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1981/3. Groundwater investigations at Seven Mile Beach for the Royal Hobart Golf Club

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CONTENTS

ABSTRACT	1
INTRODUCTION	1
Previous investigations	2
Present investigations	2
Presentation of results	4
GEOLOGY	4
General comments	4
Quaternary geology	4
HYDROLOGY	6
Surface hydrology - rainfall and drainage	6
Groundwater hydrology	7
Groundwater movement in the aquifer	7
Yields from spear bores	9
GROUNDWATER CHEMISTRY	10
General comments	10
Salinity contour map	10
Groundwater types	10
Suitability of the groundwater for irrigating fairways	11
THE PRESENT IRRIGATION SYSTEM AT THE GOLF CLUB	14
General discussion	14
Salinity of the water presently used for irrigation on the fairways	15
CONCLUSIONS	17
Discussion	17
Recommendations	18
Stage 1	18
Stage 2	18
Estimates of costs	19
REFERENCES	19
APPENDIX 1: Bore logs	20
APPENDIX 2: Detailed description and discussion of the Quaternary water-bearing sediments	58
APPENDIX 3: Chemical analyses of groundwater from selected bores at Seven Mile Beach	61
APPENDIX 4: Technical details of spear bores and specifications of screens suitable for Seven Mile Beach aquifer	77

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Abstract

The Royal Hobart Golf Club and surrounding area is underlain by up to 15 m of unconsolidated water-bearing Holocene sediments considered to be of marine and lagoonal origin. The base of the aquifer is an estuarine clay of Holocene or possibly Pleistocene age.

Three different types of groundwater exist in the sediments. Type 1 is a saline sodium chloride groundwater, unsuitable for irrigation, occurring in the lagoonal sediments west of the golf course and confined beneath a surface clay. Type 2 water is a low-moderate salinity groundwater, mainly of the calcium bicarbonate type, occurring under unconfined conditions in the marine sediments beneath the Seven Mile Beach township and the adjacent Lands Department property. Type 3 water, restricted mainly to the golf course, is a mixture of Types 1 and 2, and has probably occurred as a result of pumping groundwater from the course, causing a seaward migration of saline water. Types 2 and 3 waters are suitable for irrigating the Golf Club fairways.

The Golf Club attempts to irrigate the fairways with a mixture of fresh mains water and groundwater, but in dry periods one of the soaks (Soak 1) on the course is pumped dry, and is refilled with fresh water to operate the pump. At such times, about two-thirds of the water used is fresh, and the remainder is pumped from Soak 2 which contains poorer quality water than areas further east on the course.

By installing a linear array of shallow spear bores along the north-eastern boundary of the golf course, the Club can at least double its groundwater pumpage and at the same time pump better quality Type 2 water. A two stage groundwater development programme is suggested: the first stage involves improvements to Soak 1 and the installation of a 20-spear array to provide up to about 760 l/min (10 000 gal/hr); the second stage (which may not be needed) is the extension of the spear array north-east into the Lands Department property to increase yield, and the abandonment of Soak 2. Stage 1 is estimated to cost about \$12 000, which would be recovered in about three years by reducing excess charges on freshwater.

INTRODUCTION

In the twelve months to August 1980 the Royal Hobart Golf Club used a total of 106 000 m³ of mains water and paid over \$9000 in excess water rates. The water is obtained from the Metropolitan Water Board main supply-ing the Seven Mile Beach township, and most is used to irrigate greens, tees and fairways at night during summer. The Club augments this supply - and reduces excess water charges - by irrigating the fairways with a mixture of fresh mains water and groundwater pumped from two shallow soaks on the course.

The Club is anxious to reduce further its dependence on mains water. It approached the Department of Mines to determine whether an increased groundwater supply could economically be obtained from Club property or adjoining land.

Previous investigations

Groundwater has been used to irrigate the course since the inception of the Golf Club in the late 1950s. Early in 1958, when the fairways were under construction, the Club engaged engineering consultants Griggs, Valentine and Associates to report on the feasibility of using groundwater for irrigation. In their report* they briefly described the results of digging, observing and presumably pump-testing ten shallow wells. Water levels were surveyed, and samples collected for analysis. The location of the wells and results of analyses are unknown, but the consultants found that the eastern parts of the course contained groundwater suitable for 'agricultural purposes', and that water in some wells - presumably to the west - was unsuitable. They recommended the excavation of soaks to tap the supply.

The Club adopted these recommendations and for some years groundwater pumped from two or three soaks was used solely for irrigation. From time to time, the quality of the water deteriorated with continuous pumping, and this seems to have been the reason why the Club requested the Department of Mines to comment on the problem. As a result, Matthews (1964) investigated the salinity of water in each of the soaks, and suggested a programme of drilling and pump-testing to determine the reason for the differing water qualities. No further studies were done at the Club, which was later connected to the freshwater main supplying Seven Mile Beach.

The Seven Mile Beach area - including the Golf Club - was briefly investigated during a general study of the groundwater resources of the Seven Mile Beach spit east of the Hobart Airport (Cromer and Sloane, 1976). A water table salinity contour map was produced. In the golf course area the map was based on limited information, but it confirmed the earlier observations of a general landward decrease in groundwater quality (from a salinity of about 500 mg/l† near the coast to more than 2000 mg/l near the Club's western boundary).

Present investigations

Because previous studies were limited in scope and content, the main emphasis of the present survey was placed on obtaining a reasonably complete stratigraphy of the water-bearing unconsolidated sediments in the area. Twenty-five exploratory auger holes were drilled by a portable trailer- or tractor-mounted rig. The holes were sited to provide information along three roughly parallel section lines (fig. 1). All bore collars were surveyed relative to approximate high-water mark. Locations are accurate to 0.05 m vertically and 25 m horizontally. Sand samples from some holes were collected for grain size analysis. Water table levels were measured in each hole, groundwater qualities measured by portable conductivity meter, and selected holes were pump-tested by spear bores to provide;

- (a) a water sample for chemical analysis, and
- (b) an idea of the aquifer's ability to yield water.

A brief survey was done of the surface hydrology of the area, and the Golf Club's present methods of irrigation studied.

* Summary of investigations on ground water on Royal Hobart Golf Club property at Seven Mile Beach (Feb-April).

† mg/l = milligrams per litre of total dissolved solids (TDS), virtually equivalent to parts per million (ppm).

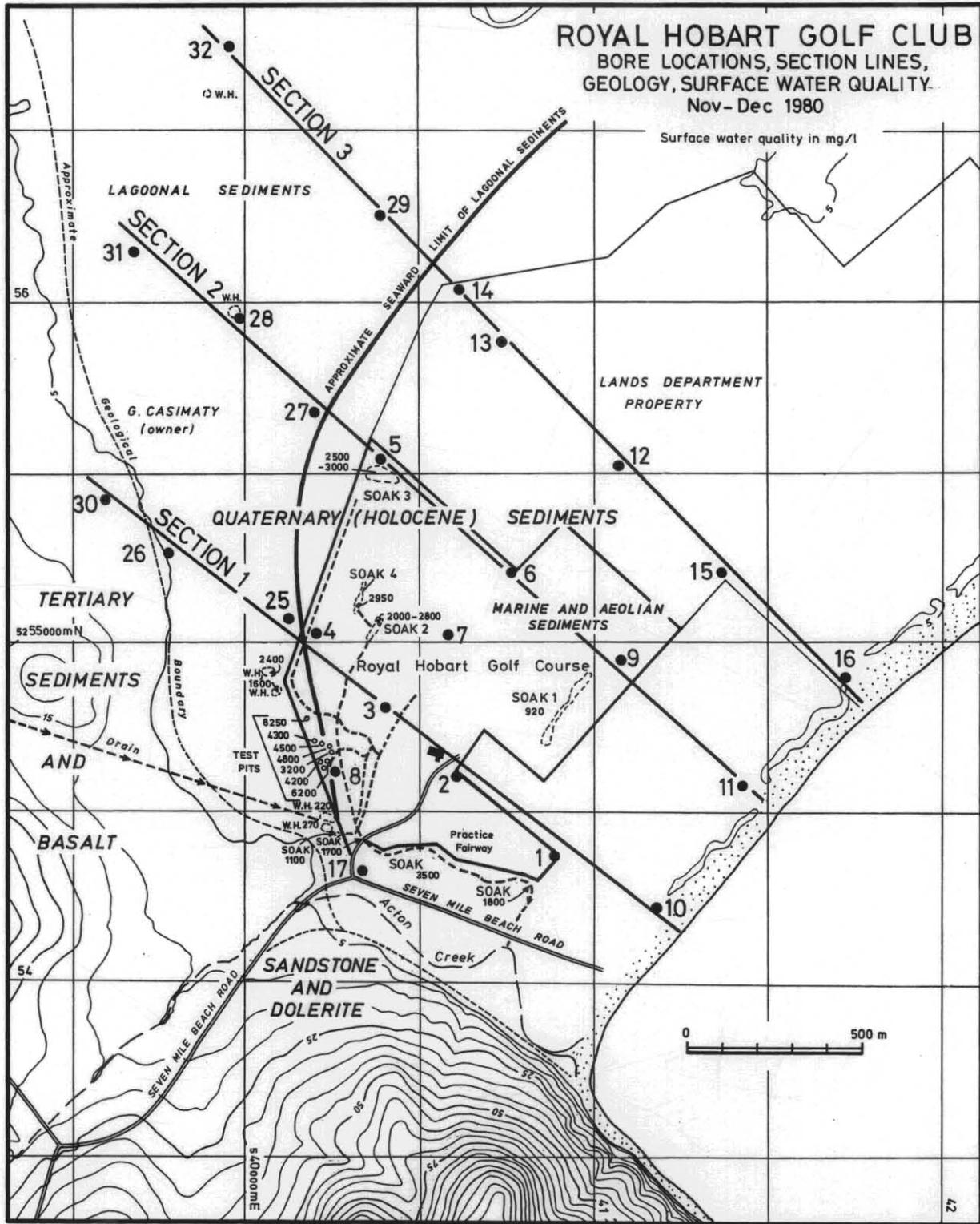
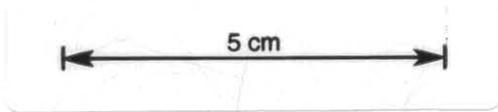


Figure 1.



Presentation of results

The text of this report deals only briefly with some aspects of the survey; other more technical details are included as appendices. Appendix 1 gives the detailed geological logs of all holes drilled, including information on salinities and spear bore yields; Appendix 2 is a detailed description and interpretation of the water-bearing sediments; Appendix 3 lists the water analyses of fifteen holes, and on each sheet the suitability of the water for agricultural purposes is briefly assessed. Appendix 4 discusses the grain size analyses of selected holes, and the methods used to determine proper specifications for spear bores.

GEOLOGY

General comments

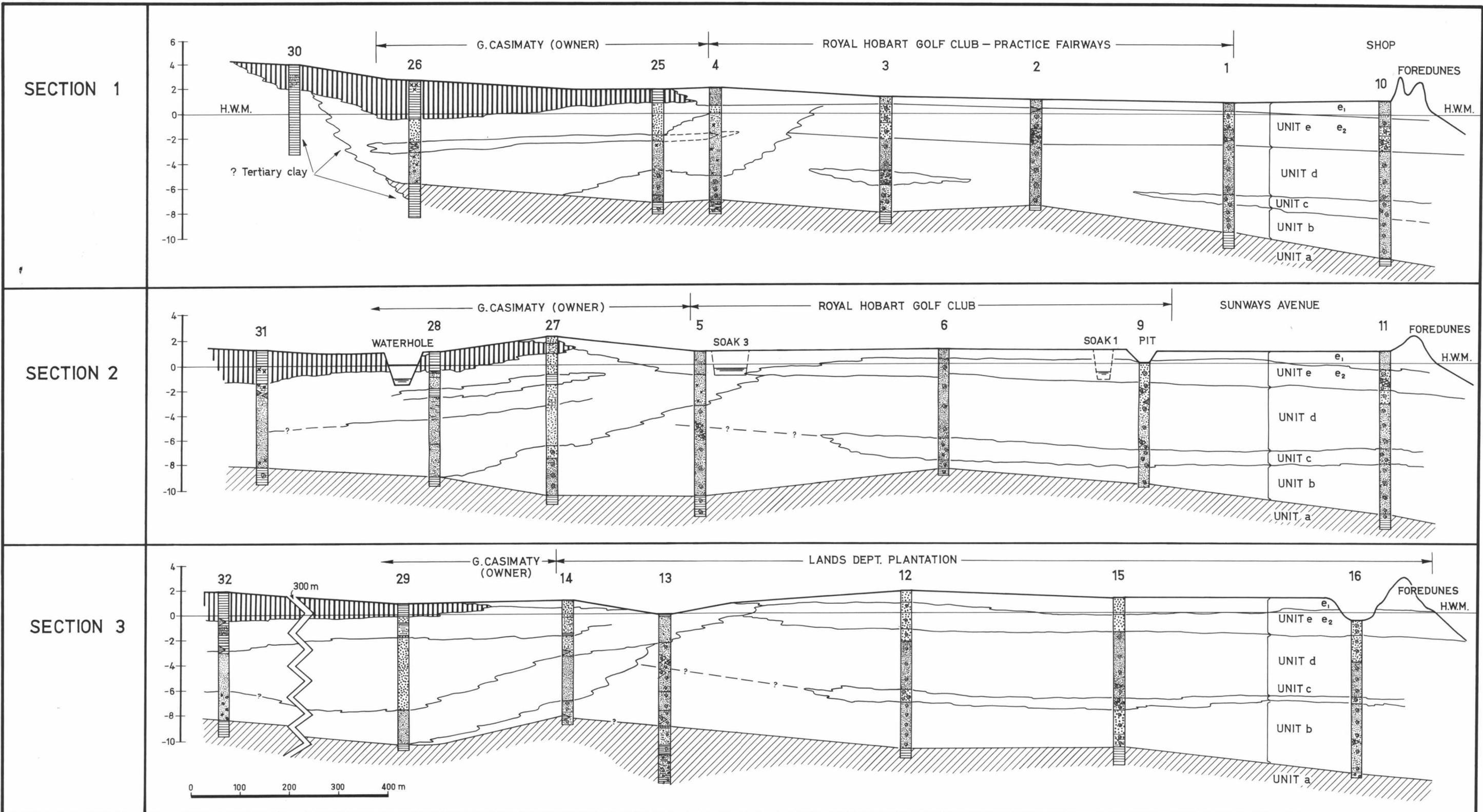
The Golf Club and surrounding district occupy a flat or gently undulating area, less than five metres above sea level, composed entirely of unconsolidated water-bearing Quaternary sediments (fig. 1). Older rocks, including Tertiary clay and basalt and Permian sandstone, underlie the land above the five metre contour to the west. On Single Hill immediately south of the golf course, Jurassic dolerite and Permian sediments crop out. These older rocks, including the Tertiary sediments, probably underlie the Seven Mile Beach area at depth, but the thickness of the Quaternary sediments has not been established.

Quaternary geology

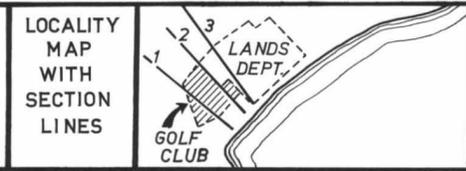
The detailed stratigraphy of the water-bearing sediments in and around the golf course has now been established by exploratory auger drilling to depths of 15 m. All the sediments are considered to be Holocene in age, with the possible exception of a basal clay layer - present throughout the area - which may in part be Pleistocene. This clay layer forms the lower impermeable boundary to the aquifer. The major stratigraphic features of the Holocene sediments are;

- (a) a marine sequence of grey and brown sand, locally enriched in shelly layers, underlying a beach and aeolian sand surface layer, which extends from the coast almost to the western edge of the golf course; and
- (b) a lagoonal sequence of fine sand, silt, clay and gravelly clay, including a surface clay layer, which extends from the Club's western boundary to about the 3-5 m contour on Mr G. Casimaty's property.

Both types of sediments are up to 10-15 m thick, and each contains groundwater. The water in the lagoonal sediments is saline and unsuitable for golf course irrigation, and is confined beneath the surface clay layer. The water in the marine sequence is unconfined and generally suitable for irrigation. The approximate extent of both sediment types is shown in Figure 1, and geological cross-sections, based on the drilling, are shown in Figure 2. A detailed description and interpretation of the Holocene sediments is given later (Appendix 2).



**GEOLOGICAL SECTIONS
 ROYAL HOBART GOLF COURSE**



- Upper confining clay (Lagoonal)
- Lower confining clay (Estuarine)

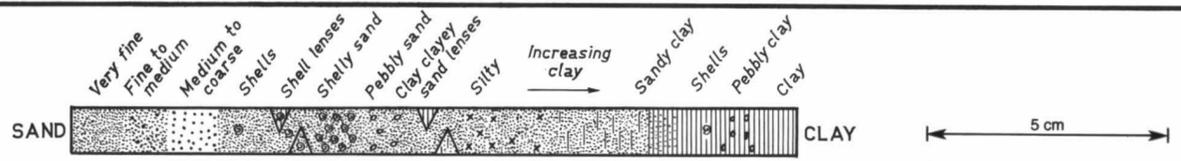


FIG. 2

HYDROLOGY

Surface hydrology - rainfall and drainage

The Seven Mile Beach area receives an average annual rainfall of 574 mm (based on a 61 year period to 1978). Average monthly distribution, and monthly rainfall for the last four years, are listed in Table 1. Precipitation is fairly evenly distributed throughout the year, with July, November and December slightly wetter. Rainfall to October 1980 was 30% below average for that year.

Table 1. AVERAGE AND MONTHLY RAINFALL, ROYAL HOBART GOLF CLUB.

	J	F	M	A	M	J	J	A	S	O	N	D	Total (mm)
Average	39	53	40	45	50	32	66	46	41	53	54	55	574
1977	82	50	73	14	46	37	83	14	41	14	83	5	542
1978	27	79	21	56	41	30	26	92	10	27	93	50	552
1979	25	24	36	29	6	-	9	46	68	31	26	39	
1980	8	21	55	19	31	40	28	23	32	65	-	-	

There are no permanent creeks in the area. The longest watercourse, Acton Creek, is intermittent. It drains Acton Hill to the west, flows eastwards to the north of Single Hill and along the Club's southern boundary, and discharges into a 200 m tidal inlet at the south-western corner of Seven Mile Beach. Elsewhere, the natural drainage has been modified by artificial drains, a series of which flow into Acton Creek after draining the south-western corner of the golf course. Here, flooding occurs after heavy rain, but during the present survey most drains were dry. The drainage system is indicated on Figure 1 by the dashed lines, and in places the water salinity (mg/l) is included.

Temporary lagoons form after heavy rain in the poorly drained areas near Holes 28, 29 and 31 (fig. 1), and also along the rear of the Lands Department property near Hole 13. In the former case, surface clay prevents the rapid infiltration of water (some of which must move through dessication cracks in the clay), but near Hole 13 surface clay is absent and the lagoons form in a topographic low where the water table temporarily intersects the surface.

The drains at the south-western corner of the golf course are occasionally subject to tidal surge. At least once in recent years a combination of high tides and storm conditions caused sea-water to back up Acton Creek along the drains to the groundsman's sheds. Since most of this water would eventually drain seawards, these rare occurrences are unlikely to have an important effect on groundwater quality.

Permanent and semi-permanent soaks or seepages occur along the drains on the golf course's southern boundary, where the water table is very close to the surface. Salinities from some of these (fig. 1) range from 220-3500 mg/l TDS (indicating that the water in some is virtually fresh rain-water, and in others is probably mainly groundwater), but there is no obvious pattern to the salinities.

Dams and waterholes have been constructed on 'Acton View', owned by G. Casimaty. Some are built across surface drains and contain good quality water (e.g. 270 mg/l). Others are excavated in the confining surface clay

of the lagoonal sediments and have penetrated the saline water beneath: salinities in these holes vary from 1600 mg/l to 20 000 mg/l TDS. The variation reflects the salinity gradients in the aquifer (see fig. 3), but is also probably complicated by the diluting effects of rain in those holes with limited catchments, and the concentrating effects of evaporation in others.

Groundwater hydrology

Permanent groundwater occurs in the unconsolidated sediments east of the heavy dashed line at the five metre contour in Figure 3. West of this approximate boundary, the Tertiary clay, basalt and Permian sandstone contain water, since successful bores have been drilled in them. The water table in these rocks is deeper and possibly discontinuous, and the bores are low-yielding. This report deals instead with groundwater beneath the low-lying areas nearer the Golf Club, where the water table is continuous and at shallow depth, and where water is easily extracted by simple methods.

The groundwater occurs in the sediments as a continuous body extending from the coast inland to about the five metre contour, and lengthwise from Acton Creek to the Dodges Ferry end of the spit. West of the Golf Club, the groundwater is confined i.e. held under pressure beneath an impermeable clay layer. Beneath the Golf Club and township, the water is unconfined i.e. the water table is in contact with the atmosphere.

The water table during the last few months of 1980 was almost horizontal, with an elevation very close to high water mark. Locally the water table is below sea level e.g. in Soak 1 which is pumped, and in some water-holes losing water by evaporation. In normal years annual fluctuations in water table elevation probably exceed one metre.

Groundwater movement in the aquifer

Groundwater moves through aquifers in response to pressure differences (in confined aquifers) or water table gradients (in unconfined aquifers). These either occur naturally, or may be induced artificially by pumping from bores, or discharging from drains. The rate of flow of groundwater through an aquifer is directly related to the pressure gradient. Thus, high water tables in wet periods cause increased groundwater flow. At Seven Mile Beach and other similar coastal situations, the natural outlet for the groundwater is the coast, and the zone between high and low water marks is a discharge boundary. Leakage also occurs to drains and watercourses. If no recharge occurs to the water table, the rate of discharge gradually slows as the water table falls. After long dry periods, water tables may be essentially horizontal; no gradients exist to induce flow, and the groundwater body is virtually stationary. This seems to be the case at Seven Mile Beach at the moment, and it may exist in the confined section in wetter years. (The presence of distinct water types in separate parts of the aquifer suggests that there is little mixing of the waters, and hence little groundwater movement). It is likely that the saline water in the confined aquifer is the least mobile, since high water tables in the unconfined aquifer probably contribute to the pressure head in the former.

In dry periods, therefore, water movement in the aquifer is very slow, and recharge is minimal. High water tables in wet periods cause discharge to drains, soaks and the coast.

Recharge to the unconfined aquifer occurs naturally by infiltration of rain, and over the golf course is supplemented artificially by irrigation.

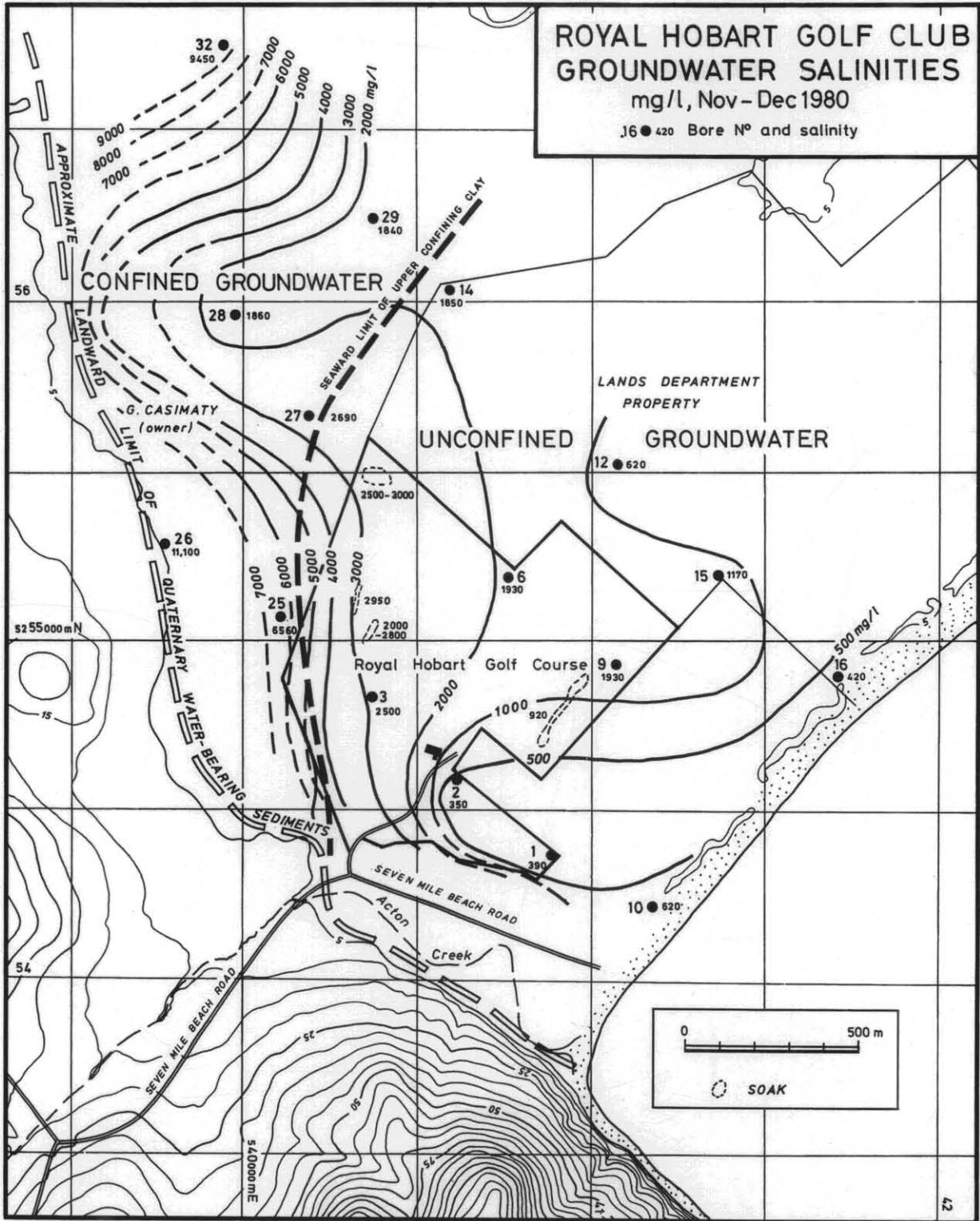


Figure 3.

Only a fraction of the rainfall, perhaps 20-30%, eventually reaches the water table because only continuous rains are likely to be effective in first wetting the soil profile.

Since the saline water in the confined section of the aquifer is believed to be mainly stationary, little recharge or discharge probably occurs. The main recharge sources would be from:

- (a) surface run-off from the west;
- (b) percolating water from the Tertiary sediments to the west,
- (c) vertical leakage from temporary lagoons, and
- (d) leakage from the adjacent unconfined sediments.

Over long periods, groundwaters may change in their chemical character, often becoming enriched in Na and Cl at the expense of Ca and HCO_3 . This is supported by the confined groundwater, which is of the Na + Cl type, but source (b) above is also indicated, since Tertiary groundwaters are often enriched in Na and Cl and the strong salinity gradients (fig. 3) in this area may indicate a recharge zone.

Yields from spear bores

To obtain representative water samples, and to determine the aquifer's ability to yield water, spears were installed in some of the stratigraphic holes (Holes 1, 2, 3, 4, 5, 6, 9, 10, 12, 14, 15, 16, 25, 26, 27, 28 and 29) and pumped for brief periods (usually about 30 minutes). The spears were installed at depths ranging from about 4.5 - 5.0 m, and screen slot openings of 0.25-0.5 mm were used. Details are recorded on the log sheets in Appendix 1.

The spears yielded water at rates varying from less than 2.3 l/min (30 gal/hr) to more than 53 l/min (700 gal/hr). In most cases these rates caused excessive drawdown, resulting in air being pumped. The lowest yielding spears occurred in the finer grained lagoonal sediments. In the unconfined aquifer beneath the golf course, the highest yield was 53 l/min (700 gal/hr) from Hole 9, but Hole 16 near the coast yielded 55 l/min (720 gal/hr). The results from the unconfined aquifer are summarised in Table 2.

Table 2. SUMMARY OF SPEAR YIELDS, UNCONFINED AQUIFER, SEVEN MILE BEACH.

Hole No.	Depth to base of spear (m)	Screen slot size (mm)	Screen length (m)	Yield (l/min)	Remarks
1	5.0	0.40	1.8	46	air pumped
2	4.7	0.40	1.8	49	air + fines
3	4.7	0.40	1.8	46	air pumped
6	4.9	0.40	1.8	46	air pumped
9	4.9	0.40	1.8	53	slight air pumped
10	5.2	0.40	1.8	33	air pumped
12	4.5	0.25	1.8	25	air pumped
15	4.5	0.50	1.8	36	air + fine sand
16	5.0	0.40	1.8	55	slight air pumped

At these pumping rates, all the test spears were pumping air and occasionally small amounts of fine sand. With proper design and installation, both these factors can be eliminated. It is considered therefore that the long-term desired yield per spear for a permanent installation at the Golf Club is about 38 l/min (500 gal/hr).

GROUNDWATER CHEMISTRY

General comments

Groundwater salinities reported in analyses (Appendix 3) range from 350 mg/l to 11 100 mg/l of total dissolved solids (TDS). The lowest values occur beneath the Seven Mile Beach township, and the highest in the confined part of the aquifer west of the golf course. These results are plotted on the salinity contour map (fig. 3) which shows the variation in groundwater quality in November-December 1980. Full analyses, and an interpretation of each, are listed in Appendix 3.

Salinity contour map (fig. 3)

The main features of the map are:

- (a) the steep salinity gradient along the western edge of the aquifer where the lagoonal sediments wedge out against the rising Tertiary basement
- (b) an elongate area of better quality water near Holes 28 and 29, possibly caused by the diluting effect of ponded rain
- (c) a lobe of moderate quality water extending eastwards across the golf course almost to the coast. This may be a natural feature but is more likely to be due to long term pumping from Soaks 1 and 2, causing migration of saline water from the confined part of the aquifer. If this is so, the contamination has been slow and is probably held in check by irrigation on the course. A combination of wet years, summer irrigation and the abandonment of Soak 2 may reverse the trend and reduce salinities
- (d) moderate-good quality groundwater extends beneath the Seven Mile Beach township north-easterly along the spit, and occurs near the Club's north-eastern boundary
- (e) strong salinity gradients probably exist along the Club's southern boundary near the drain running into Acton Creek. This area, near the main practise fairway, should therefore be avoided for future groundwater extraction even though Holes 1 and 2 contain good quality water.

Groundwater types

Inspection of the water analyses in Appendix 3 suggests that there are three basic water types in the sediments. When the relative proportions of constituents are compared (Table 3 and fig. 4) this assumption is supported.

Type 1 water occurs in Holes 3?, 14, 25, 26, 27, 28, and 29, and is restricted almost entirely to the confined section of the aquifer west of the golf course. It is a saline water with Na and Cl ions dominant.

Table 3. AVERAGE SALINITY (mg/l), pH, AND IONIC RATIOS (meq/l) FOR VARIOUS GROUNDWATER TYPES AT SEVEN MILE BEACH, NOVEMBER-DECEMBER 1980.

	Salinity	pH	Ionic ratios					SiO ₂ :total
			Ca:Mg	Na:total	Na:Cl	Cl:total	SO ₄ :total	
Type 1 (Holes 3?, 14,25,26, 27,28,29)	3530	7.2	0.73	0.34	0.93	0.37	0.03	0.01
Type 3 (Holes 6,9,15)	1883	7.4	2.0	0.26	0.80	0.32	0.04	0.01
Type 2 (Holes 1, 10,12,16)	512	7.4	4.7	0.14	0.91	0.16	0.03	0.04

Type 2 water occurs in Holes 1, 10, 12, and 16 and is restricted to the unconfined section of the aquifer. Major ions are Ca, HCO₃, Na and Cl, but Ca and HCO₃ are predominant. Type 2 water is a moderate-low salinity water typical of groundwater in coastal marine sediments, and it owes its hard nature and dominance of Ca and HCO₃ to dissolution of shelly material in the aquifer.

Type 3 water occurs in Holes 6, 9 and 15. It is intermediate in salinity and has as its dominant ions Na, Cl, Ca and HCO₃ with Na and Cl slightly more prevalent. It is regarded as a mixture of Types 1 and 2. In Table 3 the proportions of major ions are intermediate between the other waters, and in Figure 4 (where the relative cation and anion proportions are plotted, and mixed waters lie generally between two end-members) Type 3 water falls approximately on a straight line between the fields of the other water types.

Type 3 water underlies most of the golf course, and is believed to be the result of pumping from Soaks 1 and 2, causing an eastwards migration of Type 1 water into Type 2 water.

Water from Hole 2, although plotted in Figure 4, is of unusual composition and does not fall naturally into any of the above groups. Its main ions are Na and HCO₃.

Suitability of the groundwater for irrigating fairways

Brief general comments about the suitability of individual water samples are included in the remarks section of the analysis sheets (Appendix 3). The agricultural suitability of each is plotted on Figure 5a (as percent sodium) and Figure 5b (as Sodium Adsorption Ratio, SAR). These criteria are often used in water classification because under some conditions moderate-high salinity waters also high in sodium may cause deleterious effects on plants and soils. The diagrams give only a general indication of water suitability and often need to be qualified for particular applications. Thus, Figure 5a suggests that Types 1 and 3 waters are 'unsuitable in any condition'. This is clearly not the case for Type 3 water, which underlies the golf course and for at least some of the time is used to irrigate fairways with no apparent ill effects (see below). The diagrams are therefore too restrictive for the golf course where the groundwater is mixed in varying proportions with freshwater, and

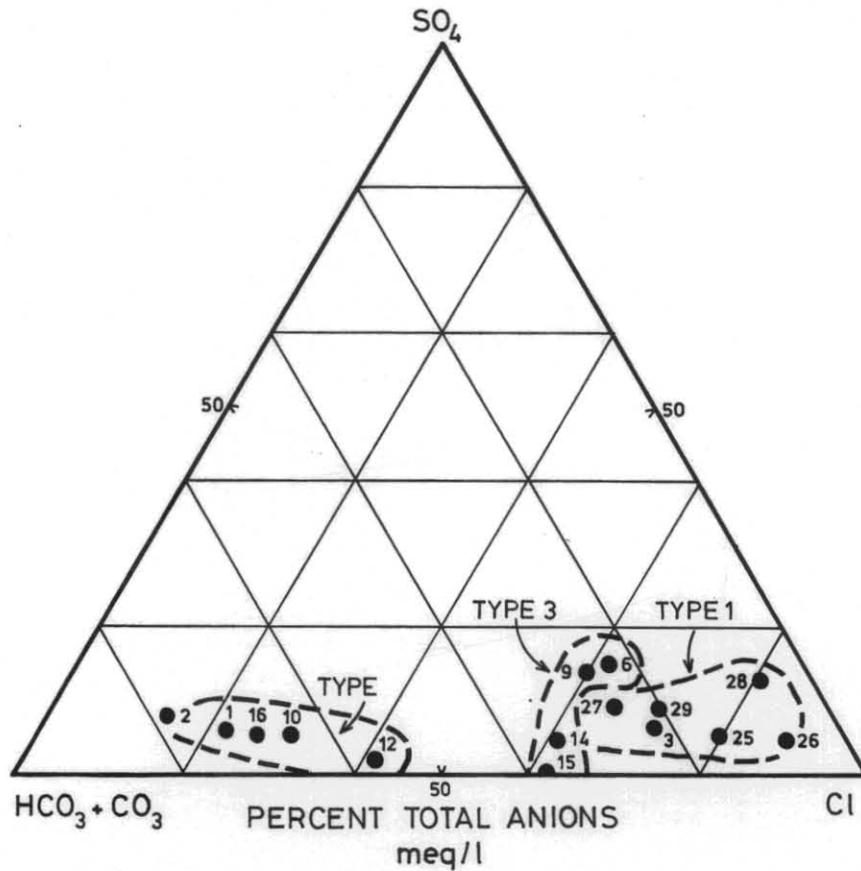
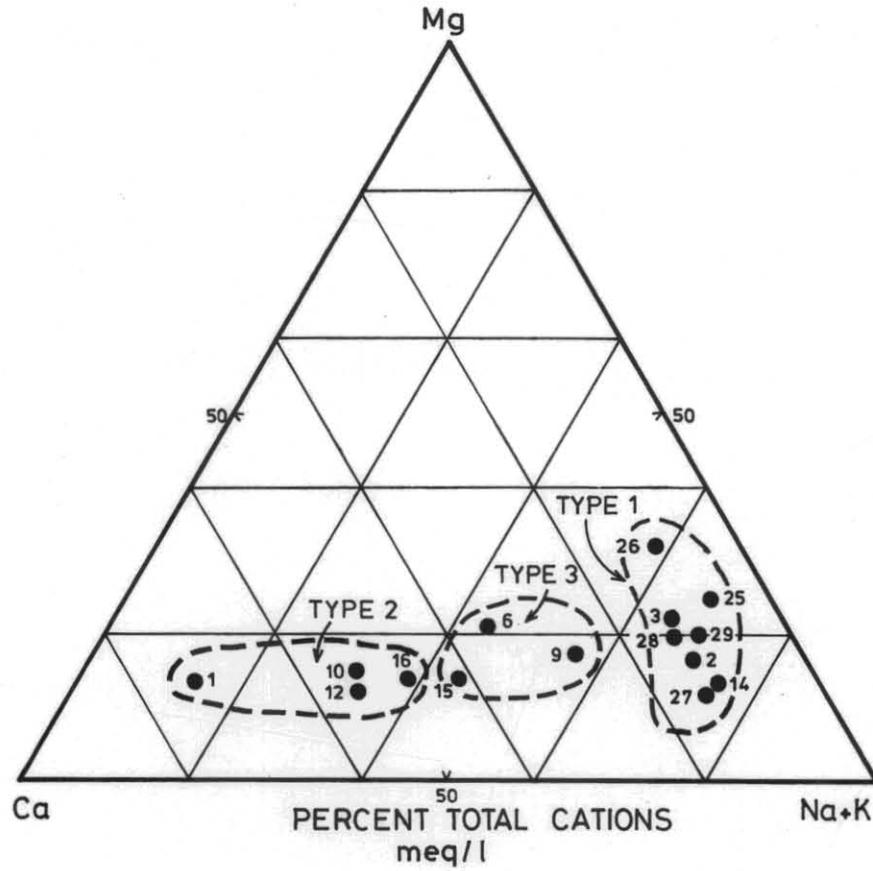
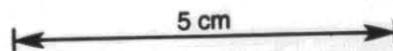


Figure 4. Type 1, 2, and 3 groundwater from Seven Mile Beach plotted on triangular diagrams to indicate that Type 3 water is probably a mixture of Types 1 and 2.



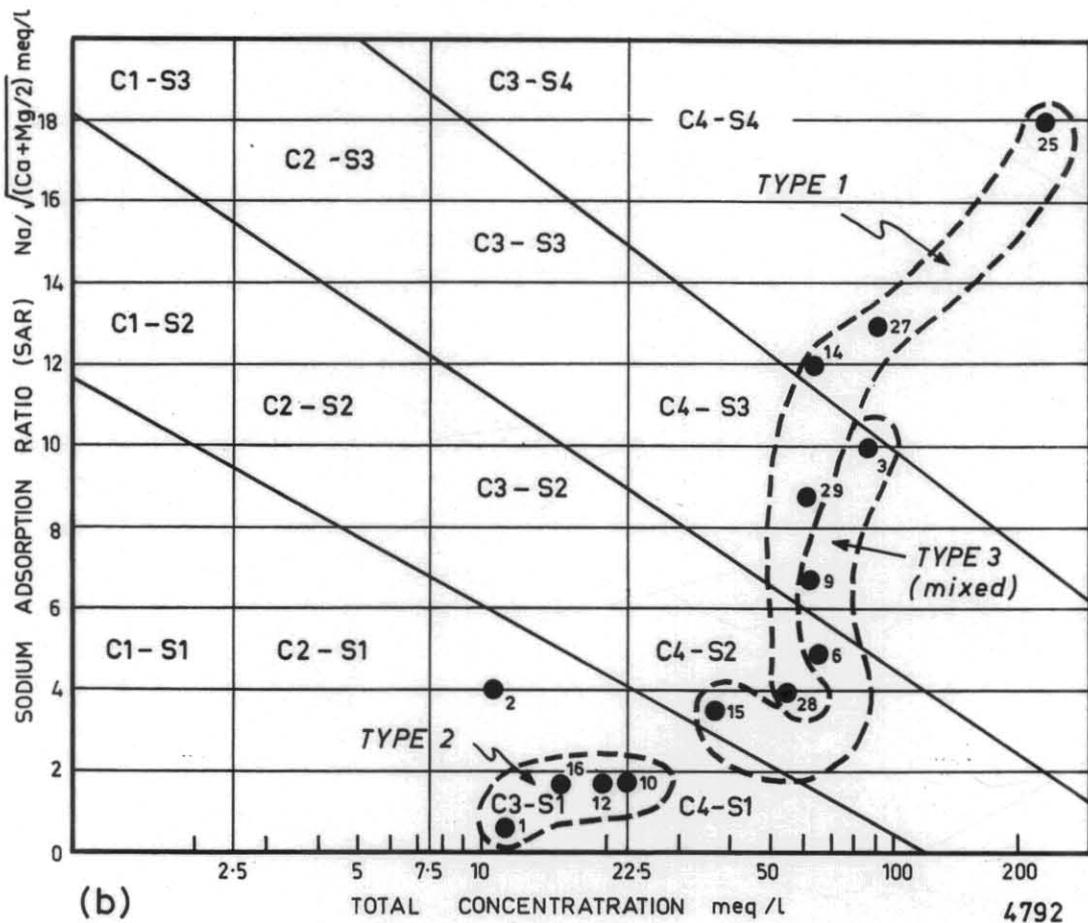
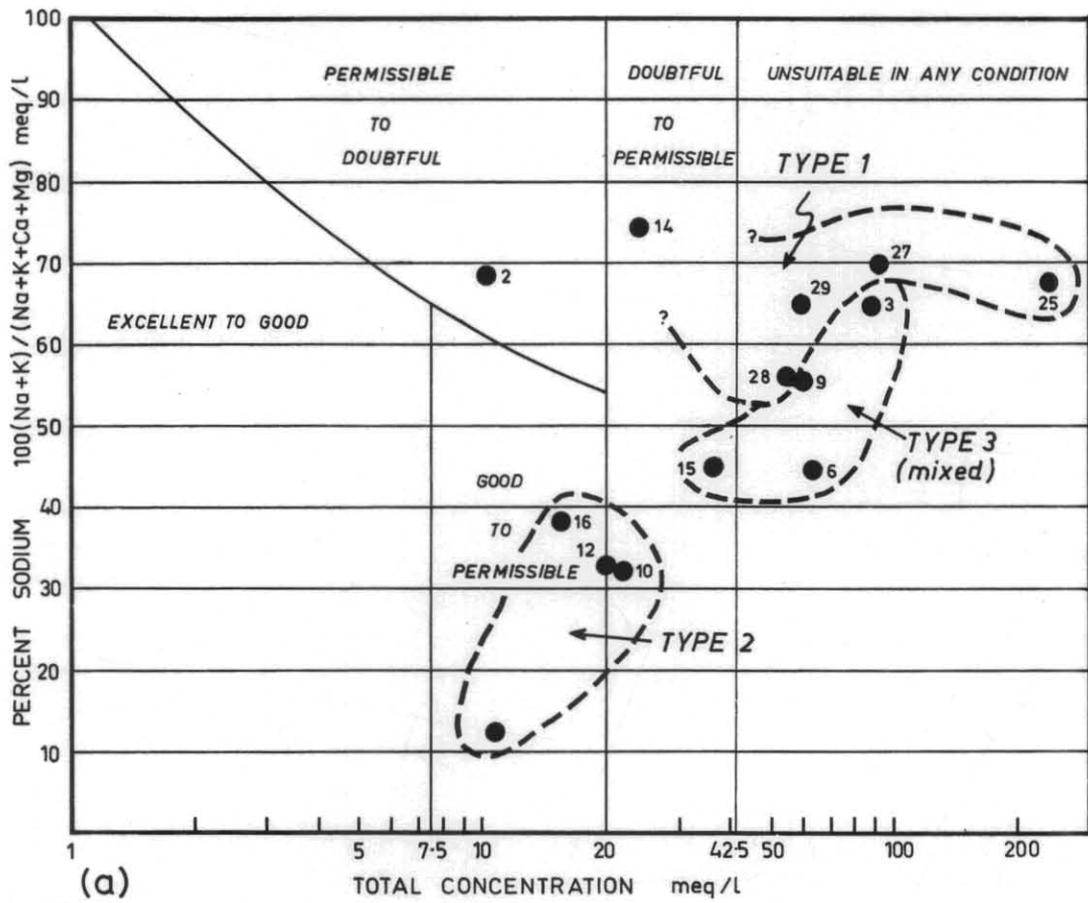
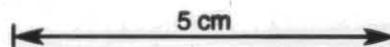


Figure 5. Suitability of Seven Mile Beach groundwater for agricultural uses; (a) %Na and (b) SAR criteria.



used on moderately salt-tolerant grasses* on sandy well-draining soils. In general, Types 2 and 3 waters are suitable in this regard, whereas Type 1 water should not be used.

As a practical guide to water use, a maximum limit to the salinity of groundwater used to irrigate the fairways should be set at about 2500 mg/l TDS. This corresponds to a specific conductance reading on the Club's portable conductivity meter of about 4000, instead of the limit of 2500 currently used. [The relationship between salinity (measured as mg/l TDS) and electrical conductivity (measured in micromhos, or the new equivalent unit microsiemens/cm) depends on the amount, type and proportions of various dissolved constituents in the water, and on water temperature. To convert electrical conductivity to salinity, the former is multiplied by a factor (A) usually between 0.5-0.9. From the analyses in Appendix 3, A has the average value 0.58 for Type 1 water, 0.62 for Type 3 water and 0.69 for Type 2 water. The conversion graphs with the Club's conductivity meter use a value of A between 0.60 and 0.65, so that it is suitable for Type 3 water used on the course].

THE PRESENT IRRIGATION SYSTEM AT THE GOLF CLUB

General discussion

The eighteen greens, tees and fairways are irrigated at night in the drier months (usually September to February) by an automatic watering system controlling 581 sprinklers. The sprinklers each rated at between 20 l/min (on tees) and 60 l/min (on fairways) are arranged in groups or stations of between 20 and 40 sprinklers and connected via 40, 50 and 75 mm subsidiary lines to 100 mm PVC or asbestos cement mains. The mains are laid in a circle around the course (fig. 6) and are connected to the Seven Mile Beach water supply near the clubhouse.

Water is also fed directly into the mains on the course from two pumps, located on Soaks 1 and 2. Soak 2 is also connected to Soak 4 by a gravity feed pipe set at about the winter water table level. The pump on Soak 1 is a Harland centrifugal pump coupled to a 15 kW (20 hp) electric motor. Inlet and outlet pipes are both 100 mm. The pump on Soak 2 is similar. The maximum yield of each pump is unknown, but is probably at least 760 l/min (10 000 gal/hr).

A mains pressure of about 515 kPa (75 psi) (measured at the pump house on Soak 1) is needed to give adequate sprinkler coverage on the fairways, and this is usually only obtained with both pumps operating. Pressures of 445-480 kPa are attained with one pump operating. The static pressure of the fresh mains supply varies, but is at most 480 kPa (70 psi) (measured at Soak 1); this drops to 200-275 kPa during irrigation if both pumps are shut off. This pressure barely operates the sprinklers and is inadequate for irrigation, so at least one pump must be operating to water the fairways.

Tees and greens are irrigated with fresh mains water only. Fairways are irrigated with a mixture of freshwater and groundwater (Soaks 1 and 2).

* The grasses grown at the Club are:

- Fairways: Kentucky Blue and Highland Bent
- Greens: Kentucky Blue, Highland Bent and Winter Grass
- Tees: Kentucky Blue, Highland Bent and Red Fescue

During a normal 9 hour 40 minutes nightly cycle, the automatic watering system operates initially with both pumps to irrigate sequentially all nineteen stations of fairway sprinklers for twenty minutes each - a total of 440 sprinklers and 6 hours 20 minutes; the pumps are then turned off, and mains freshwater delivered to the three tee stations (63 sprinklers; 1 hour) and finally to the seven greens stations (78 sprinklers, 2 hours) 20 minutes). The cycle therefore uses about 631 000 litres of water, distributed as indicated in Table 4.

Table 4. SUMMARY OF NIGHTLY IRRIGATION CYCLE, ROYAL HOBART GOLF CLUB.

	Fairways	Tees	Greens	Total
No. of stations	19	3	7	29
No. of sprinklers	440	63	78	581
Av. sprinkler rate (l/min)	59	21	55	
Pumping time per station (min)	20	20	20	
Total pumping time (hr)	6.3	1	2.3	9.6
Water used each night (l)	520 000 (mix)	25 800 (fresh)	85 100 (fresh)	630 900

It would be useful to calculate accurately the proportion of ground-water used in a typical cycle, but this is difficult to do. Firstly, the yields of the pumps are unknown, and in any case vary depending on the pressure distribution around the mains (which fluctuates continuously) and the freshwater mains pressure (which also varies from 200-480 kPa in an unpredictable way). Secondly, other portable sprinklers are used during the day on an irregular basis. Thirdly, Soak 1 is often pumped dry after the nightly cycle, especially when water tables are low, and may take two or three days to recover naturally. To overcome this problem and enable pump 1 to maintain adequate mains pressure, fresh mains water is pumped into Soak 1 during the day.

This last factor allows an estimate to be made of the amount of ground-water used. For example, in the seven days ending January 9, 1981, the Club used 5825 m³ (1 281 500 gallons) of fresh mains water. Some of this was used for clubhouse facilities and clubhouse surrounds, but most was used for irrigation. Seven nightly irrigation cycles account for 4 416 m³, and during this time Soak 1 was filled daily with freshwater. The difference (1 409 m³) is more than accounted for by eight self-tracking sprinklers each operating daily at 110 l/min. The only ground-water pumped during the week therefore came from Soak 2, which contains poorer quality water. If it is assumed that the fresh mains supply and each pump contribute equally to the system, then groundwater constitutes one-third of the total irrigation water used during this and similar weeks.

Salinity of the water presently used for irrigation on the fairways

Fresh mains water entering the golf course has a salinity varying from about 60 to 100 mg/l TDS. Groundwater salinities beneath the course range from about 1000 mg/l near Soak 1 to about 3000 mg/l near Soak 4. During a normal irrigation cycle, when both pumps are operating and fresh-water enters from the main near the clubhouse, the fairways are irrigated

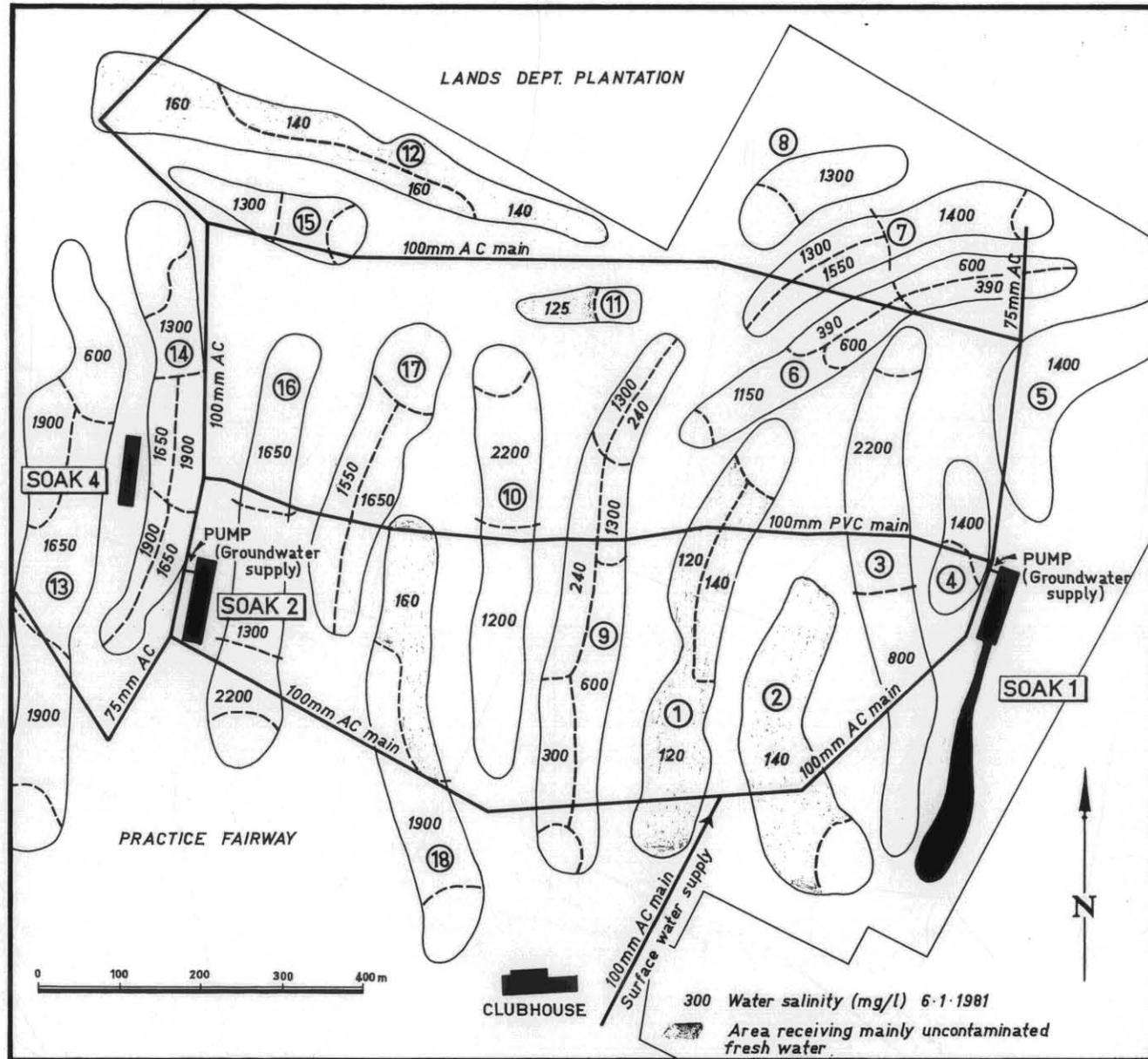


Figure 6. Irrigation water salinities

5 cm

17/86

with a fresh-groundwater mix, the salinity of which varies in a complicated way. The two waters are not evenly mixed because each enters the mains at different points and the pressure along the mains varies.

On January 6, 1981, Mr K. Flakemore measured the conductivity of water (since converted to salinity in mg/l) from all nineteen stations on all eighteen fairways as they were irrigated in turn. The results are summarised in Figure 6, where the figures on each numbered fairway indicate the salinity in mg/l irrigated from each station. The shaded fairways (1, 2, 11, 12 and part of 18) received mainly uncontaminated fresh mains water; parts of fairways 3, 9 and 16 (from stations 5, 15 and 17) received mainly undiluted groundwater with salinities varying from 1900-2200 mg/l. All other stations delivered a fresh-groundwater mix which varied considerably between fairways and even between adjacent parts of the same fairway. However, it is reasonable to assume that fairways closest to the pumps would receive on average the highest salinity water. Some of the 440 sprinklers have been corroded, while others have been unaffected, supporting this conclusion.

The pattern of salinities in Figure 6 is probably temporary, varying from day to day as the fresh mains pressure varies, and as freshwater is pumped into Soak 1 for nightly irrigation. This is a favourable situation for the Club, because it means that each fairway is constantly being irrigated with water of varying quality, apparently with no ill-effects.

From these observations it is apparent that groundwater with salinities ranging up to about 2500 mg/l could successfully be used on the fairways (and probably greens and tees), especially if the system was occasionally diluted with mains water, or a mixture of the two. If better quality groundwater were used, the ratio of groundwater to freshwater could reasonably be increased from the present 30% to at least 60-70%. By careful planning and management, the use of freshwater on the fairways could possibly be discontinued.

CONCLUSIONS

Discussion

The Club is in a good position to economically increase its use of groundwater and reduce its dependance on mains freshwater. An adequate supply of suitable groundwater (mainly Types 2 and 3) exists at the north-eastern end of the course, and on the adjacent Lands Department property. The water can be extracted economically using simple methods.

It is recommended that groundwater be obtained by pumping from a system of shallow small-diameter bores (commonly called 'spears' or 'spear points') connected directly to the existing mains on the course. (The reason for choosing spears is discussed in Appendix 4). There are various ways to do this, but it is proposed that the Club consider a two-stage groundwater plan. Stage 1 could be installed almost immediately, and might operate satisfactorily for many years. Stage 2 could be adopted later if necessary. Before discussing each stage, the following comments are relevant and should be considered:

- (1) Type 1 saline water - unsuitable for irrigation - exists immediately west of the Club boundary. Pumping from Soak 2 is inducing its migration eastwards through the course, and will in time cause a progressive decrease in water quality. (This is no doubt the reason Soak 3 was abandoned). The Club should therefore consider the abandonment of Soak 2 as a source of

11/30
groundwater, although this will not need to be done immediately. When Soak 2 is abandoned, it is likely that the salinity contours on Figure 3 will recede westwards, reversing the present trend.

- (2) Soak 2 in dry summers is the main source of groundwater despite the fact that Soak 1 intersects better quality water. This should be reversed.
- (3) Soak 1 is not fulfilling its purpose. It is too shallow and is often pumped dry overnight. This is not due to a lack of groundwater, which exists in abundance beneath it. Its shallowness is costing the Club a lot of unnecessary money since it has to be filled each night with freshwater to maintain adequate pressures to operate the sprinklers.

RECOMMENDATIONS

Stage 1

This involves maintaining the existing system on the course, but increasing the amount of groundwater used so that it would not be necessary to fill Soak 1 with freshwater each night.

The groundwater can be obtained from shallow spear bores installed to depths of between 5 and 7 m, and spaced at intervals of about 20 m, along a straight line extending along the north-eastern boundary of the course, i.e. from near the 6th tee past the 8th tee to the fence corner. Each spear, gravel packed to deliver sand-free water to minimise sprinkler damage, would be designed to deliver 38 l/min (500 gal/hr) and each would be connected to a single 100 mm PVC header main (fig. 8). This in turn is connected to a suitable pump (possibly near the 9th tee), the outlet of which is joined directly to the existing main. The pump type and yield would need to be designed so that the pressure rating of the existing AC main is not exceeded. Spear designs are discussed in detail in Appendix 4.

In addition to this system of spears, it would be desirable to increase the yield from Soak 1. This could be done by mechanically deepening it, or by installing spears in its floor along its full length. There is no danger of sea-water contamination.

With groundwater therefore entering the course mains at three widely spaced points, and freshwater entering from a fourth, it should be possible to adequately control the salinity of the water used on the fairways. Provided the groundwater quality is suitable, it might be possible to dispense with the fresh supply for long periods.

A variation of Stage 1 is to connect the new spear system to the existing mains at Soak 1 instead of at the 9th tee. This would save money on carrying electricity to the new pump (which is needed in any case).

Stage 2

Stage 2 illustrates the flexibility of any spear system. It involves simply the extension of the Stage 1 system north-easterly into the Lands Department property, so increasing the total groundwater available for pumping. At the same time, Soak 2 would be abandoned (although the pump on the soak could be connected directly to the main to boost the system and maintain pressure). After Stage 2 the Club would be irrigating mainly

with groundwater drawn from the better quality areas in the north-east, with occasional mixing with freshwater if necessary.

Estimates of costs

If the Club decides to go ahead with Stage 1, or a variation of it, the Department of Mines is prepared to supervise free of charge the installation of the spears. Club labour could be used so that costs will be restricted mainly to materials. Alternatively it would be quicker to hire a drilling rig to instal the spears. The amount of water required directly affects costs because it involves the number of spears used, the length of header main needed to connect them and the size of the pump.

Because final details of the schemes have not been made, the rough estimates given below for the major components do not include the cost of connections to the existing Club main, electrical connections and items such as valves, hire of drilling rig, and PVC fittings. Running costs (mainly electrical power) for the schemes have not been studied.

380 l/min (5000 gal/hr) supply

	\$
10 spears (complete) at \$200 each	2 000
300 m of Class 6 PVC 100 mm pressure pipe at \$6 or \$7/m	say 2 100
Pump and electric motor	say <u>3 000</u>
	<u>\$7 100</u>

760 l/min (10 000 gal/hr) supply

20 spears (complete) at \$200 each	4 000
600 m PVC 100 mm pressure pipe at \$6-\$7/m	say 4 200
Pump and electric motor	say <u>4 000</u>
	<u>\$12 200</u>

By installing a 760 l/min supply and doubling the amount of groundwater used, the Club could expect to save about \$4000-5000 annually in excess water charges. The cost of the groundwater scheme would therefore be recouped in about 3 or 4 years.

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APPENDIX 1

Bore logs

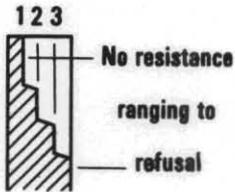
All the geological and hydrological information obtained during drilling is shown on the engineering borehole logs. Refer to the accompanying 'Explanation Sheet for Engineering Logs' which describes briefly some of the abbreviations and symbols used. The logs in this report contain extra information not mentioned on the explanatory sheet. These have been listed beneath the standard abbreviations and symbols.

EXPLANATION SHEET FOR ENGINEERING LOGS

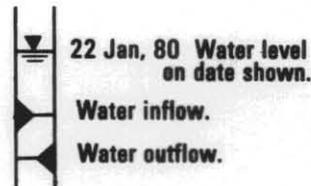
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Borehole and excavation log

Penetration



Water



Notes - samples and tests

U50 Undistributed sample
50mm diameter.
D Disturbed sample.
N Standard penetrometer
blow count for 300mm.
N* SPT + sample.

Material classification

Based on Unified Soil Classification System. In Graphic Log materials are represented by clear contrasting symbols consistent for each project.

Moisture content

D Dry, looks and feel dry.
M Moist, no free water on hand when remoulding.
W Wet, free water on hand when remoulding.
LL Liquid limit.
PL Plastic limit.
PI Plasticity Index.
eg. $M > PL$ - Moist, moisture content greater than the plastic limit.

Consistency

VS Very soft.
S Soft.
F Firm.
St Stiff.
VSt Very stiff.
H Hard.
Fb Friable.

hand penetrometer (kPa)

< 25
25 - 50
50 - 100
100 - 200
200 - 400
> 400

Density index

VL Very loose. 0 - 15
L Loose. 15 - 35
MD Medium dense. 35 - 65
D Dense. 65 - 85
VD Very Dense 85 - 100

Notes: X on log is test result
— is range of results.

Additional notes

- In the 'Support' column is listed details of test spears installed to obtain pumping rates and water samples. The date of spear installation is usually noted, as is the length, diameter and screen slot size of the spear (e.g. 1800 mm x 50 mm x 0.4 mm slot; stainless steel screen). The 1800 mm length of screen is shaded to indicate the depth penetrated. Q is the maximum yield of the spear under test, and TDS is the water salinity (mg/l) determined by laboratory analysis. Where no analysis is available, the conductivity of the water, measured in the field, is listed.
- Various notes appear in the 'Note' column. D indicates a disturbed sample was obtained from the auger, and '+2 mm sieve' indicates a sieved sample was collected.
- 'Graphic log' column. The relative size of shell fragments has been visually estimated as follows:
 ⦿ = most shells < 1 mm; ⦿ = most less than 2 mm; ⦿ = most less than 5 mm;
 ⦿ = most less than 10 mm, ⦿ = most larger than 10 mm. The density of the symbols is a rough guide to their proportion in the sample.
- 'Material' column. VF, F, M and C = very fine, fine, medium and coarse grained sand size fractions; WS, MS and PS = well-, moderately- and poorly sorted. All colours accompanied by a code in brackets are based on the Revised Standard Soil Colour Chart, 1971.

ENGINEERING LOG - BOREHOLE

project **ROYAL HOBART GOLF COURSE** location **Practise Fairway**

co-ordinates **540890 M E**
5254390 M N

R.L. **0.82m AHWM**

inclination **VERTICAL**

bearing **-**

drill type **TRIEFUS**

drill method **AUGER PULL**

drill fluid **NONE**

hole commenced **26.8.80**

hole completed **26.8.80, deepened 13.11.80**

drilled by **Blax, G. Humphries**

logged by **W.C. Cramer**

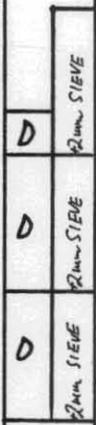
checked by

penetration	support	water	notes samples, tests	metres R.L. depth	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency density index	hand penetr-ometer kPa	structure, geology	
										25 50 100 200 400		
1 2 3				0		SP	SAND, bright yellowish brown (10YR 6/6), F, WS, with streaks and patches of brown. Trace charcoal and VF dark minerals.	D	VL		Aeolian SAND	
				1		SP	SAND, dull yellowish brown (10YR 5/4), M, WS-MS, with trace shell fragments, and some white shell (up to 15mm); trace well rounded fine gravel, VF dark minerals and weakly cemented calcareous sand patches. Dotted to yellowish brown (2.5Y 5/3) at 1.6m	M	L		? - ? MARINE SAND	
				2		SP	SAND, grey (7.5Y 4/1), mainly VF, WS, with small lenses of M, WS-MS sand. Trace shell fragments, some including intact shell, up to 25mm. Minor shelly sand lenses; trace sub-rounded - well rounded Jurassic white shells (up to 15mm) and VF dark minerals. Between 3.3-4.2m, F, WS, few shell. Trace fine gravel (well rounded quartzite). Between 5.2-7.3, VF, WS, trace M shell fragments					
				3								
				4								
				5								
				6								
				7								
				8			SAND, olive grey (10Y 4/2) and shelly SAND between 7.7 and 8m, F-M, trace well rounded fine gravel (quartzite). Between 8m and 8.9m, few shell, VF, WS, trace VF dark minerals. Below 9m, as above, but locally abundant in shell (up to 20mm). Trace clay below 10m.					
				9								
				10								

200.00

Spear jetted 11.12.80

1800mm x 50mm x 0.4mm slot S.S. screen Q=600gph TOR=390mg/l



See next sheet for continuation

ENGINEERING LOG - BOREHOLE

project *ROYAL HOBART GOLF CLUB* location *Practic Pathway*

co-ordinates *540890 m E*
525439 m N drill type *TRIEFUS 0-9m; PROLINE 9-11.7m* hole commenced *26.8.80*
R.L. *0.82 m A.H.W.M* drill method *AUGER PULL* hole completed *26.8.80* Decanned *13.11.80*
inclination *VERTICAL* drill fluid *-* drilled by *B. Cox, G. Humphries*
bearing *-* logged by *W. Croner*
checked by

penetration 1 2 3	support water	notes samples, tests	metres R.L. depth	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency density index	hand penetr- ometer kPa 25 50 100 200 400	structure, geology
			<i>10</i>		<i>GC</i>	<i>Gravelly CLAY, olive yellow (5Y6/3), low plasticity, with angular siltstone fragments generally < 5mm, occasionally up to 20mm</i>	<i>M</i>	<i>St</i>		<i>Residual soil? or weathered Permian basement?</i>
			<i>11</i>							
			<i>12</i>			<i>HOLE STOPPED AT REQUIRED DEPTH 11.7m (-10.88m)</i>				

ENGINEERING LOG - BOREHOLE

project **ROYAL HOBART GOLF COURSE** location **Practice Fairway**

co-ordinates **540620E**
5254595MN

R.L. **1.00m AHWM**

inclination **VERTICAL**

bearing **-**

drill type **TRIEFUS**

drill method **AUGER PULL**

drill fluid **NONE**

hole commenced **26.8.80**

hole completed **26.8.80**

drilled by **B. Cox**

logged by **W.L. Cromer**

checked by

penetration 1 2 3	support water	notes samples, tests	metres R.L. depth	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency density index	hand penetr- ometer kPa 25 50 100 200 400	structure, geology
		NO SHELL	0		SP	SAND, yellowish brown (10YR 5/8), VF, WS, trace wood fragments and patches, root fibres, and at 0.8m containing a zone of light yellow orange (10YR 8/3) silty clay rich in calcareous cement, with trace fine sand and root fibres	D	VL		AEOLIAN SAND
		Spear jetted 10.12.80	-1		SP	SAND, yellowish brown (2.5Y 5/4), F-M, WS, trace shell fragments, grading to olive brown (2.5Y 4/3) at 2m, and greyish olive (7.5Y 5/2) at 2.4m	M	L		MARINE SAND
		62mm sieve D	-2		SP	SAND, grey (7.5Y 4/1) and olive black (10Y 3/1), mainly VF-F, WS. At about 2.6m, 2.9m and 3.7m, thin shelly sand lenses (sand M, WS) occur with > 30% of sample +2mm. Shells in lenses mainly intact small gastropods, also with trace nodular calcarenite (up to 10mm) and angular - well rounded detrital pebbles (up to 30mm). Between lenses, sand contains trace shell fragments, and rare whole shells. Below 6m, sand grey, also with trace basaltic(?) pebbles up to 50mm, and well rounded fine quartzite gravel		MD		
		+2mm sieve D	-3							
		72mm sieve D	-4							
		180mm x 50mm 10.4mm slot s.f. screen @ = 650g ph TDS = 350mg/l	-5							
			-6							
			-7							
			-8							
			-9		CH	CLAY, brownish black (7.5YR 3/1), mottled and streaked with greyish yellow (2.5Y 4/2) and red. High plasticity	M	VSF		
			-8.9m (-7.9m)			Hole stopped at limit of augers: -8.9m (-7.9m)				

ENGINEERING LOG - BOREHOLE

project **ROYAL HOBART GOLF CLUB** location **Practice fairway, between 17th tee and 18th green.**

co-ordinates **540405 M E** drill type **TRIEFUS** hole commenced **26.8.80**
5254810 M N drill method **AUGER PULL** hole completed **26.8.80**
 R.L. **1.10 M AHW** drill fluid **NONE** drilled by **BLOK**
 inclination **VERTICAL** logged by **W.C. DUNN**
 bearing **-** checked by

penetration 1 2 3	support water	notes samples, tests	metres R.L. depth	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency density index	hand penetr- ometer kPa	structure, geology	
											25
		Spear pitted 10.12.80	0.80		SP	SAND, bright yellowish brown (10YR 6/6), F-M, WS, trace VF dark minerals	D	VL		AEGEAN SAND	
			0.1		SP	SAND, dual yellow orange (10YR 6/4), F-M, WS, with trace shell fragments, friable calcareous patches and VF dark minerals. Colour changes to greyish olive (7.5Y 5/2) below 1.5m	M W	L		MARINE SAND	
		D +2mm sieve	2		SP	SAND, olive black (10Y 3/1), M, WS; trace shell fragments, c sand and fine quartzite gravel, rare well-rounded pebbles (up to 10mm). Trace white shells. 5-8% coarser than 2mm; (mainly shells, some up to 20mm) Below 3.3m, colour grey (10Y 4/1), F, WS, with trace shells (some up to 20mm) including small gastropods, trace VF dark minerals and occasional calcarenite nodules.					
		D +2mm sieve	3								
		D +2mm sieve	4								
		D +2mm sieve	5								
		D +2mm sieve	6								
		D +2mm sieve	7		GW	SHELLS, with sand (grey, 10Y 4/1, F, WS- PS). > 90% shells: some up to 30mm, many whole (gastropods, bivalves) but most fragmented. Trace fine quartzite gravel and rock fragments.		MD			
		D +2mm sieve	8		SW	Shelly, pebbly SAND, olive black (10Y 3/2), F, PS; > 50% +2mm, including whole and fragmented shell (up to 15mm), well-rounded angular - high sphericity dolomite pebbles (up to 40mm); trace fine quartzite gravel					
			9								
			10			CLAY, mainly brownish black (10YR 3/1) mottled and streaked with red and yellowish brown. Moderately - highly plastic	M PL	ST			

1800mm
x 50mm
x 40mm slot
s.s. screen
Q = 600gph
TDS
= 2500
mg/lr.

Hole stopped at limit of augers: 10.2m (-9.1m)

ENGINEERING LOG - BOREHOLE

project **ROYAL HOBART GOLF CLUB** location **On golf club boundary, 100m N of 13th green.**

co-ordinates **540200m E**
5255050m N
R.L. **1.90m AHW**

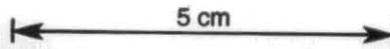
drill type **TRIEFUS**
drill method **AUGER PULL**
drill fluid **NONE**

hole commenced **27.8.80**
hole completed **27.8.80**
drilled by **B. Cox**
logged by **W.C.L. Young**
checked by

inclination **VERTICAL**
bearing

penetration 1 2 3	support water	notes samples, tests	metres R.L. depth	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency density index	hand penetr- ometer kPa				structure, geology
									25	50	100	200	
		NO SHELL ↓	+1		SP	SAND, greyish brown (7.5YR6/2), VF, WS, with irregular patches of brownish black (7.5YR2/2) VF organic sand; some roots, root fibres and trace VF dark minerals. Grades at 0.6m to light brownish grey (7.5YR7/2) F-M sand, and at 1.3m to brownish black (10YR3/2)	D	VL					
		Spear jetted 10.12.80. 180° x 30mm X0.4mm slot. SS screen	0		SP	SAND, greyish olive (7.5Y5/2) M, WS, with irregular patches of yellowish brown (10YR5/8)		L					
		Q < 2.8 l/min	-1		SP	SAND, approx. olive grey (10Y5/2), VF, WS, with patches of dark greyish yellow (2.5Y5/2) and thin lenses of greenish grey clayey sand; Trace fines		MD					
		D	-2			Interval 4-2-5.1, sand brownish black (2.5Y3/2) VF, WS; Interval 5-6m, sand greyish olive (5Y4/2) VF, WS, with trace silt and M quartzite grains; Interval 6-7.1m, sand olive black (5Y2/2), VF, WS, trace fines.							
		D	-3										
		D	-4										
		NO SHELL ↑	-5										
		D	-6		SP	SAND, dark olive grey (5GY4/1) VF, WS, trace shell, including a few up to 15mm (mainly small gastropods); trace angular to well-rounded fine quartzite gravel (up to 3mm) and occasional rock fragments (up to 10mm). Trace small (up to 5mm) dark olive grey patches of clay							
		D	-7										
		D	-8			CLAY, black (2.5GY2/1), soft, sticky, highly plastic, with trace shell fragments; some minor thin grey-black clayey sand and shaly sand lenses	M > PL	S					
			-9										
			-10										

Hole stopped at limit of auger, 10.2m (-8.30m)



ENGINEERING LOG - BOREHOLE

project *ROYAL HOBART GOLF CLUB*

location *1M sandpit adjacent to old Saak, N corner of club land.*

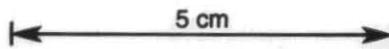
co-ordinates *540390 m E*
5255580 m N
 R.L. *0.96 m AHW*
 inclination *VERTICAL*
 bearing *-*

drill type *TRIFAS*
 drill method *AUGER PULL*
 drill fluid *NONE*

hole commenced *27.8.80*
 hole completed *27.8.80*
 drilled by *B. Cox*
 logged by *W.C. Crowe*
 checked by

penetration	support	water	notes samples, tests	metres R.L. depth	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency density index	hand penetrometer kPa	structure, geology
1 2 3											
			<i>NO SHELLS</i> ↓	0		SP	<i>SAND, greyish brown (7.5YR4/2), F, WS, with some roots and root fibres, and patches of brownish black (7.5YR2/2) organic sand. Grades below 0.6m to reddish black VF, WS, brown (10YR4/6), yellowish brown (2.5Y5/3) and dark greyish yellow (2.5Y4/2) at 1.5m.</i>	D M W	L		
			<i>D</i>	-1		SP	<i>SAND, approx. olive black (10Y3/2), F, WS, with trace fines, grading to sloppy VF sand with trace silt and VF dark minerals. Fines decrease below 3.3m.</i>	L to MD, in place VL			
			<i>D</i>	-2							
			<i>D</i>	-3							
			<i>D</i>	-4							
			<i>NO SHELLS</i>	-4		SP	<i>SAND, olive black (10Y3/2), F, WS, with trace shell, including whole and fragmented shell up to 25mm, trace well-rounded fine quartzite gravel and rock fragments and olive green calcarenite. Small lenses of shaly sand. Rock fragments include sandstone, quartzite and fossiliferous mudstone. +2mm fraction ± 10%.</i>				
			<i>D</i>	-5							
			<i>D</i>	-6			<i>Below 8.6m, grades to dark olive grey (5GY4/1), with slightly more fine shell. +2mm fraction approx. 15%.</i>				
			<i>D</i>	-7							
			<i>D</i>	-8							
			<i>D</i>	-9							
			<i>D</i>	-10							

CONTINUED NEXT SHEET.



ENGINEERING LOG - BOREHOLE

project <i>ROYAL HOBART GOLF COURSE</i>	location <i>In Sandpit</i>	
co-ordinates <i>540390m E</i> <i>5255530m N</i>	drill type <i>Palini 10-13.5m.</i>	hole commenced <i>27.8.80</i>
R.L. <i>0.96m ANWM</i>	drill method <i>Auger pull</i>	hole completed <i>Deepened 24.11.80 by</i>
inclination <i>VERTICAL</i>	drill fluid <i>none</i>	drilled by <i>G. Humphreys, C. Harris</i>
bearing <i>-</i>		logged by <i>W. Crowe</i>
		checked by

penetration	support	water	notes samples, tests	metres	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency	density index	hand penetrometer kPa	structure, geology
1 2 3				R.L. depth							25 50 100 200 400	
				-10		SP	<i>SAND, as above</i>	W	MD			
				-11								
				-12		CH	<i>CRAY dark greenish grey (SG3/1), sticky, high plasticity, locally with traces of shell fragments</i>	M	St to VSt			
				-13								
				-14			<i>Here stopped at required depth, 13.5m (-12.54m)</i>					

ENGINEERING LOG - BOREHOLE

project *ROYAL HOBART GOLF CLUB* location *At fence band, between 12th tee and 11th green.*

co-ordinates *540775m E* drill type *TRIEFUS* hole commenced *27.8.80*
5255180m N drill method *AUGER PULL* hole completed *27.8.80*
 R.L. *1.08m A.H.W.M* drilled by *B. Cox*
 inclination *VERTICAL* drill fluid *NONE* logged by *W.C. LOMER*
 bearing *-* checked by

penetration 1 2 3	support water	notes samples, tests	metres R.L. depth	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency density index	hand penetr- ometer kPa 25 50 100 200 400	structure, geology
		<i>NO SHELLS</i>	<i>+1</i>		<i>SP</i>	<i>SAND, bright yellowish brown (10YR6/6), F, WS, trace VF dark microls and brown organic sand streaks.</i>	<i>D</i>	<i>L</i>		<i>AEOLIAN SAND</i>
		<i>D</i> <i>+2mm sieve</i>	<i>0</i>			<i>SAND, dull yellowish brown (10YR5/4), F-M, WS, with trace fragmented and rare whole shell, patches of CaCO₃-cemented sand around root casts, and fine quartzite gravel. Darkens to grey (7.5Y4/1), especially below 2.4m, and black. VF, WS below 3.3m. Trace shells up to 15mm; shell fragments up to 10mm. +2mm shell absent below 4.2m</i>	<i>M</i>			
		<i>D</i> <i>+2mm sieve</i>	<i>-1</i>				<i>W</i>	<i>MD</i>		<i>MARINE SAND</i>
		<i>D</i> <i>+2mm sieve</i>	<i>3</i>							
		<i>D</i> <i>+2mm sieve</i>	<i>-2</i>							
		<i>D</i> <i>+2mm sieve</i>	<i>4</i>							
		<i>D</i> <i>+2mm sieve</i>	<i>-3</i>							
		<i>D</i> <i>+2mm sieve</i>	<i>5</i>							
		<i>D</i> <i>+2mm sieve</i>	<i>-4</i>							
		<i>D</i> <i>+2mm sieve</i>	<i>6</i>							
		<i>D</i> <i>+2mm sieve</i>	<i>-5</i>							
		<i>D</i> <i>+2mm sieve</i>	<i>7</i>							
		<i>D</i> <i>+2mm sieve</i>	<i>-6</i>							
		<i>D</i> <i>+2mm sieve</i>	<i>8</i>		<i>SW</i>	<i>Shelly SAND, grey (10Y4/1) grading to approx. dark greenish grey (7.5GY4/1); F-VF, PS; +2mm fraction approx 15-20%, mainly as fragmented shell (up to 25mm), well-rounded quartzite gravel (up to 30mm), cherty? fragments (up to 40mm)</i>				
		<i>D</i> <i>+2mm sieve</i>	<i>-7</i>							
		<i>D</i> <i>+2mm sieve</i>	<i>9</i>		<i>SC</i>	<i>Clayey SAND, dark greenish grey (10G4/1), in places sandy CLAY. Apparently</i>				
		<i>D</i> <i>+2mm sieve</i>	<i>-8</i>							<i>ESTUARINE SEDIMENTS</i>
		<i>D</i> <i>+2mm sieve</i>	<i>10</i>		<i>CL</i>	<i>CLAY, dark greenish grey (10G4/1), with trace F sand and shell fragments. Low plasticity</i>	<i>M</i>	<i>MD to S</i>		

*180mm
x 50mm
x 0.4mm
S.P. screen
Jetted
27.11.80*

Q=600gph (45.4l/min) QDS±190 mg/L

Hole stopped at limit of auger: 10.2m (-9.12m)

ENGINEERING LOG - BOREHOLE

project **ROYAL HOBART GOLF CLUB** location **between Fairways 10 and 18, 75m SSE of 18th approx. sec**

co-ordinates **S 40° 58' 0" E**
S 25° 50' 30" N

R.L. **0.81m AHW**

inclination **VERTICAL**

bearing **-**

drill type **TRIEFUS**

drill method **AUGER FULL**

drill fluid **NONE**

hole commenced **28.8.80**

hole completed **28.8.80**

drilled by **W. B. COX**

logged by **W. C. FLOWER**

checked by

penetration 1 2 3	support water	notes samples, tests	metres R.L. depth	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency density index	hand penetr- ometer kPa	structure, geology
	NONE	28.8.80 NO SHELLS	0		SP	SAND, dull yellowish brown (10YR 4/3), F, WS, with streaks and patches of brownish black (10YR 2/2); grading to brownish black (10YR 3/2) and olive black (5Y 3/2)	M	L		AERIAN SAND
			-1		SP	SAND, greyish olive (5Y 4/2), F, WS, with trace fragmented and whole shells mainly less than 5mm. +2mm fraction < 2%.				MARINE SAND
			-2			SAND, grey (7.5Y 4/1), VF, WS; trace shell fragments up to 3-4mm (+2mm fraction < 1%). Below 2.4m, some whole shells and fragments up to 20mm possibly in thin lenses				
			-3							
			-4							
			-5		SW	Shelly SAND, dark olive grey (2.5G 4/1), MG, +2mm fraction > 50%, including fragmented and whole shell (up to 20mm), fine quartzite gravel, calcarenite fragments (up to 5mm), rare rock fragments; grades to sandy shell bed 6.3-6.7m. Colour changes to bright olive below 6.7m.		MD		
			-6							
			-7							
			-8		SP	SAND, grey (10Y 5/1), F, WS; trace fine shell.				
			-9		SW	Shelly SAND, as in interval 6.7-8.3m				
			-9		CH	CLAY, mainly brownish black (10YR 3/1), mottled and streaked with red, grey (7.5Y 5/1) and yellowish brown. Trace fine organic sds. High plasticity, stiff.	M		X	
			-10							

hole stopped at limit of augers, 10.2m. (-9.39m)

ENGINEERING LOG - BOREHOLE

project **ROYAL HOBART GOLF CLUB** location **Near club boundary, 150m W of caretakers shed**

co-ordinates **540250m E**
5254600m N

R.L. **0.77m AHW**

inclination **VERTICAL**

bearing **-**

drill type **TRIEFUS**

drill method **AUGER PULL**

drill fluid **NONE**

hole commenced **28.8.80**

hole completed **28.8.80**

drilled by **B. Cox**

logged by **W. Cromer**

checked by

penetration	support	water	notes samples, tests	metres R.L. depth	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency density index	hand penetr- ometer kPa	structure, geology
1 2 3				28.880		SP	SAND, greyish olive (5Y4/2), F, WS, trace shell fragments and fines, grading to olive brown (7.5Y4/4)	W	L		
				0							
				1							
			+2mm SIEVE	-1		SP	SAND, olive black (7.5Y3/2), VF, WS trace silt; sloppy, flecked with VF shell fragments, with some small mud lenses (with shell up to 15mm). Trace calcarenite, fine quartzite gravel and rare pebbles up to 5mm		VZ		
			NO SHELL ↓	-2							
				-3		SP	SAND, olive grey (10Y4/2), darkening at 3m to grey (5Y4/1), VF-F, WS, sloppy, in places sticky, trace fines and rare calcarenite (up to 25mm). Grader in places to clayey SAND. Dark olive grey (5Y4/1) between 3.3 and 4.2m		MD		
			D	-4							
			NO SHELL ↑	-5		SM	Silty SAND, light olive grey (2.5G4/1) grading to greenish grey (7.5G4/1) with patches of light yellow. Trace shell fragments				
				-6			Reposal at 5.8m, possibly on basement (dolomite?) (-5.03m)				

ENGINEERING LOG - BOREHOLE

project *ROYAL HOBART GOLF CLUB* location *in shallow sand pit (1.5m below natural surface) E of 5th fairway*

co-ordinates *541075 m E*
5254950 m N drill type *TRIEFUS* hole commenced *2.9.80*
R.L. *0.09m AHW* drill method *Auger Pull* hole completed *2.9.80*
inclination *VERTICAL* drill fluid *NONE* drilled by *J. Lister*
bearing *-* checked by *W.C.ramer*

penetration 1 2 3	support water	notes samples, tests	metres R.L. depth	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency	density index	hand penetr- ometer kPa				structure, geology
										25	50	100	200	
			0		SP	<i>SAND, dull yellow orange (1.0YR 6/4), F-M, WS trace shell, VF dark minerals; darkening to yellowish brown (2.5Y 5/4) with trace white shell (up to 20mm). +2mm fraction < 10%.</i>	M	L						MARINE SAND
			1											
			2		SP	<i>SAND, grey (7.5Y 4/1), F, WS, with trace fine shell fragments and occasional shell white shell up to 15mm; trace calcarenite and VF dark minerals. occasional thin sand lenses.</i>								
			3											
			4			<i>Trace intact gastropods (up to 30mm) at 3.9-4.2m.</i>								
			5			<i>Fines near 5.1m (VF-F, WS), flecked with VF shell, VF dark minerals.</i>								
			6			<i>Distinctive shelly sand lens at 6.5m, with fragmented and whole shell, including scallops, up to 30mm</i>								
			7											
			8			<i>SAND, bright olive, F-VF, WS. Flecked 7.1-7.4m with VF-F shell; remaining shelled with depth between 7.4-8.7m, shelly sand, with whole and fragmented shell (up to 20mm). Trace green mudstone fragments (up to 40mm) and well rounded fine quartz gravel. Below 8.8m, possibly bright olive F-VF, WS sand with shell fragments interbedded with thin lenses? of shell-free sandy clay and clayey sand, in places gravelly sandy clay (with weakly cemented CaCO₃-rich patches and occasional sandstone up to 40mm); grading at about 10% to gravelly sandy clay.</i>								
			9											
			10											
			10.8			<i>Hole stopped at required depth, 10.8m (-10.71m)</i>								

1800mm X 50mm X 0.4m S.S. Screen
 Q = 700gph (53 L/min), TOS = 1930 mgl.

L to MID

Hole stopped at required depth, 10.8m (-10.71m)

ENGINEERING LOG - BOREHOLE

project *ROYAL HOBARD GOLF CLUB* location *Adjacent to Seven Mile Beach shq; on street corner*

co-ordinates *541175m E*
5254225m N drill type *TRIEFUS* hole commenced *9.9.80*
drill method *AUGER PUAL* hole completed *9.9.80*
R.L. *1.10m AHW* drilled by *B. COX*
inclination *VERTICAL* drill fluid *NONE* logged by *W. CRAMER*
bearing *-* checked by

penetration 1 2 3	support water	notes samples, tests	metres R.L. depth	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency density index	hand penetr- ometer kPa 25 50 100 200 400	structure, geology
			0		SP	SAND, dull yellow orange (10YR 7/4), VF, WS, slightly coarser between 0.5 and 1.5m, with trace VF dark minerals and rare fine shell fragments	D	VL		
			1							
			2				M			
			-1		SP	SAND, dull yellow orange (10YR 6/6), F-M, WS, trace shell fragments and white shells (up to 20mm). Streaked with grey near 2-6m	W	L		
			3							
		12mm sieve sample	-2		SP	SAND, greyish blue (5Y 5/2), F, WS with trace fine shell fragments, grading rapidly to grey (5Y 4/1) F-M, WS sand. Trace shell (up to 25mm). Lens of grey sandy shell 3.1-3.3m (+2mm fraction in lens ≈ 30%, mainly as fragmented shell up to 10mm and occasionally up to 40mm, trace fine quartzite gravel, and rare white pebbles up to 30mm). Between 3.3 and 4.2m, grey F-M, WS sand with trace shell (up to 15mm).				
		D	4							
			-3							
		D	5							
			-4							
			6		SP	SAND, grey (5Y 4/1), VF, WS, with trace VF-F shell fragments and VF dark minerals.				
			-5							
		D	7							
			-6							
			8							
			-7		SP	SAND dark blue grey (5GY 4/1), F, WS-MS, in places shelly SAND, with shell up to 1mm and occasionally up to 20mm including white gastropods. Trace well-rounded fine quartzite gravel and irregular green calcarenite patches. Grades to olive sand, F, WS, with VF-F shell fragments.				
			9							
			-8							
			10							
			-9							

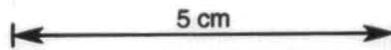
Spear jetted 10.12.84

9.9.80

1800 X 50mm X 0.4mm screen

Q = 430 gph
TDS = 620 mg/L

Pebbles? 12mm sieve



35
6

ENGINEERING LOG - BOREHOLE

project *ROYAL HOBART GOLF CLUB* location *Adjacent to Seven Mile Beach Rd.*

co-ordinates *541175 m E* drill type *Triples 0-10m; Maline 10-13.3m.* hole commenced *9.9.80*
52 54225 m N drill method *auger pull* hole completed *Deponed 24.11.80 by*
 R.L. *1.10m A.H.W.M.* drill fluid *none* drilled by *G. Humphreys, C. Harris*
 inclination *VERTICAL* logged by *W. Coomer*
 bearing *-* checked by

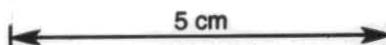
penetration 1 2 3	support	water	notes samples, tests	metres R.L. depth	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency density index	hand penetr- ometer kPa 25 100 200 400	structure, geology
				10 -9		SP	<i>As above.</i>	<i>W</i>	<i>L to MD.</i>		
				11 -10							
				12 -11							
				13 -12		CH	<i>CLAY, mainly brownish grey (10YR 4/1) streaked with greyish blue (7.5Y 4/2), grey (10Y 4/1) and dual reddish brown (5YR 4/4). High plasticity</i>	<i>M</i>	<i>St to Vst</i>		
				14			<i>Hdc stopped at required depth, 13.3m (-12.2 m)</i>				

ENGINEERING LOG - BOREHOLE

project *ROYAL HOBART GOLF CLUB* location *Junction Surf Road and Sundays Avenue*

co-ordinates *S 41 475 m E* drill type *TRIEFUS* hole commenced *9.9.80*
52 546 50 m N drill method *AUGER PULL* hole completed *9.9.80*
 R.L. *0.96 m AHW* drill fluid *NONE* drilled by *B. COX*
 inclination *VERTICAL* logged by *W. CROWER*
 bearing *-* checked by

penetration 1 2 3	support	water	notes samples, tests	metres R.L. depth	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency density index	hand penetr- ometer kPa 25 50 100 200 400	structure, geology
			NO SHELL	0 1		SP	SAND, dull yellowish orange (10YR 7/4), VF, WS, with trace dark brown (7.5YR 3/4) wood patches and friable calcareous sand patches	D	VL		
			D	-1 2		SP	SAND, bright yellowish brown (10YR 7/6), M, WS, with trace shell fragments (up to 25mm); grades to dull yellow (2.5Y 6/3) with occasional thin lenses of shelly sand		L		
			D Plum Iron	-2 3 -3 4		SP SW	SAND, grey (7.5Y 4/1) and shelly SAND, F-M, MS, trace VF dark minerals. Shell mainly fragmented (up to 5mm), but with some whole shell (up to 20mm). Trace well-rounded fine quartzite gravel		MD		
			D	-4 5		SP	SAND, grey (7.5Y 4/1), VF-F, WS; trace fine shell fragments, occasionally up to 5mm. Distinctive unit				
			D	-5 6 -6 7							
			Address?	-7 8			Position of base uncertain				
			D	-8 9		SP SW	shelly SAND, grey (10Y 4/1) changing to olive grey. Some shell, mainly fragments less than 5mm. Trace fine gravel.				
				-9 10		SP	SAND, olive grey (10Y 4/2); VF, WS, flecked with very fine shell fragments.				



ENGINEERING LOG - BOREHOLE

project *ROYAL HOBART GOLF CLUB* location *Junction of Dent Road and Sunways Avenue.*

co-ordinates *S41478m E* drill type *Tire/ps 0-10.2m; Profile 10.2-14.4m.* hole commenced *9.9.80*
S254650m N drill method *auger pull* hole completed *Deepened 24.11.80 by*
 R.L. *0.96m AHWM* drill fluid *none* drilled by *G. Humphreys, C. Harris*
 inclination *VERTICAL* logged by *W. Corner*
 bearing *-* checked by

penetration 1 2 3	support water	notes samples, tests	metres R.L. depth	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency density index	hand penetr- ometer kPa 25 50 100 200 400	structure, geology
			-9		SP	<i>As above.</i>				
			-10							
			-11							
			-12							
			-13							
			-13		CH	<i>CLAY, mottled and streaked brown, grey, orange, with trace V.C. shell fragments in upper 0.3m; with trace well-rounded fine, dark siltstone fragments up to 30mm. High plasticity</i>	M	Vsf		
			-14							
			-15			<i>He stopped at required depth, 14.4m (-13.44m).</i>				

ENGINEERING LOG - BOREHOLE

project *ROYAL HOBART GOLF CLUB* location *in pine plantation, in wide firebreak, 200m from corner.*

co-ordinates *54680m E* drill type *Trietfus* hole commenced *9.9.80*
5255525m N drill method *auger pull* hole completed *12.9.80*
 R.L. *1.83m AHW* drill fluid *none* drilled by *B. Cox*
 inclination *VERTICAL* logged by *W.C. Crower*
 bearing *-* checked by

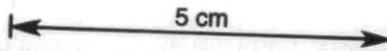
penetration	support	water	notes	metres	graphic log	classification	material	moisture	consistency	hand	structure, geology
1 2 3			samples, tests	R.L. depth		symbol	soil type: plasticity or particle characteristics, colour, secondary and minor components.	condition	density index	penetr-ometer kPa	
										25 50 100 200 400	
			<i>sear jacked</i> <i>9.12.80</i>	+1		SP	<i>SAND, dull yellow orange (10YR 6/4), F-M, WS, with streaks and patches of brown</i>	D	VL		
			<i>Q: 330 gph</i> <i>TDS = 620 mg/l</i>	0		SP	<i>SAND, dull yellow orange (10YR 6/4), M, WS, with trace shell fragments (occasionally up to 30mm) and CaCO₃ root concretions</i>	M	L to MD		
				-1							
			<i>1800 x 50mm x 0.4mm slot screen</i>	-2		SP	<i>SAND, greyish olive (7.5Y 5/2), F, M-WS, flecked with fine-coarse shell fragments (rarely up to 5mm, trace up to 30mm), trace fine quartz gravel, well rounded.</i>				
				-3		SP	<i>SAND, olive black (10Y 3/1), VF, WS, distinctive unit in many holes; Trace VF shell flecks (< 1%), with some fragments up to 5mm near 6m. Between 6-6.9m, trace shell fragments up to 15mm. [+2mm fraction < 1%, contains CaCO₃-cemented sand patches and rare angular detritic pebble (15mm)]</i>				
				-4							
				-5							
				-6							
				-7		SW	<i>Shelly SAND, olive black (10Y 3/2), F, PS; distinctive unit; [+2mm fraction ≈ 50%; contains mainly fragmented shell up to 5mm; some whole shell up to 40mm, trace detritic pebbles, and well rounded quartzite gravel (up to 10mm)]</i>				
				-8		SP	<i>SAND, olive grey (10Y 4/2) VF-F, WS, trace VF-F shell fragments. Distinctive unit.</i>				
				-9							
				-10							

ENGINEERING LOG - BOREHOLE

project *ROYAL HOBART GOLF CLUB* location *La pine plantation*

co-ordinates *541080m E* drill type *TRIEBUS 0-10.2m; PROLINE* hole commenced *9.9.80*
5255525m N drill method *AUGER PULL* *10.2-13.5m* hole completed *12.9.80* - *Deepened 14.11.80*
 R.L. *1.83m AHWM* drill fluid *none* drilled by *B. Cox, G. Humphries*
 inclination *VERTICAL* logged by *W. Crumer*
 bearing *-* checked by

penetration 1 2 3	support water	notes samples, tests	metres R.L. depth	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency density index	hand penetr- ometer kPa 25 50 100 200 400	structure, geology
						<i>CONTINUATION SHEET.</i>				
			<i>10</i>		<i>SP</i>	<i>As above; trace clay near base (below 12m)</i>	<i>W</i>	<i>L to MD</i>		
			<i>11</i>							
			<i>12</i>							
			<i>13</i>		<i>CH</i>	<i>CLAY, bright olive, high plasticity, with trace shell fragments, in localized patches, up to 5-10mm.</i>	<i>M</i>	<i>St</i>		
			<i>14</i>			<i>HERE STOPPED AT LIMIT OF AUGERS, 13.5m (-11.67m)</i>				



ENGINEERING LOG - BOREHOLE

project **ROYAL HOBART GOLF CLUB** location *In smaller of 2 adjacent marshes.*

co-ordinates **540725mE**
5255975mN

R.L. **-0.10m AHWM**

inclination **VERTICAL**

bearing **-**

drill type **Triefus**

drill method **auger-pull**

drill fluid **N/A**

hole commenced **11.9.80**

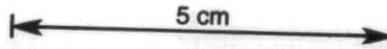
hole completed **11.9.80**

drilled by **B. Cox**

logged by **W.C. COOPER**

checked by

penetration	support	water	notes samples, tests	metres R.L. depth	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency	density index	hand penetrometer kPa	structure, geology
123												
		11.9.80	Slight H ₂ S smell No SHELL	-1		SP	SAND, dark brown (10YR 3/3), F, WS	M	L			
				1		SP	SAND, olive grey (10Y 4/2), F-VF, WS, trace fines? at 1.5m, grading to sloppy VF, WS bright olive sand with trace CaCO ₃ -cemented friable sand patches; trace VF dark minerals	W				
				2								
				3		SP	SAND, as above, VF, WS, with trace VF shell fragments (below 3.7m, trace shells up to 30mm, including whole gastropods. Trace well-rounded fine quartzite gravel and bright olive partly cemented CaCO ₃ patches. Some very thin shelly sand lenses.					
			D	4			between 4.2-5.1m, slightly greyer and coarser; [+2mm fraction ≈ 5-7%]					
				5								
			D	6								
				7		SP	SAND, bright olive (same as in hbl 12); VF-F, WS, flecked with VF shell fragments & rare larger shell up to 10mm					
			D	8		SP	SAND, olive grey (10Y 4/2), F, W-MS, with trace shell, occasionally up to 15-20mm. Some thin shelly sand lenses 8-8.7m.					
				9								
			D	10		SC	Sandy CLAY grading to clayey SAND, olive to black (10Y 3/1); shelly in places with trace shell up to 30mm.	M to W				



ENGINEERING LOG - BOREHOLE

project *ROYAL HOBART GOLF CLUB* location *1/4 smaller of two adjacent marshes*

co-ordinates *540725m E*
5253875m N
R.L. *-0.10m AHUM*
inclination *VERTICAL*
bearing *-*

drill type *TrieFuS 0-10.2m; Pistone 10.2-13.5m*
drill method *auger pull*
drill fluid *none*

hole commenced *11.9.80*
hole completed *deemed 25.11.80 by*
drilled by *G. Humphreys, C. Harris*
logged by *W. Coomer*
checked by

penetration 1 2 3	support	water	notes samples, tests	metres R.L. depth	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency	density index	hand penetr- ometer kPa 25 50 100 200 400	structure, geology
				<i>10</i>		<i>SC to CL</i>	<i>As above</i>	<i>W</i>	<i>VL</i>			
				<i>-11</i> <i>11</i>			<i>CLAY, dark olive grey (5G44/1), with a trace F-VF mud and localized F-VF shell fragments. grades to:</i>	<i>M</i>	<i>St to L</i>			
				<i>-12</i> <i>12</i>			<i>Gravelly sandy CLAY, olive grey (5G46/1) in places clayey mud; apparently shell-free, grading at 13m to grey-brown gravelly sandy clay, with angular-sub-rounded brown siltstone fragments (up to 40mm)</i>	<i>W</i>				
				<i>-13</i> <i>13</i>				<i>M</i>				
				<i>-14</i> <i>14</i>			<i> Hole stopped at required depth, 13.5m (-13.6m)</i>					

ENGINEERING LOG - BOREHOLE

project *ROYAL HAWK GOLF CLUB* location *On property boundary, about 250m NW of RH 17.*

co-ordinates *540600 m E* drill type *Triefus* hole commenced *11.9.80*
5256035 m N drill method *Auger/pull* hole completed *11.9.80*

R.L. *1.25m AHWM* drill fluid *none* drilled by *B. Cox*
 inclination *VERTICAL* logged by *W.C. Coomes*
 bearing *-* checked by

penetration 1 2 3	support water	notes samples, tests	metres R.L. depth	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency density index	hand penetr- ometer kPa	structure, geology
			+1		SP	SAND, dull yellow orange (10YR 6/4), streaked with brown, F, WS, trace fine roots, grading at 1.5m to bright yellowish brown (10YR 6/6) streaked with yellowish brown (10YR 5/8). Trace fines below 1m.	D	MD		
			1							
			0							
			2		SP	Slightly clayey SAND, mainly yellowish brown (10YR 5/8) and dull yellow (2.5Y 6/4) above 2m; yellowish brown (2.5Y 5/6) and grey-blue (9.5Y 4/4) 2.0-2.4m; grading to olive (5Y 5/4) less clayey F-W sand. [Thin CLAY lens or horizon at 2.8m; dark greenish grey (5G 4/1), low plasticity; trace sand]	W			
			-1		SC					
			3		SP	SAND, olive grey (10Y 5/2), F, WS, trace fines and C sand (well-rounded quartzite); clayier near 3.8m; thin bright olive sandy clay lens at 4.2m. Sloppy 3.8-4.2m.	M			
			-2		SC					
			4		SP	SAND, bright olive, VF, WS, trace fines, sloppy, with trace VF rock fragments and dark minerals. Slightly grey below 6m, and bright olive brown below 7m.	W			
			-3		SC					
			5		SP					
			-4							
			6							
			-5							
			7							
			-6							
			8							
			-7		SP	SAND, olive grey (10Y 4/2), F-VF, WS, trace (1%) VF shell fragments, occasionally up to 15mm. Trace (<1%) well-rounded fine quartzite gravel and angular rock fragments. Grades to:				
			9							
			-8		SC and CH	Clayey SAND, grey (10Y 4/1); % fines variable; VF, WS; includes thin lens of olive black (10Y 3/1) plastic (CH) sticky clay. Trace (<1%) shell fragments up to 4mm.				
			10							

11.9.80

NO SHELL

1800mm x 50mm x 0.4mm s.s. screen. Q = 80 gph (6.2/min) TSS = 1500 mg/l HACE

Logs stopped at limit of auger, 10.2m (-8.95m)

ENGINEERING LOG - BOREHOLE

project *ROYAL HOBART GOLF CLUB* location *Lands Dept. Plantation*

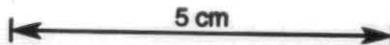
co-ordinates *541375 m E*
5255223 m N drill type *Rotary* hole commenced *13.11.80*

R.L. *1.26 m AHW* drill method *auger pull* hole completed *13.11.80*

inclination *VERTICAL* drill fluid *none* drilled by *G. Humphries, C. Harris*

bearing *-* checked by *W. Cooney*

penetration 1 2 3	support water	notes samples, tests	metres R.L. depth	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency density index	hand penetr- ometer kPa	structure, geology
									25 50 100 200 400	
		<i>Spear kitted 9.12.80</i>	+1		SP	<i>SAND, bright yellowish brown (10YR 6/6), F, WS</i>	D	VL		
			1							
			0				M			
			2			<i>SAND, as above, with trace (<1%) F shell fragments; darkening at 1.8m to greyish dive (5Y 5/2)</i>	W	L to MD		
			-1							
			3			<i>SAND, black (10YR 1.7/1), VF, WS, flecked with trace VF white shell fragments and occasional white gastropods (up to 35mm). Shell fragments slightly coarser (up to 5mm) in places below 5.4m, with occasional very thin shelly sand lenses and local patches. Below 4.5m, lightens to dark dive grey (2.5G 4/1)</i>				
		<i>1800mm x 50mm x 0.5mm spt 5" screen Q = 480gph TDS = 1170mg/l</i>	-2							
			4							
			-3							
			5							
			-4							
			6							
			-5							
			7							
			-6							
			8							
			-7							
			9		SW to GW	<i>Shelly SAND, grey (10Y 4/1), F, MS-PS, in place with trace fines. Shell fragments (up to 50% locally) mainly < 5mm, occasionally up to 20mm. Trace well-rounded dark quartzite rock fragments (up to 20mm)</i>				
			-8							
			10		SP	<i>SAND, bright olive - olive grey, VF, WS, with Trace shell fragments (5-7%) generally < 2mm and occasionally up to 20mm.</i>				



ENGINEERING LOG - BOREHOLE

project <i>ROYAL HOBART GOLF CLUBS</i>	location <i>Lands department plantation</i>
co-ordinates <i>541975m E</i> <i>5255273m N</i>	drill type <i>Proline</i> drill method <i>auger pull</i>
R.L. <i>1.26m ANWM</i> inclination <i>VERTICAL</i> bearing <i>-</i>	hole commenced <i>13.11.80</i> hole completed <i>13.11.80</i> drilled by <i>G. Humphries, C. Martin</i> logged by <i>W. Connor</i> checked by

penetration	support	water	notes samples, tests	metres R.L. depth	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency	density index	hand penetrometer kPa	structure, geology
1 2 3											25 50 100 200 400	
CONTINUATION LOG SHEET												
				-10	SP	SP	<i>As above</i>	W	MD			
				-11	SC	SC	<i>Clayey SAND, bright olive grey, FWS, trace shell-fragments in places</i>		F			
				-12	CH	CH	<i>CLAY, mainly greyish olive (5Y4/2) with streaks and patches of brownish grey (10YR4/1) with traces of yellowish brown (10YR5/8) and dark grey, mainly brownish grey below 13m. High plasticity.</i>	M	SF			
				-13								
				-14			<i>Hole stopped at limit of Auger, 13.5m (12.24m)</i>					

ENGINEERING LOG - BOREHOLE

project *ROYAL HOBART GOLF CLUB* location *Lands department beach reserve, end of Out Road*

co-ordinates *541750m E*
5254900m N

R.L. *-0.64m AHWL*

inclination *VERTICAL*

bearing *-*

drill type *Protine*

drill method *auger pull.*

drill fluid *none.*

hole commenced *13.11.80*

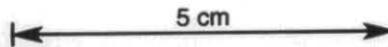
hole completed *13.11.80*

drilled by *G. Humphries, C. Harris*

logged by *W. Crowl*

checked by

penetration	support	water	notes samples, tests	metres R.L. depth	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency density index	hand penetr- ometer kPa	structure, geology
1 2 3			<i>13.11.80</i> <i>TDS</i> <i>350-400</i> <i>mg/l</i> <i>at water</i> <i>table</i>	-1		SP	<i>SAND, dull yellow brown (10YR 5/4), F, WS, with trace VF-F shell fragments. Trace VF dark minerals. Sand becomes slightly coarser below 0.8m.</i>	M	L		
			<i>10.12.80</i> <i>Spear</i> <i>jetted</i>	1				W	to		
				-2			<i>SAND, greyish olive (5Y 4/2), F, in places M, WS-MS, with trace F-VF shell (occasionally up to 15mm). Darkens at 2.5m to grey (5Y 4/1) Trace VF dark minerals.</i>				
				2							
				-3							
				3							
				-4			<i>SAND, dark grey-black, VF, WS, with trace (<1%) VF shell. Paler to grey (7.5Y 4/1) below 4m. Distinctive unit.</i>				
			<i>1800mm</i> <i>x 50mm</i> <i>x 0.4mm</i> <i>s.s. screen</i> <i>Q=720gph</i> <i>TDS=</i> <i>420 mg/l.</i>	4							
				-5							
				5							
				-6							
				6							
				-7		SC	<i>Shelly SAND, mainly grey (10Y 5/1). Up to 50% F-C shell (up to 5mm, occasionally coarser) sand F-M; grades to bright olive at 6.6m.</i>				
				7		SP	<i>SAND, dark greyish olive, VF, WS, with trace (<1%) VF shell fragments. Occasional trace of bright olive clayey sand in places, occasional white-cream friable CaCO₃-rich sand and cemented sand; some very thin shelly sand lenses. Colour below 11m: bright olive, VF, WS, trace VF shell fragments.</i>				
				-8							
				8							
				-9							
				9							
				-10							
				10							

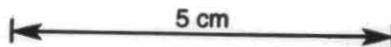


ENGINEERING LOG - BOREHOLE

project *ROYAL HOBART GOLF CLUB* location *Lands Dept. beach reserve off Dart Road.*

co-ordinates *541750m E* drill type *Proline* hole commenced *13.11.80*
525490m N drill method *auger pull* hole completed *13.11.80*
 R.L. *-0.64m ARLM* drill fluid *none* drilled by *G. Humphreys, C. Harris*
 inclination *VERTICAL* logged by *W. Cooper*
 bearing *-* checked by

penetration 1 2 3	support water	notes samples, tests	metres R.L. depth	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency density index	hand penetr- ometer kPa 25 50 100 200 400	structure, geology
			<i>10</i>		<i>SP</i>	<i>AS ABOVE</i>	<i>W</i>	<i>MD</i>		
			<i>11</i>							
			<i>12</i>		<i>SC</i>	<i>Clayey SAND, olive black (10Y 3/1), VF, WS, with small shell fragments, occasionally up to 10mm.</i>				
			<i>13</i>		<i>GW</i>	<i>Clayey sandy GRAVEL, dark olive (7.5Y 4/3), PS, with brown, white well-rounded quartzite gravel (up to 20mm)</i>	<i>W</i>	<i>MD</i> <i>SF</i>		
			<i>13</i>			<i>HOLE STOPPED AT REQUIRED DEPTH, 12.6m (-13.24m)</i>				



ENGINEERING LOG - BOREHOLE

project *ROYAL HOBART GOLF CLUB*

location *Junction Avenida Beach road, and Club entrance*

co-ordinates *S40335m E*
S254325m N
R.L. *1.02m AHW*
inclination *VERTICAL*
bearing *-*

drill type *PROLINE*
drill method *auger pull*
drill fluid *none*

hole commenced *6.1.81*
hole completed *6.1.81*
drilled by *M. Triffitt, J. Lister*
logged by *W. Crower*
checked by

penetration 1 2 3	support water	notes samples, tests	metres R.L. depth	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency density index	hand penetr- ometer kPa	structure, geology
		<i>6.1.81</i>	0		SP	<i>SAND, black, F, WS, trace silt; organic, with trace fine root</i>	<i>M</i>	<i>L</i>		
			0		SP	<i>SAND, brown (10YR 4/4), F, WS, with trace VF dark minerals and (near 0.8m) VF shell fragments</i>	<i>W</i>	<i>L</i>		
			0		SP	<i>SAND, greyish olive (5Y 4/2), MS, F, VF, flecked with M-C shell fragments (locally up to 15mm). Below 1.8m, darkens to grey and becomes shellier, grading locally to shelly sand (probably in thin lenses).</i>				
			-1							
			-2							
			-2		SP	<i>SAND, grey, VF, WS, flecked with VF shell fragments; locally abundant in coarser shell; occasional patches of organic material and rare well-rounded siderite pebbles up to 20mm. Grades to olive grey below 5.2m, with trace - some fine quartzite gravel in places</i>				
			-3							
			-4							
			-4							
			-5		SC to CL	<i>Sandy CLAY - clayey SAND, streaked with green, brown and orange; grades to sandy clay; low plasticity</i>	<i>M</i>	<i>St</i>		
			-5							
			-6							
			-6							
			-7			<i> Hole stopped at required depth, 6.3m (-5.28m)</i>				

ENGINEERING LOG - BOREHOLE

project **ROYAL HOBART GOLF CLUB**

location **G. Casinari's property**

co-ordinates **540100m E**
5255100 m N
R.L. **1.89m AHW**
inclination **VERTICAL**
bearing **-**

drill type **Paline**
drill method **auger drill**
drill fluid **none**

hole commenced **10-11-80**
hole completed **10-11-80**
drilled by **G. Humphreys**
logged by **W. Crowe**
checked by

penetration 1 2 3	support water	notes samples, tests	metres R.L. depth	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency density index	hand penetr- ometer kPa 25 50 100 200 400	structure, geology
			+1		CL	CLAY, olive brown (2.544/3), moderately plastic, with trace F sand (<1%). Silty clay at top. Grades below 0.6m to sandy CLAY, yellowish brown (2.545/4) with occasional friable CaCO ₃ -cemented patches.	M	St		
			0		SP	SAND, greyish yellow (2.546/2), VF-F, WS, with trace (<<1%) VF dark minerals, grading at 1.8m to sand, yellowish brown (2.545/4), F, WS, trace fines, sloppy, darkening to olive brown (2.544/6).	W	MD		
			-1							
			-2		SP	SAND, olive brown (2.544/3), mottled in places with greyish blue gleying; mainly F, FS, with varying amounts of fines (grades locally to clayey sand), trace M-C CaCO ₃ -cemented grains, and rare angular quartzite fine gravel. Grades to:				
			-3		SP	SAND, dark olive grey (5G44/1), VF, WS, with trace fines (mainly silt?), darkening to 5G43/1, locally with trace well-rounded M-C quartz. Sloppy. Becomes bright olive near 6m				
			-4							
			-5			SAND, bright olive, VF-F, WS, with trace VF-F shell fragments and dark minerals. Below 8m, darkens to dark olive grey (2.5644/1), VF-F, with shell fragments up to 5mm				
			-6							
			-7			SAND, dark grey-black, VF, WS, shell-free.				
			-8		CH	CLAY, dark greenish grey, sticky, high plasticity, with trace (<1%) cream fine shell fragments	M	St		
			-8			HOLE STOPPED AT REQUIRED DEPTH 9.8m (-8.07m)				

ENGINEERING LOG - BOREHOLE

project ROYAL HOBART GOLF CLUB

location G. Carimatis property.

co-ordinates 539 900 m E
52 552 50 m N
R.L. 2.56 m AHW
inclination VERTICAL
bearing -

drill type Pitane
drill method auger pull.
drill fluid none

hole commenced 10.11.80
hole completed 11.11.80
drilled by G. Humphries
logged by W. Crower
checked by

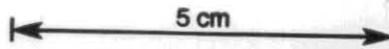
penetration	support	water	notes	metres	graphic log	classification	material	moisture	consistency	hand	structure, geology
1 2 3			samples, tests	R.L. depth		symbol	soil type: plasticity or particle characteristics, colour, secondary and minor components.	condition	density index	penetr-ometer kPa	
										25 50 100 200 400	
			Notes: Spear jetted 26.11.80 TDS = 9000 mg/l at water table Sloppy 1800 mm x 50 mm x 0.4 mm S.S. screen Q = 107 gal (42 l/min) TDS = 11000 mg/l			CL	Silty CLAY, brownish black (10YR 3/2)	D	FB		
				+2		CH to CL	CLAY, mainly yellowish brown (2.5Y 5/3), streaked and mottled in places with brownish black (2.5Y 3/2) with traces of black organic? streaks and charcoal fragments; trace M-C rock fragments and < 1% sand. occasional CaCO ₃ cemented patches. Low plasticity, below 0.9m. Between 1.8-2.7m, occasional white friable CaCO ₃ /clay patches. Below 1.8m trace (< 1%) VF-F mud, moderately plastic, with decrease of rock fragments.	M	ST to VSF		
				+1							
				0							
				-1		SP	SAND, yellowish brown (2.5Y 5/3), M, M _s with trace fines above 3.4m and trace M-C well-rounded quartz (occasionally up to 2-3mm). Grains to greyish yellow brown (10YR 5/2) sand.	W	L to MD		
				-2							
				-3		GP to SC + GW	SAND, dull yellow (2.5Y 6/3), VF, WS, trace silt?, trace (< 1%) well-rounded M quartz, interbedded with gravelly, clayey SAND, dull yellow, with some angular - fine quartzite gravel (up to 5mm) in F sand/clay, possibly as thin lenses.				
				-4							
				-5			SAND, dull yellow (2.5Y 6/4), F, WS, streaked with yellowish brown (10YR 5/3). Grains well-rounded, trace fines and VF dark minerals. Rapid dilatancy 6.7-7.2m, slightly sticky. Locally VF. Rare fragments of siltstone (up to 40mm). Below 7.2m, darkens to olive grey (2.5G 4/1), dark olive (7.5Y 4/3) and olive brown (2.5Y 4/6), and sand becomes VF				
				-6		CH	CLAY, dark olive grey (5G 4/1) and black; mottled below 9.5m with brownish grey (7.5YR 5/1), olive grey and streaks of bright yellowish brown (2.5Y 6/6), greyish olive (5Y 5/2) and brownish grey (7.5YR 5/2). High plasticity. Trace (< 1%) F sand at 10.8m.	M	VST		
				-7							
				-8							
				-9							
				-10			HOSE STOPPED AT REQUIRED DEPTH, 10.8m (-8.24m)				

ENGINEERING LOG - BOREHOLE

project *ROYAL HOBART GOLF CLUB* location *G. Carimaty's property*

co-ordinates *540175m E*
5255675m N drill type *Paline*
R.L. *2.14m AUWM* drill method *auger pull*
inclination *VERTICAL* drill fluid *none*
bearing *-* hole commenced *11.11.80*
hole completed *12.11.80*
drilled by *G. Murphy's, C. Harris*
logged by *W. Cromer*
checked by

penetration	support water	notes samples, tests	metres R.L. depth	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency density index	hand penetrometer kPa				structure, geology
									25	50	100	200	
1 2 3 4 5 6 7 8 9 10	<p><i>Spur jetted 26.11.80</i></p> <p><i>(Pal. 30 gph (2.31 l/min); 700-2690 mfl bore)</i></p> <p><i>1/800mm x 50mm x 0.4mm SS. screen.</i></p> <p><i>Poor recovery.</i></p> <p><i>Probably VL running sand.</i></p>		+2		SP	<i>SAND, dull yellow orange (10YR7/2), F, WS, with trace angular silstone fragments at base</i>	D	VL					
			SC to CL		<i>Clayey SAND-sandy CLAY, yellowish brown (2.5Y5/4), F-M, MS, with trace angular-well-rounded quartzite (up to 3mm); clayier near base</i>	M	ST						
			SP		<i>SAND, brown (10YR4/6), grading to dull yellowish brown (10YR5/4), F, WS-MS, with trace fine quartzite gravel and C sand; grading at 1.8m to very slightly clayey sand, F, WS,</i>	D	FB						
			CH		<i>CLAY, mainly olive grey (10Y4/2), with streaks and patches of dark olive grey (5G4/1) and rare small orange-brown sandy patches; occasional friable CaCO₃ patches and trace (<1%) VF sand. High plasticity</i>	M	L						
			SP		<i>SAND, pale bluish grey, M, WS, trace fines, darkening to olive grey (10Y5/2) and dark greenish grey (7.5G4/1). Fines content increases below 5m. Below 5.2m, grades to clayey SAND, dark greenish grey (10G4/1), F, WS, flecked with trace VF white quartzite. Between 5.6 and 8m, SAND, dark greenish grey, F-VF, WS, sloppy, with trace silt, grading at 8m to olive brown (2.5Y4/4), F, WS, with trace fines</i>	W	L to MD						
					<i>SAND, dark bluish grey, F, WS, with trace shell fragments (up to 3mm) and C quartzite grains</i>								
					<i>SAND, bright olive, F-VF, WS, grading to</i>								



ENGINEERING LOG - BOREHOLE

project *ROYAL HOBART GOLF CLUB* location *G. Carimaty's property*
 co-ordinates *540175mE* drill type *Proline* hole commenced *11-11-80*
5258675mN drill method *auger pull* hole completed *12-11-80*
 R.L. *2.14m AALUM* drilled by *G. Humphries, C. Martin*
 inclination *VERTICAL* drill fluid *none* logged by *W. Conner*
 bearing *-* checked by

penetration 1 2 3	support	water	notes samples, tests	metres R.L. depth	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency density index	hand penetr- ometer kPa 25 50 100 200 400	structure, geology
				8		SP	<i>dark grey, VFIWS, locally with trace F-VF shell fragments</i> <i>Apparently shell-free below 12m</i>	W	MD		
				9							
				10							
				11							
				12							
				13		CH	<i>CLAY, dark greenish grey (5G 3/1), high plasticity, shell-free. Trace VF sand.</i>	M	ST		
				14			<i>BORE STOPPED AT REQUIRED DEPTH, 13.5m (-11.36m)</i>				

ENGINEERING LOG - BOREHOLE

project **ROYAL HOBART GOLF CLUB** location **On G. Conimely's land**

co-ordinates **540000m E** drill type **Active** hole commenced **12.11.80**
52 55325m N drill method **auger pull** hole completed **12.11.80**
 R.L. **1.08m AHW** drill fluid **none** drilled by **G. Humphries, C. Harris**
 inclination **VERTICAL** logged by **W. Conner**
 bearing **-** checked by

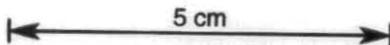
penetration	support	water	notes samples, tests	metres R.L. depth	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency density index	hand penetr- ometer kPa	structure, geology
123				+1		CH	CLAY, streaked and mottled black (5YR 1.7/1) and brownish black (10YR 3/1), grading to streaked and mottled olive brown (2.5Y 4/3) and yellowish brown (2.5Y 5/6), with trace small black organic? patches. Trace F sand below 1.2m, grades to greyish olive (5Y 5/2) sandy clay and clayey sand with trace M-C quartzite	M	ST		
			Spear pushed 27.11.80	0		CL					
			TDS 1200 mg/l.	-1		SP	SAND, olive grey (2.5G 4/5/1), F, WS, trace fines.	W	MD		
			700-1000 mg/l.	-2		CH	CLAY, dark olive grey (5G 4/4/1), high plasticity, with trace (<1%) VF sand	M	ST		
			SP @ 20 gph @ 1.5 l/min	-3		SP	SAND, in places clayey sand, olive grey (2.5G 4/5/1) to VF-F, WS, darkening below 4.5m, clayier near 5m, and grading below 5.6m to sand, VF, WS	W	MD to L		
			50mm x 0.4mm screen, installed to 2.44m, then later to 4.88m.	-4		SP					
				-5							
				-6							
				-7		SP	SAND, dark olive grey, VF, WS; grains well-rounded, high sphericity. Clayier near 9.7m				
				-8							
				-9		CH	10-10.8m: CLAY, dark greenish grey (10G 4/1), high plasticity, sticky. Locally grades to clayey sand at 10.8m.				
				-10			HOLE STOPPED AT REQUIRED DEPTH, 10.8m (-9.72m)				

ENGINEERING LOG - BOREHOLE

project ROYAL HOBART GOLF CLUB location On G. Casimaty's land near radio telescope

co-ordinates 540 350m E
525 6250m N drill type Probe hole commenced 12.11.80
R.L. 0.85m AHWL drill method auger pull hole completed 13.11.80
inclination VERTICAL drill fluid None drilled by G. Humphries, C. Harris
bearing - checked by W. Crower

penetration	support water	notes samples, tests	metres R.L. depth	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency	density index	hand penetrometer kPa	structure, geology
123					CL	Silty CLAY, brownish black (10YR3/2), many root fibres, grading at 0.2m to	D	FB			
		Spear jetted 27.11.80	0		CH	CLAY, mottled and streaked yellowish brown (10YR 5/6) and olive brown (2.5Y4/3) with small black organic? patches and spots. Mod-erate to high plasticity	M	St			
		12.11.80	-1		SC, locally CH to CL	Sandy CLAY-clayey SAND, yellowish brown (2.5Y5/8 and 2.5Y5/4). Above 1.3m sand F,WS. Clay increases below 1.3m and darkens to dark greenish grey (7.5G4/1) with patches of 2.5Y5/4. Below 2m, patches of 7.5G4/1 CH clay and sandy clay occur in clayey sand.	F to St				
		TDG=18.40 49L NaCl	-2		SP	Sand F-M, WS. Clay increases near 2.7m	W	MD			
		Ø=240 gph (R.H. min)	-3		SP	SAND, olive grey (2.5Y5/1), M, locally M-C, WS to MS, with trace fines, and C. well-rounded rock fragments and quartzite grains. Fines decrease below 3.6m → clean sand					
		Ø=240 gph (R.H. min)	-4		SP	SAND, olive-bright olive, M, MS, locally F,WS, with trace rock fragments (up to 10mm, including white quartzite, dark brown quartzite and indurated sandstone) and occasionally well-rounded indurated sandstone up to 40mm.					
		Ø=240 gph (R.H. min)	-5			Below 6m, sand VF, WS, with trace rock fragments. Below 7m, olive grey (2.5G4/1), F,WS, and locally contains rare angular quartzite fragments (up to 25mm).					
		Ø=240 gph (R.H. min)	-6			Below 8.6m, sand dark blue grey-dark grey, F-VF, WS-MS, locally with trace well-rounded C white quartzite, occasionally up to 8mm. Fines increase at 11m.					
		Ø=240 gph (R.H. min)	-7								
		Ø=240 gph (R.H. min)	-8								
		Ø=240 gph (R.H. min)	-9								
		Ø=240 gph (R.H. min)	-10								

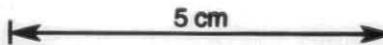


ENGINEERING LOG - BOREHOLE

project *ROYAL HOBART GOLF CLUB* location *On G. Casimatis land, near radio telescope*

co-ordinates *S40°50' ME* drill type *Proline* hole commenced *12.11.80*
S2 56 250 W N drill method *auger pull.* hole completed *13.11.80*
 R.L. *0.85m A.H.W.M* drill fluid *none* drilled by *G. Humphries, C. Harris*
 inclination *VERTICAL* logged by *W. Cooner*
 bearing *-* checked by

penetration 1 2 3	support water	notes samples, tests	metres R.L. depth	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency density index	hand penetr- ometer kPa 25 100 200 400	structure, geology
			10		SP	<i>AS ABOVE</i>				
			11		CL	<i>CL, Sandy CLAY-clayey SAND, med-plasticity, locally with trace white shell fragments up to 10mm</i>				
			12			<i>HOLE STOPPED AT REQUIRED DEPTH, 11.7m (-10.85m)</i>				



ENGINEERING LOG - BOREHOLE

project ROYAL HOBART GOLF CLUB location G. Carimaly's property

co-ordinates 53 9600m E
52 55410m N

R.L. 3.87m A.H.W.M

inclination Vertical

bearing -

drill type Admic

drill method Auger pull

drill fluid None

hole commenced 5.1.81

hole completed 5.1.81

drilled by M. Trifan, J. Lister

logged by W. Conner

checked by

penetration 1 2 3	support water	notes samples, tests	metres R.L. depth	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency density index	hand penetr- ometer kPa 25 50 100 200 400	structure, geology
	NONE		+3		CL	CLAY black, with possibly trace nit, root fibres; moderate plasticity, friable at surface, grading at 0.9m to dark greyish yellow (2.544/2) and dark olive (544/3) at 1m. Below 1m, trace sandy clay.	M =	FB to ST		Holocene LAGOONAL CLAY
	NONE ENCOUNTERED		+2		CH	Below 1.2m, changes to greyish yellow (2.546/2) with trace organic streaks and < 1% V.F.F sand.	M > PL	VSF		tertiary? CLAY
			+1			CLAY, mainly greyish brown (7.54RS/2), mottled and streaked with yellowish grey (2.545/1) and small flecks of yellowish brown and red. Nothing increases with depth.				
			0			Below 4.5m, bright yellow and red oxidized patches and streaks common, and below 6m pale to yellowish grey (2.546/1)				
			-1							
			-2							
			-3							
						None stopped at required depth, 7.2m (-3.33m)				
			8							

ENGINEERING LOG - BOREHOLE

project **ROYAL HOBART GOLF CLUB** location **G. Casimatis property**

co-ordinates **539675m E**
5256145m N

R.L. **1.18m AHW**

inclination **VERTICAL**

bearing **-**

drill type **Proline**

drill method **auger pull**

drill fluid **none**

hole commenced **5.1.81**

hole completed **5.1.81**

drilled by **M. Triffitt, J. Lister**

logged by **W. Connor**

checked by

penetration	support	water	notes samples, tests	metres R.L. depth	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency density index	hand penetrometer	structure, geology
										kPa	
1 2 3										25 50 100 200 400	
				11		CH	CLAY, black, organic, with orange-brown patches	M PL	ST		
				1		CH	CLAY, olive brown (2.54 4/3), mottled and streaked with orange brown, with small dark organic patches. Changes to greyish olive (5.45/2) near 1.8m; sticky in patches; Below 1.8m, greyish olive (5.45/2) with dark olive (5.44/4) streaks and gleying patches, with trace F quartz sand and irregular grey-white patches of calcareous? sticky sandy clay. Below 2.7m, olive grey (10.45/2), changes to sand clay mixtures, locally grading to C clayey sand and fine gravelly clay (+0.5mm fraction < 5%, of angular to well-rounded rock fragments. Below 3.6m, clayey sand-sandy clay, greyish olive (7.545/2)	W			
				2		SC to SW				MD	
				3		SP	SAND, greyish olive (7.545/2), VF, WS, grading at 5m to slightly clayey sand, grey (10.45/1), sticky, F, WS			VL	
				4			Below 6.2m, clay content decreases; sand VF, WS, greyish olive (7.545/2), with trace fines; at 6.6m, grey (10.4/1)				
				5			At 9.2m, trace silt; sand VF, WS, black, possibly organic				
				6							
				7							
				8							
				9							
				10		CH	CLAY, bright olive grey, sticky, locally with trace fine white shell fragments	M PL	ST		

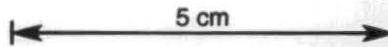
Stagnant, near surface

ENGINEERING LOG - BOREHOLE

project <i>ROYAL HOBART GOLF CLUB</i>	location <i>G. Carimatis' property</i>
co-ordinates <i>539955 mE</i> <i>5256735 mN</i>	drill type <i>Proline</i> drill method <i>Auger pull</i>
R.L. <i>approx. 2m AHW</i> inclination <i>Vertical</i> bearing <i>-</i>	hole commenced <i>6.1.81</i> hole completed <i>6.1.81</i> drilled by <i>M. Triffitt, J. Lister</i> logged by <i>W. Cramer</i> checked by <i>-</i>
drill fluid <i>None</i>	

penetration	support	water	notes	metres	graphic log	classification	material	moisture	consistency	hand penetrometer	structure, geology
1 2 3			samples, tests	R.L. depth		symbol	soil type: plasticity or particle characteristics, colour, secondary and minor components.	condition	density index	kPa	
										25 50 100 200 400	
	NONE					CL	CLAY, black, with trace silt, root fibres; moderate plasticity; friable in upper parts	D to M	FB to St		
				+1		CH	CLAY, mottled yellowish brown (2.5Y5/3), olive brown (2.5Y4/4); trace (<1%) VF sand and small dark organic patches. Occasional concretionary CaCO ₃ patches; high plasticity. Sand content increases slightly 0.9-1.8m [At 2.4m, thin (0.1m) lens of yellowish brown (2.5Y5/3) sand; F, WS, with trace VF dark minerals, loose; trace clay in places]	M > PL			
				0							
				-1		SC to CL	Clayey SAND - sandy CLAY, streaked and mottled as above; clay content decreases with depth	W	L		
				-2		CH	CLAY, yellowish brown (2.5Y5/3) with trace VF sand, grading below 3.6m to greyish olive (5Y5/2) clay with trace VF sand and grey-blue gleying patches.				
				-3		SC to SP	Sandy CLAY, yellowish brown, grading at 4.8m to SAND, dark greyish yellow (2.5Y5/2) and yellowish brown (2.5Y5/3), F, WS, with a trace of silt or clay and occasional angular fine quartzite gravel (up to 2-3mm).	W	L		
				-4							
				-5							
				-6							
				-7							
				-8		SW to GW	SAND and fine gravelly SAND, brown and grey; sand VF-F, with some angular quartzite and rock fragments (usually < 3mm, but occasionally up to 15mm)				
				-9							
				-10							

Conductivity = 16000 μ S/cm
 6.1.81



ENGINEERING LOG - BOREHOLE

project <i>ROYAL HOBART GOLF CLUB</i>	location <i>G. Carimady's property</i>
co-ordinates <i>539955m E</i> <i>5256735m N</i>	drill type <i>Proline</i> drill method <i>Auger pull</i>
R.L. <i>Approx. 2m AHW</i> inclination <i>VERTICAL</i> bearing <i>-</i>	hole commenced <i>6.1.81</i> hole completed <i>6.1.81</i> drilled by <i>M. Triffitt, J. Lister</i> logged by <i>W. Crauer</i> checked by

penetration	support	water	notes samples, tests	metres R.L. depth	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency	density index	hand penetrometer kPa	structure, geology
1	2	3									25 50 100 200 400	
				10		SW GN	<i>As above</i>	W	L			
				9 11		CH	<i>CLAY, dark olive grey, high plasticity; sticky.</i>	M > PL	ST			
				10 12			<i>Hole stopped at required depth, 11.7m (-9.7m)</i>					

5/1/86

APPENDIX 2

Detailed description and discussion of the Quaternary water-bearing sediments at Seven Mile Beach

The unconsolidated water-bearing sediments beneath the golf course and surrounding area are geologically very young deposits, here assigned to the Quaternary Period. Like other similar coastal materials, they were deposited by marine, beach, estuarine, and probably lagoonal processes under a regime of fluctuating sea levels, probably during the last 10 000 years. This time span encompasses the Holocene (or Recent) Epoch (a subdivision of the Quaternary) to which the marine, beach and lagoonal sediments are assigned. The underlying estuarine clay is considered to be either Holocene or Pleistocene in age.

In the following discussion, unit letters refer to those indicated in Figure 2. Detailed logs of boreholes are presented in Appendix 1.

Estuarine clay (unit a)

The oldest Quaternary unit is a stiff impermeable clay, intersected in most drill holes. Its upper surface shows minor relief, and in general dips gently seawards from about -7 m below sea level at its landward boundary, to -11 or -13 m beneath the foredunes at the coast. The clay is generally brownish-black, olive-black or dark greenish-grey, mottled and streaked in places with lighter colours, highly plastic and moist. Locally it contains sand and sandy clay patches (which probably become more abundant with depth), and in Holes 4, 5, 14, and 25 contains a trace of white-cream shell (bivalve) fragments. Locally it grades to gravelly clay (e.g. Hole 1) and rarely contains a trace of rock fragments and pebbles.

Because of its dark, presumably organic nature, the local presence of shelly material, and by analogy with basal clays beneath marine sequences elsewhere (Thom et al., 1978), the clay is regarded as estuarine and formed behind a rising seaward sand barrier. It therefore probably pre-dates, or formed at the same time as, the Holocene marine transgression.

Stratigraphy of the Holocene marine sequence (fig. 2)

Unit b. This is a distinctive, olive-black, grey or olive-grey very fine- to fine-grained well-sorted sand overlying the estuarine clay. It is a wedge shaped deposit, 1-6 m thick, thickening seawards. The sand is flecked with very fine to fine shell fragments, and locally contains a trace of calcareous cemented sand patches and well rounded dolerite pebbles. Occasionally it may be locally enriched in larger shell fragments, and in places contains thin shelly sand lenses.

A relatively quiet, nearshore, transgressive marine environment of deposition is suggested for this unit because of its grain size and degree of sorting, its biota, and because it overlies an estuarine horizon.

Unit c. Overlying the transgressive sheet is a thin but distinctive grey to olive-grey shelly sand, from 0 to 2 m thick, opening out seawards and displaying a gentle seawards dip on its upper surface. The sand fraction of the unit is fine- to medium-grained, well- to poorly-sorted, with a high proportion of components coarser than 2 mm. Large whole shells are locally abundant, and the unit contains well-rounded quartzite gravel and

occasional dolerite pebbles. The unit is interpreted as a near-shore marine deposit, and Thom *et al.* (1978, p.29) describing a marine Holocene sequence from Moruya on the southern New South Wales coast, describe a similar thin shelly sand bed as 'a regressive shore face sequence associated with progradation of the beach-ridge plain'. It is therefore possible that unit *c* at Seven Mile Beach is a regressive facies between two transgressive facies (units *b* and *d*) deposited during a temporary fall of sea level, probably during mid-Holocene times.

Unit d. Overlying the shelly sand horizon is an olive-black, grey or greyish-olive very fine- to medium-grained well-sorted sand 2.5-5 m thick. It is very similar to unit *b*, flecked with white very fine to fine shell fragments, and containing a trace of fine quartzite gravel, well rounded dolerite pebbles, and possibly thin sand lenses locally enriched in fine shell fragments. The unit becomes finer towards the base, commonly being fine- to medium-grained at the top, and very fine to fine at the bottom. It is considered to be a transgressive, quiet nearshore marine deposit.

Unit e. The uppermost facies at Seven Mile Beach is a tabular fine- to medium-grained well-sorted sand sheet of uniform thickness (3-4 m), generally coarser at the base and fining vertically. The sand is generally bright yellowish-brown to dull yellowish-orange, leached of carbonate in the upper levels, but containing fine shell fragments (and locally enriched in larger, whole shell) towards the base. Irregular patches of calcareous cemented sand are abundant near the water table. Soil profiles have developed on this unit, and although no detailed study of soil formation was made, there seems to be increased profile differentiation and leaching landwards. In Soak 3 near Hole 5 at the landward end of unit *e*, profile development is more obvious, with local development of 'sandrock' or 'hardpan' - a partly cemented sandy soil horizon enriched in iron oxides. The absence of hardpan (or 'coffee-rock') seawards may indicate that unit *e* becomes younger in this direction, and supports the interpretation of the facies as sand deposited by beach processes (including beach ridge formation) and capped by an irregular, thin aeolian sand.

Lagoonal sequence

A complex sequence of interbedded shell-free sand, clay and silt (and combinations of these) interpreted as lagoonal or swampy deposits occupies a basin-shaped depression landwards of the marine sequence. The sediments overlie the basal estuarine clay member and further inland presumably overlie the rising Tertiary basement. It is difficult to correlate individual units between boreholes, but most appear to dip (and thicken) inland. In general, the grain size of the sequence fines upwards, and the clay fraction also increases towards the top. The sediments are usually brightly coloured - olive-brown, bright olive, yellow-brown and grey. The youngest unit in the succession is a stiff clay which crops out in the low-lying areas west of the golf course and pine plantation.

The sequence is probably Holocene in age, formed contemporaneously with the marine sequence behind a rising sand barrier developed in the nearshore zone. This rising barrier blocked the then existing eastward draining creeks and caused deposition of sediments inland of the coastline.

Holocene depositional history

In the absence of radio-carbon dating of the sediments, it is difficult to give more than an approximate account of the sequence of events at Seven Mile Beach. By analogy with similar sequences described by Thom *et al.*

(1978) from New South Wales, a suggested reconstruction of events is as follows:

- (1) Early in Holocene times, perhaps between 8000-10 000 years BP, a low relief barrier of marine sediments started to accumulate below present sea level and seaward of the present shoreline. Estuarine muds (unit a) accumulated landwards of the barrier.
- (2) As the sea-level rose, the marine barrier (unit b) migrated landwards over the estuarine deposits. This caused the local flooding of shallow valleys and the disruption of drainage, and marked the onset of deposition in swamps and lagoons.
- (3) The transgression was possibly halted, or temporarily reversed, causing the reworking of unit b and producing the shelly sand facies (unit c). Transgression then recurred, perhaps in the period 8000-6000 years BP, producing unit d and the continued development of the lagoonal sequence behind the barrier.
- (4) From perhaps 6000 to 2500 years BP, the shoreline prograded, producing the beach and beach ridge facies (unit e) and possibly causing the formation of the uppermost clay layer of the lagoonal sequence. Leaching of unit e continued apace with its formation, so that the oldest soil profiles occur at the landward end of the marine sequence.
- (5) From about 2500 years BP to the present the shoreline has been relatively stable; a more stable drainage pattern has been developed (so that sedimentation in the lagoonal sequence has virtually ceased) and a complex system of hummocky foredunes has formed along the coastline.

APPENDIX 3

Chemical analyses of groundwater from selected bores at Seven Mile Beach. Field numbers at top of page refer to bore numbers in Figure 1 and Appendix 1.

TASMANIAN DEPARTMENT OF MINES WATER ANALYSIS	Field No. <i>RH 1</i>
	Lab. reg. no. <i>802942</i>
	Surface sample? <input type="checkbox"/>
	Groundwater sample? <i>YES</i>

Project <i>ROYAL HOBART GOLF CLUB</i>	Location <i>Practice Fairway, SE corner.</i>
---------------------------------------	--

Co-ordinates <i>540890m E</i> <i>5254390m N</i>	Date sampled: <i>10.12.80</i> Sampled by: <i>W. Cromer</i>	Date analysed: <i>6.1.81</i> Analysed by: <i>Dept. Mines, Launceston</i>
--	---	---

Sampling conditions <i>From spear bore installed to 5.0m and pumped at 4.5 litres/min (600 gph)</i>	Landowner and address (if applicable)
---	---------------------------------------

Field observations		
Colour <i>clear</i>	Odour <i>slight H₂S</i>	Taste <i>slight</i>
pH <i>8.2</i>	Eh	Temperature (°C)
Turbidity	Precipitates	Specific conductance (µS/cm at 25°C) <i>500</i>
		Other

LABORATORY ANALYSIS				Previous chemical analysis available?	<i>NO</i>
	mg/l	meq/l	% meq/l	Date	
Carbonate (CO ₃)	<i>Nil</i>			Lab. ref. number	
Bicarbonate (HCO ₃)	<i>285</i>	<i>4.67</i>	<i>38.6</i>	Bacteriological analysis available?	<i>NO</i>
Chloride (Cl)	<i>51</i>	<i>1.44</i>	<i>11.9</i>	Date	
Sulphate (SO ₄)	<i>18</i>	<i>0.37</i>	<i>3.1</i>	Lab. reg. number	
Silica (SiO ₂)	<i>14</i>	-		HARDNESS SCALE (Total hardness as Calcium Carbonate) Soft 0 - 60 mg/l Moderately Hard 61 - 120 Hard 121 - 180 <u>Very hard</u> more than 180	
Calcium (Ca)	<i>81</i>	<i>4.04</i>	<i>33.4</i>	IONIC RATIOS Ca: Mg = <i>5.0</i> Cl: total = <i>0.12</i> Na: total = <i>0.06</i> SO ₄ : total = <i>0.03</i> Na: Cl = <i>0.49</i> SiO ₂ : total = <i>0.04</i>	
Magnesium (Mg)	<i>9.8</i>	<i>0.81</i>	<i>6.7</i>	SUITABILITY a = no problems, b = doubtful, c = excessive DOMESTIC DRINKING	
Iron in solution (Fe)	<i><0.1</i>	-		Total dissolved solids	<i>a</i>
Aluminium (Al)	<i><0.2</i>	-		Total hardness	<i>b-c</i>
Potassium (K)	<i>1.7</i>	<i>0.04</i>	<i>0.3</i>	Chloride	<i>a</i>
Sodium (Na)	<i>16</i>	<i>0.70</i>	<i>5.8</i>	Sulphate	<i>a</i>
Total dissolved solids (TDS)	<i>390</i>	<i>12.1</i>		Sodium	<i>a</i>
Permanent hardness as CaCO ₃	<i>8</i>			Colour	<i>a</i>
Temporary hardness as CaCO ₃	<i>235</i>			DOMESTIC HOT WATER CYLINDER	
Alkalinity as CaCO ₃	<i>235</i>			Total dissolved solids	<i>b</i>
Other <i>TDS: conductance ratio = 0.70</i>				Cl/alkalinity ratio = <i>0.22</i>	<i>a</i>
pH		<i>7.3</i>		Chloride	<i>b</i>
Specific conductance (µS/cm at 25°C)		<i>560</i>		pH	<i>a</i>
Colour				AGRICULTURAL USE	
Turbidity				Salinity class (C1 - C4)	<i>C2</i>
% difference in anion and cation meq/l		<i>7.3</i>		Sodium class (S1 - S4)	<i>S1</i>

Remarks *A predominantly calcium bicarbonate type water of medium salinity; very hard, neutral pH, suitable for drinking and agricultural purposes*

6486

TASMANIAN DEPARTMENT OF MINES
WATER ANALYSIS

Field No. *RH2*
Lab. reg. no. *802943*
Surface sample?
Groundwater sample? *YES*

Project *ROYAL HOBART GOLF CLUB* Location *Adjacent to water tower and clubhouse*

Co-ordinates *540620m E*
5254595m N Date sampled: *10-12-80* Date analysed: *6.1.81*
Sampled by: *W. Crower* Analysed by: *Dept. Mines, Launceston*

Sampling conditions *From spear bore installed to 4.7m and pumped at 50 litres/min (650gph)* Landowner and address (if applicable)

Field observations Colour *clear* Odour *nil* Taste *nil*
pH *8.2* Eh Temperature (°C) Specific conductance (µS/cm at 25°C) *440*
Turbidity Precipitates Other

LABORATORY ANALYSIS

Previous chemical analysis available? *NO*

	mg/l	meq/l	% meq/l
Carbonate (CO ₃)	<i>Nil</i>		
Bicarbonate (HCO ₃)	<i>265</i>	<i>4.35</i>	<i>38.5</i>
Chloride (Cl)	<i>28</i>	<i>0.80</i>	<i>7.1</i>
Sulphate (SO ₄)	<i>23</i>	<i>0.48</i>	<i>4.2</i>
Silica (SiO ₂)	<i>22</i>		
Calcium (Ca)	<i>19</i>	<i>0.95</i>	<i>8.4</i>
Magnesium (Mg)	<i>10</i>	<i>0.82</i>	<i>7.3</i>
Iron in solution (Fe)	<i>0.1</i>	-	
Aluminium (Al)	<i><0.2</i>	-	
Potassium (K)	<i>4.3</i>	<i>0.11</i>	<i>1.0</i>
Sodium (Na)	<i>88</i>	<i>3.83</i>	<i>33.9</i>
Total dissolved solids (TDS)	<i>350</i>	<i>11.3</i>	
Permanent hardness as CaCO ₃	<i>Nil</i>		
Temporary hardness as CaCO ₃	<i>89</i>		
Alkalinity as CaCO ₃	<i>215</i>		
Other <i>TDS: conductance ratio = 0.71</i>			
pH		<i>7.4</i>	
Specific conductance (µS/cm at 25°C)		<i>490</i>	
Colour			
Turbidity			
% difference in anion and cation meq/l		<i>0.7</i>	

Date
Lab. ref. number
Bacteriological analysis available? *NO*
Date
Lab. reg. number

HARDNESS SCALE
(Total hardness as Calcium Carbonate)
Soft 0-60 mg/l
Moderately Hard 61-120
Hard 121-180
Very hard more than 180

IONIC RATIOS
Ca: Mg = *1.16* Cl: total = *0.07*
Na: total = *0.34* SO₄: total = *0.04*
Na: Cl = *4.79* SiO₂: total = *0.06*

SUITABILITY
a = no problems, b = doubtful, c = excessive

DOMESTIC DRINKING

Total dissolved solids	<i>a</i>	pH	<i>a</i>
Total hardness	<i>b</i>	Iron	<i>a</i>
Chloride	<i>a</i>	Sulphate	<i>a</i>
Sodium	<i>b</i>	Magnesium	<i>a</i>
Colour	<i>a</i>		

DOMESTIC HOT WATER CYLINDER

Total dissolved solids	<i>b</i>	Chloride	<i>a</i>
Cl/alkalinity ratio = <i>0.13</i>	<i>a</i>	pH	<i>a</i>

AGRICULTURAL USE

Value	Suitability (a, b, or c)
Salinity class (C1-C4) <i>C2</i>	<i>a</i>
Sodium class (S1-S4) <i>S1</i>	<i>a</i>
Percent Sodium <i>69</i>	<i>c</i>
Sodium adsorption ratio <i>4.1</i>	<i>a</i>
Residual sodium carbonate <i>2.6</i>	<i>c</i>

Remarks
A predominantly sodium bicarbonate type water, moderately hard, medium salinity and near-neutral pH, suitable for drinking, and agricultural purposes on most soil types.

65/86

TASMANIAN DEPARTMENT OF MINES WATER ANALYSIS	Field No. <i>RH3</i>
	Lab. reg. no. <i>802944</i>
	Surface sample? <input type="checkbox"/>
	Groundwater sample? <i>YES</i>

Project <i>ROYAL HOBART GOLF CLUB</i>	Location <i>Practice fairways</i>
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Co-ordinates <i>540405 m E</i> <i>5254810 m N</i>	Date sampled: <i>10.12.80</i> Sampled by: <i>W. Corner</i>	Date analysed: <i>6.1.81</i> Analysed by: <i>Dept. Mines, Launceston</i>
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Sampling conditions <i>From spear bore installed to 4.7m and pumped at 45 litres/min (600 gph)</i>	Landowner and address (if applicable)
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Field observations Colour <i>clear</i>	Odour	Taste
pH <i>7.8</i>	Eh	Specific conductance ($\mu\text{S/cm at } 25^\circ\text{C}$) <i>3000</i>
Turbidity	Precipitates	Other

LABORATORY ANALYSIS				Previous chemical analysis available?	
	mg/l	meq/l	% meq/l	Date	<i>NO</i>
Carbonate (CO ₃)	<i>Nil</i>			Lab. ref. number	
Bicarbonate (HCO ₃)	<i>600</i>	<i>9.84</i>	<i>11.0</i>	Bacteriological analysis available?	<i>NO</i>
Chloride (Cl)	<i>1170</i>	<i>33.0</i>	<i>36.9</i>	Date	
Sulphate (SO ₄)	<i>130</i>	<i>2.70</i>	<i>3.0</i>	Lab. reg. number	
Silica (SiO ₂)	<i>27</i>	<i>-</i>		HARDNESS SCALE (Total hardness as Calcium Carbonate) Soft 0—60 mg/l Moderately Hard 61—120 Hard 121—180 <u>Very hard</u> more than 180	
Calcium (Ca)	<i>110</i>	<i>5.49</i>	<i>6.1</i>	IONIC RATIOS	
Magnesium (Mg)	<i>120</i>	<i>9.86</i>	<i>11.0</i>	Ca: Mg = <i>0.56</i>	Cl: total = <i>0.37</i>
Iron in solution (Fe)	<i><0.1</i>	<i>-</i>		Na: total = <i>0.32</i>	SO ₄ : total = <i>0.03</i>
Aluminium (Al)	<i><0.2</i>	<i>-</i>		Na: Cl = <i>0.86</i>	SiO ₂ : total = <i>0.01</i>
Potassium (K)	<i>8.2</i>	<i>0.21</i>	<i>0.2</i>	SUITABILITY a = no problems, b = doubtful, c = excessive	
Sodium (Na)	<i>650</i>	<i>28.3</i>	<i>31.7</i>	DOMESTIC DRINKING	
Total dissolved solids (TDS)	<i>2500</i>	<i>89.4</i>		Total dissolved solids	<i>c</i>
Permanent hardness as CaCO ₃	<i>280</i>			pH	<i>a</i>
Temporary hardness as CaCO ₃	<i>490</i>			Total hardness	<i>c</i>
Alkalinity as CaCO ₃	<i>490</i>			Chloride	<i>c</i>
Other <i>TDS: conductance ratio = 0.63</i>				Sodium	<i>c</i>
				Colour	<i>a</i>
				DOMESTIC HOT WATER CYLINDER	
				Total dissolved solids	<i>c</i>
				Chloride	<i>c</i>
				Cl/alkalinity ratio = <i>2.4</i>	<i>b</i>
				pH	<i>a</i>
				AGRICULTURAL USE	
				Value	Suitability (a, b, or c)
				Salinity class (C1—C4)	<i>C4</i>
				Sodium class (S1—S4)	<i>S3</i>
				Percent Sodium	<i>65</i>
				Sodium adsorption ratio	<i>10.2</i>
				Residual sodium carbonate	<i>Nil</i>
					<i>a</i>

pH *7.3*
 Specific conductance ($\mu\text{S/cm at } 25^\circ\text{C}$) *4000*
 Colour
 Turbidity
 % difference in anion and cation meq/l *1.9*

Remarks
A predominantly sodium chloride type water, very hard, of high salinity and near-neutral pH, unsuitable for drinking; suitable for agricultural purposes only on well-drained sandy soils and salt-tolerant crops

66/86

TASMANIAN DEPARTMENT OF MINES WATER ANALYSIS	Field No. RH 6
	Lab. reg. no. 802898
	Surface sample? <input type="checkbox"/>
	Groundwater sample? YES

Project ROYAL HOBBART GOLF CLUB	Location Golf Course, between 12th tee and 11th green.
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Co-ordinates 540775 m E 5255180 m N	Date sampled: 27.11.80 Sampled by: W. CROWER	Date analysed: 19.12.80 Analysed by: Dept. Mines, Launceston
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Sampling conditions From spear bore installed to 4.8m and pumped at 45 litres/minute (600 gal/hour)	Landowner and address (if applicable)
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Field observations			
Colour clear	Odour trace H₂S	Taste slight	
pH	Eh	Temperature (°C)	Specific conductance (µS/cm at 25°C) 2800
Turbidity	Precipitates	Other	

LABORATORY ANALYSIS				Previous chemical analysis available?	NO			
	mg/l	meq/l	% meq/l	Date				
Carbonate (CO ₃)	Nil			Lab. ref. number				
Bicarbonate (HCO ₃)	470	7.7	11.6	Bacteriological analysis available?	NO			
Chloride (Cl)	730	20.6	31.1	Date				
Sulphate (SO ₄)	230	4.8	7.3	Lab. reg. number				
Silica (SiO ₂)	26			HARDNESS SCALE (Total hardness as Calcium Carbonate) Soft 0—60 mg/l Moderately Hard 61—120 Hard 121—180 <u>Very hard</u> more than 180				
Calcium (Ca)	235	11.7	17.7	IONIC RATIOS Ca: Mg = 1.7 Cl: total = 0.31 Na: total = 0.22 SO ₄ : total = 0.07 Na: Cl = 0.70 SiO ₂ : total = 0.013				
Magnesium (Mg)	82	6.7	10.1	SUITABILITY a = no problems, b = doubtful, c = excessive DOMESTIC DRINKING				
Iron in solution (Fe)	<0.1							
Aluminium (Al)	<0.2							
Potassium (K)	12	0.31	0.5					
Sodium (Na)	330	14.4	21.8					
Total dissolved solids (TDS)	1930	66.2						
Permanent hardness as CaCO ₃	540							
Temporary hardness as CaCO ₃	385							
Alkalinity as CaCO ₃	385							
Other TDS: conductance ratio = 0.58								
pH		7.3						
Specific conductance (µS/cm at 25°C)		3300						
Colour								
Turbidity								
% difference in anion and cation meq/l		0.0						
Remarks <i>A mixed sodium chloride - calcium bicarbonate type water, of high salinity, very hard, and near-neutral pH. Unsuitable for drinking, but suitable for agricultural purposes on well-drained sandy soils and salt-tolerant crops.</i>				DOMESTIC HOT WATER CYLINDER				
Remarks <i>A mixed sodium chloride - calcium bicarbonate type water, of high salinity, very hard, and near-neutral pH. Unsuitable for drinking, but suitable for agricultural purposes on well-drained sandy soils and salt-tolerant crops.</i>				AGRICULTURAL USE				

67/86

TASMANIAN DEPARTMENT OF MINES WATER ANALYSIS			Field No. <i>RH 9</i>	
			Lab. reg. no. <i>802899</i>	
			Surface sample?	
			Groundwater sample? <i>YES</i>	
Project <i>ROYAL HOBART GOLF CLUB</i>		Location <i>In shallow sand pit near 5th tee</i>		
Co-ordinates <i>541075 mE</i> <i>5254950 mN</i>		Date sampled: <i>27.11.80</i>	Date analysed: <i>19.12.80</i>	
		Sampled by: <i>W.C. Crower</i>	Analysed by: <i>Dept. Mines, Launceston</i>	
Sampling conditions <i>From open bore installed to 4.8m and pumped at 53 litres/min (700 gals/hour)</i>			Landowner and address (if applicable)	
Field observations				
Colour <i>clear</i>		Odour <i>slight H₂S</i>		Taste <i>slight</i>
pH	Eh	Temperature (°C)	Specific conductance (µS/cm at 25° C) <i>2300</i>	
Turbidity		Precipitates		Other
LABORATORY ANALYSIS			Previous chemical analysis available? <i>NO</i>	
			Date	
			Lab. ref. number	
Carbonate (CO ₃)			<i>Nil</i>	
Bicarbonate (HCO ₃)			<i>485</i>	<i>7.95</i>
Chloride (Cl)			<i>650</i>	<i>18.3</i>
Sulphate (SO ₄)			<i>200</i>	<i>4.2</i>
Silica (SiO ₂)			<i>21</i>	<i>-</i>
Calcium (Ca)			<i>175</i>	<i>8.73</i>
Magnesium (Mg)			<i>66</i>	<i>5.4</i>
Iron in solution (Fe)			<i>0.9</i>	<i>0.03</i>
Aluminium (Al)			<i><0.2</i>	<i>-</i>
Potassium (K)			<i>13</i>	<i>0.33</i>
Sodium (Na)			<i>405</i>	<i>17.6</i>
Total dissolved solids (TDS)			<i>1930</i>	<i>62.5</i>
Permanent hardness as CaCO ₃			<i>310</i>	
Temporary hardness as CaCO ₃			<i>400</i>	
Alkalinity as CaCO ₃			<i>400</i>	
Other <i>TDS: conductance ratio = 0.62</i>				
pH			<i>7.2</i>	
Specific conductance (µS/cm at 25°C)			<i>3100</i>	
Colour				
Turbidity				
% difference in anion and cation meq/l			<i>2.6</i>	
Remarks				
<i>A mixed sodium chloride - calcium bicarbonate type water of high salinity; very hard with a near-neutral pH. Unsuitable for drinking, but suitable for agricultural purposes on well-drained sandy soils and salt-tolerant crops. High in dissolved iron.</i>			HARDNESS SCALE (Total hardness as Calcium Carbonate)	
			Soft 0—60 mg/l	
			Moderately Hard 61—120	
			Hard 121—180	
			<u>Very hard</u> more than 180	
			IONIC RATIOS	
			Ca: Mg = <i>1.62</i>	Cl: total = <i>0.29</i>
			Na: total = <i>0.28</i>	SO ₄ : total = <i>0.07</i>
			Na: Cl = <i>0.96</i>	SiO ₂ : total = <i>0.011</i>
			SUITABILITY a = no problems, b = doubtful, c = excessive	
DOMESTIC DRINKING				
Total dissolved solids	C	pH	a	
Total hardness	C	Iron	c	
Chloride	C	Sulphate	b	
Sodium	C	Magnesium	b	
Colour	a			
DOMESTIC HOT WATER CYLINDER				
Total dissolved solids	C	Chloride	C	
Cl/alkalinity ratio = <i>1.63</i>	a	pH	a	
AGRICULTURAL USE				
Salinity class (C1—C4)	C4	Suitability (a, b, or c)	c	
Sodium class (S1—S4)	S2-S3		b	
Percent Sodium	56		b	
Sodium adsorption ratio	6.6		b	
Residual sodium carbonate	Nil		a	

68/86

TASMANIAN DEPARTMENT OF MINES WATER ANALYSIS			Field No. <i>RH 10</i>				
			Lab. reg. no. <i>802945</i>				
			Surface sample? <input type="checkbox"/>				
			Groundwater sample? <i>YES</i>				
Project <i>ROYAL HOBART GOLF CLUB</i>		Location <i>At Devon Hill Beach shop</i>					
Co-ordinates <i>S41175 m E</i> <i>S254225 m N</i>		Date sampled: <i>10.12.80</i>		Date analysed: <i>6.1.81</i>			
		Sampled by: <i>W. Crower</i>		Analysed by: <i>Dept. Mines, Launceston</i>			
Sampling conditions <i>From spear bore installed to 5.2m and pumped at 32 litres/min (430 gph)</i>			Landowner and address (if applicable)				
Field observations							
Colour <i>clear</i>		Odour		Taste			
pH <i>8.2</i> Eh		Temperature (°C)		Specific conductance (µS/cm at 25°C) <i>900</i>			
Turbidity		Precipitates		Other			
LABORATORY ANALYSIS				Previous chemical analysis available? <i>No</i>			
	mg/l	meq/l	% meq/l	Date			
Carbonate (CO ₃)	<i>Nil</i>			Lab. ref. number			
Bicarbonate (HCO ₃)	<i>430</i>	<i>7.05</i>	<i>32.2</i>	Bacteriological analysis available? <i>NO</i>			
Chloride (Cl)	<i>115</i>	<i>3.24</i>	<i>14.8</i>	Date			
Sulphate (SO ₄)	<i>46</i>	<i>0.96</i>	<i>4.4</i>	Lab. reg. number			
Silica (SiO ₂)	<i>16</i>	-		HARDNESS SCALE (Total hardness as Calcium Carbonate) Soft 0—60 mg/l Moderately Hard 61—120 Hard 121—180 <u>Very hard</u> more than 180			
Calcium (Ca)	<i>120</i>	<i>5.99</i>	<i>27.4</i>				
Magnesium (Mg)	<i>14</i>	<i>1.15</i>	<i>5.3</i>				
Iron in solution (Fe)	<i>20.1</i>	-					
Aluminium (Al)	<i><0.2</i>	-		IONIC RATIOS			
Potassium (K)	<i>3.8</i>	<i>0.10</i>	<i>0.5</i>	Ca: Mg = <i>5.2</i>	Cl: total = <i>0.15</i>		
Sodium (Na)	<i>78</i>	<i>3.39</i>	<i>15.5</i>	Na: total = <i>0.16</i>	SO ₄ : total = <i>0.04</i>		
Total dissolved solids (TDS)	<i>620</i>	<i>21.9</i>		Na: Cl = <i>1.05</i>	SiO ₂ : total = <i>0.026</i>		
Permanent hardness as CaCO ₃	<i>7</i>			SUITABILITY a = no problems, b = doubtful, c = excessive DOMESTIC DRINKING			
Temporary hardness as CaCO ₃	<i>350</i>						
Alkalinity as CaCO ₃	<i>350</i>						
Other <i>TDS: Conductance ratio = 0.74</i>							
pH			<i>7.6</i>	Total dissolved solids	<i>b</i>	pH	<i>a</i>
Specific conductance (µS/cm at 25°C)			<i>830</i>	Total hardness	<i>b-c</i>	Iron	<i>a</i>
Colour				Chloride	<i>a</i>	Sulphate	<i>a</i>
Turbidity				Sodium	<i>b</i>	Magnesium	<i>a</i>
% difference in anion and cation meq/l			<i>2.8</i>	Colour	<i>a</i>		
Remarks <i>A mixed calcium bicarbonate - sodium chloride type water of medium salinity; very hard and near-neutral pH. Suitable for drinking and most agricultural purposes.</i>				DOMESTIC HOT WATER CYLINDER			
				Total dissolved solids	<i>b</i>	Chloride	<i>b</i>
				Cl/alkalinity ratio = <i>0.23</i>	<i>a</i>	pH	<i>a</i>
				AGRICULTURAL USE			
				Salinity class (C1—C4)	<i>C2</i>	Suitability (a,b, or c)	<i>a</i>
				Sodium class (S1—S4)	<i>S2-S3</i>		<i>b</i>
				Percent Sodium	<i>32</i>		<i>a</i>
Sodium adsorption ratio	<i>1.8</i>		<i>a</i>				
Residual sodium carbonate	<i>Nil</i>		<i>a</i>				

TASMANIAN DEPARTMENT OF MINES WATER ANALYSIS	Field No. <i>RH12</i>
	Lab. reg. no. <i>802946</i>
	Surface sample? <input type="checkbox"/>
	Groundwater sample? <i>YES</i>

Project <i>ROYAL HOBART GOLF CLUB</i>	Location <i>In Lands Dept. pine plantation</i>
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Co-ordinates <i>541080m E</i> <i>5255525m N</i>	Date sampled: <i>9.12.80</i> Sampled by: <i>W. Crower</i>	Date analysed: <i>6.1.81</i> Analysed by: <i>Dept. Mines, Launceston</i>
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Sampling conditions <i>From near bore installed to 4.5m and pumped at 25 litres/min (330 gph)</i>	Landowner and address (if applicable) <i>Lands Department</i>
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Field observations Colour <i>clear</i>	Odour	Taste
pH	Eh	Specific conductance ($\mu\text{S/cm at } 25^\circ\text{C}$) <i>800</i>
Turbidity	Precipitates	Other

LABORATORY ANALYSIS				Previous chemical analysis available?			
	mg/l	meq/l	% meq/l	Date	<i>NO</i>		
Carbonate (CO ₃)	<i>Nil</i>			Lab. ref. number			
Bicarbonate (HCO ₃)	<i>750</i>	<i>5.74</i>	<i>28.6</i>	Bacteriological analysis available?	<i>NO</i>		
Chloride (Cl)	<i>150</i>	<i>4.23</i>	<i>21.0</i>	Date			
Sulphate (SO ₄)	<i>18</i>	<i>0.37</i>	<i>1.8</i>	Lab. reg. number			
Silica (SiO ₂)	<i>20</i>	<i>-</i>		HARDNESS SCALE (Total hardness as Calcium Carbonate) Soft 0—60 mg/l Moderately Hard 61—120 Hard 121—180 <u>Very hard</u> more than 180			
Calcium (Ca)	<i>110</i>	<i>5.49</i>	<i>27.3</i>	IONIC RATIOS			
Magnesium (Mg)	<i>13</i>	<i>1.07</i>	<i>5.3</i>	Ca: Mg = <i>5.13</i>	Cl: total = <i>0.21</i>		
Iron in solution (Fe)	<i><0.1</i>	<i>-</i>		Na: total = <i>0.16</i>	SO ₄ : total = <i>0.02</i>		
Aluminium (Al)	<i><0.2</i>	<i>-</i>		Na: Cl = <i>0.77</i>	SiO ₂ : total = <i>0.03</i>		
Potassium (K)	<i>1.5</i>	<i>0.04</i>	<i>0.2</i>	SUITABILITY a = no problems, b = doubtful, c = excessive			
Sodium (Na)	<i>75</i>	<i>3.26</i>	<i>16.2</i>	DOMESTIC DRINKING			
Total dissolved solids (TDS)	<i>620</i>	<i>20.1</i>		Total dissolved solids	<i>a-b</i>		
Permanent hardness as CaCO ₃	<i>43</i>			Total hardness	<i>b-c</i>		
Temporary hardness as CaCO ₃	<i>285</i>			Chloride	<i>a</i>		
Alkalinity as CaCO ₃	<i>285</i>			Sodium	<i>b</i>		
Other <i>TDS: conductance ratio = 0.69</i>				Colour	<i>a</i>		
pH			<i>7.4</i>	DOMESTIC HOT WATER CYLINDER			
Specific conductance ($\mu\text{S/cm at } 25^\circ\text{C}$)			<i>900</i>	Total dissolved solids	<i>b</i>		
Colour				Cl/alkalinity ratio = <i>0.53</i>	<i>a</i>		
Turbidity				Chloride	<i>b</i>		
% difference in anion and cation meq/l			<i>2.7</i>	pH	<i>a</i>		
Remarks <i>A mixed calcium bicarbonate-sodium chloride type water of medium salinity; very hard and near-neutral pH. Suitable for drinking and most agricultural purposes.</i>				AGRICULTURAL USE			
				Salinity class (C1—C4)	<i>C3</i>	Suitability (a, b, or c)	<i>b</i>
				Sodium class (S1—S4)	<i>S1</i>		<i>a</i>
				Percent Sodium	<i>33</i>		<i>a</i>
				Sodium adsorption ratio	<i>1.8</i>		<i>a</i>
				Residual sodium carbonate	<i>Nil</i>		<i>a</i>

70/86

TASMANIAN DEPARTMENT OF MINES WATER ANALYSIS	Field No. <i>RH 14</i>
	Lab. reg. no. <i>802900</i>
	Surface sample? <input type="checkbox"/>
	Groundwater sample? <i>YES</i>

Project <i>ROYAL HOBART GOLF COURSE</i>	Location <i>600 m NNE of Sock 3, Lands Dept. property.</i>
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Co-ordinates <i>540600 m E</i> <i>5256035 m N</i>	Date sampled: <i>27.11.80</i> Sampled by: <i>W. Cromer</i>	Date analysed: <i>19.12.80</i> Analysed by: <i>Dept. Mines, Launceston</i>
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Sampling conditions <i>From spear bore installed to 4.3m and pumped at 6 litres/min (80gph)</i>	Landowner and address (if applicable)
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Field observations		Colour	Odour	Taste
pH	Eh	Temperature (°C)	Specific conductance (µS/cm at 25° C) <i>3000</i>	
Turbidity <i>high</i>	Precipitates		Other	

LABORATORY ANALYSIS				Previous chemical analysis available?	<i>No</i>		
	mg/l	meq/l	% meq/l	Date			
Carbonate (CO ₃)	<i>Nil</i>			Lab. ref. number			
Bicarbonate (HCO ₃)	<i>685</i>	<i>11.2</i>	<i>17.0</i>	Bacteriological analysis available?	<i>No</i>		
Chloride (Cl)	<i>710</i>	<i>20.0</i>	<i>30.4</i>	Date			
Sulphate (SO ₄)	<i>68</i>	<i>1.4</i>	<i>2.1</i>	Lab. reg. number			
Silica (SiO ₂)	<i>24</i>	-		HARDNESS SCALE (Total hardness as Calcium Carbonate) Soft 0 — 60 mg/l Moderately Hard 61 — 120 Hard 121 — 180 <u>Very hard</u> more than 180			
Calcium (Ca)	<i>82</i>	<i>4.1</i>	<i>6.2</i>	IONIC RATIOS			
Magnesium (Mg)	<i>54</i>	<i>4.4</i>	<i>6.7</i>	Ca: Mg = <i>0.93</i>	Cl: total = <i>0.30</i>		
Iron in solution (Fe)	<i><0.1</i>	-		Na: total = <i>0.37</i>	SO ₄ : total = <i>0.02</i>		
Aluminium (Al)	<i><0.2</i>	-		Na: Cl = <i>1.2</i>	SiO ₂ : total = <i>0.013</i>		
Potassium (K)	<i>7.1</i>	<i>0.18</i>	<i>0.3</i>	SUITABILITY a = no problems, b = doubtful, c = excessive			
Sodium (Na)	<i>560</i>	<i>24.4</i>	<i>37.1</i>	DOMESTIC DRINKING			
Total dissolved solids (TDS)	<i>1850</i>	<i>65.7</i>		Total dissolved solids	<i>C</i>	pH	<i>a</i>
Permanent hardness as CaCO ₃	<i>Nil</i>			Total hardness	<i>C</i>	Iron	<i>a</i>
Temporary hardness as CaCO ₃	<i>425</i>			Chloride	<i>C</i>	Sulphate	<i>b</i>
Alkalinity as CaCO ₃	<i>560</i>			Sodium	<i>C</i>	Magnesium	<i>b</i>
Other <i>TDS: conductance ratio = 0.55</i>				Colour	<i>a</i>		
pH			<i>7.4</i>	DOMESTIC HOT WATER CYLINDER			
Specific conductance (µS/cm at 25°C)			<i>3350</i>	Total dissolved solids	<i>C</i>	Chloride	<i>C</i>
Colour				Cl/alkalinity ratio = <i>1.3</i>	<i>a</i>	pH	<i>a</i>
Turbidity				AGRICULTURAL USE			
% difference in anion and cation meq/l			<i>0.73</i>	Salinity class (C1 — C4)	<i>C4</i>	Value	<i>C</i>

Remarks
A predominantly sodium chloride type water of high salinity; very hard with a near-neutral pH. Unsuitable for drinking; suitable for agricultural purposes on well-drained sandy soils and salt tolerant crops.

TASMANIAN DEPARTMENT OF MINES WATER ANALYSIS	Field No. <i>RH 15</i>
	Lab. reg. no. <i>802947</i>
	Surface sample? <input type="checkbox"/>
	Groundwater sample? <i>YES</i>

Project <i>ROYAL HOBART GOLF CLUB</i>	Location <i>In Lands Dept pine plantation</i>
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Co-ordinates <i>541375m E</i> <i>5255223m N</i>	Date sampled: <i>9.12.80</i> Sampled by: <i>N. Cromer</i>	Date analysed: <i>6.1.81</i> Analysed by: <i>Dept. Mines, Launceston</i>
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Sampling conditions <i>From spear bore installed to 4.5m and pumped at 36 litres/min (480 gph)</i>	Landowner and address (if applicable) <i>Lands Department</i>
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Field observations		Colour <i>clear</i>	Odour	Taste
pH	Eh	Temperature (°C)	Specific conductance (µS/cm at 25°C) <i>1400</i>	
Turbidity	Precipitates	Other		

LABORATORY ANALYSIS				Previous chemical analysis available?	<i>NO</i>
	mg/l	meq/l	% meq/l	Date	
Carbonate (CO ₃)	<i>Nil</i>			Lab. ref. number	
Bicarbonate (HCO ₃)	<i>445</i>	<i>7.30</i>	<i>19.2</i>	Bacteriological analysis available?	<i>NO</i>
Chloride (Cl)	<i>435</i>	<i>12.3</i>	<i>32.2</i>	Date	
Sulphate (SO ₄)	<i>7</i>	<i>0.15</i>	<i>0.4</i>	Lab. reg. number	
Silica (SiO ₂)	<i>18</i>	<i>-</i>		HARDNESS SCALE (Total hardness as Calcium Carbonate) Soft 0 - 60 mg/l Moderately Hard 61 - 120 Hard 121 - 180 <u>Very hard</u> more than 180	
Calcium (Ca)	<i>160</i>	<i>7.98</i>	<i>20.9</i>	IONIC RATIOS Ca: Mg = <i>4.05</i> Cl: total = <i>0.32</i> Na: total = <i>0.22</i> SO ₄ : total = <i>0.004</i> Na: Cl = <i>0.67</i> SiO ₂ : total = <i>0.02</i>	
Magnesium (Mg)	<i>24</i>	<i>1.97</i>	<i>5.2</i>	SUITABILITY a = no problems, b = doubtful, c = excessive DOMESTIC DRINKING	
Iron in solution (Fe)	<i><0.1</i>			Total dissolved solids	<i>b-c</i>
Aluminium (Al)	<i><0.2</i>			Total hardness	<i>c</i>
Potassium (K)	<i>5.9</i>	<i>0.15</i>	<i>0.4</i>	Chloride	<i>c</i>
Sodium (Na)	<i>190</i>	<i>8.27</i>	<i>21.7</i>	Sodium	<i>b</i>
Total dissolved solids (TDS)	<i>1170</i>	<i>38.1</i>		Colour	<i>a</i>
Permanent hardness as CaCO ₃	<i>135</i>			DOMESTIC HOT WATER CYLINDER	
Temporary hardness as CaCO ₃	<i>365</i>			Total dissolved solids	<i>b</i>
Alkalinity as CaCO ₃	<i>365</i>			Cl/alkalinity ratio = <i>1.2</i>	<i>a</i>
Other <i>TDS: conductance ratio = 0.69</i>				Chloride	<i>c</i>
pH		<i>7.9</i>		pH	<i>a</i>
Specific conductance (µS/cm at 25°C)		<i>1700</i>		AGRICULTURAL USE	
Colour				Salinity class (C1 - C4)	<i>C3</i>
Turbidity				Sodium class (S1 - S4)	<i>S1</i>
% difference in anion and cation meq/l		<i>3.6</i>		Percent Sodium	<i>45</i>
Remarks	<i>A mixed sodium chloride-calcium bicarbonate type water of moderate - high salinity, very hard and of slightly alkaline pH. Probably unsuitable for drinking but suitable for agricultural purposes.</i>			Sodium adsorption ratio	<i>3.7</i>
				Residual sodium carbonate	<i>Nil</i>
				Suitability (a, b, or c)	<i>b</i>
					<i>a</i>
					<i>a</i>

72/86

TASMANIAN DEPARTMENT OF MINES WATER ANALYSIS	Field No. <i>RH16</i>
	Lab. reg. no. <i>802948</i>
	Surface sample? <input type="checkbox"/>
	Groundwater sample? <i>YES</i>

Project <i>ROYAL HOBART GOLF CLUB</i>	Location <i>Lands Dept. Day Use Area 1</i>
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Co-ordinates <i>5417 50m E</i> <i>5254900 m N</i>	Date sampled: <i>10.12.80</i> Sampled by: <i>W. Cromer</i>	Date analysed: <i>6-1-81</i> Analysed by: <i>Dept. Mines, Launceston</i>
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Sampling conditions <i>From spear bore installed to 5m and pumped at 54 litres/min (720 gph)</i>	Landowner and address (if applicable) <i>Lands Department</i>
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Field observations Colour	Odour	Taste
pH <i>7.8</i> Eh	Temperature (°C)	Specific conductance (µS/cm at 25°C) <i>540</i>
Turbidity	Precipitates	Other

LABORATORY ANALYSIS				Previous chemical analysis available?	<i>NO</i>			
	mg/l	meq/l	% meq/l	Date				
Carbonate (CO ₃)	<i>Nil</i>			Lab. ref. number				
Bicarbonate (HCO ₃)	<i>325</i>	<i>5.33</i>	<i>36.0</i>	Bacteriological analysis available?	<i>NO</i>			
Chloride (Cl)	<i>71</i>	<i>2.00</i>	<i>13.5</i>	Date				
Sulphate (SO ₄)	<i>18</i>	<i>0.37</i>	<i>2.5</i>	Lab. reg. number				
Silica (SiO ₂)	<i>15</i>	<i>-</i>		HARDNESS SCALE (Total hardness as Calcium Carbonate) Soft 0 — 60 mg/l Moderately Hard 61 — 120 Hard 121 — 180 <u>Very hard</u> more than 180				
Calcium (Ca)	<i>68</i>	<i>3.39</i>	<i>22.9</i>	IONIC RATIOS				
Magnesium (Mg)	<i>12</i>	<i>0.99</i>	<i>6.7</i>	Ca: Mg = <i>3.42</i>	Cl: total = <i>0.14</i>			
Iron in solution (Fe)	<i><0.1</i>	<i>-</i>		Na: total = <i>0.18</i>	SO ₄ : total = <i>0.03</i>			
Aluminium (Al)	<i><0.2</i>	<i>-</i>		Na: Cl = <i>1.31</i>	SiO ₂ : total = <i>0.04</i>			
Potassium (K)	<i>3.6</i>	<i>0.09</i>	<i>0.6</i>	SUITABILITY a = no problems, b = doubtful, c = excessive				
Sodium (Na)	<i>60</i>	<i>2.61</i>	<i>17.6</i>	DOMESTIC DRINKING				
Total dissolved solids (TDS)	<i>420</i>	<i>14.8</i>		Total dissolved solids	<i>a</i>			
Permanent hardness as CaCO ₃	<i>Nil</i>			Total hardness	<i>b-c</i>			
Temporary hardness as CaCO ₃	<i>220</i>			Chloride	<i>a</i>			
Alkalinity as CaCO ₃	<i>265</i>			Sodium	<i>b</i>			
Other <i>TDS: conductance ratio = 0.69</i>				Colour	<i>a</i>			
pH			<i>7.4</i>	DOMESTIC HOT WATER CYLINDER				
Specific conductance (µS/cm at 25°C)			<i>610</i>	Total dissolved solids	<i>a</i>			
Colour				Cl/alkalinity ratio = <i>0.27</i>	<i>a</i>			
Turbidity				Chloride	<i>b</i>			
% difference in anion and cation meq/l			<i>4.2</i>	pH	<i>a</i>			
Remarks	<i>A mixed calcium bicarbonate-sodium chloride type water of low-medium salinity; very hard, of near neutral pH. Suitable for drinking and agricultural purposes.</i>				AGRICULTURAL USE			
					Salinity class (C1—C4)	<i>C2</i>	Suitability (a,b, or c)	<i>a</i>
					Sodium class (S1—S4)	<i>S1</i>		<i>a</i>
					Percent Sodium	<i>38</i>		<i>a</i>
					Sodium adsorption ratio	<i>1.8</i>		<i>a</i>
					Residual sodium carbonate	<i>0.95</i>		<i>a</i>

73/86

TASMANIAN DEPARTMENT OF MINES WATER ANALYSIS	Field No. <i>RH 25</i>
	Lab. reg. no. <i>802901</i>
	Surface sample? <input type="checkbox"/>
	Groundwater sample? <i>YES</i>

Project <i>ROYAL HOBART GOLF CLUB</i>	Location <i>G. Carimaty's property</i>
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Co-ordinates <i>541000 mE</i> <i>5255100 mN</i>	Date sampled: <i>26.11.80</i>	Date analysed: <i>19.12.80</i>
	Sampled by: <i>W. Crower</i>	Analysed by: <i>Dept. Mines, Launceston</i>

Sampling conditions <i>From open bore installed to 4.6m and pumped at 1.5 litres/min (20gph)</i>	Landowner and address (if applicable) <i>G. Carimaty, "Acton View", Seven Mile Beach.</i>
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Field observations		
Colour	Odour	Taste
pH	Eh	Specific conductance ($\mu\text{S/cm at } 25^\circ\text{C}$) <i>10000</i>
Turbidity	Precipitates	Other

LABORATORY ANALYSIS				Previous chemical analysis available?	<i>NO</i>
	mg/l	meq/l	% meq/l	Date	
Carbonate (CO ₃)	<i>Nil</i>			Lab. ref. number	
Bicarbonate (HCO ₃)	<i>1065</i>	<i>17.5</i>	<i>7.5</i>	Bacteriological analysis available?	<i>NO</i>
Chloride (Cl)	<i>3250</i>	<i>91.7</i>	<i>39.1</i>	Date	
Sulphate (SO ₄)	<i>300</i>	<i>6.2</i>	<i>2.6</i>	Lab. reg. number	
Silica (SiO ₂)	<i>16</i>	<i>-</i>		HARDNESS SCALE (Total hardness as Calcium Carbonate) Soft 0—60 mg/l Moderately Hard 61—120 Hard 121—180 <u>Very hard</u> more than 180	
Calcium (Ca)	<i>170</i>	<i>8.5</i>	<i>3.6</i>	IONIC RATIOS Ca: Mg = <i>0.29</i> Cl: total = <i>0.39</i> Na: total = <i>0.94</i> SO ₄ : total = <i>0.03</i> Na: Cl = <i>0.88</i> SiO ₂ : total = <i>0.002</i>	
Magnesium (Mg)	<i>360</i>	<i>29.6</i>	<i>12.6</i>	SUITABILITY a = no problems, b = doubtful, c = excessive DOMESTIC DRINKING	
Iron in solution (Fe)	<i><0.1</i>	<i>-</i>		Total dissolved solids	<i>C</i>
Aluminium (Al)	<i><0.2</i>	<i>-</i>		Total hardness	<i>C</i>
Potassium (K)	<i>29</i>	<i>0.74</i>	<i>0.3</i>	Chloride	<i>C</i>
Sodium (Na)	<i>1850</i>	<i>80.5</i>	<i>34.3</i>	Sodium	<i>C</i>
Total dissolved solids (TDS)	<i>6560</i>	<i>234.7</i>		Colour	<i>a</i>
Permanent hardness as CaCO ₃	<i>1030</i>			DOMESTIC HOT WATER CYLINDER	
Temporary hardness as CaCO ₃	<i>875</i>			Total dissolved solids	<i>C</i>
Alkalinity as CaCO ₃	<i>875</i>			Cl/alkalinity ratio = <i>3.7</i>	<i>C</i>
Other <i>TDS: conductance ratio = 0.63</i>				Chloride	<i>C</i>
				pH	<i>a</i>
pH			<i>7.6</i>	AGRICULTURAL USE	
Specific conductance ($\mu\text{S/cm at } 25^\circ\text{C}$)			<i>10500</i>	Salinity class (C1—C4)	<i>C4</i>
Colour				Sodium class (S1—S4)	<i>S4</i>
Turbidity				Percent Sodium	<i>68</i>
% difference in anion and cation meq/l			<i>1.6</i>	Sodium adsorption ratio	<i>18.4</i>
				Residual sodium carbonate	<i>Nil</i>

Remarks
A predominantly sodium chloride type water of high salinity; very hard and of slightly alkaline pH. Unsuitable for drinking and unsuitable for most agricultural purposes - suitable for some stock watering.

7/86

TASMANIAN DEPARTMENT OF MINES WATER ANALYSIS	Field No. RH26
	Lab. reg. no. 802902
	Surface sample? <input type="checkbox"/>
	Groundwater sample? YES

Project ROYAL HOBART GOLF CLUB	Location G. Casimiro's property
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Co-ordinates 539900 m E 5255250 m N	Date sampled: 26.11.80 Sampled by: W. Crower	Date analysed: 19.12.80 Analysed by: Dept. Mines, Launceston
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Sampling conditions From open bore installed to 4.6m and pumped at 14 litres/min (190gph)	Landowner and address (if applicable) G. Casimiro, "Acton View", Seven Mile beach
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Field observations Colour pale yellow	Odour	Taste
pH	Eh	Specific conductance ($\mu\text{S/cm at } 25^\circ\text{C}$) 16000
Turbidity high	Precipitates	Other

LABORATORY ANALYSIS				Previous chemical analysis available?	NO
	mg/l	meq/l	% meq/l	Date	
Carbonate (CO ₃)	Nil			Lab. ref. number	
Bicarbonate (HCO ₃)	860	14.1	3.5	Bacteriological analysis available?	NO
Chloride (Cl)	6250	176	43.7	Date	
Sulphate (SO ₄)	515	10.7	2.7	Lab. reg. number	
Silica (SiO ₂)	27	-		HARDNESS SCALE (Total hardness as Calcium Carbonate) Soft 0—60 mg/l Moderately Hard 61—120 Hard 121—180 Very hard more than 180	
Calcium (Ca)	415	20.7	5.1	IONIC RATIOS Ca: Mg = 0.31 Cl: total = 0.44 Na: total = 0.29 SO ₄ : total = 0.03 Na: Cl = 0.65 SiO ₂ : total = 0.002	
Magnesium (Mg)	800	65.8	16.3	SUITABILITY a = no problems, b = doubtful, c = excessive DOMESTIC DRINKING	
Iron in solution (Fe)	<0.1			Total dissolved solids	c
Aluminium (Al)	<0.2			Total hardness	c
Potassium (K)	19	0.49	0.1	Chloride	c
Sodium (Na)	2650	115	28.6	Sodium	c
Total dissolved solids (TDS)	11,100	403		Colour	b
Permanent hardness as CaCO ₃	3625			DOMESTIC HOT WATER CYLINDER	
Temporary hardness as CaCO ₃	705			Total dissolved solids	c
Alkalinity as CaCO ₃	705			Cl/alkalinity ratio = 8.9	c
Other TDS: conductance ratio = 0.62				Chloride	c
pH		7.4		pH	a
Specific conductance ($\mu\text{S/cm at } 25^\circ\text{C}$)		18000		AGRICULTURAL USE	
Colour				Salinity class (C1—C4)	c4
Turbidity				Sodium class (S1—S4)	S4
% difference in anion and cation meq/l		0.3		Percent Sodium	57
				Sodium adsorption ratio	17.5
				Residual sodium carbonate	Nil

Remarks
A predominantly sodium chloride type water of very high salinity; very hard, of near neutral pH. Unsuitable for most uses except some stock watering.

75/80

TASMANIAN DEPARTMENT OF MINES WATER ANALYSIS	Field No. <i>RH27</i>
	Lab. reg. no. <i>802903</i>
	Surface sample? <input type="checkbox"/>
	Groundwater sample? <i>YES</i>

Project <i>ROYAL HOBART GOLF CLUB</i>	Location <i>G. Casimaty's property</i>
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Co-ordinates <i>540175 m E</i> <i>525 5675 m N</i>	Date sampled: <i>27.11.80</i>	Date analysed: <i>19.12.80</i>
	Sampled by: <i>W. Crower</i>	Analysed by: <i>Dept. Mines, Launceston</i>

Sampling conditions <i>From open bore, installed to 4.6m and pumped</i>	Landowner and address (if applicable) <i>G. Casimaty, "Acton View", Seven Mile Beach.</i>
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Field observations	Colour	Odour	Taste
	pH	Eh	Specific conductance ($\mu\text{S/cm at } 25^\circ\text{C}$) <i>5000</i>
	Turbidity	Precipitates	Other

LABORATORY ANALYSIS				Previous chemical analysis available?	<i>NO</i>		
	mg/l	meq/l	% meq/l	Date			
Carbonate (CO ₃)	<i>Nil</i>			Lab. ref. number			
Bicarbonate (HCO ₃)	<i>700</i>	<i>11.5</i>	<i>12.3</i>	Bacteriological analysis available?	<i>NO</i>		
Chloride (Cl)	<i>1100</i>	<i>31.0</i>	<i>33.3</i>	Date			
Sulphate (SO ₄)	<i>82</i>	<i>1.71</i>	<i>1.8</i>	Lab. reg. number			
Silica (SiO ₂)	<i>22</i>	<i>-</i>		HARDNESS SCALE (Total hardness as Calcium Carbonate) Soft 0—60 mg/l Moderately Hard 61—120 Hard 121—180 <u>Very hard</u> more than 180			
Calcium (Ca)	<i>135</i>	<i>6.74</i>	<i>7.2</i>	IONIC RATIOS Ca: Mg = <i>0.87</i> Cl: total = <i>0.33</i> Na: total = <i>0.37</i> SO ₄ : total = <i>0.02</i> Na: Cl = <i>1.10</i> SiO ₂ : total = <i>0.008</i>			
Magnesium (Mg)	<i>94</i>	<i>7.73</i>	<i>8.3</i>	SUITABILITY a = no problems, b = doubtful, c = excessive DOMESTIC DRINKING			
Iron in solution (Fe)	<i><0.1</i>	<i>-</i>					
Aluminium (Al)	<i><0.2</i>	<i>-</i>					
Potassium (K)	<i>12</i>	<i>0.31</i>	<i>0.3</i>				
Sodium (Na)	<i>785</i>	<i>34.2</i>	<i>36.7</i>				
Total dissolved solids (TDS)	<i>2690</i>	<i>93.2</i>					
Permanent hardness as CaCO ₃	<i>150</i>						
Temporary hardness as CaCO ₃	<i>575</i>						
Alkalinity as CaCO ₃	<i>575</i>						
Other <i>TDS: conductance ratio = 0.54</i>							
pH		<i>7.6</i>					
Specific conductance ($\mu\text{S/cm at } 25^\circ\text{C}$)		<i>4950</i>					
Colour							
Turbidity							
% difference in anion and cation meq/l		<i>5.1</i>		DOMESTIC HOT WATER CYLINDER			
Remarks <i>A predominantly sodium chloride type water of high salinity; very hard and slightly alkaline. Unsuitable for drinking and most agricultural purposes, except on well drained sandy soils and salt-tolerant crops.</i>							
				Total dissolved solids	<i>C</i>	Chloride	<i>C</i>
				Cl/alkalinity ratio = <i>0.4</i>	<i>a</i>	pH	<i>a</i>
				AGRICULTURAL USE			
				Salinity class (C1—C4)	<i>C4</i>	Suitability (a,b, or c)	<i>C</i>
Sodium class (S1—S4)	<i>S4</i>		<i>C</i>				
Percent Sodium	<i>70</i>		<i>C</i>				
Sodium adsorption ratio	<i>12.7</i>		<i>B</i>				
Residual sodium carbonate	<i>Nil</i>		<i>a</i>				

76/86

TASMANIAN DEPARTMENT OF MINES WATER ANALYSIS	Field No. <i>RH28</i>
	Lab. reg. no. <i>802904</i>
	Surface sample? <input type="checkbox"/>
	Groundwater sample? <i>YES</i>

Project <i>ROYAL HOBART GOLF CLUB</i>	Location <i>G. Carimaty's property</i>
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Co-ordinates <i>54000 mE</i> <i>5255325 mN</i>	Date sampled: <i>27.11.80</i> Sampled by: <i>W. Conner</i>	Date analysed: <i>19.12.80</i> Analysed by: <i>Dept. Mines, Launceston</i>
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Sampling conditions <i>From 1 year bore installed to 5m and pumped at < 1.5 litres/min (< 20gph)</i>	Landowner and address (if applicable) <i>G. Carimaty, "Acton View", Aven Lide Beach.</i>
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Field observations Colour	Odour	Taste
pH	Eh	Specific conductance ($\mu\text{S/cm at } 25^\circ\text{C}$) <i>2700</i>
Turbidity	Precipitates	Other

LABORATORY ANALYSIS				Previous chemical analysis available?	<i>No</i>
	mg/l	meq/l	% meq/l	Date	
Carbonate (CO ₃)	<i>Nil</i>			Lab. ref. number	
Bicarbonate (HCO ₃)	<i>110</i>	<i>1.80</i>	<i>3.2</i>	Bacteriological analysis available?	<i>NO</i>
Chloride (Cl)	<i>820</i>	<i>23.1</i>	<i>40.8</i>	Date	
Sulphate (SO ₄)	<i>74</i>	<i>1.54</i>	<i>2.7</i>	Lab. reg. number	
Silica (SiO ₂)	<i>23</i>	<i>-</i>		HARDNESS SCALE (Total hardness as Calcium Carbonate) Soft 0 — 60 mg/l Moderately Hard 61 — 120 Hard 121 — 180 <u>Very hard</u> more than 180	
Calcium (Ca)	<i>110</i>	<i>5.49</i>	<i>9.7</i>	IONIC RATIOS Ca: Mg = <i>0.98</i> Cl: total = <i>0.41</i> Na: total = <i>0.33</i> SO ₄ : total = <i>0.03</i> Na: Cl = <i>0.81</i> SiO ₂ : total = <i>0.01</i>	
Magnesium (Mg)	<i>68</i>	<i>5.59</i>	<i>9.9</i>	SUITABILITY a = no problems, b = doubtful, c = excessive DOMESTIC DRINKING	
Iron in solution (Fe)	<i><0.1</i>	<i>-</i>		Total dissolved solids	<i>C</i> pH <i>a</i>
Aluminium (Al)	<i><0.2</i>	<i>-</i>		Total hardness	<i>C</i> Iron <i>a</i>
Potassium (K)	<i>14</i>	<i>0.36</i>	<i>0.6</i>	Chloride	<i>C</i> Sulphate <i>b</i>
Sodium (Na)	<i>430</i>	<i>18.7</i>	<i>33.0</i>	Sodium	<i>C</i> Magnesium <i>b</i>
Total dissolved solids (TDS)	<i>1860</i>	<i>56.6</i>		Colour	<i>a</i>
Permanent hardness as CaCO ₃	<i>465</i>			DOMESTIC HOT WATER CYLINDER	
Temporary hardness as CaCO ₃	<i>91</i>			Total dissolved solids	<i>C</i> Chloride <i>C</i>
Alkalinity as CaCO ₃	<i>91</i>			Cl/alkalinity ratio = <i>9</i>	<i>C</i> pH <i>a</i>
Other <i>TDS: conductance ratio = 0.58</i>				AGRICULTURAL USE	
pH		<i>6.8</i>		Salinity class (C1 — C4)	<i>S4</i> Suitability <i>C</i>
Specific conductance ($\mu\text{S/cm at } 25^\circ\text{C}$)		<i>3200</i>		Sodium class (S1 — S4)	<i>S2-S3</i> <i>b</i>
Colour				Percent Sodium	<i>63</i> <i>C</i>
Turbidity				Sodium adsorption ratio	<i>4.0</i> <i>a</i>
% difference in anion and cation meq/l		<i>6.5</i>		Residual sodium carbonate	<i>Nil</i> <i>a</i>

Remarks
A predominantly sodium chloride type water of high salinity; very hard, with a near-neutral pH. Unsuitable for drinking but suitable for agricultural purposes on well drained sandy soils and salt-tolerant crops.

7/1/86

TASMANIAN DEPARTMENT OF MINES WATER ANALYSIS	Field No. <i>RN29</i>
	Lab. reg. no. <i>802905</i>
	Surface sample? <input type="checkbox"/>
	Groundwater sample? <i>YES</i>

Project <i>RAIAL HOBART GOLF CLUB</i>	Location <i>G. Casimaty's property</i>
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Co-ordinates <i>540350mE</i> <i>5256250mN</i>	Date sampled: <i>27.11.80</i> Sampled by: <i>W. Cooper</i>	Date analysed: <i>19.12.80</i> Analysed by: <i>Dept. Mines, Launceston</i>
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Sampling conditions <i>From spear bore installed to 5m and pumped at 18 litres/min (240gph)</i>	Landowner and address (if applicable) <i>G. Casimaty, "Acton View", near Rye Beach</i>
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Field observations	Colour <i>None</i>	Odour	Taste
	pH	Eh	Temperature (°C)
	Turbidity	Precipitates	Other

LABORATORY ANALYSIS				Previous chemical analysis available?	<i>No</i>		
	mg/l	meq/l	% meq/l	Date			
Carbonate (CO ₃)	<i>Nil</i>			Lab. ref. number			
Bicarbonate (HCO ₃)	<i>375</i>	<i>6.15</i>	<i>9.9</i>	Bacteriological analysis available?	<i>No</i>		
Chloride (Cl)	<i>775</i>	<i>21.9</i>	<i>35.4</i>	Date			
Sulphate (SO ₄)	<i>50</i>	<i>1.04</i>	<i>1.7</i>	Lab. reg. number			
Silica (SiO ₂)	<i>39</i>	<i>-</i>		HARDNESS SCALE (Total hardness as Calcium Carbonate) Soft 0 — 60 mg/l Moderately Hard 61 — 120 Hard 121 — 180 <u>Very hard</u> more than 180			
Calcium (Ca)	<i>115</i>	<i>5.74</i>	<i>9.3</i>	IONIC RATIOS Ca: Mg = <i>0.97</i> Cl: total = <i>0.35</i> Na: total = <i>0.34</i> SO ₄ : total = <i>0.02</i> Na: Cl = <i>0.95</i> SiO ₂ : total = <i>0.02</i>			
Magnesium (Mg)	<i>72</i>	<i>5.92</i>	<i>9.6</i>	SUITABILITY a = no problems, b = doubtful, c = excessive DOMESTIC DRINKING			
Iron in solution (Fe)	<i><0.1</i>	<i>-</i>					
Aluminium (Al)	<i><0.2</i>	<i>-</i>					
Potassium (K)	<i>8.5</i>	<i>0.22</i>	<i>0.4</i>				
Sodium (Na)	<i>480</i>	<i>20.9</i>	<i>33.8</i>				
Total dissolved solids (TDS)	<i>1840</i>	<i>61.9</i>					
Permanent hardness as CaCO ₃	<i>270</i>						
Temporary hardness as CaCO ₃	<i>310</i>						
Alkalinity as CaCO ₃	<i>310</i>						
Other <i>TDS:conductance ratio = 0.55</i>							
pH			<i>6.5</i>				
Specific conductance (µS/cm at 25°C)			<i>3350</i>				
Colour							
Turbidity							
% difference in anion and cation meq/l			<i>6.0</i>	DOMESTIC HOT WATER CYLINDER			
Remarks <i>A predominantly sodium chloride type water of high salinity; very hard and slightly acidic. Unsuitable for drinking but suitable for agricultural purposes on well drained sandy soils and salt tolerant crops.</i>							
				Total dissolved solids	<i>C</i>	Chloride	<i>C</i>
				Cl/alkalinity ratio = <i>2.5</i>	<i>B</i>	pH	<i>A</i>
				AGRICULTURAL USE			
				Salinity class (C1 — C4)	<i>C4</i>	Suitability (a, b, or c)	<i>C</i>
Sodium class (S1 — S4)	<i>S3</i>		<i>B</i>				
Percent Sodium	<i>65</i>		<i>C</i>				
Sodium adsorption ratio	<i>8.7</i>		<i>B</i>				
Residual sodium carbonate	<i>Nil</i>		<i>A</i>				

78/86

APPENDIX 4

Technical details of spear bores and specifications of screens suitable for Seven Mile Beach aquifer

ADVANTAGES OF USING SPEAR BORES

Any one of a number of methods of extraction could be used at the Golf Club to obtain groundwater. For example, the existing method of using soaks could be expanded, but hydrologically this is inefficient and also uses valuable land which could be better used for other purposes. Large diameter wells, horizontal collector systems, or bores installed by drilling rig could be used. Spear bores, however, have economic and hydrological advantages; they are cheap, easy to instal by unskilled labour using a minimum of equipment, are virtually maintenance free and give efficient service for years, and any system of spears can be expanded to increase yield at any time at small cost. By connecting the spears in arrays, only one pump is needed to extract the groundwater.

DESCRIPTION OF SPEAR BORES

A typical 'spear' or 'spear bore' consists of a specially designed alloy steel screen (fig. 7) usually about 50 mm in diameter and a metre or two in length, attached to the bottom of a vertical tube (often PVC pipe) of the same or similar diameter. A suction line is attached to the latter, or sometimes extended down inside it, and is in turn connected to a single suction pump. The screen holds back sediment and allows water to flow into the spear without excessive turbulence (head loss) or the passage of fine material. To do this effectively the screen must be specifically designed for each location. Commercial screens are available in a variety of diameters, slot sizes and corrosion resistant metals.

Arrays of spear bores (each spear pumping equal amounts) can be installed in virtually any configuration, and each is connected to a single header pipe (suction line). The use of one pump for all spears in an array restricts the maximum depth of spears to the suction limit of the pump - about 8 m in practise.

PROPER SCREEN DESIGN

The length of the screen and the size of the slots most effective for a particular aquifer are based on a study of sand samples collected during drilling, and on the hydrological properties of the aquifer.

As a general rule, the following criteria are recommended for unconfined aquifers:

- (a) the lower one-third to half of the aquifer should be screened
- (b) the longest possible length of screen should be used to reduce the entrance velocity of the water entering the slots
- (c) the suction intake should be above the top of the screen.

These three factors are designed to maintain a steady uniform flow of water to the spear, but in practise, (a) is often not possible or desirable, and (b) and (c) are often mutually exclusive, since (c) restricts the available drawdown. A compromise must often be reached.

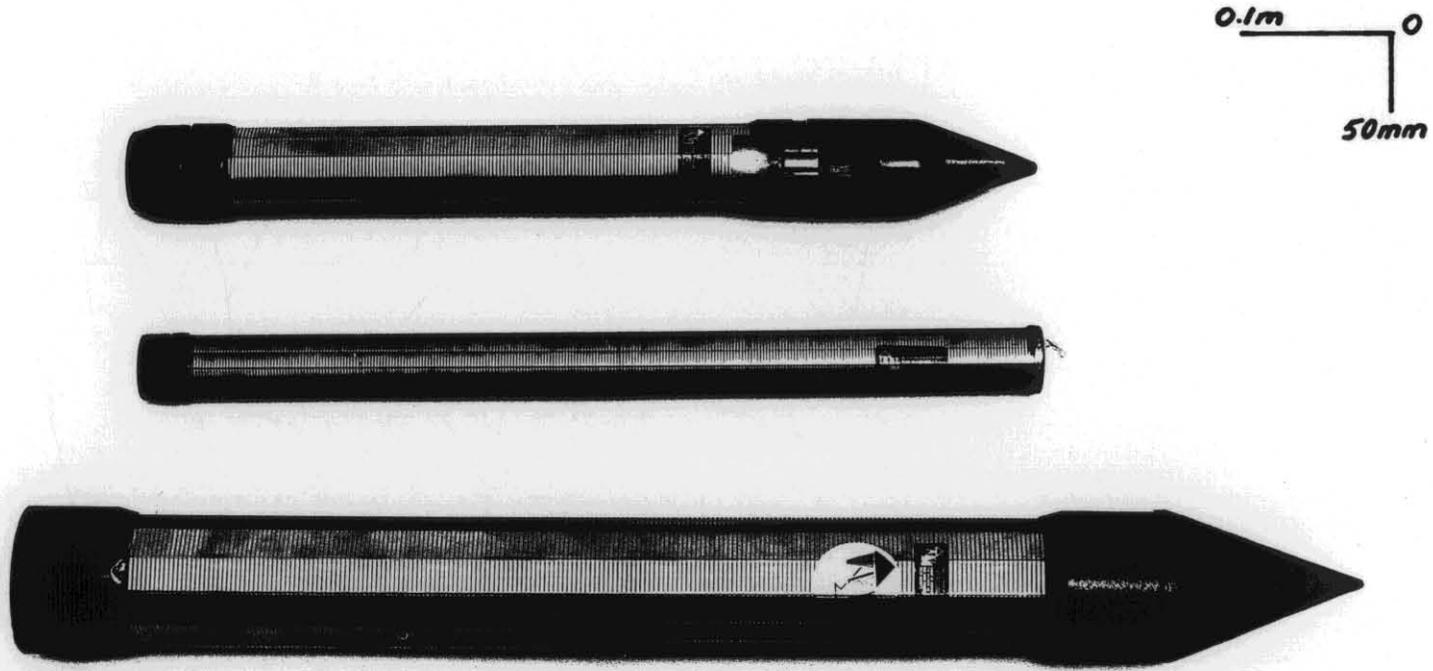


Figure 7. Typical stainless steel screens with jetting point (top), welded stainless steel tip (middle), or conical cast iron point (bottom).

The optimum length of screen needed is affected by;

- (a) the percentage open area of the slots in a screen. (This differs from the *effective* open area where on average about half the slot area of a screen is permanently blocked by aquifer material).
- (b) the character of the aquifer, including the grain size and uniformity of its constituent grains and its resultant permeability
- (c) the cost of the screen
- (d) the desired yield of each spear

CALCULATION OF OPTIMUM SCREEN LENGTH AND SLOT SIZE

In Figure 9 (a), (b) and (c) are plotted the grain size distribution of sand samples at selected depths in three holes (Holes 6, 9 and 12) near the recommended groundwater extraction area on the golf course. (The curves were obtained by passing a dried weight of sample through a graded series of sieves). For bore design, three elements of the curves are necessary to adequately describe the grain size distribution in a sample.

- (a) the fineness of the material; often described in a general way by the *median diameter* on the curve *i.e.* the 50% (or D_{50}) size. Another index used is the *effective grain size* (D_{90}) - the sieve size that retains 90% of the sample
- (b) the sorting of the material, described either by the *uniformity coefficient* D_{40}/D_{90} , or the *sorting coefficient*, $\sqrt{D_{25}/D_{75}}$. Both describe the slope of the grain size curve. The lower the value, the steeper the curve and the more uniform the material
- (c) the shape of the curve. Materials deposited by water usually form an S-shaped distribution curve, but the tails of the curves are distorted by the presence of gravel or fines at the coarser or finer ends respectively.

The first two characteristics are summarised in Table 5 for samples from each of the three holes.

Table 5. SUMMARY OF GRAIN SIZE CHARACTERISTICS FOR SAND FROM THE SEVEN MILE BEACH AQUIFER.

Depth (m)	Hole 6		Hole 9	Hole 12	
	5.6-6	6.5-6.7	4.6-6.9	5.6-5.9	6.5-6.8
Median size (D_{50}) mm	0.16	0.13	0.15	0.14	0.12
Effective size (D_{90}) mm	0.13	0.09	0.10	0.09	0.07
D_{40}/D_{90}	1.23	1.56	1.50	1.61	2.0
$\sqrt{D_{25}/D_{75}}$	1.11	1.19	1.11	1.12	1.30

There is very little variation between the three holes. The sand is very fine-fine grained, and very well sorted. Based on spear bore yields under test (summarised in the log sheets in Appendix 1) and on previous calculations of similar coastal aquifers in Tasmania, sand of this type has a permeability of about 12 m/day. Such a figure is also given by Heath and Trainer (1968, p.18) for sand with a median diameter (D_{50}) of 0.14 mm,

similar to the Seven Mile Beach aquifer.

This information can be used to calculate the most suitable screen length for the aquifer, but the spears can be made more efficient by installing an *artificial gravel pack* around each. Artificial gravel packs are usually justified in unconsolidated sediments when

- (a) the aquifer is uniform,
- (b) it has a uniformity coefficient less than 3, and
- (c) it has a median grain size less than 0.25 mm.

All three apply to the Seven Mile Beach aquifer. The use of a gravel pack prevents clogging of slots, avoids excessive settling of material above the screen and allows the use of large screen slots, so increasing yield and promoting uniform water flow. The proper selection of a gravel pack size is important, and is based on the grain size curves of the aquifer. A recommended method is to multiply the D₇₀ size of the aquifer material by a factor between 4 and 6 (for fine uniform aquifers). This becomes the D₇₀ size of the gravel pack. A grain size curve is constructed through this point with a uniformity coefficient less than 2.5, and subsequently a selected gravel pack is made up from the curve.

Commercially available gravel pack material from Industrial Sands Pty Ltd at Port Sorell has been found suitable for Tasmanian coastal sands. In Figure 9(a), the grain size curve of the gravel material (actually an angular medium-coarse sand) is represented by the heavy line. It has a median diameter (D₅₀) of 0.65 mm and a uniformity coefficient of 1.29. The shaded envelope around the curve represents the optimum gravel pack range for the materials in Hole 6, as calculated by the above procedure. Similar calculations could be made for Holes 9 and 12 to show that the Industrial Sands material is suitable for the aquifer at the Golf Club.

According to Heath and Trainer (1968, p.18), similar material with a median diameter of about 0.65 mm has a permeability of between 40 and 60 m/day (although this varies with the sorting of the material). The average permeability of the aquifer and gravel pack material is therefore about 25-35 m/day. Walton (1970, p.297) suggests that given this permeability, the optimum screen entrance velocity should be between 0.9 and 1.2 m/min (1.5-2 cm/sec).

A suitable slot opening size for a screen gravel packed with the above material is 0.5 mm, which is that size able to retain on the outside of the screen 90% of the gravel pack, *i.e.* the slot size is the D₉₀ value of the gravel pack. Commercially made screens with this slot opening have an open area (total slot area to screen area) of about 33%. Because the slots are, in practise, partially blocked by aquifer material, an *effective* open area of half the open area (*i.e.* 17%) is used to calculate the most suitable screen length to pump the desired yield.

Walton (1970, p.267) gives an equation to determine the optimum screen length:

$$S = \frac{Q}{(A)(V)}$$

- where S = length of screen, in metres
- Q = pumping rate, in m³/min
- A = effective open area, in m² per metre of screen
- V = optimum screen entrance velocity, in m/min

For the Golf Club aquifer,

desired $Q = 38 \text{ l/min (500 gal/hr)} = 0.038 \text{ m}^3/\text{min}$
 $A = 0.027 \text{ m}^2/\text{m}$. For 0.50 mm slot, 50 mm diameter screen
 $V = 0.9\text{-}1.2 \text{ m/min}$

From which

$S = 1.1 \text{ to } 1.6 \text{ m}$, depending on the value chosen for V . If
an average value for V is selected,
 $S = 1.35 \text{ m (say } 1.4 \text{ m)}$

SUMMARY OF SPEAR AND SCREEN RECOMMENDATIONS

At the north-eastern end of the golf course, the aquifer is very fine - fine grained sand, with a median diameter at the proposed depth of the screen of 0.12-0.16 mm, and a uniformity coefficient of 1.2-2.0. Gravel packing is therefore necessary, and the material commercially available from Industrial Sands, which has a median diameter of 0.65 mm and a uniformity coefficient of 1.29, is ideally suited to the aquifer.

At a desired pumping rate of 38 l/min/spear, each screen 50 mm in diameter should have a slot opening of 0.50 mm and a length of 1.3-1.4 m. Since the groundwater contains some dissolved hydrogen sulphide gas, the screens should be manufactured from stainless steel.

The above spear assembly is depicted in Figure 8. These recommendations should be adopted for the Seven Mile Beach aquifer.

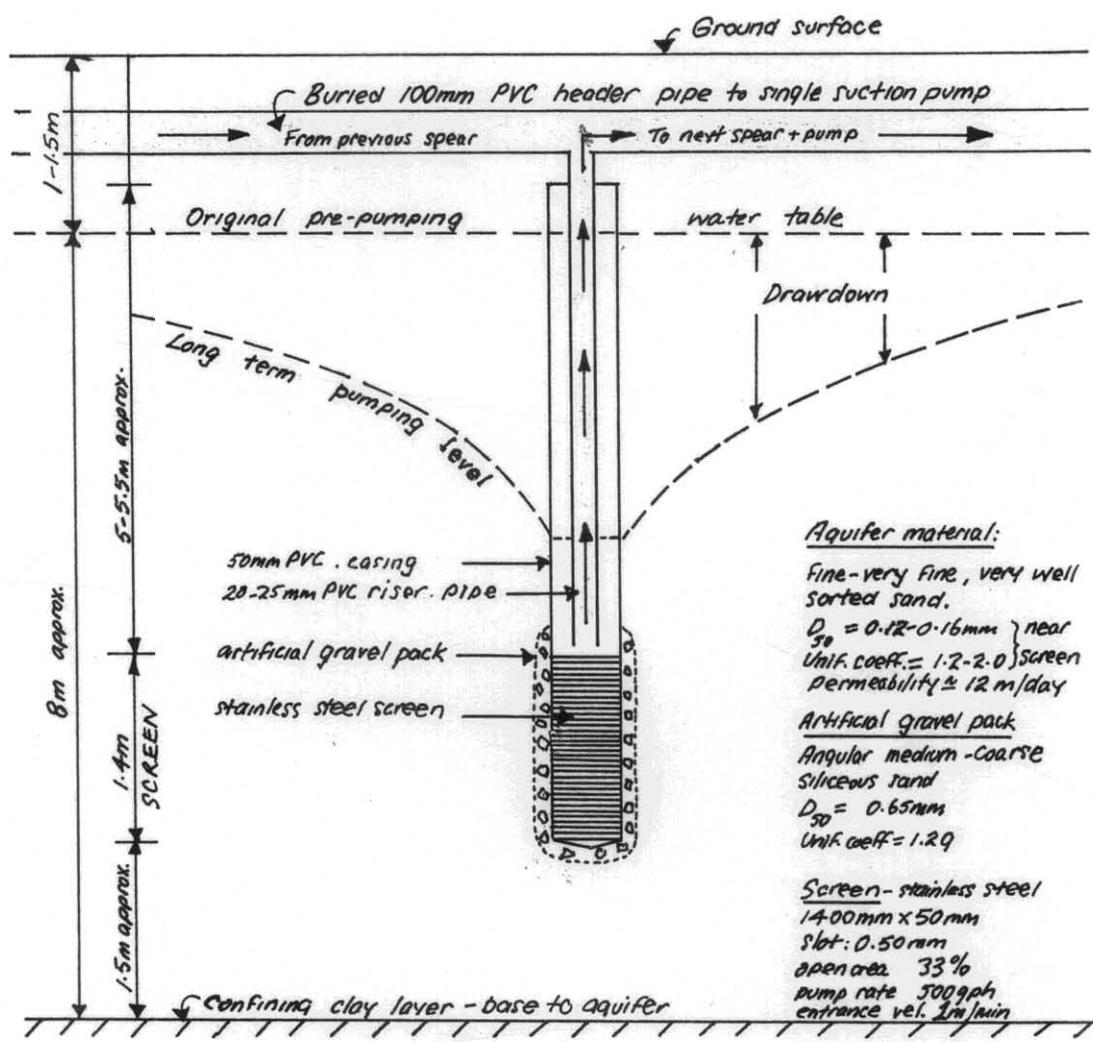
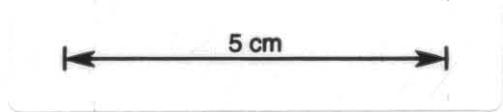
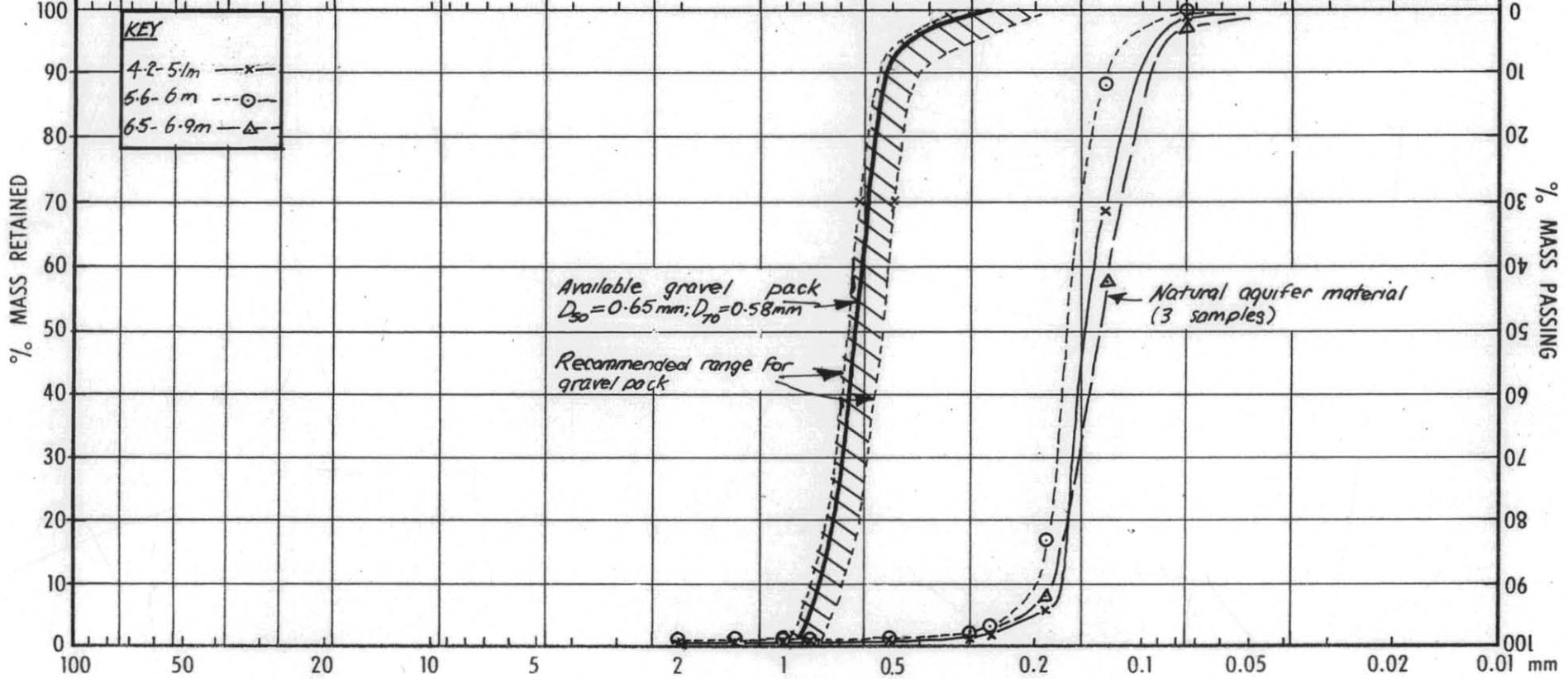


Figure 8. Diagrammatic sketch of recommended spear bore installation and screen specifications for Seven Mile Beach aquifer.

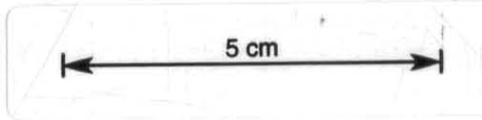


REFERENCE No.	LAB. SERIAL No.	LOCALITY				SEDIMENT ANALYSIS PARAMETERS								
HOLE RH 6		ROYAL HOBART GOLF CLUB				M =	V =	Sk =	K =					
COARSE AGGREGATE			FINE AGGREGATE				A77-1957 (concrete)							
COARSE AGGREGATE		FINE AGGREGATE		BINDER		N.A.A.S.R.A. (road materials)								
COBBLE	PEBBLE		GRANULE	SAND			SILT							
			V. COARSE	COARSE	MEDIUM	FINE	V. FINE							
-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6 ϕ		
75	53	37.5	26.5	19	9.5	4.75	2.36	1.18	0.6	0.3	0.15	0.075	0.038	Aust. Stand. Sieve



3-83

Figure 6a. Grain size distribution curve, selected samples, Hole 6, Seven Mile Beach



84/86

REFERENCE No.	LAB. SERIAL No.	LOCALITY					SEDIMENT ANALYSIS PARAMETERS									
HOLE RH 9	—	ROYAL HOBART GOLF CLUB					M =	V =	Sk =	K =						
COARSE AGGREGATE			FINE AGGREGATE					A77-1957 (concrete)								
COARSE		AGGREGATE		FINE AGGREGATE			BINDER		N.A.A.S.R.A. (road materials)							
COBBLE		PEBBLE		GRANULE	SAND					SILT						
					V. COARSE	COARSE	MEDIUM	FINE	V. FINE							
-6		-5		-4	-3	-2	-1	0	1	2	3	4	5	6 φ		
75		53		37.5	26.5	19	9.5	4.75	2.36	1.18	0.6	0.3	0.15	0.075	0.038	Aust. Stand. Sieve

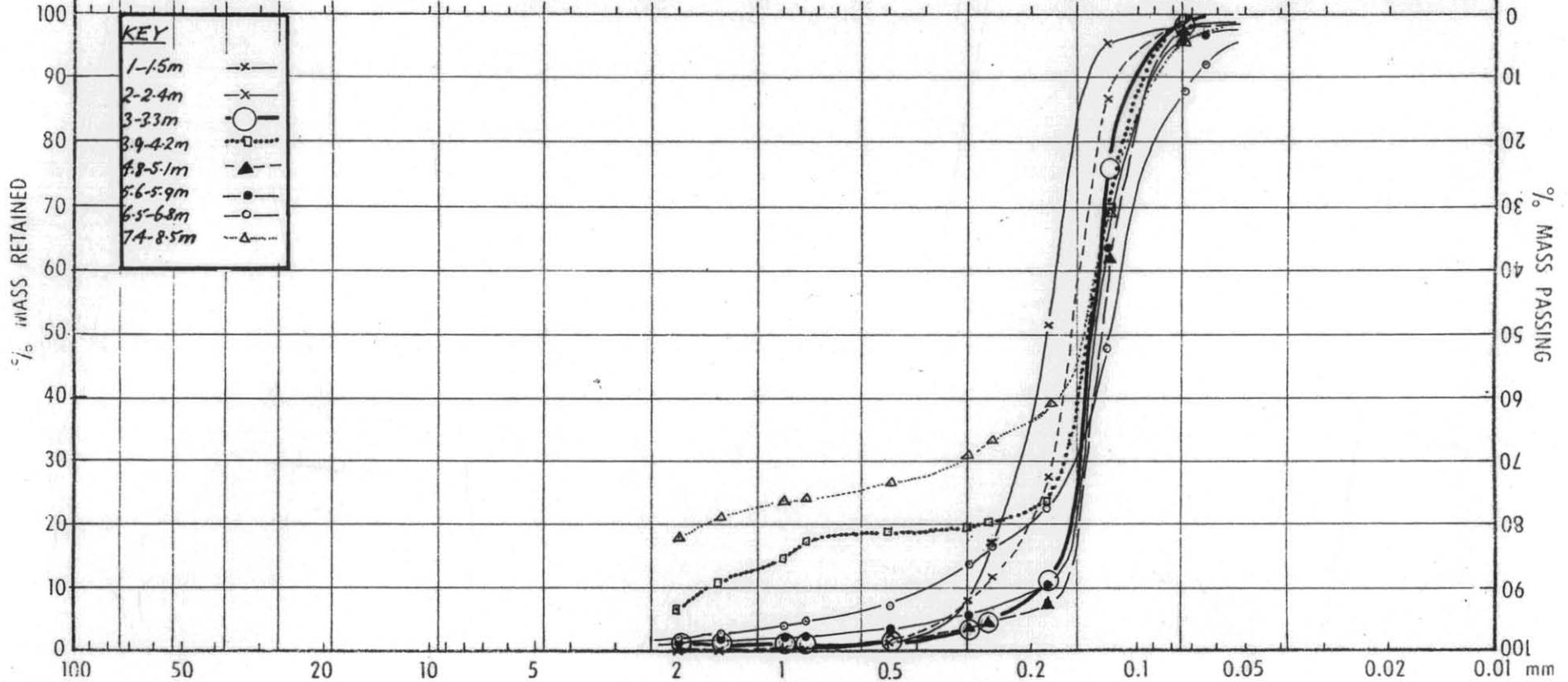
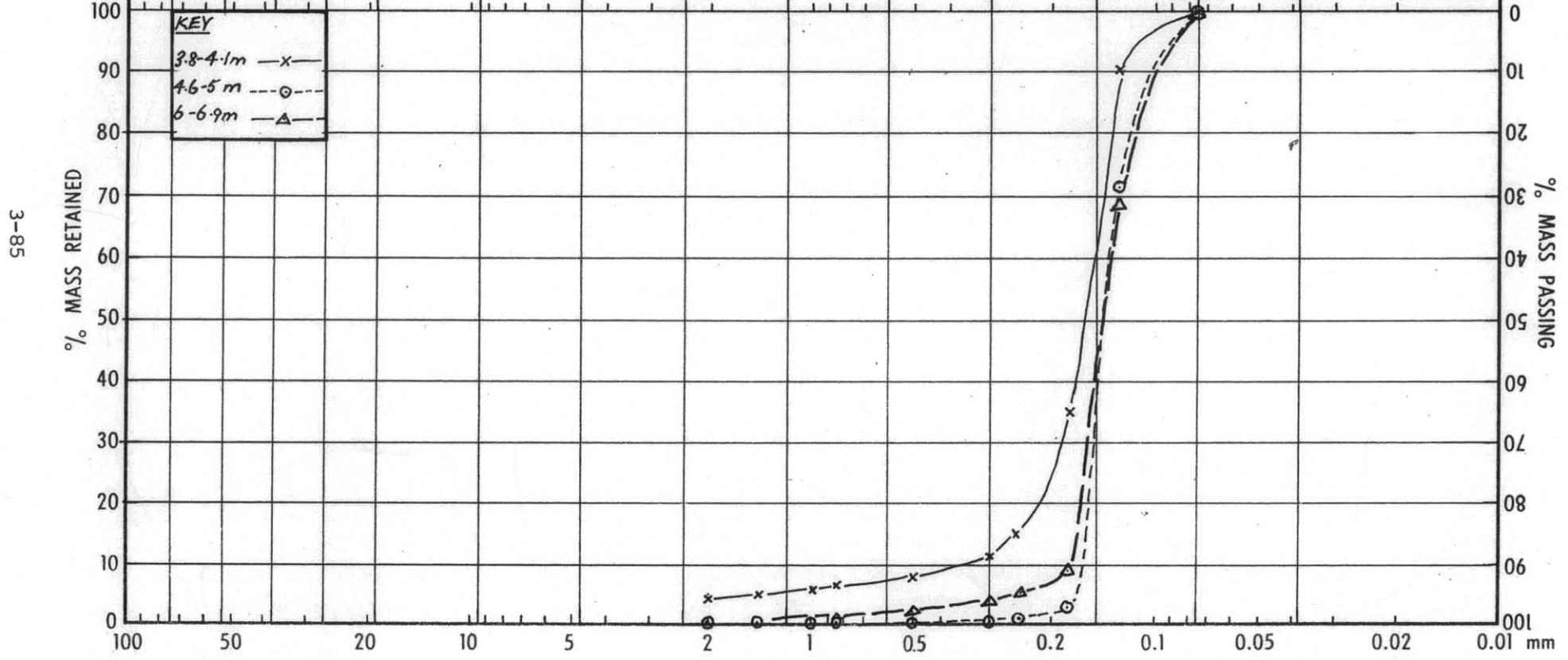


Figure 6b. Hole 9

3-84

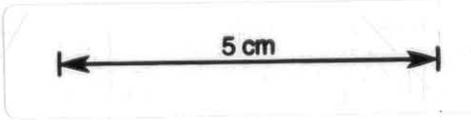
85/86

REFERENCE No.	LAB. SERIAL No.	LOCALITY				SEDIMENT ANALYSIS PARAMETERS								
HOLE R4 12		ROYAL HOBART GOLF CLUB				M =	V =	Sk =	K =					
COARSE AGGREGATE			FINE AGGREGATE				A77-1957 (concrete)							
COARSE AGGREGATE			FINE AGGREGATE		BINDER		N.A.A.S.R.A. (road materials)							
COBBLE	PEBBLE		GRANULE	SAND					SILT					
				V. COARSE	COARSE	MEDIUM	FINE	V. FINE						
-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	Ø	
75	53	37.5	26.5	19	9.5	4.75	2.36	1.18	0.6	0.3	0.15	0.075	0.038	Aust. Stand. Sieve



3-85

Figure 6c. Hole 12



86/86