CONTENTS PAGE

APPENDICES

DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

Rpt Bk No. 89/22
DME No. 332/87
Disk No. NEC2

WILLUNGA BASIN GROUNDWATER INVESTIGATION 1986/88

ABSTRACT

The Willunga Basin Groundwater Investigation commenced in 1986 as a joint project between the Department of Mines and Energy and the Engineering and Water Supply Department. This report documents activities from 1986 to August 1988. A more detailed assessment will be tabled in subsequent reports.

Activities have included the compilation of a borehole data base, the setting up of a new monitoring network, drilling, test pumping, geophysical logging of wells, water sampling, and a land use survey. Transmissivities obtained from test pumping range from 44 to 5560 m^2/D in the Pt Willunga Formation and 16 to 35 m^2/D in the Maslin Sands. Results of drilling, test pumping and salinity sampling are included in figures and appendices.

INTRODUCTION

The Willunga Basin Groundwater Investigation is a joint project involving the Mines Department and the Water Resources branch of the E&WS. It was commenced in 1986 , with field investigations commencing in the latter half of 1987.

The study was instigated in response to a request from the Noarlunga City Council for groundwater resource data to evaluate the development potential in the northern part of the basin. There was also recognition of the need for a groundwater investigation to assess the current status and to formulate a management strategy for the resource. The purpose of this report is to present results obtained by the Mines Department for the period January 1986 to August 1988.

LOCATION AND GEOLOGICAL SETTING

The Willunga Basin is a small wedge shaped embayment of the St. Vincent Basin, situated approximately 50 km south of Adelaide (Fig 1). It contains mid to late Tertiary and Quaternary clastic

and calcareous sediments. Permian sediments also occur, with known intersections being located in the north east and west of the embayment. It is flanked and underlain by Proterozoic and Palaeozoic rocks of the Adelaide system, and is bounded along its southern and eastern margins by the Willunga Fault. Sediments thin on to outcropping basement rocks at the north near the Onkaparinga Gorge, and increase in thickness from this ridge to the Willunga Fault.

STRATIGRAPHY

TERTIARY:

The Tertiary stratigraphy of the Willunga Embayment (from here on termed the Willunga Basin or the basin) has been documented by Cooper (1979) and is summarized below.

MASLIN SANDS	- NORTH MASLIN SAND MEMBER
	- SOUTH MASLIN SAND MEMBER
TORTACHILLA LIMESTONE	
BLANCHE PT FORMATION including THE GULL ROCK MEMBER	
CHINAMAN GULLY FORMATION	
PT WILLUNGA FORMATION	- ALDINGA MEMBER
	- RUWARUNG MEMBER
	- PIRRAMIMMA SAND MEMBER

MASLIN SANDS

NORTH MASLIN SAND MEMBER

The North Maslin Sand Member occurs throughout the entire basin and consists of poorly sorted red brown to yellow sands, weakly to moderately cemented, and containing varying amounts of carbonaceous and pyritic material. Maximum recorded thickness is approximately 55 metres.

SOUTH MASLIN SAND MEMBER

This unit occurs throughout most of the basin, being absent only in the extreme north east and in a small area in the central west. It consists of fine to coarse sands, generally well sorted, but containing varying amounts of clay and glauconite. It ranges in thickness to approximately 40 metres.

The Maslin Sands are interpreted as being deposited in terrestrial and shoreline environments, with winnowing by wave action being responsible for the better sorting observed in the South Maslin Sand Member.

TORTACHILLA LIMESTONE

The Tortachilla Limestone extends from the coastal cliffs in the west to the central part of the basin area. It is absent in the north and east. Maximum thickness is approximately 6 metres. This unit is described as a bioclastic limestone, containing abundant marine fossils, quartz grains and goethite pellets. It is considered to have been deposited in marine conditions behind an advancing shoreline (Cooper, 1979).

BLANCHE PT FORMATION

The Blanche Pt Formation overlies the Tortachilla Limestone, and occurs throughout most of the basin, being absent only in the north and north east. It consists of limestone, siltstone and claystone, with common cherty, pyritic and carbonaceous layers. Sand content increases near the basin margins, whereas in the central part of the basin it is generally calcareous, carbonaceous, pyritic and silty. Maximum recorded thickness is approximately 60 metres.

GULL ROCK MEMBER

Contained within the Blanche Pt Formation is the Gull Rock Member, a unit characterised by prominent chert, silt and clay layers (calcareous in part). It occurs in the central and southern parts of the basin, being absent in the north and east. Maximum documented thickness is 26 metres (Cooper, 1979).

The Blanche Pt Formation is considered to represent the extent of maximum marine transgression in the Willunga Embayment. Along the eastern margin the presence of sandy glauconitic facies are thought to indicate that sedimentation occurred in marginal marine conditions, similar to those present at the time of deposition of the South Maslin Sand Member.

CHINAMAN GULLY FORMATION

Known intersections of the Chinaman Gully Formation indicate that it occurs in a broad east-west band in the central part of the basin. It consists of micaceous, pyritic and carbonaceous sand, silt and clays. No calcareous sediments have been found within it. The Chinaman Gully Formation is

interpreted as having been deposited in marine and marginal to non marine environments, but being eroded in the northern and southern parts of the basin. Maximum unit thickness is approximately 7 metres.

PT WILLUNGA FORMATION

Cooper (1979) has divided the Pt Willunga Formation into 3 members; the Aldinga Member, the Ruwarung Member and the Pirramimma Sand Member.

ALDINGA MEMBER

This member is the basal unit of the Pt Willunga Fm, and occurs in the central and western parts of the basin. It consists of fossiliferous clays, silts, sands and limestones, and grades laterally and vertically into the Ruwarung Member and Pirramimma Sand Members. Maximum recorded thickness is approximately 20 metres.

RUWARUNG MEMBER

The Ruwarung Member occurs in an east-west band from the coast to the middle of the embayment, and consists of fossiliferous and calcareous sand, silt and clay interbedded with chert layers. Quartz sand content increases to the east where it grades into the Pirramimma Sand Members. The Ruwarung is generally less than 20 metres thick.

PIRRAMIMMA SAND MEMBER

This unit occurs from the south central to the central eastern parts of the basin, and consists of silts and fine to medium grained sands. Clay content varies considerably, with clayey sands and sandy clays being common throughout the unit. Thickness of the Pirramimma Sand Member is often in excess of 50 metres.

The relationships between these three members can be quite complex, with the Pirramimma Sand Member grading into the Aldinga and Ruwarung Members in most areas, but overlying them in some. Widespread dissolution and recrystallization has occurred in the limestone facies of the Aldinga Member, whilst leaching of organic matter, silicification and ferruginous cementation is common in all three.

QUATERNARY

Quaternary sediments occur extensively in the Willunga Basin, particularly in the south, east and west. They consist of gravels, sands, silts and clays of the Carisbrooke Sand and Hindmarsh Clay (or equivalents). Along the Willunga Fault, a considerable thickness of alluvial fan and outwash sediments have been deposited by creeks originating in the hills of the Willunga scarp.

HYDROGEOLOGY OF THE WILLUNGA BASIN

The rock units of the Willunga Basin have formed a multiaquifer system, with groundwater being withdrawn from aquifers in Quaternary, Tertiary, and basement rocks. For this report, the system has been divided into 4 aquifers; Basement, Maslin Sands, Pt Willunga Fm, and Quaternary (Fig 2). Lithostratigraphic names have been retained, because at this stage the aquifer system is not sufficiently well understood to warrant a different nomenclature.

AQUIFERS - WILLUNGA BASIN

BASEMENT:

Groundwater is extracted from cracks, joints and zones of dissolution in outcropping Adelaidean rocks north and east of the limits of Tertiary sedimentation in the Willunga Basin. In the northeast of the basin, wells have also been drilled through the Maslin Sands and successfully completed in basement. Yields vary considerably, ranging from less than 1 l/s to greater than 10 l/s, whilst water quality varies from less than 1000 mg/l to over 5000 mg/l. No groundwater is extracted from basement rocks in the central, southern and western parts of the basin. Recharge is thought to occur by direct infiltration of rainfall and possibly from stream losses. Flow paths have not been established.

MASLIN SANDS:

This aquifer occurs throughout the entire basin area, and is the principle source of groundwater in the north and northeast of the basin (Fig 3). In these areas it is essentially unconfined or semi confined, with depth to water bearing strata generally less than 100 metres. Further south, the Maslin Sands aquifer is not used for irrigation purposes because it becomes deeper in that direction, water quality deteriorates, and because there is better quality groundwater available closer to the surface in the Pt Willunga Formation. Thickness of the Maslin Sands aquifer is usually less than 60 metres, although it may also include a considerable thickness of Permian sands in places. Water quality ranges from approximately 700 mg/l in the north east to greater than 6000 mg/l in the west. Yields from wells are usually less than 12 l/s. The principal flow direction is from north east to south west, whilst recharge is thought to occur by direct infiltration of rainfall, stream losses, and by through flow from basement.

PT WILLUNGA FORMATION:

This aquifer is the principle source of groundwater in the central, southern and western parts of the Willunga Basin (Fig 4). It is separated from the Maslin Sands by the silts and clays of the Blanche Pt Formation. In the central part of the basin, the Pt Willunga Formation is unconfined to semi confined, but becomes confined further south. The aquifer consists of the silts and sands of the Pirramimma Sand Member in the east, and the limestones and sands of the Aldinga Member in the south and west. The principle flow direction is from the north east to the south west, and water quality deteriorates in that direction, ranging between approximately 400 mg/l and 2000 mg/l. Well yields are often in the order of 25 l/s from the limestone, but are usually less than 20 l/s from the sands. Recharge is thought to occur by direct infiltration of rainfall and from stream losses in the central (unconfined) area, and by throughflow from basement along the Willunga Fault. Around the eastern margins of the basin groundwater in the Pt Willunga Formation aquifer may also be in direct contact with that in the Maslin Sands because of leakage through higher permeability sandy facies of the Blanche Pt Formation.

QUATERNARY

In the west of the basin, the Quaternary aquifers consist of sands and gravels within the Carisbrooke Sand/Hindmarsh Clay sequence. These permeable zones are usually in direct contact with the Pt Willunga Formation aquifer, although small perched aquifers also occur. Further inland, small supplies have been obtained from sand and gravel layers occurring in alluvial outwash fans along the Willunga Fault. The degree of connection of these layers is not known. At present, the Quaternary aquifer system is a relatively unimportant groundwater resource.

CONFINING BEDS

A number of confining beds are thought to separate aquifers in the Willunga Basin groundwater system, none of which have been studied in detail.

BASEMENT:

A number of wells have intersected up to 20 metres of white clay formed by the weathering of basement rocks, which may form an effective seal between the Basement aquifers and the Maslin Sands. However, the distribution and effectiveness of this layer is yet to be established.

BLANCHE PT FORMATION:

The main confining bed in the Willunga Basin is the Blanche Point Formation/Chinaman Gully Formation/Tortachilla Limestone group, separating the Pt Willunga Formation aquifers from those in the Maslin Sands. The rock types within this confining bed sequence vary considerably, ranging from clayey limestone and carbonaceous clay, to silt, silty sand and sand. Sand content in the Blanche Pt Formation

increases near the eastern margins of the basin, which may allow movement of groundwater between the Pt Willunga Formation and the Maslin Sands. In a number of places, groundwater is being extracted from the Blanche Pt Formation.

QUATERNARY:

Confining beds may occur within the Quaternary sequence and also between it and the Pt Willunga Formation (and Maslin Sand) aquifers. These layers are most likely to be clay lenses within the Carisbrooke Sands and the Hindmarsh Clay, and also in the alluvial fans along the Willunga Fault. No study has yet been made of this system.

PREVIOUS WORK

The Mines Department undertook an initial groundwater investigation program in the Willunga Basin in 1974. This involved the drilling of a number of observation wells for use in a monitoring network (water levelling and salinity), stream sampling, geophysical logging, and a water consumption survey. Bowering (1982) summarized the results of this investigation, whilst Water Search (1985) conducted a review of the area, outlining trends in availability and consumption of groundwater, and highlighting problems associated with the observation network and data storage.

WILLUNGA BASIN GROUNDWATER INVESTIGATION 1986-1988

This study was instigated to improve the understanding of the groundwater systems in the Willunga Basin in order to provide information to local government bodies, and to enable a management strategy to be formulated. Activities have included:-

- setting up a data base
- land use survey
- upgrading the monitoring network
- drilling
- geophysical logging of observation wells
- water sampling

DATA BASE: a comprehensive review of available information was undertaken by the E&WS, forming the basis of the Willunga Basin data base. Information collated includes well completion details, stratigraphy (from drillers and geologists logs), salinity data (from drilling records and field surveys) and hydrograph data from the old monitoring network. This information has enabled structure contour, isopach, potentiometric surface and salinity maps to be generated for each aquifer (the latter two including time series data). Selected Information from this review is to be used in the Mines Department

Data base, but will be supplemented by more recent data, particularly from drilling.

LAND USE STUDY: a land use study was completed by the E&WS in 1987. This information will be of use in identifying areas of concentrated groundwater withdrawal, highlighting trends in groundwater usage, and in calculating the water budget for the basin.

MONITORING NETWORK: prior to the commencement of this study, the Willunga Basin network consisted of 43 wells in 5 aquifers read every 3 months, with 12 of these read monthly. The distribution of these wells was of little use in establishing potentiometric surfaces and flow paths. This network has since been supplemented by another 47 wells, bringing the total to 90, all read monthly. The extent and monitoring frequency of the network is under constant review, and more wells will be added if the need arises. Of those new to the network, 5 have been drilled by the Mines Department, whilst the others are private wells. The distribution of wells in the network is shown in Fig 5.

DRILLING: a total of 6 wells were drilled in the basin in the period 1986-88; 2 by cable tool and 4 by rotary rig. The cable tool holes were drilled to investigate Quaternary aquifers, and in both cases it was found that these aquifers were in direct contact with the underlying Pt Willunga Formation. Of the rotary holes, one was drilled with air into the Pt Willunga Formation, but collapsed and was abandoned, whilst the other 3 were drilled with mud circulation and successfully completed, one in the Maslin Sands and 2 in the Pt Willunga Formation. All wells successfully completed have been incorporated into the monitoring network. Laboratory analyses of cored samples obtained from the Blanche Point Formation in well no. WLG 92 (P/N 94896) indicate that this formation (confining layer) has a vertical permeability of 3.9×10^{-8} - 5.1×10^{-8} m/sec at 20^0C. Results of drilling are summarized in Table 1. Well logs are in appendix 1, and drillsite locations are shown in Figure 6.

GEOPHYSICAL LOGGING: logs were run in a number of the older observation wells to determine the condition of casing, and the aquifer being monitored. In this program, gamma, neutron, caliper, density, and casing collar locating tools were run. All holes drilled with rotary rig and mud circulation in 1987 and 1988 were also logged. In these holes, gamma, neutron, caliper, density, SP and/or various resistivity tools were used. The location of these wells is given in Fig 7.

TEST PUMPING: a series of pumping tests were conducted in 1987 and 1988 to establish aquifer properties. In pumping test 6, two Mines Department wells were used for observation purposes, but in all other tests, private wells were used. All production wells were privately owned. A total of 10 tests were completed from October 1987 to August 1988, 3 of which were in the Maslin Sands, and 7 in the Pt Willunga Formation (Fig 8). Values of Transmissivity, Storage Coefficient, and Leakage Factor were obtained in some tests, whilst in others, the results were less satisfactory. Transmissivities obtained from tests in the Maslin Sands were less than 50 m^2/D. This unit is comprised of sediments of many facies, ranging from shoreline to terrestrial. Sediment type ranges from gravel and sand to silt, clay and coal/lignite. Sand layer (aquifer) thickness is generally only a few metres, so the transmissivity values

obtained are consistent with wells completed in such sediments. However, boundaries (facies changes) are common, so long term yields may vary. All tests were conducted in the central and northern parts of the basin, so it may be inappropriate to use these figures basinwide, particularly as sand content is known to increase to the south and west. No tests have been conducted in this region.

The Pt Willunga Formation is comprised of 3 members, the most important as groundwater resources being the Aldinga and Pirramimma Sand Members. Transmissivities obtained from pumping tests range from 44 to 5560 m^2/D. The highest values were obtained from test no. 8, which was conducted in the limestone of the Aldinga Member. Such a high T value may be caused by the presence of dissolution features or fractures. and is not expected to be typical of the aquifer. All other tests were conducted in wells completed in sandy facies, most probably in the Pirramimma Sand Member. T values range from 44 to 463 m^2/D. Unfortunately, in most of these tests, the aquifer thickness was not known, and facies changes occur laterally and vertically over short distances, so accurate pump test analysis was difficult. Therefore, these figures should be taken as approximations only. Results are summarized below. Analyses and discussion of results are included in appendix 2.

WILLUNGA BASIN TERTIARY AQUIFER PROPERTIES- SUMMARY

AQUIFER	TRANSMISSIVITY (m^2/D)	STORAGE COEFF	COMMENTS
PT WILLUNGA	44 - 5560	2.1×10^{-4} to 1.1×10^{-2}	
MASLIN SANDS	16 - 35		no response in Obs wells at sites tested

WATER SAMPLING: a program of sampling of pressure cemented wells for total dissolved solids commenced in November 1987 and concluded in March 1988. A total of 90 wells in Basement, Maslin Sands and the Pt Willunga Formation were sampled. TDS values are shown in Fig 9. Some wells are recently drilled Mines Department observation wells (salinities obtained during development), but the majority are private stock or irrigation wells.

SUMMARY AND CONCLUSIONS

As of August 1988, the investigation has resulted in the establishment of a data base, the drilling of 6 wells, the upgrading of the observation well network, the test pumping of 10 wells, and a land use survey. These activities have enabled some preliminary concepts to be formulated (eg Fig 2). Further refinement is required. Anticipated activities include better defining the basin configuration and unit boundaries, obtaining hydrogeologic parameters (T, K, S, K', L), and basin throughflow and recharge figures. This action together with groundwater extraction data from the land use survey will enable a water budget to be established, leading to the formulation of a management strategy for groundwater usage within the basin.

As stated previously, the old monitoring network was considered inadequate in terms of assessing the impact of more recent development and in establishing groundwater flow patterns and gradients. The network was upgraded to 90 wells, which has resulted in a more useful set of data being collected. However, there may be a need to add more wells in this network to better define flow patterns in certain areas, for example the north east and south for the Maslin Sands, and the south west for the Pt Willunga Formation. The drilling of three observation wells into the Maslin Sands is needed to better define the potentiometric surface of this aquifer in the south of the basin, whilst it may be possible to add private wells to the network for this unit in the north east. Expansion of the Pt Willunga Formation network in the southwest can be achieved by adding a number of wells drilled by the E&WS around the proposed Sellicks Marina site, although more drilling may also be necessary. Problems will be encountered in reading this monthly network if many more equipped (private) wells are added, because these wells need to be given sufficient time to recover before the water level is read. This can be difficult to coordinate in the irrigation season.

Another series of pumping tests in the Maslin Sands and Pt Willunga Formation would be useful to get a more even distribution of hydraulic data in the basin. At this stage no pumping tests have been conducted in the south west of the basin, which is an area where the Pt Willunga Formation is an important resource. Tests also need to be carried out in the north east of the basin to get similar data for the Maslin Sands. These tests are important as numerous facies have been identified in both aquifers, and it is necessary to establish the range and distribution of parameters in each.

Computer modelling of the basin will be attempted, to enable the impact of increased groundwater usage to be assessed.

The geochemistry of the various aquifers is also to be investigated, in conjunction with the C.S.I.R.O.

R. ALDAM

REFERENCES

BOWERING, O.J.W., 1979. Willunga Basin Groundwater Investigation. Progress Report No. 3. South Australian Department of Mines and Energy unpublished report 79/18.

COOPER, B.J., 1979. Eocene to Miocene Stratigraphy of the Willunga Embayment. South Australian Department of Mines and Energy Report of Investigations No. 50.

VANDENBURG, A., 1976. Tables and Curves for Analysis of Pump Tests in Leaky Parallel Channel Aquifers. Technical Bulletin No. 96. Inland Waters Directorate, Water Resources Branch Ottowa, Canada.

WATER SEARCH, 1985. Willunga Basin Groundwater Review. (Consultants report to the Engineering and Water Supply Department).

APPENDIX A

DRILL HOLE AND COMPOSITE LOGS OF MINES DEPARTMENT DRILLED WELLS

APPENDIX B

PUMPING TEST NO. 1 12/11/87

This test was conducted with a production and two observation wells (Fig. 8). All are privately owned and completed in the Aldinga Member of the Pt. Willunga Formation.

PRODUCTION WELL 6627-6875:	depth 84m, 152mm steel casing to 55m. 125mm steel casing from 55m to 84m, pressure cemented. Casing slotted from 61m to 84m, open at base.
OBSERVATION #1 6627-7393:	depth 79.4m, 152mm steel casing to 56.2m, pressure cemented, open hole completion.
OBSERVATION #2 6627-7159:	depth 68m, 152mm steel casing to 56m, pressure cemented, open hole completion.
DISCUSSION:	A step drawdown test on the production well resulted in the equation $s = 3.4Q + 7.6Q^2 + 4.6Q\log t$ (where Q is in M^3/min and t is in mins)

The main production test lasted 30 hrs during which time the influence of leakage and a discharging boundary were noted (Fig B2).

Observation well responses were analyzed on the assumption that the system was behaving as a leaky aquifer, and segments of the field data plot prior to the occurrence of the boundary effect were matched with leaky aquifer type curves (Fig B4). The drawdown plot for well OBS #2 was analyzed using the Theiss curve since the test did not last long enough for leakage to be detected at the site (Fig B4). Results are presented in Table B-1.

TABLE B-1 WILLUNGA BASIN PUMPING TEST 1 - SUMMARY OF RESULTS

	WELL NO	DATE	TEST DURATION	RECOVERY (MINS)	AQUIFER (MINS)	ANALYSIS TYPE	r (M)	T (M^2/D)	S	COMMENTS
PROD	6627-6875	12/11/87	1800	180	PWF	LOG/LIN		130		LEAKAGE AND BOUNDARY EFFECTS OBSERVED AT LATE TIME
OBS#1	6627-7393			"	"	LOG/LOG	197	166	$1.3x10^{-3}$	B = 328 m
OBS#2	6627-7159				"	LOG/LOG	250	190	$3x10^{-3}$	NON LEAKY TYPE CURVE

APPENDIX C

PUMPING TEST NO. 2 18/11/87

The test was conducted with a production and one observation well (Fig. 8). Both are privately owned and completed in the Maslin Sands.

PRODUCTION WELL 6627-7656: depth 84m, 152mm steel casing to 78m, pressure cemented, 0.64mm steel screen from 78m to 80m.

OBSERVATION #1 6627-7055: depth 86.5m, 152mm steel casing to 83.5m, not pressure cemented, 0.41mm steel screen from 83.5m to 86.5m.

DISCUSSION: The test was abandoned after 23 hours of pumping because of poor response. The production well started to drawdown for a few minutes, but then rose and stabilized, whilst the observation well showed a constant water level rise. This may have been due to barometric effects, changing head conditions due to the test discharging through an irrigation system or because the aquifer was recovering from the pumping of a well nearby. This latter possibility may be the most likely, although checks were made for pumping wells in the area. The only result was an approximation of transmissivity. Recovery was not recorded. Results of the test and drillers logs are summarized below:

TABLE C1 WILLUNGA BASIN PUMPING TEST 2 - SUMMARY OF RESULTS

WLL NO.	DATE	AQUIFER	TEST DURATION (min)	ANALYSIS TYPE	T (M^2/D)
6627-7656	18/11/87	M.S.	1380	LOG/LIN (LOGANS APPROX)	35

(TEST ABANDONED DUE TO OBS WELL NOT RESPONDING TO PUMPING)

Drillers og production well, observation well

PROD 6627-7656

0 - 1	sand
1 - 8	red clayey sand
8 - 15	coloured clayey sand
15 - 17	yellow sand
17 - 25	marly clay
25 - 36	soft marly sand
36 - 36.2	ironstone
36.2 - 42	yellow sand
42 - 45	ironstone
45 - 47	yellow sand
47 - 57	yellow/white clay
57 - 67	white sandy clay
67 - 70	yellow sand
70 - 71	yellow sandy clay
71 - 74	gravel, sandy clay
74 - 77.5	yellow sandy clay
77.5 - 80.5	gravel
80.5 - 84	white/blue clay
84 -	basement

OBS # 1 6627-7055

0 - 0.7	white sand
0.7 - 9	yellow sandy clay
9 - 14	white sandy clay
14 - 23	yellow sandy clay
23 - 25	green sandy clay
25 - 28	yellow sandy clay
28 - 29	maroon sandy clay
29 - 40	yellow marly clay
40 - 51	yellow sandy clay
51 - 65	lignitic clay
65 - 75	white sandy clay
75 - 79	cemented yellow sand
79 - 83	white sandy clay
83 - 86	yellow sand
86 - 86.5	white clay
86.5	quartzite

APPENDIX D

PUMPING TEST NO. 3 25/11/87

This test involved the monitoring of the production well only, no observation wells were available (Fig. 8). The aquifer is the Pirramimma Sand Member of the Pt Willunga Formation, and is considered to be unconfined.

PRODUCTION 6627-7805: depth 112m, backfilled to 84m, 152mm steel casing to 73.5m, pressure cemented, 0.15mm steel screen from 73.5m to 83.5m. PRIVATE WELL.

DISCUSSION: The test was conducted with a Mines Department submersible pump. The standing water level was 74m, which necessitated placement of the pump inside the screen. The well was pumped for 250 minutes and abandoned because the drawdown response was considered insufficient to continue the test. The drawdown was analyzed after the application of Jacob's correction to drawdown, since the aquifer was unconfined at the start of the test (Fig D-1). Results are shown in Table D-1. Drilling ogs are listed below.

TABLE D-1 WILLUNGA BASIN PUMP TEST 3 - SUMMARY OF RESULTS

WELL NO	DATE	AQUIFER	TEST DURATION (MIN)	ANALYSIS TYPE	T (M^2/D)
6627-7805 (PROD)	25/11/87	PWF (unconfined)	250	LOG/LIN	156

DRLLERS LOG, WELL 6627-7805

0-4m	Red clays
4-12	Red/yellow clays
12-15	Big gravels with some clays
15-22	White sandy clays
22-56	Sandstone/clay, becoming coarser to 56m
56-73	Fine sandstone 30% clays
73-84	Fine to medium sandstone, clean
84-87	Fine sands, 30% clays
87-100	Cemented sandstone, hard with iron staining
100-112	Black silty sandstone, hard with shell fragments, and some black clay bands.

APPENDIX E

PUMPING TEST NO. 4 1/12/87

There are two wells at this site - the production well completed in the Maslin Sands, and an unequipped well at a distance of approximately 20m completed in the Pt Willunga Fm.

PRODUCTION 6627-7387: depth 110m, completed depth 102.4m, 152mm steel casing to 99.2m, pressure cemented, 0.64mm aperture steel screen from 99.2-102.4m. Full aquifer penetration. PRIVATE WELL.

OBSERVATION #1 6627-6224: depth 60m, completed depth 53m, 140mm swell joint casing to 52.88m, not pressure cemented, 0.20mm aperture steel screen from 39-41m and 44.5-45.5m. PRIVATE WELL.

DISCUSSION: The well was pumped for 25 hours with measurable drawdown response occurring in the production well only. The observation well did not respond, implying that vertical leakage through the Blanche Pt Formation is not a major contributor to the water supply. Drawdown and residual drawdown in the production well were analyzed using the Jacob straight line method. (Fig E-1). Results are summarized in Table E-1. Drilling Logs are listed below.

Table E-1 WILLUNGA BASIN PUMPING TEST 4 SUMMARY OF RESULTS

WELL NO	DATE	TEST DURATION (min)	RECOVERY (MIN)	AQ	ANALYSIS TYPE (m^2/D)	T D)
6627-7387 (PROD)	1/12/87	1500	1942	MS	LOG/LIN	15.5
					LOG/LIN (RES DRAWDOWN)	16.4
6627-6224				PWF	NO RESPONSE TO PUMPING	

DRILLERS LOGS, PRODUCTION AND OBSERVATION WELL

6627-7387 PRODUCTION WELL

0 - 2	yellow clay
2 - 13.4	yellow ironstone and clay
13.4 - 14.4	yellow sand
14.4 - 27.2	yellow ironstone and clay
27.2 - 36	yellow marl
36 - 38	silt
38 - 39	coarse sand
39 - 43	lignite
43 - 86	silt
86 - 99.2	lignite
99.2 - 102.2	brown sand
102.4 - 110	green clay

6627-6224 OBS # 1

0 - 0.5	top soil
0.5 - 12	yellow sand, clay and gravel
12 - 13	sand and gravel
13 - 21	sand, clay
21 - 28	sand-soft
28 - 36.5	marl
36.5 - 38	grey silt
38 - 39	sand
39 - 41	lignite and sand
41 - 44	lignite
44 - 44.80	grey silt
44.80- 45.50	lignite and sand
44.5 - 60	grey silt

APPENDIX F

PUMPING TEST, NO.5 16/12/87

The production well was the only well monitored in this test. It is completed in the Maslin Sands.

PRODUCTION 6627-7241: depth 82m, completed depth 71.5m, 152mm steel casing to 66.5m, pressure cemented, 0.30mm aperture steel screen from 66.5 - 71.5m. PRIVATE WELL.

DISCUSSION: Problems were encountered when pumping commenced because the discharge was directed through the owners irrigation system. In this system, water is pumped up a hill and then into a number of distributory pipes before discharging through drippers in a vineyard. The discharge rate varied considerably with time as water entered the various sections of the irrigation system causing drawdown to fluctuate with the changing external head conditions. To overcome this, the test was restarted with a new discharge system where water was pumped into sprinklers near the wellhead. Pumping time was restricted to 220 minutes, and recovery was not monitored because of irrigation commitments. Results of the test were analyzed using the Jacob straight line method (Fig F-1). Results are summarized in Table F9, and the lithological log is presented below.

TABLE F-1 WILLUNGA BASIN PUMPING TEST 5 - SUMMARY OF RESULTS

WELL NO	DATE	TEST DURATION (MINS)	RECOVERY (MINS)	AQ	ANAL TYPE	T (m^2/D)
6627-7241 (PROD)	16/12/87	220	-	MS	LOG/ LIN	35

1987 PUMP TEST SITE 5

PROD 6627-7241

0 - 0.5	white sand
0.5 - 11	yellow sandy clay
11 - 12	white sandy clay
12 - 13	red sandy clay
13 - 13.5	yellow marly clay
13.5 - 19	yellow marly limestone
19 - 19.5	orange sandy clay
19.5 - 26	yellow marly clay
26 - 28.5	yellow marly limestone
28.5 - 32	white limestone
36 - 38	green marly limestone
38 - 47	yellow gravelly clay
47 - 47.5	green marly sandy clay
49.5 - 58	lignitic clay
58 - 66	fine Maslin Sands
66 - 71.5	coarser Maslin Sands
71.5 - 82	white clay

APPENDIX G

PUMPING TEST NO. 6, 24/5/88 - 27/5/88

The test was conducted with a production and 4 observation wells (Fig 8). All are completed in the Pirramimma Sand Member of the Pt Willunga Formation.

PRODUCTION WELL 6627-6647: depth 120m, 150mm steel casing to 96m, pressure cemented, 0.38mm aperture steel screen from 96-110m. PRIVATE WELL.

OBSERVATION #1 6627-7776 (WLG 51): depth 50m, 80mm pvc casing to 40m, 80mm slotted pvc casing from 40-50m, wrapped with "Terra Firma", not pressure cemented. DME DRILLED WELL.

OBSERVATION #2 6627-7792 (WLG 67): depth 134m, 102mm steel casing to 127.5m, pressure cemented, 0.38mm aperture steel screen from 119-121m, DME DRILLED WELL.

OBSERVATION #3 6627-2089 (WLG 15): depth 61m, 150mm steel casing "to bottom", no record of screen,not pressure cemented. One of the original DME obs wells in the Willunga Basin.

OBSERVATION #4 6627-2088: depth 93m, 150mm steel casing to 90m, not pressure cemented, no record of screen, PRIVATE WELL.

DISCUSSION: All wells are completed in the Pirramimma Sand Member of the Pt Willunga Formation. OBS #2 and OBS #4 are completed at the same level as the production well. OBS #1 and OBS #3 are completed higher in the section. Logs for each well are listed below.

The production well was pumped for 4140 minutes (69 hours), with drawdowm being recorded in OBS #1, OBS #2 and OBS #4. No response was detected in OBS #3. A nearby well (6627-7095) was also monitored to observe barometric
fluctuations outside the radius of influence of pumping. Unfortunately this well was equipped with an airline, and readings were not accurate enough to use with confidence. No corrections were made for the effects of partial penetration, because the aquifer thickness is not known.

Drawdown values for the production well (Fig. G-1) were obtained only sporadically due to the probe getting caught on the power cable down the hole. No residual drawdown data were obtained. The response of OBS #1 at r = 20m (Fig G-2) completed 44m above the production interval cannot be easily analyzed quantitatively. It does, however show a time delay in response, indicating that the vertical hydraulic conductivity of the Pt Willunga Formation in this area is

considerably lower than the horizontal hydraulic conductivity. Drawdown in well OBS #2 (Fig. G-3) and well OBS #4 (Fig G-4) indicate either leaky aquifer or early stage delayed yield response.

Differences in values of T for OBS #2 and OBS #4 can be attributed to facies changes occurring near the margin of the basin. The stratigraphic succession at OBS #4 contains less low permeable material, whereas the sediments at OBS #2 are considerably more clay rich. Results are summarized in Table G-1. Drillers logs are listed below.

TABLE G-1 BASIN PUMPING TEST 6 - SUMMARY OF RESULTS

WELL NO	AQUI-	DATE	TEST DURATION (mins)	RECOVERY (mins)	ANALYSIS TYPE	Q (m^3/D)	r (m)	T (M^2/D)	S	B (m)	L	K'	C	COMMENTS
PROD 6627-6647	PWF	24/5/88	4140	3280	LOG/LOG	1280	-	442						Transmissivity may be spurious due to difficulty in reaching water level, and T may be affected by leakage.
OBS#1 6627-7776	PWF					20	463	-						Delayed yield response.
OBS#2 6627-7792	PWF				LOG/LOG	300	208	$5.5x10^{-4}$		600				L, K', C not attempted due to difficulty in establishing confining bed thickness.
OBS#3 6627-2089	PWF													No response to pumping - completed at top of aquifer, whilst pumped well completed at base.
OBS#4 6627-2088	PWF				LOG/LOG	600	443	$5.1x10^{-4}$		857		b'		(thickness of confining bed) = 50m, estimated from drillers log.

DRILLERS LOGS, PROD, OBS 1, OBS 2, OBS 3, OBS 4

PROD 6627 - 6647

0 - 8	clays with slate & gravel
8 - 12	lt grey sandy clays
12 - 18	fine sands
18 - 26	sandy clays
26 - 32	medium sands
32 - 46	yellow grey sandy clays
46 - 48	red gravels
48 - 56	red sandy clays & red gravels
56 - 92	yellow sandy clays
92 - 96	sandy clays & red gravels
96 - 102	med (and minor coarse) sands
102 - 114	med sands
114 - 118	red sandy clays
118 - 120	lignite and coasre sand
	AQUIFER 96-114 m

1988 PUMP TEST # 1

OBS # 1 6647-7776

0 - 4	clay
4 - 10	gravelly clay
10 - 16.5	sandy clay
16.5 - 23	clay
23 - 50	sand
	AQUIFER 23-50m

OBS # 2 6647-7776

0 - 3	Black loam & sand
3 - 21	clayey sand
21 - 24	sand (fine-coarse)
24 - 36	sandy clay
36 - 60	clayey sand
60 - 63	sandy gravel
63 - 84	carbonaceous clay, silt minor sand
84 - 96	sand (v fine - fine)
96 - 99	carbonaceous silt
99 -134	sand (v fine - med)
	AQUIFER 99-?

OBS # 3 6627-2089

"down through clays,
sandstone & sands,
bottoming in coarse
gravel and quartz sand
TOTAL DEPTH 61m

OBS # 4 6627-2088

0 - 2	clay, silt, sand	
2 - 5	soft sandstone	
5 - 16	clay & rocks	
16 - 21	sandstone	
31 - 52	clayey sandstone	
52 - 58	sand sharp dark	
58 - 63	sandstone brown red	
63 - 69	clay & sand brown	
69 - 79	sand white	
79 - 86	clay and sand	
86 - 93	sand, loose, sharp some gravel with	cemented beds.

AQUIFER 86 - ?

APPENDIX H

PUMPING TEST NO.7, 31/5/88 - 3/6/88

This test was conducted with a production and three observation wells; two to measure drawdown and one to monitor background fluctuations (Fig. 8). All wells are completed in the Pt Willunga Formation.

PRODUCTION WELL 6627-7037: depth 80m. 150mm steel casing to 63m, pressure cemented, open hole completion. PRIVATE WELL.

OBSERVATION #1 6627-7771: depth 71m, 150mm steel casing to 58m, pressure cemented, open hole completion. PRIVATE WELL.

OBSERVATION #2 6627-1573: depth 67m, 150mm steel casing to 62.5m. No other information. PRIVATE WELL.

OBSERVATION #3 6627-6998: depth 76m, 150mm steel casing to 55.6m, pressure cemented, open hole completion. PRIVATE WELL.

DISCUSSION: The production well, OBS #1 and OBS #3 are completed at the same stratigraphic level. Although no information is available on the stratigraphy of OBS #2, it is assumed to be completed in the same sediments as the others. This is because the depths are approximately the same, ground elevation is relatively constant in the area, and because private wells are usually completed in the shallowest useable aquifer. OBS #1 and OBS #3 were unequipped. OBS #3 was originally chosen to observe background fluctuations. Distance from the production well is 1000m, which was thought to be greater than the radius of influence of pumping.

The production well was pumped for 2880 minutes (48hrs), and drawdown stabilized quickly, with a drawdown per log cycle of approximately 0.02m (Fig. H-1). After about 500 minutes, a drawdown per log cycle of 0.2m was observed. Wells OBS #1 (Figs. H2 and H3) and OBS #2 (Fig. H4) showed a drawdown response after approximately 10 minutes of pumping. OBS #3 (Fig. H-5) responded to pumping in less than 120 minutes. The drawdown in these wells did not match those of the Theiss type curves. Therefore no values of Transmissivity and Storage Coefficient were calculated using this method. However, a good match was made using type curves constructed for analysis of pump tests in leaky parallel channel aquifers (Vandenberg, 1976).

Unfortunately the facies distribution and geometry of the aquifer are not well known, so the validity of this method is in doubt. However, distance drawdown analysis tends to support the high transmissivity values obtained from the leaky strip model analysis. Results are summarized in Table H-1. Drillers logs are included below.

DRILLERS LOGS, PRODUCTION OBS # 1, OBS # 3

PROD 6627-6647

0 - 2	sandy loams
2 - 6	red clays
6 - 22	red/yel clays
22 - 28	red/yel sandy clays
28 - 48	white/yel sandstone, fine grained, 20% clay
48 - 56	white/yel clays
56 - 63	white sandstone (med grained, clean, well graded)
63 - 80	Limestones and corals.

OBS # 1 6627 - 7771

0 - 1	top soil
1 - 12	red clays
12 - 18	red yel clays with slate gravels
18 - 25	yel/grey clays
25 - 28	clay & shale gravels
28 - 50	yel grey sandy clays
50 - 56	sandstone with silicified quartz bands.
56 - 71	limestone and coral.

OBS # 2 6627 - 1573

NO LOG AVAILABLE

OBS # 3 (BACKGROUND) 6627 - 6998

0 - 4	red clay
4 - 18	yel/red clays
18 - 22	yel clays and gravels
22 - 26	yel white clays
26 - 28	white clays
28 - 42	white/red sandy clays
42 - 55	white/yellow sandy clays
55 - 59	limestone and corals
59 - 76	weathered corals

TABLE H-1 WILLUNGA BASIN PUMPING TEST 7 - SUMMARY OF RESULTS

WELL NO.	AQUI-FER	DATE	DURA-(mins)	TEST (mins)	VERY TYPE	RECO-YSIS (m^3/D)	ANAL-(m)	Q r T S (m^2/D)	B	L	K'	C	COMMENTS
PROD 6627-7037	PWF	31/5/88-	2280	2990	LOG/ LIN	1200							
		3/6/88			LATE LOGANS		1098						
					APPROX.	976							
OBS#1 6627-7771	PWF				LOG/ LOG	250	1984	$1.1x10^{-3}$	1136				INTERPRETED USING STRIP MODEL - SEE DISCUSSION
					LOG/ LOG	2500	$1.1x10^{-2}$	1666					USING DATA LOGGER (TRANSDUCER) DRAWDOWN VALUES INTERPRETED USING STRIP MODEL SEE DISCUSSION DATA LOGGER READINGS
OBS#2 6627-1573	PWF				LOG/ LOG	300	1704	$1.1x10^{-3}$	1000				INTERPREDTED USING STRIP MODEL.
OBS#3 6627-6998	PWF				LOG/ LOG	1000	5560	$1.7x10^{-3}$	3333				
DISTANCE DRAWDOWN							3660						

APPENDIX I

PUMPING TEST NO. 8, 7/6/88 - 18/6/88

The test at this site in 1987 was a success, but irrigation requirements did not enable the test to proceed to a stage where leakage was observed at all wells. A second test was scheduled for the winter of 1988.

This test was conducted with a production and three observation wells; two to measure the response to pumping and a third to observe background fluctuations (Fig. 8). All are private wells completed in the Pt Willunga Formation. The aquifer thickness is not known.

PRODUCTION WELL 6627-6875:	depth 84m, 152mm steel casing to 58m, pressure cemented. Casing slotted from 61-84m, open at base. PRIVATE WELL.
OBSERVATION #1 6627-7393:	depth 79.4m, 152mm steel casing to 56.2m, pressure cemented, open hole completion. PRIVATE WELL.
OBSERVATION #2 6627-7159:	depth 68m, 152mm steel casing to 56m, pressure cemented, open hole completion. PRIVATE WELL.
OBSERVATION #3 (bgnd) 6627-7861:	depth 120m, 152mm steel casing to 104m, pressure cemented, open hole completion. PRIVATE WELL.

DISCUSSION: The production well was pumped for 14720 minutes (10.2 days), with drawdown being observed in OBS #1 (Fig I-3) and OBS #2 (Fig I-4). The background well (OBS #3) remained unaffected by pumping. Drawdown (Fig I-1) and residual drawdown (Fig I-2) in the production well were analyzed by the Jacob straight line method.

Background (ie non pumping) fluctuations were removed by monitoring OBS #3 before, during and after the test. Before the test, a static water level was marked on this well (as on all others), and the change in level with time was monitored, along with barometric pressure. The difference between original water level and that observed at various times was noted, and this difference was used to remove background fluctuations from the other wells. This method was successful in the production well and OBS #1, particularly after several days when the drawdown change was small, resulting in a smoother curve with fewer irregularities. However, in OBS #2 the correction changed the shape of the drawdown curve, but not necessarily for the better, since irregularities are still apparent. This poor result is probably due to inaccuracies in measurement of

the water level in this well, due to probe problems, and poor access at the well head. Barometric efficiency of the well was not calculated because aquifer thickness is not known. Results have been analyzed using the Theiss type curves for non steady state drawdown in leaky confined aquifers. All wells that showed a response to pumping gave similar results for T and S. These values compare well with those obtained during Test #1 at the same site (Table I-1). Results are summarized in Table I-1. Drillers logs are listed below.

TABLE I-1 WILLUNGA BASIN PUMP TEST 8 - SUMMARY OF RESULTS

WELL NO	AQU-IFER	DATE	TEST DURA-TION (mins)	RECOV-ERY (mins)	YSIS TYPE	ANAL-	Q (m^3/D)	r (m)	T (m^2/D)	S	B	L	K'	C	COMMENTS
PROD 6627-6875	PWF	7/6/88-18/6/88			14720	11480	LOG/LIN	792			132				
					LOG/LIN (RES DRAWDOWN)			145							
OBS#1 6627-7393	PWF					LOG/LOG	197	143		$1.7x10^{-3}$	328				CORRELATED FOR BAROMETRIC EFFECTS.
OBS#2 6627-7159	PWF					LOG/LOG	250	197		$9.2x10^{-4}$	357				
					PUMP TEST #1 (SADME SITE) FOR COMPARISON										
PROD								130							
OBS#1								166							
OBS#2								190							

DRILLERS LOGS

PRODUCTION WELL 6627-6875

0	-	0.6	Loan
0.6	-	4.8	sandy brown clay
4.8	-	6.7	sandy brown clay with stones
6.7	-	41.4	sandy brown/grey clay
41.4	-	41.7	sandstone
41.7	-	48.7	sandy brown/grey clay
48.7	-	56.4	seams sandy party clay (stiff), sand and gravel
56.4	-	57.9	stiff orange clay
57.9	-	84	seams (limestone / sandstone) and sand

OBSERVATION #1 6627-7393

0	-	2	Red clay
2	-	10	yellow clay
10	-	12	yellow/red clay
12	-	16	yellow clay
16	-	17	white sandy clay
17	-	19	yellow sandy clay
19	-	27	yellow marly clay
27	-	43	white sandy clay
43	-	43.2	ironstone gravel
43.2	-	53	coloured sand
53	-	54.6	yellow limestone sand
54.6	-	54.8	soft limestone
54.8	-	79.4	yellow limestone

OBSERVATION #2 6627-7159

0	- 0.3	Top soil
0.3	- 6	brown clay
6	- 18.5	yellow sandy clay
18.5	- 22	white sandy clay
22	- 27	yellow clay
27	- 32	yellow sandy clay
32	- 35.1	white sandy clay
35.1	- 36.3	creek gravel
36.3	- 49	yellow sandy clay
49	- 50	red sandy clay
50	- 54.8	yellow sandy clay
54.8	- 68	sandy limestone

OBSERVATION #3 (BACKGROUND) 6627-7861

0	- 12	Red clays with shale gravels
12	- 36	white/grey clays with shale gravels
36	- 50	grey/yellow clays
50	- 60	red/grey sandy clays
60	- 64	red clay sands
64	- 85	grey/yellow sandy clays
85	- 86	silic sandstone, white
86	- 88	sandy clays
88	- 90	grey/yellow clays
90	- 96	yellow sands,med-fine, clay 20%
96	- 100	weathered coral and clays
100	- 114	white coral
114	- 120	green grey sandy coral with fine sands.

APPENDIX J

PUMPING TEST NO. 9 20/7/88 - 21/7/88

Three new (private) wells were drilled into the Pt Willunga Formation near an existing observation well at the time of the pump testing program, resulting in a well distribution suitable for testing. Three other wells nearby were also monitored, two of which were not listed in Departmental records. The distance between the production and observation wells range from less than 100m to approximately 600m. Well OBS #7 was monitored to observe background fluctuations.

PRODUCTION 6627-7364: depth 88m, completed depth 77m, 150mm steel casing to 69m, pressure cemented, 0.15mm aperture steel screen from 69.0m to 72.5m, 0.25mm aperture steel screen from 72.5m to 77.0m. PRIVATE WELL.

OBSERVATION #1 6627-7876: depth 88m, completed depth 77.5m, 150mm steel casing to 69m, pressure cemented, 0.15mm aperture steel screen from 69.5m to 71.5m, 0.25mm aperture steel screen from 71.5m to 77.5m.PRIVATE WELL.

OBSERVATION #2 6627- 7877: depth 80m, completed depth 77.5m, 150mm steel casing to 68.5m, pressure cemented, 0.15mm aperture steel screen from 68.5m to 71.5m, 0.25mm aperture steel screen from 71.5m to 77.5m. PRIVATE WELL.

OBSERVATION #3 NOT ON DEPARTMENTAL RECORDS.

OBSERVATION #4 6627-7001: depth "approximately 41m", no other information.

OBSERVATION #5 NOT ON DEPARTMENTAL RECORDS.

OBSERVATION #6 6627-7878: depth 66m, completed depth 61.5m, 150mm steel casing to 52.5m, pressure cemented, 0.15mm aperture steel screen from 52.5m to 55.5m, 0.25mm aperture steel screen from 55.5m to 61.5m. PRIVATE WELL.

OBSERVATION #7 6627-6998: depth 76m, completed depth 58.5m, 152mm steel casing to 55.6m, pressure cemented, open hole completion. PRIVATE WELL.

DISCUSSION: The production well was pumped for 1636 minutes at a rate of $288m^3/D$. The power supply to the pump failed at this time, with the subsequent loss of recovery data. Wells OBS #1 and OBS #2 responded to pumping, whilst all other wells showed no measurable response.

Due to the short pumping time, it was not considered necessary to correct for barometric effects. Drawdown in the production well was analyzed using the Jacob straight line method (Fig J-1). Drawdown in wells OBS #1 (Fig J-2) and OBS #2 (Fig J-3) were analyzed using leaky aquifer type curves. Results are summarized in Table J-1, and drillers logs are included below.

TABLE J-1 WILLUNGA BASIN PUMPING TEST 9 - SUMMARY OF RESULTS

WELL NO.	AQUI-FER	DATE TEST DURA-TION	RECOV-ERY	ANALYSIS TYPE	Q (m^3/D)	r (m)	T (m^3/D)	S	B	L	K'	C	COMMENTS
PROD 6627-7364 (WLG70)	PWF	20/7/88 21/7/88	1636	NIL	LOG/LIN	288	68						
OBS 6627-7876 #1	"	"		LOG/LOG		140	44	$2.8x10^{-4}$	200	200	0.0165	909	Confining bed thickness very approximate. All parameters calculated using this figure (m') to be taken very approximately.
OBS 6627-7877 #2	PWF	"	"	LOG/LOG		87	45	$2.6x10^{-4}$	185				Confining bed thickness not defined, therefore unable to evaluate vertical permeability (K'), hydraulic resistance (C) and leakage factor (L).
OBS #3 NO UNIT NO. NOT ON DEPARTMENTAL RECORDS.													NO RESPONSE TO PUMPING.
OBS #4 6627-7877 (SHALLOW)	PWF												" " " "
OBS #5 NO UNIT NO., NOT ON DEPARTMENTAL RECORDS.													" " " "
OBS #6 6627-7878	PWF												" " " "

DRILLERS LOGS, PRODUCTION AND OBSERVATION WELLS

6627 - 7364 PRODUCTION WELL

0 - 2	black clays
2 - 28	white/yellow silty sands
28 - 32	yellow sands, medium to coarse
32 - 36	limestone
36 - 44	limestone weathered
44 - 68	brown/yellow sandstone
68 - 78	white/yellow sands, medium-fine
78 - 88	grey sandy siltstone with fossil fragments

6627 - 7876 OBS # 1

0 - 18	white/yellow sandstone and clays
18 - 38	white/brown sandstone and sandy clays
38 - 54	red/brown sandstone and sandy clays
54 - 69	red/brown sandy clays with some sandstone bands
69 - 78	fine white sands
78 - 88	grey/black clays, sandy, with shell fragments and sandstone bands

6627 7877 OBS # 2

0 - 8	white sandstone
8 - 12	yellow sandstone
12 - 28	white/yellow sandstone
28 - 40	white sandstone, hard
40 - 54	brown sandstone, hard
54 - 68	brown/yellow sandstone, some clays
68 - 79	white sands, fine
79 - 80	grey/black clays with shell fragments

OBS#3, OBS#4 AND OBS#5 - NO LITHOLOGICAL RECORDS.

6627 - 7878 OBS # 6

0 - 0.5	black soils
0.5 - 1	limestone marl
1 - 6	grey clay
6 - 8	white sandy clays
8 - 15	yellow sandy clays
15 - 30	white/yellow sands, fine
30 - 40	limestone and sands, yellow
40 - 48	weathered limestone
48 - 55	weathered limestone sands
55 - 62	yellow sands, fine, some sandstone bands
62 - 64	yellow sandy clays
64 - 66	black clays with shell fragments

6627 6998 OBS # 7 (BACKGROUND)

0 - 4	red clays
4 - 18	yellow-red clays
18 - 22	yellow clays and gravels
22 - 26	yellow white clays
26 - 28	white clays
28 - 42	white - red sandy clays
42 - 55	white-yellow sandy clays
55 - 59	limestone and coral
59 - 76	weathered coral

APPENDIX K

PUMPING TEST NO. 10, 2/8/88 -/5/8/88

This test was conducted with a production and six observation wells, one of which (6627-6998, Wlg 69) was monitored to observe background fluctuations. All wells are privately owned and completed in the Pt Willunga Formation. The location of this test is shown in Figure 8.

PRODUCTION WELL 6627-6505: depth 129m, completed depth 124m, 150mm steel casing to 115m, pressure cemented. 0.20mm aperture steel screen from 115m to 118m. 0.25mm aperture steel screen from 118m to 124m. PRIVATE WELL.

OBSERVATION #1 6627-7827: depth 142.5m, completed depth 142.5m, 152mm steel casing to 123.5m, pressure cemented. 0.63mm aperture steel screen from 123.3m to 126.3m , 0.25mm aperture steel screen from 126.3m to 129.3m, gravel at base. PRIVATE WELL.

OBSERVATION #3 6627-7911: Not on Departmental records.

OBSERVATION #4 6627-6182: depth 145m, completed depth 118m. 140mm steel casing to 109m, no record of pressure cementing. 0.9mm aperture steel screen from 108m to 113m, 0.116mm aperture steel screen from 113m to 118m. PRIVATE WELL.

OBSERVATION #5 6627-7038: depth 136m, completed depth 133m, 150mm steel casing to 123m, pressure cemented, 0.25mm aperture steel screen from 123m to 127m, 0.20mm aperture steel screen from 127m to 133m. PRIVATE WELL.
OBSERVATION #6 6627-6998: (observed to measure background fluctuations) see log in appendix J.

DISCUSSION: The well was pumped for 4260 minutes at a rate of 480m^3/D. Drawdown was observed in all wells monitored. Production well drawdown (Fig K-1) and residual drawdown (Fig K-2) were analyzed by the Jacob straight line method. Observation well responses (Figs K-3 to K-7) were analyzed using leaky aquifer type curves to produce values of transmissivity (T), storage coefficient (S), and leakage factor (B). Changes in clay content and thickness of the confining bed occurs over small distances in this area, so the values of B should be taken as approximations only. In addition the steady state drawdown observed in wells OBS #3, OBS #4, and OBS #5 were analyzed using the Hantush-Jacob Distance-Drawdown straight line method (Fig K-8) and the De Glee method (Fig K-9), resulting in values of T and B which are consistent with values obtained from time - drawdown analyses for individual wells. Results are summarized in Table K-1. Drillers logs are listed below.

TABLE K-1 WILLUNGA BASIN PUMPING TEST 10 - SUMMARY OF RESULTS

WELL NO.	AQUIFER	DATE TEST DURATION	RECOVERY (min)	ANALYSIS TYPE	Q (m^3/D)	r (m)	T (m^2)	S	B (m)	COMMENTS
PROD 6627-6505	PWF	2/8/88 4260	4240	LOG/LIN	480	-	63			
	4/8/88		LOG/LIN (RES. DRAWDOWN)		51					
OBS#1 6627-7827	PWF		4250	LOG/LOG		205	46	$2.3x10^{-4}$	315	Stratigraphy not well enough defined to obtain confining bed thickness. Therefore cannot calculate K', C.L.
OBS#2 6627-6225	PWF		4245	LOG/LOG		180	95	$3.9x10^{-4}$	600	
OBS#3 6627-7911	PWF		4235	LOG/LOG		110	54	$2.1x10^{-4}$	550	No stratigraphic record, therefore unable to calculate K', L, C.
OBS#4 6627-6182	PWF		4230	LOG/LOG		127	64	$2.5x10^{-4}$	635	
OBS#5 6627-7038	PWF		4230	LOG/LOG		450	119	$1.4x10^{-3}$	643	Curve not well enough developed to get B.
DISTANCE DRAWDOWN drawdown, C=4186				HANTUSH-JACOB			78		571	OBS# extrapolated to steady state DAYS.
OBS 3, 4, 5				DE GLEE	76		420			

DRILLERS LOGS, PRODUCTION AND OBSERVATION WELLS

6627 - 6505 PRODUCTION WELL

0 - 0.5	Top soil
0.5 - 27	gravelly red clay
27 - 36	yellow and white clay
36 - 48	white sandy clay
48 - 69	yellow sandy clay
69 - 72	coloured clay
72 - 73.8	brown sandy clay
73.8 - 74.4	brown sandstone
74.4 - 74.5	brown sandy clay
74.5 - 75.7	brown sandstone
75.7 - 76.0	brown sandy clay
76.0 - 77.6	hard clay
77.6 - 78.2	brown sandy clay
78.2 - 79	brown sandstone
79 - 85	brown sandy clay
85 - 109	brown sandy clay
109 - 124	black sand and water
124 - 129	black clay mud.

6627 - 7827 OBS NO. 1

0 - 6	red gravelly clay
6 - 15	yellow clay
15 - 21	red shaley clay
21 - 27	coloured clay
27 - 33	white sandy clay
33 - 39	coloured clay
39 - 47	white sandy clay
47 - 55	yellow sandy clay
55 - 72	white sandy clay
72 - 80	yellow sandy clay
80 - 114	black sandy clay
114 - 123.3	black sand
123.3 - 126.3	black sand and gravel
126.3 - 139	black sand
139 - 142.5	black sandy clay

6627 - 6225 OBS NO. 2

0 - 0.5	top soil
0.5 - 30	red clay and gravel
30 - 33	yellow clay and gravel
33 - 70	yellow sandy clay
70 - 73	yellow sand and limestone
73 - 80	yellow sandy clay
80 - 100	brown sand with hard layers
100 - 110	brown sandy clay
110 - 116	sandstone
116 - 120	sandstone, white

120 - 124	fine white snad
124 - 127	coarse sand
127 - 130	fine sand.

6627 - 7911 OBS NO. 3

No drillin record

6627 - 6182 OBS NO. 4

0 - 20	clay - red brown
20 - 40	sandy clay
40 - 44	sandy clay
44 - 59	white sand
59 - 61	sandstone
61 - 62	soft sandstone
62 - 77	coral - varying hardness
77 - 79	sticky corals, clay
79 - 84	sloppy sands, water
84 - 90	hard sands
90 - 96	soft sands
96 - 98	sands - darker
98 - 108	sands - brown to black
108 - 113	sands - water bearing
113 - 114	sands - consolidated
114 - 118	sands water bearing
118 - 145	consolidated sands, no water

6627 - 7038 OBS NO. 5

0 - 2	red clays
2 - 20	red clays with slatey gravels
20 - 36	yellow/white sandy clays
36 - 42	yellow/white clays
42 - 60	yellow/white sandy clays
60 - 70	weathered limestone
70 - 72	limestone
72 - 80	weathered limestone, sandy clays
80 - 90	white grey sandy clays
90 - 100	lignitic clays, sandy in part
100 - 114	fine silty sandstone
114 - 122	lignitic sandy clays with medium sands
122 - 127	white sandstone, fine, well rounded
127 - 136	fine white sandstone, becoming finer and silty at 136 m.

6627 - 6998 OBS NO. 6 (BACKGROUND)

see log in Appendix J

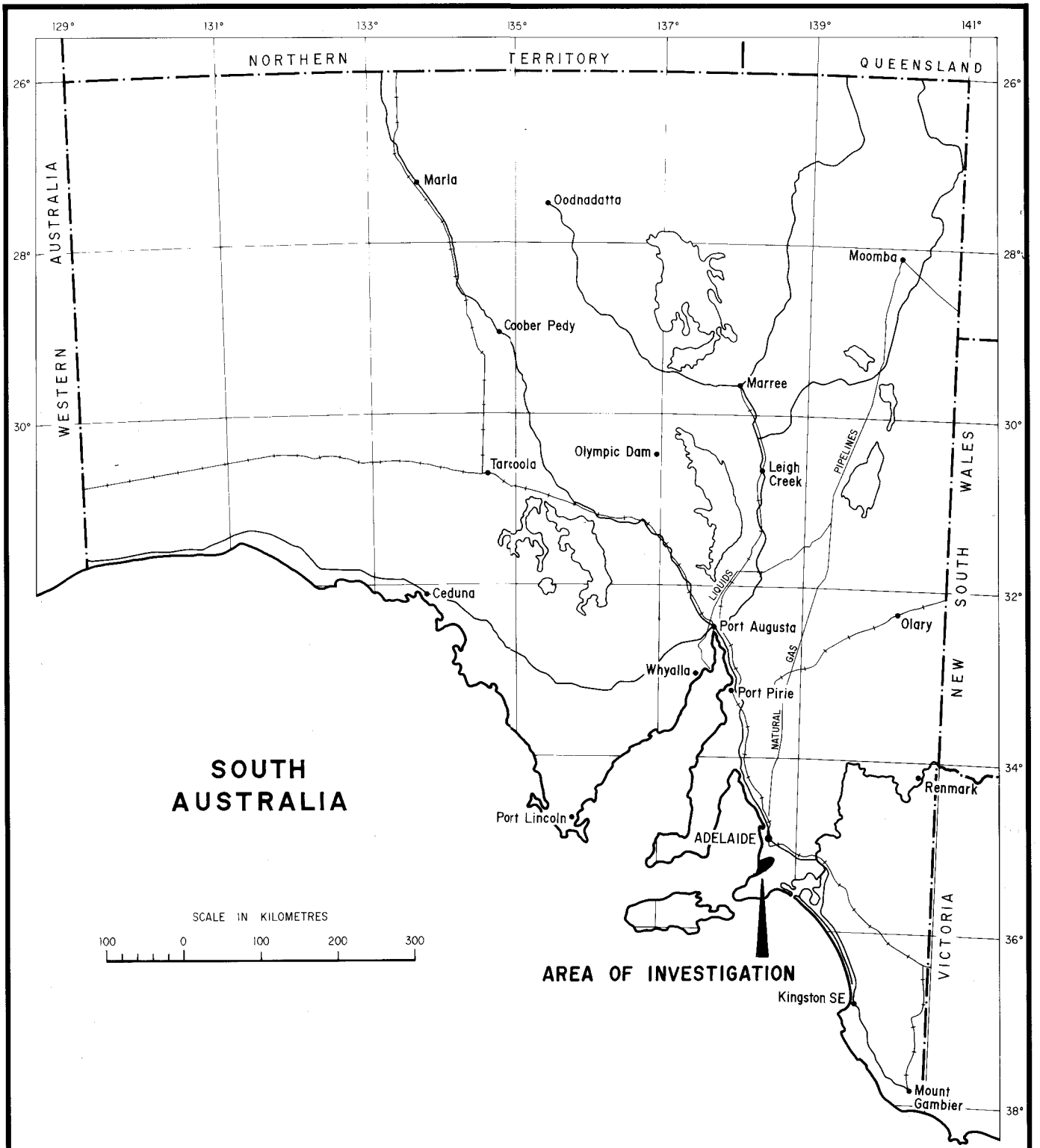


Fig.....1

DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

COMPILED R.A.	C.D.O. 9-5-89 DATE
DRAWN R.H.	SCALE AS SHOWN
DATE SEPT 1988	PLAN NUMBER
CHECKED	S 20455

WILLUNGA BASIN GROUNDWATER INVESTIGATION

LOCALITY PLAN

4694

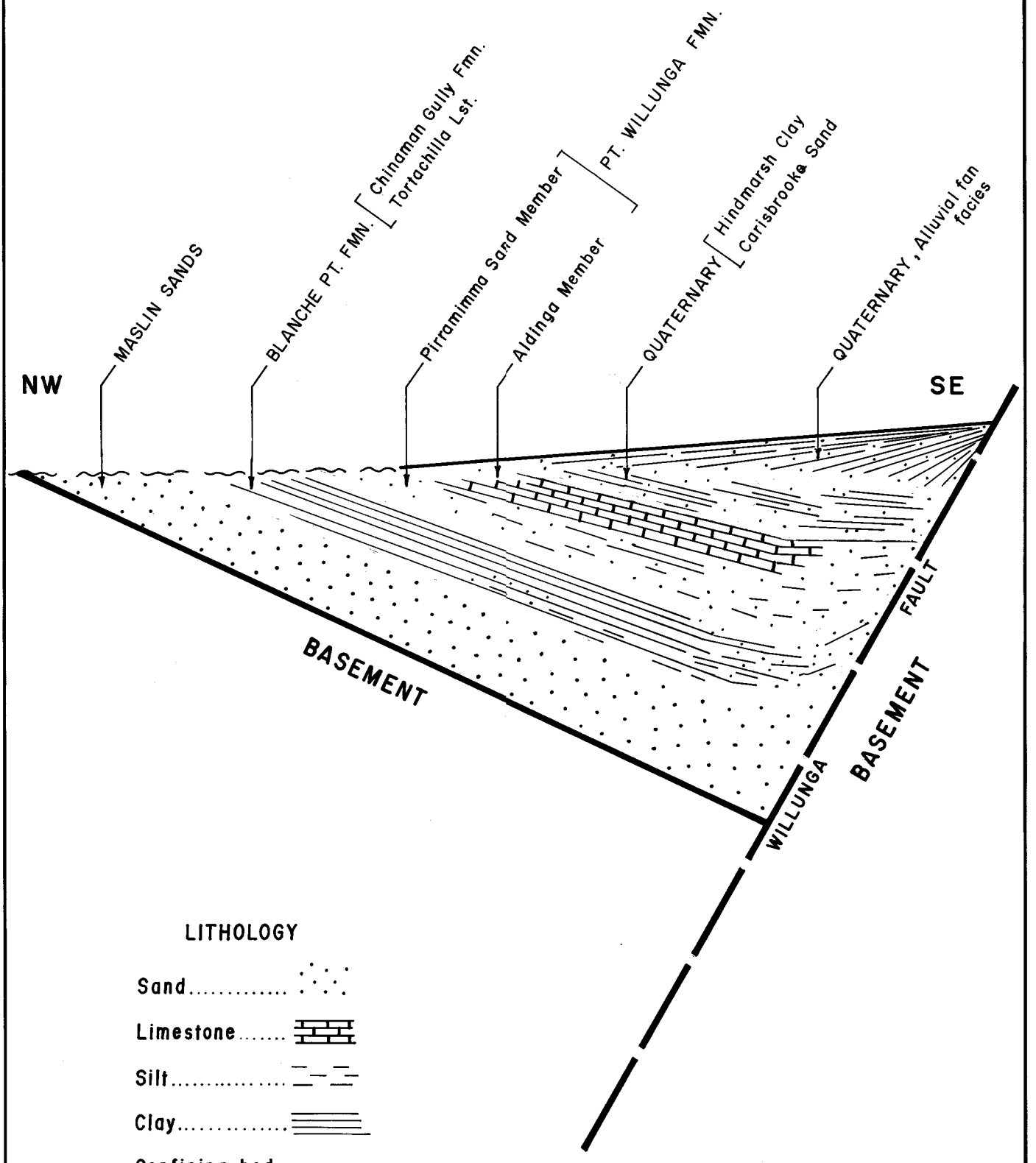


Fig.....2

DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA	COMPILED R.A.	CDO 9.5.89 DATE
WILLUNGA BASIN GROUNDWATER INVESTIGATION	DRAWN R.H.	SCALE NOT TO SCALE
CONCEPTUAL SECTION SHOWING AQUIFERS AND CONFINING BEDS	DATE SEPT. 1988	PLAN NUMBER S 20456
	CHECKED	

4694

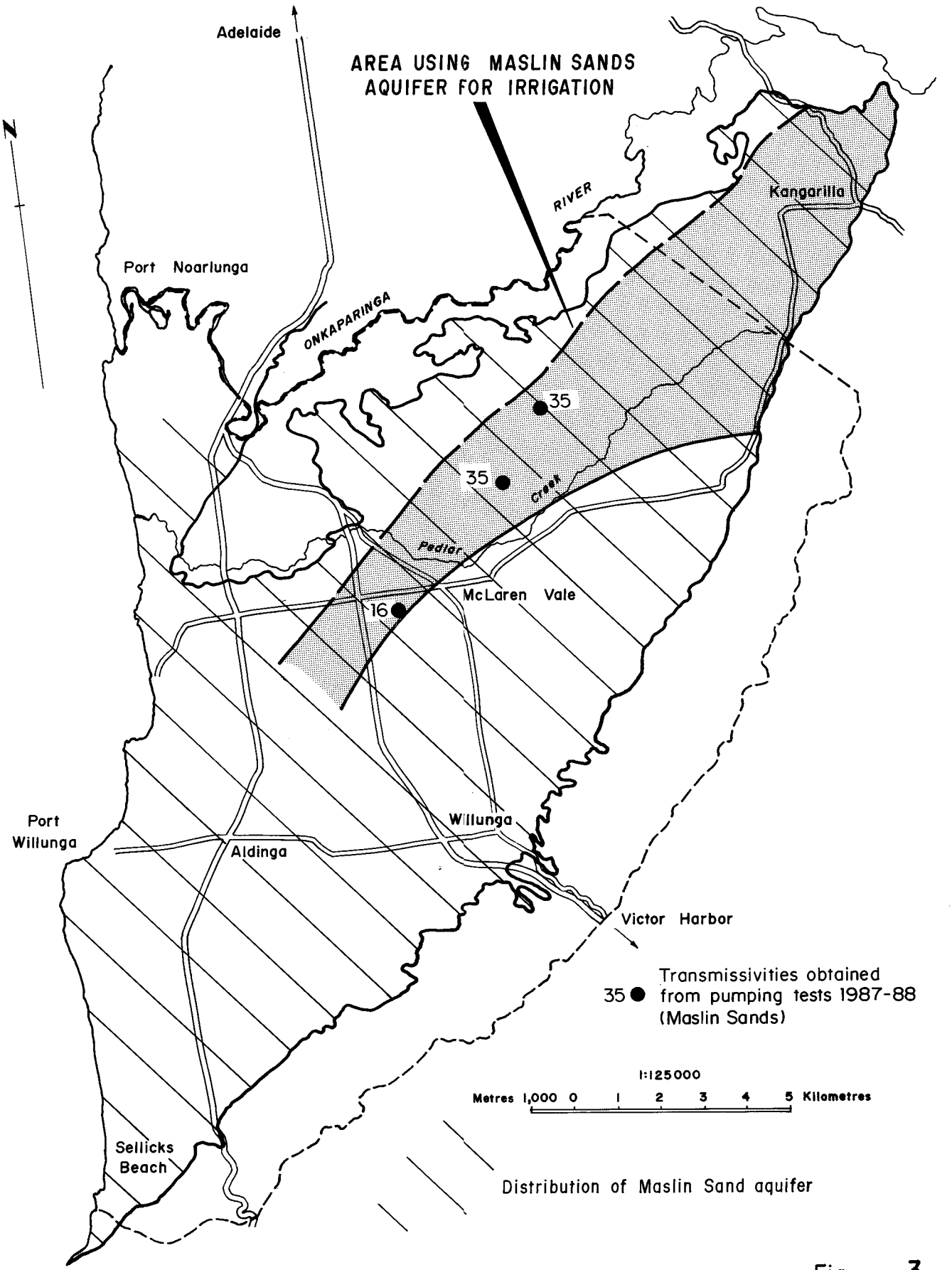


Fig..... 3

DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA	COMPILED R.A.	CDO 9-5-89 DATE
WILLUNGA BASIN GROUNDWATER INVESTIGATION	DRAWN R.H.	SCALE AS SHOWN
MASLIN SANDS UNIT DISTRIBUTION AND MAIN AREA OF USAGE	DATE SEPT 1988	PLAN NUMBER S 20457
	CHECKED	

4694

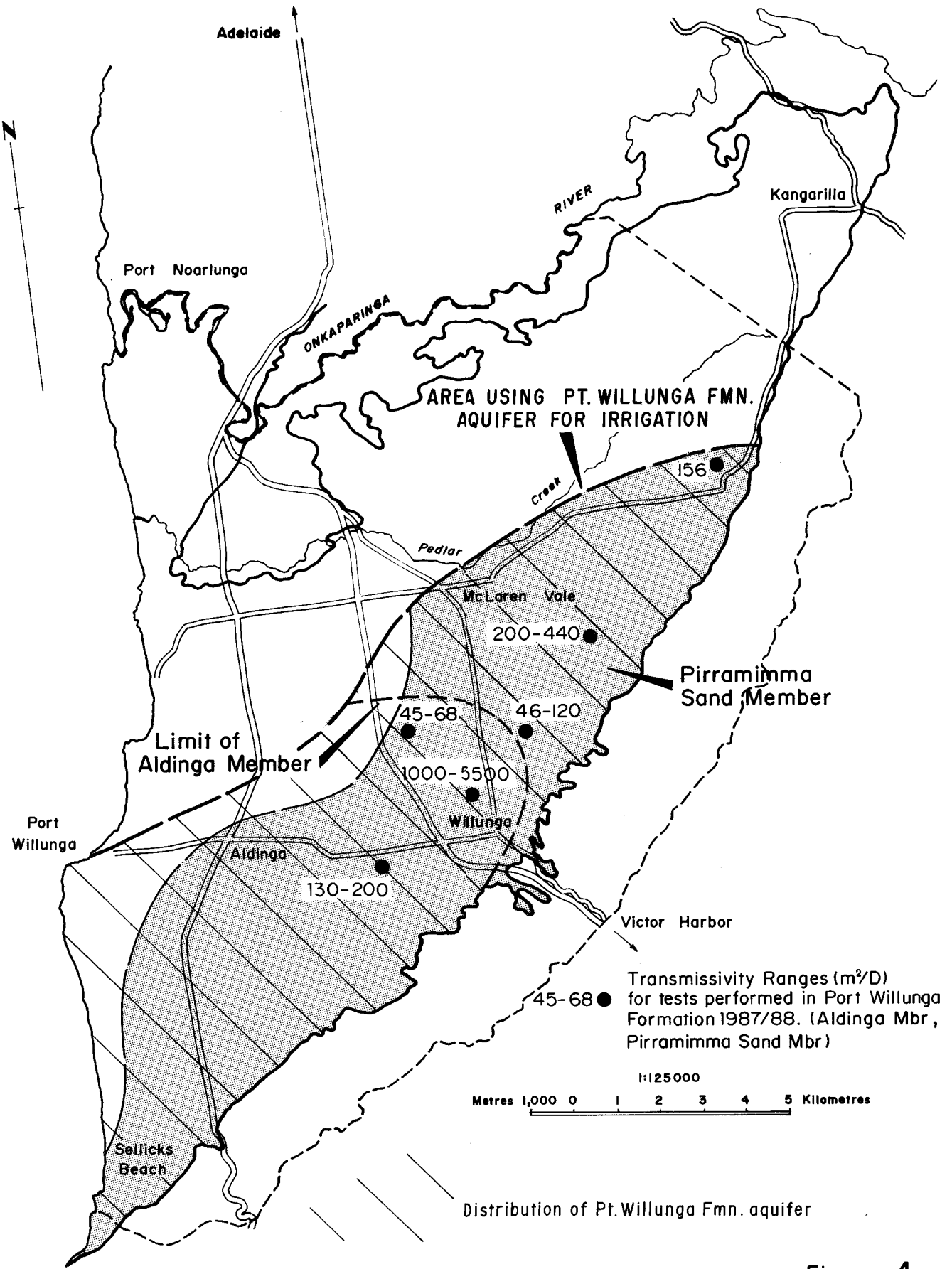


Fig.....4

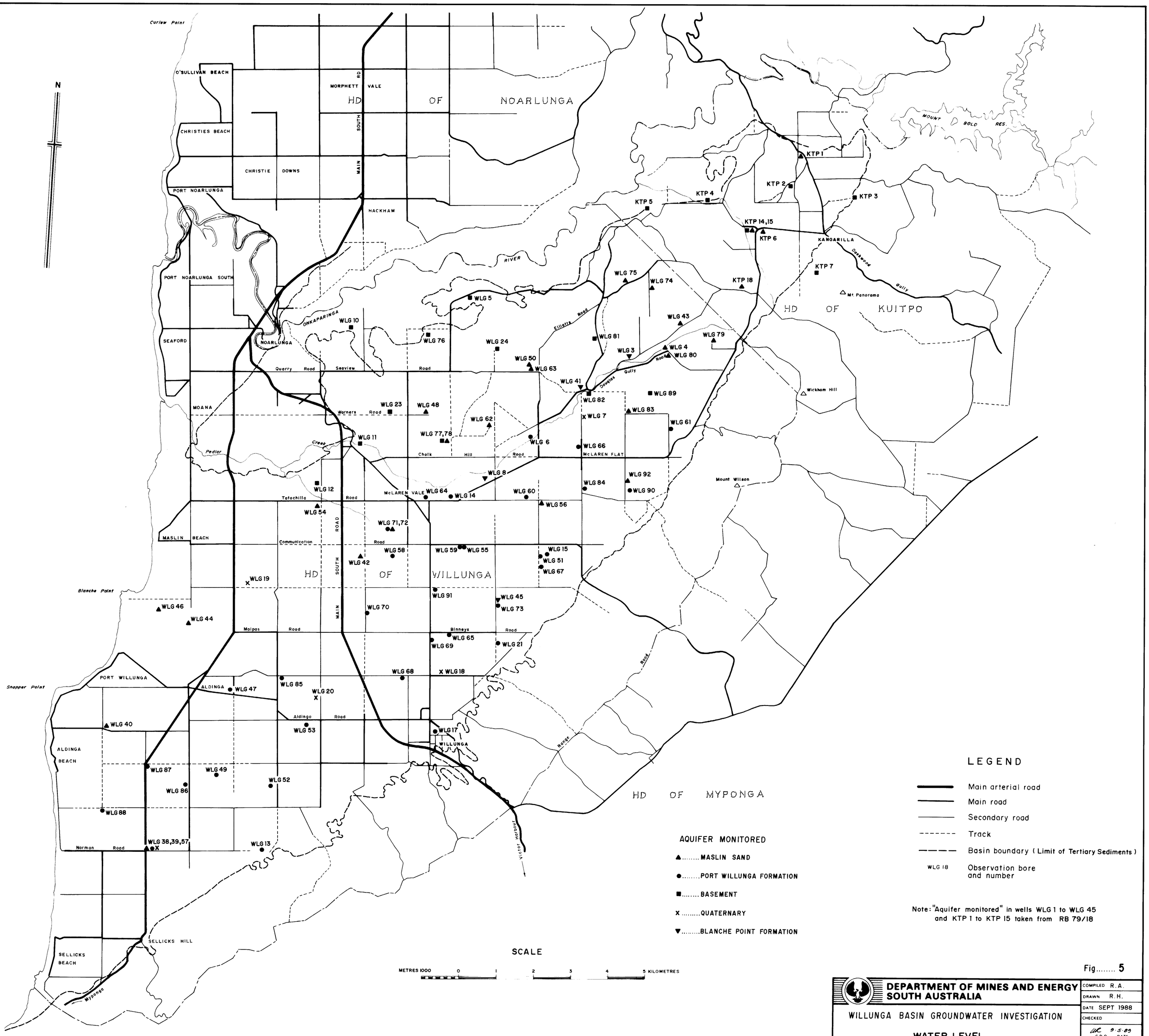
DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

WILLUNGA BASIN GROUNDWATER INVESTIGATION

PT. WILLUNGA FORMATION
UNIT DISTRIBUTION AND MAIN AREA OF USAGE

COMPILED R.A.	CDO 9.5.89 DATE
DRAWN R.H.	SCALE AS SHOWN
DATE SEPT 1988	PLAN NUMBER S20458
CHECKED	

4694



LEGEND

- Main arterial road
- Main road
- Secondary road
- Track
- Basin boundary (Limit of Tertiary Sediments)
- WLG 18 — Observation bore and number

AQUIFER MONITORED

- ▲ ..... MASLIN SAND
- ● ..... PORT WILLUNGA FORMATION
- ■ ..... BASEMENT
- x ..... QUATERNARY
- ▼ ..... BLANCHE POINT FORMATION

Note: "Aquifer monitored" in wells WLG 1 to WLG 45 and KTP 1 to KTP 15 taken from RB 79/18

SCALE

METRES 1000 0 1 2 3 4 5 KILOMETRES

Fig..... 5

DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA

WILLUNGA BASIN GROUNDWATER INVESTIGATION

WATER LEVEL MONITORING NETWORKS

COMPILED	R.A.
DRAWN	R.H.
DATE	SEPT 1988
CHECKED	
CDO DATE	9.5.89
SCALE	AS SHOWN
PLAN NUMBER	88-554

1694

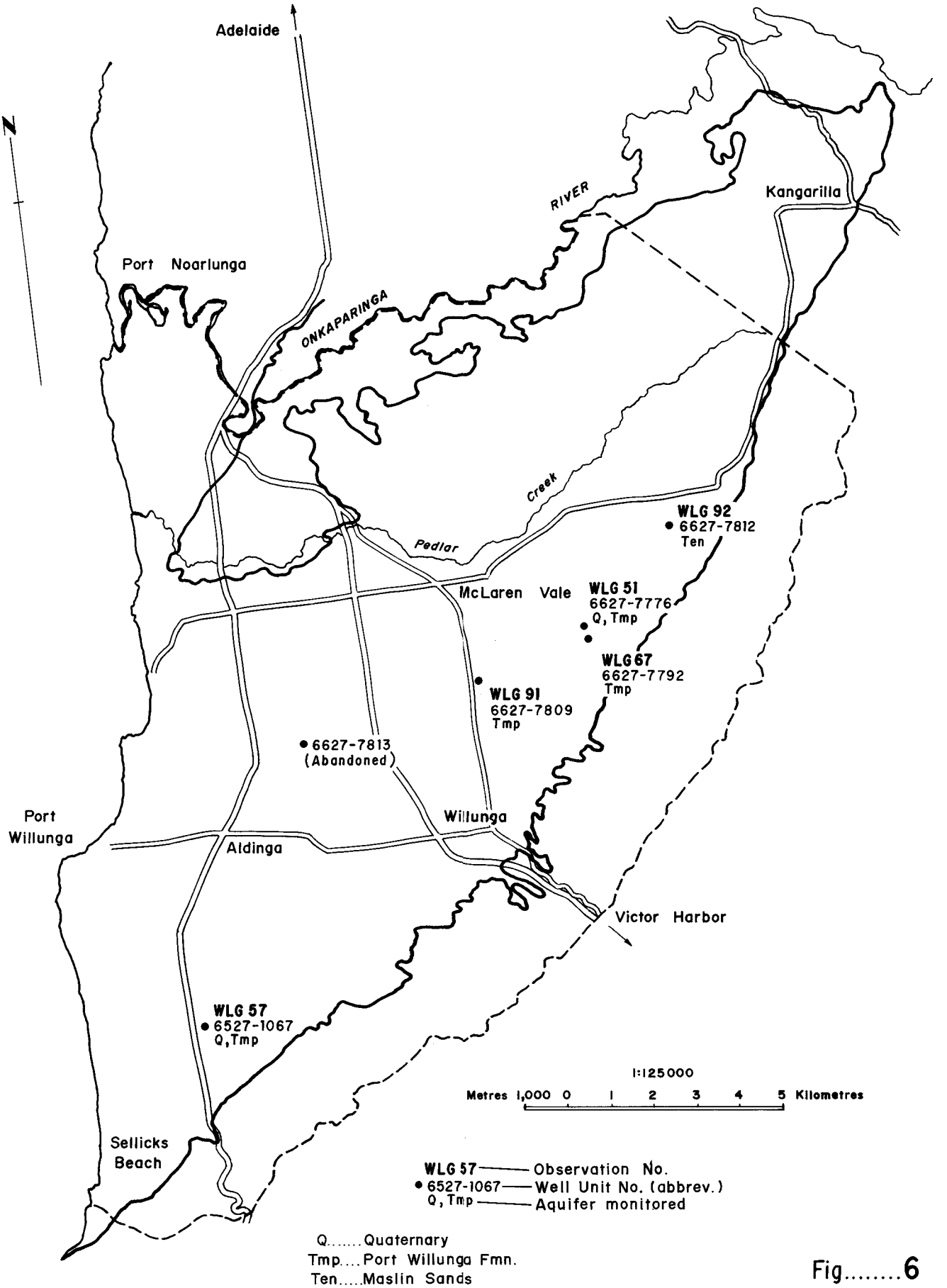


Fig.....6

DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

WILLUNGA BASIN GROUNDWATER INVESTIGATION

1987-88 DRILLING PROGRAMME
LOCATION OF WELLS

COMPILED R.A.	CDO 9.5.89 DATE
DRAWN R.H.	SCALE AS SHOWN
DATE SEPT 1988	PLAN NUMBER S 20459
CHECKED	

4694

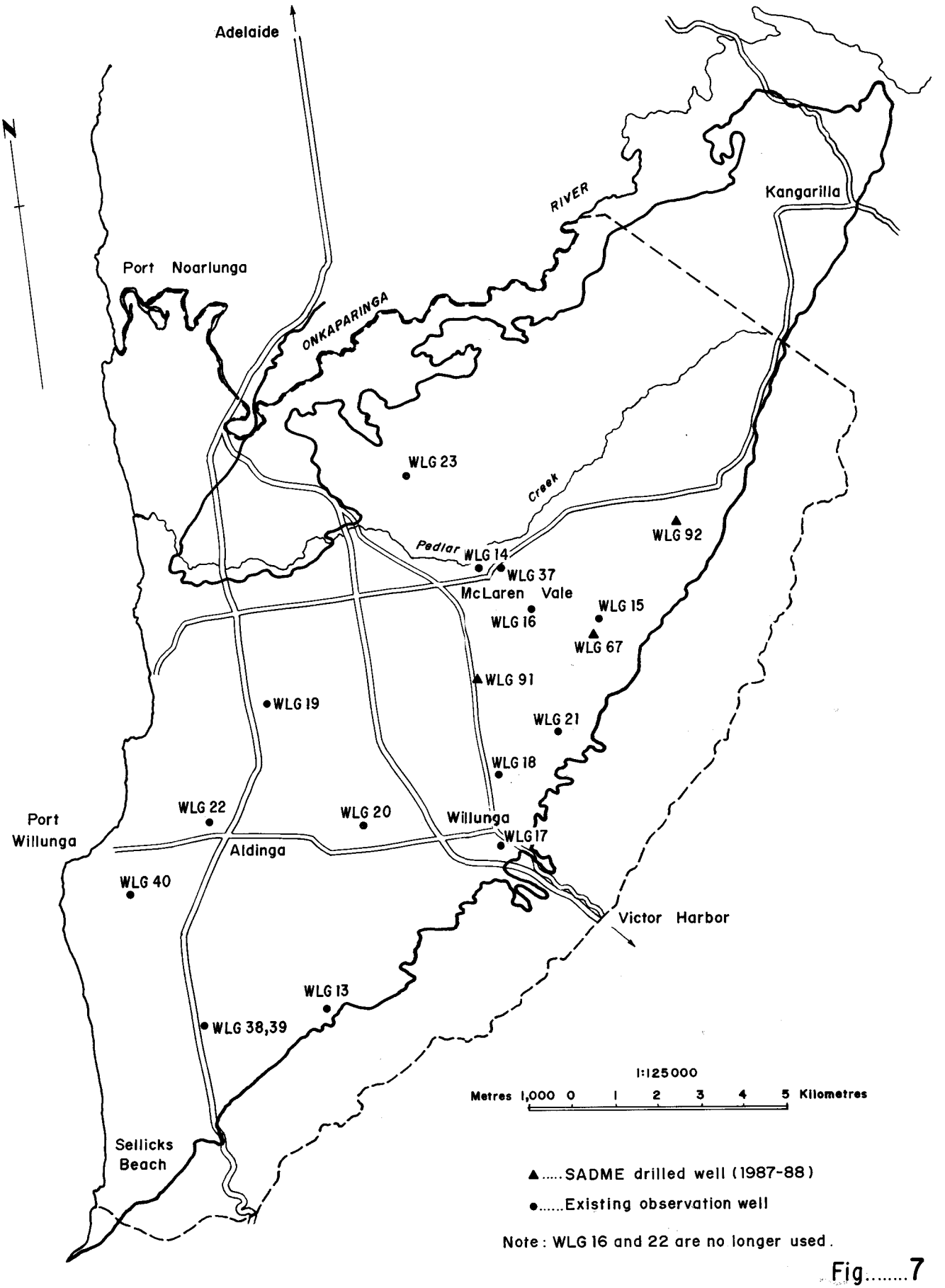


Fig.....7

DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

WILLUNGA BASIN GROUNDWATER INVESTIGATION

SADME GEOPHYSICALLY LOGGED OBSERVATION WELLS - 1987/88

COMPILED R.A.	WR 9.5.89 C.D.O. DATE
DRAWN R.H.	SCALE AS SHOWN
DATE SEPT 1988	PLAN NUMBER S20460
CHECKED	

4694

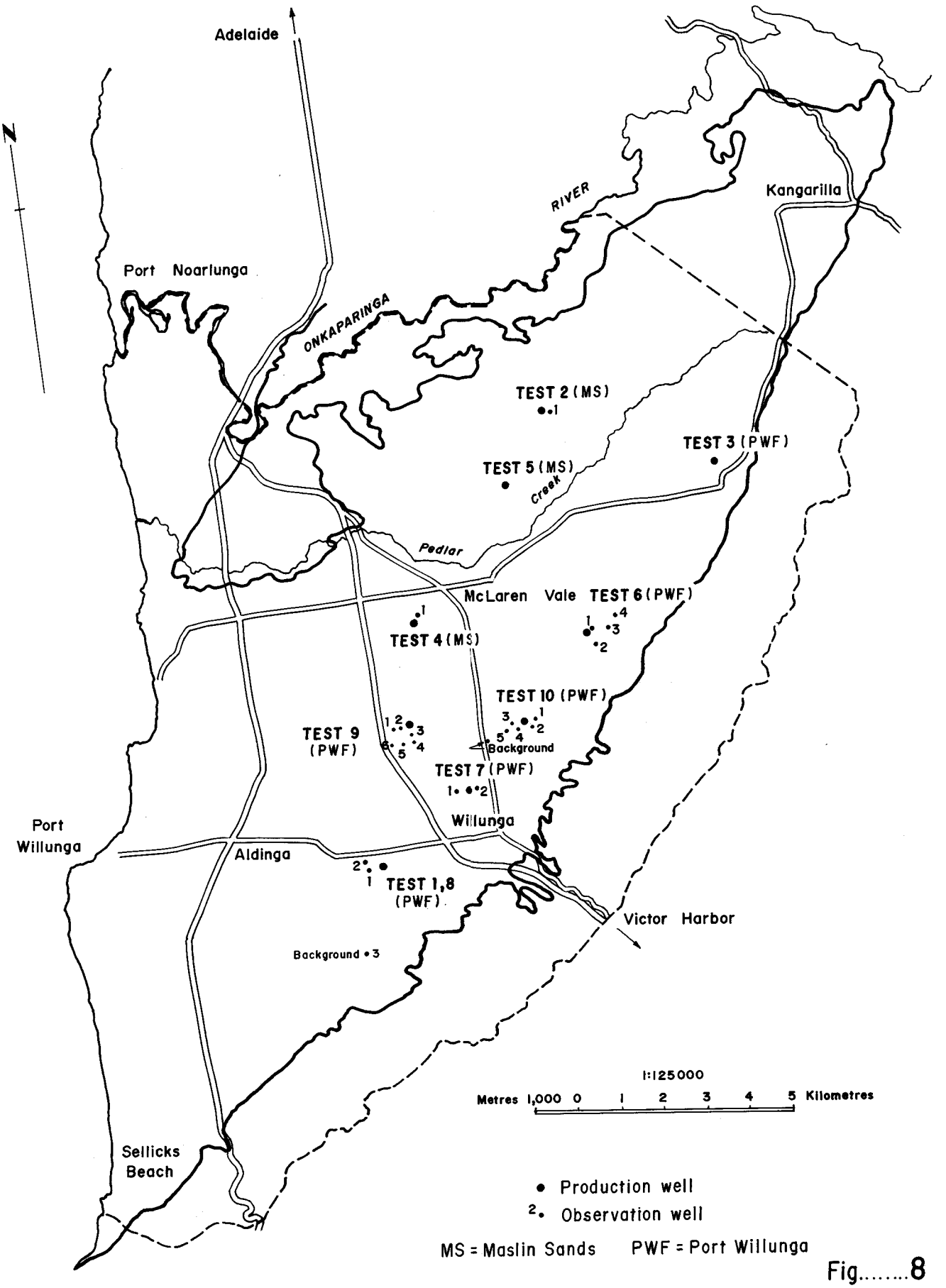


Fig.....8

DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA	COMPILED R.A.	9.5.89 CDO DATE
WILLUNGA BASIN GROUNDWATER INVESTIGATION	DRAWN R.H.	SCALE AS SHOWN
PUMP TEST LOCATIONS	DATE SEPT 1988	PLAN NUMBER S 20461
	CHECKED	

4694

N

Curlew Point

O'SULLIVAN BEACH

MORPHETT VALE

HD OF NOARLUNGA

CHRISTIES BEACH

CHRISTIE DOWNS

PORT NOARLUNGA

HACKHAM

PORT NOARLUNGA SOUTH

SEAFORD

NOARLUNGA

MOANA

MAIN SOUTH RD

MAIN ROAD SOUTH

ONKAPARINGA RIVER

Quarry Road

Seaview Road

Warners Road

Pedlar Creek

Chalk Hill Road

McLAREN FLAT

McLAREN VALE

Tatachilla Road

Communication Road

MASLIN BEACH

Malpas Road

Blanche Point

HD OF WILLUNGA

Blackeys Road

Snapper Point

PORT WILLUNGA

ALDINGA

Aldinga Road

WILLUNGA

ALDINGA BEACH

Norman Road

SELLICKS HILL

SELLICKS BEACH

Myponga

Victor Harbour Road

Range Road

HD OF MYPONGA

Elliotts Road

Douglas Gully Road

Dashwood Gully

KANGARILLA

Mt. Panorama

HD OF KUITPO

Wickham Hill

Mount Wilson

MOUNT BOLD RES.

815 930 1440 741 1165 775 1905 690 725 790 703 1124 1220 2205 635 1850

1990 935 1325 1220 1490 1850 730 1280 1795 665 1470 815 495 709 450 456 416 545 756 1060 363 617 1435 1515 1525 506 938 624 595 743 1535 605 677 828 762 593 589 540 550 628 638 965 1160 1120 1105 795 1170 1265 1185 1280 1240 1105 1125 1510 1200 1225 1140 965 1035 1855 1330 1985 1765 1845 8750

AQUIFER SAMPLED

× .....QUATERNARY

• .....PORT WILLUNGA FORMATION

▲ .....MASLIN SANDS

■ .....BASEMENT

1375 .....Salinity (mg/L)

LEGEND

- Main arterial road
- Main road
- Secondary road
- Track
- Basin boundary

SCALE

METRES 1000 0 1 2 3 4 5 KILOMETRES

Fig.....9

DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA

WILLUNGA BASIN GROUNDWATER INVESTIGATION

PRESSURE CEMENTED WELL SAMPLING PROGRAMME

NOV. 1987 - MAR. 1988

COMPILED	R.A.
DRAWN	R.H.
DATE	SEPT. 1988
CHECKED	
CDO DATE	9.5.89
SCALE	AS SHOWN
PLAN NUMBER	88-555