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DEPARTMENT OF MINES - SOUTH AUSTRALIA

UNDERGROUND WATER RESOURCES OF THE NORTHERN PART OF THE ADELAIDE PLAINS.

by

M. SOLOMON, ASSISTANT GEOLOGIST

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DEPARTMENT OF MINES - SOUTH AUSTRALIA

UNDERGROUND WATER RESOURCES IN THE SALISBURY AREA

Introduction

The E.&W.S. Dept., has requested a report on the potentialities of the underground water basins near Salisbury with a view to augmenting the Metropolitan Water Supply by pumping to the mains from bores.

The area concerned is the northerly part of the Adelaide - Gawler Plains and includes Two Wells, Gawler, Gepp's Cross and Lefevre Peninsula. This district was hydrologically surveyed by the Mines Department in 1946, but in order to more fully assess its potentialities the work has been extended and more recent information incorporated. Consideration has also been given to the underground water prospects in the bedrock hills east of Salisbury.

Existing Government Bores at Salisbury.

Of five Government bores sunk in 1945, four were satisfactory and these are now supplying the Munition Works. In the period 1950 - 1952 another eight holes were bored, each of which was successful. The average yield per bore is about 7,000 gallons per hour and the total salt content of the water is below 80 grains per gallon. As yet these later bores have not been equipped with pumping apparatus.

Government bores are placed approximately threequarters of a mile apart, this spacing being considered desirable to minimise the possibility of interference between the bores. However, it must be pointed out that this figure for spacing is not based on any tests and if developmental work is to proceed smoothly it is advisable that pump and drawdown tests should be made to determine the radius of influence of the bores. In the meantime, it is considered advisable to continue with the threequarters of a mile grid. This leaves room for seven more bores in the Salisbury area and it has therefore become necessary to seek new areas containing good quality water.

The policy as regards interference with bores owned by landholders has not been defined, but, where possible, the proposed sites have been chosen so as to be situated at least a quarter of a mile from any such bores using large supplies.

Physiography

The area concerned is an extension of the Adelaide Plains, the principal physiographic features of which have been described in Bulletin 27 (by Dr. K.R. Miles) of the S.A. Department of Mines.

South of the Gawler River, the ground rises gradually from the swamps near the coast towards the Para Fault escarpment, which dominates the low-lying plain. Numerous streams flowing down the scarp spread out and disappear on the plain but the Gawler and Little Para Rivers find their way to the sea. Flow in these rivers generally ceases in the late summer or early autumn.

North of the Gawler River and east of Two Wells, the seaward fall of the surface is broken by sand dunes, generally aligned N.W.

Geological History

The geology of the Adelaide Plains has been described in Bulletin 27, but a brief summary is given below.

The following two bore logs, one from the north and one from the south of the area, illustrate the general geological succession:-

(a) H.G. Brooks, Section 7511, Hundred of Port Adelaide. Serial No.4.

0 - 235:	Sands and clays	Recent to Pleistocene
235 - 237:	Grey sandstone	Pliocene
237 - 283:	Dark fossiliferous clay	
283 - 294:	Sand	
294 - 330:	"Coral" limestone	Miocene

(b) Metropolitan Abattoirs Board, Section 97, Hundred of Yatala.

Serial No. 23

0 - 323:	Clays, sands and gravels	Recent to Pleistocene
323 - 333:	Black clay and lignite	Pliocene
333 - 490:	Clay, sand and shells	
490 - 500:	Clay passing to limestone	
500 - 635:	Fossiliferous limestone and calcareous sandstone	Miocene
635 - 705:	Blue clay	
705 - 820:	Fossiliferous sandstone with clay bands.	

The ages assigned to the rock formations are not as yet fully established but are useful in discussion. The basin is cut off on the east by Pre Cambrian bedrock which is on the upthrown side of the Para Fault zone and as this zone is covered by thick outwash sands and gravels, it is difficult to determine the exact eastern extent of the Tertiary beds.

In the Adelaide area described in Bulletin 27, the relevant geologic history begins in the Lower Tertiary, in Oligocene times, when a peneplaned Pre Cambrian surface was covered by a considerable depth of lacustrine sands, gravels and clays. It is not known whether these sediments spread over the area under discussion as no bores have penetrated to the base of the overlying Miocene limestone.

Miocene

Marine incursion in the ensuing Miocene period resulted in the deposition of limestone, calcareous sandstone and clay. The beds are typically white to cream coloured and consist largely of bryozoal limestones and sandstones with dark grey marls becoming conspicuous below 50 ft. The total thickness in this area is unknown but an 820 ft. bore sunk at the Metropolitan Abattoirs penetrated 400 ft. including 60 ft. of blue clay (see preceding bore logs).

At distances ranging from one half to about three miles west of the Para Fault scarp, the limestone is largely replaced by sand. This was probably derived from erosion of the Lower Tertiary sandy rocks, exposed by uplift due to block faulting in the east of the area. This north-east directed faulting continued throughout the Tertiary and Quaternary periods and brought about the gradual development of the Mt. Lofty Ranges.

The eroded Miocene surface is contoured in Fig. 6. It is highest near Virginia and falls south and west, the gradient increasing at Port Gawler and more noticeably at Pooraka and Glanvill The surface probably continues to rise north of the Gawler River, as Miocene limestone outcrops 200 ft. above sea level near Red Banks (Hundred of Grace).

Pliocene

Post-Miocene faulting caused uplift of the ground west of the Para Fault scarp and also a general southerly tilt of the Miocene surface. The uneven surface and a continuation of faulting produced an irregular and unstable Pliocene shore line, and the uplifted western block gradually excluded the Pliocene seas from some of the area. Pliocene beds are absent in the Gawler-Virginia-Direk area while near Salisbury the marine series is replaced by lignites and gravels characteristic of lacustrine and fluviatile environments. (See fig. 5).

The Pliocene sediments are typically blue-grey in colour and are characterised by a dominance of fine sands in the upper part and of shell beds and sands in the lower part of the succession. Lateral and vertical lithological changes take place rapidly, presenting a marked contrast to the uniformity which is observed in the Miocene limestone.

Recent to Pleistocene

Following a period of erosion, fluviatile sands and gravels and clays were deposited on the Pliocene and Miocene surfaces, materials derived from both overlying soft Tertiary sediments and harder Pre-Cambrian bedrock being swept down from the high ground of the Mt. Lofty Range.

Typically, sands and gravel lenses are found in clays and sandy clays, the lenses being discontinuous and variable in thickness and form. Gravel lenses are frequent on either side of the Gawler and Little Para rivers, marking the courses of the old stream beds. Recent to Pleistocene deposits thicken from 200 ft. near the Gawler River to 300 ft. at Pooraka.

Hydrology

The general hydrological picture is set out in Bulletin 27 but additional information has been gathered from bores sunk by the Department of Mines and a number of private contractors. Water sampling has been continued and the majority of bores in the area have been inspected. With the data thus gathered, it has been possible to extend and modify the existing isohalsine plans though there are still some areas over which information is scanty.

Information for all bores entering the artesian aquifers is included in the tables accompanying this report. There are separate tables for each Hundred and the locations of the bores may be found by referring the serial numbers to Fig. 10.

Each of the formations described in the previous section carries underground water. Water in the Recent to Pleistocene sands is not under pressure and occurs in lenticular sands and gravels, generally separated from underlying beds by impermeable clays. Within one and a half to two miles of the Para Fault, the clays are thin or absent and this provides an intake area where water fed onto the plains from the major water courses is more readily able to percolate downwards to the underlying Pliocene and Miocene beds.

Intake is largely from the Gawler and Little Para rivers, principally where they cross the fault escarpment, the total annual recharge from the Little Para being estimated by K.R. Miles to be 1050 million gallons and from the Gawler River, about 3,000 million gallons. It may be assumed that a fairly large proportion of the annual recharge gains access to the artesian aquifers and flows westward, being confined under pressure where the deeper aquifers are overlain by Pleistocene clays.

The Pliocene and Miocene aquifers containing this artesian or subartesian water are to some extent hydraulically linked, there being no widespread, impermeable seal between the two. The extent of the link is uncertain and varies from place to place - a 4 ft. limestone band, possibly lenticular, is the only bed that separates the Miocene and Pliocene in the E.&.W.S. bores at Osborne, and the static water levels are the same. A small drawdown in the Pliocene water level was noticed after pumping at 9000 g.p.h. from the Miocene aquifer and there consequently appears to be a hydraulic connection between the two groups of strata.

The quality of the underground water deteriorates away from the two major intake areas, the zones of potable water with less than 100 grains per gallon being confined to the vicinities of the Gawler and Little Para rivers, where downward percolation from surface run off may be expected to be a maximum. Separate salinity distribution diagrams have been prepared for each aquifer, and, when these diagrams are used in conjunction with the contour plans, the probable results of boring to a specified depth at any particular locality may be forecast with a fair degree of accuracy.

The distribution of different quality waters is much the same for each of the deeper aquifers, areas of increasing or decreasing salinity in one series of strata roughly corresponding to similar areas in the beds above and below. Salinities do not always correspond, however, the most notable example being the Waterloo Corner - St. Kilda area where Pliocene water containing about 50 - 60 grains per gallon overlies 100 - 150 grain water in the Miocene strata below. This indicates the existence of a local seal between the two strata, but since the isohals in each have a roughly similar configuration, such a seal is likely to be only a partial one.

The variations in salinity could be a reflection either of a decreased recharge from surface runoff as the flow in the Little Para River diminishes westward across the plain, with less fresh water penetrating to depth or it might be the result of local differences in the salt content available for solution from the rocks themselves.

The salinity distribution at Waterloo Corner has been confused by the fact that in a few bores (e.g. Section 5014) the shallow saline waters which occur in disconnected lenses in the post-Pliocene beds have corroded through the bore casing or worked their way down outside and mixed with the deeper artesian waters, causing contamination and increased salinity. Such a situation requires close observation, particularly as analyses indicate that the quality of the waters in the contaminated bores is worsening.

It is obvious that where such a danger exists, not only should the greatest care be exercised in constructing bores in a sound mechanical manner so that any upper saline waters are effectively excluded, but it is most important that their mechanical condition be not allowed to deteriorate dangerously with age. The life of unprotected bore casing in contact with saline water is limited, and old bores whose casing corrodes through are a real source of danger.

Such bores should be effectively plugged if no longer in use, or relined and cemented to exclude the saline waters, if they are to be preserved as a source of water supply.

The Aquifers

No bores have encountered the Oligocene aquifers in this area and it is not known whether they underlie the limestone. They have been encountered near the River Torrens and found to contain saline water.

The Miocene limestone is the main aquifer in the district, principally because of its areal extent and great thickness, its high permeability, the ease with which it may be drilled and its ability to stand in an open borehole unsupported by casing. The sandy Pliocene beds also yield large supplies of water but they are less extensive, more variable in nature and occasionally cause difficulties in boring.

Adjacent to the Para fault scarp, sands predominate in both Quaternary and Tertiary formations and in several bores along this margin of the basin (e.g. Sections 3201 and 3183, Hundred of Munno Para), difficulty has been experienced in satisfactorily completing water bores because of the occurrence of drift sand. For this reason, it is possible that the underground water supplies within some distance of the Para fault may not be capable of such effective development as elsewhere.

Miocene Limestone

This is the most reliable and extensive aquifer and is widely utilised in the Virginia and Salisbury areas.

There are two areas in which potable water is encountered viz:-

(a) Near Salisbury, where a zone of potable water covering an area of about 20 square miles has resulted from downward percolation of surface runoff water from the Little Para River. This is an area where such water is of considerable economic value, and firm control measures to ensure its continued existence are warranted. For this reason the discharge underground near the intake areas of any fluids which might possibly cause pollution should be strictly discouraged.

Since the ground water body and the annual recharge are each limited in quantity, the danger of depletion by overpumping is an ever present one, and the district has already been so well developed by boring that at this stage it is felt that the construction of a further seven bores probably represents the limit to which development can be taken. It may be that when further data are obtained regarding drawoff, mutual interference between bores and recharge rates, some further drilling may be found possible without serious risk, but the collection of such information is only possible over an extended time period, and in its absence any more intensive drilling than is at present envisaged is not thought to be warranted.

A complicating factor is that, as previously stated, the eastern limit of the main Miocene aquifer is not definitely known and not only does this mean that the future possibilities of development near the Pre Cambrian eastern margin are difficult to estimate but there is little direct information on which to base predictions regarding its potential intake.

(b) Along the Gawler River, a total area of about 90 square miles. The limits of this zone are not well defined because of the insufficiency of detailed bore information.

The supply obtainable is not thought to have been fully tested but it is known that yields of up to 20,000 g.p.h. are obtained from individual bores near Virginia, where the water is used for the irrigation of market gardens.

No bores are known to have penetrated Miocene limestone north of Angle Vale, but large supplies are obtained in the Lower Pleistocene beds. These appear to be freely connected hydraulically with the underlying Miocene limestone, and the two may be regarded as one continuous aquifer.

The quality of water in the limestone deteriorates with depth below the upper 50 to 75 ft., possibly because of the shallow "freshening" effect of water percolating downward from surface intake

In the E.&.W.S. bore at Osborne the salinity rose from 104 to 215 grains per gallon after clay horizons were encountered 50 ft. below the Miocene surface. The salinity distribution diagram (Fig. 4) only applies to the "shallow" limestone water and where two salinity figures are shown for one bore, the greater applies to water cut below 50 or 60 ft.

Contours of static water levels in the Miocene aquifer (Fig. 7) show a gradual westward fall in the piezometric surface, along a gradient which is considerably less than that of the natural surface. Westward migration of the groundwater from these intakes near the eastern fault boundary where the elevation is greatest may therefore be expected to be slow compared with surface runoff although heavy pumping might accelerate it. Movement under gravity would be further limited because of the depressed level of the beds as compared with sea level. This however is possibly no disadvantage, as much of the potential energy of the mass resulting from the elevation of the water surface near the intakes is available as static head in the bores rather than velocit head, bringing the static water level nearer the surface than would otherwise be the case in such porous media. Most of the subcoastal bores are artesian.

Pliocene sands

A considerable number of bores tap water from these beds, particularly near Gepps Cross and Port Adelaide, where the Miocene limestone is less accessible. This aquifer is not as extensive as the underlying limestone and is therefore of less economic importanc as a source of water supply. Only one area of potable water has been proved, extending from Salisbury to Waterloo Corner and St. Kilda (Fig. 4). An improvement in quality is noticeable on LeFevre Peninsula but the salinity there does not fall below 90 grains per gallon.

The best yields are obtained from bores entering coarse shell beds - where these are absent and the water has to be taken from the dominant fine sands, considerable mechanical difficulty is experienced in drawing off a good supply. Static water levels (see Fig. 7) vary considerably in depth from the surface, indicating a poor hydraulic connection between the water bearing beds, which are probably in the main lenticular.

Recent - Pleistocene clays and sands

Water usually occurs in the sand and gravel lenses, but owing to the variable nature of the beds they are not reliable aquifers. The clay content is often considerable and the permeability correspondingly low. The zones of potable water along the river courses are only small (see Fig. 5) and salinities are inclined to vary rapidly over short distances. Occasional large supplies (up to 10,000 gallons per hour) are obtained near the river courses where the gravels are more uniform and are probably in direct hydraulic link with the river waters. Away from the rivers the sand lenses are less frequent and of finer grain and yield only poor supplies.

Since the strata are essentially flood plain deposits, it is to be expected that the coarser grained sediments would occur near the rivers where flood water velocities are highest, with the grain size decreasing as the transporting power of the floodwaters diminishes with their lateral spread over the plain.

Prospects east of the Para Fault

The Pre-Cambrian beds east of Salisbury and Smithfield consist of slates with two or three interbedded quartzites which are involve in a south-pitching synclinorium with the axis some 6 miles east of Salisbury (see Fig. 6). It was suggested by the Regional Geology Section that if the quartzites were sufficiently continuous and permeable to retain and transmit water, local intake should concentrate in these beds along the axis of the synclinorium.

A study of the outcrops revealed that, though fairly well jointed, the quartzites are dense and tend to grade laterally to more shaley, compact beds, unsuitable for storing large supplies of water. It may be worth noting that up to 2 or 3,000 g.p.h. might be obtained by boring near the Little Para River where it intersects the axis of the synclinorium, but drilling would be considerably slower in the hard Pre Cambrian rocks than it is on the Salisbury Plains. The water occurs in joints and fissures in the rock, rather than in the intergranular interstices.

Development

Because of the continued expansion of built up areas in the Adelaide suburbs, an increasing number of market gardeners is transferring to the Salisbury and Virginia districts, and the demand for groundwater for irrigation purposes is rapidly increasing

As will be apparent from this report, the supply is limited. and intensive and indiscriminate development could easily result in its being dangerously diminished. The practical maximum limit to pumping is of course at a point where yield balances intake, and insufficient information is available to enable this yield to be determined other than within very broad limits. It should not in any circumstances be exceeded, not only because rapid depletion of reserves would result, but also because there would be a very rea danger of contamination of the aquifers by water of a quality unsuitable for use.

To avoid damage to the potable water zones therefore, it is most desirable that there should be adequate legislation to control and direct all drilling as well as the use of the underground water. If such control is to be exercised successfully, further information from field tests is required to determine the optimum spacing of bores in the different aquifers. While such field tests have their limitations, particularly in regard to studying the variation in permeability in the aquifers, they would serve as a useful guide in planning development of the basin by boring.

Another problem that has to be studied carefully in considering the utilisation of large quantities of underground water for domestic uses, is that of the possibility of contamination. Where shallow waters are salt, particular care has to be taken to seal off these waters during boring. Also, when developing a zone of potable water pumping has to be controlled to ensure that salt water is not drawn in either from above, below or by lateral movement.

Again, it is essential that the water withdrawn by bores should be of a high standard of bacteriological purity and the drainage of polluted water from factories, schools etc. should be strictly controlled to ensure that the water does not enter any water-charged bed from which it may subsequently gain access to the Pliocene and Miocene aquifers from which water supplies are drawn.

The greatest direct danger of pollution exists in the area lying on either side of the fault zone to the east, where large quantities of surface runoff are believed to have ready access to the pressure aquifers. Water entering in this zone must constitute the bulk of the feed water supplying both Miocene and Pliocene aquifers.

On the plains to the west the possibility of pollution from surface sources is still present, first because there may be areas where a direct connection exists between the upper and lower water bearing beds, and second because of the danger of badly constructed bores, or old bores in which the casing has corroded through, acting as conduits down which polluted water could pass unrestrictedly into the lower aquifers.

Conclusions

As a result of the investigations described above it is concluded that:

(a) there are two separate districts in this section of the Adelaide Plains where potable groundwater is obtainable. One centres around Salisbury, the other about Gawler - Virginia.

(b) neither has its groundwater potential as yet fully developed.

(c) there is room for approximately seven more deep bores in the Miocene potable water zone near Salisbury, assuming that the policy of spacing the bores threequarters of a mile apart is to be continued. Decreasing of this spacing is not considered advisable unless detailed observations during a long period indicate that it would be possible.

(d) there is a zone between St. Kilda and Waterloo Corner where better quality water is obtainable from the Pliocene beds than from the underlying Miocene limestone. Drilling for domestic or first quality garden supplies should therefore be confined to shallow bores.

(e) there is a zone of potable water in the Miocene limestone between Virginia and Gawler but that available information is yet insufficient for exact determination of the extent ot the zone and also the nature of the limestone east of Angle Vale.

Within this area is should be possible to obtain good supplies of water in the Pleistocene gravels close to the Gawler River.

(f) because of the relatively small yields anticipated and the high cost of drilling, boring in the bedrock hills east of Salisbury is not recommended.

(g) if development of the Virginia-Gawler area proceeds on the lines being adopted for the Salisbury area, a total supply of the order of about 15,000,000 gallons per day should be available from the former. It should be emphasised that this estimate be based on limited data and must be regarded as very approximate.

(h) because of the danger of polluting the main aquifers, discharge underground of any trade waste, septic tank effluent etc., should be strictly avoided.

Recommendations

Drilling for water on behalf of the E.&.W.S. in the Salisbury area is at present in abeyance, and has not yet been commenced arou Gawler-Virginia, but as a guide to future operations, it is recommended that:

(a) A further maximum number of seven holes (Nos. 14 - 20) be sunk in the Salisbury area on the sites indicated in Fig. 8. No. 20 is experimental in that it is situated near the Para fault, where precise stratigraphical information is not available.

(b) Eleven holes be sunk in the St. Kilda - Waterloo Corner area, to penetrate the Pliocene aquifers only. Care will be needed to shut off the shallow saline waters and avoid penetrating to the underlying Miocene limestone which contains poor quality water. Most of these bores are fairly near to the existing Salisbury reticulation scheme.

(c) Thirteen holes (Nos. 32 - 44) be sunk to more fully delineate the Gawler River zone. If these are successful and providing ther has been no significant increase in the number of private bores sunl in the area, there should be room for considerable extension.

Boring Estimates

These estimates are very approximate, but are included to give some idea of the footage involved in the recommendations made above:

No. of Bore	Probable casing requirements in feet.	Total Depth in feet.
(a) Salisbury Zone		
14	320	385
15	310	385
16	320?	390?
17	420	475
18	390	450
19	450	400
20	500?	
(b) St. Kilda - Waterloo Corner Zone		
27 - 31	250?	250?
(c) Gawler River Zone		
32	235	300
33	270	350
34	350?	400?
35	200	275
36	210	385
37	210	285
38	220	285
39	250	325
40	300?	375
41	300?	375
42	250	325
43	200	275
44	200	275

M. Solomon

(M. Solomon)
ASSISTANT GEOLOGIST.

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