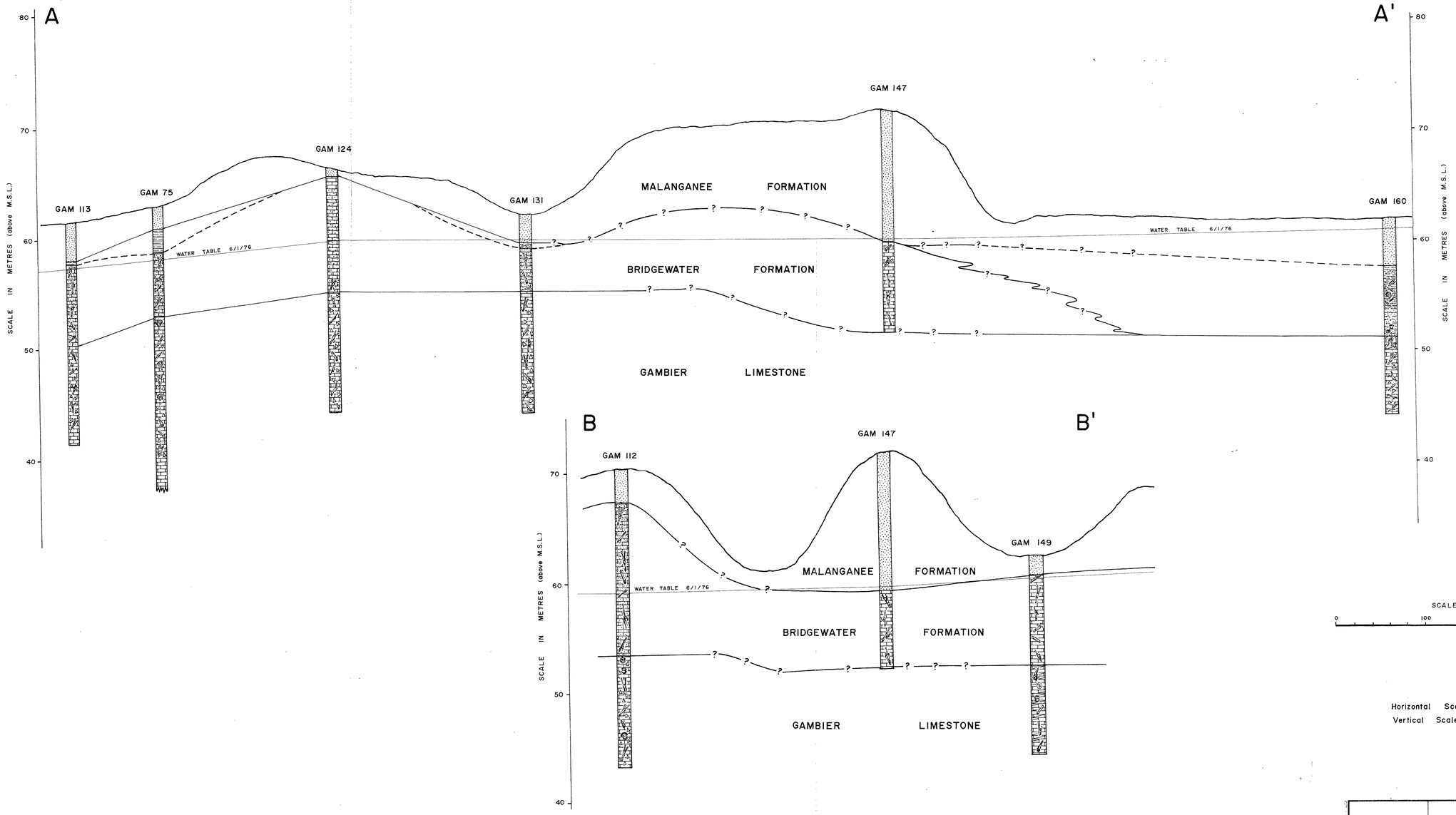


FIG. 2

	DEPARTMENT OF MINES — SOUTH AUSTRALIA	SCALE As shown
COMPILED S. Barnett	SOUTH EAST WATER RESOURCES	DATE 6th Oct. 1976
DRN T.E. CKD	MIL-LEL-INNER NETWORK	PLAN NUMBER
	SITE TOPOGRAPHY AND WELL LOCATION PLAN	76-769

7022-11

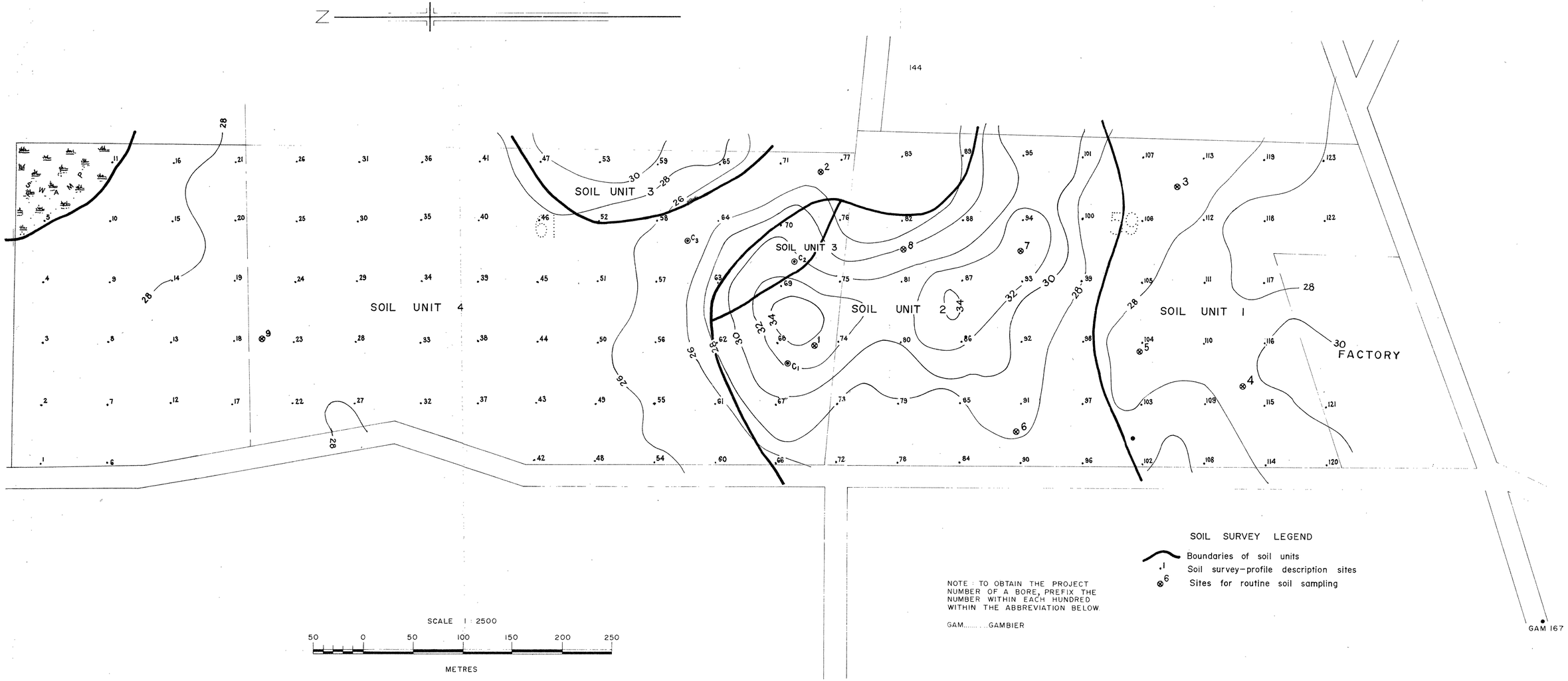


Horizontal Scale : 1:2,500
Vertical Scale : 1cm. rep. 2m.

FIG. 3

	DEPARTMENT OF MINES – SOUTH AUSTRALIA	SCALE As Shown
COMPILED: S. Barnett	KRAFT FOODS MIL-LEL	DATE: September 1976
DRN: T.E. CKD.	SPRAY EFFLUENT INVESTIGATION	PLAN NUMBER:
	GEOLOGICAL CROSS-SECTION	76-738

7022-11



SCALE 1 : 2500

50 0 50 100 150 200 250

METRES

NOTE : TO OBTAIN THE PROJECT NUMBER OF A BORE, PREFIX THE NUMBER WITHIN EACH HUNDRED WITHIN THE ABBREVIATION BELOW.

GAM.....GAMBIER

SOIL SURVEY LEGEND

- Boundaries of soil units
- .1 Soil survey–profile description sites
- ⊗6 Sites for routine soil sampling

FIG. 4

	DEPARTMENT OF MINES – SOUTH AUSTRALIA	SCALE As shown
COMPILED D. Armstrong	SOUTH EAST WATER RESOURCES	DATE 6th Oct. 1976
DRN T.E. CKD	MIL-LEL-INNER NETWORK	PLAN NUMBER
	SOIL MAP AND SAMPLING POINTS	76-770

7022-11

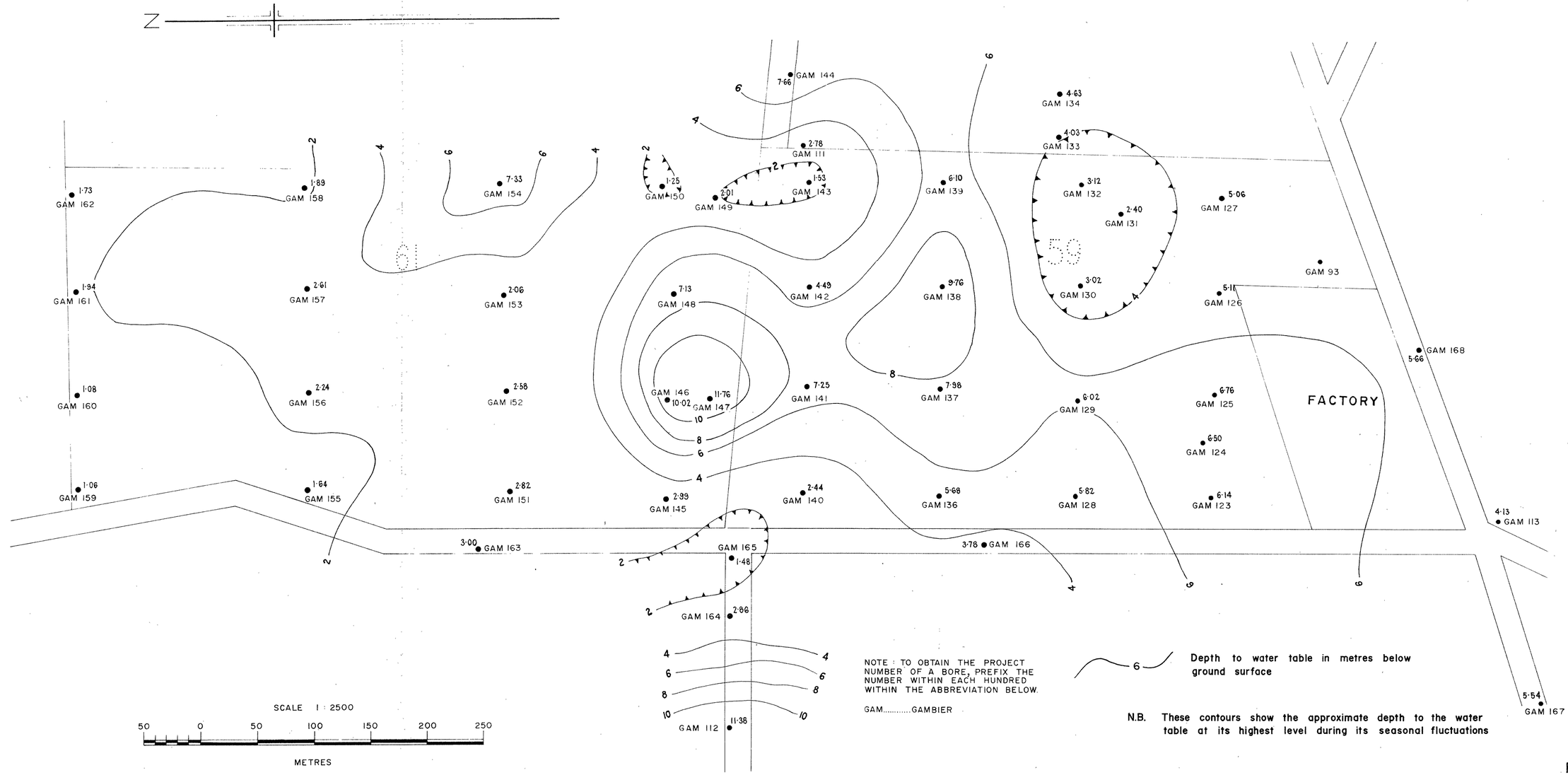


FIG. 5

	DEPARTMENT OF MINES – SOUTH AUSTRALIA	SCALE As shown
COMPILED S. Barnett	SOUTH EAST WATER RESOURCES	DATE 5th OCT. 1976
DRN T.E. CKD	MIL-LEL-INNER NETWORK	PLAN NUMBER
	DEPTH TO WATER TABLE – JAN. 1976	76-771

7022-11

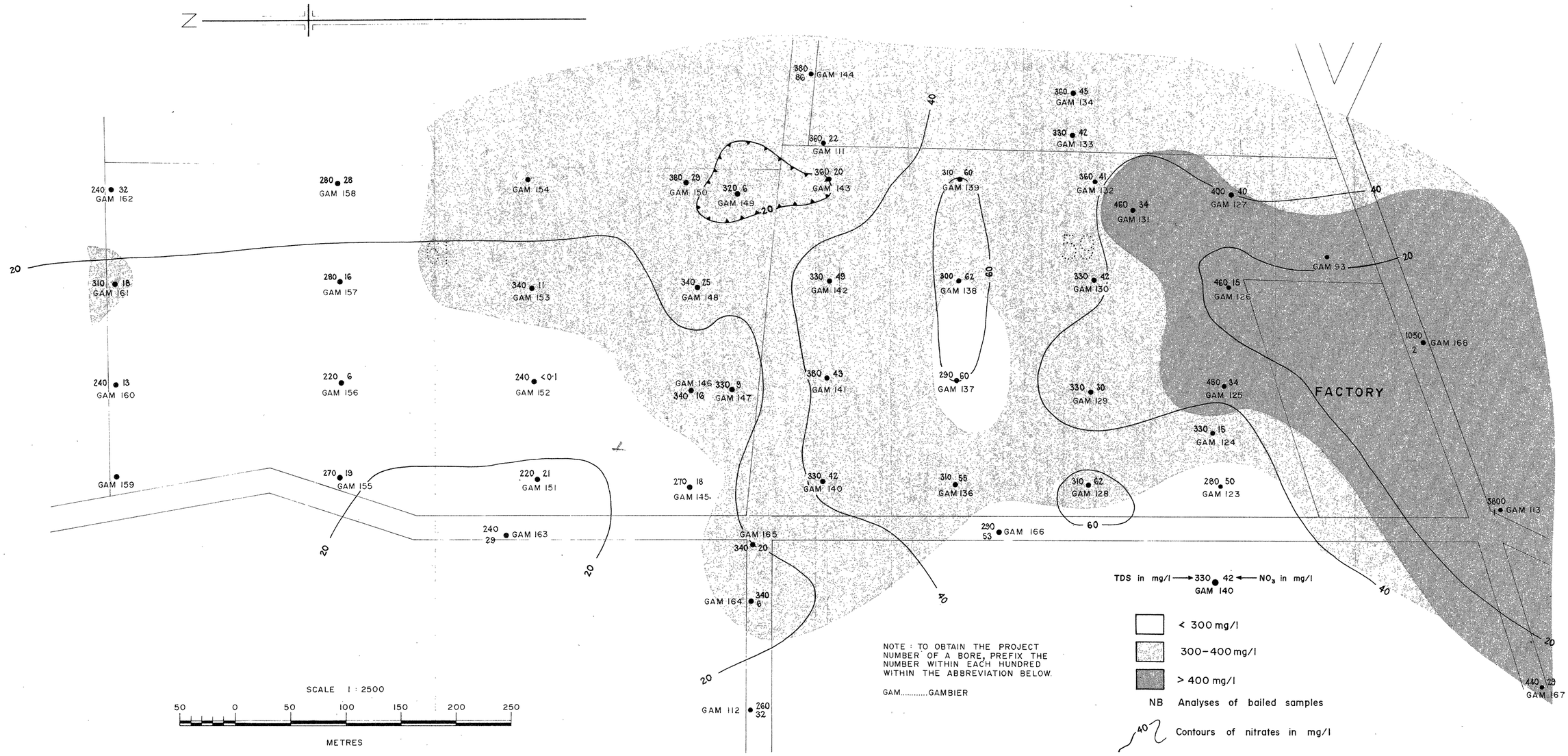


FIG. 6

	DEPARTMENT OF MINES—SOUTH AUSTRALIA	SCALE As shown
COMPILED S. Barnett	SOUTH EAST WATER RESOURCES	DATE 6th Oct. 1976
DRN T. E. CKD	MIL-LEL-INNER NETWORK	PLAN NUMBER
	SALINITY & NITRATE CONTOURS-APR '76	76-772

70 2-11

N

HUNDRED OF MINGBOOL

SPRAY SITE

FACTORY

Mullet Waterhole Reserve

GAM 24

63·57 GAM 110

63·42 GAM 106

63·72 GAM 109

63·43 GAM 107

63·20 GAM 105

63·41 GAM 108

62·94 GAM 94

62·79 GAM 95

61·01 GAM 103

61·46 GAM 104

60·51 GAM 96

59·501 GAM 97

GAM 111 60·02

59·39 GAM 102

58·96 GAM 112

GAM 13

57·38 GAM 101

59·27 GAM 88

dry GAM 93

57·98 GAM 100

57·38 GAM 99

56·94 GAM 98

58·55 GAM 89

58·74 GAM 92

57·731 GAM 91

57·70 GAM 113

56·66 GAM 84

55·17 GAM 83

53·07 GAM 82

57·90 GAM 90

55·47 GAM 87

54·24 GAM 86

54·98 GAM 85

63 62 61 60 59 58 57 56 55 54

NOTE : TO OBTAIN THE PROJECT NUMBER OF A BORE, PREFIX THE NUMBER WITHIN EACH HUNDRED WITHIN THE ABBREVIATION BELOW.

GAM.....GAMBIER

60 — WATER TABLE CONTOUR (metres above M.S.L. Port Adelaide)

COMPILED: S. BARNETT

FIELD WORK: J. LAWSON 6·1·76

SCALE 1 10000

200 0 200 400 600 800 1000

METRES

FIG. 7

	DEPARTMENT OF MINES – SOUTH AUSTRALIA	SCALE As shown
COMPILED A.B.H.	SOUTH EAST WATER RESOURCES	DATE June 1976
DRN L.P.R. CKD	MIL-LEL-OUTER NETWORK	PLAN NUMBER
	WATER TABLE CONTOURS – JAN '76	76-534

7022-27

N

HUNDRED OF MINGBOOL

Mullel Waterhole Reserve

SPRAY SITE

FACTORY

GAM 24
GAM 88
59·58 GAM 102
58·07 GAM 89
57·55 GAM 90
55·21 GAM 87
63·16 GAM 110
62·86 GAM 106
60·54 GAM 103
61·00 GAM 104
58·33 GAM 92
59·60 GAM 111
dry GAM 93
57·33 GAM 91
54·08 GAM 86
63·17 GAM 109
62·84 GAM 107
62·61 GAM 105
57·28 GAM 113
62·80 GAM 108
62·34 GAM 94
58·59 GAM 112
57·61 GAM 100
54·76 GAM 85
62·20 GAM 95
60·11 GAM 96
59·15 GAM 97
GAM 13
56·34 GAM 84
57·06 GAM 99
56·63 GAM 98
54·94 GAM 83
56·08 GAM 101
52·51 GAM 82

63 62 61 60 59 58 57 56 55 54 53

NOTE · TO OBTAIN THE PROJECT NUMBER OF A BORE, PREFIX THE NUMBER WITHIN EACH HUNDRED WITHIN THE ABBREVIATION BELOW.

GAM.....GAMBIER

60 — WATER TABLE CONTOUR (metres above M.S.L. Port Adelaide)

COMPILED: S. BARNETT

FIELD WORK: J. LAWSON 6·4·76

SCALE 1 10000

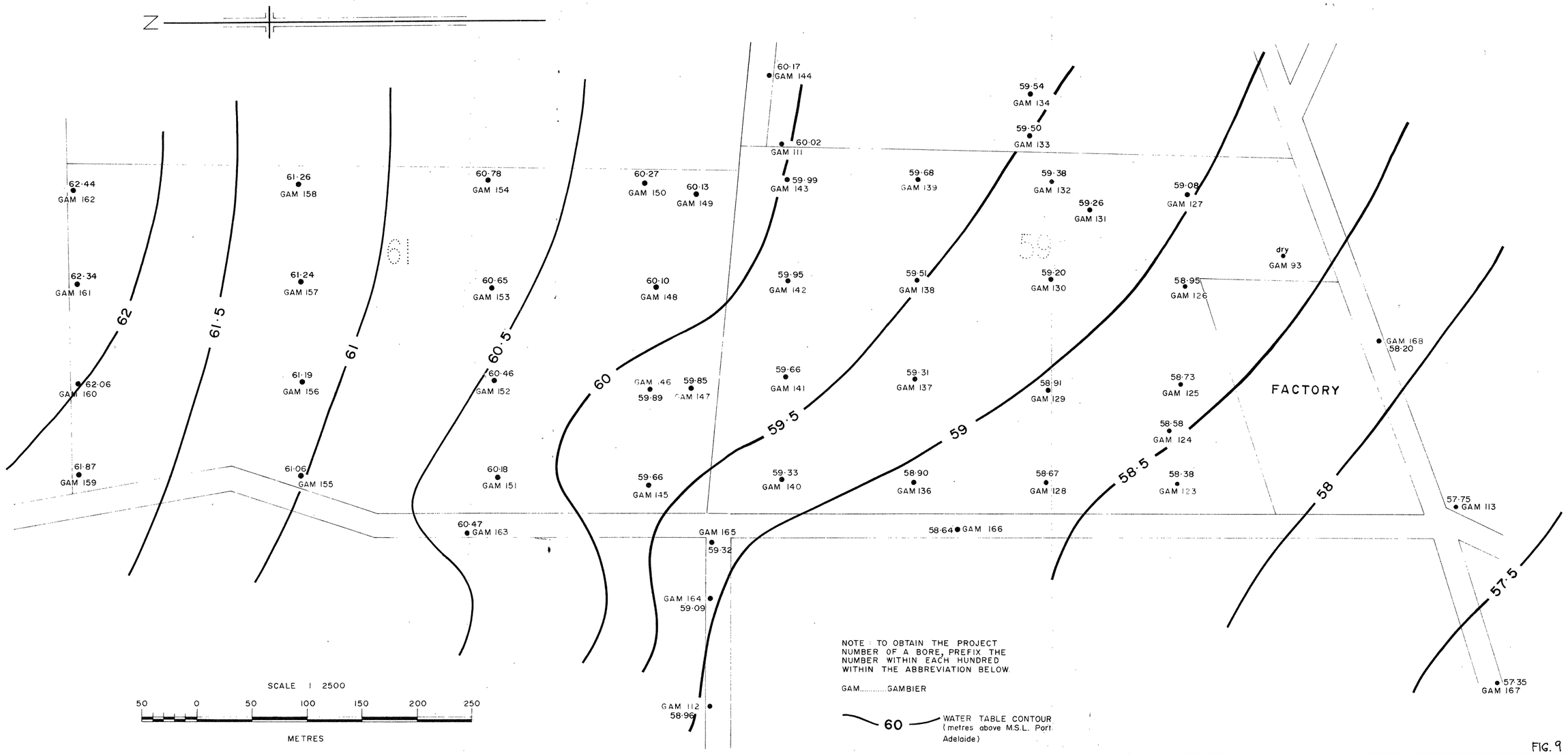
200 0 200 400 600 800 1000

METRES

FIG. 8

	DEPARTMENT OF MINES – SOUTH AUSTRALIA	SCALE As shown
COMPILED A.B.H.	SOUTH EAST WATER RESOURCES MIL-LEL-OUTER NETWORK WATER TABLE CONTOURS – APRIL '76	DATE June 1976
DRN L.P.R. CKD		PLAN NUMBER 76-535

7022-27



NOTE : TO OBTAIN THE PROJECT NUMBER OF A BORE, PREFIX THE NUMBER WITHIN EACH HUNDRED WITHIN THE ABBREVIATION BELOW.

GAM.....GAMBIER

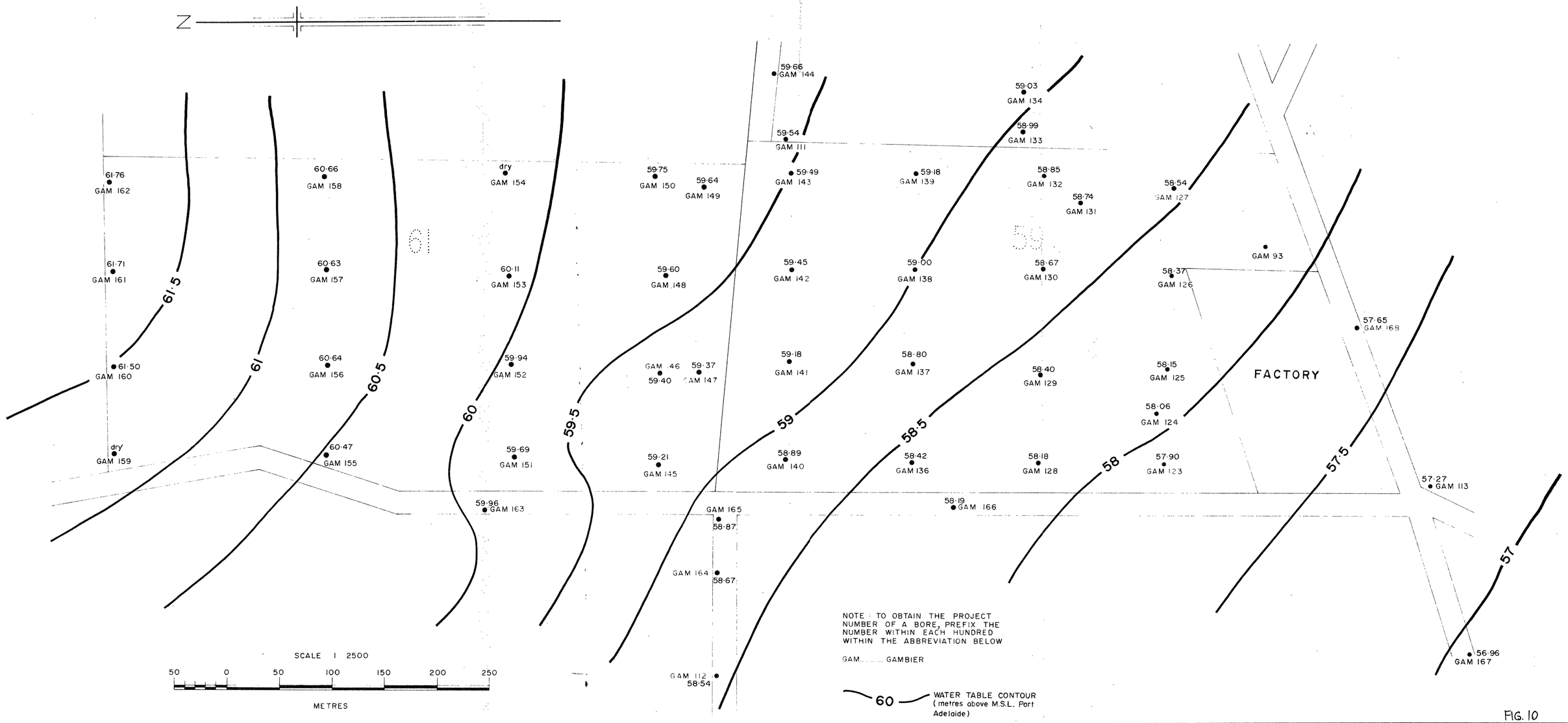
60 — WATER TABLE CONTOUR (metres above M.S.L. Port Adelaide)

COMPILED: S. BARNETT

FIELD WORK: J. LAWSON 6·1·76

FIG. 9

	DEPARTMENT OF MINES – SOUTH AUSTRALIA	SCALE As shown
COMPILED	SOUTH EAST WATER RESOURCES MIL-LEL-INNER NETWORK WATER TABLE CONTOURS – JAN '76	DATE
DRN CKD		PLAN NUMBER 76-532



NOTE : TO OBTAIN THE PROJECT NUMBER OF A BORE, PREFIX THE NUMBER WITHIN EACH HUNDRED WITHIN THE ABBREVIATION BELOW

GAM..... GAMBIER

60 — WATER TABLE CONTOUR (metres above M.S.L. Port Adelaide)

COMPILED: S. BARNETT

FIELD WORK: J. LAWSON 20·4·76

FIG. 10

	DEPARTMENT OF MINES – SOUTH AUSTRALIA	SCALE As shown
COMPILED	SOUTH EAST WATER RESOURCES MIL-LEL-INNER NETWORK WATER TABLE CONTOURS – APRIL '76	DATE
DRN. CKD.		PLAN NUMBER 76-533

7022-27