DEPARTMENT OF MINES
SOUTH AUSTRALIA

GEOLOGICAL SURVEY

HYDROLOGY SECTION

REPORT ON INVESTIGATION OF THE COASTAL SALINE ZONE IN THE ST. KILDA AND BUCKLAND PARK AREAS, NORTHERN ADELAIDE PLAINS.

by

P. G. Miller - Geologist

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REPORT ON INVESTIGATION OF THE COASTAL SALINE ZONE IN THE ST. KILDA AND BUCKLAND PARK AREAS, NORTHERN ADELAIDE PLAINS

ABSTRACT

Drilling to locate a salt-fresh interface within the upper Tertiary marine aquifer of the northern Adelaide plains has revealed the existence of a body of highly saline water, overlying and truncating the low salinity water. The saline water is contained in a much less permeable facies of Pliocene sedimentation, and it is considered that the facies change has imposed a permeability barrier, restricting the flushing out of the saline waters by low salinity recharge waters. The saline water is therefore "fossil", and not the ingression of seawater under the influence of heavy withdrawals further inland. Provided the permeability barrier is continuous, the upper aquifer is protected from saline ingression, which will only occur in the outlets for the pressure waters. Further testing to prove the continuity of the barrier, and to discover possible outlet zones is recommended.

I. INTRODUCTION

The pressure waters of the Northern Adelaide Plains are contained in two main aquifers within the Tertiary marine sediments, the upper comprising Pliocene sands and Miocene limestones, the lower comprising Miocene limestones. Separating the two aquifers is a Miocene marine clay band, sufficiently impermeable to act as an aquiclude. In some areas the two aquifers contain water of essentially similar salinity, whereas in others quite marked salinity variations occur.

A previous investigation had revealed that the contrast between the groundwaters of the two aquifers is greatest in the coastal areas, where the upper aquifer contains water of very high salinity whilst low salinity water occurs in the lower aquifer. A short distance inland, low salinity water which is extensively used for market garden irrigation occurs in the upper aquifer, there being apparently a rapid transition from the highly saline water.

The occurrence of the highly saline water was considered to present a serious threat to the good quality groundwater of the upper aquifer. Because of localised high withdrawals,

particularly in the Waterloo Corner and Virginia areas, there is a lowering of the piezometric surface causing a reversal of the natural hydraulic gradient. The direction of groundwater movement being reversed, the saline water would move inland and contaminate the existing low salinity groundwaters.

It was assumed that the highly saline water in the coastal areas was either connate water or the ingression of sea-water, moving inland under the influence of the heavy summer withdrawals. In either case it was assumed that to the east of the highly saline water there would be a zone where the salt and fresh water were in hydrostatic equilibrium, with the formation of an interface between the two waters. These interfaces have been discovered in other countries where similar hydrological conditions occur, and considerable research has been done, particularly in the United States and Israel. The interfaces investigated have often been well defined, and always with the heavier saline water toeing out beneath the fresh.

The position of the interface is a reflection of the hydrostatic balance between the saline and fresh waters, and variation in the head of either will cause the interface to move into the area of reduced potential, until hydrostatic balance is restored. Consequently, observation of an interface will reveal the effect of overpumping of an aquifer, and permit an assessment of the dangers of saline ingression.

Seasonal movement of an interface is quite normal in aquifers that are developed, the interface moving inland in the summer at times of high withdrawal, and retreating in the winter months as the aquifers are recharged. However, if the summer advance is greater than the winter retreat, it is obviously an indication that more water is being withdrawn than can be replaced by natural recharge processes.

To assess this situation in the western margins of the northern Adelaide Plains it was recommended that a testing programme be instigated to determine the location and behaviour of an interface in the upper aquifer, initially in the St. Kilda area, and later in other coastal areas adjacent to zones of high withdrawal. (Status Report, Saline Ingression, Northern Adelaide Plains. 11.12.1961).

A series of specially constructed observation bores was recommended, and approval was granted for the construction of six bores at an estimated cost of £7,500.

Construction of the holes commenced in September, 1962.

II. BORE CONSTRUCTION AND SAMPLING PROCEDURES

The original estimate for the programme of six test holes allowed for the use of a rotary plant to drill the upper 200 feet of each hole, the remainder to be completed by normal percussion methods. In an investigation of this type it is obvious that with the exception of the initial hole in an area, the locations of the following holes cannot be forecast, as they will depend upon the information obtained from the first. Consequently the use of two drilling plants for the project would have necessitated the rotary plant standing idle after drilling the upper portion of the hole, until the information obtained from the remainder of the hole determined the location of the next hole.

The Failing W.W.1 which was used for the rotary drilling could not be spared for such a protracted period because of other commitments, and was used only twice, once at St. Kilda, and once in the Buckland Park area. The remaining two holes of the programme were constructed with a percussion plant. Comments on the advantages and disadvantages of both rotary and percussion methods will be made at a later stage in the report.

A total of four holes were drilled, three in the St. Kilda area, and one in the Buckland Park area. Sampling procedures adopted in the investigation were as follows. Sediment samples were obtained at intervals of five feet or at change in strata, and in Bore S.W.D. 3 in the St. Kilda Area, continuous tube samples were taken in the unconsolidated material. Water samples were taken at intervals of 10 feet throughout the aquifers, with the casing as close to the bottom of the hole as practicable. A small electric submersible pump was lowered into the bore, and the bore pumped to obtain each sample. This has been found to provide more reliable information on salinity variations than the method of bailing previously adopted.

If an interface had been located it was intended that perforated plastic casing be inserted to straddle it, and fluctuations of the interface measured. A recording resistivity probe was developed by the Geophysical Section for this purpose.

The locations of test holes are shown on the attached plans, and detailed bore logs and groundwater salinities appended to the report. To distinguish the bores from previous observation bores, each bore was given the prefix S.W.D., (Saline Water Detection).

III. GEOLOGY

Three separate ages of material were encountered in the testing programme. These are in decreasing chronological order, Pleistocene to Recent, Pliocene, and lower to middle Miocene. Stratigraphic boundaries were determined on both sedimentary and palaeontological evidence, and the co-operation of the Palaeontology Section is gratefully acknowledged.

Pleistocene to Recent

With the exception of a thin cover of Recent to present day soils, and some Recent estuarine and marine sediments in the coastal area, the sediments in this division are of Pleistocene age, with a total thickness of approximately 200 feet. The

upper portion is composed of a series of fan delta and valley floor deposits, consisting essentially of red-brown variegated clays and sandy clays, with lenticular sand and gravel bands. The clays are mainly of fresh-water origin, although some brackish water fauna are found in the western limits of the area tested.

The lower portion of the sequence consists of a series of yellow fine grained clayey sheet sands. The origin of the sands is not clear, but they could have resulted from the reworking of Pliocene dunes, as although non fossiliferous, occasional small carbonate fragments are encountered, and the grain size of the sands is similar to these of aeolian origin. In some areas the yellow sands merge into the underlying Pliocene marine sands with only a colour change and the appearance of fauna to indicate the transition. In the two areas tested, the sands thin towards the west, and appear to be absent in the coastal areas.

At the base of the Pleistocene sequence is a discontinuous band of coarse grained sand, often glauconitic. This sand is most strongly developed in the vicinity of Bore S.W.D. 1, St. Kilda, and is here capped with a dense sandy limestone. The sand appears to be of marine origin, and being confined to the western margins of the coastal plains probably represents a limited Pleistocene marine phase of sedimentation. Although limited in extent it does have significance as an aquifer in some areas.

Pliocene (Dry Creek Sands).

These are a series of marine sediments deposited in an epineritic environment of stable shelf association. They consist essentially of siliceous and marly sands, occasionally consolidated, with irregular coarse shell horizons. The thickness varies as they rest on the eroded upper surface of the underlying Miocene limestones, but in general the sequence thickens and deepens from the Virginia area to the south and south-west, forming a wedge shaped deposit, the northern limits of which are shown on the attached plan.

They are approximately 50 feet thick in the Waterloo Corner area, and 90 feet at St. Kilda and Buckland Park. At Virginia, which is close to the northern limits of these sediments, they are either absent or represented by a thin bed of reworked Miocene material containing Pliocene fauna.

A facies change occurs within these sediments, the essentially siliceous sands of the Waterloo Corner area becoming finer grained and marly in the coastal areas. The change in facies, which has an important bearing on groundwater salinities, is apparently indicative of the deeper water sedimentary environment in these areas, the chemical and biologic factors of deposition increasing as the physical factors decrease with distance from the old Pliocene shoreline. The finer grained facies overlaps the siliceous facies in some areas, indicating minor depositional environment changes during the Pliocene, probably caused by eustatic variation during sedimentation.

The top of the sequence is marked by a discontinuous band of carbonaceous clay. A dense limestone occurs in some areas. These two features, which are of local hydrological significance, indicate that the marine sediments were exposed at the close of the Pliocene and prior to the deposition of the overlying Pleistocene sediments, and that limited paralic conditions prevailed, particularly in the present day coastal areas.

Lower to Middle Miocene (Port Willunga Beds)

These consist of a series of buff to grey fine grained sandy limestones, deposited in the shallow waters of a stable shelf association. The upper surface of the limestone is irregular, apparently due to erosion prior to and during the deposition of the overlying Pliocene. In some areas the top of the limestones have been recemented, forming a dense hard capping to the underlying softer varieties.

At varying depths below the top of the sequence is a band of blue-grey silty and slightly fossiliferous clay. The bed is of varying thickness, but rarely exceeds 25 feet, and is the aquiclude separating the upper and lower pressure water aquifers. It is well defined in the Waterloo Corner and St. Kilda areas, but is less defined and possibly discontinuous in the Buckland Park area. It is one of the few marker horizons occurring in the Tertiary sediments and indicates minor flexuring within the Miocene.

IV. HYDROLOGY AND CONFIGURATION OF SALINITY ZONES

The testing programme revealed that a different set of conditions to those envisaged at the commencement of the investigation prevail. The salt-fresh interface was not encountered, and an unexpected situation was revealed, with highly saline water overlying water of low salinity. This apparently anomalous condition was encountered in both the St. Kilda and Buckland Park areas, but because of variations at each site, the areas will be discussed separately.

Waterloo Corner - St. Kilda

Three test bores were constructed on this section line, Bores S.W.D. 1, S.W.D. 2, and S.W.D. 3, and the information collated with existing bores at St. Kilda and Waterloo Corner.

In Bore S.W.D. 1 saline water was encountered throughout the upper aquifer, although overlain by a thin perched low salinity aquifer at the base of the Pleistocene. This was essentially similar to conditions in the E. & W. S. Bore at St. Kilda, and it was assumed that saline ingression had advanced further east. Accordingly Bore S.W.D. 2 was constructed approximately 30 chains east of Bore S.W.D. 1.

Saline water was encountered throughout the Pliocene sediments, but immediately below a band of dense limestone at the top of Miocene sediments relatively low salinity water occurred, and continued to the base of the upper aquifer, i.e. to

the blue-grey clay. The dense limestone is sufficiently impervious to have acted as an aquiclude, and it was assumed that the saline-fresh interface was still farther east, the upper aquifer being divided into two aquifers by the limestone in this area. Bore S.W.D. 3 was constructed approximately 25 chains to the east of Bore S.W.D. 2.

In Bore S.W.D. 3 the upper portion of the Pliocene sequence contained highly saline water, greater than 28,000 p.p.m., (2,000 grains per gallon), whereas in the remainder of the upper aquifer low salinity water, 580 to 870 p.p.m., (40 to 60 grains per gallon) was encountered. The transition was sharp, but no obvious permeability barrier separated the two widely contrasted salinity zones, although it was observed that the saline water was contained in sediments which were much less permeable than those containing the low salinity water.

The varying salinity zones, and the inferred zone boundaries are shown on the attached section. It shows that the saline water overlies the fresh, with the exception of the eastern margins of the saline zone. In this area a normal type of saline fresh interface probably occurs within the lower Pleistocene sands. This has been postulated on indirect evidence, as no interface was encountered, but bores to the south and north of the section indicate that there is a strong possibility of a zone of fresh water overlying the saline.

The lens of low salinity water encountered in the Pleistocene sands in Bore S.W.D. 1 is of limited extent, apparently recharged from the south, and protected from the overlying and underlying saline waters by the dense limestone capping and carbonaceous clay base.

When completed, all three observation bores were adapted for long term observation purposes. Bore S.W.D. 1 was modified to permit a study of the behaviour of the saline water, and Bores S.W.D. 2 and S.W.D. 3 were modified so that both the saline and fresh waters could be observed simultaneously.

Regular static water level measurements of both waters is proposed to check on the behaviour of the saline water under the influence of the fluctuating low salinity water levels.

Virginia - Buckland Park

A similar situation to that of the St. Kilda area was encountered in this section, in that a zone of saline water, underlain by low salinity water was detected. With only two bores the area cannot be evaluated as fully as at St. Kilda, but sufficient information is available to assess the conditions.

In Observation Bore E, which was constructed during a previous investigation, it was discovered that the Pliocene sediments contained highly saline water. The underlying Miocene limestones contained low salinity water, the two salinity zones being separated by a 1 feet thick sandy clay aquiclude at the base of the Pliocene. The Pliocene sediments appeared to be of similar permeability to those containing low salinity water farther inland, and it was assumed that the saline-fresh interface was located further east. Therefore Bore S.W.D. 1 Buckland Park was constructed approximately 55 chains east of Bore E in an attempt to detect the interface.

In this bore saline water was encountered in the upper portion of the Pliocene sediments, underlain by low salinity water. No obvious impermeability barrier separates the two zones, but as in the St. Kilda area the saline water is contained in the finer grained, clayey, and less permeable facies of the Pliocene sediments.

To check on the salinity variations in Bore S.W.D. 1 Buckland Park, the bore was backfilled for a depth of 80 feet, the casing being withdrawn and the bore backfilled with clay and cement in 10 feet stages, and further samples were taken. The saline-fresh boundary was not detected during the process of backfilling, and as can be seen from the salinities on the attached

section, lower salinities than those recorded when the hole was being constructed were obtained. The reason for this is not clear, but it is thought, that, although every precaution was taken in the backfilling operations, a complete seal was not obtained, and when the bore was pumped low salinity water was drawn up past the seal.

V. CONCLUSIONS

The test drilling in the St. Kilda and Buckland Park areas has revealed that the Pliocene sediments thicken and deepen in these areas, and that a facies change is associated with the deepening. The siliceous sands of the Waterloo Corner area become finer grained with a marked increase in clay and marl content in the coastal areas, reflecting the changing sedimentary environment associated with the gradual deepening of the Pliocene bottom. The transition between the siliceous facies and the marly facies is relatively sharp, and within the transition zone there appears to be a greater clay content than elsewhere.

The facies variations within the Pliocene have a resultant effect upon permeabilities, the finer grained marly and clayey varieties being much less permeable than the siliceous sands in the shallower portions of the basin. The varying permeabilities within the sediments have a marked effect on groundwater salinities within the upper aquifer, the permeable varieties containing low salinity water, generally less than 850 p.p.m., (60 grains per gallon), whereas highly saline water occurs in the less permeable.

This relationship occurs even when the less permeable sediments are underlain by the permeable facies, and in these cases a zone of highly saline water is underlain by low salinity water, the transition occurring within a few feet. No obvious

impermeability barrier separates the two salinity zones, and obviously the saline water must be contained in sediments which are sufficiently impermeable to prevent the downward percolation of the heavier saline water under the influence of gravity.

Similarly these sediments would oppose lateral groundwater movement, and consequently the replacement of the high salinity waters by low salinity recharge waters would be prevented or retarded. That some replacement has occurred is evident in the differences in salinity within the saline zone, and lithological variations within the Pliocene sediments must be such that all degrees of flushing by the low salinity water have taken place.

Therefore in the areas tested it is considered that the zone of highly saline water is not the result of saline ingression, but is due to incomplete flushing of the aquifer by low salinity recharge water. The westerly migration of the recharge waters is arrested by a permeability barrier within the Pliocene sediments, and the saline water contained within the finer grained and marly facies is either connate or "fossil" groundwater, much older than the present day low salinity waters. The paralic nature of the sedimentary environment at the close of the Pliocene and beginning of the Pleistocene eras would permit intake of various quality waters into the sediments, and the abnormally high salinities recorded in some areas probably result from evaporation during the periods of exposure.

Instances of groundwater salinities varying with aquifer permeabilities have also been recorded in other areas. In the Port Gawler area, (Sect. 28, Hundred Port Gawler) highly saline water, (500 to 1000 grains per gallon), was encountered in a very clayey Pliocene facies, whereas surrounding bores in which the normal Pliocene sands were encountered contain low salinity water. In the Lockleys district, a band or lens of saline water was discovered in a bore on the Kooyonga Golf Course, the saline water being contained in a clayey facies sandwiched between more permeable sediments containing low salinity water. Other

instances have been found in the Murray Basin.

The occurrences appear more pronounced in areas of lower pressure head, as in areas with greater pressures, apparently similar impermeable sediments have been completely flushed of original saline waters. In these cases the restrictions imposed by the lower permeabilities are apparently overcome by the greater pressures.

Whether Pliocene sediments to the west of the saline-fresh boundary are all of a similar impervious nature or whether the low permeability is confined to a linear zone of the transition between the two facies is not known for sure, but indications are that the least permeable material does occur in the transition zone.

The existence of this permeability barrier will greatly reduce the danger of widespread lateral saline ingression in the coastal areas. The restrictions of groundwater movement imposed by the barrier would apply to the saline water as well as the fresh, and consequently inland movement of the saline water will be possible only through zones of higher permeability within the Pliocene sediments.

There must be an outlet for the low salinity waters at some area in the western margins, otherwise replacement of the original saline waters would not have taken place. Presumably the outlets are where higher permeabilities occur within the Pliocene sediments, the low salinity waters being diverted at the permeability barrier to these points. Because of the lack of accessible bores in the area, there is insufficient water level information to construct a detailed piezometric surface for the upper aquifer, but from the information available it would appear that possible outlets are to the south of St. Kilda. At these outlets there would be a direct connection between the fresh water and the sea, and probably also a salt-fresh interface reflecting the hydrostatic balance between the two.

Rapid saline ingression would only occur where there is a direct connection, and from the available information it would appear that this is well to the south of the heavily developed areas. Therefore, provided the permeability barrier is continuous in the coastal area between Pt. Gawler and St. Kilda, the encroachment of saline water into the upper aquifer in the Waterloo Corner and St. Kilda areas is not imminent.

However the continuity of the permeability barrier has not been established, and further investigation of the problem will be required before the situation can be fully evaluated.

VI. RECOMMENDATIONS

To validate the conclusions that the areas of high withdrawal are protected from saline ingression by a permeability barrier, two lines of investigation will be necessary, the first to establish the continuity of the barrier adjacent to the heavily developed areas, the second to locate possible outlet zones south of St. Kilda.

1. The permeability barrier has been established in only two localities, and continuity between St. Kilda and Port Gawler has yet to be established. This is of the utmost importance, as the dangers of saline ingression into the Virginia and Waterloo Corner areas are only reduced if a continuous coastal barrier is present.

Testing in at least two other localities is recommended, to reduce the amount of interpolation necessary with the present available information. The two areas are indicated on the attached plan (Areas A and A'), and have been located approximately mid-way between existing lines of observation bores. The number of bores required to establish the saline-fresh water boundary is difficult to assess, but it is estimated that three bores to a depth of 300 feet would be required in each area.

Similar drilling and sampling procedures to those adopted in the St. Kilda and Buckland Park areas are suggested. In addition, undisturbed sampling techniques should be adopted wherever practicable, and laboratory determinations on the permeabilities and porosities of the varying sedimentary facies undertaken. From these it may be possible to assess more fully the protection offered by the permeability barrier.

A study of the relationship between the water levels of the saline and fresh water, similar to that at present being carried out in the St. Kilda area, is suggested in boreholes where both saline and fresh water are encountered in the upper aquifer.

2. The extension of the less permeable Pliocene facies to the south of St. Kilda has not been established. As can be seen from the attached plan the postulated eastern boundary of the zone of saline water swings sharply to the south-west below St. Kilda, crossing the northern portion of Torrens Island, and extending across the northern tip of Le Fevre Peninsula. This boundary has been positioned from the information from only three bores, all of which are standard water supply bores, and were not sampled in the detail of observation bores. Consequently the boundary is interpretive, and the origin of the saline water, and the aquifer characteristics are not known. The saline water could be of similar origin to that occurring in the St. Kilda area, or it could be the seaward side of advancing saline ingression.

To assess the situation a series of observation bores within the upper aquifer is recommended. The area for the series is indicated on the attached plan, (Area B). It is situated within the I.C.I. evaporating ponds, and drill sites will be confined to the western banks of the ponds. A line of bores commencing at the northern end of the indicated area and extending south is suggested.

Bores in this area will outline the southerly extension of the Pliocene impermeable facies, and will also provide information on possible outlet points for the pressure waters. In addition they will act as outpost observation bores against saline ingression should the outlet occur in the area.

A minimum of three 300 feet deep bores will be required, and sampling procedures similar to these mentioned above should be adopted.

The testing programmes outlined above imply the use of percussion constructional methods. The use of rotary methods in this investigation was not an unqualified success, as the two inherent disadvantages of rotary drilling, straightness of hole and poor sample return were particularly apparent. In an area where no precise lithological information is available, and where significant facies variations may be represented by a few feet of sediments, the poor quality samples of the rotary methods do not provide sufficient information on lithology, and salinity variations within an aquifer are not detected. Where long term measurement is proposed, especially where waters of varying salinities are being observed, the mechanical soundness of the bore is very important, and this is difficult to achieve within the necessary small limits with the rotary methods. To obtain the maximum amount of information in the testing programmes percussion methods are therefore recommended.

However because of the relatively low cost and rapid construction rates of uncased rotary holes, rotary methods could be used to advantage provided electric logging, particularly micro logging was available. This would apply mainly to exploratory bores, where the bores are not required for long term observation, and provided the logging equipment can be calibrated to ensure reliable salinity determinations, the method would be invaluable.

Similar techniques have been developed overseas, and it is suggested that the provision of micro logging equipment warrants further investigation.

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PGM:CH:AGK
4.10.63

APPENDIX

BORE LOGS AND SALINITIES

St. Kilda Area: Bores SWD1, SWD2 and SWD3

Buckland Park Area: Bore E and SWD1

DEPARTMENT OF MINES, ADELAIDE

WATER BORE LOG

Name: DEPARTMENT OF MINES — **Bore Serial No.:** 597/63

Address: ST. KILDA — **D.M.:** 2193/61

Hundred: PORT ADELAIDE — **SECTION:** Road Junction N.E. Corner Sect. 316

Hirer's Bore No.: S.W.D. 1. St. Kilda — **Driller:** D.R. PHILLIPS & R. STREMPEL

Date Drilling commenced: 12.9.1962 **Completed:** 4.12.1962

Rotary Samples — **LOG**

Surface to 168'

At 20'	Grey-brown, reddish-brown and light grey mottled clay. Frequent pockets lime and shell fragments.
" 40'	As above.
" 60'	Red-brown, light greenish-grey and grey brown mottled clay. Frequent small lime nodules.
" 80'	Yellowish-brown, light-grey and reddish-brown silty and sandy clay. Frequent quartz grit.
" 100'	As above.
" 120'	Yellowish-brown, light grey and reddish-brown sandy clay. Micaceous.
" 140'	As above.
" 160'	Light brown, light grey and yellowish-brown sandy clay. Occasional small shells.
" 168'	As above.

Percussion Samples

168' - 175'	Yellow, fine sand with some clay.
175' - 185'	Travertine limestone, white with some pale green mottling.
185' - 190'	Pale-grey to white fine sand.
190' - 197'	Off-white fine to coarse grey sand with occasional shell fragments and some glauconite (73 grains water).
197' -200'	Greenish-grey and yellowish-grey silty and finely sandy clay.
200' - 205'	Dark grey-brown carbonaceous and micaceous clay.
205' - 211'	Pale grey-brown medium grained sand with quartz grit and occasional shell fragments.
211' - 212'	Light grey finely sandy marl.
212' - 215'	Light grey medium to coarse grained sand with occasional shell fragments, and pockets of carbonaceous clay.
215' - 245'	Light grey sandy and silty marl with occasional small shells,

WATER BORE LOG No. S.W.D. 1
(contd.)

245' - 260' Light grey sandy marl to light grey calcarenite with frequent shells and shell fragments.

260' - 266' Light-grey calcareous sand with very abundant shell fragments.

266' - 290' Light-grey marly sand with occasional shell fragments, and thin hard consolidated limestone bars.

290' - 306' Yellowish-grey sandy limestone. Slightly fossiliferous.

306' Blue-grey clay.

END OF BORE AT 306'

Casing Details

240' of 1½" diam. pipe. Seated to clay band 200'-205'.

R.L. top of pipe 122.8.

WATER CUT feet below surface	WATER LEVEL feet below surface	SUPPLY		ANALYSIS	
		G.P.H.	How Tested	grs./gall	No.
175'	8'	-	-	75.9	W2266/62
265'	10'	-	-	1216.7	W2267/62
285'	-	-	-	1800(D.T.)	
295'	-	-	-	7200(D.T.)	
310'	-	-	-	2880(D.T.)	

Remarks: All for palaeontological examination.

Bore logged by: P.G. Miller

Date: 6.2.1963.

DEPARTMENT OF MINES, ADELAIDE

WATER BORE LOG

Name: DEPARTMENT OF MINES
Bore Serial No.: 612/63
Address: ST. KILDA
D.M.: 2193/61
Hundred: PORT ADELAIDE
Section: Road Junction N.E. Corner Section 130
Hirer's Bore No.: S.W.D. 2. St. Kilda
Driller: D. Phillips
Date Drilling commenced: 2.10.1962 Completed: 19.11.1962

LOG

1' - 5'	Reddish-brown slightly clayey sand.
5' - 15'	Brown and grey-brown silty clay. Occasional lime nodules.
15' - 30'	Light grey, reddish-brown and pale brown silty and sandy clay. Occasional lime nodules.
30' - 35'	Grey silty clay with pockets of light greenish-grey and reddish-brown mottled clay. Occasional lime nodules.
35' - 42'	Light grey and reddish-brown sandy clay with frequent lime nodules.
42' - 45'	Grey-brown silty clay, occasional lime nodules.
45' - 55'	Slightly clayey coarse grained sand and fine gravel.
55' - 70'	Red-brown and light-greenish grey mottled sandy clay with frequent quartz grains. Occasional small lime nodules.
70' - 90'	Yellowish-brown and light-grey mottled silty and sandy clay with occasional small lime nodules.
90' - 95'	Reddish-brown, light grey and yellowish-brown sandy and silty clay. Occasional lime nodules.
95' - 105'	Red-brown and light greenish grey mottled sandy clay with frequent quartz gravel fragments.
105' - 120'	Reddish-brown and light grey sandy clay, occasional quartz grit.
120' - 135'	Yellowish-brown and light-grey slightly clayey fine sand, becoming coarser grained with depth.
135' - 150'	Light-grey and yellowish-brown sandy clay, grading to a clayey fine sand with depth.
150' - 200'	Fine yellow sand, slightly clayey with occasional small quartz gravel.
200' - 205'	Grey-brown fine sand, slightly clayey.
205' - 210'	Dark grey carbonaceous sandy clay.
210' - 220'	Grey clayey sand, occasional shell fragments. Calcareous.
220' - 225'	Grey clayey calcareous sand, abundant large shell fragments.
225' - 265'	Pale grey marly fine sand, occasional shell fragments. Large shell fragments 255' - 265'.

WATER BORE LOG NO. S.W.D. 2 St. Kilda (contd.)

265' - 275'	Hard grey sandy limestone, fossiliferous.
275' - 285'	Grey calcareous sand with lumps of consolidated sandy limestone. Fossiliferous.
285' - 290'	Light grey sandy limestone. Fossiliferous.
290' - 300'	Pale-brown sandy limestone. Fossiliferous.
300' - 305'	Dark grey sandy clay with pockets of clayey sand.
305' - 327'	Grey clay with pockets of dark grey clay and frequent lime nodules.
327' - 330'	Grey clay with patches of bryozoal limestone.
330' - 340'	Light grey bryozoal limestone.

END OF BORE AT 340'.

Casing Details

264' of 8" casing. Seated on hard bar. Slotted.

258'6" of 1½" pipe. Sealed to casing at 257'6".

R.L. top of casing 119.1.

R.L. top of pipe. 120.0

WATER CUT Feet below surface	WATER LEVEL Feet below surface	SUPPLY		ANALYSIS	
		g.p.h.	How tested	grs./gall	No.
15'	-	-	-	(D.T.) 1750	W2271/62
50'	-	-	-	(D.T.)4200	W2272/62
225'	-	-	-	(D.T.)1900	W2653/62
235'	-	-	-	(D.T.)1900	W2654/62
245'	-	-	-	(D.T.)1775	W2655/62
255'	-	-	-	(D.T.)1650	W2656/62
265'	-	-	-	2025(D.T.)	W2657/62
275'	-	-	-	117.5	W2658/62
285'	-	-	-	270.3	W2659/62
295'	-	-	-	303.7	W2660/62
330'	-	-	-	181.7	W2661/62
340'	-	-	-	182.2	W2662/62

Remarks: 200' - 300' for Palaeo.

Bore logged by: P.G. Miller

Date: 6.2.1963

DEPARTMENT OF MINES, ADELAIDE

WATER BORE LOG

Name: DEPARTMENT OF MINES
Bore Serial No.: 668/63
Address: ST. KILDA
D.M.: 2193/61
Hundred: PORT ADELAIDE
Section: Road Junction N.E. Corner Section 185
Hirer's Bore No.: S.W.D. 3 St. Kilda
Driller: D. Phillips
Date Drilling commenced: 7.12.1962 **Completed:** 21.12.1962.

LOG

0' - 5'	Sandy clay, abundant pockets lime. Red-brown.
5' - 20'	Sandy clay. Grey brown and yellow brown mottled. Occasional pockets and nodules of lime.
20' - 40'	Silty and sandy clay with small lime nodules. Brown and light greenish-grey mottled.
40' - 60'	Silty and sandy clay with small lime nodules. Micaceous. Reddish-brown and light greenish-grey mottled.
60' - 70'	Sandy clay. Micaceous. Yellow-brown and light grey mottled.
70' - 75'	Medium to coarse grained clayey sand. Brown.
75' - 100'	Silty clay with pockets of sand. Micaceous. Brown, grey and yellow-brown mottled. Occasional quartz gravel and lime nodules.
100' - 115'	Clayey medium grained sand with occasional quartz grit. Yellow-brown.
115' - 130'	Coarse grained clayey sand with quartz grit. Brown to yellowish-brown.
130' - 165'	Fine grained clayey sand to sandy clay. Pale grey, reddish-brown and yellow-brown mottled. Occasional quartz gravel.
165' - 175'	Fine grained slightly clayey sand. Pale brown.
175' - 195'	Fine siliceous sand. Yellow, becoming orange with depth.
195' - 200'	Fine siliceous sand. Grey to grey-brown.
200' - 210'	Fine marly sand. Occasional shell fragments. Grey.
210' - 222'	Fine marly sand and silt. Moderately abundant shells and shell fragments.
222' - 224'	Hard sandy limestone. Fossiliferous.
224' - 235'	Fine grained limey and marly sand and silt. Occasional shell fragments. Grey.
235' - 240'	Marly silty sand, frequent shell fragments. Grey.
240' - 241'	Very fine grained calcareous sand, slightly marly. Very occasional shell fragments. Grey.
241' - 249'	Fine grained marly sand and silt with frequent shells and shell fragments. Very abundant shells 241'-243'.
249' - 251'	Fine grained siliceous sand, slightly marly. Very abundant shells. Pale grey.

WATER BORE LOG NO. S.W.D. 3
(contd.) ST. KILDA

251' - 253' Moderately hard sandy limestone. Fossiliferous. Grey.

253' - 280' Grey sandy limestone. Soft. Fossiliferous. Grey.

280' - 290' Fossiliferous sandy limestone. Yellowish-grey.

290' - 295' Clay, slightly fossiliferous. Blue grey.

END OF BORE AT 295'

Casing Details

6" casing seated at 253'. Slotted 218' - 228'

1½" diam. pipe. Sealed to casing at 253'.

R.L. top of 6" casing 121.3

R.L. top of 1½" pipe 124.2

WATER CUT Feet below	WATER LEVEL Feet below	SUPPLY		ANALYSIS	
		g.p.h.	How Tested	grs./gall.	No.
20	5	-	-	3650(D.T.)	W601/63
115	115	-	-	1970(D.T.)	W602/63
185	115	-	-	2640(D.T.)	W603/63
205	30	-	-	2400(D.T.)	W604/63
215	30	-	-	2700(D.T.)	W605/63
225	30	-	-	2900(D.T.)	W606/63
235	30	-	-	2600(D.T.)	W607/63
245	-			41.4	W608/63
251				53.7	W609/63
265				160.1	W834/63
275				63.2	W835/63
285				65.4	W836/63
295				58.7	W837/63

Remarks: 200' - 295' for Palaeontological examination.

Bore logged by: P.G. Miller

Date: 6.2.1963

DEPARTMENT OF MINES, ADELAIDE

WATER BORE LOG

Name: DEPARTMENT OF MINES **Bore Serial No.:** PD 606/62
Address: BUCKLAND PARK **D.M.:** 1651/60
Hundred: PORT ADELAIDE **Section:** 161
Hirer's Bore No.: E **Driller:** D. Phillips
Date Drilling commenced: 1.11.1961 **Completed:** 24.11.1961

LOG

0 - 4'	Clay embankment.
4 - 12'	Grey silty clay with shell fragments.
12 - 42'	Grey-blue and grey-brown mottled clay, small lime nodules.
42 - 60'	Bluish-grey yellow brown to brown finely sandy clay with occasional shell fragments.
60 - 70'	As above with grit fragments.
70'- 80'	Light brown clayey sand with frequent quartz gravel.
80 - 100'	Red-brown and light greenish-grey mottled slightly sandy clay. Occasional quartz grit.
100 - 105'	Reddish-brown clayey sand with abundant rounded quartz gravel fragments.
105 - 138'	Red-brown and light greenish-grey mottled clay with frequent quartz grit fragments.
138'- 165'	Light grey and light yellowish-grey mottled finely sandy clay. Occasional gravel fragments.
165 - 180'	Grey and yellow-brown mottled sandy clay.
180 - 205'	Light-grey and yellow-grey mottled finely sandy clay. Micaceous. Small lime nodules.
205 - 210'	Grey and yellow mottled finely sandy clay, indurated in part.
210 - 212'	White sugary limestone.
212 - 225'	Grey sandy limestone. Slightly fossiliferous. Sugary texture.
225 - 235'	Grey finely sandy limestone.
235 - 257'	Grey sand with large shells.
257 - 271'	Grey sandy limestone, possible bryozoa.
271 - 278'	Hard sandy limestone bars with interstitial softer limestone with frequent shell fragments.
278 - 298'	Grey sandy limestone, fossiliferous. Hard bar 292' - 292'6".
298 - 299'	Blue-grey sandy clay with frequent shell fragments
299 - 310'	Grey and yellowish-grey bryozoal limestone.
310 - 320'	Dark blue-grey clay with frequent shell fragments.
320 - 350'	Grey-bryozoal limestone.

END OF BORE AT 350'.

Casing 274' of 8", 321' of 6", 40' of 5" Slotted

WATER BORE LOG No. E BUCKLAND PARK
(contd.)

WATER CUT Feet below surface	WATER LEVEL Feet below surface	SUPPLY		ANALYSIS	
		g.p.h.	How tested	grs./gall.	No.
250	161	-	-	6708.4	W466/61
290	14	-	-	2345.5	W469/61
300	1	-	-	ATS 152	W470/61
310	45	-	-	ATS 232	W471/61
320	30	-	-	ATS 124	W472/61
330	25	-	-	ATS 81	W473/61
340	9	-	-	ATS 131	W474/61
350	1	1000+	-	55.4	

Remarks: All for palaeontological examination

Bore logged by: P.G. Miller

Date:

DEPARTMENT OF MINES, ADELAIDE

WATER BORE LOG

Name: DEPARTMENT OF MINES	**Bore Serial No.:** PD 610/63
Address: BUCKLAND PARK	**D.M.:** 2193/61
Hundred: PORT ADELAIDE	**Section:** Roadway, Northern corner Sect. 175
Hirer's Bore No.: SWD 1	**Driller:** D.R. Phillips, A. Sturak, R.Strempel
Date Drilling commenced:	**Completed:** 24.1.1963

LOG

Surface to 200' drilled with Rotary Plant

At 20'	Clayey medium grained sand. Reddish-brown.
40'	Silty and finely sandy clay. Reddish-brown, grey brown and greenish-grey mottled. Pockets and nodules of lime.
60'	As above.
80'	Silty clay with pockets and nodules of lime. Red-brown, brown and light greenish-grey mottled.
100'	Silty clay. Red-brown and light greenish-grey mottled.
120'	Gritty and sandy clay, and clayey sand. Reddish-brown.
140'	Silty and finely sandy clay. Reddish-brown, grey-brown and light greenish grey mottled.
160'	Sandy clay with frequent quartz gravel. Reddish-brown and light greenish-grey mottled.
180'	As above.
200'	As above, with pockets of medium grained sand.

Percussion Samples.

200' - 205'	Fine grained slightly clayey sand. Pale yellow
205' - 212'	Hard sandy limestone. Offwhite to pale yellow.
212' - 222'	Fine grained to medium grained slightly clayey sand with abundant shells and shell fragments. Pale grey.
222' - 242'	Fine grained clayey sand with frequent small shells and shell fragments. Grey.
242' - 252'	Sandy limestone and clayey sand with abundant shells and shell fragments. Grey.
252' - 282'	Sandy limestone. Fossiliferous. Grey.
282' - 292'	Fine grey sand with lumps of sandy limestone. Abundant shells and shell fragments. Light grey.
292' - 302'	Sandy limestone and sand with frequent shells. Grey.
302' - 310'	Fine grained sand with frequent shells and shell fragments. Pale grey.

WATER BORE LOG NO. SWD 1
BUCKLAND PARK (contd.)

310' - 320'	Very fine grained marly and clayey sand. Fossiliferous grey.
320' - 325'	As above with bands of blue grey clay.
325' - 330'	Bryozoal limestone with bands blue grey clay.
330' - 335'	Fine grained sandy limestone. Pale grey. Fossiliferous.

END OF BORE AT 335'

WATER CUT Feet below surface	WATER LEVEL Feet below surface	SUPPLY		ANALYSIS	
		g.p.h.	How tested	grs./gall.	No.
220'	40	-	-	878.1	W2781/62
230'	40	-	-	450.4	W2782/62
240'	40	-	-	447.5	W2783/62
250'	40	-	-	700.8	W2784/62
263'	10	-	-	88.5	W2785/62
270'	10	-	-	64.1	W2786/62
270'	10	-	-	52.8	W695/63
280'	10	-	-	52.1	W696/63
290'	10	-	-	52.5	W697/63
300'	10	-	-	54.5	W2800/63
310'	10	-	-	55.7	W692/63
320'	10	-	-	66.2	W693/63
330'	10	-	-	90.9	W694/63
Samples obtained when bore was backfilled					
245'	9	-	-	66.2	W690/63
255'	9	-	-	48.5	W689/63
265'	9	-	-	45.5	W688/63
275'	9	-	-	43.7	W687/63
285'	10	-	-	41.9	W686/63
295'	10	-	-	46.4	W685/63
305'	10	-	-	51.4	W684/63
315'	10	-	-	52.6	W683/63
325'	10	-	-	53.9	W682/63

Remarks: All for palaeontological examination.
Bore backfilled and casing removed.

Bore logged by P.G. Miller

Date 18.2.1963.

Hº PORT ADELAIDE — Hº MUNNO PARA

ST KILDA — E.&W.S. Bore, St Kilda — S.W.D.1 — S.W.D.2 — S.W.D.3 — Bore B Sect. 5021 — Bore J Sect. 5022 — Bore B Sect. 5023 — WATERLOO CORNER — Port Wakefield Rd — Bore A Sect. 4252 — DIREK

R.L. 100·0 — R.L. 100·0

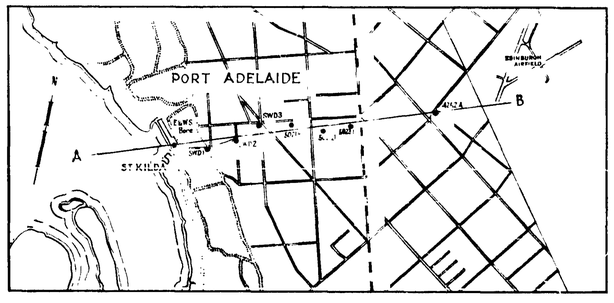
Upper Marine Aquifer — 1200+

Lower Marine Aquifer — 116 — Grey foss. limestone — Grey-green, soft sandy silty limestone

147 — 101 — 47 — 45 — 45 — 162

SCALE
Horizontal — 10 chains to 1 inch
Vertical — 50 feet to 1 inch

LOCALITY SKETCH



LEGEND

PLEISTOCENE TO RECENT
- Mottled clays with minor sands & gravel lenses
- Fine grained sands, slightly clayey in part
- Dense, hard, sandy limestone
- Medium to coarse grained sands

PLIOCENE
- Dark brown carbonaceous silty clay
- Fine grained siliceous & marley sands with irregular horizons containing abundant large shells & shell fragments (Dry Creek sands)

MIOCENE
- Dense hard sandy limestone slightly fossiliferous
- Soft sandy limestone, v fossiliferous (Port Willunga Beds)
- Blue grey silty clay, fossiliferous

SALINITIES
- Greater than 1000 grains per gallon
- Greater than 200 grains per gallon
- Less than 200 grains per gallon
- 1060 — Salinity grains per gallon at this depth
- 162 — Salinity grains per gallon, reported over this range

To accompany report by P.G. Miller

S.A. DEPT. OF MINES

Associated Drawing	No.	No.	Amendment	Exd.	Date

Req. No.
D.M.
Compiled from

ST. KILDA AREA
DETECTION OF COASTAL SALINE WEDGE
SECTION: ST. KILDA - WATERLOO CORNER - DIREK

Approved	Passed		
Director of Mines		Drn.	
		Tcd. F.B.	
		Ckd.	
		Exd.	

Scale: As Above
63-507
Ha 1/2
Date 20·6·63

KORUNYE

ROSEWORTHY

LIGHT RIVER

PORT GAWLER

MUDLA WIRRA

GAWLER

GAWLER RIVER

ANGLE VALE

SOUTH PARA RIVER

PORT GAWLER

VIRGINIA

MUNNO PARA

PORT ADELAIDE

WATERLOO CORNER

ELIZABETH

PARA WIRRA

PARA RIVER

BOLIVAR

SALISBURY

LITTLE RIVER

OUTER HARBOUR

YATALA

GEPPS CROSS

138° 25′ 138° 30′ 138° 35′ 138° 40′ 138° 45′

34° 35′ 34° 40′ 34° 45′ 34° 50′

LEGEND

Less than 80 grains/gall.
Suitable for most market garden irrigation

80-100 grains/gall.
Suitable for limited garden irrigation

100-200 grains/gall.
Suitable for lucerne and pasture irrigation and for very tolerant vegetable

Greater than 200 grains/gall.
Generally not suitable for any irrigation
Suitable for most stock purposes.

Area where the upper marine aquifer contains water less than 80 grains/gall. whereas the lower marine aquifer is of the quality indicated

Area where the upper marine aquifer contains highly saline water whereas the lower marine aquifer is of the quality indicated.

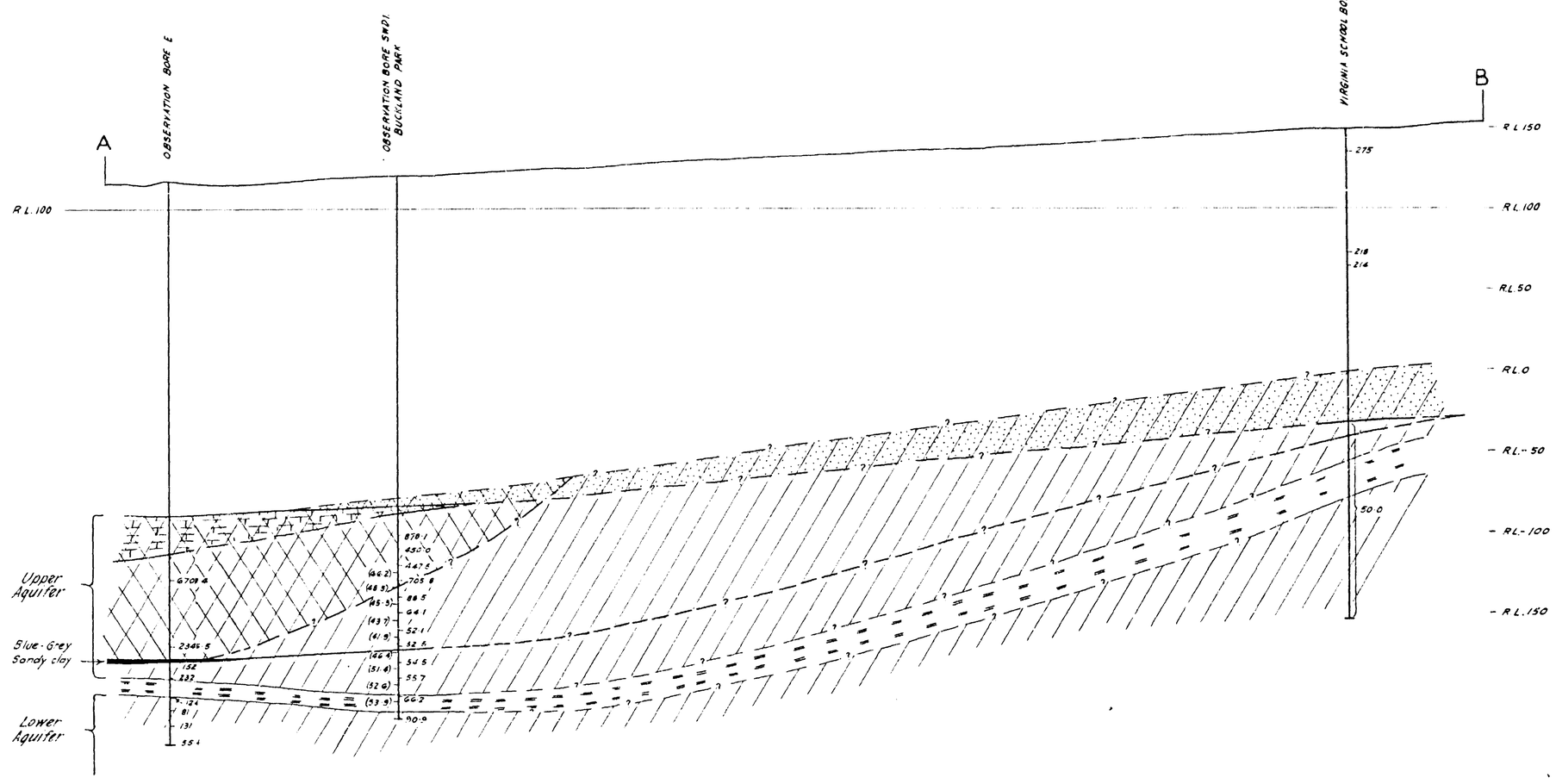
SCALE

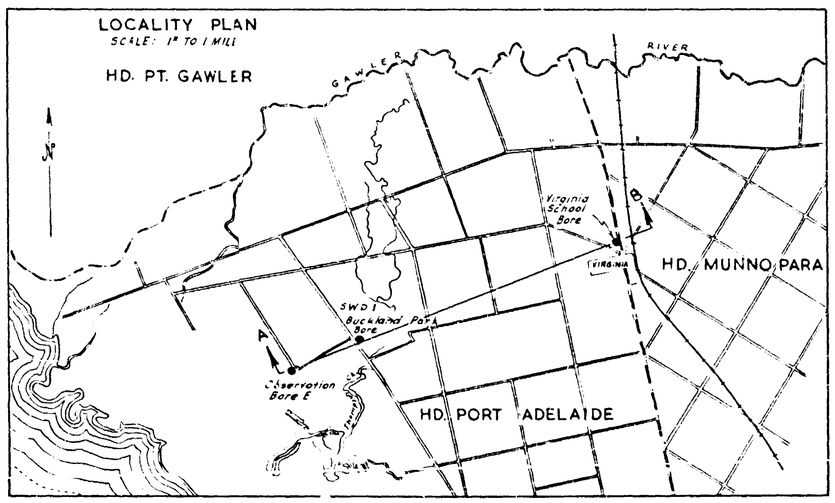
MILES 1 0 1 2 3 4 5 MILES

62-775

P. G. Miller Geologist

S. A. Dept. of Mines





LEGEND

PLEISTOCENE TO RECENT

- Mottled clays with irregular gravel and sand lenses
- Fine grained sands

PLIOCENE

- Sandy limestone with hard dense capping
- Fine grained siliceous and marly sands, consolidated in part, with irregular horizons containing abundant shells and shell fragments (Dry Creek Sands) Blue-grey sandy clay.

MIOCENE

- Fossiliferous sandy limestones. (Port Willunga Beds)
- Blue-grey silty fossiliferous clay.

SALINITIES

- Greater than 500 grains per gallon
- Less than 200 grains pre gallon

- 60 — Salinity grains per gallon at this depth. Figures in brackets are samples taken when bore was being back filled (SWD 1 only)
- >120 — Salinity in grains per gallon over this range.

SCALE HORIZONTAL 1" = 20 CHAINS
VERTICAL 1" = 50 FEET

To accompany report by P.G. Miller

S.A. DEPT. OF MINES

Associated Drawing	No.	No.	Amendment	Exd.	Date

Req. No.
D.M.
Compiled from

BUCKLAND PARK AREA
DETECTION OF COASTAL SALINE WEDGE
SECTION FROM BUCKLAND PARK TO VIRGINIA

Approved	Passed
Director of Mines	

Drn.
Tcd. A.O.W.
Ckd.
Exd.

Scale: As Shown
63 - 674
Ha 1/2
Date 14-8-63