DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

GEOLOGICAL SURVEY
ENGINEERING DIVISION

DRILLING FOR WATER
-Proposed Mineral Information Series Pamphlet-

by

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DRILLING FOR WATER

INTRODUCTION

This pamphlet gives advice to any person wishing to employ a contractor to drill, or make repairs to a water well*. Drilling a well can be complex and expensive, and it is important to make the correct decision about whether to drill and, if so, where to site the well and how to construct it. This must be based on the best available information concerning the expected well yield and water quality. Proposed use of the water, initial and continuing costs, and whether or not there are any legal constraints on the amount of water that can be extracted, must also be considered.

OCCURRENCE OF UNDERGROUND WATER

This water infills pore spaces and fractures in sediments and rocks, which are referred to as aquifers if significant quantities of groundwater can be extracted from them.

The source of most underground water is rainwater soaking into the ground, and the pamphlet "Underground Water in South Australia" gives more information on this subject.

WHERE TO GET ADVICE

1. The Department of Mines and Energy

The following information is freely available from head office and all regional offices:-

*water well: the term includes both shallow dug wells and water bores.

.... Information on all known water supply and drainage wells is stored in the Department's well records system. This data is available to all enquirers and enables an assessment of general water prospects to be made for a particular area.

.... Free pamphlets and maps are available for some areas describing the occurrence and use of local underground water.

.... Department of Mines and Energy investigations are carried out in areas where underground water use is significant. Some of these have been published and many unpublished reports are also available for purchase or inspection.

.... General advice on well drilling methods, type and size of casing, well screen design etc., can be obtained from the Department's Drilling & Mechanical Branch at Thebarton. (Tel: 438 053).

2. <u>Drilling Contractors</u>

Drillers often work in particular areas and can often give a good idea of the supply and quality available, and what type of construction and drilling method is usually required. A list of drillers can be found under "Boring and/or Drilling Contractors" in the yellow pages of the telephone directory.

3. <u>Groundwater Consultants</u>

Private consultants are geologists experienced in working with underground water. They can give advice about the prospects of obtaining a supply in any area, plus detailed information about well siting, well depth, probable yield and quality, the most appropriate drilling method, and production testing, of the completed well. They may also be hired to supervise the drilling and testing operations.

Although cost may deter people from hiring consultants, their services are inexpensive when compared with the total cost of a well and pumping equipment, and their advice may save large amounts of money. The Department of Mines and Energy can provide a list of consultants, and seeking their advice is recommended.

4. The Engineering and Water Supply Department (Water Resources Branch).

The E. & W.S. Department is responsible for water resources planning and management in South Australia. Advice is available about the conditions which would be applied to a permit authorising the drilling of a well, and whether or not there are any restrictions placed on the use of underground water in the area. (Phone 227 2577.)

WATER DIVINERS

Water diviners are people who claim to be able to detect the presence of significant supplies of underground water, usually with the aid of a divining rod of wood or metal. Some claim to be able to predict the depth at which water will be found, and its salinity. Diviners work on the assumption that good supplies come from underground streams, and that they can detect the movement of this water. They claim a high success rate, and account for a significant proportion of well site selections in South Australia.

There is no scientific explanation for the claims of water diviners, but there is ample evidence that water does not form underground streams. It is true that many wells drilled on the advice of diviners are successful, however this is often in areas where supplies are plentiful, and any well would be successful.

Few water wells drilled in South Australia are completely unproductive. One study carried out on a large number of privately drilled wells showed that sites selected by diviners were no more productive than those selected by farmers for their own convenience, e.g. at paddock corners. Some divined wells have been very successful in areas where other attempts to obtain water have failed.

The advice of a qualified groundwater consultant is recommended by this Department. It is a matter of personal choice whether a person wishes to seek the advice of a water diviner.

SELECTING SITES FOR DRILLING

1. Hard Rock Areas (e.g. Mount Lofty Ranges)

The ability of these rocks to store and transmit water can vary markedly over distances as small as 10 to 20 metres.

Careful selection of the well site is important to ensure that the most suitable rock type is penetrated at the right depth, and in a locality where recharge by surface water is mostly likely to occur. Figure 1 shows an example of successful and unsuccessful siting, and demonstrates the importance of obtaining good advice prior to drilling a well.

2. Sediments

Most large supplies of underground water are obtained from storage in sedimentary basins. These can be either extensive deep basins or smaller, irregular areas such as valley floors and outwash fans.

Sediments in large basins are generally uniform except near the basin margins (Figure 2). There is rarely an advantage in selecting any particular drilling site within a sedimentary basin; it should be one of convenience based on factors such as the distance from electric power, farm house or irrigated area.

Wells drilled in small areas of sediment in narrow valleys may require careful site selection. In all cases it is sensible practice to seek advice about well siting before drilling.

3. General Advice

New wells should always be sited as far as practicable from existing wells, to avoid interference effects which may limit the amount which can be pumped; they should also be located away from drainage wells or septic tanks to avoid any possibility of pollution.

All wells should be sited so that surface water drains away from them, to avoid problems of access. This is particularly important in areas where flowing wells occur.

Remember that drilling rigs are often mounted on large vehicles and require sites which can be reached by a 4 wheel drive truck, and which are on level ground.

WELL DRILLING METHODS

Most water wells are drilled by one of two basic methods; .... The cable-tool or percussion method relies upon the lifting and dropping of a heavy drill string for the drilling action and generally uses casing to support the walls of the hole during drilling operations (Plate 1). It is particularly suitable for penetration of soft material, and the collection of representative water samples during drilling. For a private driller the plant is inexpensive to purchase and maintain, is simple and reliable when compared with rotary machines, and does not require a large supply of water during drilling.

Hard rocks and holes deeper than 100-200 metres present a major problem to cable-tool rigs as penetration is very slow, and rotary machines are usually preferred.

.... Rotary drilling relies upon the rotation of a drill bit mounted on drill pipe, through which fluid is circulated to return the cuttings to the surface (Plate 2). In unconsolidated materials, water or mud is circulated to support the wall of the hole; in stable materials (hard rock) compressed air is used, often in conjunction with a pneumatic down-hole hammer drill. This method is generally accepted as the best way of drilling water wells in hard rocks. Cavernous formations such as limestones are major hazards to rotary drilling.

Auger drilling is a form of rotary drilling, suitable only for relatively soft material and for shallow wells 5-10 metres deep; it is not widely used.

Dug wells were common in the early period of the State's development, usually tapping shallow groundwater in relatively soft sediments, often near rivers. Although some are still in use, virtually none are being constructed or repaired now.

WELL CONSTRUCTION METHODS

All well construction permits are issued with a set of general specifications for drilling within South Australia. They require the use of certain techniques and materials, some of which are explained here.

(a) Casing

Casing is used to support the wall of a well in unstable material. There are many materials used (steel, stainless steel, various plastics, and occasionally fibreglass) depending upon the depth of the well, the presence of corrosive water, the well yield, and the period for which the well is expected to be used. The casing may be a large proportion of the initial cost so it is important to make the correct decision about the type and size if a well is to be drilled economically. For example, if stock water is required and a windmill-driven pump of low capacity is to be installed, 100 mm diameter PVC casing may be used in preference to 150 mm steel casing. The cost saving in some circumstances can be very significant. The decision can usually be made before a well is drilled if advice is sought, although unexpected results from drilling may necessitate modifying that decision.

(b) Well Screens

Well screens are used to support unconsolidated aquifer material whilst allowing the maximum rate of flow of sand-free water into the well (Plate 3); this also protects the pump against damage by sand entering the well.

The choice of screen-type depends upon the type of aquifer material and the quality of the water. It is usually possible to predict from the geology of an area, and from records of previous drilling, whether or not a screen will be needed for a particular well and, if so, the most suitable type. It is generally bad practice to order a screen before the sand has been sampled by drilling, as the size of the slots is determined by the grain size of the sand and cannot be predicted reliably. If the slots are too large, sand-free development may be impossible and if too small, the well will be inefficient and pumping costs will be excessive.

Artificial gravel packing between the well screen and the aquifer is used in some circumstances, for example when very fine sand is developed.

The wire-wound well screen is the most satisfactory screen for most environments, and it is usually false economy to use cheaper screen types, such as slotted casing, except in extremely coarse material, or to support very fractured rock.

(c) Cementing

Cement is used in well construction to provide an effective and permanent seal between casing and the walls of the hole. There are two main reasons for providing this seal:

.... Polluted surface water is prevented from running down the well outside the casing by a cement seal at ground level, and

.... aquifers with different water quality are separated from one another by pressure cementing between the casing and the wall of the hole from the top of the lower aquifer to the surface. This prevents wastage of water or deterioration in water quality, and also protects steel casing from corrosion (Figure 3).

(d) Headworks for Flowing Wells

The pressure of the water stored in some aquifers is high enough for a well to overflow. Control is achieved by cementing between the casing and the wall of the hole from the top of the aquifer to the surface, and by fitting a control valve to the top of the casing. Unless this is done at the time of construction, considerable wastage of water and drop in pressure will occur. Rehabilitation can be expensive, and poor siting can allow water to pond around the well and make access difficult. In parts of the Great Artesian Basin the flowing water is hot, making the job of rehabilitation even more difficult.

WELL DEVELOPMENT AND TESTING

Development includes the processes of cleaning out a well after the completion of drilling and increasing the permeability of the adjacent aquifer material so that water can flow freely through it. It stabilises sands around a screened well so that water pumped from the well is free of sand.

Development is essential to the proper completion of every water well because:

.... Most drilling methods damage the aquifer material to some extent by repacking sand grains tighter together, or by clogging pore spaces or fractures through which the water moves. This damage must be corrected if a well is to be efficient or to produce at its maximum capacity.

.... A high permeability zone near the well reduces drawdown, and therefore minimises pumping costs and maximises the yield of the well.

.... Removal of fine sand from the aquifer near a well fitted with a screen is essential for sand-free pumping. This can only be achieved by thorough development work prior to testing.

Proper testing of a well is essential to its efficient operation. A well test is the only sound basis for selection of a suitable pump. HIgh pumping costs and unsatisfactory pump performance can often be traced to the selection of an inappropriate pump. It is recommended that the well test be carried out by the driller or pump supplier immediately after construction and development of the well.

From a properly conducted well test is is possible to calculate the Specific Capacity of the well; this is defined as:

$$\text{SPECIFIC CAPACITY OF WELL} = \frac{\text{PUMPING RATE in kilolitres/day}}{\text{CORRESPONDING DRAWDOWN in metres}}$$

A diagram explaining this concept together with the terms used in a well test is given in Figure 4. Changes in specific capacity can occur due to hole collapse and encrustation of the screen. It is therefore essential that this quantity be established early in the life of the well so that any future problems can be recognized before they become serious.

Recommended testing periods for some well uses are as follows:

USE	TESTING TIME (hours)
Stock/domestic	4
Irrigation	8 - 12
Industrial	8 - 12 (or longer)
Town Water Supply	72

More complex well testing methods are available for particular purposes; however professional supervision will almost certainly be required for such tests and their interpretation, and in South Australia they are usually restricted to Department of Mines and Energy work and jobs supervised by groundwater consultants.

The selection of an appropriate pump for a well must follow well testing, so that the required production rate and the drawdown are known. There is a large variety of pump types available and the potential user is recommended to seek advice from pump manufacturers before deciding upon the pump most suitable for his requirements.

REHABILITATION

Most rehabilitation work is necessary because the yield of a well has fallen below requirements, water quality has deteriorated, a well has started to produce sand, or has started or stopped flowing because of casing corrosion or inadequate cementing. Each of these problems is likely to be related to the well itself, but can also be an indication of depletion or deterioration of local or regional underground water resources.

If, after seeking suitable advice, the problem is judged to be one related to well construction, a drilling contractor will probably be required to carry out the work.

Rehabilitation sometimes can be far more difficult and expensive than drilling a new well and backfilling the old one, and the importance of seeking advice cannot be over-stressed. Cheap short-cuts during the initial well construction may lead to premature failure necessitating rehabilitation, and are often false economy.

ASSESSING EXISTING WELLS

Wells are often found on properties by new owners, after purchase, or are known to exist without any information about water quality, yield, construction, or depth, being available.

The fact that they are disused may be regarded by the owner as an indication of their general unsuitability. This is not necessarily correct, and it is possible to test such wells and assess their potential.

A properly conducted pumping test is the only way of determining whether a well is suitable for use.

To decide whether it is feasible to test the output of the well you should:

1. Try to obtain as much information as possible from previous owners and neighbours. If the approximate date of drilling and the name of the contractor can be obtained from neighbours, it may be possible to get

further information from the driller's own records; the record system of the Department of Mines and Energy can also be consulted in case the well has been located during a field survey, or was drilled under a Water Resources Act permit.

2. Check the diameter, type and condition of any casing in the well. If there is no casing, the well cannot be used without a significant risk of surface collapse on top of downhole pumping equipment, and work will be required by a drilling contractor.

3. Measure the total depth of the well with a weighted length of cord. Measure the depth to water (if the well is not dry) by listening carefully for the plop as the weight hits the surface of the water. Do not drop anything down the well. If the cord does not run freely to the bottom of the well, there may have been some collapse or dumping of material down the well. Pumps are sometimes lost down wells, which are then abandoned. If the well is obstructed a drilling contractor would be required to clean it out prior to pump testing.

Water samples collected from unequipped wells can be quite unreliable, and trust should only be put in samples taken during pumping.

If the well is cased, free of obstruction and apparently in good condition, contact a contractor or pump supplier and arrange for the well to be tested. Take several water samples during the test, so that salinity can be assessed using the free testing service provided at all Department of Mines and Energy offices.

LEGISLATION

Under the Water Resources Act a permit is required for drilling, deepening, backfilling or altering the casing of wells deeper than 2.5 metres; a permit is also required for changing the use of a well from water supply to drainage or vice-versa. Permits can be obtained from the Engineering and Water Supply Department, and all wells must be constructed by a licenced driller, unless drilled by the owner on his property to a depth shallower than 15 metres.

Conditions put on a permit may restrict the amount of water used and this applies in the present Proclaimed Regions of the Northern Adelaide Plains and Padthaway area; it can also specify the type of waste that may be disposed of down a well.

The pamphlet "Underground Water Legislation" is recommended for further information. Permit enquiries should be directed to the Water Resources Branch, E. & W.S. Department, and enquiries regarding well driller's licences, to the Department of Mines and Energy.

LOOKING AFTER YOUR WELL

Many well or pump failures are either caused by neglect of maintenance or failure to notice signs of gradual deterioration. For example a well that "suddenly" fails to produce adequate supplies may have an unrecorded history of gradual deterioration, which is only noticed when its pump sucks air; this would have been detected earlier by regular water level measurements, allowing rehabilitation to be carried out at a convenient time.

<u>What to do?</u>

1. Measure the water level in the well several times each

year after pumping has been stopped and the water level has stopped rising. This check will show if the underground water in storage is being depleted over a long period.

2. Sample the water when the pump has been running for at least 20-30 minutes, and have the salinity tested; a free testing service is available at all Department of Mines and Energy offices. This check should be carried out at least once a year, or more often in areas where salinity may be a problem.
3. Test the specific capacity of the well at least once a year. This test will show if the well is becoming less efficient due to clogging of the aquifer, or the well screen, if one is installed.
4. Carry out pump maintenance according to the manufacturer's specification.
5. Check the water for suspended solids (especially if a screen is installed) by collecting a water sample in a bucket or drum and allowing any material to settle. The water should be free of solids, although small quantities may be produced when the pump is started up after a long period of disuse.
6. Do not overpump a well by pumping to open discharge when the pump is designed to give an appropriate discharge against a pressure head - for example when pumping to a hilltop tank.

J.D. WATERHOUSE

CONVERSION TABLES

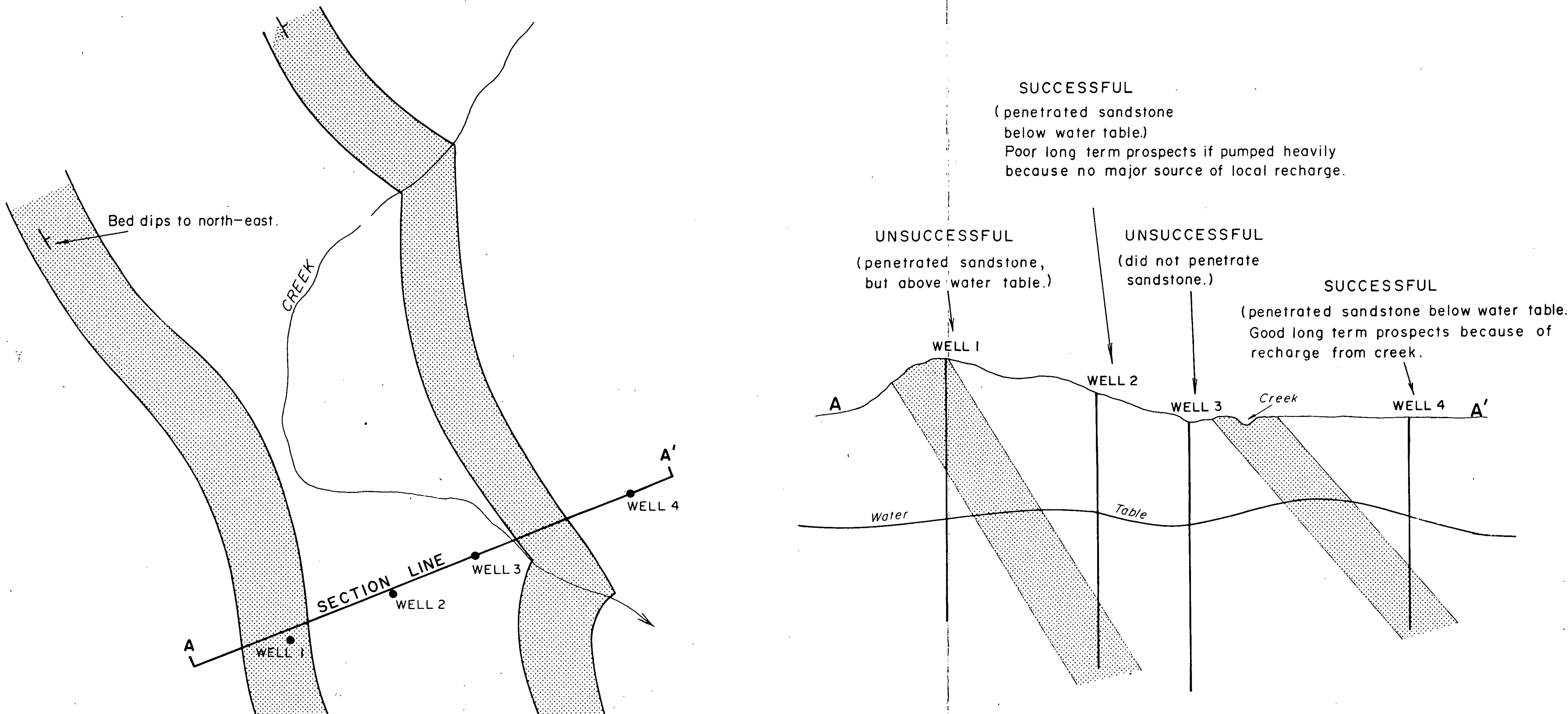
Metric Conversion of Well Yields

kl/day	gals/hr
100	910
200	1 820
300	2 730
400	3 650
500	4 550
600	5 460
700	6 370
800	7 280
900	8 190

Note: For quick approximate conversions use 100 kl/day = 1 000 gals/hr.

Milligrams/litre*	Grains/gallon	EC Units (25°C)
500	35	930
600	42	1 100
700	49	1 270
800	56	1 440
900	63	1 600
1 000	70	1 780
2 000	140	3 470
3 000	210	5 000
4 000	280	6 500
5 000	350	7 800

*numerically the same as parts per million



CROSS-SECTION A—A'

SANDSTONE (Good aquifer)

SLATE (Poor aquifer)

FIG. 1

	DEPARTMENT OF MINES – SOUTH AUSTRALIA	SCALE. Dgtc.
COMPILED. J.W.	EXAMPLES OF WELL SITING IN A HARD ROCK ENVIROMENT	DATE: 25/1/78
DRN: P.D. CKD.		PLAN NUMBER 78 – 101

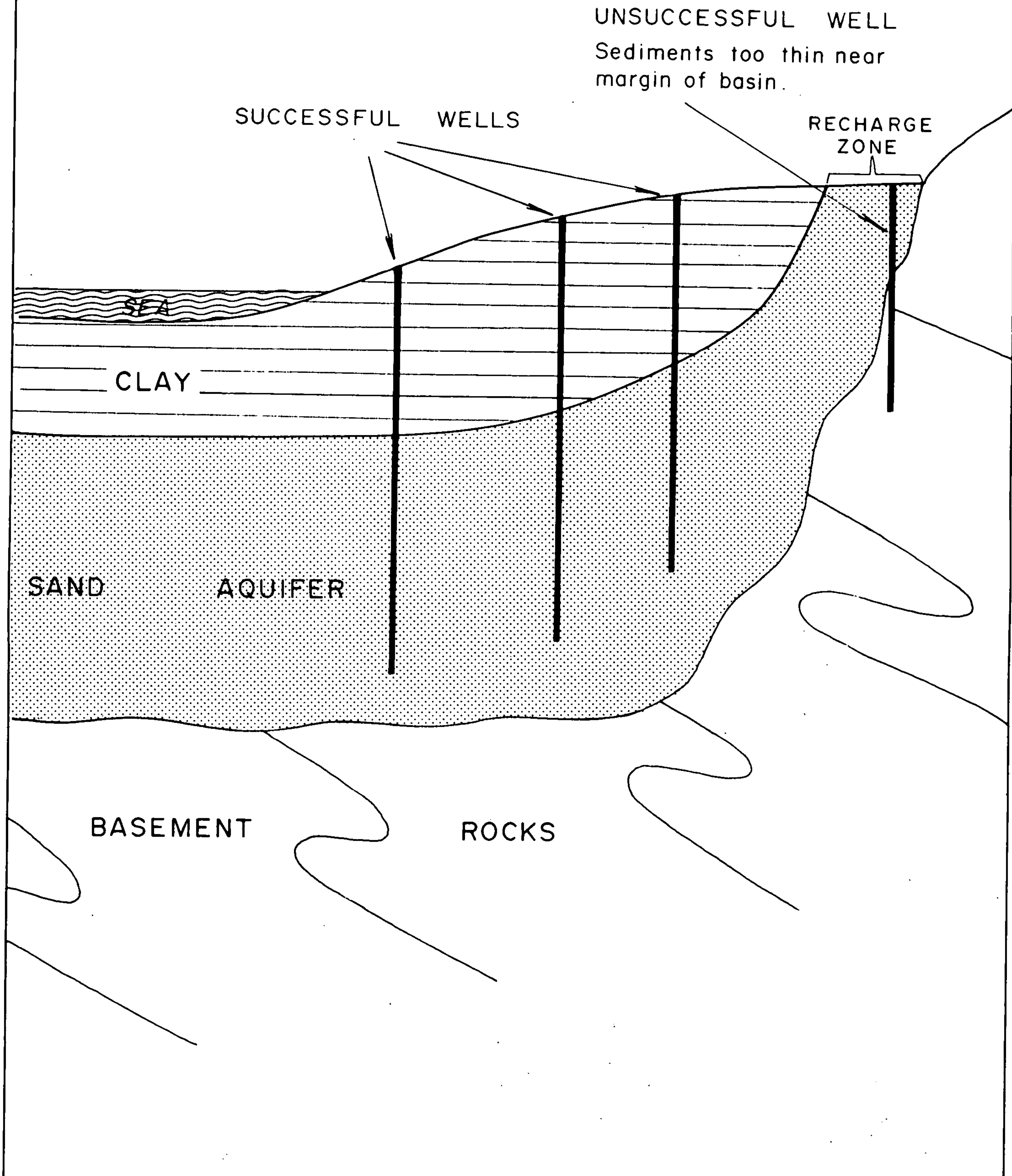
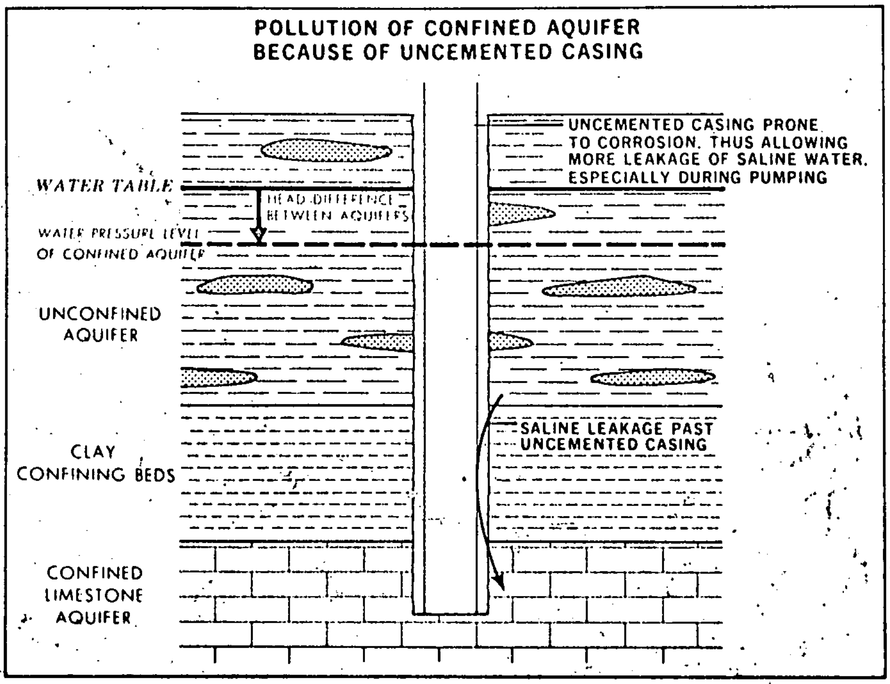


FIG. 2

	DEPARTMENT OF MINES – SOUTH AUSTRALIA	SCALE: Dgtc.
COMPILED: J.W.	EXAMPLES OF WELL SITING IN A SEDIMENTARY BASIN	DATE: 26/1/78
DRN: P.D. CKD.		PLAN NUMBER: S13220



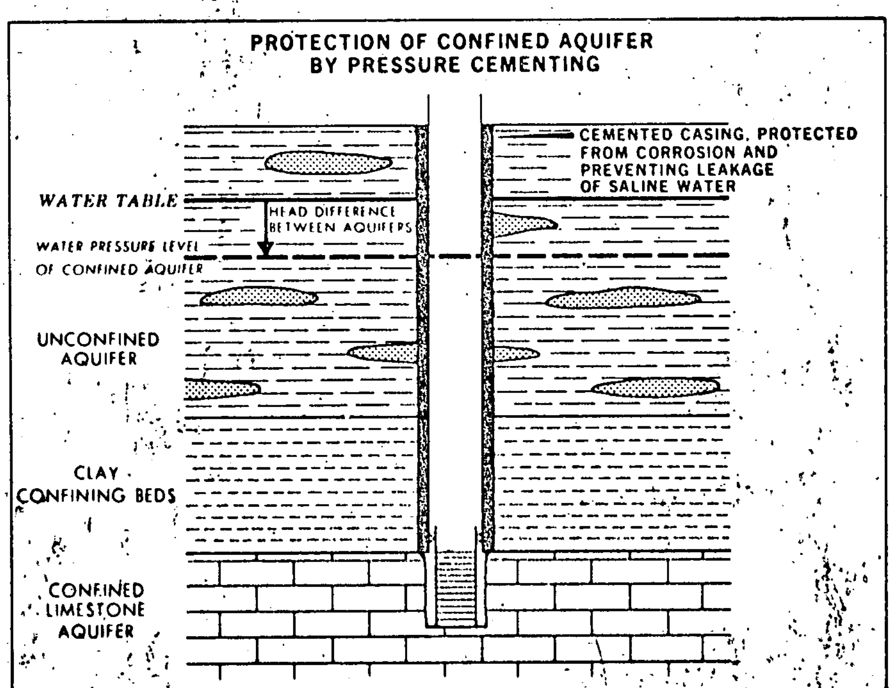
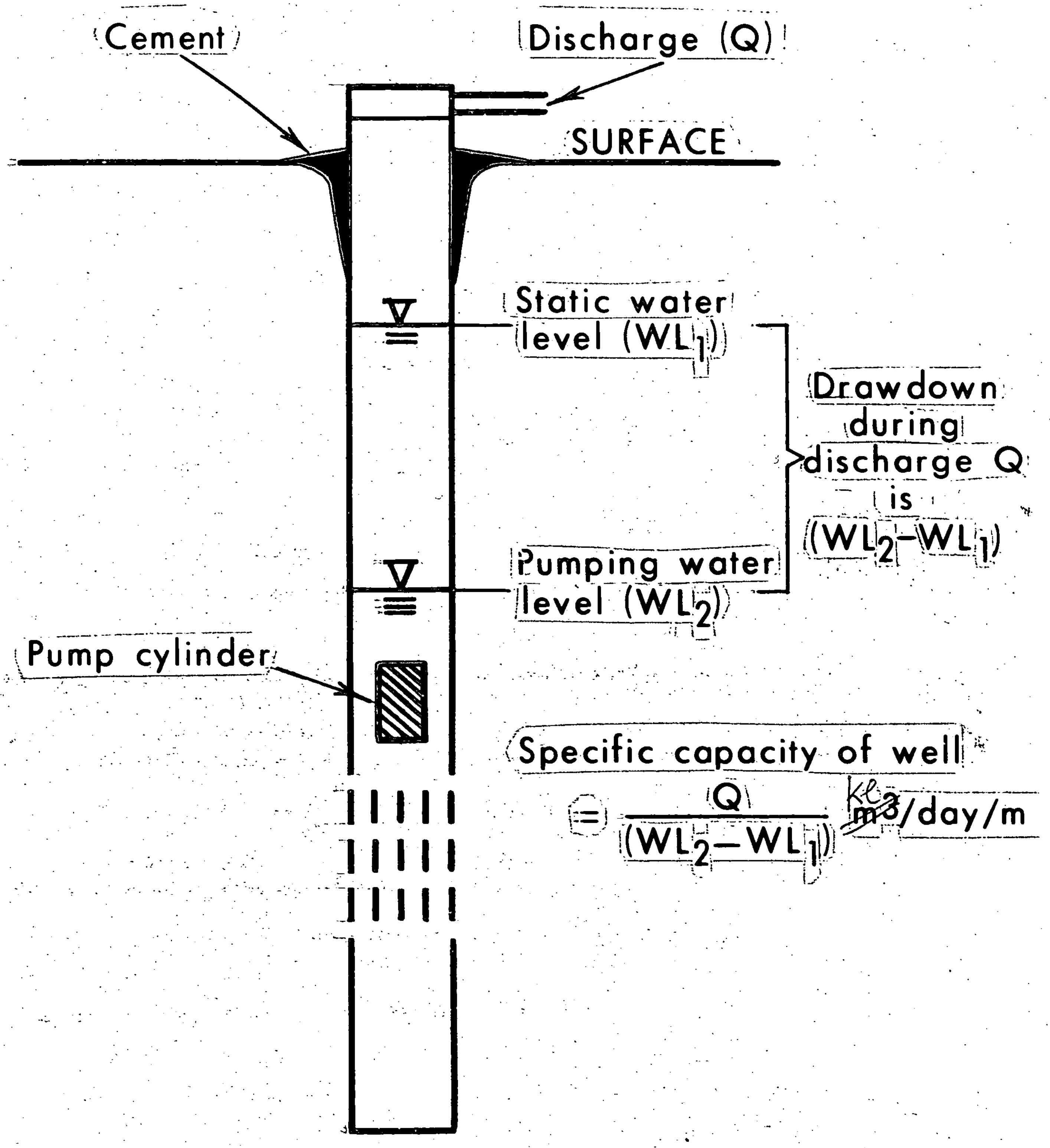


FIG. 3

ENGINEERING DIVISION	DEPARTMENT OF MINES – SOUTH AUSTRALIA	SCALE DIAGRAMMATIC
COMPILED J.D.W.	ANGAS – BREMER IRRIGATION AREA	DATE NOV. 1977
DRN R.H. CKD	WELL CONSTRUCTION REQUIREMENTS AND PROBLEMS	PLAN NUMBER S13146



NOTE: 1000 gals/hour=110 ~~cubic metres~~ Kilolitres */day
(or approx. 100)

S 12288 *~~1 cubic metre is a kilolitre~~ FIG 4

TERMS USED IN WELL TESTING