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GEOLOGICAL SURVEY BULLETIN 67

Geology and groundwater resources of the Devonport – Port Sorell – Sassafras Tertiary Basin

TASMANIA DEPARTMENT OF MINES

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Geology and groundwater resources of the Devonport – Port Sorell – Sassafras Tertiary Basin

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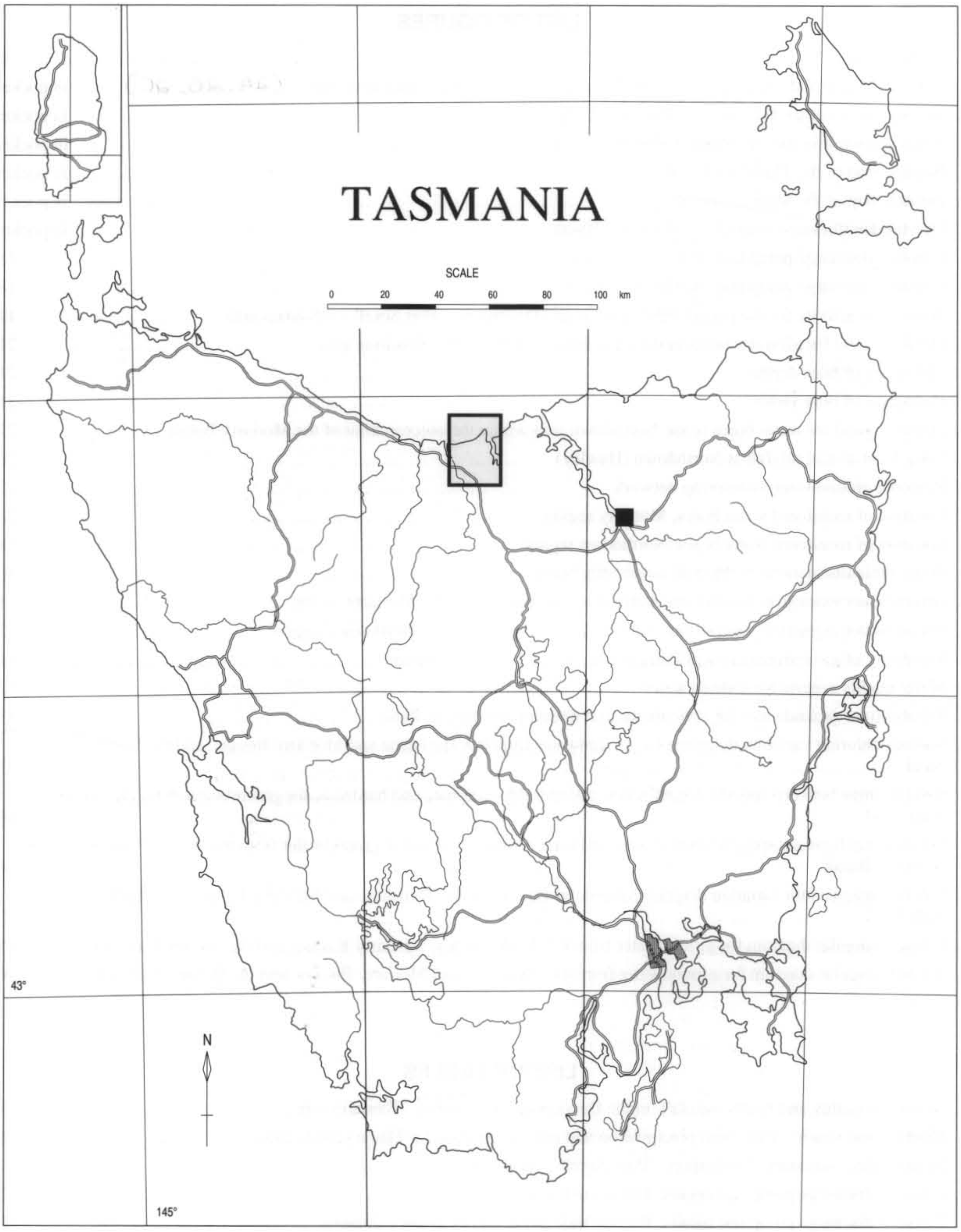
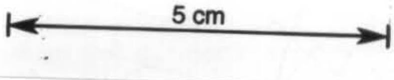


Figure 1. Location map.



INTRODUCTION

The northern Tasmanian coastal region between the Mersey and Rubicon River estuaries, and extending south to the Bass Highway, includes an area of about 180 km^2 in the municipalities of Latrobe and Devonport. Roughly triangular in shape, it consists mainly of a gently undulating, dissected surface sloping seawards from the Bass Highway, between the towns of Devonport and Port Sorell (fig. 1).

Purpose and scope of investigations

This report is one of a series dealing with regional groundwater investigations in Tasmania. Broadly, it is an assessment of the present use and importance of groundwater in the Devonport–Port Sorell–Sassafras area. It identifies the main aquifers in the district and provides a sound geological basis for future use and conservation of the resource.

The area has a moderate annual rainfall of between 800 and 1000 mm, but it is unevenly distributed, with dry summers. Rich basalt soils support intensive farming, and groundwater has long been a supplementary source of water for landowners. Since the 1960s, however, the use of groundwater has increased to the extent that many farmers rely on it almost exclusively as a primary supply.

The study started early in 1972, and continued intermittently until late 1975. In its initial stages it involved a survey of existing bores and wells which yielded valuable information on the occurrence, yield and quality of water in various rock types. The Department of Mines subsequently conducted geophysical surveys in the district and drilled twenty-two water bores and four stratigraphic holes. Many of the former were pump tested, and water analyses done. The Department of Mines is presently monitoring groundwater levels, use and quality from selected water bores.

Private drilling contractors are active in the area, and the combined information from all sources has proved to be a useful predictive tool in the continuing search for successful water bores.

Previous investigations

The district has received considerable attention from geologists since the 1920s, initially because of the occurrence of oil shale reserves in Permian rocks south of Devonport. The Mersey Valley Oil Company, Tasmanian Oil Company and Adelaide Oil Exploration Company were all formed early this century to explore and exploit the deposits. Between 1921 and 1928 the area around Latrobe was extensively drilled, and many deep exploration bores were sunk in the Permian sediments. Following reports of oil seepages near Sassafras, the rigs were moved to the Tertiary non-marine rocks north of the town. After a number of unsuccessful holes, drilling was tried in the deep bores on the coast at Northdown in an attempt to locate marine intercalations in the Tertiary sequence.

Reid (1924) was the first to issue a major report on the region. He was mainly concerned with an evaluation of oil shale reserves, but briefly described Tertiary sediments north of Sassafras, and published detailed logs of the oil bores.

Nye (1928) visited the coast at Northdown and reported on the then recently completed deep oil bore. Apparently most of the core had been removed but Nye published a log of the hole based on the remaining samples.

Elliston (1952) compiled an unpublished geological map of the region south of Port Sorell.

Jennings *et al.* (1959) and Jennings (1979) described the area south-west of Latrobe as part of the geology of the Sheffield quadrangle. Burns (1960) report was the first to deal solely with the Tertiary sediments of the area. He described their occurrence near Port Sorell, noting the presence of clay, sand, lignite and basalt.

Hughes and Burns (1961) reported on the results of shallow drilling in sediments and weathered basalt at the site of the then proposed Associated Pulp and Paper Mills factory near Wesley Vale.

The western half of the area is included in the Devonport 1:63360 geological map series (Burns, 1963*b*). In the accompanying explanatory notes, Burns (1964) discussed the occurrence, morphology and lithology of the Tertiary sequence. Earlier, and as a result of investigations made during regional mapping of the quadrangle, the same author (Burns, 1963*a*) discussed the locations and logs of deep oil bores described by Reid, and found and corrected many location errors appearing in the 1924 report.

The eastern half of the area, south of Port Sorell and east of Thirlstane, was unsuccessfully drilled for oil by C. Sulzberger in the 1960s. Four deep holes were drilled, and brief logs of each were reported by Leaman (1973, p.102).

Sutherland (1969) correlated the Tertiary basalts of the area with other northern Tasmanian occurrences in a comparison of Tasmanian and Victorian volcanism.

The district has been the subject of various geophysical surveys. Parts of it were included in a regional gravity coverage of northern Tasmanian Tertiary basins (Longman and Leaman, 1971), and the area around Port Sorell was covered in a subsequent more detailed regional survey by Leaman, Symonds and Shirley (1973). Leaman (1973) extended the coverage south and west of Port Sorell, and Cromer (1977*a*) completed the survey of the area. Leaman (1974) conducted deep resistivity probes near Moriarty and Thirlstane.

The eastern half of the region was mapped as part of the Beaconsfield quadrangle (Gee and Legge, 1971, 1979), and the area east and south of Sassafras as part of the Frankford quadrangle (Gulline, 1973). Threader (1974) reported on the occurrence of beach deposits east of Devonport. Cromer (1974, 1975) discussed the hydrology of Quaternary and Tertiary sediments near Port Sorell, and presented (1977*b*) the results of deep stratigraphic holes drilled by the Department of Mines. Cromer (1980) reported a Late Eocene potassium-argon date obtained from basalt from the area and included palynological dates from interbedded sediments. Baillie (1986) obtained a Late Oligocene date on basalt near Sassafras. Cromer (1989) summarised the stratigraphy and structure of the area in relation to other Tertiary basins in northern Tasmania including Bass Basin.

GEOGRAPHY AND CLIMATE

Geography

PHYSIOGRAPHY

The district forms part of the coastal lowlands of northern Tasmania which can be divided into three topographic areas (Burns, 1964):

(1) a low, gently seaward-sloping marine platform up to two kilometres wide extending from Devonport to Port Sorell, and also occurring along the Mersey and Rubicon River estuaries. The surface is both erosional and depositional in origin, and is the result of Quaternary sea level changes.

(2) a prominent escarpment, roughly parallel to the coast, extending from Devonport to Point Sorell at the rear of the marine platform. The boundary between the two features is abrupt, and the escarpment is characterised in places by scree deposits and areas of actual or potential slope instability. It extends up both the Rubicon and Mersey river estuaries.

(3) a gently undulating, dissected basalt plateau, sloping seawards from an elevation of about 160 m near Sassafras to 60 m at the edge of the coastal escarpment. North-east of Wesley Vale, the Northdown plateau is higher than this surface, and elsewhere isolated higher points include unnamed hills near East Sassafras.

DRAINAGE

Although the district is bounded by the Mersey and Rubicon Rivers, both receive most of their drainage from outside the area. The district is therefore a first-order interfluve. Second-order watercourses within it are largely intermittent, and almost all are spring-fed from soaks draining the more elevated basalt areas. Panatana Rivulet, the areas's largest stream, has a catchment area of about 70 km^2 fed by 140 springs. Its main tributaries are Eastford, Westford, Tullamona and Appleby Creeks, all of which rise in springs draining the basalt plateau near Sassafras. Panatana Rivulet has an overall gradient of 8 m/km (1:125) along its 20 km length, flowing to the Rubicon River near Port Sorell.

The western half of the district is drained by Pardoe Creek (12 km), which rises near Wesley Vale and discharges intermittently beneath Devonport Airport to Pardoe Point. Its sub-catchment of 36 km^2 includes 234 springs draining the Northdown plateau. The overall gradient is 8 m/km.

Greens Creek (12 km; gradient 12 m/km) has a sub-catchment of 30 km^2 fed by 62 springs. It rises in basalt country near Sassafras and flows north towards Harford.

Agriculture has altered the direction and discharge of all the natural watercourses. Competition for surface water is strong but regulated, and the discharge from most creeks and streams is successively diminished downstream. Farm dams are common, and some larger ones have capacities of 50–100 million litres.

None of the streams in the area is gauged, which makes it difficult to estimate the districts water balance between rainfall, evaporation, runoff and groundwater recharge and discharge.

ACCESS

The Bass Highway runs along the southern boundary of the district, which is also bisected east-west by the Frankford Highway. The area is well served by a network of high standard mainly sealed secondary roads, many of which follow the interfluves between modern valleys.

Apart from Devonport and Latrobe, both of which lie just outside the district, the principal towns are Wesley Vale, Port Sorell and Sassafras. Minor towns include Moriarty, Northdown, Thirlstane, Harford, Hawley and East Sassafras.

LAND USE

The developed country is confined mainly to areas underlain by Tertiary basalt, and to a lesser extent Tertiary sediments. These areas have been cleared of original vegetation since the rich, leached kraznozem basalt soils are valuable assets. Areas of Jurassic dolerite are generally left uncleared, and support an open eucalypt forest with bracken and shrub understorey.

Because the basalt soils are so fertile, the area is intensively farmed. Holdings are small. The district has long been known for dairying, but dairy production has fallen in the last few years, and many farmers grow vegetables exclusively. Increasingly, farmers are growing higher profit, commissioned, cash crops, such as peas, brussels sprouts and poppies.

Climate

RAINFALL

Recording stations at Devonport, Latrobe, Devonport Airport, Northdown (Hawley) and East Sassafras submit regular rainfall figures. Average annual rainfall (table 1) ranges from about 800 mm at Northdown to about 1000 mm at East Sassafras. Precipitation is not evenly distributed throughout the year. For example, the mean deviation of the average annual rainfall at Devonport is 17.5%, and it is probably higher for the rest of the district since variability increases eastward. Consequently, summers are often dry and rainfall alone is often less than that required to sustain plant growth. The estimated effective rainfall (that required to initiate and maintain growth) for Devonport is higher on average than the actual rainfall in all but two months (July and August).

Table 1. AVERAGE MONTHLY AND YEARLY RAINFALL IN THE DEVONPORT – PORT SORELL – SASSAFRAS AREA (mm)

	Devonport	Devonport Airport	Latrobe	Hawley	East Sassafras
Years	65	15	66	58	11
January	39	39	41	35	46
February	57	52	48	44	51
March	51	60	49	43	62
April	83	60	72	60	74
May	108	89	101	82	98
June	92	83	115	91	97
July	126	117	127	103	144
August	109	102	116	89	129
September	81	77	89	72	88
October	86	68	87	75	70
November	59	59	63	56	68
December	68	56	61	53	70
Total	959	862	969	803	997

TEMPERATURE

The region experiences relatively small temperature fluctuations because of the moderating maritime influence of Bass Strait. Maximum summer temperatures rarely exceed 21°C, and the highest recorded during the period 1954–1967 was 32°C. Temperatures seldom fall below 4°C in winter.

Table 2. MONTHLY AND YEARLY VARIATION IN PRECIPITATION AND PAN EVAPORATION FOR ELLIOTT (1954-1964)

Month	Precipitation	Pan evaporation
January	44	139
February	62	104
March	57	84
April	87	51
May	119	54
June	134	23
July	108	22
August	151	33
September	114	50
October	111	73
November	75	93
December	72	115
Total	1185	840

Frosts are relatively rare, and from 1954–1967 Devonport recorded an average 30 days of mild frosts annually. Ten severe frosts per year were recorded during the same period.

EVAPORATION

Evaporation data for the area are not available, and the nearest stations are at Forthside and Elliott 10 km west of

Devonport. At Forthside the pan evaporation on an annual basis exceeds the actual rainfall. At Elliott (table 2), pan evaporation is 70% of precipitation.

DROUGHTS AND FLOODS

Severe droughts are unknown in the district, but since records were started in the 1890s, fourteen dry years – on a prominent six year cycle – have been recorded. Floods are rarer, and are only of minor and local importance.

GEOLOGY

Introduction

The district is covered by four published 1:63 360 geological map sheets – Devonport, Beaconsfield, Sheffield and Frankford. As such, it has been mapped on a scale considered adequate for a regional groundwater survey. Various minor alterations have been made to the published maps as a result of local more detailed mapping and additional drilling information. The geology of the area is shown in Figure 2. In the sections that follow, emphasis is given to the Tertiary rocks because they constitute the district's most important aquifers.

Geological setting

Burns (1964) interpreted the belt of Tertiary sediments between Devonport and Port Sorell as basin infillings occupying second order fault-controlled structures within a larger first order graben – the Mersey Graben.

The Mersey Graben has in turn been considered by various workers as forming part of a regional structure which continues south towards Cressy and possibly north into Bass Strait. In a detailed account of its structure, Burns (1964, p. 201) described the flanks of the Mersey Graben as being composed of Lower Palaeozoic and Precambrian rocks, which crop out east of Port Sorell and west of Devonport. The western boundary of the graben appears to be a series of major faults and associated smaller *en echelon* fractures trending roughly NW–SE. From south to north, the Tiers, Aberdeen, Tugrah and Devonport Faults extend from the Western Tiers to Lillicos Beach. The resultant first order structures have a pre-Tertiary relief of the order of 300 m. The eastern side of the graben is marked by a major fault extending the length of the Port Sorell estuary with a throw of about 200 m (Burns, 1964 p. 201), and in an *en echelon* fashion continues south-east through Sassafras and West Frankford.

The eastern half of the Devonport – Port Sorell – Sassafras area, south of Port Sorell, was extensively drilled for oil in the 1920s and 1960s. As a result, the Tertiary sequence occupying the first order graben is now well established. More recently, regional gravity surveys (fig. 3) using oil bore logs for control and correlation, have delineated the second order structural features of the area, defined by Cromer (1977*a*) as the Wesley Vale, Port Sorell and Sassafras Basins. Cromer (1989) grouped these into the Devonport – Port Sorell sub-basin, a continental fracture related to the offshore Bass Basin.

Tertiary stratigraphy

The Tertiary stratigraphy of the area is summarised in Table 3 from Cromer (1989), slightly modified to incorporate Baillie's (1986) radiometric dating of the Moriarty basalt. The succession has been formally defined by Burns (1964).

Table 3. STRATIGRAPHIC SUMMARY, DEVONPORT – PORT SORELL – SASSAFRAS AREA

Formation	Approx. maximum thickness *(m)*	Description	Age
Harford Beds (Th)	>250	Carbonaceous claystone, fine sandstone, mudstone lignite, minor conglomerate. Lacustrine, fluviatile	Palaeocene – Early Eocene
Thirlstane Basalt (Tt)	175	Basin infill of subaerial to locally aquagene alkali- olivine basalt	(?)Middle Eocene – (?)Early Oligocene
Wesley Vale Sand (Tw)	75	Mainly weakly consolidated sandstone, claystone, mudstone; minor conglomerate, volcaniclastics; fluviatile to lacustrine	Early Oligocene – Late Oligocene
Moriarty Basalt (Tm)	50	Lead and plateau capping of subaerial to locally aquagene alkali-olivine basalt	(?)Late Oligocene – Miocene

The Tertiary rocks are at least 350 m and possibly 500 m thick, occupying a 200 km^2 basin between Devonport and Port Sorell, and extending south to the Bass Highway. The Harford Beds are not exposed but extend to at least 300 m below present sea level. Drill core from near the base of the Beds contains Palaeocene *Lygistepollenites balmei* Zone assemblages (S. M. Forsyth, pers comm., in Cromer, 1980), and core from near the top contains Eocene (probably Early Eocene) assemblages.

The Thirlstane Basalt is a repetitious accumulation of thin, subaerial and possibly in part aquagene flows of olivine basalt, locally strongly zeolitised and vuggy. Diamond drill core from 100 m above its base gave a Late Eocene K-Ar age of 38 Ma (Cromer, 1980). The basalt extends to at least 100 m below present sea level and is largely unexposed. The Wesley Vale Sand contains microflora belonging to the Early Oligocene – Early Miocene *Proteacidites tuberculatus* Zone (Cromer, 1980) supporting a previously published Late Oligocene age (Cookson in Burns 1964).

The Moriarty Basalt forms shallow leads and thin plateau cappings over the Wesley Vale Sand. Its almost completely weathered nature indicated at least a Miocene age to Sutherland (1969); who later (1980) suggested parts of it were aquagene.

Cromer (1989) inferred a Miocene age for the formation. Baillie (1986) obtained a K-Ar date of 26 My for basalt from a road-cutting near Sassafras, thus establishing a Late Oligocene age for at least part of the Moriarty Basalt.

No detailed stratigraphic, petrological or palynological work has been done on the Tertiary succession.

The Tertiary rocks are underlain and bounded by older rocks, principally Jurassic dolerite and Permian sediments, which crop out or are shallowly buried along basin margins. Thus, the Wesley Vale Basin (which may be more than 500 m deep) is bounded by dolerite and Permian rocks on Staggs Hill along its south-western side, and by the dolerite of Horseshoe Reef along the coast. Its eastern limit is the N-S line of partly exposed dolerite horsts extending from west of Port Sorell south to Thirlstane. This dolerite also marks the western boundary of the Port Sorell Basin (>300 m deep), which in turn is bounded by dolerite along its eastern edge. The southern

Plate 1. Looking north-west from the Port Sorell estuary towards Wesley Vale and Northdown.

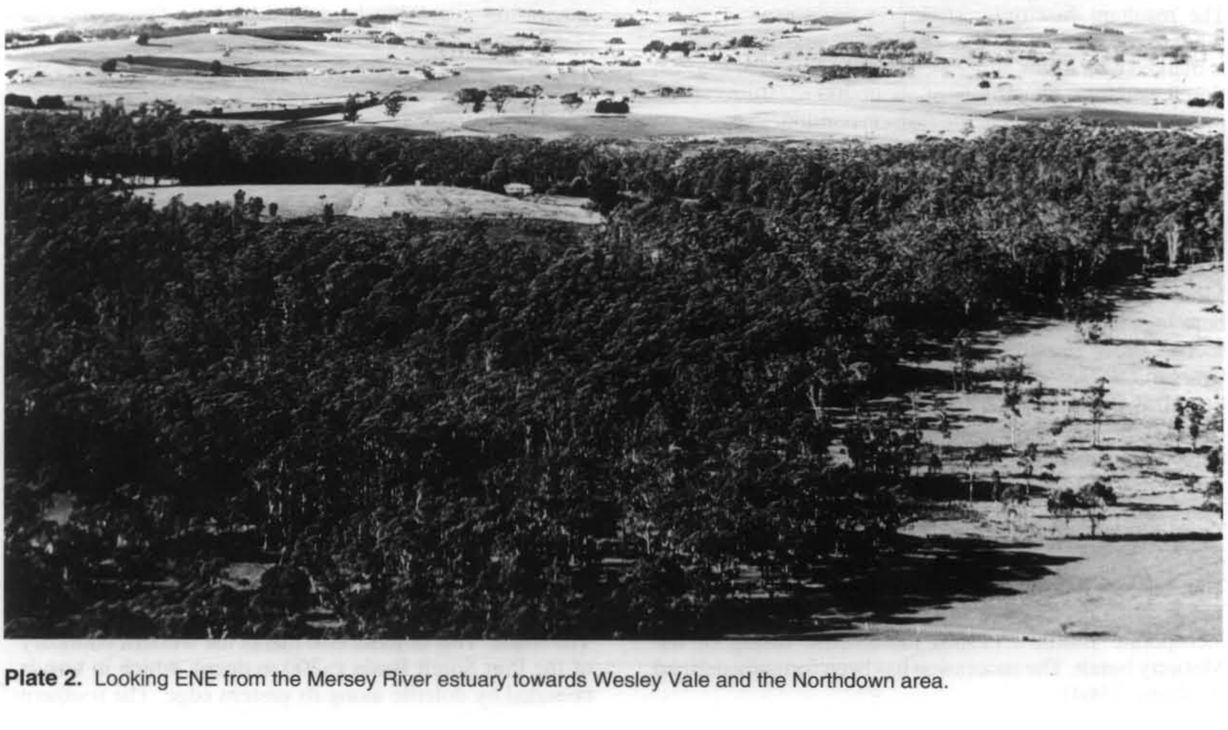


Plate 2. Looking ENE from the Mersey River estuary towards Wesley Vale and the Northdown area.

Plate 3. Looking west from the Rubicon River towards the Wesley Vale Basin.

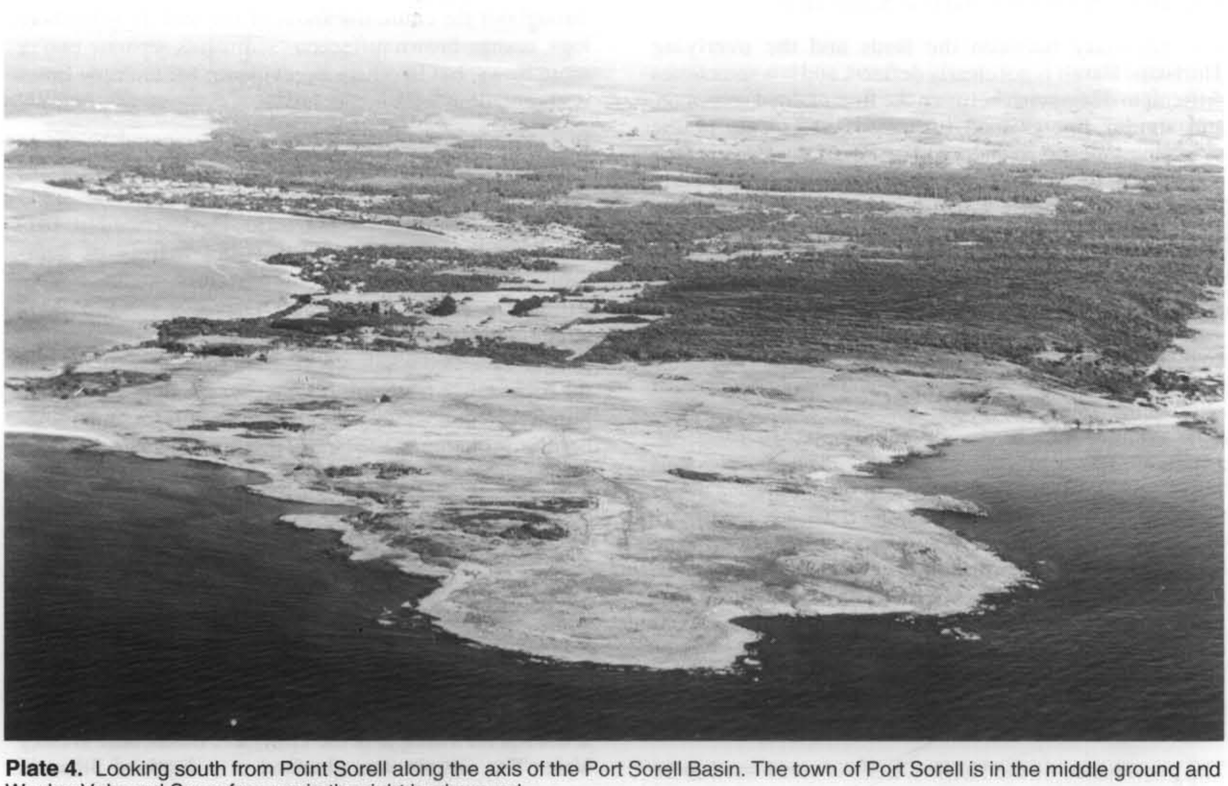


Plate 4. Looking south from Point Sorell along the axis of the Port Sorell Basin. The town of Port Sorell is in the middle ground and Wesley Vale and Sassafras are in the right background.

limit of the Sassafras Basin (>300 m deep) is near the Bass Highway, where dolerite and Permian sediments are exposed in the escarpment south of the road. The Sassafras Basin is separated from the other two basins by low buried dolerite saddles about 5–6 km north of Sassafras.

Permian rocks underlie the plateau basalts at Sassafras, and probably form parts of the basement beneath the Wesley Vale and Sassafras Basins. Indurated mudstone of probable Permian age was intersected in the 1928 Northdown Foreshore oil bore [DQ582448] at relatively shallow depth (Burns, 1963*a*; detailed log unknown). Similar material was recovered from 15 m in a water bore [DQ615431] drilled at the Shearwater Country Club at Port Sorell (Cromer, 1974).

HARFORD BEDS

The Harford Beds (Burns, 1964) are defined as those clay, gravel and mudstone deposits intersected in Parson's Bore [DQ605358] (fig. 4, collar elevation 73 m) between 116 m and 351 m where they overlie Jurassic dolerite and are in turn overlain by the Thirlstane Basalt.

The Beds do not crop out, but their occurrence in the neighbouring Wesley Vale and Sassafras Basins has been established by deep drilling. Monotonous sequences of fine grained sediments – correlated with the Harford Beds, and presumably contemporaneous with them – were intersected in all deep stratigraphic holes drilled during the present investigations.

The Beds are predominantly composed of pink-buff, partly consolidated and commonly finely laminated mudstone. Fissile carbonaceous and rarely, bituminous, horizons containing abundant plant impressions occur at all levels in the sequence. Minor lithological variations include fine sand, quartz gravel and grit, partly cemented mudstone, lignite and rare vivianite nodules and horizons.

The Harford Beds attain their greatest thickness near the centres of the three basins in the area, and they thin rapidly toward structural margins. Thus, they are deepest and thickest north of Harford, beneath the township of Wesley Vale, and about 4 km north of Sassafras. They are absent beneath the Northdown and Port Sorell areas.

The boundary between the Beds and the overlying Thirlstane Basalt is not clearly defined, and it is sometimes difficult to distinguish between the fine-grained sequence, and similar fine-grained tuffaceous sediments of the overlying volcanic sequence. The top of the Beds is thus considered to be the first occurrence of conclusively volcanic material. Lithologies at the top vary considerably: in places grey clayey quartz gravel occurs beneath volcanic material; in others, the transition is marked by volcanic breccias and fine-grained tuffaceous sandstone. Plant roots occur at the top of the Harford Beds.

Deposition of the Harford Beds probably accompanied basin subsidence but started later than the Late Cretaceous sedimentation in the adjacent Tamar Graben (S. Forsyth, pers. comm.) and Boobyalla sub-basin (Moore *et. al.* 1984). Gravity data (fig. 3) suggest the Devonport – Port Sorell sub-basin was land-locked, or did not have a major outlet at the time, and the Harford Beds are apparently devoid of marine intercalations. The Beds appear to have been deposited on a surface of uneven but subdued relief. A low-energy environment from the onset of deposition is indicated by fine-grained sediments containing plant impressions resting directly on Jurassic dolerite. Minor altercations of coarser material representing higher energy phases probably represent activation of bounding fault margins.

The provenance of the Harford Beds is considered to be mainly the Palaeozoic sediments south of Sassafras.

THIRLSTANE BASALT

The Thirlstane Basalt is defined by Burns (1964, p. 117) as that basalt intersected in Parsons' Bore [DQ605359] between 18.3 m and 116 m. The maximum thickness (168 m) established by drilling is in Burgess' bore [DQ608343]. From these occurrences in the Port Sorell Basin, Burns correlated basalt in the Wesley Vale Basin with the Thirlstane Basalt. Basalt outcrops in the East Devonport area he left undifferentiated. Since 1965, the Thirlstane Basalt and rocks correlated with it have been intersected in many water bores and deep stratigraphic holes. From these, and resultant geological cross-sections, it has been found possible to assign all basalt in the district to either the Thirlstane or Moriarty Basalt and most of Burns' original correlations have been shown to be consistent. The basalts at East Devonport are here assigned to the Thirlstane Basalt.

The Thirlstane Basalt is a thick, widely distributed and hydrologically significant unit. Morphologically, it is a lens-shaped body formed from ponding of lava flows which interrupted sedimentation of the Harford Beds in the Wesley Vale, Port Sorell and Sassafras Basins. Accordingly it is thickest near the basin centres (about 180 m beneath the Northdown area in the Wesley Vale Basin, and probably 170 m near Harford in the Port Sorell Basin), and thinnest where it drapes over buried margins (e.g. <20 m in the Thirlstane area) or overtops the basins on gently rising basement rocks (e.g. East Devonport). Near fault-controlled and steeper basin margins (e.g. along the north-eastern and eastern edges of the Port Sorell and Wesley Vale Basins) it thins abruptly over short distances. Generally, the top of the unit rises gently inland towards Sassafras. The morphology of the Thirlstane Basalt has important implications for water bore siting since it is the most reliable aquifer in the district.

In core from diamond drill holes, the Thirlstane Basalt displays a characteristic gross texture: a monotonous, rhythmic alternating succession of (*a*) massive, hard, non-vesicular to slightly vesicular basalt, and (*b*) highly vesicular and amygdaloidal, in places deeply weathered, basalt. This regular banding, in zones 1–2 m thick, extends throughout the entire thickness of the unit. In some bore logs, orange-brown tuffaceous sediments separate two or more flows, but in others the evidence for multiple flows is absent, or at least inconclusive.

In a comparative discussion of Tasmanian and Victorian volcanism, Sutherland (1969) briefly described the basalts in the Northdown area and correlated them with other northern Tasmanian volcanic rocks. He described (p. 181) the Thirlstane Basalt as consisting mainly of near-saturated olivine basalt. In thin section, samples from Findlay's [DQ543400] and Oliver's [DQ585327] stratigraphic bores (Appendix 1) range from unsaturated to near-saturated alkali olivine basalt varieties. In general the rocks range from non-porphyritic and intergranular, to porphyritic and amygdaloidal with intergranular-sub-ophitic groundmasses. Grain size ranges from fine and glassy to coarse. The mineralogy is relatively constant, with phenocrysts of olivine (sometimes chloritised and iddingsitised), clinopyroxene and plagioclase in an intergranular to sub-ophitic groundmass of clino-pyroxene, plagioclase (andesine-oligoclase), opaque oxide and interstitial K-feldspar and feldspathoid. In Findlay's bore between 149 and 165 m, the Thirlstane Basalt consists of tuffaceous sediments and agglomerate.

Cromer (1980) reported a whole-rock K-Ar date of 38.1 ± 0.6 Ma for a sample of the Thirlstane Basalt near Wesley Vale. The sample was obtained at a depth of 58 m in Findlay's Bore (fig. 4, [DQ543400]).

WESLEY VALE SAND

The Wesley Vale Sand is a generally thin unit exhumed by erosion of the overlying Moriarty Basalt and cropping out extensively in the district. Burns (1964, p. 119) defined it on the basis of sand and partly consolidated sandstone underlying the Moriarty Basalt on the hillsides west of Moriarty. The unit is 82 m thick on the coastal escarpment south of Moorlands Point, where according to Burns the succession contains clay, sand, basalt and tuffaceous sediments. At Parkers Ford, where sediments overlie the Thirlstane Basalt, Burns (p. 119) correlated 46 m of sand, blue clay, lignite and tuff with the Wesley Vale Sand.

Around the edges of basins, where dolerite basement was exposed during sedimentation, the Wesley Vale Sand is predominantly composed of partly consolidated siliceous conglomerate, friable gravel, poorly sorted gravelly sand and sand. Finer grained sediments are subordinate. Towards basin centres the proportion of silt and clay increases, and the unit in some areas is composed entirely of clay.

At Oppenheim Hill on the Bass Highway [DQ553332] a 4–5 m section of Wesley Vale Sand underlying 4 m of Moriarty Basalt (plate 7) has been exposed in a 400 m road cutting. The sediments consist of yellow, cream and orange clayey sand with abundant quartzite gravel horizons and interbedded mottled blue-red clay horizons, Cross-bedding is common, and generally the grain size of the material, and the proportion of gravel, decreases from the south-east to the north-west along the cutting. At the extreme south-eastern end, *in situ* extremely weathered and fractured dolerite is apparently faulted against the sediments. Only minor movement is indicated, but the contact suggests post-Wesley Vale Sand faulting along basin margins. Adjacent to the contact, and overlain by the sand, is a large fractured mass of pink-cream and red-purple clay with rare quartzite pebbles. Its contact with the sediments is irregular, and bedding in the Wesley Vale Sand drapes over the clay. Isolated boulders of similar clay occur elsewhere in the section and it is evident they represent extremely weathered and partly transported doleritic material probably deposited along a stream channel and then buried by the Wesley Vale Sand.

In some localities at least, the Wesley Vale Sand was partly eroded before eruption of the Moriarty Basalt. Fractured Wesley Vale Sand infilled with red-brown tuffaceous(?) clay, and scoured depressions containing red-brown sandy clay and quartzite gravel lenses indicate the upper surface of the unit was alternately exposed to sub-aerial and sub-aqueous environments before and during volcanism. Towards the south-eastern end of the Oppenheim Hill exposure, the Moriarty Basalt is extremely and spheroidally weathered with occasional fresher centres of hard, vesicular basalt. The proportion of basalt decreases to the north-west and is successively replaced by mottled granular basaltic clay, and finally red-brown tuffaceous clay and sandy clay overlain by grey-brown sandy silt. Volcanic material was apparently deposited sub-aerially near the middle of the exposure, and sub-aqueously, in a shallow basin at the north-western end.

The upper 20 m of Wesley Vale Sand is also exposed in a gravel pit and adjacent road cuttings and culverts on the Bass Highway 2 km south-east of Oppenheim Hill. In the road cuttings [DQ562313] weathered Moriarty Basalt overlies sediments but the actual contact is not exposed. The top of the Wesley Vale Sand is probably represented by a 2 m thick bed of clayey quartzite gravel and sand, which underlies about 4 m of red-brown mottled tuffaceous? clay, and grey-brown clayey silt containing pisolitic ironstone concretions and bands. Beneath the gravel bed at least 15 m of mottled white-grey and pink-red clay are exposed in a culvert. A similar sequence is exposed in a nearby gravel pit [DQ562319] where about 6–8 m of cross-bedded quartzite gravel, coarse sand, and silty sand dipping 5–10°NW overlie sub-horizontal clay and sandy clay.

In a gravel pit near the Sassafras–Harford Road [DQ594327] the Moriarty Basalt and Wesley Vale Sand are exposed in a 4–5 m section, 40 m long. The basalt is represented by dark brown to red-brown tuffaceous clay containing fresh basalt cobbles and minor sand and gravel lenses. In some parts of the section the top of the Wesley Vale Sand is represented by stiff blue clay, but the succession is predominantly composed of interbedded and lensing cross-bedded units of partly consolidated conglomerate and coarse sand. The conglomerate consists of angular quartzite grains up to 3–4 mm in diameter, but some lenses are composed mainly of larger pebbles up to 20 mm in diameter. Invariably, the larger quartzite grains are well-rounded. Clay pellets and lenses are common in the conglomerate horizons. The contact between the sediments and the volcanic material is irregular, and the sediments were scoured and eroded as volcanism interrupted sedimentation.

The base of the Wesley Vale Sand and its contact with the underlying Thirlstane Basalt is exposed on the Harford Road near the 'Tullamona' homestead [DQ596348]. The basalt is extremely and spheroidally weathered to orange-brown clay with fresher basalt centres. The contact is apparently horizontal or gently dipping. The sub-horizontal Wesley Vale Sand is represented, from the base upwards, by one metre of stiff, mottled grey-blue and red-brown clay which may represent extremely weathered and partly transported basaltic material; 0.2 m of red-brown and grey-orange silty sand; 2 m of consolidated, poorly sorted, in places iron-stained and cemented medium- to coarse-grained sandstone, containing gravel lenses, and grading down to conglomerate (plate 5) containing pebbles up to 40 mm of quartzite, quartz, sheared quartzite, sandstone and clay;

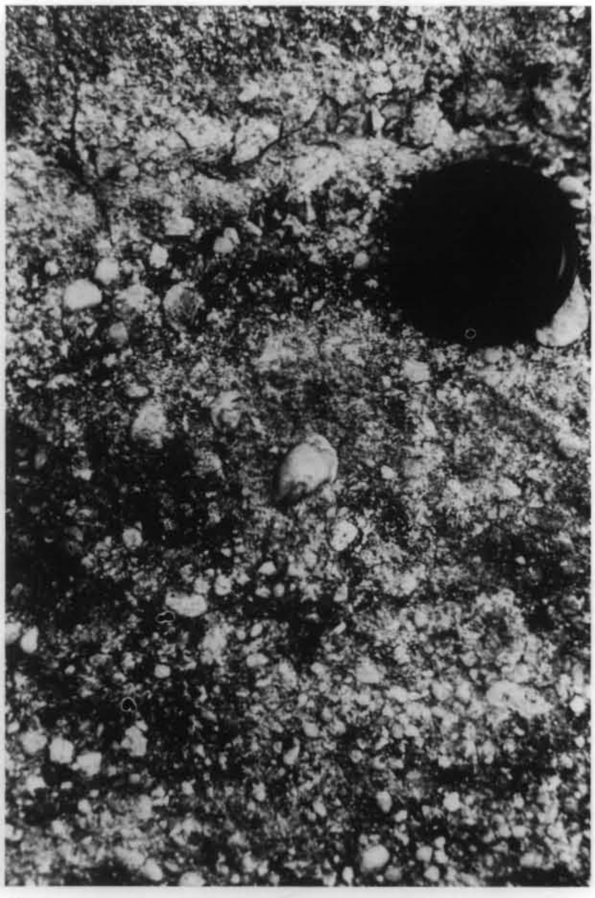


Plate 5. Detail of conglomerate unit in the Wesley Vale Sand on the Harford Road [DQ605247].

5 cm

Plate 6. Weathered Thirlstane Basalt in a cutting on the Bass Highway.

5 cm

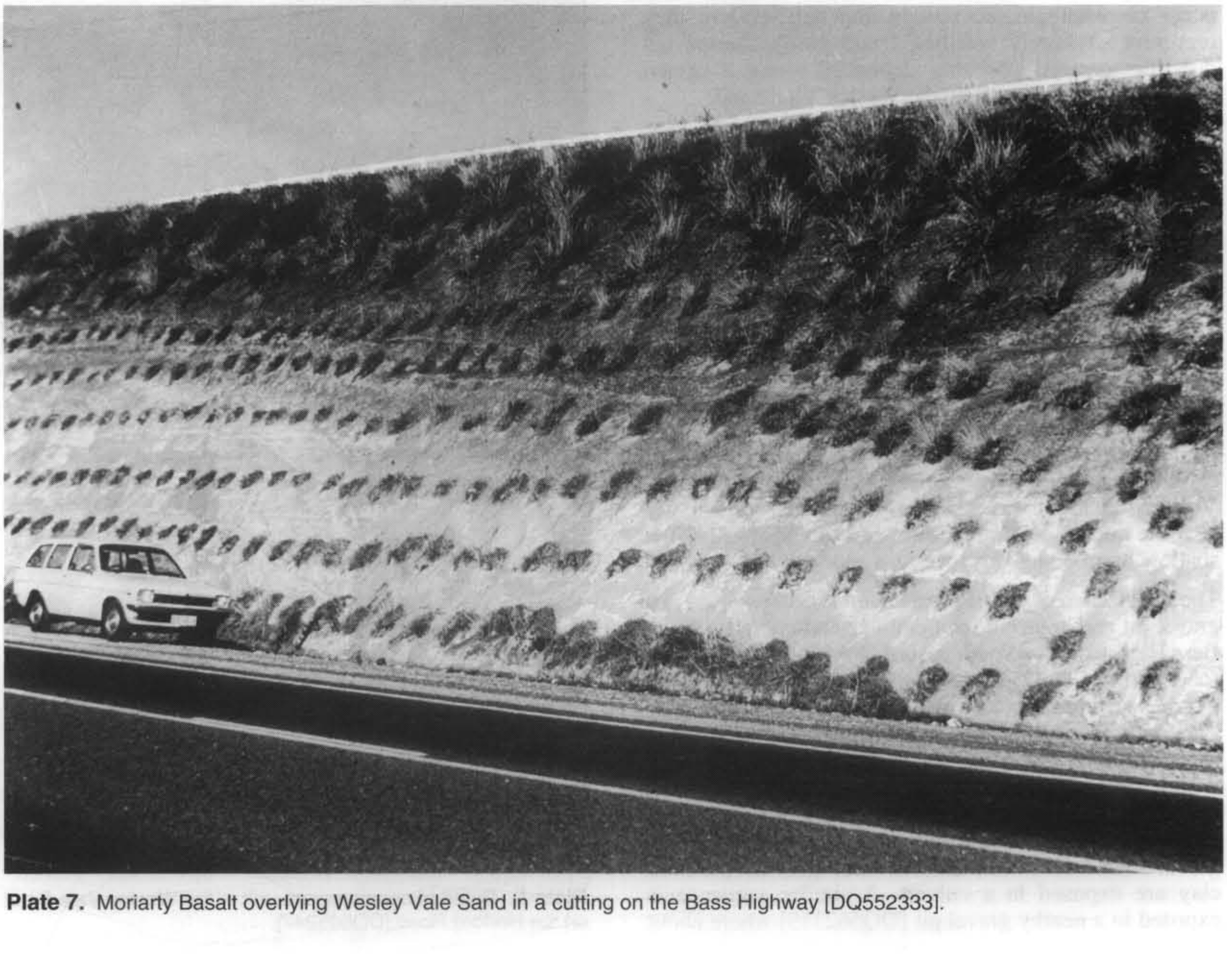


Plate 7. Moriarty Basalt overlying Wesley Vale Sand in a cutting on the Bass Highway [DQ552333].

one metre of mottled orange-brown and grey silty sand and sandy silt with some clay lenses and quartzite pebbles; one metre of orange-brown silty clay with some quartzite pebbles; and at the top, 0.5 m of grey-brown pebbly silty soil.

The Wesley Vale Sand overlies dolerite in a cutting on the Frankford Highway near the Rubicon River on the eastern edge of the Port Sorell Basin [DQ629347]. The dolerite is weathered to red-brown clay with fresh boulders. Adjacent to the contact, the Wesley Vale Sand is composed of brown gravelly silt with ironstone and iron-cemented quartzite cobbles, dipping about 10°N, over orange-brown quartzite gravel, poorly cemented conglomerate and coarse-grained quartz sand. About 6 m of sediments stratigraphically underlying this material are exposed in a gravel pit immediately below the road cutting on the old gravel road [DQ629350]. The bottom unit in the quarry is a one metre-thick bed of pink, grey, blue and orange-brown fine silty sand apparently dipping 5–10°E. Its top is truncated by a 2–3 m thick lensing bed of cross-bedded poorly cemented conglomerate and coarse sand dipping 10°W. Clay pellets, grains and lenses are common. Overlying this unit is a thin bed of blue-grey fine sand and clay, which in turn underlies 1–2 m of yellow-brown poorly sorted quartz sand.

The Wesley Vale Sand overlies dolerite in a road cutting at [DQ569321] where about 5 m of sand (with quartzite gravel lenses and clay pellet horizons) and laminated sandy silt are exposed adjacent to strongly fractured and extremely weathered dolerite. The contact is not exposed, but bedding in the sediments dips 10°S. These sediments were described as Quaternary by previous workers, but they are lithologically similar to the Wesley Vale Sand.

It is clear from bore log information and exposures throughout the district that the Wesley Vale Sand is an extensive, but generally thin, interbasaltic deposit of sand, gravel and clay which initially accumulated contemporaneously with the later stages of the Thirlstane Basalt. Its formation was apparently interrupted by extrusion of the overlying Moriarty Basalt, and much of the clay and clayey sand in the sequence is either tuffaceous or derived from weathering of the Thirlstane Basalt. A youthful dissected surface probably developed rapidly on the basalt, and in places the Wesley Vale Sand formed shallow lead systems where it was superimposed on the underlying drainage system.

The Wesley Vale Sand apparently does not contain marine intercalations and it may be a proximal, non-marine equivalent of parts of the shallow marine Torquay Group in the off-shore Bass Basin (Cromer, 1989).

Cookson (in Burns, 1964, p.119) reported a probable Late Oligocene age for microflora in lignite near the base of the Wesley Vale Sand at Parkers Ford. Harris (1968) obtained a mid-Tertiary age for similar sediments of the same locality. Forsyth (in Cromer, 1980) showed that microfloras in the Wesley Vale Sand at 59 m in Wilson's Bore [DQ563407] belong to the *Proteacidites tuberculatus* Zone and are Early Oligocene–Early Miocene (probably Late Oligocene).

The Wesley Vale Sand thus probably ranges from Early to Late Oligocene.

MORIARTY BASALT

Burns (1965) defined the Moriarty Basalt as that basalt overlying the Wesley Vale Sand and cropping out on the hillsides west of Moriarty. The unit occurs extensively in the Northdown area where it is up to 50 m thick, forming a deeply and sometimes entirely weathered plateau basalt. Outcrops of fresh basalt are rare; boulders are sometimes encountered during drilling but is usual in this area for the basalt to be completely weathered to red-brown and grey-brown mottled clay.

The plateau basalts in the Sassafras area, which are up to 50 m thick and are also extensively weathered, are correlated on the basis of drilling logs and geological cross-sections with the Moriarty Basalt. These larger areas of basalt, and isolated remnants elsewhere in the district, are the remains of an originally more extensive lava sheet which probably covered much of the area. The unit has since been largely dissected to reveal both the underlying Wesley Vale Sand and the Thirlstane Basalt.

A rare occurrence of fresh basalt interpreted as part of the Moriarty Basalt crops out in a road cutting [DQ585287] 50 m north of the Bass Highway at Sassafras. The rock is porphyritic olivine basalt with olivine phenocrysts in a groundmass of plagioclase, pyroxene and iron oxides. A whole-rock K-Ar radiometric age of 25.9 ± 0.2 Ma has been established by Baillie (1986). The Moriarty Basalt is therefore, at least in part, Late Oligocene in age.

Quaternary and Recent sediments

Quaternary sand, clay, gravel and boulders underlie the gently sloping marine platform extending from Devonport to Port Sorell, and deposits of probable Quaternary age occur along the Port Sorell estuary. Sediments containing Quaternary and Recent microflora were obtained from the top few metres of Oliver's Bore [DQ585327] on Westford Creek (S. M. Forsyth, pers. comm.) and thin deposits of similar age probably occur along most of the creeks and rivulets in the district.

Sediments of Recent origin are mainly confined to coastal sand dunes and beach deposits. Threader (1974) reported on the occurrence and nature of beach shingle along Northdown, Pardoe and Moorlands Beaches.

REGIONAL GROUNDWATER HYDROLOGY

Definitions

Almost all groundwater is derived directly or indirectly from precipitation, a proportion of which (after surface runoff and evaporation) infiltrates the soil as subsurface water. Some of the subsurface water is removed by plants during transpiration, some is drawn upwards by capillary action and evaporated, and some is retained indefinitely in microscopic voids in the soil profile. During and after continuous and wetting rain, the remainder infiltrates downwards, intermittently and successively saturating the material through which it passes until the water reaches the *zone of saturation* where the soil or rock voids are completely filled with water. The water is then called *groundwater*, and the upper surface of the zone of saturation is known as the *water table*. The proportion of rain infiltrating the soil is very variable, ranging from perhaps a few percent on steep rocky slopes to about 30–50% in sandy or gravelly areas with internal drainage and little surface runoff. Groundwater is therefore a part of the general hydrological cycle, and as such is directly related to the surface movement of water.

Groundwater in permeable rocks is rarely static, moving in response to gravity and hydrostatic and lithostatic pressure from recharge to discharge points. Discharge occurs wherever the water table intersects the land surface in springs, swamps, rivers and the sea. Depending on the relative portions of water levels in creeks and rivers and the water table in adjacent rocks, streams flowing through permeable rocks may in turn receive water from (effluent stream) or leak water to (influent) the aquifer.

Groundwater movement is controlled by the permeability of the aquifer and the slope on the water table. Rates range from as low as a few millimetres a day in fine-grained sediments to velocities measured in kilometres per hour in cavernous limestones and some porous basalts.

An *aquifer* is a body of rock, or series of rocks, capable of supplying useful quantities of water. The term is therefore relative, and an aquifer capable of yielding only small amounts of water for domestic use may not be classed as such by (say) a municipal authority needing town supplies.

An aquifer has two major hydrological functions. It *stores* and *transmits* water, and the nature of each rock type determines the relative importance of each function. Some rocks (e.g. fractured cemented sandstone) store only small amounts of water but transmit it freely, and are reliable aquifers, because of the interconnecting arrangement of water-filled joints. Conversely, some fine-grained porous rocks (e.g. clay) may be capable of large storage but only small yield because water is not transmitted easily through their microscopic voids.

Aquifers are of two main types. A *water table* (or *unconfined aquifer*) occurs in unconsolidated sediments (sand, gravel), fractured rocks (e.g. dolerite or hard sandstone and mudstone) or weathered rocks (e.g. basalt) where the water table is a free surface in contact with the atmosphere at atmospheric pressure. Water held by capillary action in the partly saturated zone above the water table may be at pressures less than atmospheric. The pressure of water at any point below the water table in an unconfined aquifer is a result only of the vertical distance from the water table to the point in question. Groundwater in a bore tapping an unconfined aquifer remains in the bore at the level of the water table.

The water table is not a stationary surface, although in general it is itself a subdued replica of the overlying topography. Its movement is a result of the recharge-discharge balance. It periodically rises in response to vertical infiltration during wet periods, and falls during dry periods as previously stored water is discharged under the influence of gravity to lakes, streams, springs and the sea, or is pumped from bores or wells.

Examples of unconfined aquifers in the Devonport–Port Sorell–Sassafras area include the coastal sand deposits near Port Sorell and Devonport Airport, much of the deeply weathered Moriarty Basalt at Northdown and Sassafras, and probably parts of the Wesley Vale Sand.

Perched water table conditions may exist where restricted layers of more impermeable material (e.g. clay) occur in unconfined aquifers. The layers create a zone of saturation within the zone of aeration by locally preventing the continued downward percolation of water to the main aquifer below.

If an aquifer is bounded above and below by relatively impermeable materials, it is said to be *artesian* or *confined*. The aquifer receives water not by direct infiltration from above, but from a recharge area elsewhere, where the permeable zone is exposed at the land surface, and where at least local water table or unconfined conditions exist.

The water in confined aquifers is not in contact with the atmosphere, and therefore by definition a water table does not exist. The groundwater is at a pressure greater than atmospheric, since it is subject to both a hydrostatic pressure (represented by the difference in head between the recharge area and any point in the aquifer) and a lithostatic pressure (caused by the weight of the overlying confining rocks). Water in bores tapping confined aquifers therefore rises up the bore to a level higher than that at which it was first encountered. The bore is termed an *artesian bore* when water flows at the surface, and the final water level is known as the *potentiometric level*. The imaginary surface represented by the piezometric levels of all points in the aquifer is called the *potentiometric surface*, and is analogous to the water table surface in unconfined aquifers. The potentiometric surface in some confined aquifers may lie above the land surface, and water discharges freely from *flowing artesian bores* drilled into them.

The ability of an aquifer to transmit water is described by its transmissivity (T), the rate of which water passes through a unit width of the aquifer under a unit hydraulic gradient. It is measured in cubic metres per day per metre (m^3/day/m, usually written as square metres per day, m^2/day). Values of T from Tasmanian rocks vary from as low as one m^2/day in fine-grained clayey sediments, or relatively unjointed hard fine rocks, to over 1000 m^2/day in such high yielding aquifers as loose gravel, strongly fractured rocks, cavernous limestone or some basalts.

The ability of an aquifer to store water is described by its *storage coefficient* (S) which is the volume of water it releases (or takes into storage) per unit surface area per unit charge of hydraulic head. The term is only strictly applicable to confined aquifers, where water derived from storage comes from a slight compression of the aquifer and a simultaneous and smaller expansion of the water. Values of S for confined aquifers are often in the range 10^{-5}–10^{-1}. In unconfined aquifers these factors are negligible compared with the much larger volume of water obtained from simple gravity drainage of the material. Storage is then described by an analogous term, *specific yield*, which is the ratio of the volume of water supplied by gravity drainage to the total volume of material affected by pumping. In most unconfined aquifers, gravity drainage is incomplete to varying degrees, and the portion of water remaining is known as the *specific retention*. Specific yield plus specific retention is equivalent to *porosity*, the percentage of open voids in the unconfined aquifer. Specific yields for unconfined aquifers range from 10^{-2}–0.35.

Both the transmissivity and storage coefficient are related to porosity. The higher the porosity, the greater will be the ability of the aquifer to store water; the better the interconnection of the voids, the higher the permeability. Voids in rocks may be of any size, but there is a lower void size limit below which free motion of water is greatly inhibited. If the voids are microscopic (for example, subcapillary openings in clay), molecular attraction exceeds gravitational force, and any water present is retained indefinitely in them.

Voids in rocks include intergranular openings in uncemented sediments, microscopic intercrystal and intracrystal openings in crystalline rocks (e.g. dolerite), larger pores such as vesicles, holes or tubes (e.g. basalt), solution cavities, openings and caverns (e.g. limestone), and planar fractures such as joints and faults of all sizes and arrangements in all types of competent consolidated rocks. Voids are classified either as *primary* or *secondary* depending on whether they are formed at the same time as the rock (e.g. intergranular openings, vesicles) or later during its subsequent history (e.g. fractures, solution openings).

Rock units and their hydrological properties

MORIARTY AND THIRLSTANE BASALT

Basalts in general are among the most productive of aquifers because of their often well-developed and interconnected (primary) voids. In the Devonport–Port Sorell–Sassafras area the Moriarty and Thirlstane Basalts are the most reliable sources of groundwater, although the primary porosity of the former is often reduced by deep weathering.

The hydrological characteristics of basalts depend on the nature of the original lava flows. Some lavas may be highly gaseous, producing basalts which are scoriaceous and vesicular, often with interconnected voids. Other less gaseous lavas solidify to massive, non-vesicular basalt. Extremes of vesicularity may occur over quite small distances, so that permeability varies not only between different flows (many of which may be superimposed on each other to great depths), but also within individual flows. Often, the upper and lower parts of flows are less porous than the centres, or the reverse may be the case, so that horizontal permeabilities may differ markedly from vertical permeabilities. Accordingly, downward percolation of water from one porous zone to another is inhibited, and some saturated horizons in basalts may be artesian, with large pressure differences between superimposed layers.

Older basalts are generally poorer aquifers than younger ones, since in the former many initial openings in the rocks have been filled with crystalline precipitates or weathering products. On the other hand, basalts exposed at the surface weather rapidly, producing deep soil profiles which may reduce permeability and infiltration relative to less weathered rock.

Many of these general comments of the hydrological properties of basalts apply to the Moriarty and Thirlstane Basalts. The Moriarty Basalt has been exposed to sub-aerial weathering for a considerable time and has been almost entirely weathered to red, brown and grey mottled clay to at least 70 m in places. Boulders of fresh basalt are sometimes encountered during drilling, and only in rare instances (e.g. near Sassafras at [DQ584289] and in road cuttings on the Bass Highway), does relatively hard basalt crop out. The effects of weathering have been to progressively decrease the water-yielding ability of the material, and because the decomposition of the basalt has proceeded to varying degrees throughout its outcrop area, the selection of successful bore sites is difficult.

The Thirlstane Basalt also exhibits variations in its gross texture, but to a lesser degree. Since the aquifer has largely been concealed beneath the Wesley Vale Sand, weathering is less advanced. In diamond drill cores, the rock shows a characteristic rhythmic banding of vesicular and non-vesicular horizons on a scale of 1–2 m, which is interpreted as evidence of multiple flows. The water is confined and under pressure, and some holes in the district are flowing artesian bores. In rare cases, bores penetrating the full thickness of the aquifer and intersecting both vesicular and non-vesicular horizons remained dry. Others drilled nearby were successful. Evidently the water-bearing horizons are restricted in some areas, and this may have long-term implications for high-yielding bores. In a road cutting on the Bass Highway [DQ540338] basalt correlated with the Thirlstane Basalt exhibits a wide range of textural variations from massive fresh basalt to very vesicular basalt. Two scoriaceous zones, roughly circular in shape and defined by concentric lineations, cut across the road and may represent infilled lava tubes. The exposure is a good example of the textural variations which may be expected elsewhere in the Thirlstane Basalt.

Non-vesicular, massive basalt has a low porosity. Values may be as low as 1 or 2 per cent. Vesicular varieties may exhibit porosities as high as 35%. Values of transmissivity correspondingly range from almost nil to about 3000 m^2/day. Accordingly, yields from bores in basalt are exceedingly variable. Some holes are dry in the Thirlstane Basalt, and most are dry in the Moriarty Basalt. The highest yielding bore in the area occurs in the Thirlstane Basalt, and is capable of pumping at least 1300*l*/min.

Detailed bore yields and success rates are discussed on page 23.

PUMP TESTING TO DETERMINE T AND S IN THE THIRLSTANE BASALT

During the course of regional groundwater investigations five water bores (1, 7, 15, 18, 20 in Figure 4 and Appendix 4) were pump tested to evaluate the hydrological properties of the Thirlstane Basalt. Results from each are summarised in Table 4. Calculated transmissivity in the basalt shows a wide range of values from 2.5–40 m^2/day. Only one value for storage coefficient (6×10^{-3}) was obtained. Because of the high relative use of the Thirlstane Basalt as a water-bearing body, the complicated nature of the saturated horizons in it and the small number of sampling points, the T and S values should be used with caution in predicting individual bore yields and overall aquifer storage. T values for a particular bore enable optimum yields to be calculated for each site but they should not be freely extended to other localities. Similarly, the single S value obtained is of limited use. It indicates that near bore 20, for example, a rise (or fall) of one metre in the potentiometric water level will result in the recharge (or discharge) of 6×10^{-3} m^3 of water for every square metre of aquifer. Applying this value of S to the entire surface area – about 100 km^2 or 10^8 m^2 – of the aquifer a one metre rise (or fall) in the potentiometric level is equivalent to an increase in storage (or discharge) of $10^8 \times (6 \text{ x } 10^{-3}) = 6 \times 10^5$ m^3 of water (about 130 million gallons). If the Thirlstane Basalt were a simple confined aquifer with a single potentiometric surface, a combined total yield of about 6×10^6 m^3 (1.3 thousand million gallons) would produce a 10 m fall in piezometric level over its entire area. However, the basalt does not constitute a simple system: it is composed of many superimposed saturated horizons, each with its separate potentiometric surface. Moreover, many zones are limited in the horizontal direction so that adjacent bores often intersect water-bearing zones at different and unpredictable depths. In some places the basalt or its weathering products are exposed at the surface, and here at least local unconfined (recharge) conditions may exist.

As an example of T and S calculations, the results of the constant discharge pump test on bore 20 are shown in Figure 8.

JURASSIC DOLERITE

Dolerite in an unweathered, unfractured state is a massive, crystalline and virtually impermeable rock. The primary porosity of the fresh material is low (less than one percent) and is the result of intercrystal and intracrystal cavities produced during cooling. However, dolerite may show shrinkage cracks near the body margins, which increases the primary porosity. Secondary porosity in dolerite results from fracturing caused by mechanical forces, and the hydrological properties of dolerite in general are largely a function of the size, frequency, interconnection and weathering characteristics of these fractures.

Results of drilling in dolerite (see page 24) are few for two reasons: firstly; the rock was considered too hard to drill with the early percussion rigs, and secondly, the few bores drilled in dolerite in recent years have almost all been failures. Values for T and S are therefore unknown but are probably similar to other fractured igneous rocks.

WESLEY VALE SAND

Unconsolidated sediments in general exhibit large variations in grain size, degree of compaction and sorting, and hence in porosity, permeability and storage capacity. Lithologies are often very complicated and may change abruptly over short horizontal distances (for example, see descriptions of Wesley Vale Sand on p. 13). As a result, porous and permeable zones may be limited in extent, and it is obviously unwise to extrapolate the results of pump testing too freely outside the area tested.

Generally, well-sorted sediments of all grain sizes exhibit the highest porosity (which may approach 50%) but porosity is reduced as the degree of sorting is reduced and voids are occupied by smaller or larger grains. Thus clayey sand is less porous than clay-free sand. Since permeability is related to the size and interconnection of spaces, pure sand and gravel are more permeable than fine sand and

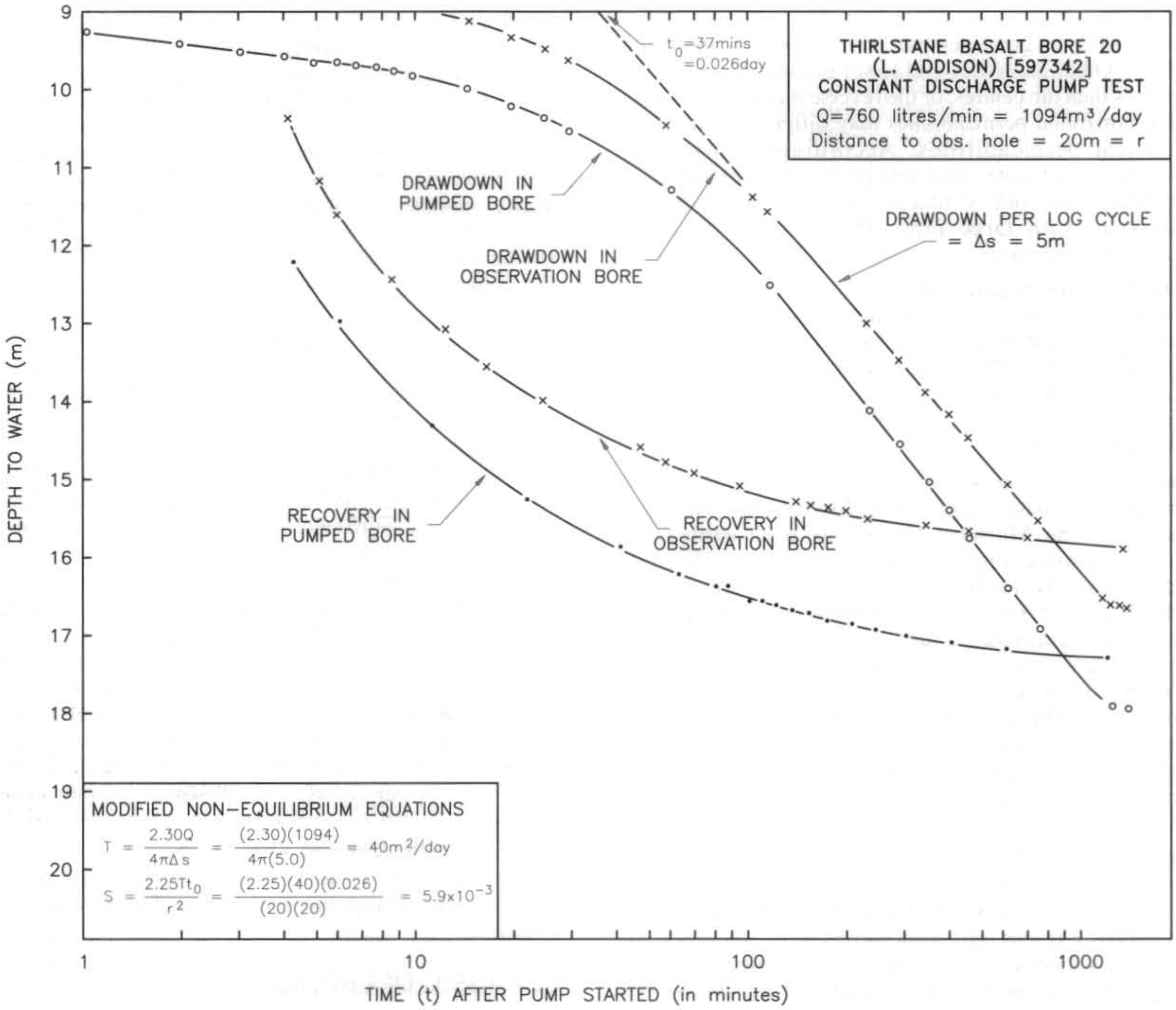


Figure 8. Constant discharge pump test, Thirlstane Basalt.

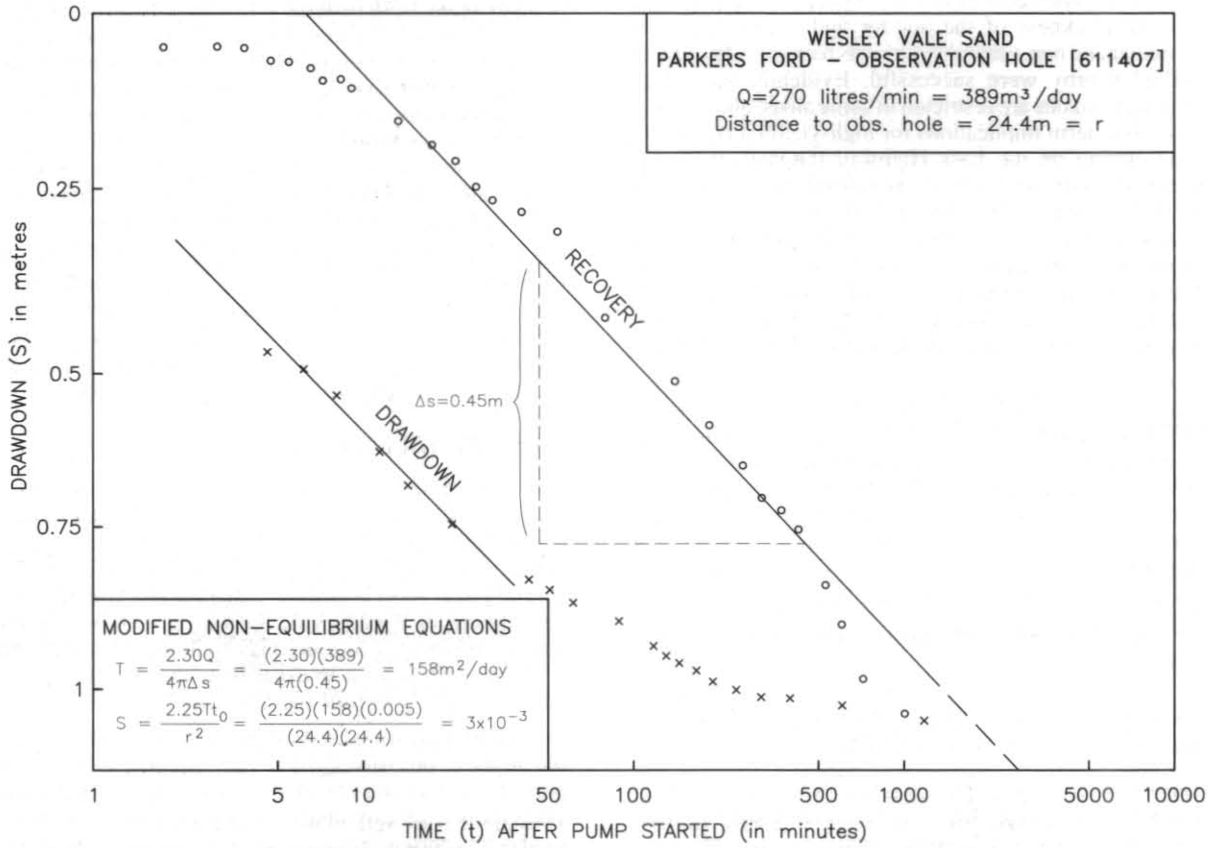


Figure 9. Constant discharge pump test, Wesley Vale Sand.

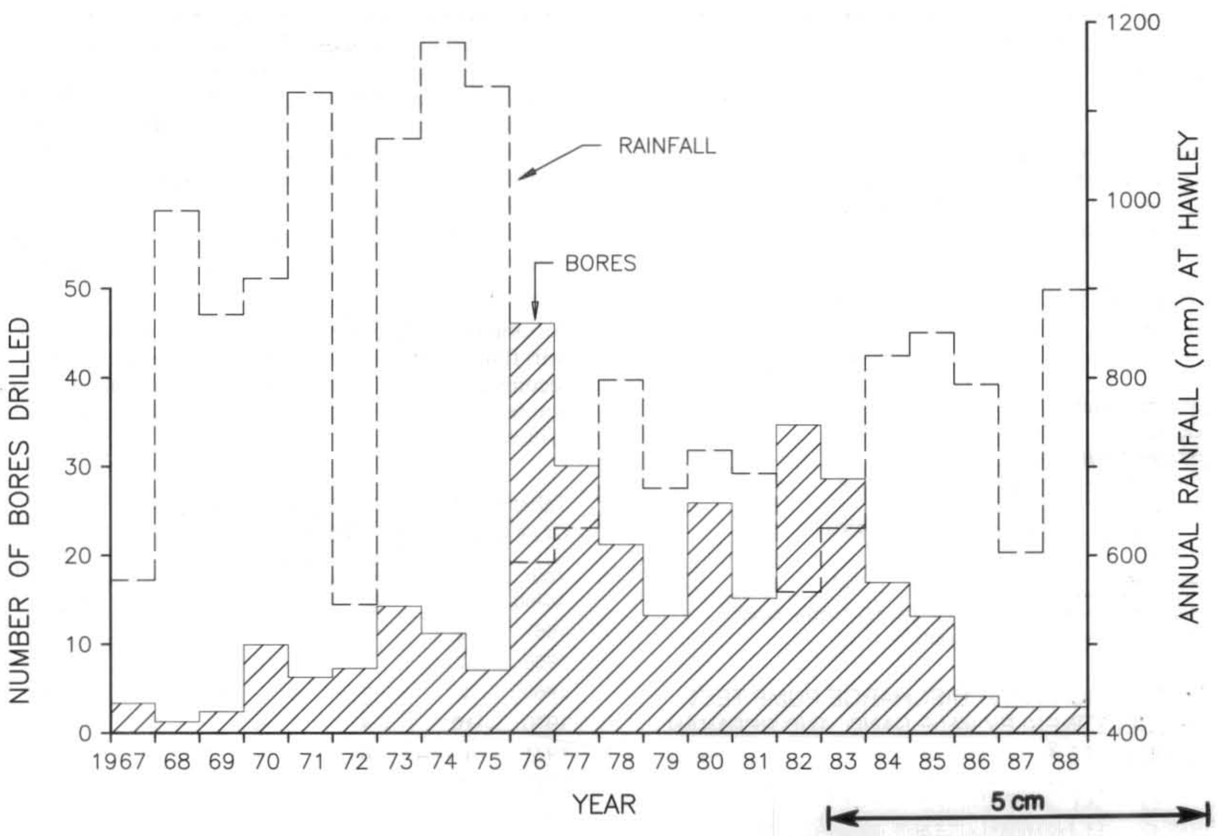


Figure 10. Water bore activity for the period 1967–1988 in the Devonport–Port Sorell–Sassafras area.

clay even though each rock type may show the same porosity.

Yields from bores in the Wesley Vale Sand vary considerably, and an analysis of drilling results is presented in Table 7.

PUMP TESTING TO DETERMINE T AND S IN THE WESLEY VALE SAND

Four holes were drilled and pump tested to evaluate the hydrological properties of the Wesley Vale Sand. The results (from bores 2, 3, 4 and 5, Figure 4 and Appendix 4) are summarised in Table 5. Transmissivity (T) varies considerably from bore to bore, and the range of values (1–158 m^2/day) reflects the high degree of lithological variation between sites, and at individual bore localities. The values for S ($5.8 \times 10^{-4} - 3 \times 10^{-3}$) are fairly typical of confined and semi-confined sediments but in many areas throughout the district the Wesley Vale Sand is an unconfined aquifer. Tests to determine specific yield in such cases have not been made, and in any case the complicated lithology of the aquifer would restrict their application to specific bore sites.

As an example of T and S calculations, the results of a constant discharge pump test on a bore at Parkers Ford are shown in Figure 9.

PERMIAN ROCKS

The hydrological properties of fractured sedimentary rocks (which include the Permian sandstone and mudstone of the district) are similar to those of crystalline fractured rocks such as dolerite. Primary porosity during initial sedimentation may have been as high as 10–50%, but has progressively decreased through compaction and cementation. Voids between grains may have been further reduced by metamorphic processes which may cause the growth of secondary minerals between grains, or the recrystallisation of pre-existing minerals. Sediments near dolerite contacts may have been affected in this way. In general, primary porosity is not a major factor affecting the hydrological properties of the rocks. Secondary porosity (mainly faults and fractures of all kinds) is generally much more important, especially if the fractures are continuous and interconnected and are relatively free of clayey weathering products. Near dolerite contacts, and depending on the metamorphic effects, the degree of fracturing in sediments may be increased or decreased relative to the main body of rock in an unpredictable way.

Results of drilling in Permian sediments are summarised in Table 7. Only one bore site (fig. 4, no. 14 and Appendix 4) was pump tested to evaluate the hydrological properties of the Permian aquifer. The yield during test was maintained at 91 *l*/min, which is quite high for such rocks, but the associated large drawdown of 26 m is a response to the low transmissivity of 1.9 m^2/day (table 5). As aquifers, Permian rocks are suitable for small-scale gardening and domestic uses, but cannot be compared to the higher-yielding basalts, or most of the unconsolidated sediments of the district.

Results and implications of previous drilling for water

GENERAL

This section is designed mainly as a guide to landowners and private drilling contractors prospecting for groundwater in the Devonport–Port Sorell–Sassafras area. As of 1989, there were at least 360 bores and 100 hand-dug wells in the district. Their locations are shown in Figure 4. The resulting bore density of about two bores per square kilometre is undoubtedly the State's highest and is a reflection of the importance of groundwater in the district. All the bores surveyed have been drilled since 1964 and private drilling contractors remain active in the area. For many farmers groundwater is a supplementary source of water, but for others it is their major supply. It seems inevitable that as agriculture turns increasingly to more intensive contract cash-cropping as well as beef and dairy farming, the small spring-fed surface streams draining the higher basalt areas will be incapable of meeting demands.

Table 4. CONSTANT DISCHARGE PUMP TEST RESULTS, THIRLSTANE BASALT

Bore No.	1	7	15	18	20
Test date	24.6.74	6.11.74	21.7.75	13.8.75	24.9.75
Standing water level *(m)*	8.4	8.5	4.7	11.4	10
Discharge rate *(l/min)*	91	83	227	189	760
Depth of bore *(m)*	91.5	65	50.3	58	50
Pump intake depth *(m)*	61	40	37	38	45
Duration of test *(hours)*	24	20	24	15	24
Total drawdown *(m)*	38	19	3.3	26	8.4
Duration of recovery test *(hours)*	6	4.5	2	2	5
Transmissivity *(m^2/day)*	2.5	5.0	23.4	8.2	40
Storage coefficient	n.d.	n.d.	n.d.	n.d.	6×10^{-3}

Bore owners: 1, Green; 7, Peirce; 15, Richardson; 18, M. Addison; 20, L. Addison.

Table 5. CONSTANT DISCHARGE PUMP TEST RESULTS, WESLEY VALE SAND, AND PERMIAN SEDIMENTS [2]

Bore No.[1]	2	3	4	5	14
Owner	Findlay	Peirce	Shear-water	Clark	Lowe
Test date	23-24.7.74	6.8.74	24-25.9.74	16.10.74	10.7.75
Standing water level *(m)*	1.5	7.7	2.2	1.5	2.8
Discharge rate *(l/min)*	90	38	400	270	91
Depth of bore *(m)*	24.4	62.5	14.9	27.5	44
Pump intake depth *(m)*	21.4	22.9	12	20	40
Duration of test *(hours)*	21	5	17.3	26	5
Total drawdown *(m)*	18.8	14.3	5	11	26.2
Duration of recovery test *(hours)*	1	2	8	6	1
Trans-missivity *(m^2/day)*	1-11	4	37	158	1.9
Storage coefficient	n.d.	n.d.	5.8×10^{-4}	3×10^{-3}	n.d.

1. Refer to Figure 4 for bore locations, and to Appendix 4 for bore details.
2. Bore 14 in Permian sediments; all others in Wesley Vale Sand

Drilling activity for the period 1967–1988 is shown in Table 6 and Figure 10. Fifty-nine per cent of bores were considered successful by landowners and remained operative. The remainder were abandoned but not all of these were failures; seventy-three (23%) were dry and 55 (43%) struck water. The yield of most of these wet-but-abandoned bores was too low to run irrigation sprinklers, which require yields greater than about 300l/min. This trend has increased in recent years. There is also an inverse correlation between annual rainfall and bores drilled. It is also likely that the original Department of Mines drilling programme, involving twenty-two bores drilled between 1973 and 1975, attracted interest in groundwater and was partly responsible for the increased activity of private contractors in succeeding years.

This section is based on all available bore information from the district. It has been found possible to delineate major aquifers and to estimate the chances of success of any bore drilled into these. The accompanying maps (fig. 4–7) may be used to avoid unfavourable areas or select potentially successful ones, and to predict the depth to favourable aquifers. Using the overburden map (fig. 7), the amount of bore casing needed can be determined within reasonable limits and overall drilling costs more accurately estimated.

One of the most important conclusions of the study is that many of the abandoned bores may have been successful if drilled deeper.

A common practice after an unsuccessful hole has been to drill further holes nearby to roughly the same depth. It is recommended that in areas where a suitable thickness of aquifer exists beneath the site, bores should in future be drilled deeper.

Table 6. BORES DRILLED BY PRIVATE CONTRACTORS 1967-1988

Year drilled	No. of Bores	Operative bores	Abandoned bores	Dry bores	Success %
1967	3	1	2	2	33
1968	1	1	-	-	100
1969	2	2	-	-	100
1970	10	4	6	5	40
1971	6	6	-	-	100
1972	7	7	-	-	100
1973	14	11	3	3	79
1974	11	4	7	5	36
1975	7	7	-	-	100
1976	46	23	23	15	50
1977	30	19	11	8	63
1978	21	9	12	5	43
1979	13	11	2	1	85
1980	26	13	13	5	50
1981	15	9	6	3	60
1982	35	16	19	12	47
1983	29	20	9	2	69
1984	17	10	7	5	59
1985	13	8	5	-	62
1986	4	1	3	2	25
1987	3	3	-	-	100
1988	3	3	-	-	100
Totals	316	188	128	73	
% bores drilled		59	41	23	

Figure 11 shows the relationship between reported bore depth and yield for all bores in the area, irrespective of the underlying geology. Figures 12 and 13 are histograms of bore depths and bore yields respectively.

The main conclusions from these historical data are:

- the deepest bores are up to 160 m deep
- the highest reported yields were about 1500 l/min (22 500 gph) from the bores, but less than 2% of bores yielded more than 800 l/min (12 000 gph)
- about 20% of bores yielded irrigation supplies (at least 300 l/min, 4500 gph)
- up to depths of about 60–100 m, yield increases with depth, but yields on average decrease at greater depths
- 47% of bores were drilled to depths less than 40 m; only 20% of these yielded more than 100l/min (1500 gph), and only 4% yielded more than 300 l/min (4500 gph)
- 53% of bores are deeper than 40 m; of these 44% yielded more than 100 l/min (1500 gph), and 30% yielded more than 300 l/min (4500 gph)

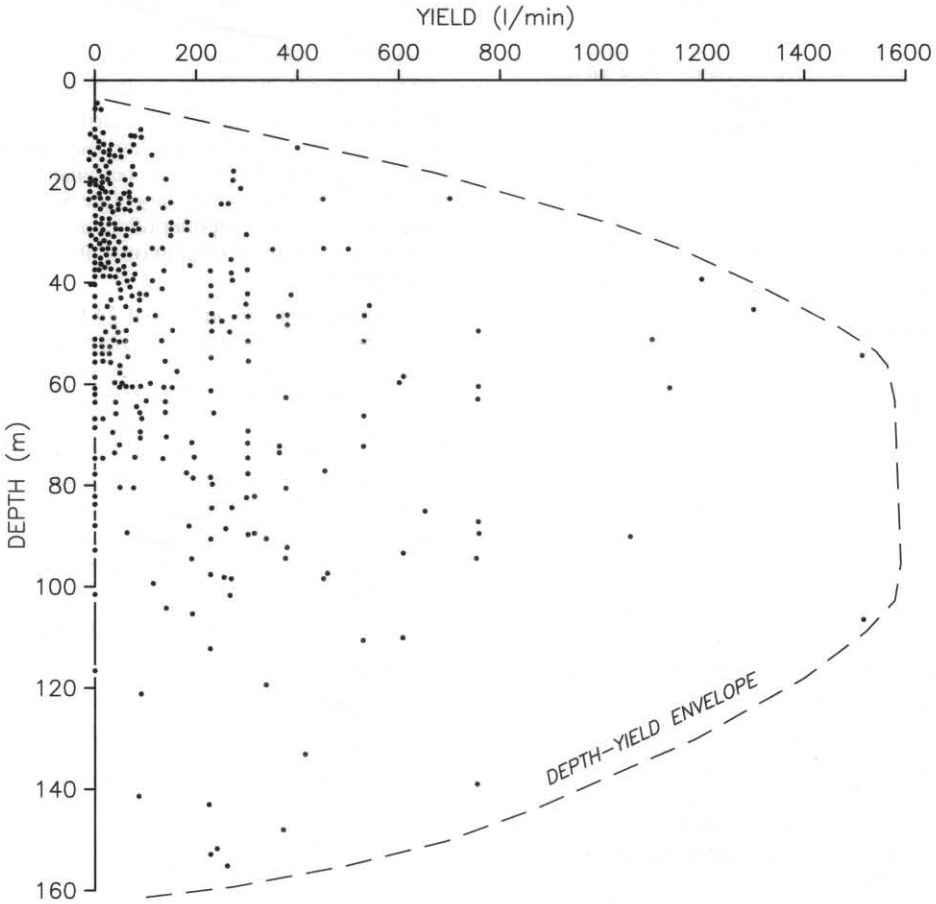
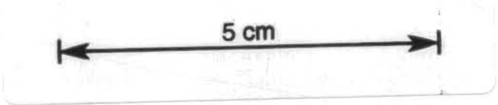


Figure 11. Depth *vs* yield for all water bores in the Devonport–Port Sorell–Sassafras area.



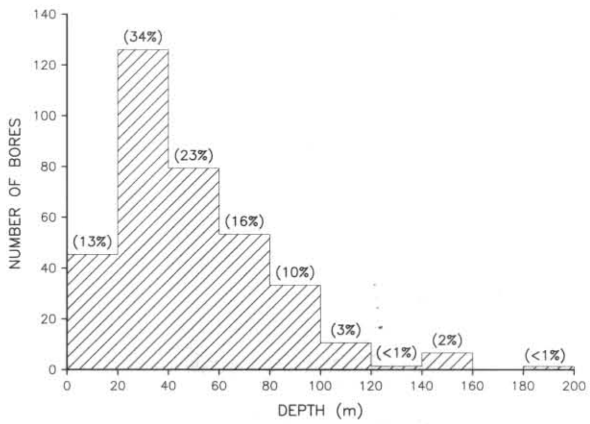


Figure 12. Histogram of bore depths (% of total bores in parentheses).

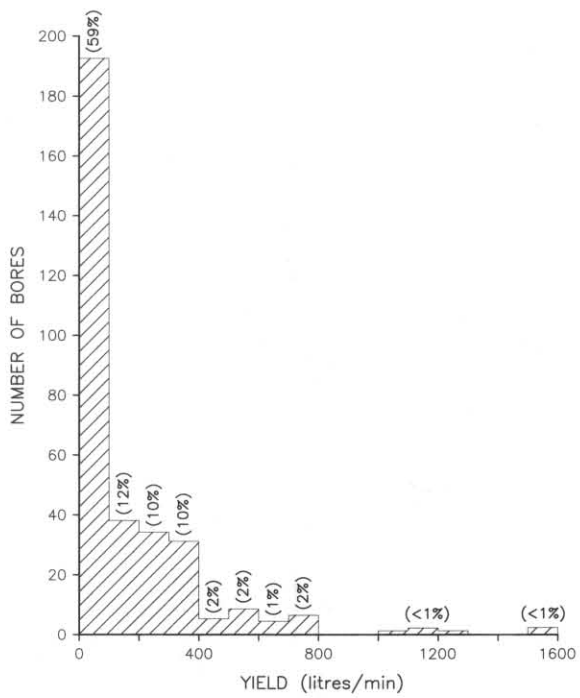


Figure 13. Histogram of bore yields (% of total bores in parentheses).

- the depth distribution of bores yielding at least 300 *l*/min is:

Depth *(m)*	Bores yielding at least 300 *l*/min	% of all bores
0–20	1	<1
20–40	6	1.7
40–60	18	5.2
60–80	14	4.1
80–100	16	4.6
100–120	4	1.2
120–140	2	<1
140–160	1	<1
	62	≈18

About 25% of bores yielded less than 20 *l*/min (300 gph) and 19% of bores were reported as 'dry'.

The following section discusses success rates, yields and bore depths in the main aquifers in the area, and concludes that historical success rates can be improved by using the accompanying maps (fig. 4–7).

DRILLING IN THE MORIARTY BASALT AT NORTHDOWN AND SASSAFRAS

Up to the end of 1988, forty-seven bores had been drilled on the Northdown plateau entirely within the outcrop area of the Moriarty Basalt. Underlying the basalt are, in order, the Wesley Vale Sand, the Thirlstane Basalt and the Harford Beds.

Prior to 1979, twenty-three bores had been drilled, to an average depth of >64 m and average yield 130 *l*/min (2000 gph). The success rate was then 57% and the average depth of successful bores 73 m. The highest recorded yield to 1979 was 300 *l*/min (4500 gph). The average depth of the ten failures was 52 m. Of these failed bores, two were drilled entirely in the Moriarty Basalt, seven passed through the basalt and bottomed in the Wesley Vale Sand, and one penetrated both these units and bottomed in the Thirlstane Basalt.

Of the thirteen successful bores drilled to 1979, six and possibly seven (including the highest yielding) bottomed in the Thirlstane Basalt, three bottomed in the Moriarty Basalt and three in the Wesley Vale Sand. The Moriarty Basalt was the main supplier of water in only three of the twenty-three bores, giving an overall success rate for this rock type of 13%.

From 1979–1988, an additional 24 bores were drilled in the northern area. Significantly, nine of these were deeper than 100 m: all of these were successful (average yield 512 *l*/min or 7700 gph; max. yield 1520 *l*/min or 22 800 gph). All nine bottomed in the Thirlstane Basalt or Harford Beds. The Thirlstane Basalt was the main aquifer in each bore. The Wesley Vale Sand contributed no water, and the Moriarty Basalt supplied water in only two of the nine.

The average yield of all 24 bores since 1979 in the area is 280 *l*/min (4200 gph) and the average depth 88 m (max. 156 m; min. 24 m).

Overall, records of the 47 bores drilled since 1967 show:

- 18 failures (38%)
- average depth 71 m
- average yield 207 *l*/min (3100 gph)
- average success rate for 4 bores in Moriarty Basalt only: 50%
- average success rate for 16 bores penetrating Moriarty Basalt and Wesley Vale Sand only: 25%
- average success rate for 27 bores entering Thirlstane Basalt: 90%

Thus, the Moriarty Basalt supplied water to only six (13%) of the 47 bores. The Wesley Vale Sand supplied water in only 4 bores (9%). The Thirlstane Basalt supplied water in 20 bores (47%). Therefore, the Moriarty Basalt at Northdown should be disregarded as a source of irrigation groundwater supplies. Bores drilled for this purpose have

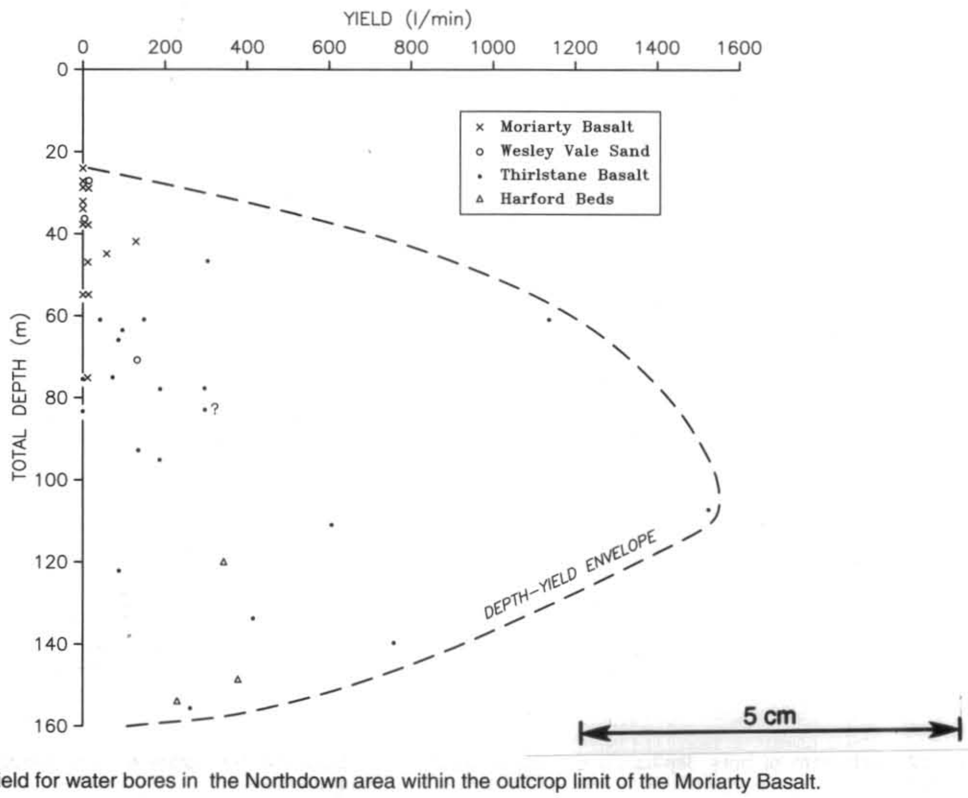


Figure 14. Depth *vs* yield for water bores in the Northdown area within the outcrop limit of the Moriarty Basalt.

only a small chance of success. The chances of obtaining useful amounts of water are better (25%) if drilling is continued into the underlying Wesley Vale Sand. If the bore remains dry, deeper drilling, to perhaps at least 20 m into the Thirlstane Basalt, has a very good chance of success. In all cases the decision to drill deeper is both geological and economic, but there is no doubt that in the outcrop area of the Moriarty Basalt at Northdown, yields generally increase with depth.

The Moriarty Basalt is a more reliable aquifer in the Sassafras area. Of 44 bores drilled there, 24 (55%) were abandoned but only ten (23%) were completely dry. The average yield of the five wet but abandoned bores was 85 *l*/min and the average depth of all 24 was 44 m. One of the dry bores penetrated 6 m into the Thirlstane Basalt, six bottomed in the Wesley Vale Sand and three bottomed in the Moriarty Basalt.

The average depth and yield of the 20 successful and operating bores is 49 m and 320 *l*/min respectively (fig. 14). Sixteen of these received most of their water from the Moriarty Basalt, Permian sediments were the main aquifer for one, the Wesley Vale Sand for another and no logs are available for the remaining two. Of the 44 bores, ten were total failures and 34 (77%) struck some water. Twenty (45%) obtained useful supplies. The Wesley Vale Sand was the main aquifer for only one bore, although 34 intersected this unit. There is therefore little point in drilling beneath the base of the Moriarty Basalt in the Sassafras area. Importantly, the Thirlstane Basalt does not exist beneath much of the area here, and only 3 bores (13 and 79) intersected it. The depth limit for drilling at Sassafras, outside the outcrop limit of the Thirlstane Basalt, is therefore about 50 m. Within the outcrop limit of the Thirlstane Basalt, the basalt should be targetted only when it is at least 20 m thick (fig. 5).

DRILLING IN THE WESLEY VALE SAND

The Wesley Vale Sand is not a reliable aquifer. Of the 251 bores for which adequate logs exist, 197 passed through varying thicknesses of, or bottomed in, the unit. One hundred and eleven (56%) of these were failures and the formation was the main aquifer in only 17 (7%) bores. With the notable exception of the Port Sorell area (where basalt is absent), the Wesley Vale Sand is underlain by varying thicknesses of Thirlstane Basalt, which is a much more reliable aquifer. In these cases, the Wesley Vale Sand should be cased off and drilling continued into the basalt.

DRILLING IN THE THIRLSTANE BASALT

This is the most reliable aquifer in the district and it also contains the largest amount of groundwater. The unit occurs over an area of about 120 km^2, is up to 170 m thick in places and has an average thickness of perhaps 80 m. Of 193 bores drilled into the basalt, 142 (74%) were successful and remain operative. Only 9 (5%) were completely dry. Their average depth of penetration into the aquifer is 42 m and the average yield 220 *l*/min. The highest yield is about 1500 *l*/min. If basin margins and saddles (where the basalt is thinnest) were avoided, close to 90% success rate could be expected with adequate penetration.

The importance of the Thirlstane Basalt as an aquifer can be better understood by examining the records of bores drilled throughout the whole district in areas outside the outcrop limit of the Thirlstane Basalt, and areas inside the outcrop limit.

Outside limit of Thirlstane Basalt

Up to 1988, eighty-three bores were drilled. Forty-five are operative with an average depth of 31 m and average yield 165 *l*/min. Thirty-eight bores (46%) were failures (average depth 28 m) and in all cases yields would not have increased with depth.

Inside limit of Thirlstane Basalt

Up to 1988, 277 bores were drilled in areas underlain by the Thirlstane Basalt and therefore had a good chance of success if drilled through the overlying Moriarty Basalt or Wesley Vale Sand, and were drilled where the Thirlstane Basalt is thick enough (fig. 5). One hundred and ninety-five (70%) were successful and remained operative, with an average depth of 69 m and average yield 325 *l*/min (>4900 gph). Of the failed bores, only a fifth were reported as 'dry' (average depth about 35 m). The remainder had an average yield of 90 *l*/min (1350 gph) and average depth of 47 m.

All the highest yielding bores in the district (up to 1500 *l*/min, 22 800 gph) are within the outcrop limit of the Thirlstane Basalt. In every case, the Thirlstane Basalt was the main aquifer.

If the 'unsuccessful-but-wet' bores are included with successful bores, the basalt supplied water to about 95% of bores drilled within its boundaries.

There are several reasons for the unsuccessful bores:

(1) Many bores, for example (145–149, 164, 166, 167, including six drilled closely together and to roughly the same depth) were all sited on the edge of the basins, most passed through thin and deeply weathered Thirlstane Basalt and many entered Jurassic dolerite. Few struck water.

(2) Several bores (e.g. 53, 54, 55, 213, 214, 215) were drilled in the Thirlstane area on the buried dolerite saddle between the Wesley Vale and Port Sorell Basins. Here the Thirlstane Basalt is thin (about 20 and the saddle represents a groundwater divide producing groundwater flows away to the basin centres. Probably there is restricted groundwater storage.

(3) Many bores (e.g. 12, 13, 58, 59, 101, 105, 113, 114, 116, 117, 118, 132, 133) were probably not drilled deep enough. There is a general correlation between yield and depth of aquifer penetrated, and most bores have a better chance of success if deeper vesicular horizons are intersected.

(4) Thirteen bores penetrated dry Thirlstane Basalt. In most cases the rock was deeply and unusually weathered.

The overall success rate for each rock type in the district is shown in Table 7.

Selecting future bore sites

DOMESTIC WATER SUPPLIES

Many landowners are only interested in obtaining small amounts of water for gardening and household supplies. Bores yielding as little as 5-10 *l*/min may be considered useful. In such cases, drilling is recommended irrespective of the geology beneath the site as few rocks are completely dry. Most failures can be expected in Jurassic dolerite, especially in the low horst areas between Port Sorell and Northdown.

IRRIGATION WATER SUPPLIES

Previous experience has shown that farmers wanting irrigation quantities of groundwater will abandon bores yielding less than 75 *l*/min, and sometimes 300*l*/min. Many desire to irrigate direct form the bore, but bores with relatively low yields can be used for irrigation by pumping first into holding dams and then reticulating the water from there. The chances of obtaining useful yields can be increased by the use of the enclosed geological, isopach and overburden maps (figs. 2, 5, 6, 7 in pocket).

Table 7. SUCCESS RATES OF DRILLING FOR WATER IN VARIOUS ROCK TYPES IN THE DEVONPORT – PORT SORELL – SASSAFRAS AREA

Rock unit	No. of bores penetrating rock unit	Success-ful (%)	Un-success-ful (%)	Approximate average yield of successful bores (l/min	gph)
Moriarty Basalt, Northdown	47	13	87	200	3000
Sassafras	44	45	55	320	4800
Wesley Vale Sand	197	44	56	50	750
Thirlstane Basalt	193	74	26	220	3300
Jurassic dolerite	22	18	82	150	2250
Permian rocks	11	64	36	150	2250
Precambrian rocks	1	0	100	no data	

Using the geological map

The map (fig. 2) shows the surface distribution of the various rock types in the district. Some boundaries are approximate because of the difficulty of mapping in areas without outcrop; often soils are the only indication of rock type. Locating the proposed bore site on the map, and referring to the geological succession in Table 3 will indicate to the driller the likely sequence of rock types beneath the site. Drilling should not proceed in areas marked dolerite or Permian sediments. Other areas may also be unsuitable, and these can be determined by using the isopach and overburden maps.

Using the isopach map of the Thirlstane Basalt

This map (fig. 5) shows the thickness of the Thirlstane Basalt, irrespective of the overlying topography or how deeply it is buried. The zero contour line indicates the probable extent of the basalt, which does not exist outside this limit. Since the upper surface of the unit is gently sloping, the map clearly reveals that the basalt is mainly a basin infilling with probable sources south-west of Oppenheim Hill. Here the basalt flowed down a deep-sided valley cut in Jurassic dolerite and Permian sediments, and accumulated in the basins. The maximum thickness is about 170 m in the Port Sorell Basin west of Harford. It is about 150 m thick beneath Wesley Vale. The basalt is draped over the shallowly buried basin divide in a roughly N-S line passing through Thirlstane, where it is only about 20 m thick. It is significant that many bores drilled here were dry, possibly because any permeable zones in the basalt dip away towards the basin centres.

Figure 5 should be regarded as approximate even where adequate drill control exists. In some areas few bores have been drilled and the map is an indication only.

Because the basalt flowed into pre-existing basins flanked in some areas by steep dolerite slopes and cliffs, it thins rapidly or abruptly towards the margins (see figs. 2, 5). Therefore, if bores are sited in these areas there is a danger that the aquifer may be missed altogether and the bore be unsuccessful. Problem areas in this regard are:

(1) along the eastern margin of the Port Sorell Basin where faulted (?) and almost vertical cliffs of dolerite have dammed the basalt,

(2) south of Port Sorell at Parkers Ford, where the northwards advance of basalt was checked by a steeply rising basement,

(3) along the north-eastern margin of the Wesley Vale Basin, and

(4) near Oppenheim Hill on the Bass Highway.

In all these cases, the basalt varies rapidly in thickness over small distances and bore siting will be critical.

The northern limit and thickness of the Thirlstane Basalt along the coast is not known with certainty because of a lack of drilling control.

The minimum thickness of basalt required for irrigation supplies is perhaps 20 m and preferably 40 m. Where the basalt is thicker than this, it should be made the main drilling target and all overlying rocks (if dry) cased off.

Using the isopach map of the Moriarty Basalt

This map (fig. 6) shows the variation in thickness of the Moriarty Basalt. Because the rock occurs at the top of the Tertiary succession and is not overlain by any other major rock type, its zero contour line corresponds with its surface outcrop shown in Figure 2 and its contoured thickness reflects the topographic map. In the Northdown area it is an unreliable aquifer and the map indicates the minimum thickness of casing required if no water is struck in it. (Often, the underlying Wesley Vale Sand will be dry and will also need to be cased off). In the Sassafras area the basalt is a more reliable aquifer, and in most cases the map indicates the maximum recommended depth for drilling; bores drilled here beneath the base of the basalt generally did not strike water. The minimum thickness of basalt required for successful bores in this area is not known with certainty, but it is probably better to drill where the rock is thickest.

Using the overburden thickness map of the Thirlstane Basalt

The Thirlstane Basalt has proved to be the most reliable aquifer in the district and generally irrigation water supplies will not be obtained in the overlying Wesley Vale Sand and Moriarty Basalt. The map (fig. 7) shows the combined thickness of these materials overlying the top of the basalt. The outer limit corresponds to the zero thickness contour in Figure 5, outside which the Thirlstane Basalt does not exist. The basalt or its weathering products are exposed at the surface within all areas bounded by the zero contour line. Bores drilled here will need little or no casing and their overall depths will be less than bores sited on the Northdown and Sassafras plateaus, where in places the aquifer is buried beneath 70 m of overburden. In these latter areas bores should, where possible, be sited in topographically low-lying areas to reduce metreage and casing. The map is especially useful in that it indicates directly the amount of casing that will be required in the bore and an immediate minimum drilling cost can be estimated. In fact, the contours will reliably reflect the variation in minimum drilling costs in the district, provided that the Thirlstane Basalt is the main target.

Since the map is based on 20 m topographic contours, depths are probably accurate to ± 10 m in the Northdown and Sassafras areas, and to ± 5 m in the lower lying areas, near Moriarty, Thirlstane and Harford.

Drilling for water is always a gamble and even in the most promising areas bores may fail. Unexpectedly successful bores may also be drilled at apparently unfavourable sites. Nevertheless, this section has shown that by analysing all the bore data for a particular district it is possible to reduce the risks involved, and that with an understanding of the geology of the site and surrounding area, drilling is not necessarily a hit-and-miss operation.

The maps remain an aid only and are no guarantee of success. At the very least, they predict an approximate log of any bore site before the hole is drilled, and give estimates of overburden thicknesses and minimum bore depths (and hence cost). Results from future drilling will enhance their usefulness. On the other hand, they provide no information on water quality (which in any case is good to excellent and relatively constant throughout the area), bore yields (which are highly variable and unpredictable because of the many factors involved) and depths at which water will be struck (again highly variable).

AMOUNT OF GROUNDWATER AVAILABLE AND THE WATER BALANCE IN THE AREA

Volumetrically the Thirlstane Basalt is easily the most important groundwater reservoir in the district, and it supplies most of the groundwater pumped for irrigation supplies. The aquifer underlies about 120 km^2, has an average thickness of about 80 m and therefore has a volume of about 10 km^3 (10^{10} m^3). Assuming an average and probably conservative porosity of 5%, the total volume of water in storage in the Thirlstane Basalt is estimated at 5×10^8 m^3. Most of this is extractable by pumping.

This volume of water would, for example, supply 300 irrigation bores pumping continuously at 500 m^3/day (20 000 *l*/hr) for ten years. However, this overall pumping rates is highly undesirable since it would progressively deplete reserves.

To ensure long-term continuity of supply, groundwater reserves should be maintained at a relatively constant level. Desirable management thus requires long-term usage on a sustained yield basis where total average, groundwater extraction does not exceed long-term net recharge. This approach was used for a small groundwater catchment at Greens Beach (Cromer, 1979) but generally not enough is known of other groundwater areas (Leaman, 1971; Matthews, 1983).

Recharge can be estimated by considering the overall water balance in the district. All components of the hydrological cycle are involved. These include rainfall, evapotranspiration, surface runoff, and recharge to and discharge from aquifers causing changes in groundwater storage.

Recharge is essentially equal to discharge when the period of study is sufficiently long to minimise the effect of changes in groundwater storage. Continuing monitoring by the Department of Mines suggests the main aquifer (Thirlstane Basalt) is essentially recharged on an annual basis.

Thus, for periods longer than a year, a first approximation is that Recharge = discharge. The components of recharge are precipitation (P), evapotranspiration (ET) and surface runoff (R) such that

$$\text{Recharge} = P - ET - R$$

Average rainfall over the catchment area of about 200 km^2 is 0.9 m/year so that $P = 200 \times 10^6\ m^2 \times 0.9$ m/year = 1.8×10^8 m^3/year. Evapotranspiration is difficult to estimate but the figures for Elliott are probably typical of much of the cleared farmland on the North West Coast - about 0.84 m/year (pan evaporation). Actual ET may be about 75% of pan evaporation, so that within the catchment area, ET = 1.3×10^8 m^3/year.

Surface runoff is difficult to estimate due to the absence of gauging stations. Most streams are spring fed by discharging groundwater, but most stream flows are effectively dammed by landowners and used for irrigation in combination with groundwater. Stream flow tends to diminish downstream because of this, and it is likely that except during prolonged heavy rain run-off is minimal. As a first approximation, therefore, R = 0, so

$$\text{Recharge} = (1.8 \times 10^8\ m^3/\text{year}) - (1.3 \times 10^8\ m^3/\text{year}) = 0.5 \times 10^8\ m^3/\text{year}$$

This implies that groundwater in storage (essentially all in the Thirlstane Basalt) represents about 10 years of recharge. Alternatively, recharge is equivalent to about 300 bores pumping continuously at 500 m^3/day each year, which approximates the overall safe yield of the area.

There is clearly a need to refine these estimates by determining overall annual groundwater usage for the district and the resultant changes in groundwater storage. The latter is currently being monitored.

Groundwater monitoring

W. L. Matthews
R. C. Donaldson

In the area between East Devonport, Port Sorell and Sassafras there is extensive use of groundwater for irrigation of cash crops, the most important being potatoes, peas, corn, onions and beans. During the late 1970s and early 1980s (fig. 15) there was a series of dry years when surface water and groundwater resources were extensively used. There were suggestions from private drilling contractors and property owners that the groundwater resources were becoming depleted. Despite the extensive use of groundwater within the area no information on the amount used and the effect of this on water table levels was available. In 1984 a system of bores was established so that groundwater use and its effects could be monitored.

BOREHOLE MONITORING NETWORK

Sites were selected throughout the area to undertake the monitoring (see fig. 16–18). A number of holes were drilled by the Department of Mines. An adequate coverage for a monitoring network was established using these bores and existing property owners' bores.

(1) A series of observation bores was drilled by the Department, specifically in the Northdown and Moriarty areas, on three properties where groundwater extraction is known to be large. These holes were sited in proximity to existing irrigation bores and drawdown and recovery measurements taken in pump tests using both the observation and irrigation bores. In addition, the irrigation bores were fitted with water meters to obtain accurate values for extraction rates. Initially these were monitored on a weekly basis, but later at intervals of about one month.

(2) A series of twelve bores was drilled throughout the remainder of the area to monitor groundwater on a regional basis. Wherever possible the bores were sited some distance from existing irrigation bores to minimise the direct effects of individual bores and to indicate whether the overall effect of groundwater extraction was having a regional effect. Ten bores were drilled into the Thirlstane Basalt aquifer. The other two bores were drilled into the Moriarty Basalt as Sassafras.

In addition to the holes established by the Department of Mines information has been collected from the bores established by property owners throughout the area. This information includes water level measurements and estimates of yearly outputs from the high-yielding bores used for irrigation.

Water quality is monitored from a series of bores used for irrigation throughout the area on a yearly basis.

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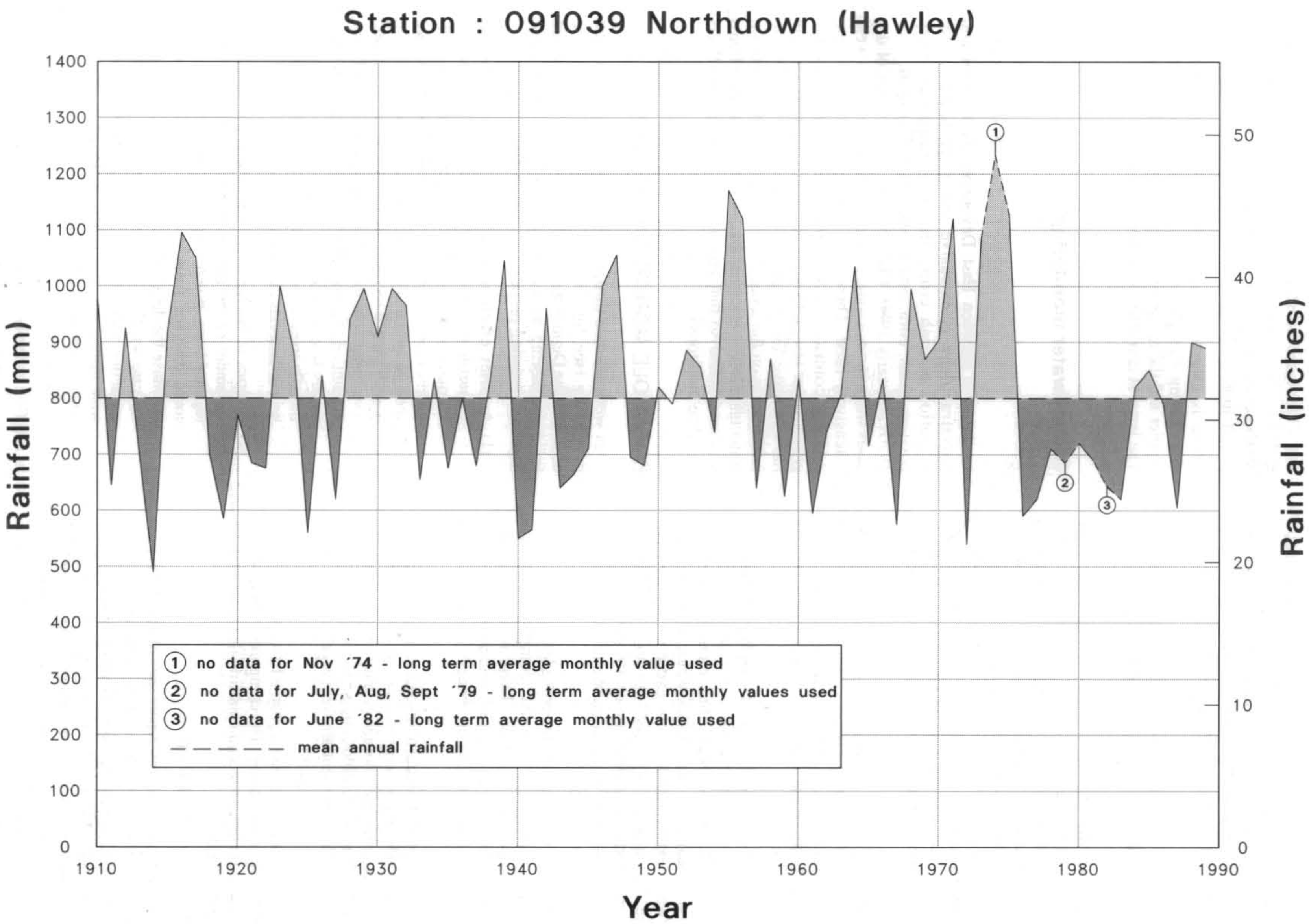

Figure 15. Long-term annual rainfall at Northdown (Hawley).

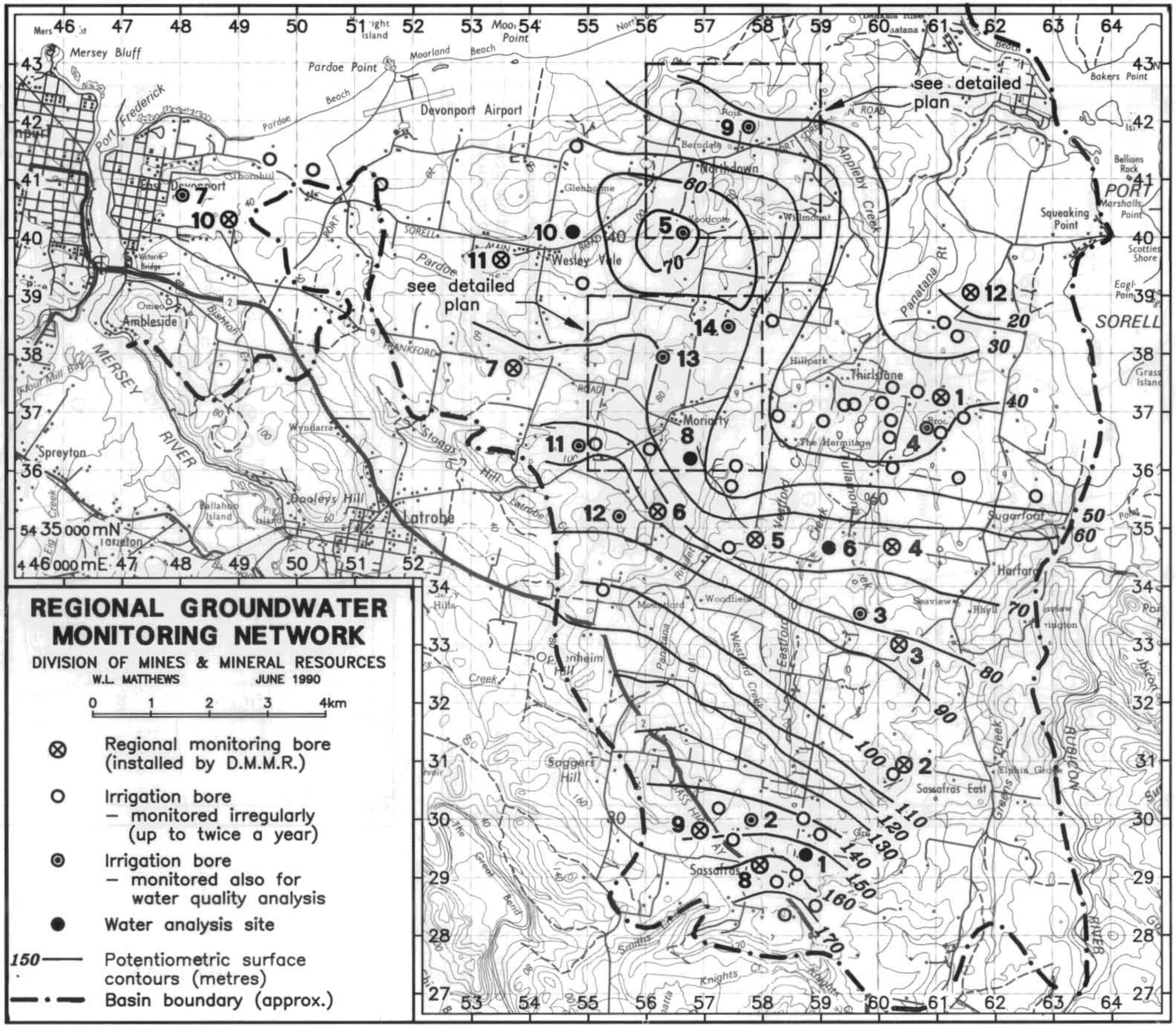

Figure 16. Regional groundwater monitoring network.

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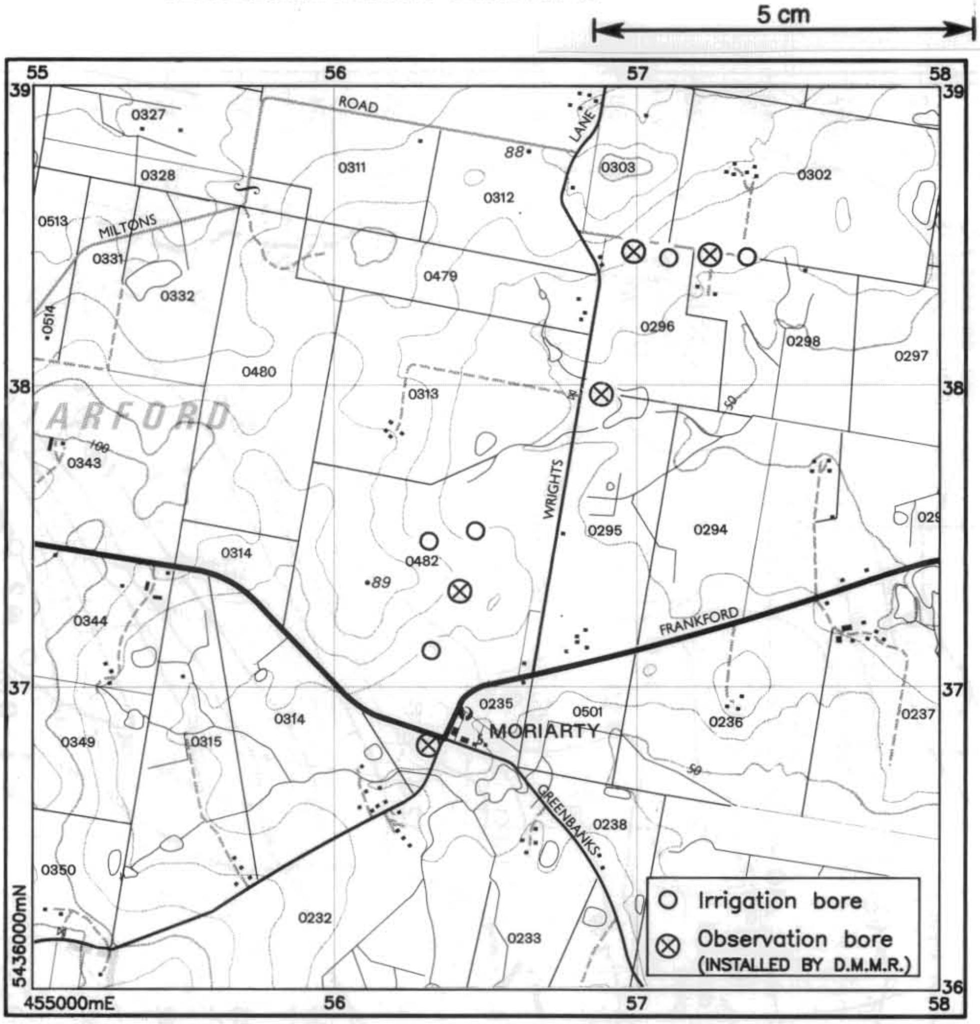


Figure 17. Location of monitored water bores, Moriarty region.

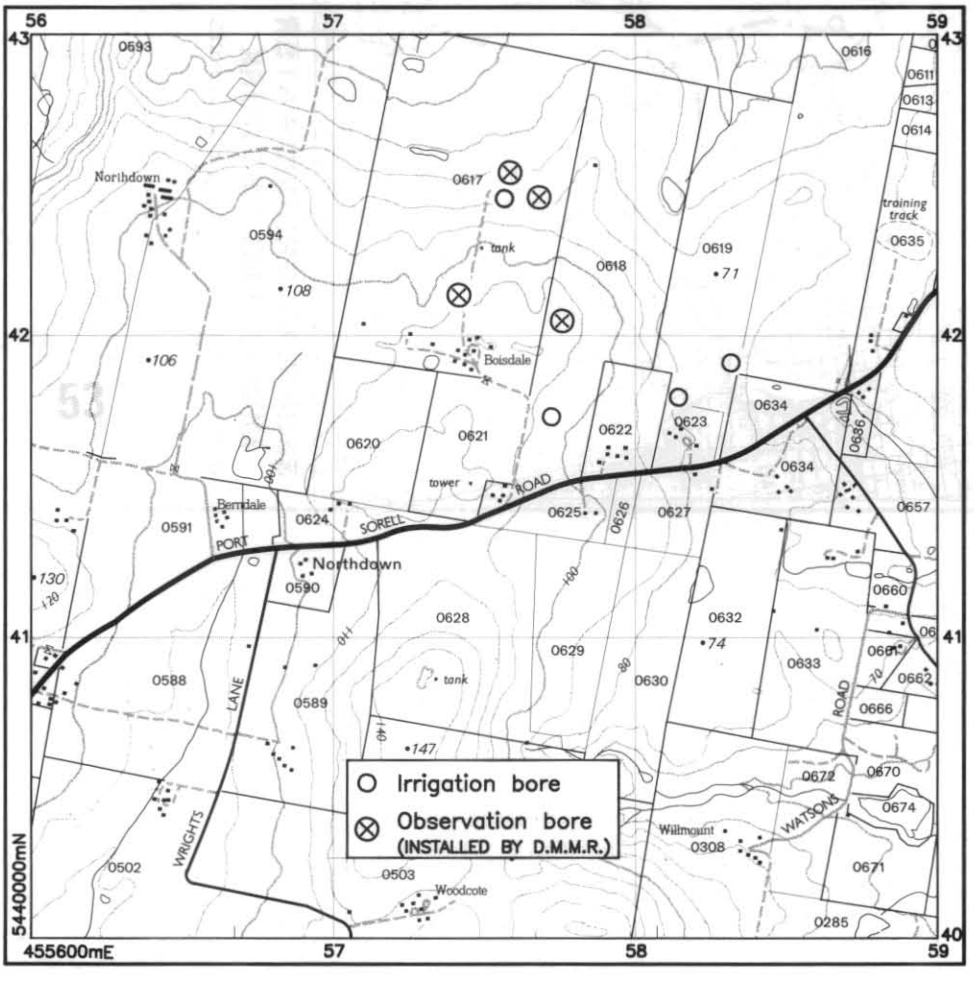


Figure 18. Location of monitored water bores, Northdown region.

RESULTS OF MONITORING

Estimates of groundwater use in the region over several years are given in the Table 8. The higher values correspond to years when the annual rainfall has been low or there has been an extended dry period throughout the growing season for the crops being produced. This period is from about October to April for most years but may extend outside this range.

Very high groundwater use occurred in 1983–1984 and 1987–1988. Low groundwater use occured in years where there was unusually high summer rainfall, e.g. in 1986.

Table 8. GROUNDWATER USE IN THE EAST DEVONPORT – PORT SORELL – SASSAFRAS AREA

Period	Megalitres	Million gallons
1983–1984	3150	700
1984–1985	1720	382
1985–1986	1180	262
1986–1987	1436	319
1987–1988	2560	569

REGIONAL BORES

The plots of water level measurements for the regional bores, most of which are not affected by nearby irrigation bores, are shown in the Figure 19. The summer to winter fluctuation can be clearly seen and unusually wet winters (e.g. 1988) can be seen as particularly prominent. Water level fluctuation is only a few metres in these bores. Over the period of measurement, the trend has been towards complete recovery of the bores by winter rains over the whole period. There are dry winters when recovery is not to the level of that in the wet years, e.g. in 1987 the winter peak was lower than in wet years such as 1988. In 1988 the water levels reached the highest levels attained over the period of measurement.

Taking the results of the regularly monitored bores and water levels measured in the bores established by property owners (mainly high-yielding bores) the potentiometric surface has been contoured for a particular period, e.g. Figure 16. It can be seen that there is a general gradient towards the sea apart from an anomalous feature in the Northdown area. The validity of this surface is a little doubtful as it is not known whether all of the aquifers in the bores used in this diagram are interconnected. Certainly there will be different degrees of inter-connection. The reason for the anomalous area on the potentiometric surface is unknown but it may be due to a local perched water table or recharge/discharge area.

Water level fluctuations show recharge takes place in some of the bores more rapidly than in others. The 1988 winter rains demonstrate this clearly. Irrigation of land near some of the bores also has a nearly instantaneous effect on water levels (see fig. 19).

NORTHDOWN–MORIARTY REGION

The results of regular monitoring of the seventeen bores (9 irrigation, 8 observation) in this intensively irrigated area of the Wesley Vale Basin over the period 1984–1989 strongly suggest that some areas appear to be under stress, in the short term at least.

Figures 20 and 21 depict the typical relationship between water level fluctuations (Thirlstane Basalt aquifer), the volume of groundwater extracted, and rainfall, in the Moriarty and Northdown areas respectively.

Table 9 shows the total volume of water extracted from both areas over the five-year monitoring period.

Table 9. EXTRACTION RATES (Ml) IN THE NORTHDOWN – MORIARTY REGION

Irrigation Season	Northdown	Moriarty
1984–1985	67.9	196.6
1985–1986	60.3	163.5
1986–1987	70.9	123.4
1987–1988	110.7	267.1
1988–1989	51.9	112.9
Cumulative total	361.7	863.5

The results presented in Figure 20 clearly indicate that the water levels recorded in the bores in the Moriarty area fully return to their pre-pumping season high at the end of the winter recharge period. This appears to be the case irrespective of the volume of water extracted in any particular year even when combined with the cumulative nett shortfall in rainfall that has occurred during the period of monitoring.

In contrast, the bores monitored in the Northdown area have shown a progressive decline in water levels between 1984–1988 of approximately 7 m overall, with a partial recovery in the 1989 winter recovery period. Figure 21 shows three basic water level gradients over the period. The initial decline between 1984–1986 is minimal and indicates that despite the good rainfalls in 1985 and 1986, combined with the low 1986 extraction values, the result was that nett recharge was slightly less than nett groundwater extraction. The period of greatest water level decline occurred in 1987–1988 and was due to the culmination of a series of below-average rainfall periods coupled with corresponding high extraction rates until mid 1988. It is significant that the high winter rainfall of 1988 (32% above average) failed to alter the downward trend in the water levels during this period. This suggests poor local recharge conditions. The recovery of the water table in 1989 may be partly the result of a delayed response to the winter rains of 1988. The low extraction rates in 1989 would also contribute to the recovery of the water table.

Monitoring has indicated that despite the fact all the bores are drawing from the same aquifer (Thirlstane Basalt), there appear to be significant differences in recharge conditions and aquifer properties across the basin. This is not unexpected and is perhaps due in part to the differences in the geological profile in each area. For instance, in the Moriarty region, the Wesley Vale Sand is seen to crop out over much of the area and directly overlies the main productive aquifer (Thirlstane Basalt). The Wesley Vale Sand is, on average, only between 5 and 30 m thick in this region. This unit has a relatively high permeability overall, allowing rapid infiltration into the underlying basalt aquifer. The end result is good recharge conditions.

On the other hand, at Northdown, the Wesley Vale Sand is overlain by the Moriarty Basalt. This upper basalt unit is up to 50 m in thickness in the area and has largely weathered to a clay material of relatively low permeability. It follows that the infiltration rate will be relatively slow and the nett result is poor recharge conditions.

A further contributing factor to be considered is the relationship between recharge and the porosity (vesicularity or fracture intensity) of the Thirlstane Basalt itself. The irrigation bores monitored in the Moriarty area tend to be higher yielding than their counterparts in the Northdown region suggesting higher transmissivities and therefore greater recharge potential.

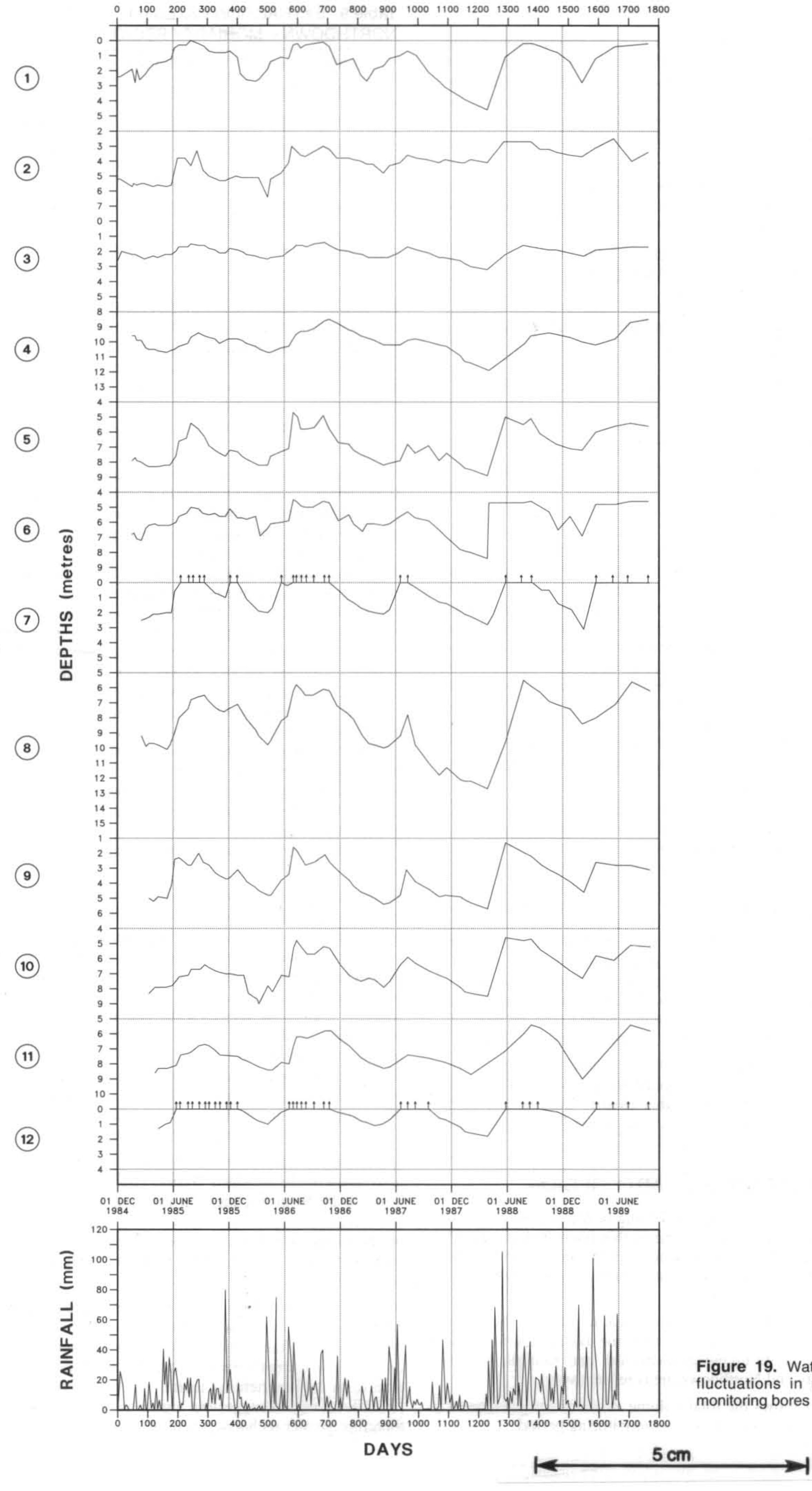


Figure 19. Water table fluctuations in regional monitoring bores

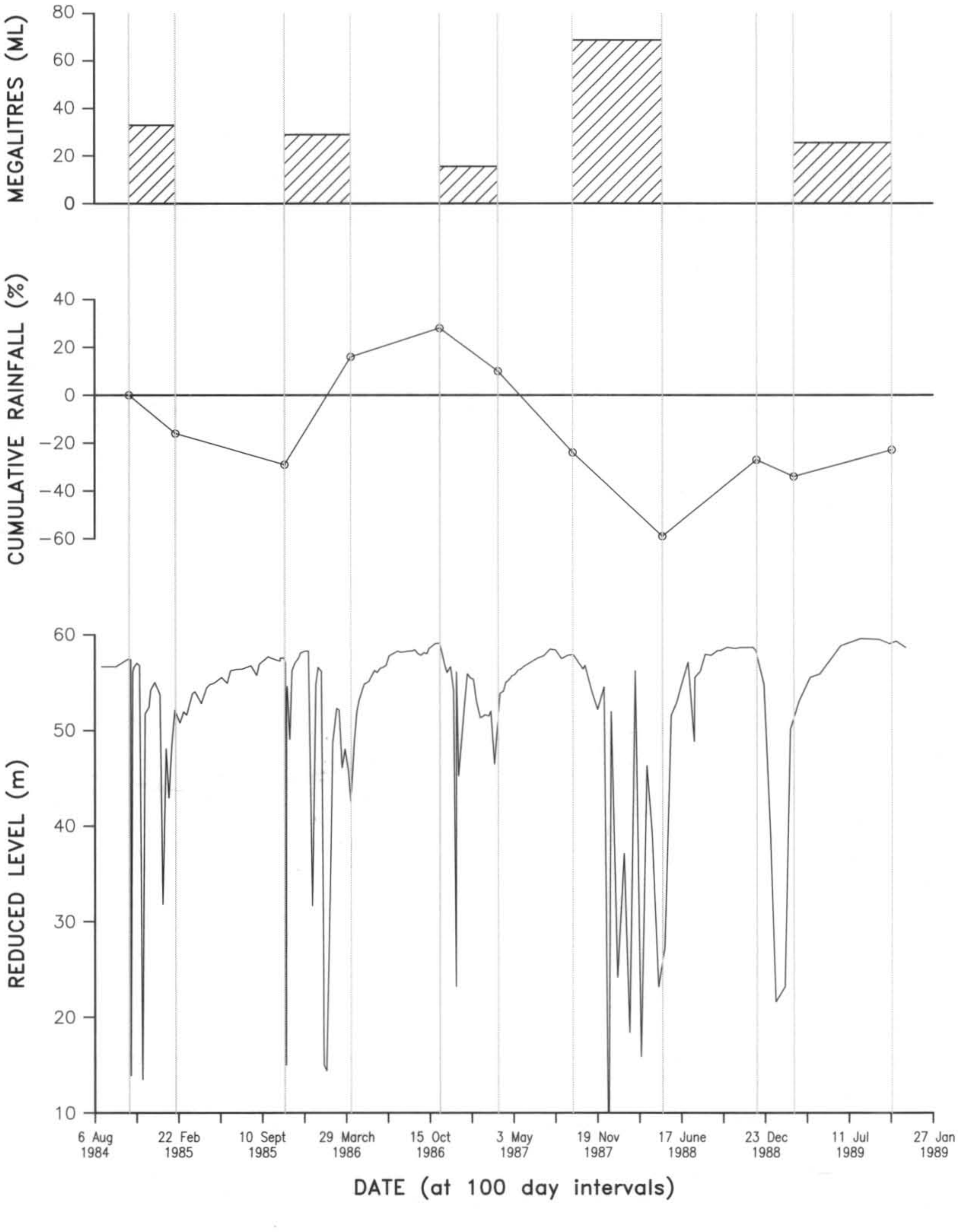
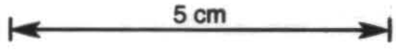


Figure 20. Groundwater extraction, rainfall and water level relationships in the Moriarty region.



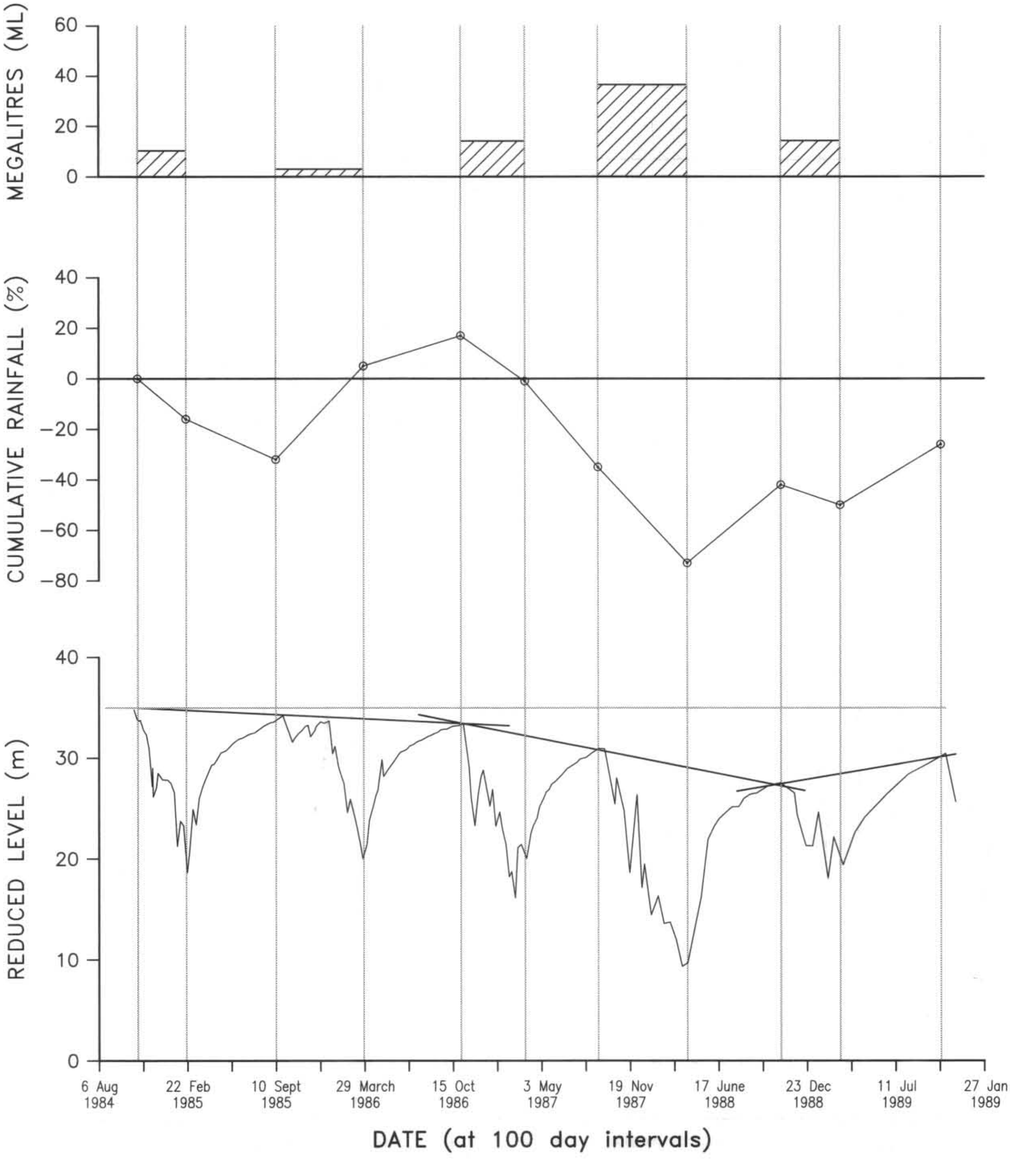


Figure 21. Groundwater extraction, rainfall and water level relationships in the Northdown region.

5 cm

Table 10. CHEMICAL ANALYSES OF GROUNDWATER FROM BORES IN THE NORTHDOWN – MORIARTY AREA

	1				2				3			
Owner	A. V. Rockliff				J. Coughlan				L. Richardson			
Locality	Sassafras				Sassafras				Harford			
Grid Reference	571298				578298				598334			
Year	1986	1987	1988	1989	1986	1987	1988	1989	1986	1987	1988	1989
pH	6.6	6.6	7.0	6.9	7.1	7.1	6.7	6.7	6.7	8.2	8.0	6.9
Conductivity	280	290	290	280	300	300	280	280	270	220	360	340
CO_3	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil
HCO_3	76	66	71	115	105	85	78	71	105	47	140	76
Cl	53	42	46	46	35	30	33	31	39	28	47	45
SO_4	<5	<5	6.8	<5	<5	7.2	11.5	6.3	6.6	<5	5.6	<5
Ca	17	12	11.0	15.5	15.5	14.0	8.7	11.0	18.5	13	17.0	16.5
Mg	12.5	11	10.0	16.5	17.5	15.0	11.0	13.0	11.0	3.6	11.5	8.6
Fe	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Al	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
K	2	2.5	2.0	2.5	2.2	3.0	2.5	1.8	2.1	0.8	2.9	1.1
Na	26	34	27	22	21	27	24	19.0	28	32	34	26
TDS	230	240	220	220	250	250	230	195	190	150	240	190
Hardness Perm.	31	21	11	11.5	23	27	3	23	4	8	nil	145
Hardness Temp.	63	54	58	95	86	70	64	58	88	39	90	62
Alk. as $CaCO_3$	63	54	58	95	86	70	64	58	88	39	175	62
P	0.13	0.11	0.12	0.21	0.19	0.14	0.17	0.16	<0.01	<0.01	<0.01	<0.01
NO_3	40	35	<5	<10	50	40	15	15	<10	40	<5	10
NH_4												

	4				5			
Owner	B. Iles				Wilson			
Locality	Harford				Northdown			
Grid Reference	608368				568401			
Year	1986	1987	1988	1989	1986	1987	1988	1989
pH	7.8	9.2	7.8	7.3	5.5	8.3	6.5	5.9
Conductivity	500	550	530	580	310	570	510	310
CO_3	nil	19.8	nil	nil	nil	nil	nil	nil
HCO_3	125	90	130	135	17	87	43	11.0
Cl	100	99	99	110	72	120	130	70
SO_4	13.0	13.0	5.2	13.0	<5	8.4	<5	10.0
Ca	9.7	8.1	5.7	11.5	2.5	22	6.5	2.1
Mg	4.9	4.2	4.7	5.0	4.8	15.0	13.0	5.0
Fe	<0.1	<0.1	<0.1	<0.1	0.1	<0.1	<0.1	<0.1
Al	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
K	1.5	1.4	1.4	1.0	2.0	3.5	3.0	1.1
Na	110	140	115	110	51	84	70	50
TDS	330	330	320	320	190	360	350	200
Hardness Perm.	nil	nil	nil	nil	12	47	35	190
Hardness Temp.	44	38	34	49	14	71	35	8.9
Alk. as $CaCO_3$	100	105	110	110	14	71	35	8.9
P	0.03	<0.02	0.01	<0.01	<0.01	<0.01	<0.01	0.05
NO_3	<10	7.5	<5	<10	30	7.5	15	<10
NH_4					<0.5			

	6			7		
Owner	J. Bramich			Bovill		
Locality	Moriarty			E. Devonport		
Grid Reference	578348			485407		
Year	1986	1987	1988	1986	1987	1988
pH	7.0	7.0	7.5	7.4	7.5	7.7
Conductivity	430	440	450	540	570	560
CO_3	nil	nil	nil	nil	nil	nil
HCO_3	160	150	170	185	175	175
Cl	70	63	71	99	87	95
SO_4	<5	<5	<5	<5	10.5	<5
Ca	31	23	27	41	33	29
Mg	15.5	9.5	10.5	25	18.5	18.5
Fe	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Al	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
K	2.7	2.5	2.4	4.4	4.1	3.6
Na	47	53	50	44	46	45
TDS	300	280	280	350	390	350
Hardness Perm.	11	nil	nil	53	13.5	4
Hardness Temp.	130	97	110	150	145	145
Alk. as $CaCO_3$	130	125	140	150	145	145
P	0.05	0.02	0.04	0.04	0.04	0.04
NO_3	<10		<5	<10	<5	<5
NH_4						

	8			9				10			
Owner	Slater			A. Duff				A.C. Loane			
Locality	Moriarty			Northdown				Wesley Vale			
Grid Reference	568362			577418				551403			
Year	1986	1987	1988	1986	1987	1988	1989	1986	1987	1988	1989
pH	8.4	9.0	6.7	7.7	8.7	8.6	8.1	7.2	8.0	7.9	8.1
Conductivity	260	300	290	510	550	530	530	330	350	340	360
CO_3	6.7	10.5	nil	nil	6.2	7.2	nil	nil	nil	nil	nil
HCO_3	99	84	93	180	160	165	150	160	150	150	150
Cl	46	36	33	78	77	75	87	43	35	39	42
SO_4	<5	<5	9.1	19.0	19	16.5	10.5	<5	<5	23.5	<5
Ca	5.9	8.2	8.4	3.2	1.9	1.3	5.2	11	12.5	9.4	13.5
Mg	1.8	1.6	8.5	0.5	0.3	1.6	0.9	4.5	4.6	4.1	4.8
Fe	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	0.2	<0.1	<0.1	<0.1	<0.1
Al	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
K	0.9	1.2	1.4	1.2	1.3	1.1	0.9	4.6	4.8	4.0	3.6
Na	57	76	32	125	170	140	115	64	64	60	60
TDS	175	200	210	350	340	320	280	220	220	210	210
Hardness Perm.	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil
Hardness Temp.	22	27	56	10	6	9.8	17.0	46	50	40	54
Alk. as $CaCO_3$	92	86	76	145	140	145	120	130	125	120	125
P	0.04	<0.01	0.06	0.02	0.02	0.03	0.04	<0.01	0.02	0.05	0.05
NO_3	<10	<5	25	<10	<5	<5	<10	<10	<5	<5	<10
NH_4								<0.05			

	11				12			
Owner	L. Redpath				L. Redpath			
Locality	Moriarty (228)				Moriarty (49)			
Grid Reference	552364				556352			
Year	1986	1987	1988	1989	1986	1987	1988	1989
pH	6.2	7.8	7.3	7.5	8.1	7.7	7.7	7.8
Conductivity	200	240	240	240	370	490	460	500
CO_3	nil	nil	nil	nil	12	nil	nil	nil
HCO_3	46	89	89	77	125	165	165	155
Cl	36	32	32	34	43	69	71	78
SO_4	9.4	<5	<5	<5	<5	<5	<5	<5
Ca	6.9	10	6.5	8.3	3.6	15.5	13	78
Mg	3.7	4.2	3.4	46	0.2	7.2	8.5	2.6
Fe	<0.1	<0.1	<0.1	<0.1	0.1	<0.1	<0.1	<0.1
Al	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
K	1.4	2.7	2.1	1.4	1.3	2.1	1.9	1.1
Na	29	48	37	34	87	84	77	100
TDS	120	150	135	150	220	300	280	260
Hardness Perm.	nil	nil	nil	nil	nil	nil	nil	30
Hardness Temp.	32	43	30	40	10	68	67	nil
Alk. as $CaCO_3$	38	73	73	63	120	135	135	130
P	<0.01	0.01	0.02	<0.01	0.02	0.01	0.02	0.05
NO_3	15	<5	<5	15	<10	<5	<5	<10
NH_4	<0.05				<0.05			

	13				14		
Owner	R. Radford				M. Murdoch		
Locality	Moriarty				Moriarty		
Grid Reference	563378				573385		
Year	1986	1987	1988	1989	1987	1988	1989
pH	7.2	8.6	8.6	8.2	7.9	7.4	7.4
Conductivity	460	350	370	390	430	370	370
CO_3	nil	4.9	5.4	nil	nil	nil	nil
HCO_3	180	130	140	135	160	130	115
Cl	54	40	44	46	46	48	51
SO_4	9.4	<5	8.7	<5	9.4	22	8.4
Ca	17	8.1	4.0	5.6	31	17	17.5
Mg	7.7	3.7	2.3	2.0	15.5	13	15.0
Fe	0.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Al	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
K	4.7	3.3	1.9	1.7	4.1	3.4	2.6
Na	72	87	84	80	39	30	27
TDS	290	220	220	210	290	240	240
Hardness Perm.	nil	nil	nil	nil	11	nil	12.5
Hardness Temp.	75	34	19.5	22	130	96	93
Alk. as $CaCO_3$	150	115	120	110	130	105	93
P	0.16	<0.01	0.06	0.08	0.02	0.04	0.05
NO_3	<10	<5	<5	<10	10	10	<10
NH_4	<0.05						

Bore locations (1–14) are shown on Figure 16.

Water quality monitoring

Samples of water have been obtained from fourteen bores used for irrigation. These are presented in Table 10. No significant trends can be seen in quality variations as far as the items analysed are concerned. Of particular interest is a relatively high nitrate content in some of the bores. This again is variable from year to year but appears to be higher in areas where recharge is fairly rapid (or where the water occurs at shallow depth), e.g. in the Sassafras area. The source of the nitrate is thought to be from the application of fertiliser for crops although other sources may contribute, e.g. legume fixation of nitrogen from the air (clovers, peas, beans, lucerne). In some analyses the nitrate content is a little above that recommended by World Health Organisation for drinking water (40 mg/*l*).

All samples indicate good quality irrigation water and fall within Class 2 for irrigation water (Hart, 1974).

Groundwater quality is discussed more fully in the following section

Summary of monitoring

Monitoring has shown that the groundwater resource is being fully replenished by winter rains over most of the region. However, in the Northdown area there has been a steady decline in water levels over the period of measurement, suggesting that this area is under stress, at least in the short term.

There does not appear to be any significant variation in water quality for the items being analysed.

CHEMICAL QUALITY OF THE GROUNDWATER

The suitability of groundwater for its various intended uses depends to a large extent on its chemical quality. Samples for chemical analysis were collected during the regional investigations from various bores and wells. Analyses are presented in Appendices 5–7. The Department of Mines is currently monitoring groundwater quality from various bores in the district on a long term basis.

Presentation of results

Results of water assays are presented as milligrams per litre of dissolved constituents (mg/*l*; very nearly equal to parts per million), milligram equivalents per litre (meq/*l*; i.e. equivalents per million) and percentage milligram equivalents per million (% meq/*l*). The first of these is determined by laboratory methods. The second is derived from mg/*l* by dividing by the equivalent weight of the species involved. In analyses expressed in meq/*l*, unit concentrations of all ions are chemically equivalent: i.e. one meq/*l* of a cation will react with one meq/*l* of an anion. The chemical behaviour of the dissolved constituents, and of the mixing of different groundwaters, can therefore be more easily understood. Ionic charges are balanced in solution, so that the total meq/*l* of the major cations (calcium, magnesium and sodium) should usually equal the total meq/*l* of the major anions (chloride, bicarbonate and sulphate). Concentrations in mg/*l* may be readily converted to meq/*l* by multiplying by the appropriate factor in Table 11. Any non-ionised species (SiO_2, H_2S) and in some cases Fe is not normally reported as meq/*l*.

The expression of the analyses in % meq/*l* is useful for graphical comparisons of various groundwaters, and also allows easy evaluation of the major components in the sample.

Table 11. CONVERSION FACTORS, MILLIGRAMS PER LITRE (mg/*l*) TO MILLIGRAM EQUIVALENTS PER LITRE (meq/*l*)

Ion	Ion Factor
Calcium	0.0499
Chloride	0.0282
Magnesium	0.0822
Sulphate	0.0208
Sodium	0.0435
Carbonate	0.0333
Potassium	0.0256
Bicarbonate	0.0164
Aluminium	0.1112

Natural variability of groundwater and sampling bias

As well as analysing groundwater to determine its suitability for any intended use, it is often constructive to attempt to investigate the natural variability of the water in each major aquifer and between various aquifers.

Natural variability in groundwater is inherent and unavoidable. The nature and relative proportions of dissolved constituents reflect to varying degrees the original composition of the rainwater from which most groundwater is initially derived, the chemical composition, degree of weathering and physical properties of the rocks in which it is stored and through which it passes, and the duration and area of contact between water and rock. All these factors can be expected to vary in any natural system.

Sampling bias is an inevitable consequence in a regional groundwater investigation where analyses are made on water samples collected in various ways from different depths in the aquifers by different people ('operator variability'), and from a haphazard distribution of bores and wells. For example, if stratification of groundwater quality is expected in an aquifer, physical field sampling should be done on a systematic basis. Thus the eleven analyses of water from the Moriarty Basalt are of limited value because most bores drilled were dry, and only wells tapping the upper parts of the aquifer were sampled. Clearly, the single analysis of water in Permian sediments cannot claim to be representative. Even the 28 analyses from the Wesley Vale Sand and the 19 analyses from the Thirlstane Basalt are too small a sampling population to reflect more than the water quality at various random points in the respective aquifers. Sampling bias, coupled with analytical variability in the laboratory, means there is little hope that the analyses are fully representative, and that the natural variability of the groundwater is obscured to a largely unknown degree. Economically it is an impractical to adequately sample the aquifer to the extent that sampling variability approaches natural variability, and this should be remembered when drawing conclusions about regional groundwater quality.

Source of constituents in groundwater

Most groundwaters are initially derived from percolating rainwater which itself acquires various dissolved constituents before it reaches the ground. The main constituent present is usually dissolved carbon dioxide, which renders rainwater weakly acidic and permits the water to more easily leach soluble ions from the rocks through which it percolates. Rainwater often contains sulphates derived from industrial air pollution, and sodium and chloride from wind-blown sea spray.

Table 12. AVERAGE COMPOSITION OF IGNEOUS AND SEDIMENTARY ROCKS, AND SEA WATER, WITH RESPECT TO VARIOUS CONSTITUENTS DISSOLVED IN NATURAL GROUNDWATER (mg/kg) (Adapted from Hern, 1970; analysis for average Tasmanian olivine basalt from Sutherland, 1969)

Constituent	Tasmanian olivine basalt	Igneous rocks	Sand, sandstone, gravel	Clay, mudstone	Limestone, dolomite	Seawater
Si	207200	277000	367500	272800	24200	0.02–4
Al	78140	81300	25300	81900	4300	0.2–2
Fe	86310	50000	9900	47300	4000	0.002–0.02
Ca	67070	36300	39500	22300	304500	400
Na	21740	28300	3300	9700	370	10560
K	11870	25900	11000	27000	2700	380
Mg	56580	20900	7100	14800	47700	1272
Ti	15380	4400	960	4300	–	trace
P	2620	1180	350	740	175	0.001–0.1
Mn	3250	1000	trace	620	385	0.001–0.1
F		600-900	–	510	250	1.4
S		520	2800	2600	1100	850
C	410	320	13800	15300	113500	28
Cl		314	trace	–	200	18980

The greater the extent of contact of rock and water, either as a function of exposed surface area, or duration of contact or both, the more mineralised the water becomes. The major elements present in most major types of rocks, and their relative concentrations, are shown in Table 12. Percolating groundwater containing dissolved carbon dioxide is able to selectively leach most of these elements from the rocks through which it passes.

SODIUM (Na)

Sodium is an important constituent of igneous rocks, and its major source in the Devonport–Port Sorell–Sassafras area is the feldspar minerals of the Thirlstane and Moriarty Basalts. In contact with groundwater containing dissolved CO_2, the feldspar albite, for example, decomposes to SiO_2, Na_2CO_3 and clay. The sodium carbonate is readily soluble and sodium leached in this way is likely to remain in solution. The sodium in groundwater in the Wesley Vale Sand is probably derived from detrital feldspars, or from sodium salts deposited initially in the matrix of the sediments. Secondary sources of sodium are particulate NaCl in rainwater (derived from salt spray contamination or seawater evaporation) and mixing of groundwater from different aquifers.

CALCIUM (Ca)

In the Devonport–Port Sorell–Sassafras area, the major source of calcium is the silicate minerals (plagioclase, pyroxene) of the basaltic rocks, which weather to clays and release soluble Ca^{++} ions. Low values of Ca in groundwater may imply the absence of soluble minerals, or may indicate that base exchange (Ca replaces Na) is occurring on clay particles in contact with percolating groundwater.

MAGNESIUM (Mg)

Magnesium is an important constituent of igneous rocks, where it mainly occurs in silicate minerals (olivines, pyroxenes, amphibole, micas) in association with calcium. Ca/Mg ratios in groundwater usually range from 5.1 to 1:1, higher values imply a source of calcium from relatively pure limestones and the lower values indicate that Mg silicate minerals (or dolomite) are being weathered. Groundwater from the Wesley Vale Sand, Thirlstane Basalt and Moriarty Basalt have Ca:Mg ratios of 1:2.3, 1:2.3 and 1:1 respectively, suggesting that weathering of the silicate minerals in the basalts is the main source of Mg. (Low ratios may also indicate the preferential deposition of $CaCO_3$ from solution, or the contamination of groundwater by sea water which has a Ca:Mg ratio of about 1:5. There is no evidence to support either of these two possibilities).

POTASSIUM (K)

Potassium is slightly less abundant than sodium in igneous rocks where it occurs mainly in the feldspar minerals. The relative abundance of the two elements is not maintained in groundwater because their behaviour during chemical weathering is different. Sodium forms soluble salts which remain in solution but potassium is readily combined with weathering products, particularly clay minerals, in fine-grained sediments. Potassium is therefore a relatively minor constituent of groundwater.

IRON (Fe)

Iron is an abundant and important element in igneous rocks, where it occurs in pyroxenes, amphiboles and micas. It tends to become concentrated in fine-grained sediments and is a common cementing material in sands and sandstones. Its presence in groundwater is complicated by its ability to occur in two oxidation states, Fe^{2+} and Fe^{3+}. Both may be present in groundwater, but ferric iron (Fe^{3+}) is very insoluble in waters of pH 6-8 where its solubility is in the range $10^{-6} - 10^{-10}$ mg/*l* (Hem, 1970). By comparison, ferrous (Fe^{2+}) iron is soluble to the extent of 10000 mg/*l* at pH 7, and 100 mg/*l* at pH 8. In the presence of dissolved oxygen, ferrous iron readily oxidises to ferric iron and precipitates as the insoluble ferric oxide or hydroxide. Care should therefore be taken in interpreting iron analyses in groundwater: most of the iron analysed in solution will be present as Fe^{2+}, but deposits of rust-brown insoluble Fe^{3+} hydroxide and oxide are commonly seen in sample bottles, indicating that the groundwater in its natural state contains more iron than is actually analysed. Rust-coloured deposits of iron oxide are common in pipes and fittings carrying groundwater containing iron in solution.

Table 13. AVERAGE COMPOSITION OF GROUNDWATER FROM THE THIRLSTANE BASALT, WESLEY VALE SAND AND MORIARTY BASALT Number of analyses for each aquifer in parentheses

Constituent	Thirlstane Basalt (19)			Wesley Vale Sand (28)			Moriarty Basalt (11)		
	mg/l	meq/l	%meq/l	mg/l	meq/l	%meq/l	mg/l	meq/l	%meq/l
Silica	23	-	-	19	-	-	10	-	-
Iron	<0.3	-	-	<0.4	-	-	<0.1	-	-
Aluminium	<0.2	<0.02	<0.18	<0.2	<0.02	<0.16	<0.2	<0.02	0.48
Calcium	19	0.95	8.34	22	1.10	8.62	6	0.30	7.18
Magnesium	17	1.40	12.3	21	1.73	13.6	7	0.58	13.9
Sodium	80	3.48	30.6	81	3.52	27.6	29	1.26	30.1
Potassium	2.5	0.06	0.53	3.4	0.09	0.71	1.6	0.04	0.96
Carbonate	nil	-	-	nil	-	-	nil	-	-
Bicarbonate	156	2.56	22.5	87	1.43	11.2	18	0.30	7.18
Sulphate	16	0.33	2.90	32	0.67	5.25	10	0.21	5.02
Chloride	92	2.59	22.7	149	4.20	32.9	52	1.47	35.2
Total dissolved solids	363	11.39	-	425	12.76	-	168	4.18	-
Total hardness	119	2.4	-	148	2.6	-	44	0.9	-
Alkalinity	128	2.6	-	72	1.4	-	14	0.3	-
pH	7.4	-	-	6.4	-	-	6.3	-	-
Percent sodium	60	-	-	56	-	-	61	-	-
Sodium adsorption ratio	3.6	-	-	22.8	-	-	2.0	-	-
Residual sodium carbonate	0.21	-	-	0	-	-	0	-	-

Note:

Variation diagrams graphically depicting the relationships between various constituents are included as Figures 22–30.

ALUMINIUM (Al)

Aluminium is a major component of igneous rocks where it occurs in alumino-silicates such as feldspars, micas and feldspathoids. It is highly resistant to removal by percolating groundwater, tending to remain after weathering in clay minerals. It is therefore a minor constituent of most groundwater.

SILICA (SiO_2)

After oxygen, silicon is the most abundant element in the earth's crust, and in combination with oxygen as silica or silicate minerals is the major component of most rocks. It is present in basalts in feldspars, olivines, pyroxenes, feldspathoids and occasionally as free silica. Silica is extremely resistant to weathering and is usually a minor constituent of groundwater. In a complex series of steps, silicate minerals break down to SiO_2, H^+ (removed by hydrolysis), clay and mobile cations. Concentrations of SiO_2 up to 100 mg/*l* are fairly common in groundwater, but its solubility is reduced by the presence of $CaCO_3$. Silicate ions enter hydrolysis reactions readily, removing H^+ from solution and sometimes contributing to alkalinity reported as HCO_3^- and $CO_3^=$.

CHLORIDE (Cl)

Chlorine is only a minor constituent of most rocks (in igneous rocks it occurs in feldspathoids and apatite) and the most important source of the element in groundwater appears to be either from connate water in sedimentary rocks, or from cyclic chloride from sea water. Oceanic chloride is circulated widely in the meteorologic cycle, originating as dissolved Na^+ and Cl^-, or particulate NaCl, during evaporation from the oceans. Airborne chloride may be carried long distances inland from the oceans in this way. Cyclic chloride is present in groundwater to the extent of about 1–10 mg/*l* on average, but locally in coastal areas values may be much higher. Often, Cl and Na are the major ions in solution in groundwater, and water high in one element will usually be high in the other.

SULPHATE (SO_4)

Sulphur or sulphates are not important constituents of igneous rocks and the major sources of sulphate are probably industrial air pollution (burning of coal, etc.), the solution of evaporite minerals (e.g. gypsum) in sedimentary rocks, and the oxidation of particulate sulphide minerals in sediments. Both sodium and magnesium sulphate are very soluble, and sulphate is thus stable in most groundwater conditions.

BICARBONATE (HCO_3) AND CARBONATE (CO_3)

Because of the relative abundance of carbonate minerals in sedimentary rocks, and because carbon dioxide is readily available from the atmosphere, either HCO_3^- or $CO_3^=$ are to be expected in most groundwater. Percolating rainwater is weakly acidic because it contains carbonic acid (H_2CO_3) formed during precipitation from atmospheric carbon dioxide. Carbonic acid dissociates weakly in solution so that as long as CO_2 is present, the system $H_2O–CO_3^=–HCO_3^-$ is maintained at equilibrium:

$$H_2CO_3 \Leftrightarrow H^+ + HCO_3^- \Leftrightarrow H^{+} + CO_3^=$$

This balance is altered if CO_2 is allowed to escape (e.g. pumping groundwater to the surface from a bore) and under these conditions $CaCO_3$ is likely to precipitate from solution if Ca is present in sufficient quantities. Conversely, any conditions which increase the solubility of CO_2 in groundwater increases the solubility of $CaCO_3$. Groundwater may contain several hundred mg/*l* of CO_2 in solution, but CO_2 is rarely present in waters with pH <8.2. At this pH value, the theoretical ratio of $HCO_3^-:CO_3^=$ is 100:1. In more acidic waters, HCO_3^- is the predominant anion of the two. At pH <4.5, bicarbonate is usually absent.

Chemical characteristics of the groundwater from various rock types

THIRLSTANE BASALT

An average of nineteen analyses of groundwater from the Thirlstane Basalt (table 13) indicates that the water can be described as low to medium salinity, slightly alkaline, hard, NaCl – $NaHCO_3$ – $Mg(Ca)HCO_3$ type. The average pH is 7.4, with a range of 6.9–8.2. The average salinity is 363 mg/*l*, ranging from 68–685 mg/*l*. The relative abundances of cations and anions are Na>Mg>Ca, Na<Cl, and Cl $\approx HCO_3 \gg SO_4$. Since most samples were obtained during pump testing of bores, and were derived from various levels in a confined aquifer, contamination of shallower unconfined groundwater is unlikely. On this basis, it can be assumed that some of the Na, and most of the Ca, Mg and K, are derived from the weathering of silicate minerals in the basalt. Bicarbonate is enriched relative to water from the Wesley Vale Sand and Moriarty Basalt, and it is possible some of the bicarbonate originated from breakdown of secondary minerals containing carbonate. The source of some of the Cl may be explained by the same process, and juvenile water, rich in chlorine, is a recognised phenomenon of volcanic activity.

WESLEY VALE SAND

Groundwater from the Wesley Vale Sand (table 13) is slightly acidic on average, with a mean pH of 6.4 but varying over a wide range from 4.7–9.8. Most of the analyses were obtained from shallow wells. Samples with the lowest and highest pH also showed the lowest salinities. The water in general is very hard, moderately saline, of the NaCl–Mg (Ca) HCO_3 type. Typically, Na>Mg>Ca, Na<Cl and $Cl > HCO_3 > SO_4$. The average salinity is 425 mg/*l*, with a range of 61–1490 mg/*l*.

MORIARTY BASALT

Groundwater from the Moriarty Basalt is slightly acid (table 13), of low salinity, soft-moderately hard, and of the NaCl type. The relative abundances of cations and anions are Na>Mg>Ca, Na≈Cl, $Cl \gg HCO_3 \approx SO_4$. There is a marked contrast between the relative percentages of anions between groundwater from the Moriarty and Thirlstane Basalts. In the former, bicarbonate is only of minor importance, and ranks equally with sulphate, but in the latter, both chloride and bicarbonate are predominant and equal constituents. Most of the analyses from the Moriarty Basalt are from wells tapping the upper levels of the aquifer, and it is probable the ionic proportions reflect more closely the original composition of rainwater. If such is the case, then percolation of water through the Thirlstane Basalt produces a relative and absolute enrichment of bicarbonate, relative depletion but absolute enrichment of chlorine and sulphate, and an absolute enrichment (but relatively no change) of iron, calcium, magnesium, sodium and potassium. Silica increases markedly in the lower basalt, and as expected, the relative decrease in aluminium reflects its propensity to remain in clay minerals.

The average salinity of water from wells in the Moriarty Basalt is 168 mg/*l*, with a range of 70–300 mg/*l*. The average pH is 6.3, with a range of 4.7–9.7.

Suitability of the groundwater for domestic use

The chemical quality of groundwater as determined by the type, quantity and relative abundances of dissolved constituents governs its suitability for different uses. The following general comments, summarised in Table 14, refer only to the inorganic constituents of groundwater.

TOTAL DISSOLVED SOLIDS (TDS)

Total dissolved solids is the residue left after evaporation of the water sample in the laboratory. It may differ from the computed total dissolved solids obtained by summing the individual constituents reported in the analysis because some constituents may not have been separately determined, and others previously analysed may be partially or totally reduced during evaporation (e.g. bicarbonate to carbonate).

Water with a TDS value less than about 500 mg/*l* generally has little or no taste and is suitable for human consumption and general domestic uses as well as all agricultural purposes. Values higher than 500 mg/*l* may indicate the water is unsuitable for drinking but there is no recommended upper limit for drinking water supplies: consumer acceptability is a function of necessity and adaptation. Communities and individuals may have no choice in the matter and often accept poorer quality water if no other is available. Nevertheless, water with TDS >1500 mg/*l* is generally unsuitable for drinking. In this respect, virtually all the groundwater in the district, from all three major aquifers, is suitable for drinking. Water from bore 4 (Shearwater Country Club) is probably not fit for drinking, and water from two wells (74 and 75) near Port Sorell is similarly unsuitable.

HARDNESS

Hardness (simply, the soap-wasting effect of the water) is caused by the presence of bicarbonates, chlorides, sulphates and nitrates of calcium and magnesium. All these compounds are relatively soluble, but boiling or heating the water reduces the bicarbonates to insoluble carbonates, causing the release of carbon dioxide and the deposition of a calcium and magnesium carbonate encrustation on pipes, fittings, domestic appliances (including kettles and saucepans) and hot water cylinders. *Temporary hardness*, removed in this way by boiling the water, is caused by these insoluble carbonates. *Permanent hardness* is due to the presence, if any, of the remaining chlorides, nitrates and sulphates. The following commonly adopted scale of hardness (expressed as an equivalent amount of $CaCO_3$) is an indication of the usefulness of the water:

0–60 mg/*l* $CaCO_3$	soft
61–120 mg/*l* $CaCO_3$	moderately hard
121–180 mg/*l* $CaCO_3$	hard
>180 mg/*l* $CaCO_3$	very hard

Water from the Thirlstane Basalt is on average (table 13) moderately hard; that from the Wesley Vale Sand is hard and from the Moriarty Basalt, soft. Water from individual bores in the district may therefore range from soft to very hard.

IRON

Iron is a highly objectionable constituent in water supplies for domestic use, and its recommended upper limit in this regard is 0.3 mg/*l*. Values higher than this are a nuisance rather than a physiological danger since pipes, pumps, fittings and laundered clothing may become stained with rust-brown iron oxides and hydroxides. As indicated earlier, care must be taken when interpreting iron analyses in water. The concentrations in analyses (table 13; Appendices 5, 6, 7) indicate only the dissolved iron present in solution at the time of analysis and may not reflect the total iron present in the groundwater. Some iron is removed by oxidation before collection, and during storage when ferric iron precipitates:

$$2Fe^{3+} + 4HCO_3^- + H_2O + O_2 \rightarrow 2Fe(OH)_3 + 4CO_2$$

The reaction requires only one molecule of oxygen for the precipitation of four molecules of ferric hydroxide. Where groundwater high in iron is to be used in reticulated domestic supplies, advantage may be taken of the propensity of iron to precipitate by aerating the water at the extraction site, or elsewhere in the reticulation system, possibly into temporary holding tanks which can be economically replaced if necessary.

On average, groundwater from the Thirlstane and Moriarty Basalts has an acceptably low iron content for domestic use (table 13). Water from the Wesley Vale Sand is marginal. Individual bores and wells in all aquifers vary considerably in iron content, and water from bores 2, 4, 5, 18, 19, 20 and wells 72, 77 and 79, may need to be aerated for domestic use.

CALCIUM AND MAGNESIUM

Calcium and magnesium contribute to hardness. Excessive calcium may be a factor in the formation of body concretions (e.g. kidney stones). Working levels for calcium are set mainly because of its detrimental effects through hardness. Magnesium affects the taste of water and its hardness, and in the presence of sulphate may cause gastrointestinal irritation. According to Hart (1974) recommended levels for magnesium are 30–150 mg/*l*, depending on the sulphate concentration. If sulphate exceeds 250 mg/*l* then magnesium should not exceed 30 mg/*l*. If sulphate is less than 250 mg/*l*, up to 150 mg/*l* of magnesium, may be tolerated. All the groundwater in the district is suitable with respect to calcium and magnesium.

BICARBONATE AND CARBONATE

Bicarbonate and carbonate contribute to hardness, but in terms of health there is no upper recommended limit for either constituent. Carbonate is absent from groundwater with pH <8.2, and only two samples (from well 84, pH = 9.8, and well 91, pH = 9.7) showed any carbonate. Bicarbonate does not exist in water below pH 4.5. None of the samples analysed was as acid as this, although bore 96 (pH = 4.8) and wells 9 (pH = 4.7) and 68 (pH = 4.7) showed very low bicarbonate levels.

SULPHATE

Excess sulphate in drinking water causes gastrointestinal irritation, and the recommended level for domestic supplies is about 250 mg/*l* (Hart, 1974). Wells 10 and 76 exhibited values of 208 and 200 respectively, but these are extreme cases. The average sulphate content of groundwater from the Thirlstane Basalt, Wesley Vale Sand and Moriarty Basalt is 16, 32 and 10 mg/*l* respectively.

CHLORIDE

Excessive amounts of chloride impart taste to water and in this regard the general upper limit for drinking supplied is 200 mg/*l*. Levels up to 600 mg/*l* may be tolerated if necessary (Hart, 1974). Chloride also causes corrosion of domestic hot water cylinders, and Wellington (Department of Mines, pers. comm.) has devised recommended working limits for Tasmanian conditions (table 15). On average, water from the Thirlstane Basalt, Wesley Vale Sand and Moriarty Basalt has chloride contents of 92, 149 and 52 mg/*l*, respectively (table 13). On this basis, most of the water will be satisfactory in hot water cylinders, but some may cause corrosion and a few are definitely not recommended. On average, water from both the Wesley Vale Sand and the Moriarty Basalt has Rl values greater than 2, but chloride levels from the Moriarty Basalt are generally low.

SODIUM

Sodium is not a detrimental constituent of domestic water unless the level exceeds about 270 mg/*l*. This level may be too high for people on severe sodium-restricted diets. The average sodium content (table 13) for the Thirlstane Basalt, Wesley Vale Sand and Moriarty Basalt is 80, 81 and 29 mg/*l* respectively. Two bores (4 and 7) and two wells (74 and 75) have sodium levels between 200 and 300 mg/*l*, but these are isolated cases. High sodium with respect to calcium and magnesium may cause problems if the water is used in irrigation (see below).

pH

pH expresses the concentration of hydrogen ion (H^+) in solution, which is a measure of the alkalinity or acidity of the water. A pH of 7 is neutral; acid waters have pH's between 0 and 7, and alkaline waters pH's between 7 and 14. Domestic water should have a pH in the range 6.5–9.0, and preferably 7–8.5. Many of the samples analysed show pH levels outside this preferred range, and in a few cases some waters are decidedly acid (wells 8, 9, 68 and 96) or alkaline (bore 83, wells 84 and 91). On average (table 13), water from the Thirlstane Basalt is near neutral and relatively constant in pH, and water from the Wesley Vale Sand and Moriarty Basalt are both acid (pH 6.4 and 6.3 respectively) and show large variations in pH.

TOXIC TRACE ELEMENTS AND BIOLOGICAL QUALITY

Various trace elements (notably lead, mercury, cadmium, nitrate nitrogen, fluorine, arsenic, chromium, boron and barium) have toxic effects on humans if they exceed recommended limits. It is not expected that their concentrations in bore waters are sufficient to cause a hazard and they are not normally analysed.

Waters intended for domestic consumption may or may not be potable even if in terms of dissolved chemical constituents they are apparently suitable. A biological analysis is needed to determine whether the water contains deleterious bacterial constituents. Most bore waters are safe in this regard, but domestic water drawn from shallow wells may be contaminated by surface runoff from livestock feeding pens, etc. Such waters should be tested before drinking; inquiries may be made to the Government Analyst, Hobart or the Department of Primary Industry Laboratories, George Street, Launceston.

Table 14. CLASSIFICATION OF DOMESTIC DRINKING WATER WITH RESPECT TO DISSOLVED CONSTITUENTS AFFECTING SUITABILITY (adapted from Hart, 1974)

Class[1]	←B→	←C→	←D→
Constituent	Preferred level (mg/*l*)		Recommended working level (mg/*l*)
Cl	<200	200	600
SO_4	<50	50	250
Ca	<75	75	200
Mg[2]	<30	30	150
Fe	<0.1	0.1	0.3
Na	<20	20	270
TDS	<500	500	1500
hardness	<50	100	500
Cu		0.3	1
Mn		0.01	0.01–0.05
P			0.2
Zn		1	5
Alkalinity	<30	30	500
pH	7–8.5		6.5–9.0

1. B = desirable, C = can be tolerated, D = is unsatisfactory

The effect on groundwater of pesticides and insecticides has not been determined in the study area. A sampling and monitoring programme is recommended.

Table 15. SUITABILITY OF WATER FOR DOMESTIC HOT WATER CYLINDERS *(after Wellington, Dept. of Mines Laboratories, Launceston, pers.comm.)*

Class[1]	←A→	←B→	←C→	←D→
TDS	200	500	1500	
Cl	35	100	200–250	
RI[2]		2		
pH	6–8	6–8		

1. A = suitable for town supplies
   B = probably satisfactory
   C = may be used but corrosion likely
   D = not recommended.
2. RI = Cl/Alkalinity, (mg/*l*). Should not exceed 2 for satisfactory operation.

Suitability of the groundwater for agricultural and irrigation use

Agricultural irrigation is the largest consumptive use of groundwater in the district, and its importance is certain to increase. Evaluation of the suitability of groundwater (and surface water) for irrigation must consider the quality of the water, nature of the soil, type of crop irrigated, climate and good management practice. All these factors are variable. Some aspects of water quality affecting irrigation are discussed here, but details may be obtained from publications dealing more fully with the subject (e.g. Hart, 1974, from which much of the following is derived).

Table 16. GENERAL CRITERIA FOR IRRIGATION WATER SALINITY (from Hart, 1974)

Class	Total dissolved solids (mg/*l*)	Electrical conductivity (μS/cm)
Class 1 (C1): Low salinity water, generally safe; little chance of salinity problems, some leaching needed on clayey low-permeability soils.	0–175	0–280
Class 2 (C2): Medium salinity water; may be used if moderate leaching occurs; Plants with medium salt tolerance may be grown. Sprinkler irrigation may cause leaf-burn in sensitive crops.	175–505	280–805
Class 3 (C3): High salinity water; cannot be used on soils with restricted drainage. Soils must be permeable; salt-tolerant crops need to be considered.	500–1500	800–2300
Class 4 (C4): Very high salinity-water, not generally suitable for irrigation; soils must be permeable, drainage adequate, water applied in excess to promote leaching; salt-tolerant crops selected.	1500–3500	2300–5500

TOTAL DISSOLVED SOLIDS

The salinity or total dissolved solids content of irrigation water is a very important aspect of water quality. High salinity causes an increase in the osmotic pressure of the soil solution resulting in a decreased availability of nutrients and water to plants. This effect is related more to the total salinity of the irrigation water rather than to the concentrations of individual ionic species. The accompanying salinity criteria (table 16) adapted from Hart (1974) show that soils, crops, climate and irrigation methods all influence the suitability of the water.

Groundwater from the Thirlstane Basalt, Wesley Vale Sand and Moriarty Basalt is C2, C2 and C1 respectively. Individual samples vary widely in salinity, and although most water is suitable for irrigation, some bores yield high salinity water (C3), i.e. bore 4 and wells 67, 71, 74 and 75, all from the Wesley Vale Sand, and bore 7 from the Thirlstane Basalt.

SODIUM, PER CENT SODIUM AND SODIUM ABSORPTION RATIO

Sodium is of considerable importance in irrigation water, as it may accumulate in the soil by ion exchange. The magnitude of the effect is related to the total salinity of the water, and the relative abundance of sodium with respect to calcium and magnesium. The suitability of irrigation water containing these ions may be evaluated in terms of per cent sodium and sodium absorption ratio:

$$\text{Percent sodium} = \frac{100\,(Na + K)}{Na + K + Ca + Mg} \quad (\text{in meq}/l)$$

$$\text{Sodium absorption ratio SAR} = \frac{Na}{\sqrt{(Ca + Mg)/2}} \quad (\text{in meq}/l)$$

Undesirable soil effects may occur in poorly drained soils irrigated with medium-high salinity water if percent sodium considerably exceeds 50. On average (table 13) water from the Thirlstane Basalt, Wesley Vale Sand and Moriarty Basalt show similar values: 60, 56 and 61 respectively. Both the highest (86, bore 1) and lowest values (26, bore 15) occur in the Thirlstane Basalt. Values from the Moriarty Basalt show much less scatter (from 51–74). Per cent sodium from groundwater in the Wesley Vale Sand varies from 26 to 77.

The relationship between per cent sodium, salinity and suitability for irrigation use is conveniently shown in Figure 22. Water from the Moriarty Basalt is restricted to a relatively small field of salinity and per cent sodium, and most samples are classed as excellent to good for irrigation uses. Water from the Thirlstane Basalt varies from permissible to doubtful over a wide range of percent sodium values but a relatively narrow salinity range. Water from the Wesley Vale Sand shows a wide scatter of both percent sodium and salinity, and its suitability for irrigation use varies from good to unsuitable in any condition. The diagram also shows that, during pumping, consecutive water samples (e.g. from bores 7, 15, 18, 20) from the Thirlstane Basalt decreased in salinity, calcium and magnesium, and showed a resultant increase in per cent sodium.

Irrigation water containing sodium may also be classed as low-sodium (S1), medium-sodium (S2), high-sodium (S3) or very high-sodium (S4) according to the ratio of sodium to calcium and magnesium (fig. 23). Water from the Moriarty Basalt is confined to a very restricted area in the low-sodium field, and most of the waters from the Thirlstane Basalt and the Wesley Vale Sand are scattered over the low-sodium field. Samples from bores 4 and 7 in the Thirlstane Basalt are medium-sodium water. During pumping, analyses of consecutive samples show a decrease in both sodium and calcium and magnesium so that the overall trend is towards the low-sodium field. The suitability of the four water classes for irrigation uses is described by Hart (1974) as:

Low-sodium water (S1) can be used on most soils, but sodium-sensitive crops (e.g. stone fruit trees) may be affected.

Medium-sodium water (S2) may be a problem if fine-grained and clayey soils are irrigated. No problems on well drained granular and sandy soil.

High-sodium water (S3) may cause problems on most soils and will require high leaching, good drainage and some management.

Very high-sodium water (S4) is generally unsatisfactory for irrigation except at low-medium salinity levels.

The extent to which the sodium content of the soil is increased by irrigating with sodium water is related to the sodium absorption ration (SAR) of the irrigation water and the exchangeable sodium percentage (ESP) of the soil. In general, water with SAR <4 is suitable for most soils and crops, and for most crops a range in SAR of 8–18 is probably satisfactory depending on the type of soil. In Figure 24, where SAR is plotted against total ionic concentration (salinity) all the groundwater in the district has SAR values less than 8, and most are below 4, so no problems are expected. The graph is also divided into various fields of salinity and sodium content as described above, so that C2–S1, for example, is a medium salinity-low sodium water. Most water in the district is either C2–S1 or C3–S1.

BICARBONATE HAZARD

Irrigation water becomes more concentrated in soils because of evapo-transpiration, and in waters high in bicarbonate there is a tendency for the proportion of bicarbonate to increase in soil water by the precipitation of calcium and magnesium as unstable carbonates. This reduction in Ca + Mg will cause an increase in SAR and may ultimately produce a sodium hazard where, from analysis of the water, none previously existed. There is thereforen a relationship between bicarbonate and sodium hazard, and the likelihood of water causing such damage to soils is described by the *residual sodium carbonate* (RSC):

$$RSC = (HCO_3^- + CO_3^=) - (Ca^{2+} + Mg^{2+}) \text{ (in meq/}l\text{)}$$

RSC is therefore the *excess* of titratable alkali over the calcium + magnesium ions. Water with RSC greater than about 2.5 meq/*l* are not generally suitable for irrigation, values in the range 1.25–2.5 meq/*l* are marginal, and waters with less than 1.25 meq/*l* RSC are probably safe. In cases where permeable soils occur and no better water is available, RSC values up to 6 meq/*l* may be used on selected crops.

Most of the groundwater analysed from the district has little or no RSC. Samples from bores 1, 7, 8, all in the Thirlstane Basalt, have marginal values in the range 1.25–2.5.

CROP TOLERANCE LEVELS AND STOCK SALINITY LIMITS

Plants vary widely in their tolerance to water and soil salinity, and within each crop-type salt-tolerance may vary according to the age of the plant. Many crops show decreasing growth rate and size with increasing water and soil salinity, and most fruit crops are more sensitive than vegetables or forage crops. An indication of salt-tolerance in various plants is given in Table 17, but the actual effect of saline water depends also on the frequency and type of irrigation, seasonal and daily times of irrigation, and soil type and drainage. Most of the groundwater in the district will present no problems during irrigation.

Salinity limits for stock are shown in Table 18.

Table 17. CROP TOLERANCE LIMITS (adapted from Hart, 1974)

Water Class	Electrical conductivity (μS/cm)	Total dissolved solids (mg/*l*)	Crop	Remarks
1–2	0–800	0–505	Clover, most stone fruits, strawberry, blackberry, beans, peas, onion, carrot, potato, lettuce, cucumber, parsnip, most ornamentals	Avoid wetting leaves on hot days
3	800–2300	500–1500	Perennial type grass, apple, pear, raspberry, cauliflower, cabbage, broccoli, tomato	Avoid wetting leaves during day; water quickly, using continuous-wetting sprinklers
4	2300–5500	1500–2500	Oats (hay) wheat (hay), rye (hay), lucerne, barley, spinach, beets, asparagus, kale	Avoid wetting leaves if possible. Adequate leaching necessary

Table 18. SALINITY LIMITS FOR STOCK (Hart, 1974)

	Desirable maximum salinity (mg/*l*)	Maximum salinity to maintain good condition (mg/*l*)
pigs, poultry	2000	3000
horses	4000	6000
dairy cattle	3000	4000
beef cattle	4000	5000
sheep, dry feed	6000	13000

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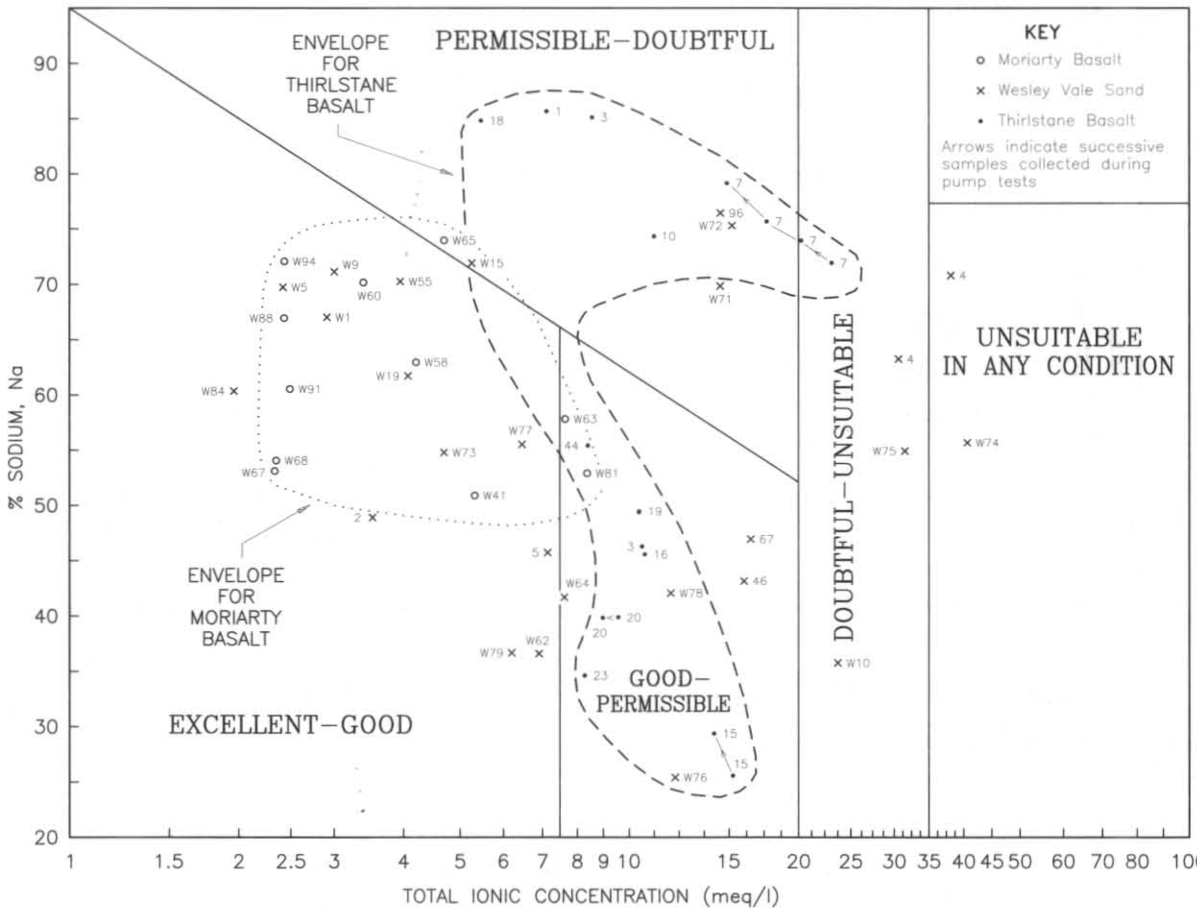

Figure 22. Suitability of groundwater for agricultural use: per cent sodium criterion.

5 cm

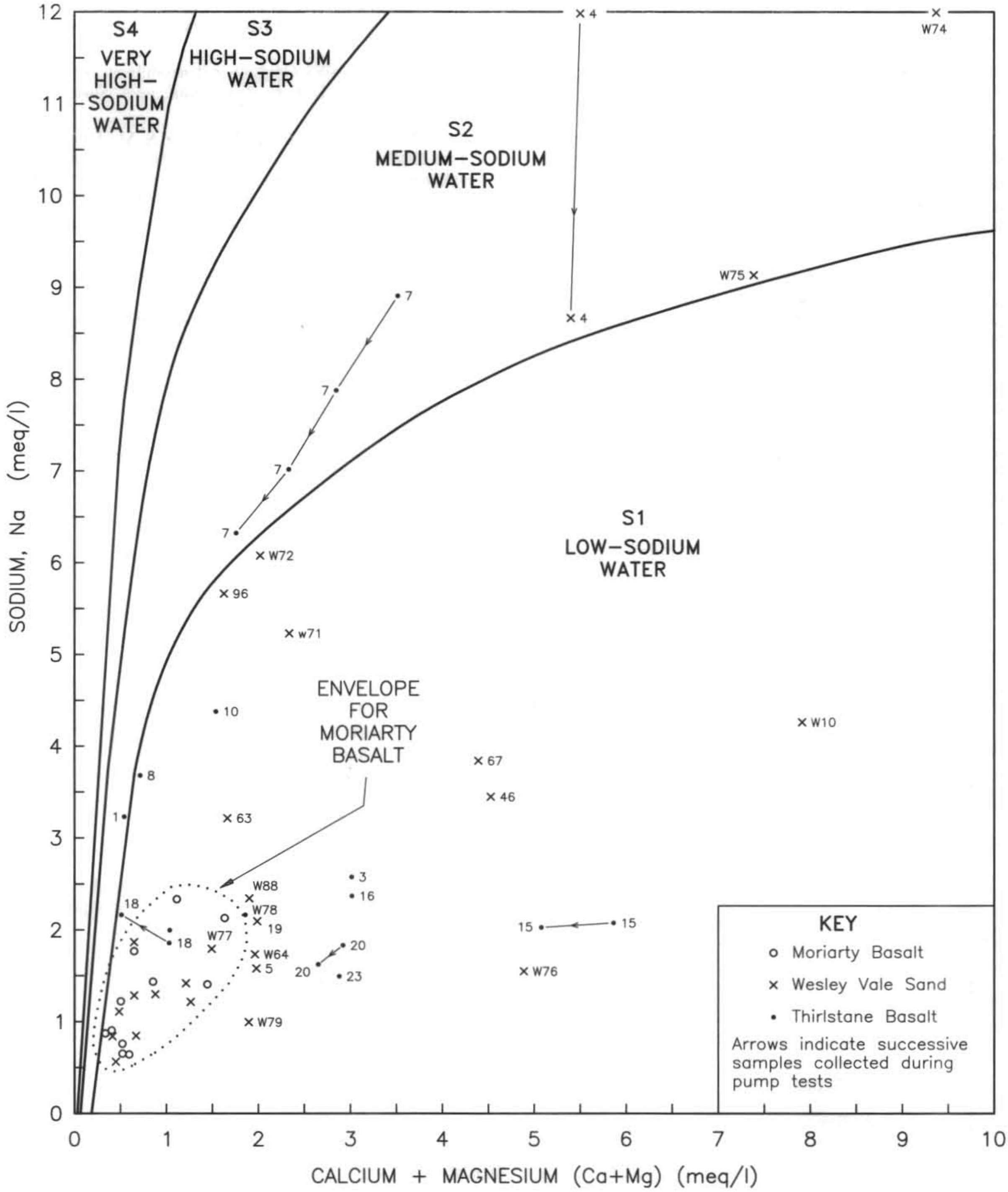

Figure 23. Water quality criteria for sodium water.

5 cm

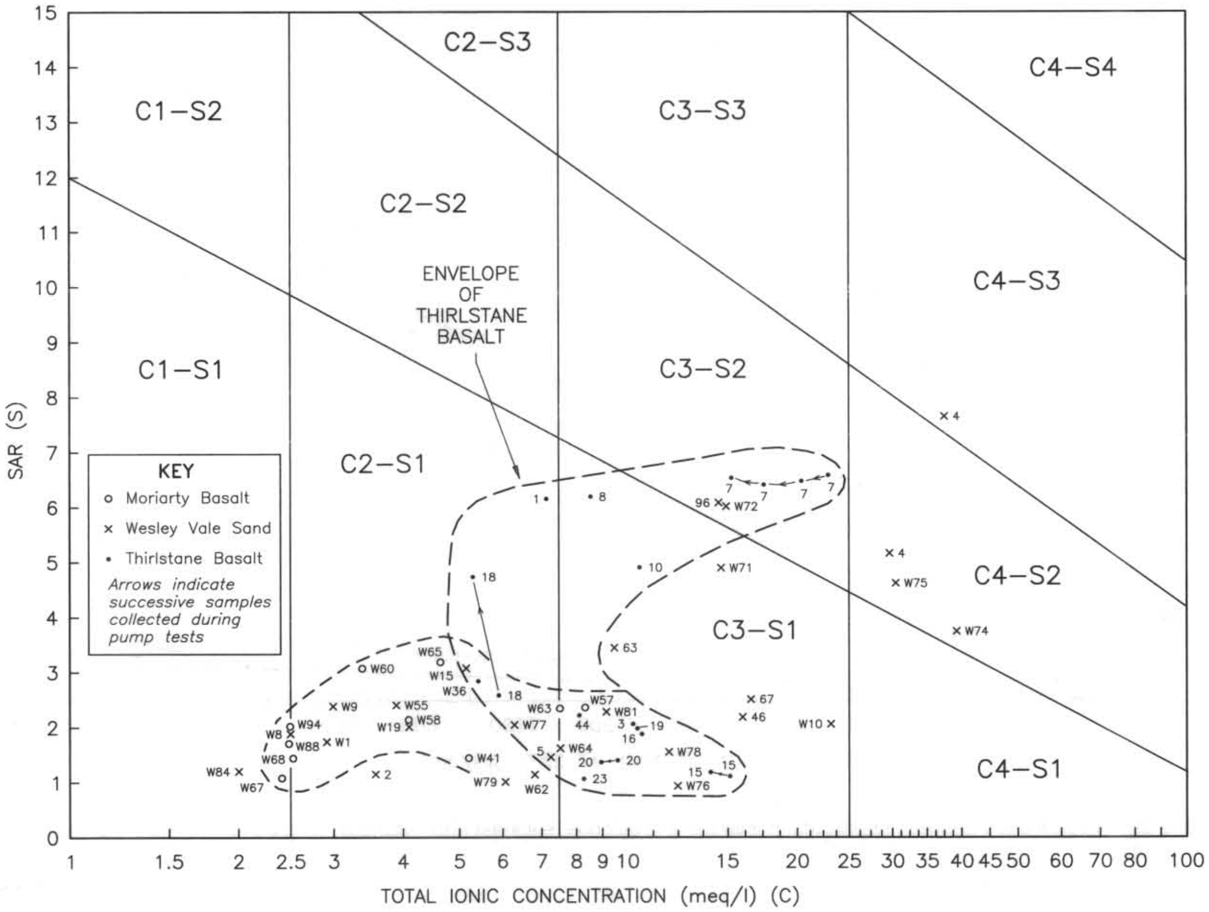

Figure 24. Suitability of groundwater for agricultural use: Sodium Absorption Ratio.

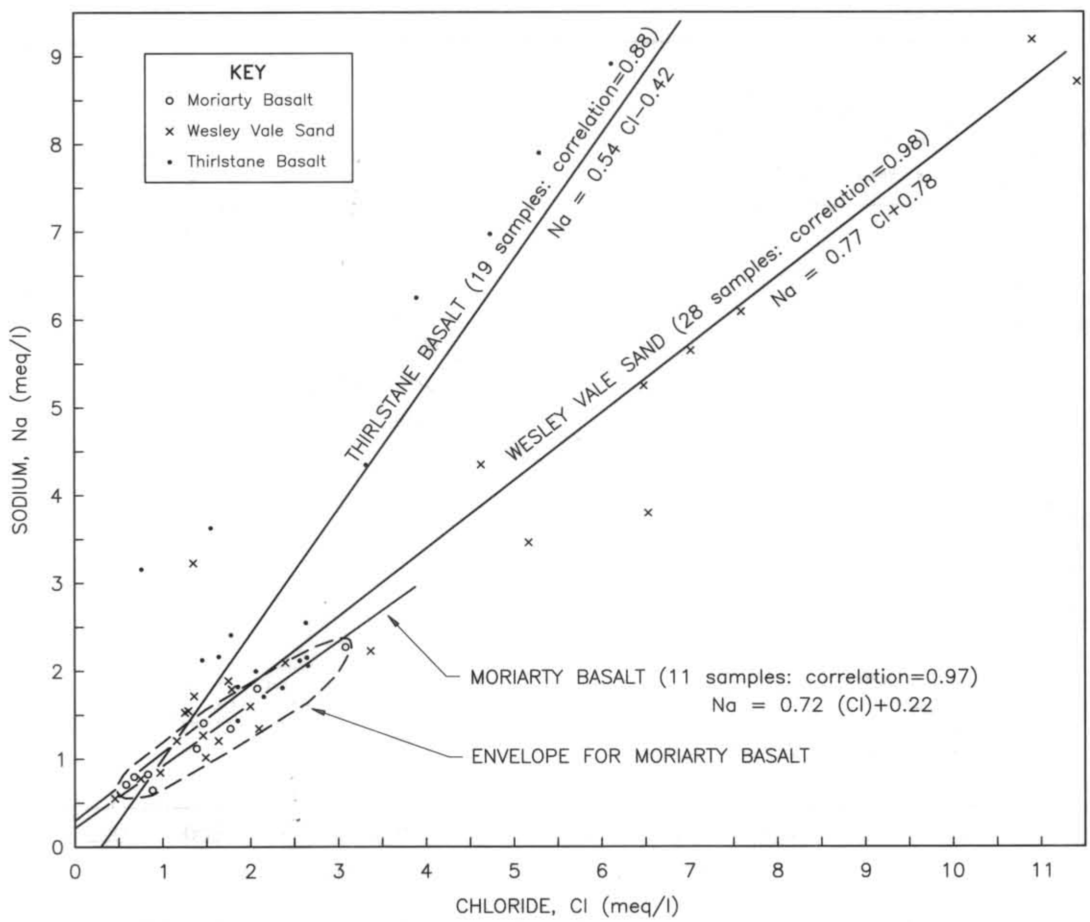

Figure 25. Sodium-chloride variation diagrams for groundwater from the Thirlstane and Moriarty Basalts, and the Wesley Vale Sand.

5 cm

5 cm

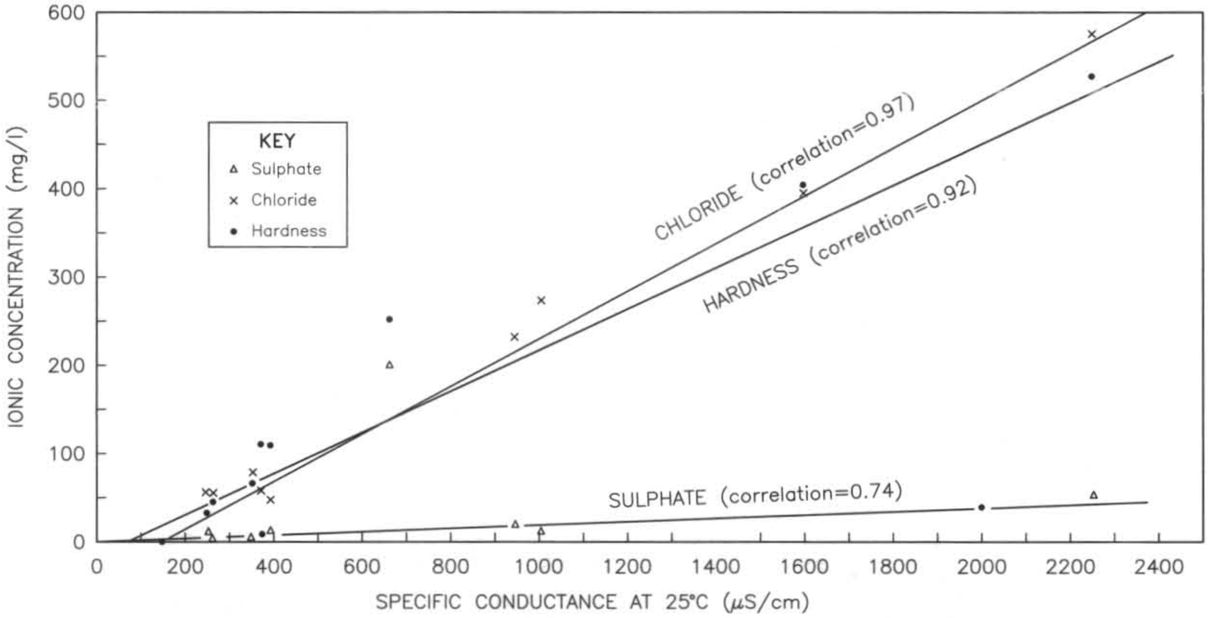

Figure 26. Relationships between specific conductance, and chloride, sulphate and hardness, for groundwater from the Wesley Vale Sand.

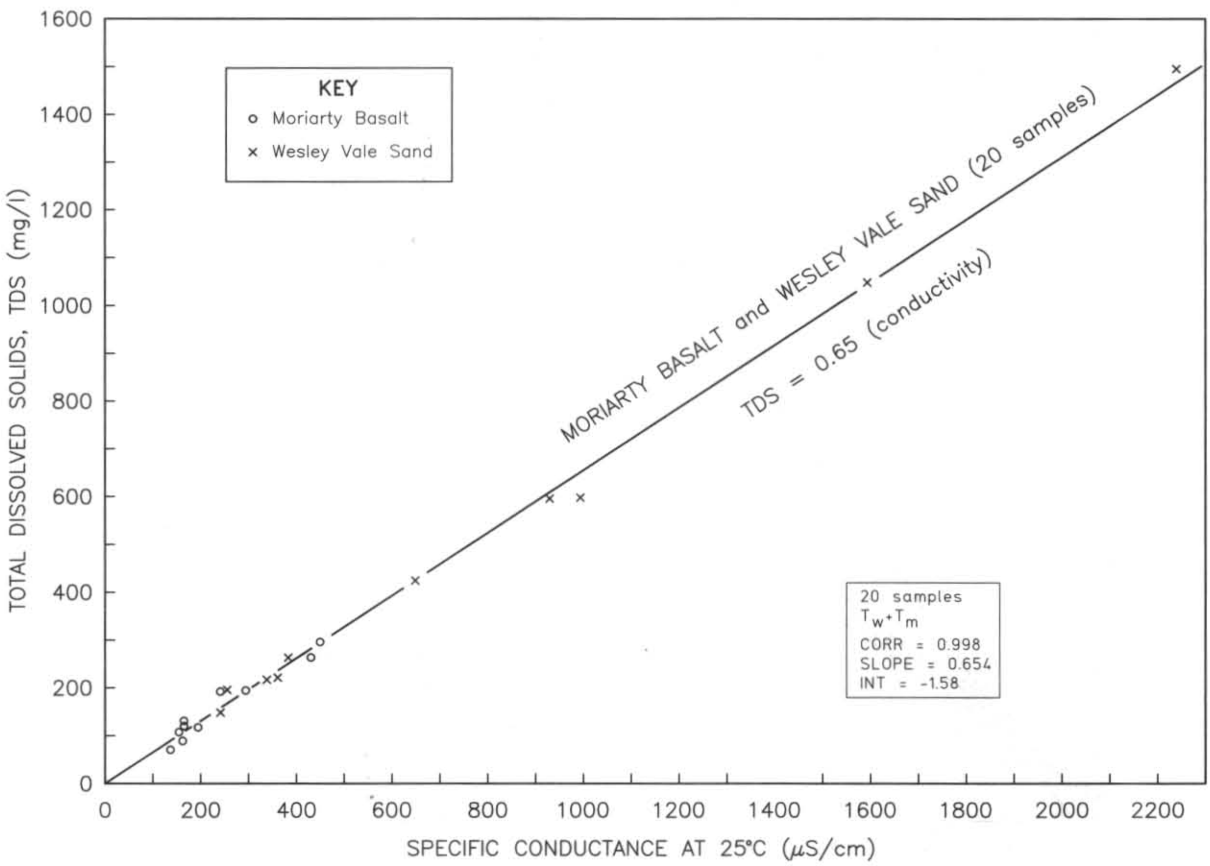

Figure 27. Relationship between specific conductance and total dissolved solids for groundwater from the Wesley Vale Sand and Moriarty Basalt.

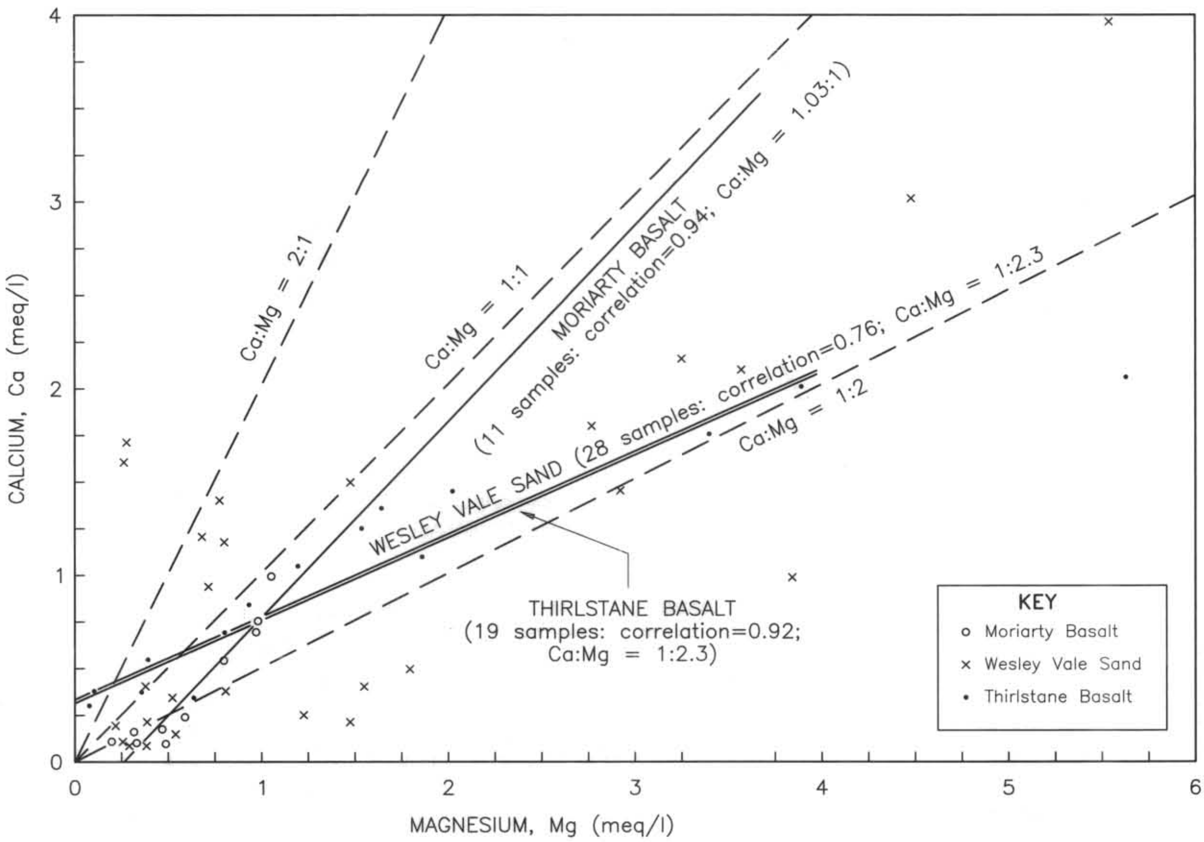

Figure 28. Calcium-magnesium variation diagram for groundwater from the Thirlstane and Moriarty Basalts, and the Wesley Vale Sand.

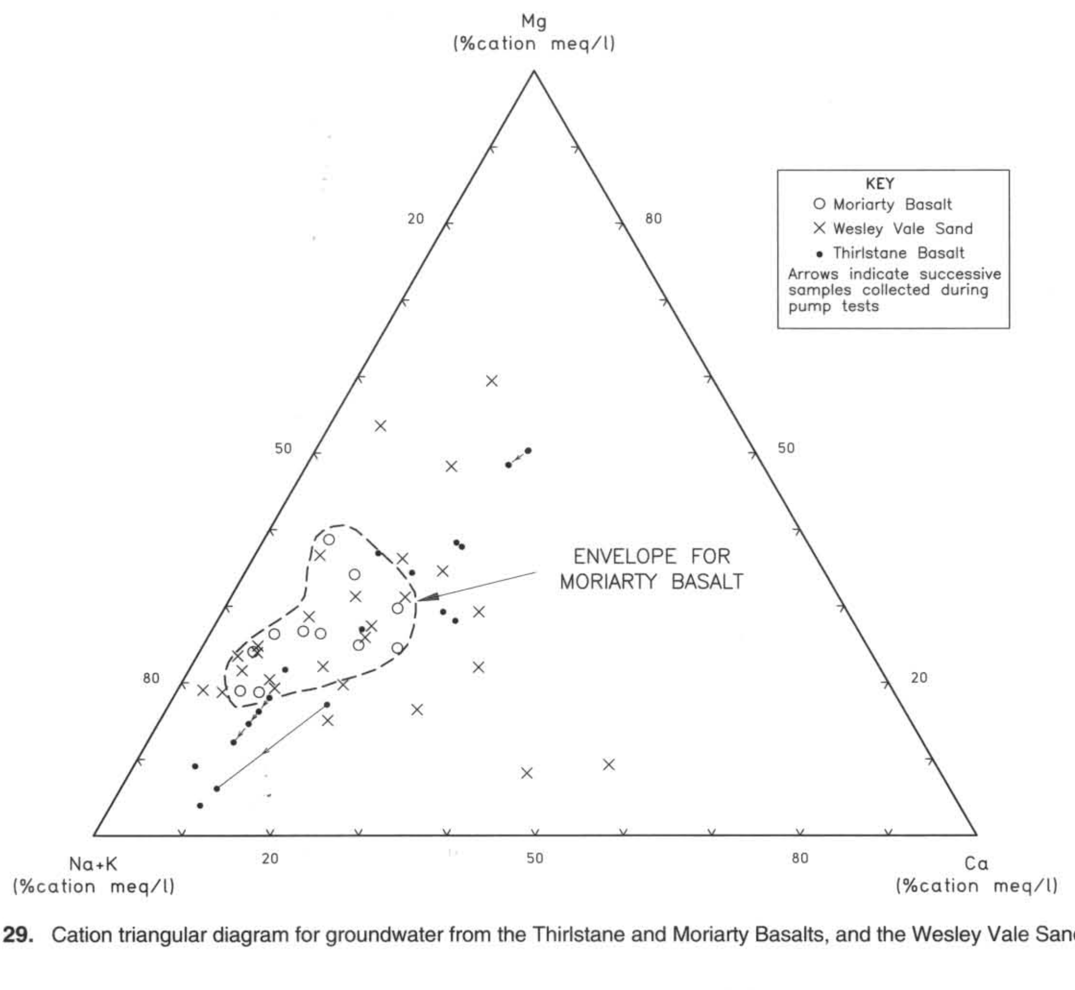

Figure 29. Cation triangular diagram for groundwater from the Thirlstane and Moriarty Basalts, and the Wesley Vale Sand.

5 cm

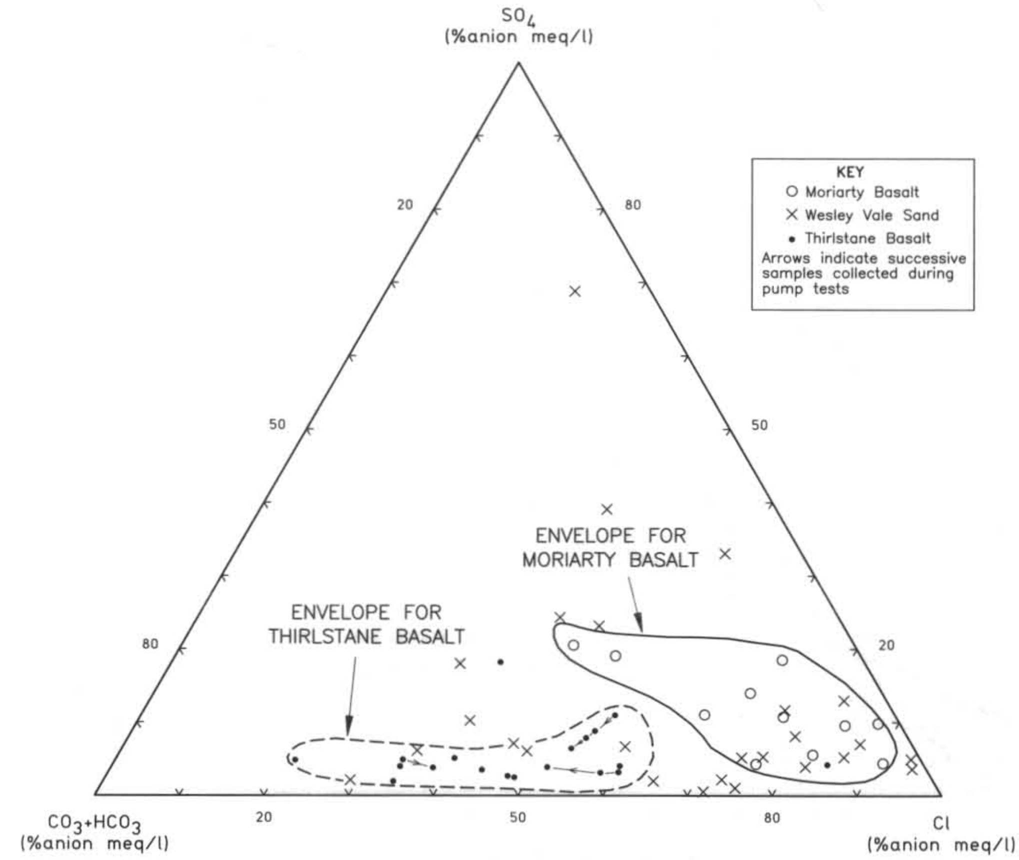

Figure 30. Anion triangular diagram for groundwater from the Thirlstane and Moriarty Basalts, and the Wesley Vale Sand.

5 cm

Appendix A

DEPARTMENT OF MINES STRATIGRAPHIC DIAMOND DRILL HOLES IN THE DEVONPORT – PORT SORELL – SASSAFRAS AREA, 1973 – 1977

Bore	Date drilled	AMG co-ordinates[1]	Altitude *(m)*	Total depth *(m)*	Summary geological log (depths in metres)
Findlay's, Wesley Vale	27.6.1973– 5.2.1974	543400	60	365.6	0–9.2 ironstone quartz gravel and gravelly clay, 9.2–61.5 basalt, 61.5–62.1 tuff, 62.1–148.5 basalt, 148.5–165.3 tuffaceous sediments and agglomerate, 165.3–365.6 mudstone
Oliver's, Eastford Creek	5.1974– 3.1975	585327	80	333.0	0–6.0 clayey sand, 6.0–9.0 basalt, 9.0–24.5 tuffaceous(?) sediments, 24.5–53.0 basalt, 53.0–57.7 agglomerate and weathered basalt, 57.7–333.0 mudstone
Wilson's, Northdown	30.10.1976– 6.5.1977	562405	95	236.2	0–49.6 completely weathered basalt, 49.6–62.4 alternating shale and friable sandstone, 62.4–185 basalt and interbedded tuff and agglomerate, 185–208.2 tuff and agglomerate, 208.2–236.2 sandstone and mudstone
Richardson's, Sassafras	2.6.1977– 12.7.1977	593297	150	101.5	0–19.9 completely weathered basalt, 19.9–26.0 fresh basalt, 26.0–77.5 mudstone, carbonaceous shale, friable sandstone, 77.5–79.8 weathered dolerite, 79.8–101.5 dolerite

Note:

1. Approximate Australian Map Grid Co-ordinates, 100-kilometre grid square prefix: DQ.

Appendix B
SUMMARY OF OIL EXPLORATION BORES IN THE DEVONPORT – PORT SORELL – SASSAFRAS AREA

Bore	Date completed	AMG co-ordinates[1]	Altitude *(m)*	Total depth *(m)*	Geological log (depths in metres)	Driller
Windy Ridge	n.d.	574369	60	n.d.	not available	n.d.
Racecourse	1922	532353	35	203.4	0–4 clay, 4–203.4 Permian sandstone and mudstone	Mersey Valley Oil Company
Staggs	1922	535353	45	305.0	0–3 clay, 3–4 weathered Permian sandstone, 4–301.6 sandstone, mudstone, conglomerate and shale, 301.6–305.0 dolerite	Mersey Valley Oil Company
Haines	1922	501389	50	87.2	0–5.8 clay, 5.8–87.2 Permian sandstone and mudstone	Mersey Valley Oil Company
Burgess	1923	608343	100	355.3	0–18.3 Clay, sand, soft sandstone, 18.3–168.4 basalt, 168.4–338.6 clay, gravel, lignite, 338.6–355.3 dolerite	Adelaide Oil Exploration Company
Iles	1923	613363	43	335.5	0–7.9 clay and ironstone, 7.9–117.7 basalt, 117.7–124.4 tuffaceous material, 124.4–126.6 basalt, 126.6–335.5 clay and sand with lignite, 335.5 quartz sand	Adelaide Oil Exploration Company
Parsons	1923	605359	60	353.8	0–18.3 clay, gravel and conglomerate, 18.3–115.6 basalt, 115.6–351.4 mudstone and soft sandstone, and lignite	Mersey Valley Oil Company
Hermitage	1923	584359	55	204.4	0–12.2 basalt, 12.2–131.8 mudstone, clay and sand, 131.8–204.4 dolerite	Mersey Valley Oil Company
Northdown Beacon	1923	561431	20	n.d.	Bottomed in dolerite. No log available	–
Northdown Foreshore	1923	580448	<10	206.2	0–6.7 pebbles, 6.7–205.6 Permian sandstone, mudstone and quartzite, 205.6–206.2 Precambrian(?) quartzite	Adelaide Oil Exploration Company
Parkers Ford	10.2.67	610408	20	305.0	0–38 sand, 38–151 basalt, 151–180 sand, 180–305.0 dolerite	C. G. Sulzberger
Elphinstone	29.4.67	624394	20	381.0	0–332 sand and clay, 332–381.0 dolerite	C. G. Sulzberger
Browns	5.7.67	619399	20	335.0	0–256 sand and clay, 256–335.0 dolerite	C. G. Sulzberger
Hardys	24.9.67	618364	60	381.0	0–34.7 sand and clay, 34.7–94.5 basalt, 94.5–365.8 sand and clay, 365.8–381.0 dolerite	C. G. Sulzberger

Note:
1. Approximate Australian Map Grid Co-ordinates, 100-kilometre grid square prefix: DQ.

Appendix C
HAND-DUG WELLS IN THE DEVONPORT – PORT SORELL – SASSAFRAS AREA

(well numbers correspond to those in Figure 4)

Well no.	Owner and address	AMG co-ordinates[1]	Depth *(m)*[2]	SWL *(m)*[2]	TDS[3]	Date visited	Status[4]	Use[5]	Frequency of use	Situation	Date dug	Construction; surface dimensions *(m)*	Remarks[6]
1	B. Richardson, Harford	617348	r4	flowing	75	5.1972	o	dom, s	often	slope	pre–1935	concrete, 2 × 2	A722374, sy=20, e, gravel bottom
2.	B. Richardson, Harford	619354	r4	flowing	–	5.1972	o	dom, s	daily	gully	1963	unlined, 4 × 4	sy=20, e, clay bottom
3.	H. B. Richardson, Thirlstane	621383	r14	variable	190	5.1972	o	dom, s	daily	flat	pre–1900	brick, 1–3	A722375, sy=70, e, flowing in winter
4.	E. R. Green, 'Grange', Moriarty	580372	r≈10	r1	255	5.1972	o	dom	–	hill flat	pre–1920	–	A722377, e, weathered basalt bottom
5.	E. R. Green, 'Grange', Moriarty	582372	r>10	–	–	5.1972	o	s	often	slope	–	–	–
6.	Webb, 'Harbury', Moriarty	569373	r>8	r6	–	5.1972	c	–	–	flat	–	concrete, 1.3	in weathered basalt
7.	D. Oliver, Moriarty	563378	–	3	–	5.1972	o	dom	–	slope	–	concrete, 1.3	e, in sand and clay
8.	L. Bramich, Moriarty	573303	r6	r1	20	5.1972	o	dom, g	–	slope	pre–1960	unlined	A722376, e, summer SWL=6, clay/sand bottom
9.	Murdoch, Moriarty	573387	r≈125	r9	95	5.1972	o	dom	–	slope	–	1.3	A722370, sometimes dry, Tertiary sediments
10.	Iles, Thirlstane	598379	r4	r1.5	505	5.1972	o	s, g	daily	slope	–	concrete, 4 × 3	A722372, e, occ. flowing, Tertiary sediments
11.	E. R. Green, 'Grange', Moriarty	612369	–	6	220	5.1972	o	dom	–	slope	–	concrete, 1	A722368, e
12.	E. R. Green, 'Grange', Moriarty	611371	>6	2	–	5.1972	a	–	–	slope	–	unlined, 1.6 × 1.6	–
13.	K.C. Cross, Harford	622377	r4	r0.6	f130	5.1972	o	dom, s	daily	flat	–	concrete, 1.3	e, in ironstone and Tertiary sediments
14.	–	625377	r5	–	–	5.1972	–	–	–	flat	–	–	in ironstone and Tertiary sediments
15.	W. Bailey	625385	–	4	200	5.1972	o	dom	–	flat	–	concrete, 1.3	A722371, e, in Tertiary sediments

Notes:
1. Approximate Australian Map Grid co-ordinates. 100-kilometre Grid Square: DQ.
2. Depths, and standing water levels (SWL), measured during survey, unless otherwise indicated as reported (r) by owners.
3. Values are field salinity (f) measurements (total dissolved solids) made using a portable conductivity meter. Values *not* preceded by f were obtained from full laboratory analysis.
4. a = abandoned, c = capped, o = operating.
5. d = drinking, dom = domestic, excluding drinking, g = garden, i = irrigation, s = stock.
6. sy (where given) = esimated safe yield in *l*/min, e = electric pump, w = windmill; SWL ±2 m = annual fluctuation in water level; A722372 = registered number of Department of Mines water analysis, listed in Appendices 5–7.

Well no.	Owner and address	AMG co-ordinates[1]	Depth *(m)*[2]	SWL *(m)*[2]	TDS[3]	Date visited	Status[4]	Use[5]	Frequency of use	Situation	Date dug	Construction; surface dimensions *(m)*	Remarks[6]
16.	W. Bailey	624385	–	flowing	–	5.1972	o	s	–	flat	–	–	in Tertiary sediments
17.	W. Bailey	624384	–	2	–	5.1972	o	s	–	flat	–	–	w, in Tertiary sediments
18.	G. Anderson, 'Winterfield'	608384	r4	flowing	'high'	5.1972	o	s	seldom	flat	1969	unlined	in Tertiary sediments
19.	Mitchellson	609387	r4	r1.3	f165	5.1972	o	dom, s	–	flat	1958	concrete	e, A770275, never dry, in Tertiary sediments
20.	B. & J. Slater, Moriarty	566358	r8	r1	135	5.1972	o	dom, s	–	slope	pre–1930	concrete, 2	A722373, e, SWL ±2m, Tertiary basalt
21.	H. L. Bramich, Newground	578348	r7	3	280	5.1972	o	dom, s	daily	slope	pre–1920	brick, 1	A722816, e, SWL ±7m, Gravel bottom
22.	F. Towner, Newground	579346	>7	6.5	–	5.1972	o	dom?	–	slope	1972	concrete, 1	e, bottom in yellow clay and basalt fragments
23.	Beveridge	600356	r8	–	–	5.1972	o	dom	daily	slope	pre–1975	–	high TDS when SWL low
24.	Thomas	595353	r11	r6	290	5.1972	o	dom	daily	slope	–	unlined	A722813, sy=10, 0–3 m clay, 8–11 m sand, clay
25.	Dawson	563349	r14	–	–	5.1972	c	–	–	hilltop	'old'	–	in weathered basalt?
26.	Dawson	567348	r8	5	–	5.1972	o	dom	daily	gully	–	–	in Tertiary sediments? runs dry
27.	–	554356	r5.5	–	–	5.1972	o	–	–	–	recent	backhoed	water struck 5.5 m
28.	N. Badcock, Moriarty	571361	r5	1.5	245	5.1972	o	s	daily	slope	–	brick	A722815, e, basaltic clay bottom
29.	Ingram, Sassafras	579289	r8.5	–	–	5.1972	o	s	–	flat	–	–	in weathered basalt
30.	J. Casey	508384	r16	r4	160	5.1972	o	dom	–	slope	≈1940	brick, 1	A723871, e, w, in doleritic clay. SWL ±1m
31.	Baldock	509388	r13	–	–	5.1972	o	dom, s	seldom	slope	–	brick	in clay
32.	Baldock	510387	r4	flowing	–	5.1972	o	s	–	slope	–	–	–
33.	L. Mundy	507389	–	–	120	5.1972	o	dom	–	slope	≈1950	–	A723870, in clay?
34.	Badcock	503391	–	3	140	5.1972	o	dom	–	slope	–	unlined, 1.3	A723872, in Tertiary sediments near dolerite
35.	G. D. Douglas	523385	r14	11	–	5.1972	o	s	–	hill flat	–	1.3	w, in weathered basalt
36.	D. Peirce	523390	r>9	9	280	5.1972	o	s	–	hill flat	–	–	A728367, e, in weathered basalt
37.	McWhirter	518397	r4	1.5	250	5.1972	o	dom	–	gully	–	–	A723862, in creek deposits
38.	Allen	508404	415	5	225	5.1972	o	dom, s	daily	–	–	brick, 1.5	A723865, w, in dolerite, soap turns hot water green
39.	Winspear	518404	r18	–	–	5.1972	c	s	–	hilltop slope–	–	–	in weathered basalt
40	Winspear	517406	r8	–	–	5.1972	o	dom	–	slope	–	–	in weathered basalt
41.	A. C. Duff, Northdown	577416	r15	6	240	5.1972	o	–	–	slope	–	–	A723868 in weathered basalt

Well no.	Owner and address	AMG co-ordinates[1]	Depth (m)[2]	SWL (m)[2]	TDS[3]	Date visited	Status[4]	Use[5]	Frequency of use	Situation	Date dug	Construction; surface dimensions (m)	Remarks[6]
42.	Thomas, Northdown	near 565425	r22	–	–	7.1972	c	dom	–	slope	1900–1910	–	in weathered basalt
43.	Thomas, Northdown	near 565425	–	flowing	250	7.1972	o	dom	–	slope	–	–	A723863, in weathered basalt, flows 20 l/min
44.	Thomas, Northdown	near 565425	r15	–	–	7.1972	o	–	–	slope	–	–	in weathered basalt, fails in dry autumn
45.	Thomas, Northdown	near 565425	–	flowing	–	7.1972	c	–	–	slope	–	–	in weathered basalt, excavator spring, flows 10 l/min
46.	Thomas, Northdown	near 565425	r9	–	–	7.1972	o	dom, s	–	slope	–	–	in weathered basalt
47.	Thomas, Northdown	near 565425	r23	–	–	7.1972	c	–	–	slope	–	–	0–15 m weathered basalt, 15–23 m basalt, sy low
48.	Thomas, Northdown	near 565425	–	–	–	7.1972	a	–	–	slope	pre–1900	–	originally deep, in basalt, near house
49.	Thomas, Northdown	near 565425	–	–	–	7.1972	a	–	–	slope	pre–1900	–	originally deep, in basalt, near house
50.	Thomas, Northdown	near 565425	r18	–	–	7.1972	o	dom, s	–	slope	1971–1972	–	in basalt
51.	Thomas, Northdown	565428	spring	flowing	1025	7.1972	o	i	–	slope	–	–	A723866, sy=10, water leaves white residue
52.	Loane, Northdown	562415	r28	r10	335	7.1972	o	dom	daily	flat	–	2.5	A723864, in basalt, SWL ±2–3m
53.	Latrobe Council (Port Sorell)	625428	r15	1	5140	11.1.1977	c	–	–	flat	–	concrete, 1–3	A770120, in Quaternary sediments
54.	J. Cubit, Port Sorell	621422	41	0.9	high	11.1.1977	o	i	often	flat	1973	concrete, 2	in sand
55.	A. Brown, Wesley Vale	539400	excavated spring	flowing	150	12.1.1977	o	dom, i	often	gully	–	unlined, 1.5	A770116, in Tertiary sediments
56.	A. Brown, Wesley Vale	535405	–	–	–	12.1.1977	c	–	–	gully	≈1870	–	w, in Tertiary sediments
57.	A.C. Duff, Northdown	571419	10	5	300	12.1.1977	o	d, dom, s	often	hilltop	–	unlined, 1.5	A770123, e, in weathered basalt
58.	A.C. Duff, Northdown	579418	5	1.9	200	12.1.1977	o	dom	often	slope	≈1890	brick, 2	A770122, w, in weathered basalt
59.	Post Office, Wesley Vale	54398	–	–	–	12.1.1977	o	dom	often	flat	–	1.5	e, w, in Tertiary sediments
60.	P. Bryan, Wesley Vale	565410	–	0.6	120	12.1.1977	o	d, dom	often	gully	–	3.5	A770117, e, pumped 75 l/min
61.	E.R. Wilson, Wesley Vale	554405	15	3.2	–	12.1.1977	o	dom	often	flat	–	concrete, 1.3	e, in weathered basalt
62.	E.R. Wilson, Wesley Vale	543402	3	1	230	12.1.1977	c	–	–	flat	≈1890	unlined, 2	A770118, in Tertiary sediments

Well no.	Owner and address	AMG co-ordinates[1]	Depth *(m)*[2]	SWL *(m)*[2]	TDS[3]	Date visited	Status[4]	Use[5]	Frequency of use	Situation	Date dug	Construction; surface dimensions *(m)*	Remarks[6]
63.	E.R. Wilson, Wesley Vale	556400	13	10	270	12.1.1977	c	i	seldom	gully	≈1890	concrete, 1.6	A770114, in Tertiary basalt
64.	G. Manard, Wesley Vale	537399	r5.5	2	270	18.1.1977	o	dom, i	often	flat	1969	unlined, 6	A770145, e, in clay
65.	J. Byron, Northdown	556408	8	–	200	18.1.1977	o	s	often	gully	1927	unlined, 1.3	A770146, w, clay bottom
66.	A.C. Leave, Northdown	558413	r21	r15	–	18.1.1977	o	dom, s	often	hilltop	1938	unlined, 1.3	w, in weathered basalt
67.	G. Hall, Northdown	565390	r7	r4	89	18.1.1977	o	d, dom, s	often	flat	≈1910	unlined, 1.3	A770148, in weathered basalt?
68.	G. Hall, Northdown	567391	6.5	5	120	18.1.1977	o	d, dom, s	often	flat	1941	unlined, 1.3	A770147, w, in weathered basalt?
69.	G. Hall, Northdown	564400	6	4	240	18.1.1977	o	s	often	flat	pre–1920	unlined 1.3	A564400, w, in weathered basalt?
70.	G. Hall, Northdown	562389	7	5	–	18.1.1977	o	s	seldom	slope	pre–1920	unlined 1.3	–
71.	G. Ray, Port Sorell	611423	spring	0	605	25.1.1977	o	i	often	slope	–	–	A770280, never dry
72.	Cutts, Port Sorell	613424	spring	–	600	25.1.1977	o	g	often	gully	1975	excavated, dam	A770277, e, in Tertiary sediments
73.	D. Sheehan, Port Sorell,	616425	1.3	1.1	220	25.1.1977	–	–	–	flat	1976	unlined, 1.3	A770278, e, in Tertiary sediments
74.	Quinn, Port Sorell	609438	3	1.3	1490	25.1.1977	o	dom	seldom	flat	1976	concrete, 1.3	A770276, e
75.	K. Sharman, Port Sorell	608439	4.5	2	1050	25.1.1977	o	i	often	flat	1966	asbestos, 1 × 1	A770272, e, Tertiary sand and clay, with hard pan
76.	D. Jones, Squeaking Point	634398	3.2	2.5	430	26.1.1977	c	dom, s	seldom	flat	–	concrfete, 2 × 1.5	A770279, e
77.	Squeaking Point	635398	–	1	230	26.1.1977		dom, i	–	gully	–	2 × 2	A770274
78.	Squeaking Point	638403	3.3	2	370	26.1.1977	o	dom, i	often	slope	–	concrete, 1	A770270, e, near coast, in Tertiary sediments
79.	G. Atkins, Squeaking Point	635400	2.7	1.3	270	26.1.1977	o	dom	seldom	gully	–	concrete, 2.5	A770281, e, in Tertiary sediments
80.	J. Peart, Squeaking Point	637405	5.5	4	–	26.1.1977	c	–	–	flat	–	concrete, 3 × 3	e, in Tertiary sediments
81.	Elphinstone, Squeaking Point	626392	3.1	1.6	300	27.1.1977	o	s	–	flat	–	concrete, 1.5	A770271, w, in Tertiary sediment
82.	N. Storey, Squeaking Point	626398	3	2	260	27.1.1977	o	s	often	rise	pre–1960	concrete, 1.5	A770273, w, in Tertiary sediments
83.	Port Sorell	619430	spring	–	270	27.1.1977	–	–	–	gully	–	dammed	A770269, in Quaternary sediments
84.	M. Elphinstone, 'Brookhead'	615322	r5–6	r0	70	9.1977	o	dom	daily	flat	≈1960	unlined	A772995, e
85.	Pixley, 'Elphin Grove'	621311	–	–	–	9.1977	a	–	–	flat	pre–1910	unlined, 2	w
86.	P. Rockcliff, Sassafras	592314	r15	r12	–	9.1977	o	dom	–	flat	pre–1900	unlined, 2.5	in weathered basalt
87.	P. Rockcliff, Sassafras	695311	r5	r1	–	9.1977	o	s	seldom	flat	pre–1900	unlined, 2.5	in weathered basalt, sy=10

Well no.	Owner and address	AMG co-ordinates[1]	Depth *(m)*[2]	SWL *(m)*[2]	TDS[3]	Date visited	Status[4]	Use[5]	Frequency of use	Situation	Date dug	Construction; surface dimensions *(m)*	Remarks[6]
88.	C. Richardson, 'Brierley Grove'	587299	–	–	130	9.1977	o	d, dom, s	daily	flat	–	unlined, 2	A772996, e, corrosive, (pH=5.3), weathered basalt
89.	D. Yaxley, 'Westfield'	579305	–	–	–	9.1977	o	dom	daily	gully	–	–	e
90.	D. Lamprey	603293	–	r0.6	–	9.1977	o	dom	–	slope	pre–1920	unlined, 2.5	–
91.	D. W. Rockcliff	593287	r3.5	0	110	9.1977	o	dom, s	daily	flat	pre–1900	–	A772997, e, pH=9.7
92.	K. L. Chilcott	603285	>5.5	4.2	–	9.1977	c	–	–	flat	pre–1955	galv.iron, 1.7	–
93.	F. B. Elphinstone, 'Sea View'	613337	r10	–	–	9.1977	o	dom, s	daily	flat	pre–1920	unlined, 1.6	e
94.	R. Richardson, Sassafras	574318	r10	0	70	9.1977	o	d, dom, s	daily	flat	–	unlined, 8	A772999, e
95.	P. Laycock, 'Ingomar'	579288	–	–	–	9.1977	o	dom	daily	flat	–	unlined, 1.6	e
96.	M. Serafin, Northdown	585414	r6	r4	180	11.1977	o	d, dom, s, i	daily	flat	–	unlined, 1.5	A773181, e, water turns blue with soap
97.	Clark, Northdown	595401	r10	r2	–	11.1977	o	d, dom, s, i	daily	gully	1977	unlined, 3 × 3	e
98.	Blyth	591393	r8	r2	240	11.1977	o	dom, s, g	daily	flat	–	unlined 1.5	A773182, w
99.	Blyth	592392	r5	–	–	11.1977	o	i	daily	flat	–	unlined, 1.5	e, sy>100
100.	E. J. Chaplin	581393	r8.5	r5.5	–	11.1977	o	d, dom, s	daily	flat	pre–1880	unlined, 1.2	
101.	E. J. Chaplin	584394	r9	r4	–	11.1977	o	s	daily	flat	pre–1935	unlined, 1	w
102.	J. D. Chaplin	584391	r deep	–	–	11.1977	o	dom, g	daily	flat	pre–1925	brick	e
103.	C. McDonnell	538366	r5	–	–	11.1977	o	d, dom, s	–	–	≈1950	unlined, 1.6	e
104.	McCulloch	541366	r3	r2.1	110	11.1977	o	d, dom, s, g	daily	flat	–	unlined, 1.3	A773183, w
105.	De Haan, Wesley Vale	538368	r3	–	–	11.1977	o	dom, s	daily	flat	–	unlined, 1.6	e
106.	Dick, Wesley Vale	539380	r7	r6	–	11.1977	o	s, g	–	flat	≈1945	unlined, 1.6	e, w
107.	W. Campbell, Wesley Vale	525375	r10	r1.2	–	11.1977	o	dom, s	daily	flat	pre–1850	unlined, 1.3	e
108.	R. Bellchambers, Wesley Vale	524379	r15	–	200	11.1977	o	s	daily	flat	–	unlined, 2	A773184, w
109.	T. Bellchambers, Wesley Vale	523376	r7	–	–	11.1977	o	s	daily	flat	≈1957	unlined, 2	w
110.	D. White, Wesley Vale	535374	r10.6	r10	–	11.1977	o	dom	daily	flat	≈1930	unlined, 1.3	e

Appendix D
RESULTS OF DRILLING FOR WATER IN THE DEVONPORT – PORT SORELL – SASSAFRAS AREA, 1967 – 1988

Bore	Owner and address	Date completed	AMG ref.[1]	Total depth (m)	SWL (m)[2]	Yield (l/min)	TDS[3]	Driller's log (aquifer italicised)[4]	Remarks[5]
1.	E. R. Green, 'The Grange', Moriarty	26.6.74	579373	142	9	90	270	0–81 weathered fresh *basalt*, (Tt), 81–142 grey gravelly clay	D, o, g, p, s, w
2.	M. Findlay, 'Tullock Farm', Wesley Vale	19.7.74	538370	26	1	90	180	0–26 *sand, grit*, (Tw), clayey sand, 26– dolerite	D, c, g, p, s, w
3.	H. Peirce, Wesley Vale	13.9.74	532398	62	16	230	340	0–28 brown clay, 26–62 *basalt* (Tr) weathered in places	D, o, g, p, s, w
4.	Shearwater Country Club, Port Sorell	18.9.74	615431	14	1.5	400	950	0–14 sand and *quartz gravel* (Q?), 14– hard mudstone	D, o, g, p, u, w
5.	P. Clark, Port Sorell	15.10.74	611407	39	1.5	270	220	0–27 *sand* (Tw), 27–39 clay	D, c, g, p, s, w
6.	Crown land, near Port Sorell	25.10.74	625405	18	0.3	<10	200	0–18 clay, *sand, gravel* (Tw) 18– fresh dolerite	D, a, g, s
7.	R. Peirce, 'Moorlands'	8.11.74	532418	65	3	80	470	0–6 basalt boulders, 6–33 clay (weathered basalt?), 33–65 *basalt* (Tt)	D, o, g, p, s, w
8.	A. Dick, Wesley Vale	22.11.74	544390	80	10	230	≈250	0–33 clay and sandy clay, 33–80 *basalt* (Tt)	D, o, g, p, s, w
9.	F. Piper, 'Hillcrest', Moriarty	2.12.74	558382	64	–	dry	–	0–30 clay, clayey sand, 30–64 basalt (Tt)	D, a, g
10.	E. R. Green, Moriarty	16.12.74	610365	64	4	140	340	0–5 weathered basalt, 5–64 *basalt* (Tt)	D, o, g, p, s, w
11.	Richardson Bros., Harford	11.2.75	620355	74	25	35	≈250	0–5 yellow clay, 5–74 *basalt* (Tt)	D, o, g, p, s, w
12.	Skurving Bros, 'Rose Hill', East Sassafras	25.2.75	624296	61	–	dry	–	0–61 grey, brown, blue, green clay (Tw)	D, a, g
13.	P. Rockliff, Sassafras	24.3.75	588305	69	nd	<10	190	0–6.5 weathered basalt, 6.5–15 clayey sand and grit, 15–22 grit, 22–63 tuffaceous (?) sand and grit, 63–69 fresh basalt (Tt)	D, a, g, w
14.	D. Lowe, 'Miranda Vale', Latrobe	10.7.75	536336	44	3	90	350	0–5 clay and sand, 5–44 *mudstone* and *sandstone* (Pm)	D, o, g, p, s, w
15.	A. Richardson, 'Woodfield', Sassafras	22.7.75	575336	50	0	230	440	0–5 clay, 5–50 *basalt* (Tt)	D, o, g, p, s, w
16.	D. Addison, 'Keigh Hill', Newground Road	29.7.75	553339	55	1	230	310	0–13 clay, tuffaceous clay (Tw), 13–34.5 clay and sand clay (Tw), 34.5–55 *basalt* (Tt)	D, o, g, p, s, w
17.	B. Edwards, Port Sorell	6.8.75	601389	38	–	dry	–	0.5 dolerite boulders, clay 5–38 dolerite	D, a, g, s
18.	M. Addison, 'Highfield', Moriarty	13.8.75	562365	58	11	160	160	0–15 clay, 15–17 weathered basalt, 17–58 *basalt* (Tt)	D, o, g, p, s, w
19.	D. Parsons, 'Vernon Park', Thirlstane	20.8.75	590376	61	2	60	280	0–11 clay, ironstone, 11–12 *gravel* (Tw) 12–15 *basalt* (Tt), 15–61 clay	D, a, g, s, w
20.	L. Addison, Harford Road	12.9.75	597342	50	2	760	290	0–15 clay, 15–26 weathered basalt, 26–50 *basalt* (Tt)	D, o, g, p, s, w
21.	M. Elliston, 'Cherry Hills', Latrobe	16.9.75	525335	37	–	dry	–	0–5 clay, 5–37 Precambrian quartzite, siliceous mudstone (Ꝑ)	D, a, g

Notes:

1. All localities lie within AMG 100 kilometre grid square DQ. Precise locations are not always known.
2. SWL = standing water level on completion of well – may fluctuate.
3. TDS = Total dissolved solids (water quality expressed in milligrams per litre, virtually equivalent to parts per million); nd = no data.
4. Depths in metres; Tw = Wesley Vale Sand; Tt = Thirlstane Basalt; Q = Quaternary; Pm = Permian; Ꝑ = Precambrian; nd = no data; WS = water struck – at depths (in metres) during drilling.
5. C = drilled by private contractors; D = drilled by Department of Mines; o = operating; a = abandoned or filled; c = capped; d = divined; g = geologist's log; l = driller's log; p = pump tested; s = (sub)artesian; u = unconfined; w = water analysis available.

Bore	Owner and address	Date completed	AMG ref.[1]	Total depth (m)	SWL (m)[2]	Yield (l/min)	TDS[3]	Driller's log (aquifer italicised)[4]	Remarks[5]
22.	M. Marshall, East Devonport	15.10.75	487402	70	nd	35	nd	0–70 *basalt* (Tt)	D, o, g, s
23.	Badcock Bros, Moriarty	5.7.67	574360	22	1	290	310	0–6 clay, 6–13 *basalt*, 13–19 clay, 19–22 basalt (Tt)	C, o, l, s, w
24.	Badcock Bros, Moriarty	12.10.72	572358	25	1	265	230	0–3 sandy clay, 3–4.5 clay and gravel, 4.5–14 *weathered basalt*, 14–25 basalt (Tt); WS 4–10	C, o, l, s, w
25.	Badcock Bros, Moriarty	30.1.73	573362	15	4	55	nd	0–15 brown and grey clay with patches of *gravel* (Tw)	C, a, l, s
26.	W. Bovill, East Devonport	7.1.73	494414	48	4	230	nd	0–18 brown clay with basalt boulders, 18–48 *basalt* (Tt)	C, o, l, s
27.	W. Bovill, East Devonport	8.1.73	494410	33	25	nd	nd	0–5 clay (with boulders) and minor gravel, 5–33 *basalt* (Tt)	C, a, l, s
28.	A. H. Buchanan, Sassafras	10.3.70	574297	53	–	dry	–	0–4 sandy clay, 4–11 weathered basalt, 11–35 basalt, 35–53 sand over clay	C, a, l
29.	A. H. Buchanan, Sassafras	10.3.70	574298	59	–	dry	–	0–7 clay, 7–18 weathered basalt, 18–24 basalt, 24–59 sand and clay	C, a, l
30.	A. H. Buchanan, Sassafras	4.4.70	578299	48	26	250	nd	0–7 clay, 7–15 weathered basalt, 15–40 *basalt* (Tm), 40–48 *sand, gravel*, clay; WS 28, 41, 45	C, o, l.s
31.	W. N. Cumming, Harford	17.3.70	unknown	38	22	nd	nd	0–6 clay, 6–26 sand, 26–37 basalt, 37–38 *sand;* WS 38, 39	C, o, l.s
32.	Dawson, Moriarty	23.1.73	562368	35	nd	20	nd	0–26 clay, 26–35 *weathered basalt*, 35 basalt (Tt); WS 4, 34	C, a, l, s
33.	D. De Haan, Devonport	15.10.74	508407	24	–	dry	–	0–6 clay, 6–24 dolerite	C, a, l
34.	D. De Haan, Devonport	18.10.74	508408	23	–	dry	–	0–17 clay and gravel, 17–23 dolerite	C, a, l
35.	D. De Haan, Devoport	24.10.74	508407	57	3	50	nd	0–17 clay, 17–24 *basalt and gravel*, 24–29 basalt (Tm), 29–33 *clay*, 3357 basalt; WS 18, 23–32	C, o, l, s
36.	J. Dover, Wesley Vale	8.10.75	541377	21	5	70	220	0–11 *clay*, 11–12 weathered basalt, 12–21 *basalt* (Tt); WS 6, 9–20	C, o, l, s, w
37.	A. C. Duff, Northdown	22.3.70	573419	117	–	dry	–	0–59 clay (weathered basalt, Tm), 59–96 sand and clay, 96–110 sandstone and siltstone (Tw?)	C, a, l
38.	A. C. Duff, Northdown	30.6.72	574415	66	18	90	nd	0–48 *weathered basalt* (Tm), 48–66 sand; WS 14–24	C, c, l, s
39.	A. C. Duff, Northdown	30.6.72	575415	42	89	130	nd	0–19 clay (weathered basalt), 19–42 *basalt* (Tm); WS 15–35	C, c, l, s
40.	A. C. Duff, Northdown	4.73	577416	24	9	≈450	nd	0–24 coloured *clay* (weathered basalt, Tm); WS 4–17	C, o, l, s
41.	T. Fords, East Devonport	26.4.69	unknown	36	4	270	nd	0–3 sand, 3–5 clay, 5–7 tuff, 7–36 *basalt*, >36 clay; WS 27, 29	C, o, d, l, s
42.	B. Freer, Wesley Vale	19.3.70	590423	53	–	3	–	0–1 weathered dolerite, 1–53 dolerite; WS 8	C, a, l
43.	A. C. Hampton, East Devonport	16.8.73	490394	33	12	30	342	0–22 clay and minor gravel, 22–33 *basalt;* WS 24	C, o, d, l, s, w
44.	E. Heald, Wesley Vale	11.6.71	518402	25	5	350	220	0–18 coloured clay (weathered basalt), 18–25 *basalt* (Tt); WS 18	C, o, a, l, s, w
45.	B. Ingram, Sassafras	2.1.73	583289	34	3	350	nd	0–3 clay, 3–34 *basalt* (Tm), weathered in places	C, o, d, l, s
46.	L. King, Wesley Vale	25.6.71	498392	42	3	50	550	0–6 clay, boulders, gravel, 6–26 *rock*, weathered in places (basalt?), 26–27 *wash, gravel*, 27–35 *rock*, 35–36 wash, 36–39 *rock*, 39–42 clay (Tw)	C, o, l, s, w
47.	D. McKenzie, Devonport	6.10.75	545375	89	24	260	nd	0–33 clay and sand, 33–89 *basalt* (Tt); WS 73–88	C, o, l, s

Bore	Owner and address	Date completed	AMG ref.[1]	Total depth (m)	SWL (m)[2]	Yield (l/min)	TDS[3]	Driller's log (aquifer italicised)[4]	Remarks[5]
48.	J. McLean, Latrobe	19.7.71	unknown	17	9	75	700	0–11 clay, gravel, basalt boulders, 11–25 *basalt* (weathered in places); WS 12–14	C, o, l, s
49.	G. Norris, Wesley Vale	23.10.75	545379	34	3	500	nd	0–14 clay, sand, coal, 14–34 *basalt* (weathered in places, Tt); WS 30–34	C, o, l, s
50.	Norton, Devonport	4.4.72	516416	26	4	65	nd	0–7 gravel, sand with shells, 7–11 weathered basalt, 11–26 *basalt* (Tt); WS 50	C, o, l, s
51.	R. Oliver, Hawley Beach	24.1.73	608441	5	–	dry	–	0–4 sand, sandy clay, 4–5 dolerite	C, a, l
52.	R. Oliver, Hawley Beach	25.1.73	608441	13	3	35	nd	0–3 sand, 3–5 *sandy clay*, 5–9 *gravel*, clay, 9–13 *sandy clay* (Tw), >13 dolerite	C, o, l
53.	D. Parsons, Thirlstane	1.8.67	599361	39	–	dry	–	0–16 clay, basalt boulders, weathered basalt, 16–39 basalt	C, a, d, l
54.	D. Parsons, Thirlstane	2.8.67	599359	15	–	dry	–	0–8 clay, 8–15 basalt (Tt)	C, a, d, l
55.	D. Parsons, Thirlstane	8.10.75	585372	17	8	15	nd	0–11 clay, 11–13 *basalt* (Tt), 13–17 clay WS 11	C, a, l, s
56.	D. Parsons, Thirlstane	9.10.75	586370	30	6	45	nd	0–22 *basalt* (Tt), 22–27 weathered basalt, 27–30 clay; WS 15, 17, 20	C, a, l, s
57.	D. Parsons, Thirlstane	15.10.75	584370	45	6	540	665	0–6 basalt, 6–17 sand, clay, 17–45 *basalt* (Tt), weathered in parts; WS 35, 46	C, o, l, s, w
58.	R. Radford, Bakers Lane	1.10.74	572396	33	–	dry	–	0–6 clay, 6–33 sand (Tw)	C, a, l
59.	R. Radford, Bakers Lane	8.10.74	577396	83	–	dry	–	0–63 clay and sand, 63–83 basalt (weathered in parts, Tt)	C, a, l
60.	R. Radford, Bakers Lane	11.10.74	573384	46	6	1300	213	0–17 clay, 17–46 *vesicular basalt* (Tt), weathered in parts; WS 9+	C, o, l, s, w
61.	U. L. Redpath, Sassafras	26.7.72	565306	35	9	55	nd	0–15 clay (weathered basalt?), 15–35 *mudstone* and *shale* (Pm); WS 21–30	C, c, l, s
62.	J. & B. Slater, Moriarty	14.8.73	570364	81	6	50	nd	0–4 clay (weathered basalt), 4–81 *basalt* (weathered in parts, Tt); WS 4, 8, 16, 50, 79	C, o, d, l, s, w
63.	J. & B. Slater, Moriarty	5.5.69	568357	86	10	650	280	0–7 clay (weathered basalt), 7–86 basalt (Tt); WS 15, 46, 78, 80	C, o, l, s, w
64.	B. Stewart, Thirlstane	4.1.73	616373	43	9	100	nd	0–9 clay and minor *gravel*, 9–43 *basalt* (weathered in parts, Tt); WS 5, 9, 13, 32	C, o, l, s
65.	H. Thomas, Hawley	10.7.74	608441	12	–	dry	–	0–6 sand and clay, 6–12 dolerite WS 6	C, a, l
66.	H. Thomas, Hawley	11.7.74	608441	11	3	15	nd	0–56 *sand* and clay, 6–11 dolerite	C, o, l
67.	A. G. Turnbull, Newground	19.6.71	594348	75	27	130	625	0–3 clay, sand, 3–17 clay (weathered basalt?), 17–75 *basalt* (Tt); WS 64	C, o, l, s, w
68.	E. R. Wilson, Northdown	1.7.74	563403	45	0	60	nd	0–45 clay, sand and 'conglomerate' (running sand 20–30 m)	C, a, l
69.	E. R. Wilson, Northdown	5.7.74	566401	75	27	75	296	0–20 clay, sand, 20–33 *basalt*, 33–75 *clay and basalt* (Tt?)	C, o, l, w
70.	R. Winspear, 'Pardoe'	27.6.74	unknown	26	9	45	nd	0–23 *basalt* (weathered in parts), 23–26 boulders, clay and sand	C, o, d, l
71.	D. Yaxley, Devonport	25.4.70	498381	45	11	300	nd	0–9 clay, 9–26 grey sandy *shale*, 26–45 *shale* (Pm); WS 19, 25, 26, 32	C, o.l, s
72.	D. Yaxley, Devonport	22.1.73	498381	30	–	dry	–	0.3 sandy clay, 3–10 clay, 10–30 grey shale (Pm)	C, a, l

Bore	Owner and address	Date completed	AMG ref.[1]	Total depth (m)	SWL (m)[2]	Yield (l/min)	TDS[3]	Driller's log (aquifer italicised)[4]	Remarks[5]
73.	D. Yaxley, Devonport	23.1.73	492381	29	4	180	nd	0–28 *clay* 28–29 *conglomerate* (Pm), >29 dolerite	C, o, l, s
74.	Westbrook Holdings, Sassafras	23.4.70	unknown	15	1	dry	–	0.2 boulders and clay, 2–15 boulders	C, a, l
75.	Westbrook Holdings, Sassafras	23.4.70	unknown	45	–	dry	–	0.8 clay, 8–16 boulders and clay, 16–22 sand and gravel, 22–23 clay, 23–45 sandy clay	C, a, l
76.	Westbrook Holdings, Sassafras	23.4.70	unknown	30	12	150	na	0–2 clay, 2–22 basalt, 22–23 sand, 23–30 sandy clay and clay; WS 24, 25, 26	C, o, l, s
77.	A. G. Turnbull	6.71	595349	70	27	90	nd	–	C, o, s
78.	C. M. Richardson 'Brierley Grove'	1976	590297	24	0.6	700	nd	0–24 *basalt*, weathered in places (Tm)	C, o, s
79.	R. S. Shadbolt	1968	595318	91	nd	230	nd	nd	C, o
80.	R. Laycock, 'Ingomar', Sassafras	≈1971	583289	nd	na	≤300	nd	In Tertiary basalt	C, o
81.	P. C. Green	11.77	588388	52	nd	50	nd	nd	C, o
82.	D. White, Wesley Vale	18.2.77	538372	43	9	75	nd	0–20 clay and sand, 20–23 weathered basalt, 23–42.7 *basalt* (Tt); WS 23–39.6	C, o, l, s
83.	M. Barnes, East Devonport	11.3.76	488393	53	nd	23	380	0–0.6 topsoil, 0.6–22.5 clay, 22.5–53 *basalt;* WS 23.5	C, o, l, w
84.	E. Beveridge, East Devonport	15.3.76	478402	50	3	265	nd	0–55 clay, 5–38 *basalt*, 38–50 clay; WS 5.5	C, o, l, s
85.	M. & N. De Haan, Wesley Vale	1976	539366	12, 11, 15, 21, 6, 9	all 6 dry	–	–	0–21 sand and clay (Tw), overlying dolerite	C, a, l
86.	W. Duniam, Wesley Vale	16.2.76	542382	30	15	150	230	0–3 clay, 3–7 sand, 7–12.5 clay, 12.5–30 *basalt* (Tt); WS 26	C, o, l, s, w
87.	H. W. Hingston, Wesley Vale	19.11.76	543397	38	6	60	nd	0–1.5 clay, 1.5–16 yellow *sand* (Tw), 16–38 *basalt* (Tt, weathered 21–30); WS 15, 35	C, o, l, s
88.	M. Imlach, East Devonport	10.3.76	unknown	42.7	–	83	350	0–20 topsoil and clay, 20–42.7 *basalt;* WS 20	C, o, l, s, w
89.	Latrobe Municipal Council	12.76	612425	29.6	–	dry	–	0–3 loam and clay, 3–3.4 gravel, 3.4–29.6 clay, with gravel at 16, 25.6 (Tw)	C, a, l
90.	Latrobe Municipal Council	12.76	615425	24.4	–	dry	–	0–3 loam and sand, 3–3.4 gravel, 3.4–24.4 clay (Tw)	C, a, l
91.	Latrobe Municipal Council	12.76	606427	4.6	–	dry	–	0.3 loam and clay (Tw), 3–4.6 dolerite	C, a, l
92.	Latrobe Municipal Council	12.76	615429	18.3	–	dry	–	0–3.4 sand, 3.4–6.4 sand and clay, 6.4–6.7 gravel, 6.7–11 clay, 11–12.8 gravel, 12.8–18.3 green clay (Tw)	C, a, l
93.	Latrobe Municipal Council	17.1.77	605442	21	–	dry	–	0.18 sand and clay (Tw), 18–21 dolerite	C, a, d, l
94.	Latrobe Municipal Council	12.76	613431	11.3	–	dry	–	0–11.3 clay with gravel (Tw)	C, a, l
95.	Latrobe Municipal Council	12.76	595405	21	–	dry	–	0–0.6 loam, 0.6–6 sand and clay, 6–18 sand (Tw), 18–21 dolerite	C, a, l
96.	Latrobe Municipal Council	1.77	610419	18.3	–	275	500	0–0.6 peat, 0.6–5.5 white sand, 5.5–18 compact sand (Tw), 18–18.3 dolerite	C, o, l, p, w
97.	R. Mathews, Wesley Vale	20.1.77	528381	33.6	–	dry	–	0–4.5 topsoil and clay, 4.5–15 sand and clay, 15–21 basalt, 21–33.6 clay	C, a, l
98.	R. Mathews, Wesley Vale	21.1.77	525382	60	9	45	nd	0–3 topsoil and clay, 3–4.5 sand, 4.5–16 clay, 16–25 *basalt*, 25–33.6 'mudstone', 33.6–60 *basalt* (Tt); WS 16–50	C, o, l, s
99.	M. Nalder, Moriarty	20.6.77 (deepened 28.8.78)	565369	25.9	4	68	nd	0–4.5 clay, 4.5–12 *decomposed material* (Tt), 12–26 *basalt;* WS 6, 20, 23	C, o, l, w, s

Bore	Owner and address	Date completed	AMG ref.[1]	Total depth (m)	SWL (m)[2]	Yield (l/min)	TDS[3]	Driller's log (aquifer italicised)[4]	Remarks[5]
100.	D. Parsons, Thirlstane	6.7.77	604372	71.6	13.7	190	nd	0–14 clay and boulders, 14–71.6 basalt (Tt); WS 58, 63	C, o, l, w, s
101.	D. Parsons, Thirlstane	6.7.77	≈604368	24	–	dry	–	0–1 'pudding stone', 1–5.8 clay, 5.8–17 basalt and clay, 17–24 basalt (Tt)	C, a, l, w
102.	B. Richardson, Harford	10.8.76	620348	74.7	8.5	300	nd	0–1 clay and gravel, 1–16 clay, 16–56 *basalt* (Tt) 56–74.7 basalt and mudstone; WS 16, 55	C, o, l, s
103.	B. Richardson, Harford	12.8.76	621348	60	nd	110	nd	0–12 sand, gravel and clay, 12–60 basalt (Tt)	C, o, l
104.	B. Richardson, Harford	27.7.76	622362	39.6	nd	270	nd	nd	C, o
105.	R. Richardson, Thirlstane	12.1.77	617369	15	2.5	7.5	nd	0–7.3 clay and *boulders*, 7.3–15 basalt (Tt); WS 6	C, a, l, s
106.	R. Richardson, Thirlstane	14.1.77	617369	61	4.6	61	nd	0–6.7 clay, 6.7–16.7 *decomposed material* (Tt) 16.7–61 basalt; WS 6.7–16.7	C, a, l, s
107.	R. Richardson, Thirlstane	15.1.77	617369	47.3	4.6	83	nd	0–0.6 ironstone, 0.6–6 clay, 6–16.5 *decomposed material* (Tt), 16.5–47.3 basalt; WS 6–16	C, o, l, s
108.	R. Richardson, Thirlstane	16.1.77	617368	29	4.6	83	nd	0–9 clay, 9–18 *decomposed material* (Tt), 18–29 basalt; WS 11–18	C, o, l, s
109.	A. A. Rundle, Squeaking Point	4.3.77	633397	17.1	6	23	nd	0–15.2 grey loam and sand, 15.2–17.1 *gravel* (Tw); WS 15	C, o, l, s
110.	G. Sims, Wesley Vale	27.10.76	538370	16.5	–	dry	–	0–1 topsoil, 1–15.9 clay and sand (Tw), 15.9–16.5 dolerite	C, o, l
111.	G. Sims, Wesley Vale	28.10.76	538370	19.8	2.1	136	nd	0–1 topsoil, 1–10.7 clay, 10.7–19.8 *clay and gravel* (Tw); WS 11	C, o, l, s
112.	G. Spinks, Wesley Vale	12.2.76	544382	53.1	7.6	23	nd	0–3 topsoil and sand, 3–10.4 clay, 10.4–17.1 coarse sand, 17.153.1 *basalt* (Tt); WS 22.8	C, o, l, s
113.	P. Stevenson, Moriarty	14.9.76	553361	38.4	–	dry	–	0–32.9 clay and basalt, 32.9–38.4 weathered basalt (Tm)	C, a, l
114.	Thomas Bros, Northdown	23.11.76	565424	54.9	–	dry	–	0–3 clay, 3–7.6 boulders and clay, 7.6–48.8 clay (Tm), 48.8–54 sand	C, a, l
115.	Thomas Bros, Northdown	23.11.76	565424	54.9	3	68	nd	0–3 clay, 3–7.6 boulders and clay, 7.6–49 clay (Tm), 49–54.9 sand; WS 3, 5	C, a, l, s
116.	Thomas Bros, Northdown	24.11.76	565424	38.1	–	dry	–	0–0.6 topsoil, 0.6–38.1 clay (Tm)	C, a, l
117.	Thomas Bros, Northdown	24.11.76	565424	29	–	dry	–	0–0.3 topsoil, 0.3–29 clay (Tm)	C, a, l
118.	Thomas Bros, Northdown	24.11.76	565424	38	–	dry	–	0–0.6 topsoil, 0.6–38 clay (Tm)	C, a, l
119.	Thomas Bros, Northdown	29.11.76	564424	71.4	nd	135	nd	0–0.6 topsoil, 0.6–11.6 clay, 11.6–64 *basalt* (Tm), 64–71.4 sand; WS 15, 37, 53	C, o, l, s
120.	W. Anderson, Thirlstane	14.10.76	609385	34.7	6	55	nd	0–0.6 topsoil, 0.6–10.7 clay, 10.7–18.3 *weathered basalt*, 18.3–26.8 *basalt* (Tt), 26.8–28.9 blue clay, 28.9–34.7 basalt; WS 11, 20	C, o, l, s
121.	B. A. Badcock, Hawley	18.11.76	604423	10.7	0	90	nd	0–0.6 topsoil, 0.6–6 clay and *sand* (Tw), 6–7.6 dolerite, 7.6–10.7 decomposed material	C, o, l, s
122.	R. Byard, Port Sorell	23.12.76	600423	11.3	4.6	90	nd	0–0.3 topsoil, 0.3–9.5 clay, 9.5–11.3 *coarse sand* (Tw); WS 9.5	C, o, l, s
123.	G. Collins, Wesley Vale	27.10.76	≈525414	53.4	12.2	18	nd	0–1 topsoil, 1–21 sand and clay, 21–50.3 *basalt* (Tm), 50.3–53.4 clay; WS 20, 47	C, o, l, s
124.	A. C. Duff, 'Boisdale', Northdown	22.11.76	576421	28.9	–	dry	–	0–0.6 topsoil, 0.6–28.9 clay (Tm)	C, a, l

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125.	A. C. Duff, 'Boisdale', Northdown	22.11.76	574419	38.1	–	dry	–	nd (Tm)	C, a
126.	A. C. Duff, 'Boisdale', Northdown	12.7.77	576421	77.8	nd	190	nd	0–0.3 topsoil, 0.3–9.1 clay, 9.1–33.5 clay and 'weathered material', 33.5–42.7 sand and clay, 42.7–51.9 blue and black clay, 51.9–77.8 *basalt* (Tt); WS 64	C, o, l, s
127.	Education Dept, Moriarty School	31.5.77	565369	22.9	11.6	83	nd	0–0.6 topsoil, 0.6–6.4 clay, 6.4–11.6 clay and boulders, 11.6–22.9 *basalt* (Tt); WS 11, 16, 20	C, o, l
128.	C. A. Eastaugh, Wesley Vale	12.1.76	≈560408	53.1	24.4	23	380	0–0.6 topsoil, 0.6–42.2 clay and sand, 42.2–48.5 *basalt* (Tm), 48.5–53.1 sand; WS 44	C, o, l, s, w
129.	R. Gamble, Wesley Vale	30.12.76	≈544383	34.8	12.2	45	310	0–0.6 topsoil, 0.6–4.6 clay, 4.6–5.2 ironstone, 5.2–13.7 clay, 13.7–16.5 *weathered basalt* (Tt), 16.5–34.8 basalt; WS 18, 32	C, o, l, s, w
130.	P. Green, Bakers Lane	25.10.77	589390	29.6	–	dry	–	0–0.3 topsoil, 0.3–3 clay, 3–29.6 sand (Tw)	C, a, l
131.	P. Green, Bakers Lane	27.10.77	587389	51.9	nd	46	nd	0–0.3 topsoil, 0.3–16.8 sand and clay, 16.8–44.2 *basalt* (Tm), 44.2–51.9 *weathered basalt;* WS 17.4, 46	C, o, l
132.	D. Houston, Parkers Ford	20.10.77	612408	15.9	–	dry	–	nd (Tw)	C, a, l
133.	D. Houston, Parkers Ford	21.10.77	612409	21.9	–	dry	–	nd (Tw)	C, a, l
134.	D. Houston, Parkers Ford	25.10.77	612408	24.4	1.5	nd	nd	0–0.3 topsoil, 0.3–11 *sand*, 11–20.7 sand and clay, 20.7–24.4 *coarse sand* (Tw); WS 4, 21	C, o, l, s
135.	Kelley Bros, Sassafras	10.12.76	564289	39.7	–	dry	–	0–0.6 topsoil, 0.6–3 clay and boulders (Tm), 3–39.7 clay and sand	C, a, l
136.	Kelley Bros, Sassafras	10.12.76	564289	41.2	nd	60	nd	0–0.6 topsoil, 0.6–18.3 *clay and basalt boulders* (Tm), 18.3–27.4 basalt, 27.4–34.8 sand and coarse gravel, 34.8–36.6 basalt, 36.6–41.2 clay; WS 15, 21	C, a, l
137.	Kelley Bros, Sassafras	13.12.76	564289	42.7	nd	50	nd	0–0.6 topsoil, 0.6–16.8 clay, 16.8–36.6 *basalt* (Tm), 36.6–42.7 white sand; WS 21.4	C, a, l
138.	Kelley Bros, Sassafras	14.12.76	564289	36.6	nd	53	nd	nd (Tm)	C, a
139.	Kelley Bros, Sassafras	nd	564289	59.2	nd	53	nd	0–0.6 topsoil, 0.6–10.7 clay, 10.7–12.2 *weathered basalt*, 12.2–33.6 *basalt* (Tm), 33.6–39.7 coal, 39.7–53.1 basalt, 53.1–59.2 clay and sand; WS 12.2, 21.4, 39.7	C, a, l
140.	R. H. Loane, Wesley Vale	12.8.76	548416	77.5	22.9	300	nd	0–0.6 topsoil, 0.6–19.8 clay, 19.8–43.3 *sand*, 43.3–74.7 *basalt* (Tt), 74.7–77.5 black clay; WS 19.8, 43.3, 56.4, 68.6	C, o, l, s
141.	R. H. Loane, Wesley Vale	16.8.76	546416	64.1	10.7	100	nd	0–0.6 topsoil, 0.6–15.3 clay, 15.3–24.4 *weathered basalt* (Tm), 24.4–41.8 *sand* (Tw), 41.8–56.4 *basalt* (Tt), 56.4–64.1 black clay; WS 10.7–42, 50.3	C, o, l, s
142.	R. H. Loane, Wesley Vale	17.8.76	548412	61	nd	35	nd	0–0.6 topsoil, 0.6–25.6 clay, 25.6–29 *weathered basalt* (Tm), 29–61 sand; WS 25.6	C, a, l
143.	R. H. Loane, Wesley Vale	19.8.76	549416	61	12.2	150	nd	0–0.6 topsoil, 0.6–25.6 *clay* (Tm), 25.6–29 weathered basalt, 29–61 *sand;* WS 11, 20, 24.5, 50.3	C, o, l, s

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144.	D. E. Richardson, Sassafras	26.5.76	585293	51.8	1.2	1100	270	0–0.6 topsoil, 0.6–4.7 *honeycomb basalt*, 4.7–7.6 clay and basalt boulders, 7.6–24.4 *honeycomb basalt* (Tm), 24.4–25.6 grey clay, 25.6–39.6 ?, 39.6–50.3 basalt, 50.3–51.8 white sand; WS 0.64.7, 7.6–24.4	C, o, d, l, s, w
145.	E. Beveridge, East Devonport	15.1.78	477389	38.2	0.3	23	nd	0–4 topsoil and clay, 4–5.5 dolerite, 5.5–11.6 clay, 11.6–38.2 dolerite; WS 11.6	C, a, l, s
146.	E. Beveridge, East Devonport	13.1.78	479389	19.5	–	dry	–	0–1.2 honeycomb basalt, 1.2–18.9 *clay* (Tw), 18.9–19.5 dolerite	C, a, l
147.	E. Beveridge, East Devonport	14.1.78	477388	19.5	nd	60	nd	0–10.7 clay, loose basalt, 10.7–18.3 clay, 18.3–19.5 dolerite; WS 10.7	C, a, l
148.	E. Beveridge, East Devonport	16.1.78	478388	19.5	–	dry	–	0–3.7 topsoil and clay, 3.7–7 weathered basalt, 7–18.9 clay, 18.9–19.5 dolerite	C, c, l
149.	E. Beveridge, East Devonport	16.1.78	478389	29.3	–	dry	–	0–0.6 honeycombe basalt, 0.6–7.6 decomposed material, 7.6–28.1 clay, 28.1–29.7 dolerite	C, a, l
150.	V. Mitchell, Moriarty	19.1.78	≈560353	105.2	5.5	135	nd	0–0.3 topsoil, 0.3–3.7 clay, 3.7–11.9 *loose basalt*, 11.9–102 *basalt* (Tt), 102–105 red and brown clay; WS 10.7, 74.7	C, a, l, s
151.	V. Mitchell, Moriarty	23.1.78	≈561355	106.1	22.9	190	nd	0–0.3 topsoil, 0.3–20.4 clay, 20.4–22.9 *weathered basalt*, 22.9–104 *basalt* (Tt), 104–106.1 clay; WS 21, 49, 61.3	C, a, l, s
152.	S. Parsons, Thirlstane	7.2.78	600379	51.9	–	dry	–	0–1.5 loose basalt and clay, 1.5–21.4 clay, 21.4–26.5 weathered basalt, 26.5–51.9 black clay	C, a, l
153.	S. Parsons, Thirlstane	8.2.78	598377	47.3	flowing artesian	380	nd	0–0.3 topsoil, 0.3–15.9 boulders and clay, 15.9–39.3 black clay, 39.3–47.3 *basalt* (Tt); WS 42.7–47.3; flowing at 140*l*/min	C, o, l
154.	B. Iles, Thirlstane	16.12.77	≈603363	50.3	1.5	50	nd	0–0.3 topsoil, 0.3–7.3 clay, 7.3–9 boulders, 9–50.3 *basalt* (Tt); WS 9, 19.8	C, o, l, s
155.	B. Iles, Thirlstane	20.12.77	≈603362	66.5	nd	230	nd	0–0.3 topsoil, 0.3–9 clay, 9–12.2 boulders, 12.2–66.5 *basalt* (Tt); WS 12.2, 62.5	C, o, l
156.	L. Richardson, Moriarty	nd	≈597353	39.7	3	1140–1500	nd	0–0.3 topsoil, 0.3–3.7 clay, 3.7–15.9 weathered basalt, 15.9–38.7 *soft basalt* (Tt), 38.7–39.7 loose basalt; WS 15.9, 21, 38	C, o, l
157.	Bainsbridge 'Penrive'	≈1972	617343	≈50	–	–	–	–	C, o
158.	A. H. Higgs, Port Sorell	nd	625421	–	–	–	–	In Quaternary sediments	C, o
159.	Rex, Port Sorell	–	618427	–	–	–	–	In Quaternary and Tertiary sediments	C, o
160.	APPM, Wesley Vale	11.12.64	546413	195	–	70	–	0–1 topsoil, 1–8.5 sand clay and silty sand, 8.5–22.9 weathered basalt, 22.9–52.5 clay and gravelly clay with plant and shell remains, 52.5–190 basalt, 190–195 sand, gravel, clay	D, a, g
161.	D. Dick, Wesley Vale	27.4.78	551398	144.9	15	227	–	0–51.9 topsoil and clay, 51.9–61 sand, 61–62.5 weathered basalt, 62.5–144.9 *basalt* (Tt); WS 73, 137	C, o, l, s
162.	B. Slater, Moriarty	30.8.78	568355	97.6	0.6	230	–	0–10.7 topsoil and clay, 10.7–17.7 weathered basalt, 17.7–97.6 *basalt* (Tt); WS 15, 60, 78	C, o, l, s
163.	C. Aspinall, Wescombes Rd	25.8.78	554354	24.4	4.6	6.8	–	0–13.7 topsoil and clay, 13.7–18.3 weathered basalt, 18.3–24.4 *vesicular basalt* (Tt); WS 14, 18–24	C, o, l, s

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164.	G. Norton	30.8.78	517413	16.8	–	dry	–	0–1.5 loam and clay, 1.5–5.5 gravel and clay, 5.5–7.6 basalt, 7.6–15.3 clay, 15.3–16.8 dolerite	C, a, l
165.	G. Norton	1.9.78	517413	29.0	1.2	150	–	0–1.4 clay, 1.4–5.5 boulders and clay, 5.5–21.4 basalt, 21.4–27.5 *clay and gravel*, 27.5–29 dolerite; WS 21.4–27.5	C, o, l, s
166.	G. Norton	31.8.78	517413	33.6	0.6	low	–	0–1.5 grey loam and sand, 1.5–7.3 clay and boulders, 7.3–21.4 basalt, 21.4–32 clay, 32–33.6 dolerite; WS 7.3	C, a, l, s
167.	G. Norton	4.9.78	517413	33.6	0.6	23	–	0–1.5 topsoil and clay, 1.5–6.1 boulders and clay, 6.1–22.9 basalt, 22.9–32 clay, 32–33.6 dolerite; WS 6.1	C, a, l, s
168.	G. Norton	29.9.78	517413	47.3	–	230	–	0–1 topsoil, sand and clay, 1–13.7 *sand*, 13.7–21.4 *sandstone and boulders*, 21.4–47.3 dolerite; WS 12.2, 22, 33.6	C, o, l, s
169.	A. V. Rockliffe 'Brierley Rise', Sassafras	10.5.78	588293	51.9	7.6	130	–	0–4.3 topsoil and clay, 4.3–16.8 *loose basalt* and clay, 16.8–32 *basalt* (Tm), 32–51.9 clay and white sand; WS 10.7, 24.4, 29	C, a, l, s
170.	A. V. Rockliff 'Brierley Rise', Sassafras	11.5.78	589294	31.1	7.6	300	–	0–10.7 topsoil and clay, 10.7–15.3 weathered basalt, 15.3–30.5 *basalt* (Tm), 30.5–31.1 white clay; WS 19.8, 22	C, o, l, s
171.	A. V. Rockliff 'Brierley Rise', Sassafras	11.5.78	587292	42.7	4.6	300	–	0–4.6 clay, 4.6–7.6 weathered basalt, 7.6–29 *vesicular basalt*, 29–32.6 weathered basalt, 32.6–38.1 basalt, 38.1–42.7 clay and sand; WS 7.6, 27.8	C, o, l, s
172.	C. Sienesi, Bakers Lane	13.9.77	584387	24.4	6.1	68	–	0–4.3 grey loam and clay, 4.3–10.7 *weathered basalt*, 10.7–24.4 *basalt*; WS 8.2, 21.4	C, o, l, s
173.	R. Baldock, Wesley Vale	18.1.79	540364	18.3	nd	75	nd	0–9.1 *yellow clay* (Tw), 9.1–10.7 weathered dolerite, 10.7–18.3 dolerite; WS 8.5	C, o, l
174.	R. Radford, Moriarty	14.12.78	562374	97.5	21.3	455	nd	0–13.7 clay (Tw), 13.7–21.9 sand, clay and wood (Tw), 21.9–25.6 clay, 25.6–97.5 *basalt* (Tt); WS 33.5, 73.1, 91.4	C, a, l, s
175.	R. Radford, Moriarty	19.12.78	564374	97.5	6.1	265	nd	0–10.7 clay (Tw), 10.7–16.4 weathered basalt, 16.4–97.5 *basalt* (Tt); WS 82.2	C, a, l, s
176.	R. Radford, Moriarty	4.1.79	563371	88.3	nd	>760	nd	0–10.7 clay and sand (Tw), 10.7–21.3 weathered basalt, 21.3–88.3 *basalt* (Tt); WS 25.9–44.2	C, o, l
177.	G. Green, Port Sorell	10.2.79	592439	15.2	nd	1315	nd	0–4.6 clay, 4.6–15.2 *dolerite;* WS 12.8	C, o, l
178.	K. Green, Thirlstane	6.12.78	580372	73.1	nd	45	nd	0–11.3 clay (Tt), 11.3–13.1 weathered basalt (Tt), 13.1–70.1 *basalt* (Tt), 70.1–73.1 clay (Tt); WS 22.8	C, o, l
179.	K. Green, Thirlstane	7.12.78	581366	59.7	6.1	>600	nd	0–9.1 clay and boulders (Tt), 9.1–11.3 weathered basalt (Tt), 11.3–59.7 *basalt* (Tt); WS 19.8, 33.5	C, o, l, s
180.	K. Green, Thirlstane	8.12.78	578369	64	nd	38	nd	0–13.7 clay and boulders (Tt), 13.7–21.3 *clay*, 21.3–62.1 basalt (Tt), 62.1–64 clay (Tt); WS 19.8	C, a, l
181.	T. Halley, Port Sorell	10.2.79	591439	19.8	–	dry	–	0–11.3 clay, 11.3–19.8 dolerite	C, a, l, d
182.	T. Halley, Port Sorell	12.2.79	591439	42.6	–	dry	–	0–19.8 clay, 19.8–28.9 weathered dolerite, 28.9–42.6 dolerite	C, a, l, d
183.	Montgomery, Port Sorell	17.10.78	591423	15.2	nd	4	nd	0–1.5 clay, 1.5–12.2 sandy clay, 12.2–15.2 dolerite	C, a, l
184.	Montgomery, Port Sorell	17.10.78	591423	12.2	–	dry	–	0–4.6 clay, 4.6–10.7 sandy clay, 10.7–12.2 dolerite	C, a, l
185.	A. C. Duff, Northdown	1976	574424	≈83	60	>300	nd	Bottomed in hard *basalt* (Tt); WS 110, 140, 150	C, o

APPENDIX D

Bore	Owner and address	Date completed	AMG ref.[1]	Total depth (m)	SWL (m)[2]	Yield (l/min)	TDS[3]	Driller's log (aquifer italicised)[4]	Remarks[5]
186.	A. C. Loane, Northdown	18.5.79	557412	153	60	>230	nd	0–47 clay (Tm), 47–70.1 sand and clayey sand, some tuffaceous sand, 70.1–153 *basalt* (Tt); WS ?	C, o, g
187.	R. Anderson, Thirlstane	17.5.81	590390	24.4	–	152	–	0–4.3 clay, 4.3–85 mudstone, 8.5–24.4 *basalt* (Tt); WS 20.7	C, o, l
188.	J. Beveridge, Thirlstane?	25.6.76	619348	50.3	–	22.7	–	0–0.6 grey loam, 0.6–1.5 white gravel, 1.5–30.5 clay, 30.5–47.3 *basalt* (Tt), 47.3–50.3 clay; WS 39.6–45.7	C, o, w, l
189.	N. Badcock, Moriarty	6.11.80	582368	38.1	–	–	–	0–0.3 topsoil, 0.3–18.3 clay, 18.3–25.9 basalt clay, 25.9–38.1 brown clay	C, a, l
190.	N. Badcock, Moriarty	7.11.80	583363	88.4	–	–	–	0–0.3 topsoil, 0.3–10.7 clay, 10.7–88.4 basalt; WS 42.7–61	C, a, g
191.	N. Badcock, Moriarty	17.7.80	605365	94.5	6.1	379	–	0–0.3 topsoil, 0.3–12.2 clay, 12.2–17.4 *decomposed basalt* (Tt), 17.4–88.4 *basalt* (Tt), 88.4–94.5 clay; WS 9.1–24.4	C, o, l
192.	N. Badcock, Moriarty	24.7.80	607363	38.1	–	abandoned 3.8	–	0–0.3 topsoil, 0.3–15.2 clay, 15.2–25 decomposed basalt, 25–38.1 basalt; WS 25	C, a, l
193.	R. Chaplin, Moriarty	23.10.79	586387	102.1	3.1	abandoned 273	–	0–0.3 topsoil, 0.3–9.1 clay, 9.1–12.2 decomposed basalt, 12.2–102.1 basalt (Tt); WS 9.1–85.4	C, a, l
194.	R. Chaplin, Moriarty	24.10.79	584386	47.3	–	abandoned 114	–	0–0.3 topsoil, 0.3–9.1 clay, 9.1–18.3 *loose basalt* (Tm), 18.3–30.5 hard basalt, 30.5–47.3 brown clay; WS 9.1–15.2	C, a, l
195.	R. Chaplin, Moriarty	25.10.79	583385	47.3	3.1	531	–	0–0.3 topsoil, 0.3–9.1 clay, 9.1–12.2 decomposed basalt, 12.2–47.3 basalt; WS 6.1–36.6	–
196.	Latrobe Council, Parkers Ford	17.12.76	?	29.6	–	–	–	0–3.1 grey loam and clay, 3.1–3.4 gravel, 3.4–15.9 clay, 15.9–16.2 floaters, 16.2–25.6 clay, 25.6–25.9 clay, 25.9–29.6 hard clay	C, a, l
197.	Latrobe Council, Applebys Road	–	?	6.1	–	–	–	0–0.5 clay, 5.5–6.1 dolerite	C, a, l
198.	E. P. Mace, Squeaking Point	8.6.79	634400	16.5	6.1	15.2	–	0–0.3 topsoil, 0.3–5.5 sand, 5.5–6.1 gravel, 6.1–16.5 *sand* (Tw); WS 12, 15	C, o, l
199.	R. Parsons, Thirlstane	12.3.81	599358	54.9	12.2	abandoned 22.7	–	0–0.3 topsoil, 0.3–1.5 clay, 1.5–21.3 basalt, 21.3–54.9 brown clay; WS 18.3	C, a, l
200.	F. Phillpot, Squeaking Point	21.2.77	635399	11.3	3.1	75.8	–	0–10.7 sand, clay, 10.7–11.3 *gravel* (Tw); WS 10.7	C, o, l
201.	L. Padman, Moriarty	6.2.80	582377	38.1	–	–	–	0–0.5 topsoil, 0.5–14.6 clay, 16.4–38.1 mudstone (Tw)	C, o, l
202.	W. Rundle, Squeaking Point	14.2.77	633398	25.0	4.6	19	–	0–12.2 sand, 12.2–17.1 gravel, 17.1–25.0 *sand and clay* (Tw); WS 17.1	C, o, l
203.	R. Richardson, Thirlstane	16.1.77	617368	29, 99.1	4.6, 1.8	83.4, 273	–	0–0.6 topsoil, 0.6–9.1 clay, 9.1–18.3 *decomposed material*, 18.3–29.0 basalt [29.0–83.8 *basalt* (Tt), 83.8–99.1 clay]; WS 10.7–18.3, 47.2–82.3	C, o, l
204.	R. Richardson, Thirlstane	13.12.77 (deepened 17.8.81)	610369	61.0	–	–	–	0–0.3 topsoil, 0.3–10.1 clay, 10.1–32.0 basalt, 32.0–34.4 clay, 34.4 basalt	C, a, l
205.	R. Richardson, Thirlstane	15.12.77	–	51.8	9.1	303	–	0–0.3 topsoil, 0.3–3.7 clay, 3.7–9.1 *loose basalt*, 9.1–33.5 *soft basalt* (Tt), 33.5–51.8 hard basalt; WS 3.7, 18.3	C, o, l
206.	R. Richardson, Thirlstane	18.3.81	615369	85.4	1.5	273	–	0–0.3 topsoil, 0.3–6.1 clay, 6.1–15.2 *decomposed basalt*, 15.2–85.4 *basalt* (Tt), clay; WS 9.1, 27.4, 76.2	C, o, l

Bore	Owner and address	Date completed	AMG ref.[1]	Total depth (m)	SWL (m)[2]	Yield (l/min)	TDS[3]	Driller's log (aquifer italicised)[4]	Remarks[5]
207.	L. Sienesi, Bakers Lane	13.9.77	584387	24.4	6.1	68.2	–	0–4.3 grey loam, clay, 4.3–10.7 decomposed material, 10.7–24.4 basalt; WS 8.2, 21.4	C, o, l
208.	B. Sharmar, Port Sorell	18.11.81	593429	15.2	3.1	114	–	0–0.3 topsoil, 0.3–15.2 *clay* (Tw?); WS 6.1, 9.1, 12.2	C, o, l
209.	J. R. Stephenson, Squeaking Point	6.5.81	637402	14.0	3.1	49.3	–	0–14.0 *sand*, quartz grains (Tw); WS 10.7–13.7	C, o, w
210.	Russell Parsons, Thirlstane House, Thirlstane	8.6.82	599373	33.5	–	455	–	0–0.3 topsoil, 0.3–7.6 clay, 7.6–21.3 *decomposed basalt*, 21.3–33.5 *basalt* (Tt); WS 18.3–30.5	C, o, l
211.	B. Anderson, Thirlstane	2.6.82	600382	47.3	–	364	–	0–0.3 topsoil, 0.3–1.8 clay, 1.8–38.1 basalt, 38.1–41.2 *decomposed basalt*, 41.2–47.3 *basalt* (Tt); WS 37.5–42.7	C, o, l
212.	Royce Green, Moriarty	11.8.82	611367	67.1	3.1	531	–	0–0.3 topsoil, 0.3–4.6 clay, 4.6–17.7 decomposed material, 17.7–67.1 *basalt* (Tt); WS 18.3–54.9	C, o, l
213.	S. Parsons, Thirlstane	4.6.82	595373	42.7	–	190	–	0–0.3 topsoil, 0–3–4.6 clay, 4.6–10.7 decomposed basalt, 10.7–15.2 *basalt* (Tt), 15.2–24.4 grey clay, 24.4–42.7 sandstone; WS 12.2	C, a, l
214.	S. Parsons, Thirlstane	6.6.82	593372	24.4	–	–	–	0–0.3 topsoil, 0.3–2.4 clay, 2.4–3.7 decomposed basalt, 3.7–24.4 brown clay	C, a, l
215.	S. Parsons, Thirlstane	7.6.82	593373	15.2	4.6	abandoned	–	0–0.3 topsoil, 0.3–1.5 clay, 1.5–7.0 decomposed basalt, 7.0–10.4 basalt, 10.4–15.2 brown clay; WS 6.1	C, a, l
216.	S. Parsons, Thirlstane	8.6.82	597371	19.5	–	273	–	0–0.3 topsoil, 0.3–5.8 yellow clay, 5.8–6.1 gravel, 6.1–18.3 *decomposed basalt* (Tt), 18.3–18.6 basalt, 18.6–19.5 brown clay; WS 6.1–16.8	C, o, l
217.	Michael Nichols, Harford	5.2.83	622345	61	18.3	91	–	0–0.3 topsoil, 0.3–12.2 sand, 12.2–18.3 clay, 18.3–61 *basalt* (Tt); WS 24.2–54.9	C, o, l
218.	K. R. Champion, Port Sorell	27.9.83	637402	11.1	6.1	76	–	0–0.6 topsoil, 0.6–9.1 sand, 9.1–10.7 *gravel* (Tw), 10.7–11.1 clay; WS 9.1–10.6	C, o, l
219.	Fred Ward, Port Sorell	23.3.83	630399	13.4	–	76	–	0–1.2 topsoil, 1.2–11.6 sand, 11.6–13.4 *gravel* (Tw); WS 12–13	C, o, l
220.	W. G. Anderson, Thirlstane	21.6.83	615385	48.8	–	151	–	0–0.3 grey loam, 0.3–7.6 clay and sand, 7.6–15.2 *decomposed basalt*, 15.2–48.8 *basalt* (Tt); WS 12.2, 36.6	C, a, l
221.	W. G. Anderson, Thirlstane	23.6.83	614383	77.7	3.1	455	–	0–0.3 topsoil, 0.3–3.1 clay, 3.1–12.2 *loose basalt*, 12.2–73.8 *basalt* (Tt), 78.8–77.7 clay; WS 10.4, 36.6, 73.2	–
222.	W. G. Anderson, Thirlstane	25.6.83	615382	67.1	–	91	–	0–0.3 topsoil, 0.3–1.5 loose basalt, 1.5–7.6 clay, 7.6–13.7 decomposed basalt, 13.7–91 basalt; WS 13.7	–
223.	Simon Houghton, Hawley Beach	2.6.83	612457	36.6	12.2	76	–	0–0.6 topsoil, 0.6–6.1 sand, 6.1–11 clay, 11–12.2 decomposed rock, 12.2–22.9 *soft dolerite*, 22.9–76.6 dolerite; WS 18.3, 22.9	C, o, l
224.	Leon Connors, Port Sorell	6.2.84	597425	24.4	15.2	60.6	–	0–0.3 topsoil, 0.3–10.6 clay, 10.6–12.2 gravel, 12.2–18.3 mudstone, 18.3–21.3 *decomposed rock*, 21.3–24.4 dolerite; WS 18.3–21.3	C, o, l
225.	J. Finch, Hawley	28.11.83	599425	15.2	7.6	37.9	–	0–0.6 topsoil, 0.6–9.1 clay, 9.1–12.8 *decomposed dolerite*, 12.8–15.2 dolerite; WS 9.1–12.8	C, o, l
226.	K. R. Champion, Port Sorell	12.10.83	6384404	14.3	6.1	76	–	deepening existing bore – 11.3–17.7 clay, 13.7–14.3 *gravel*; WS 13.7	C, o, l

Bore	Owner and address	Date completed	AMG ref.[1]	Total depth (m)	SWL (m)[2]	Yield (l/min)	TDS[3]	Driller's log (aquifer italicised)[4]	Remarks[5]
227.	J. Clark, Applebys Road, Port Sorell	26.10.83	589408	53.2	–	–	–	0–0.3 topsoil, 0.3–3.1 sandstone, 3.1–21.3 clay, 21.3–45.7 weathered dolerite, 45.7–51.7 dolerite, 51.7–53.2 sand	C, a, l
228.	G. Green, Port Sorell	?	598423	67	–	–	–	Dolerite	–
229.	J. Beveridge, Harford	29.10.85	612347	90	–	60.6	–	0–16 clay, 16–90 *basalt*; WS 18, 22, 26, 70	D, c, w, g
230.	R. Beveridge, Moriarty	28.11.84	598355	39.8	1.8	abandoned 60.6	–	0–1.2 topsoil, 1.2–4.9 clay, 4.9–12.2 *loose basalt*, 12.2–33.5 clay, 33.5–38.1 basalt, 38.1–39.6 clay; WS 9.1–12.2	C, a, l
231.	R. Beveridge, Moriarty	29.11.84	602357	47.2	4.6	379	–	0–1.2 topsoil, 1.2–4.9 clay, 4.9–18.3 *decomposed rock*, 18.3–45.7 *basalt* (Tt), 45.7–47.2 clay; WS 18.3, 38.1, 45.1	C, o, l
232.	B. T. Stewart, Thirlstane	24.10.85	611373	72	3	303	–	0–12 clay and *basalt*, 12–26 *weathered basalt* (Tt), 26–72 basalt; WS 6, 15, 24	D, c, w, g
233.	A. Day, Port Sorell	15.1.85	588408	57.9	30.5	45.5	–	0–0.3 topsoil, 0.3–3.7 clay, 3.7–18.3 sand, 18.3–42.7 black clay, 42.7–51.8 green clay, 51.8–54.9 *decomposed dolerite*, 54.9–57.9 dolerite; WS 51.8–54.9	C, o, l
234. [no 235]	Dr Scott Bell, Port Sorell	21.12.84	599414	53.7	–	–	–	0–0.3 topsoil, 0.3–3.7 clay, 3.7–18.2 sandy clay, 18.2–24.4 sand, 24.4–39.0 grey sandy clay, 39.0–53.7 dolerite	C, a, l
236.	Shearwater Golf Club, Port Sorell	10.4.85	604390	74	–	371	–	0–0.3 surface soil, 0.3–2 gravel, 2.–28.5 silty clay, 28.5–41 *decomposed basalt* (Tt), 41–67 basalt, 67–72 sand, 72–74 clay; WS 31	D, c, w, d
237.	Charlie Radford, Moriarty	8.4.85	588390	112.8	–	227	–	0–0.3 topsoil, 0.3–11.3 clay, 11.3–12.2 sand, 12.2–20.1 clay, 20.1–109.7 *basalt* (Tt), 109.7–112.8 soft clay; WS 27, 52, 85, 93	C, o, l
238.	Port Sorell Golf Club	22.10.86	614433	16.8	–	–	–	0–16.8 sand	C, a, l
239.	G. T. & J. Shechloth, Thirlstane	20.4.88	592380	85.4	15.2	114	–	0–0.3 topsoil, 0.3–21.3 clay, 21.3–39.6 *decomposed basalt* 39.6–76.2 *basalt* (Tt), 76.2– 85.4 basalt or dolerite. WS 21.3, 45.7, 48.8, 76.2	C, o, l
240.	B. T. & P. H. Stewart, Thirlstane	12.11.87	612372	73.2	3.1	379	–	0–0.3 topsoil, 0.3–1.8 clay, 1.8–6.1 *decomposed basalt* (Tt), 6.1–7.3 basalt; WS 6.1, 19.8, 36.6	C, o, l
241.	Allan Waddle, Port Sorell	14.4.88	618413	21.3	12.2	30.3	–	0–0.3 topsoil, 0.3–9.1 sand clay, 9.1–21.3 *dolerite* WS 15.2	C, o, l
242.	G. Trickett, Wesley Vale	31.12.84	510408	30.5	3.1	227	–	0–0.3 topsoil, 0.3–4.6 clay, 4.6–27.4 soft dolerite, 27.4–30.5 *broken dolerite;* WS 27.4–30.5	–
243.	T. Luck, Moriarty	4.10.85	564347	33.5	13.7	38	–	0–1.2 topsoil, 1.2–6.1 clay, 6.1–10.7 decomposed basalt, 10.7–33.5 *basalt* (Tt); WS 18.3, 30.5	C, o, l
244.	M. Barnes	7.86	498393	42.7	–	227	–	?	C, o, l
245.	Piper & Beveridge, Wesley Vale	11.11.87	557365	79.3	3.1	190	–	0–0.3 topsoil, 0.3–9.1 clay, 9.1–79.3 *basalt* (Tt); WS 3.1, 6.1, 24.4	C, o, l
246.	C. Aspinall, Moriarty	11.5.79	554354	24.4	–	22.7	–	0–0.3 topsoil, 0.3–18.3 clay, 18.3–21.3 decomposed basalt, 21.3–24.4 *basalt* (Tt); WS 21.3–24.4	C, o, l
247.	N. Badcock, Moriarty	11.7.80	574357	51.8	–	abandoned 45.5	–	0–0.3 topsoil, 0.3–6.1 clay, 6.1–11.3 decomposed basalt, 11.3–51.8 *basalt* (Tt), WS 12.2–27.4	C, a, l

Bore	Owner and address	Date completed	AMG ref.[1]	Total depth (m)	SWL (m)[2]	Yield (l/min)	TDS[3]	Driller's log (aquifer italicised)[4]	Remarks[5]
248.	N. Badcock, Moriarty	14.7.80	572356	56.4	–	abandoned 136	–	0–0.3 topsoil, 0.3–6.1 clay, 6.1–15.2 *decomposed basalt,* 15.2–56.4 *basalt* (Tt), WS 6.1, 12.2, 30.5	C, a, l
249.	N. Badcock, Moriarty	15.7.80	575354	33.5	–	abandoned 37.9	–	0–0.3 topsoil, 0.3–6.1 clay, 6.1–12.2 *decomposed basalt,* 12.2–33.5 *basalt* (Tt); WS 9.1, 12.2 16.3	C, a, l
250.	N. Badcock, Moriarty	18.7.80	578358	61	–	abandoned 136	–	0–0.3 topsoil, 0.3–12.2 clay, 12.2–15.2 *decomposed basalt,* 15.2–61 *basalt* (Tt); WS 15.2, 21.3, 33.5	C, a, l
251.	N. Badcock, Moriarty	21.7.80	578357	65.6	–	abandoned 136	–	0–0.3 topsoil, 0.3–3.1 loose basalt, 3.1–62.5 *basalt* (Tt), 62.5–65.5 brown clay; WS 12.2–38.1	C, a, l
252.	N. Badcock, Moriarty	22.7.80	573353	38.1	–	abandoned 2.3	–	0–0.3 topsoil, 0.3–10.7 clay, 10.7–32 *hard basalt* (Tt), 32–38.1 brown clay; WS 10.7	C, a, l
253.	N. Badcock, Moriarty	23.7.80	572361	38.1	–	abandoned 15.2	–	0–0.3 topsoil, 0.3–10.1 clay, 10.1–33.5 *basalt* (Tt), 33.5–38.1 brown clay; WS 9.1, 12.2	C, a, l
254.	N. Badcock, Moriarty	24.7.80	580358	38.1	–	abandoned 45.5	–	0–0.3 topsoil, 0.3–12.2 clay, 12.2–21.3 *decomposed basalt* (Tt), 21.3–38.1 basalt; WS 12.2–21.3	C, a, l
255.	N. Badcock, Moriarty	24.9.80	569355	74.7	0.9	190	–	0–0.3 topsoil, 0.3–6.1 clay, 6.1–12.2 *decomposed basalt,* 12.2–73.2 *basalt* (Tt), 73.2–74.7 sandy clay; WS 9.1–18.3, 54.0	C, o, l
256.	N. Badcock, Moriarty	25.9.80	577352	79.3	–	227	–	0–0.3 topsoil, 0.3–9.1 clay, 9.1–10.7 decomposed basalt, 10.7–23.8 clay, 23.8–79.3 *basalt* (Tt); WS 24.4–61	C, o, l
257.	N. Badcock, Moriarty	31.3.81	580355	99.1	12.2	455	–	0–0.3 topsoil, 0.3–22.9 clay, 22.9–98.8 *basalt* (Tt), 98.8–99.1 *gravel* (quartz) (Th); WS 30.5–99.1	C, o, l
258.	T. Baldock, Latrobe	28.11.80	500393	27.4	6.1	30.3	–	0–1.5 topsoil, 1.5–15.2 soft brown clay, 15.2–21.3 hard clay, some soft spots, 21.3–27.4 *sand* (Tw); WS 21.3	C, o, l
259.	E. Beveridge, Moriarty	30.11.77	555356	93.9	0.1	606	–	0–0.3 clay, 0.3–7.3 boulders, 7.3–93.9 *basalt* (Tt); WS 10.7, 51.8, 93.1	C, o, l
260.	E. Beveridge, Moriarty	6.2.80	554356	91.4	3.1	1061	–	0–0.3 topsoil, 0.3–6.1 clay, 6.1–12.2 *broken basalt,* 12.2–19.8 *soft basalt,* 19.8–33.5 *hard basalt,* 33.5–91.4 *soft basalt* (Tt); WS 7.6, 30.5–76.2	C, o, l
261.	A. C. Duff, Northdown	1976	574424	83	–	>300	–	No official report supplied.	
262.	A. Duff, Northdown	21.6.79	567416	149.4	61	379	–	0–0.3 topsoil, 0.3–45.7 clay and *basalt* (Tm), 45.7–66.5 *sand* (Tw), 66.5–149.4 *basalt* (Tt), >149.4 quartz gravel (Th); WS 10.67–149.4	C, o, l
263.	A. Duff, Northdown	5.7.79	575424	120.4	–	341	–	77.7–115.8 *basalt* (Tt), 111.5–118.9 grey clay, 118.9–120.4 white sand; WS 91.4–106.7	C, o, l
264.	Max Hortle, Moriarty	9.1.80	574351	47.3	–	273	–	0–3.1 clay, 3.1–16.8 *decomposed basalt,* 16.8–45.1 *basalt* (Tt), 45.1–47.2 clay; WS 12.2–41.2	C, o, l
265.	H. Horne, Wesley Vale	14.5.80	540367	30.5	–	41.7	–	0–9.1 red sand, 9.1–12.2 *decomposed material,* 12.2–30.5 sand; WS 9.1–12.2	C, o, l
266.	H. Horne, Wesley Vale	15.5.80	545365	30.5	–		–	0–0.5 topsoil, 0.5–30.5 yellow and brown sand Tw	C, a, l
267.	A. C. Loane, Northdown	18.5.79	557412	?	?	?	–	0–47.0 orange, brown, purple clay (Tm), 47.0–70.1 sand, clayey sand (Tw), >70.1 basalt (Tt)	–
268.	A. C. Loane, Northdown	25.5.79	556411	153.9	–	227	–	0–0.3 topsoil, 0.3–51.8 clay (weathered basalt), 51.8–71.0 sand, 71.0–72.5 soft basalt, 72.5–153.9 *basalt* (Tt); WS 112.8	C, o, l

Bore	Owner and address	Date completed	AMG ref.[1]	Total depth (m)	SWL (m)[2]	Yield (l/min)	TDS[3]	Driller's log (aquifer italicised)[4]	Remarks[5]
269	A. C. Loane, Northdown	2.7.79	556406	61.0	12.2	1137	–	0–0.3 topsoil, 0.3–15.2 clay, 15.2–30.5 sand, 30.5–36.6 black clay, 36.6–41.2 decomposed basalt, 41.2–61 *basalt* (Tt); WS 45.7–59.4	C, o, l
270.	V. Mitchell, Moriarty	14.7.79	562349	111.3	12.3	531	–	0–0.3 topsoil, 0.3–9.1 clay, 9.1–12.3 decomposed basalt, 12.3–38.1 *basalt*, 38.1–106.7 *soft basalt*, 106.7–111.3 *hard basalt* (Tt); WS 21.5–106.7	C, o, l
271.	Perc Mitchell, Moriarty	12.5.80	558356	24.4	0.9	106	0	0–0.6 topsoil, 0.6–6.1 yellow clay, 6.1–14.6 *decomposed basalt*, 14.6–24.4 *basalt* (Tt); WS 9.1–10.9	–
272.	Mr Norton, Devonport	4.4.72	516416	25.9	3.7	68.2	–	0–0.9 gravel filling, 0.9–7.0 yellow, grey sand, some shells, 7.0–11.6 decomposed rock (grey), 11.6–25.9 *basalt* (Tt); WS 16.8	C, o, l
273.	N. Papas, Latrobe	18.12.75	504371	38.1	7.3	303	280*	0–0.3 topsoil, 0.3–6.1 clay, 6.1–24.4 *tillite*, 24.4–27.4 fossils, 27.4–38.1 sandstone (Pm); WS 22.9	C, o, l
274.	C. Radford, Moriarty	23.6.79	582389	91.4	6.1	341	–	0–0.3 topsoil, 0.3–9.1 clay, 9.1–13.7 decomposed basalt, 13.7–76.2 *basalt*, 76.2–88.4 *yellow clay*, 88.4–91.4 dolerite; WS 35–88.4	C, o, l
275.	Les Redpath, Moriarty	26.11.80	553362	51.8	6.1	531	–	0–3.1 soft brown clay, 3.1–24.4 soft sandstone, 24.4–27.4 hard sandstone, 27.4–51.8 *hard basalt* (Tt). Later deepened to 106.7 m; WS 36.6	C, o, l
276.	Thomas Bros, Northdown	21.1.82	566422	74.7	–	abandoned 15.2	–	0–0.3 topsoil, 0.3–29.3 clay, 29.3–38.1 *decomposed basalt* (Tm), 38.1–67.1 yellow clay, 67.1–74.7 sand; WS 30.5	C, o, l
277.	B. M. Thomas, Northdown	10.1.81	568417	94.5	48.8	190	–	0–0.3 topsoil, 0.3–54.9 clay and sandy clay, 54.9–62.5 sand, 62.5–91.4 *basalt and red clay*, 91.4–94.5 yellow clay and dolerite(?); WS 62.5–91.4	C, o, l
278.	G. Thomas, Northdown	22.1.82	567425	67.1	–	abandoned	–	0–0.3 topsoil, 0.3–22.9 clay, 22.9–38.1 basalt, 38.1–61 decomposed basalt, 61.0–67.1 sand; WS 33.5	C, a, l
279.	D. Trambas, Wesley Vale	8.10.81	525380	29.0	9.1	91	–	0–0.3 topsoil, 0.3–15.9 clay, 15.9–21.3 *basalt* (Tt), 21.3–29.0 brown clay; WS 15.9–21.3	C, o, l
280.	N. Webb, Wesley Vale	21.1.81	567415	47.3	30.5	18.2	–	0–0.3 topsoil, 0.3–12.2 red clay, 12.2–36.6 clay and decomposed basalt, 36.6–42.7 *hard basalt* (Tm), 42.7–47.3 *sand* (Tw); WS 36.6–47.3	C, o, l
281.	D. Yaxley, East Devonport	23.1.73	498378	32.0	–	abandoned	–	0–0.6 topsoil, 0.6–0.9 clay and gravel, 0.9–14.9 red, yellow clay, 14.9–24.4 decomposed basalt, 24.4–32.0 basalt; WS 0.9, 3.4, 24.4	C, a, l
282.	Geneva Fellowship, Latrobe	19.4.82	528359	34.1	9.8	136	300	0–9.8 clay, 9.8–17.1 sandstone, 17.1–34.1 *mudstone*; WS ≥ 17.1	C, o, l
283.	W. T. Plumbridge, Wesley Vale	2.4.82	529398	24.4	18.3	53.1	–	0–0.3 topsoil, 0.3–21.3 clay, 21.3–24.4 *basalt* (Tt); WS 21.3–24.4	C, o, l
284.	L. W. R. Slater, Moriarty	9.6.82	573370	102.1	–	273	–	85.4–93.0 basalt, 93.0–96.0 mudstone, brown clay, 96.0–102.1 *basalt* (Tt); WS 97.5	C, o, l
285.	Ian McCormick, Frankford Highway	31.12.82	512383	38.1	–	53.1	–	0–0.3 topsoil, 0.3–16.8 clay, 16.8–18.0 loose basalt, 18.0–38.1 basalt (*dolerite*?); WS 30.5–35.1	C, o, l
286.	Paul Stevenson, Wesley Vale	6.8.82	543397	73.2	15.2	531	–	0–0.3 topsoil, 0.3–9.8 clay, 9.8–11.3 sand, 11.3–17.1 clay, 17.1–73.2 *basalt* (Tt); WS 33.5–39.6	C, o, l

Bore	Owner and address	Date completed	AMG ref.[1]	Total depth (m)	SWL (m)[2]	Yield (l/min)	TDS[3]	*Driller's log (aquifer italicised)*[4]	Remarks[5]
287.	Thomas Bros, Northdown	20.9.82	566426	33.5	–	–	–	0–0.3 topsoil, 0.3–24.4 clay, 24.4–30.5 decomposed basalt, 30.5–33.5 sandy clay	C, a, l
288.	Thomas Bros, Northdown	27.9.82	565424	93	45.7	136	–	0–0.3 topsoil, 0.3–36.6 clay, 36.6–45.7 decomposed basalt, 45.7–62.5 sand, 62.5–85.4 *basalt* (Tt), 85.4–88.4 dolerite, 88.4–93 mudstone; WS 67.1–82.3	C, o, l
289.	Thomas Bros, Northdown	8.11.82	561421	29	–	–	–	0–0.3 topsoil, 0.3–12.2 clay, 12.2–25.9 decomposed basalt, 25.9–29 sand	C, a, l
290.	Thomas Bros, Northdown	9.11.82	569421	29	–	–	–	0–0.3 topsoil, 0.3–24.4 clay, 24.4–29 sandstone	C, a, l
291.	Thomas Bros, Northdown	9.11.82	565428	24.4	–	–	–	0–0.3 topsoil, 0.3–12.2 clay, 12.2–22.9 decomposed basalt, 22.9–24.4 sand	C, a, l
292.	Thomas Bros, Northdown	10.11.82	562429	47.3	3.7	303	–	0–0.3 topsoil, 0.3–6.1 clay, 6.1–7.0 shingle, 7.0–42.7 *basalt* (Tt), 42.7–47.3 mudstone; WS 7.6–27.4	C, o, l
293.	Addison Bros, New Ground Rd, Latrobe	14.1.83	550389	80.5	–	abandoned 76	–	0–3.7 topsoil and subsoil, 3.7–12.2 clay, 12.2–48.8 *basalt* (Tt), 48.8–80.5 clay, shale, mudstone and *sandstone*; WS 30.5–48.8	C, a, l
294.	Addison Bros, New Ground Rd, Latrobe	15.1.83	557338	36.6	15.2	190	–	0–2.4 topsoil, 2.4–22.0 clay, 22.0–34.1 *basalt*, 34.1–35.4 *mudstone*, 35.4–36.6 *clay*; WS 29.3	C, o, l
295.	John Bramich, Moriarty	11.1.83	570348	70.7	–	abandoned 91	–	0–3.1 topsoil, subsoil, 3.1–7.6 clay, 7.6–16.8 *decomposed rock*, 16.8–70.1 *basalt* (Tt), 70.1–70.7 clay; WS 15.2–30.5	C, a, l
296.	John Bramich, Moriarty	13.1.83	573348	80.5	6.1	379	–	0–2.4 topsoil, subsoil, 2.4–7.0 clay, 7.0–24.4 *decomposed rock*, 24.4–75.6 *basalt* (Tt), 75.6–78 sand, *gravel*, 78–80.5 clay (Th); WS 15.2–30.5, 75.6	C, o, l
297.	Ross Bennett, East Devonport	4.11.82	481392	41.2	–	68.2	–	0–0.3 topsoil, 0.3–6.4 clay, 6.4–10.7 broken basalt, 10.7–24.4 *brown, grey clay*, 24.4–30.5 sandstone, 30.5–41.2 dolerite; WS 21.3–24.4	C, o, l
298.	Ross Bennett, East Devonport	4.11.82	–	44.2	–	abandoned 27.3	–	0–0.3 topsoil, 0.3–6.4 clay, 6.4–12.2 broken basalt, 12.2–21.3 hard basalt, 21.3–27.4 *basalt* (Tt); clay, 27.4–36.6 basalt, 36.6–44.2 dolerite; WS 21.3–24.4	C, a, l
299.	Ross Bennett, East Devonport	4.11.82	–	24.4	3.1	68.2	–	0–0.3 topsoil, 0.3–6.4 clay, 6.4–11.3 broken basalt, 11.3–24.4 *clay* (Th?); WS 21.3–24.4	C, o, l
300.	Wesley Vale Football Club, Wesley Vale	6.10.82	541372	30.5	–	–	–	0–6.1 orange clay, 6.1–9.1 sand, 9.1–30.5 green clay	C, a, l
301.	Wesley Vale Football Club, Wesley Vale	6.10.82	541373	30.5	–	–	–	0–6.1 orange clay, 6.1–9.1 sand, 9.1–30.5 green clay	C, a, l
302.	Lyall Allen, Devonport	12.1.83	497387	30.5	18.3	60.6	–	0–0.6 topsoil, 0.6–7.6 orange clay, 7.6–18.3 red, white clay, 18.3–27.4 *grey clay*, 27.4–30.5 *grey shale* (Pm); WS 27.4	C, o, l
303.	M. Brown, Wesley Vale	14.7.83	554419	107.8	–	1520	–	0–0.3 topsoil, 0.3–5.5 clay, 5.5–6.1 *sand*, 6.1–35.1 clay, 35.1–42.1 sand, 42.1–48.8 *hard basalt*, 48.8–54.9 soft basalt, 54.9–85.4 *basalt*, 85.4–88.5 mudstone and sandstone, 88.5–107.8 *basalt* (Tt); WS 42.7, 54.9, 100.6	C, a, l
304.	A. C. Loane, Wesley Vale	22.7.83	555416	155.5	–	265	–	0–0.3 topsoil, 0.3–15.2 clay, 15.2–21.3 decomposed basalt, 21.3–36.6 clay and sand, 36.6–42.7 basalt, 42.7–64.1 sand and clay, 64.1–152.4 *basalt* (Tt), 152.4–155.5 clay; WS 67.1, 97.6	C, o, l

Bore	Owner and address	Date completed	AMG ref.[1]	Total depth (m)	SWL (m)[2]	Yield (l/min)	TDS[3]	Driller's log (aquifer italicised)[4]	Remarks[5]
305.	A. C. Loane, Wesley Vale	July ? 1983	555415	140.2	–	758	–	0–0.3 topsoil, 0.3–12.2 clay, 12.2–15.2 decomposed basalt, 15.2–42.7 clay, 42.7–51.9 sand, 51.9–54.9 decomposed basalt, 54.9–140.2 *basalt* (Tt); WS 80.1–12.2?	C, o, I
306	Malcolm Murdoch, Moriarty	6.4.83	580385	56.4	–	abandoned 30.3	–	0–0.3 topsoil, 0.3–9.1 clay, 9.1–21.3 *basalt*, 21.3–45.7 clay, 45.7–56.4 dolerite(?); WS 21.3	C, a, I
307.	Malcolm Murdoch, Moriarty	7.4.83	576384	41.2	6.1	abandoned 227	–	0–0.3 topsoil, 0.3–9.1 clay, 9.1–15.2 *decomposed basalt*, 15.2–41.2 *dolerite*(?) (basalt, Tt?); WS 7.6–33.5	C, a, I
308.	Malcolm Murdoch, Moriarty	8.4.83	574384	61	6.1	758	–	0–0.3 topsoil, 0.3–12.2 *clay*, 12.2–24.4 *decomposed basalt*, 24.4–57.9 *basalt*, 57.9–61 clay; WS 6.1, 21.3, 42.3, 54.9	C, o, I
309.	Les Redpath, Moriarty	3.2.83	558363	93	12.2	381	–	0–0.3 topsoil, 0.3–18.3 clay, 18.3–93 *basalt* (Tt); WS 21.3, 36.6, 54.9, 85.4	C, o, I
310.	D. A. Addison, Moriarty	16.5.81	561357	63.4	18.3	381	–	0–2.4 clay, 2.4–5.5 broken basalt, 5.5–18.3 basalt, 18.3–21.3 broken basalt, 21.3–63.4 *basalt* (Tt); WS 24.4, 47.9, 48.8	C, o, I
311.	D. Dick, Wesley Vale	29.12.83	550392	111.3	15.2	606	–	0–0.3 topsoil, 0.3–6.1 clay, 6.1–9.1 sand, 9.1–25 clay, 25–111.3 *basalt* (Tt); WS 48.7–106.7	C, o, I
312.	Alan Wilson, Wesley Vale	13.1.84	562400	75.3	–	–	–	0–13.7 topsoil, clay, 13.7–21.3 sand, 21.3–28.7 sandstone, 28.7–36.6 clay, 36.6–42.6 sandy clay, 42.6–45.7 decomposed rock, 45.7–75.3 basalt.	C, a, I
313.	Alan Wilson, Wesley Vale	24.1.84	562405	122	–	abandoned 91	–	0–0.6 topsoil, 0.6–39.6 clay, 39.6–56.1 sandstone, 56.1–57.8 decomposed rock, 57.8–122 *basalt* (Tt); WS 73.2, 82.3	C, a, I
314.	A. M. Cooper, Wesley Vale	11.10.84	537398	30.4	4.6	183	–	0–1.2 topsoil, 1.2–7.6 clay, 7.6–16.7 *decomposed rock*, 16.7–30.4 *basalt* (Tt); WS 7.6, 16.7, 25.9, 29	C, o?, I
315.	W. T. Thompson, Devonport	2.4.84	494387	14.6	9.1	37.9	–	0–10.7 well, 10.7–14.6 *basalt* (Tt); WS 10.6–13.1	C, o, I
316.	Bovill Bros, East Devonport	3.84	480406	56.4	–	303	–	0–0.3 topsoil, 0.3–4.6 clay, 4.6–16.2 *loose basalt*, 16.2–53.3 *basalt* (Tt), 53.3–56.4 dolerite; WS 10.7, 16.2, 42.7, 51.8	C, o?, I
317.	R. Loane, Wesley Vale	16.5.84	552418	134.1	–	417	–	0–0.6 topsoil, 0.6–19.8 clay, 19.8–43 sand, 43–78 *basalt* (Tt), 78–94.5 clay, 94.5–134.1 basalt; WS 64.9–78.0	C, o, I
318.	J. Bramich, Moriarty	13.11.84	578348	90	–	303	–	0–12 clay, 12–15 *weathered basalt*, 15–90 *basalt*; WS 12, 15, 54, 88	C, c, I
319.	V. R. Mitchell, Moriarty	6.12.84	560352	87.5	–	182	–	0–0.5 surface soil, 0.5–4.1 clay, 4.1–15 clay, decomposed basalt, 15–86.5 basalt and clay, 86.5–87.5 grey clay	C, c, I
320.	Myra Dawson, Moriarty	4.4.85	559258	48.8	–	37.9	–	0–0.3 topsoil, 0.3–5.8 clay, 5.8–9.1 sandy clay, 9.1–10.4 sand, 10.4–36.6 clay, 36.6–48.8 *honeycomb basalt*; WS 42.7–45.7	C, o, I
321.	A. P. & E. Dick, Wesley Vale	14.4.88	544387	89.9	–	760	–	0–0.3 topsoil, 0.3–4.6 clay, 4.6–39.6 *basalt*, 39.6–42.7 clay, 42.7–77.7 *basalt* (Tt), 77.7–85.3 clay, 83.5–89.9 basalt; WS 24.4, 48.8, 76.2	–
322.	R. Jarmens, Moriarty	11.9.87	555354	30.4	6.1	76	–	0–06 topsoil, 0.6–18.3 clay, 18.3–21.3 decomposed basalt, 21.3–30.4 soft basalt	–

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323.	Julie Moore, Wesley Vale	23.2.86	540363	21.3	9.1	7.6	–	0–0.3 topsoil, 0.3–1.5 clay, 1.5–1.8 dolerite boulder, 1.8–3.7 clay, 3.7–21.3 *dolerite*;WS 12.2–15.2	–
324.	C. Radford, Moriarty	14.6.85	580392	61	–	abandoned 45.5	–	0–0.3 topsoil, 0.3–2.1 clay, 2.1–6.1 sandy clay, 6.1–24.4 and 24.4–43.3 clay, 43.3–61 *basalt* (Tt); WS 48.8	–
325.	T. Atkins, Wesley Vale	1.4.85	537398	90	–	303	–	0–0.3 surface soil, 0.3–5.5 clayey sand, 5.5–15.5 clay, 15.5–19 basalt and clay, 19–90 *basalt* (Tt); WS 42–79	–
326.	Foster, Wesley Vale	5.2.85	535378	55	–	1516	–	0–0.3 surface soil, 0.3–13.5 clay, 13.5–15.5 *broken basalt*, 15.5–55 *basalt* (Tt); WS 14–36	–
327.	M. Marshall, East Devonport	18.3.85	489402	100	–	114	–	0.0.3 surface soil, 0.3–16.5 basalt clay, 16.5–24 *broken basalt* (Tt), 24–54 basalt, 54–100 decomposed basalt; WS 16.5	–
328.	R. Nicholas, Sassafras	15.2.82	582298	38.1	6.1	136	–	0–0.3 topsoil, 0.3–6.1 clay, 6.1–9.1 *loose basalt*, 9.1–33.5 *basalt* (Tm), 33.5–38.1 sand, (Tw); WS 9.1, 18.3, 27.4	C, o, I
329.	R. Nicholas, Sassafras	12.2.82	582295	33.5	–	abandoned 45.5	–	0–0.3 topsoil, 0.3–2.4 clay, 2.4–21.3 *decomposed basalt* (Tm), 21.3–31.1 hard basalt, 31.1–33.5 sandy clay; WS 10.7–21.3	C, a, I
330.	Perry, Sassafras	22.9.80	582283	70.1	0.3	303	–	0–0.3 topsoil, 0.3–24.4 clay, 24.4–35.1 *decomposed basalt*, 35.1–70.1 *mudstone* (Pm?); WS 24.4–54.9	C, o.I
331.	Perry, Sassafras	29.9.80	584285	65.5	–	abandoned 37.9	–	0–0.3 topsoil, 0.3–6.1 clay, 6.1–61 *basalt* (Tm), 61–64.0 *sandy quartz*, 64.0–65.5 sand; WS 18.3, 61	C, a, I
332.	T. Padman, Sassaftras	7.11.77	608248	56.4	30.5	109.9	–	0–0.3 topsoil, 0.3–1.8 clay, 1.8–56.4 mudstone	C, o, I
333.	J. Padman, Sassafras	2.4.80	593253	33.5	–	75.8	–	0–17.7, sand and clay, 17.7–33.5 mudstone; WS 31.4	C, a
334.	J. Padman, Sassafras	3.4.80	593252	33.5	–	15.2	–	0–6.1 sand and clay, 6.1–38.1 mudstone	C, o
335.	C. Richardson, Brierley Creek, Sassafras	21.4.81	587307	33.5	6.1	60.6	210	0–0.3 topsoil, 0.3–10.7 clay, 10.7–12.8 decomposed basalt, 12.8–29.0 *basalt* (Tm), 29.0–32.6 sandy clay, 32.6–33.5 sand; WS 15.2–29	C, o, I
336.	C. Richardson, Brierley Creek, Sassafras	22.4.81	587307	29.0	–	abandoned 30.3	–	0–0.3 topsoil, 0.3–7.6 topsoil, 7.6–24.4 *basalt* (Tm), 24.4–29.0 clay and sand; WS 9.1	C, a, I
337.	C. Richardson, Brierley Creek, Sassafras	23.4.81	592301	24.4	–	–	–	0–0.3 topsoil, 0.3–3.1 clay, 3.1–22.9 basalt, 22.9–24.4 sand	C, a, I
338.	C. Richardson, Brierley Creek, Sassafras	23.4.81	589299	27.4	–	–	–	0–0.3 topsoil, 0.3–6.1 clay, 6.1–25.9 basalt, 25.9–27.4 sand	C, a, I
339.	C. Richardson, Brierley Creek, Sassafras	4.5.81	592295	29.0	–	abandoned 37.9	–	0–0.3 topsoil, 0.3–6.1 clay, 6.1–12.2 *decomposed basalt* (Tm), 12.2–25.9 basalt, 25.9–28.4 clay, 28.4–29 sand; WS 9.1, 12.2	C, a, I
340.	C. Richardson, Brierley Creek, Sassafras	4.2.82	595299	15.2	–	–	–	0–0.3 topsoil, 0.3–4.6 clay, 4.6–15.2 basalt	C, a, I
341.	C. Richardson, Brierley Creek, Sassafras	4.2.82	594299	39.6	–	abandoned 75.8	–	0–0.3 topsoil, 0.3–9.1 *clay*, 9.1–19.8 *decomposed basalt*, 19.8–24.4 clay, 24.4–36.6 sandy clay, 36.6–39.6 broken clay; WS 6.1, 12.2, 18.3	C, a, I
342.	C. Richardson, Brierley Creek, Sassafras	5.2.82	591300	33.5	–	abandoned 15.2	–	0–0.3 topsoil, 0.3–7.6 clay, 7.6–16.8 *basalt* (Tm), 16.8–29.0 sandy clay, 29.0–33.5 brown clay; WS 6.1, 12.2, 18.3	C, a, I

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343.	C. Richardson, Sassafras	12.2.82	593300	33.5	6.1	abandoned 7.6	–	0–0.3 topsoil, 0.3–6.1 clay, 6.1–29.0 *hard basalt* (Tm), 29.0–33.5 sand; WS 6.1	C, a, I
344.	Brierley Grove, Sassafras	6.4.82	591293	93	–	–	–	32–93 sandy clay and mudstone	C, a, I
345.	Rockliff, Sassafras	1.6.83	596288	38.6	–	abandoned 76	–	0–0.3 topsoil, 0.3–7.6 clay, 7.6–24.4 *decomposed basalt* (Tm), 24.4–30.5 clay, 30.5–36.6 sand; WS 12.2	C, a, I
346.	Bill Rockliff, Sassafras	30.6.83	590285	61	–	?	–	0–0.3 topsoil, 0.3–2.4 clay, 2.4–36.6 *honeycomb basalt* (Tm), 36.6–48.8 clay, 48.8–54.9 decomposed dolerite, 54.9–61 clay; WS 2.4–26.6	C, o, I
347.	C. Richardson, Sassafras	20.6.83	588298	94.5	–	758	–	0–7.6 soil, clay, 7.6–10.7 decomposed basalt, 10.7–29 *basalt*, 29–88.4 silt, clay, *sand*, 88.4–93 *coarse gravel* (Tw), 93–94.5 decomposed basalt (Tt); WS 13.7–29.4, 45.7, 88.4	C, o, I
348.	Swan, East Sassafras	17.11.83	604308	33.5	24.4	114	–	0–0.3 topsoil, 0.3–12.2 sandy clay, 12.2–23.1 basalt clay, 23.1–33.5 *basalt* (Tt); WS 29	C, o.I
349.	L. Richardson, East Sassafras	31.10.84	604329	64	–	758	–	0–18 clay, 18–58 *basalt* (Tt), 58–64 clay; WS 12, 21, 24	C, c, w, I
350.	P. Swan, East Sassafras	8.11.84	605309	78	–	7.6	–	0–23 clay and sand, 23–78 basalt (very hard); WS 25, 63	C, c, I
351.	R. Nicholas, Sassafras	13.2.85	581294	59	–	606	–	0–0.3 soil, 0.3–13.5 clay, 13.5–24 *decomposed basalt*, 24–38 *basalt*, 38–48 clay, 48–59 *clayey beach sand* (Tw), 59 basalt?; WS 13.5–59	C, c, I
352.	John Brown, Sassafras	27.1.82	556292	82.9	–	abandoned 7.6	–	0–10.4 clay, 10.4–14.6 soft mudstone, 14.6–43.9 grey mudstone, 43.9–53.7 conglomerate, 53.7–82.9 sandstone, mudstone; WS 2.7	C, a, I
353.	R. Nicholas, Sassafras	5.2.82	582294	38.1	–	227	–	0–0.3 topsoil, 0.3–10.7 clay, 10.7–21.3 *decomposed basalt*, 21.3–33.5 hard basalt, 33.5–38.1 *clay and sand* (Tw); WS 10.7, 21.3, 38.1	C, o.I
354.	B. Redpath, Sassafras	11.12.80	574292	47.3	–	abandoned 75.8	–	0–0.3 topsoil, 0.3–1.5 decomposed basalt, 1.5–40.5 *basalt* (Tm), 40.5–47.3 sand and clay (Tw); WS 33.5, 40.8	C, a, I
355.	B. Redpath, Sassafras	12.12.80	573291	47.3	–	37.9	–	0–0.3 topsoil, 0.3–1.8 clay, 1.8–19.8 hard basalt, 19.8–24.4 *decomposed basalt* (Tm), 24.4–45.7 basalt, 45.7–47.2 gravel(Tw); WS 19.8–24.4	C, o.I
356.	Chris Boyes, Shale Road, Latrobe	11.11.82	520312	24.4	12.2	136	–	0–0.3 topsoil, 0.3–6.1 clay, 6.1–24.4 *shale* (Pm); WS 16.8, 21.3	C, o, I
357.	G. Garland, Sassafras	29.6.83	575296	54.9	–	?	–	0–0.3 topsoil, 0.3–1.8 clay, 1.8–19.8 *honeycomb basalt* (Tm), 19.8–36.6 basalt, 36.6–48.8 *coarse sand*, 48.8–54.9 clay (Tw); WS 12.2, 36.6	C, o, I
358.	Rockliff, Sassafras	14.2.85	570298	49	5.2	36.4	–	0–0.3 topsoil, 0.3–6 clay, 6–8 decomposed basalt, 8–12 basalt and clay, 12–48 *basalt* (Tm); WS 12.5	D
359.	G. Garland, Sassafras	19.7.84	572301	41.2	–	–	–	0–0.6 topsoil, 0.6–9.1 loose basalt, 36.6–41.2 sand	C, a
360.	G. Garland, Sassafras	21.7.84	577298	47.3	–	–	–	0–0.6 topsoil, 0.6–6.1 clay, 6.1–42.7 basalt, 42.7–47.3 sand	C, a
361.	T. Pintar, Sassafras	14.2.86	576292	39.6	18.3	114	–	0–0.6 topsoil, 0.6–7.6 clay, 7.6–9.1 decomposed rock, 9.1–39.6 *mudstone*; WS 29, 36.6	C, a

Appendix E
CHEMICAL ANALYSES OF GROUNDWATER FROM THE THIRLSTANE BASALT

Constituent	1[1]	26.6.1974[2]		3	13.9.1974		7	7.11.1974		7	7.11.1974		7	7.11.1974		7	8.11.1974		8	22.11.1974		10	12.12.74	
	741550[3]			742040			742476			742477			742478			742479			742682			742687		
	mg/l	meq/l	%meq/l	mg/l	meq/l	%meq/l	mg/l	meq/l	%meq/l	mg/l	meq/l	%meq/l	mg/l	meq/l	%meq/l	mg/l	meq/l	%meq/l	mg/l	meq/l	%meq/l	mg/l	meq/l	%meq/l
Silica	6	–	–	2.5	–	–	35	–	–	25	–	–	25	–	–	15	–	–	8	–	–	3	–	–
Iron	0.1	–	–	0.2	–	–	0.1	–	–	0.1	–	–	0.1	–	–	0.1	–	–	0.2	–	–	0.4	–	–
Aluminium	<0.1	<0.1	0.1	1.0	0.11	1.0	<0.2	<0.02	0.0	<0.2	<0.02	0.1	<0.2	<0.02	0.1	<0.2	<0.02	0.1	<0.2	<0.02	0.2	<0.02	0.02	0.1
Calcium	7.6	0.38	5.2	2.2	1.10	10.2	29	1.45	6.1	25	1.25	6.0	21	1.05	5.7	17	0.85	5.4	6.5	0.32	3.6	14	0.70	5.9
Magnesium	1.6	0.13	1.7	23	1.88	17.6	25	2.04	8.6	19	1.55	7.5	15	1.22	6.7	11	0.90	5.7	4.2	0.34	3.8	<10	<0.81	6.9
Sodium	73	3.2	43.4	60	2.60	24.4	205	8.91	37.7	180	7.82	37.9	160	6.95	38.1	145	6.30	40.2	84	3.65	40.8	100	4.34	36.7
Potassium	1.7	0.04	0.5	3	0.07	0.7	4.7	0.12	0.5	5.4	0.13	0.6	5.4	0.13	0.7	5.1	0.13	0.8	2.1	0.05	0.6	1.4	0.03	0.3
Carbonate	nil	–	–	nil	–	–	nil	–	–	nil	–	–	nil	–	–	nil	–	–	nil	–	–	nil	–	–
Bicarbonate	160	2.62	35.8	120	1.96	18.4	225	3.68	15.6	220	3.60	17.4	205	3.36	18.4	185	3.03	19.3	170	2.78	31.1	140	2.29	19.4
Sulphate	10	0.2	2.8	12	0.25	2.3	55	1.14	4.8	41	0.85	4.1	32	0.66	3.6	22	0.45	2.9	10	0.20	2.3	10	0.20	1.7
Chloride	26	0.73	10.0	95	2.67	25.0	220	6.19	26.2	190	5.35	25.9	170	4.78	26.2	140	3.94	25.2	55	1.54	17.3	120	3.38	28.5
Total dissolved solids	270	7.3	–	340	10.6	–	685	23.5	–	645	20.6	–	550	18.2	–	470	15.6	–	260	8.9	–	350	11.8	–
Permanent hardness as $CaCO_3$	nil	–	–	50	1.00	–	nil	–	–	nil	–	–	nil	–	–	nil	–	–	nil	–	–	nil	–	–
Temporary hardness as $CaCO_3$	26	0.52	–	100	2.00	–	175	3.50	–	140	2.80	–	115	2.30	–	85	1.70	–	33	0.66	–	76	1.52	–
Alkalinity	133	2.66	–	100	2.00	–	185	3.70	–	180	3.60	–	165	3.30	–	150	3.00	–	140	2.80	–	110	2.20	–
pH	7.8	–	–	6.9	–	–	7.3	–	–	7.4	–	–	7.5	–	–	8.0	–	–	8.2	–	–	8.2	–	–
Percent sodium[4]	86	–	–	47	–	–	72	–	–	74	–	–	76	–	–	79	–	–	85	–	–	74	–	–
Sodium adsorption ratio[5]	6.2	–	–	2.1	–	–	6.7	–	–	6.6	–	–	6.5	–	–	6.7	–	–	6.3	–	–	4.9	–	–
Residual sodium carbonate[6]	2.01	–	–	nil	–	–	0.19	–	–	0.80	–	–	1.1	–	–	1.3	–	–	2.12	–	–	0.78	–	–
% ionic difference[7]	–	2.4	–	–	8.3	–	–	6.4	–	–	4.7	–	–	3.2	–	–	4.9	–	–	1.5	–	–	0.4	–

Notes:
1. Bore or well (W) number: corresponds to bores tested in Appendix A.
2. Collection date
3. Department of Mines Registered Number.
4. Percent sodium %Na = 100 × (Na + K) / Na + K + Mg + Ca) in meq/. Undesirable soil leaching effects may occur in irrigated areas if the value is considerably greater than 50.
5. Sodium adsorption ratio SAR = Na / √ ((Ca+Mg) / 2) in meq/l. Undesirable soil leaching effects may occur in areas irrigated with medium salinity water (250–750 mg/l) if SAR exceeds 10–20.
6. Residual sodium carbonate RSC = (HCO_3 + CO_3) – (Ca + Mg) meq/l. Undesirable soil leaching effects may occur in irrigated areas if RSC is higher than about 105.
7. An indication of the accuracy of the analysis. Error should be zero only if all major species have been determined. % ionic difference = 100 × I(difference of cation and anion meq/l)I ÷ total.

* Partial analysis by Government Analyst.

Constituent	15	22.7.1975		15	22.7.1975		16	29.7.1975		18	13.8.1975		18	13.8.1975		19	20.8.1975		20	12.9.1975		20	12.9.1975	
		750969			750970			751093			751150			751151			751295			751296			751297	
	mg/l	meq/l	%meq/l	mg/l	meq/l	%meq/l	mg/l	meq/l	%meq/l	mg/l	meq/l	%meq/l	mg/l	meq/l	%meq/l	mg/l	meq/l	%meq/l	mg/l	meq/l	%meq/l	mg/l	meq/l	%meq/l
Silica	25	–	–	25	–	–	25	–	–	12	–	–	10	–	–	20	–	–	52	–	–	48	–	–
Iron	<0.1	–	–	<0.1	–	–		–	–	0.2	–	–	0.5	–	–	11	–	–	1.2	–	–	0.7	–	–
Aluminium	<0.2	<0.02	0.1	<0.2	<0.02	0.1	1.6	0.17	1.6	<0.2	<0.02	0.3	<0.2	<0.02	0.4	17	1.89	17.0	<0.2	<0.02	0.2	<0.2	<0.02	0.2
Calcium	40	2.0	12.6	35	1.75	12.4	27	1.35	12.2	11	0.55	9.0	6	0.30	5.4	12	0.6	5.4	22	1.10	11.1	20	1.00	10.8
Magnesium	48	3.93	24.7	41	3.36	23.8	20	1.63	14.8	5.3	0.43	7.1	1.2	0.09	1.7	20	1.63	14.7	22	1.80	18.3	21	1.72	18.7
Sodium	48	2.08	13.1	49	2.13	15.0	56	2.43	22.0	43	1.86	30.9	50	2.17	39.3	49	2.13	19.1	42	1.82	18.5	40	1.73	18.9
Potassium	1.5	0.03	0.2	1.8	0.04	0.4	4.1	0.07	0.7	1.0	0.02	0.4	0.9	0.02	0.4	0.5	0.01	0.1	3	0.07	0.7	2.9	0.07	0.8
Carbonate	nil	–	–	nil	–	–	nil	–	–	nil	–	–	nil	–	–	nil	–	–	nil	–	–	nil	–	–
Bicarbonate	290	4.75	29.9	240	3.93	27.8	210	3.44	31.1	70	1.14	18.9	79	1.29	23.4	97	1.57	14.1	150	2.45	25.0	140	2.29	25.0
Sulphate	17	0.35	2.2	13	0.27	1.9	5	0.1	0.9	5	0.1	1.7	5	0.1	1.8	9	0.18	1.6	5	0.1	1.0	5	0.10	1.1
Chloride	95	2.67	16.8	92	2.59	18.3	64	1.8	16.3	67	1.88	31.2	53	1.49	26.9	95	2.67	24.0	85	2.39	24.3	78	2.19	23.9
Total dissolved solids	460	15.8	–	440	14.1	–	310	11.0	–	170	6.0	–	160	5.5	–	280	10.7	–	320	9.75	–	290	9.1	–
Permanent hardness as $CaCO_3$	60	1.2	–	60	1.2	–	150	3.00	–	49	0.98	–	20	0.40	–	110	2.20	0	150	3.00	–	140	2.80	–
Temporary hardness as $CaCO_3$	240	4.80	–	200	4.00	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Alkalinity	240	4.80	–	200	4.00	–	170	3.40	–	58	1.16	–	65	1.30	–	79	1.58	–	130	2.60	–	120	2.40	–
pH	6.8	–	–	7.0	–	–	7.8	–	–	6.7	–	–	8.0	–	–	7.0	–	–	7.0	–	–	6.7	–	–
Percent sodium	26	–	–	30	–	–	46	–	–	66	–	–	85	–	–	49	–	–	40	–	–	40	–	–
Sodium adsorption ratio	1.2	–	–	1.3	–	–	1.9	–	–	2.6	–	–	4.8	–	–	2.0	–	–	1.5	–	–	1.4	–	–
Residual sodium carbonate	nil	–	0	nil	–	–	0.5	–	–	0.2	–	–	0.9	–	–	nil	–	–	nil	–	–	nil	–	–
% ionic difference	–	1.8	–	–	3.6	–	–	3.0	–	–	3.8	–	–	4.6	–	–	20.0	–	–	0.8	–	–	0.1	–

Constituent	23	8.6.1972		24	9.2.1973		44	21.7.1972		83	11.3.1976*		86	16.2.1976*		88	10.3.1976		129	30.12.1976		W36	5.1972	
		722812			730523			723869									763319			763308			728367	
	mg/l	meq/l	%meq/l	mg/l	meq/l	%meq/l	mg/l	meq/l	%meq/l	mg/l	meq/l	%meq/l	mg/l	meq/l	%meq/l	mg/l	meq/l	%meq/l	mg/l	meq/l	%meq/l	mg/l	meq/l	%meq/l
Silica	55	–	–	–	–	–	10	–	–	–	–	–	–	–	–	–	–	–	–	–	–	10	–	–
Iron	n.d	–	–	–	–	–	<0.1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	<0.1	–	–
Aluminium	n.d	–	–	–	–	–	<0.1	<0.01	0.1	–	–	–	–	–	–	–	–	–	–	–	–	<0.1	<0.01	<0.2
Calcium	18	0.90	10.5	–	–	–	14	0.70	8.3	11.6	–	–	13.2	–	–	17.2	–	–	20.4	–	–	7.0	0.35	6.3
Magnesium	23	1.89	22.0	–	–	–	13	1.06	12.6	3.2	–	–	2.2	–	–	23.1	–	–	19.7	–	–	8.0	0.66	11.8
Sodium	34	1.47	17.3	–	–	–	51	2.21	26.3	–	–	–	–	–	–	–	–	–	–	–	–	47	2.04	36.4
Potassium	0.9	0.02	0.2	–	–	–	1.7	0.04	0.5	–	–	–	–	–	–	–	–	–	–	–	–	2.2	0.06	1.1
Carbonate	nil	–	–	–	–	–	nil	–	–	–	–	–	–	–	–	–	–	–	–	–	–	nil	–	–
Bicarbonate	137	2.24	26.2	106	–	–	114	1.86	22.2	–	–	–	–	–	–	–	–	–	–	–	–	17	0.28	5.0
Sulphate	6	0.12	1.4	–	–	–	39	0.81	9.6	–	–	–	–	–	–	–	–	–	–	–	–	5.0	0.10	1.8
Chloride	67	1.88	22.0	70	–	–	60	1.69	20.0	–	–	–	–	–	–	–	–	–	–	–	–	74	2.09	37.3
Total dissolved solids	310	8.5	–	–	–	–	300	8.4	–	380	–	–	230	–	–	350	–	–	310	–	–	280	5.6	–
Permanent hardness as $CaCO_3$	28	0.56	–	–	–	–	nil	–	–	42	0.84	–	42	0.84	–	138	2.76	–	132	2.64	–	37	0.74	–
Temporary hardness as $CaCO_3$	112	2.24	–	–	–	–	89	1.88	–	–	–	–	–	–	–	–	–	–	–	–	–	14	0.28	–
Alkalinity	112	2.24	–	97	–	–	89	1.78	–	–	–	–	–	–	–	–	–	–	–	–	–	14	0.28	–
pH	7.2	–	–	6.8	–	–	6.9	–	–	8.9	–	–	8.2	–	–	6.9	–	–	7.8	–	–	7.1	–	–
Percent sodium	35	–	–	–	–	–	56	–	–	–	–	–	–	–	–	–	–	–	–	–	–	68	–	–
Sodium adsorption ratio	1.2	–	–	–	–	–	2.3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2.9	–	–
Residual sodium carbonate	nil	–	–	–	–	–	0.10	–	–	–	–	–	–	–	–	–	–	–	–	–	–	nil	–	–
% ionic difference	–	0.3	–	–	–	–	–	3.9	–	–	–	–	–	–	–	–	–	–	–	–	–	–	12	–

Appendix F
CHEMICAL ANALYSES OF GROUNDWATER FROM THE WESLEY VALE SAND

Constituent	2[1]	19.4.1974[2]		4	18.9.1974		4	18.8.1976		5	15.10.1974		46	21.7.1972		63	5.1972		67	8.6.1972		96	24.2.1977	
	741548[3]			742038			761623			742475			723872			722369			722814			770177		
	mg/l	meq/l	%meq/l	mg/l	meq/l	%meq/l	mg/l	meq/l	%meq/l	mg/l	meq/l	%meq/l	mg/l	meq/l	%meq/l	mg/l	meq/l	%meq/l	mg/l	meq/l	%meq/l	mg/l	meq/l	%meq/l
Silica	14	-	-	13	-	-	10	-	-	10	-	-	30	-	-	14	-	-	52	-	-	22	-	-
Iron	0.7	-	-	0.5	-	-	0.1	-	-	0.7	-	-		-	-	-	-	-	-	-	-		-	-
Aluminium			0.3	1.0	0.11	0.3	-	-	-			0.3			0.0	-	-	-	-	-	-			0.1
Calcium	6.9	0.34	9.3	43	2.15	7.0	42	2.09	5.5	24	1.20	16	36	1.80	10.7	19	0.95	9.7	29	1.45	8.4	4.3	0.21	1.4
Magnesium	6.5	0.53	14.4	40	3.27	10.8	44	3.6	9.5	10	0.81	10.9	34	2.78	16.6	9	0.73	7.5	36	2.95	17.1	18	1.48	9.9
Sodium	19	0.82	22.4	200	8.69	28.6	300	13.1	34.6	36	1.56	20.9	80	3.47	20.7	75	3.26	33.5	88	3.82	22.2	130	5.65	37.9
Potassium	1.4	0.03	0.9	16	0.40	1.3	17	0.44	1.2	5	0.12	1.7	0.8	0.02	0.1	2	0.05	0.5	5	0.12	0.7	2.0	0.05	0.3
Carbonate	nil	-	-	nil	-	-	nil	-	-	nil	-	-	nil	-	-	nil	-	- nil	-	-	nil	-	-	
Bicarbonate	59	0.96	26.2	200	3.27	10.8	150	2.46	6.5	135	2.21	29.5	181	2.96	17.6	198	3.24	33.4	137	2.24	13.0	5	0.08	0.5
Sulphate	10	0.20	5.6	41	0.85	2.8	70	1.46	3.9	10	0.20	2.7	27	0.56	3.3	4	0.08	0.8	4	0.08	0.4	18	0.37	2.5
Chloride	26	0.73	19.8	410	11.54	38.0	520	14.7	38.8	46	1.29	17.3	18.3	5.15	3.7	49	1.38	14.2	232	6.53	37.9	250	7.05	47.3
Total dissolved solids	182	3.6	-	950	30.3	-	1200	37.9	-	24.5	7.4	-	550	16.7	-	280	9.7	-	625	17.2	-	500	14.9	-
Permanent hardness as $CaCO_3$	nil	-	-	110	2.20	-	155	3.10	-	nil	-	-	82	1.64	-	nil	-	-	108	2.16	-	81	1.62	-
Temporary hardness as $CaCO_3$	44	0.88	-	160	3.20	0	130	2.60	-	100	2.00	-	148	2.96	-	162	3.24	-	112	2.24	-	4	0.08	-
Alkalinity	48	0.96	-	160	3.20	-	130	2.60	-	110	2.20	-	148	2.96	-	162	3.24	-	112	2.24	-	4	0.08	-
pH	6.3	-	-	7.4	-	-	6.7	-	-	6.9	-	-	7.0	-	-	7.2	-	-	6.8	-	-	4.8	-	-
Percent sodium[4]	50	-	-	63	-	-	70	-	-	46	-	-	43	-	-	66	-	-	47	-	-	77	-	-
Sodium adsorption ratio[5]	1.2	-	-	5.2	-	-	7.8	-	-	1.5	-	-	2.2	-	-	3.5	-	-	2.5	-	-	6.1	-	-
Residual sodium carbonate[6]	0.09	-	-	nil	-	-	nil	-	-	0.2	-	-	nil	-	-	1.6	-	-	nil	-	-	nil		
% ionic difference[7]	-	3.5	-	-	3.3	-	-	1.6	-	-	0.5	-	-	3.4	-	-	2.9	-	-	2.9	-	-	0.6	-
Conductivity (µS/cm at 25°C)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Notes:
1. Bore or well (W) number: corresponds to bores tested – Appendix D or wells – Appendix C.
2. Collection date
3. Department of Mines Registered Number.
4. Percent sodium %Na = 100 × (Na + K) / Na + K + Mg + Ca) in meq/*l*. Undesirable soil leaching effects may occur in irrigated areas if the value is considerably greater than 50.
5. Sodium adsorption ratio SAR = Na / √ ((Ca+Mg) / 2) in meq/*l*. Undesirable soil leaching effects may occur in areas irrigated with medium salinity water (250–750 mg/*l*) if SAR exceeds 10–20.
6. Residual sodium carbonate RSC = (HCO_3 + CO_3) – (Ca + Mg) meq/*l*. Undesirable soil leaching effects may occur in irrigated areas if RSC is higher than about 105.
7. An indication of the accuracy of the analysis. Error should be zero only if all major species have been determined. % ionic difference = 100 × I(difference of cation and anion meq/*l*)I ÷ total.

* Partial analysis by Government Analyst.

Constituent	W1	5.1972		W8	5.1972		W9	5.1972		W10	5.1972	
		722374			722376			722370			722372	
	mg/l	meq/l	%meq/l	mg/l	meq/l	%meq/l	mg/l	meq/l	%meq/l	mg/l	meq/l	%meq/l
Silica	16	-	-	4	-	-	4	-	-	40	-	-
Iron		-	-		-	-		-	-		-	-
Aluminium		-	-		-	-		-	-		-	0.0
Calcium	3.5	0.17	5.9	1.7	0.08	3.3	1.7	0.08	2.7	41	2.05	8.6
Magnesium	3.0	0.24	8.3	4	0.32	12.8	5	0.40	13.1	72	5.9	25.0
Sodium	19.0	0.82	28.1	20	0.86	34.2	28	1.21	39.1	100	4.34	18.4
Potassium	1.1	0.02	0.9	1.3	0.03	1.3	0.8	0.02	0.6	1.2	0.03	0.1
Carbonate	nil	-	-	nil	-	-	nil	-	-	nil	-	-
Bicarbonate	29	0.47	16.1	4	0.06	2.5	5	0.08	2.5	140	2.29	9.7
Sulphate	19	0.39	13.4	8	0.16	6.5	5	0.10	3.3	208	4.33	18.3
Chloride	28	0.78	26.8	35	0.98	38.7	42	1.18	38.1	165	4.64	19.6
Total dissolved solids	75	2.9	-	20	2.5	-	95	3.1	-	505	23.6	-
Permanent hardness as $CaCO_3$	nil	-	-	18	0.36	-	21	0.42	-	283	5.66	-
Temporary hardness as $CaCO_3$	24	0.48	-	3	0.06	-	4	0.08	-	115	2.30	-
Alkalinity	24	0.48	-	3	0.06	-	4	0.08	-	115	2.30	-
pH	6.1	-	-	4.8	-	-	4.7	-	-	6.3	-	-
Percent sodium	67	-	-	69	-	-	71	-	-	36	-	-
Sodium adsorption ratio	1.8	-	-	1.9	-	-	2.4	-	-	2.1	-	-
Residual sodium carbonate	0.06	-	-	nil	-	-	nil	-	-	nil	-	-
% ionic difference	-	13	-	-	3.8	-	-	12	-	-	4	-
Conductivity (µS/cm at 25°C)	-	-	-	-	-	-	-	-	-	-	-	-

Constituent	W15	5.1972		W19	5.1972		W55	1.1977		W62	1.1977	
		722371			770275			770116			770118	
	mg/l	meq/l	%meq/l	mg/l	meq/l	%meq/l	mg/l	meq/l	%meq/l	mg/l	meq/l	%meq/l
Silica	8	-	-	17	-	-	8	-	-	6	-	-
Iron		-	-		-	-		-	-		-	-
Aluminium		-	-		-	-		-	-		-	-
Calcium	3.3	0.16	3.0	8	0.40	9.7	4	0.20	5.0	28	1.40	20.0
Magnesium	7.0	0.57	10.6	5	0.41	10.0	5	0.41	10.2	10	0.82	11.7
Sodium	44	1.91	35.4	30	1.31	31.8	30	1.31	32.7	29	1.26	18.0
Potassium	0.6	0.01	0.2	1.0	0.03	0.73	5	0.13	3.2	1.8	0.05	0.7
Carbonate	nil	-	-	nil	-	-	nil	-	-	nil		
Bicarbonate	55	0.90	16.7	22	0.36	8.74	15	0.25	6.2	96	1.57	22.5
Sulphate	2.0	0.04	0.7				11	0.23	5.7	11	0.23	3.3
Chloride	63	1.77	32.9	53	1.49	36.2	53	1.49	37.2	58	1.64	23.5
Total dissolved solids	200	5.3	-	200	4.12	-	150	4.04	-	230	6.99	-
Permanent hardness as $CaCO_3$	nil	-	-	27	0.54	-	19	0.38	-	32	0.64	-
Temporary hardness as $CaCO_3$	45	0.90	-	18	0.36	-	12	0.24	-	78	1.56	-
Alkalinity	45	0.90	-	18	0.36	-	12	0.24	-	78	1.56	-
pH	6.1	-	-	5.9	-	-	5.8	-	-	8.1	-	-
Percent sodium	72	-	-	62	-	-	70	-	-	37	-	-
Sodium adsorption ratio	3.1	-	-	2.1	-	-	2.4	-	-	1.2	-	-
Residual sodium carbonate	0.17	-	-	nil	-	-	nil	-	-	nil	-	-
% ionic difference	-	-	-	5	-	-	2	-	-	2	-	
Conductivity (µS/cm at 25°C)	-	-	-	260	-	-	250	-	-	370	-	-

Constituent	W64	1.1977		W71	1.1977		W72	1.1977		W73	1.1977		W74	1.1977		W75	1.1977		W76	1.1977		W77	1.1977	
	770145			770280			770277			770278			770276			770272			770279			770274		
	mg/l	meq/l	%meq/l	mg/l	meq/l	%meq/l	mg/l	meq/l	%meq/l	mg/l	meq/l	%meq/l	mg/l	meq/l	%meq/l	mg/l	meq/l	%meq/l	mg/l	meq/l	%meq/l	mg/l	meq/l	%meq/l
Silica	15	-	-	25	-	-	23	-	-	8	-	-	61	-	-	56	-	-	12	-	-	11	-	-
Iron		-	-		-	-	0.5	-	-	0.8	-	-	2.5	-	-		-	-		-	-	1.7	-	-
Aluminium				0.2	0.02	0.1	0.5	0.05	0.3						0.0	0.9	0.09	0.3						
Calcium	34	1.70	22.0	10	0.50	3.3	8.5	0.42	2.6	7.5	0.37	7.7	79	3.94	9.7	60	2.99	9.3	20	1.00	7.9	5	0.25	3.8
Magnesium	3.5	0.29	3.8	22	1.81	12.0	19	1.56	9.8	10	0.82	17.1	68	5.59	13.7	55	4.52	14.0	47	3.86	30.6	15	1.23	18.9
Sodium	40	1.74	22.5	120	5.22	34.6	140	6.09	38.3	32	1.39	29.0	280	12.2	30.0	210	9.14	28.4	36	1.57	12.5	42	1.83	28.2
Potassium	2	0.05	0.6	0.8	0.02	0.1	4.7	0.12	0.8	2.9	0.07	1.5	6.5	0.17	0.4	4.3	0.11	0.3	4.2	0.11	0.9	1.4	0.64	0.6
Carbonate	nil	-	-	nil	-	-	nil	-	-	nil	-	-	nil	-	-	nil	-	-	nil	-	-	nil	-	-
Bicarbonate	140	2.30	29.8	41	0.67	4.4	6	0.10	0.6	22	0.36	7.5	100	1.64	4.0	260	4.26	13.2	33	0.54	4.3	17	0.28	4.3
Sulphate	12	0.25	3.2	18	0.37	2.5	11	0.23	1.4				52	1.08	2.7	6	0.12	0.4	200	4.16	33.0	48	1.00	15.4
Chloride	49	1.38	17.9	230	6.49	43.0	270	7.61	47.9	74	2.09	43.5	570	16.1	39.6	390	11.0	34.2	46	1.30	10.3	64	1.80	27.7
Total dissolved solids	270	7.73	-	600	15.1	-	600	15.9	-	220	4.8	-	1490	40.7	-	1050	32.2	-	430	12.6	-	230	6.5	-
Permanent hardness as $CaCO_3$	nil	-	-	86	1.72	-	105	2.10	-	47	0.94	-	435	8.70	-	180	3.60	-	223	4.46	-	66	1.32	-
Temporary hardness as $CaCO_3$	110	2.20	-	34	0.68	-	5	0.10	-	18	0.36	-	85	1.70	-	220	4.40	-	27	0.54	-	14	0.28	-
Alkalinity	120	2.40	-	34	0.68	-	5	0.10	-	18	0.36	-	85	1.70	-	220	4.40	-	27	0.54	-	14	0.28	-
pH	6.7	-	-	6.4	-	-	5.5	-	-	6.0	-	-	7.0	-	-	7.0	-	-	6.6	-	-	5.5	-	-
Percent sodium	47	-	-	69	-	-	76	-	-	55	-	-	56	-	-	55	-	-	26	-	-	56	-	-
Sodium adsorption ratio	1.7	-	-	4.9	-	-	6.1	-	-	1.8	-	-	3.7	-	-	4.7	-	-	1.0	-	-	2.1	-	-
Residual sodium carbonate	0.3	-	-	nil	-	-	nil	-	-	nil	-	-	nil	-	-	nil	-	-	nil	-	-	nil	-	-
% ionic difference	-	2	-	-	0	-	-	6	-	-	12	-	-	8	-	-	5	-	-	4	-	-	4	-
Conductivity (µS/cm at 25°C)	390	-	-	940	-	-	1000	-	-	350	-	-	2250	-	-	1600	-	-	660	-	-	360	-	-

Constituent	W78	1.1977 741548		W79	1.1977 742038		W81	1.1977 761623		W84	11.1977 770177	
	mg/l	meq/l	%meq/l	mg/l	meq/l	%meq/l	mg/l	meq/l	%meq/l	mg/l	meq/l	%meq/l
Silica	16	-	-	17	-	-	21	-	-	11	-	-
Iron		-	-	1.7	-	-		-	-		-	-
Aluminium												
Calcium	30	1.50	12.2	32	1.60	25.8	24	1.20	12.8	2.1	0.10	4.9
Magnesium	18.1	1.49	12.1	3.4	0.28	4.5	8.6	0.71	7.6	3.3	0.27	13.3
Sodium	49	2.13	17.3	24	1.04	16.8	52	2.26	24.2	13	0.57	28.1
Potassium	2.2	0.06	0.5	2.5	0.06	1.0	2	0.05	0.5	0.6	0.02	1.0
Carbonate	nil	-	-	nil	-	-	nil	-	-	4.3	0.14	6.9
Bicarbonate	210	3.44	28.0	93	1.53	24.7	72	1.18	12.6	13	0.21	10.3
Sulphate	62	1.29	10.5	10	0.21	3.4				12	0.25	12.3
Chloride	85	2.40	19.5	53	1.49	24.0	120	3.38	36.1	16	0.45	22.2
Total dissolved solids	370	12.3	-	270	6.2	-	300	9.4	-	70	2.03	-
Permanent hardness as $CaCO_3$	nil	-	-	34	0.68	-	51	1.02	-	1	0.02	-
Temporary hardness as $CaCO_3$	160	3.20	-	76	1.52	-	59	1.18	-	0.36	-	
Alkalinity	170	3.40	-	76	1.52	-	59	1.18	-	18	0.36	-
pH	6.6	-	-	6.7	-	-	6.4	-	-	9.8	-	-
Percent sodium	42	-	-	37	-	-	55	-	-	61	-	-
Sodium adsorption ratio	1.7	-	-	1.1	-	-	2.3	-	-	1.3	-	-
Residual sodium carbonate	0.45	-	-	nil	-	-	nil	-	-	nil	-	-
% ionic difference	-	16	-	-	4	-	-	0.3	-	-	3	-
Conductivity (µS/cm at 25°C)	540	-	-	380	-	-	480	-	-	130	-	-

Appendix G
CHEMICAL ANALYSES OF GROUNDWATER FROM THE MORIARTY BASALT

Constituent	W41[1]	5.1972[2] 723868[3]		W57	1.1977 770123		W58	1.1977 770122		W60	1.1977 770117		W63	1.1977 770119		W65	1.1977 770146		W67	1.1977 770148		W68	1.1977 770147	
	mg/l	meq/l	%meq/l	mg/l	meq/l	%meq/l	mg/l	meq/l	%meq/l	mg/l	meq/l	%meq/l	mg/l	meq/l	%meq/l	mg/l	meq/l	%meq/l	mg/l	meq/l	%meq/l	mg/l	meq/l	%meq/l
Silica	10	-	-	16	-	-	7	-	-	<5	-	-	13	-	-	7	-	-	<5	-	-	<5	-	-
Iron	0.3	-	-	<0.1	-	-	<0.1	-	-	<0.1	-	-	<0.1	-	-	<0.1	-	-	<0.1	-	-	<0.1	-	-
Aluminium	0.1	0.01	0.2	<0.2	<.02	<0.2	<0.2	<0.2	<0.5	<0.2	<0.02	<0.6	<0.2	<0.02	<0.3	<0.2	<0.02	<0.4	<0.2	<0.02	<0.8	<0.2	<0.02	<0.8
Calcium	11	0.55	10.0	20	1.0	11.8	4.8	0.24	5.7	2.4	0.12	3.5	14	0.70	9.2	3.5	0.17	3.5	3.5	0.17	7.0	2	0.1	4.2
Magnesium	10	0.81	14.9	13	1.07	12.6	7.4	0.61	14.4	5.0	0.41	11.9	12	0.99	13.0	5.8	0.48	10.0	5.6	0.46	18.9	6.2	0.51	21.5
Sodium	32	1.39	25.4	53	2.31	27.3	33	1.44	34.0	27	1.17	33.9	50	2.18	28.6	42	1.83	38.0	15	0.65	26.6	15	0.65	27.4
Potassium	0.4	0.01	0.1	0.9	0.02	0.2	1	0.03	0.7	1.4	0.04	1.2	5.2	0.13	1.7	0.6	0.02	0.4	2.8	0.07	2.9	2.8	0.07	3.0
Carbonate	nil	-	-	nil	-	-	nil	-	-	nil	-	-	nil	-	-	nil	-	-	nil	-	-	nil	-	-
Bicarbonate	37	0.60	11.0	48	0.79	9.3	15	0.25	5.9	13	0.21	6.1	34	0.56	7.3	7	0.11	2.3	4	0.07	2.9	1	0.02	0.8
Sulphate	14	0.29	5.3	8	0.17	2.0	10	0.21	5.0	5	0.10	2.9	24	0.50	6.6	<5	<0.1	2.1	<5	<0.1	4.1	<5	<0.1	4.2
Chloride	63	1.77	32.4	110	3.10	36.6	51	1.44	34.0	49	1.38	40.0	90	2.54	33.3	74	2.09	43.4	32	0.90	36.9	32	0.90	38.0
Total dissolved solids	240	5.4	-	300	8.46	-	200	4.24	-	120	3.45	-	270	7.62	-	200	4.82	-	89	2.44	-	120	2.37	-
Permanent hardness as $CaCO_3$	37	0.74	-	60	1.20	-	29	0.58	-	17	0.34	-	56	1.12	-	29	0.6	-	30	0.6	-	30	0.60	-
Temporary hardness as $CaCO_3$	30	0.60	-	40	0.80	-	13	0.26	-	10	0.20	-	28	0.56	-	6	0.12	-	3	0.06	-	1	0.02	-
Alkalinity	30	0.60	-	40	0.80	-	13	0.26	-	10	0.20	-	28	0.56	-	6	0.12	-	3	0.06	-	1	0.02	-
pH	7.0	-	-	6.1	-	-	5.9	-	-	5.6	-	-	7.2	-	-	5.4	-	-	5.1	-	-	4.7	-	-
Percent sodium[4]	51	-	-	53	-	-	63	-	-	70	-	-	58	-	-	74	-	-	53	-	-	54	-	-
Sodium adsorption ratio[5]	1.6	-	-	2.3	-	-	2.2	-	-	3.1	-	-	2.4	-	-	3.2	-	-	1.2	-	-	1.2	-	-
Residual sodium carbonate[6]	nil	-	-	nil	-	-	nil	-	-	nil	-	-	nil	-	-	nil	-	-	nil	-	-	nil	-	-
% ionic difference[7]	-	2.1	-	-	4	-	-	10	-	-	1	-	-	5	-	-	4	-	-	12	-	-	13	-
Conductivity (µS/cm at 25°C)	-	-	-	460	-	-	250	-	-	200	-	-	440	-	-	300	-	-	165	-	-	170	-	-

Notes:
1. Number preceded by W indicates a hand-dug well: corresponds to wells tested – Appendix C.
2. Collection date
3. Department of Mines Registered Number.
4. Percent sodium %Na = 100 × (Na + K) / Na + K + Mg + Ca) in meq/*l*. Undesirable soil leaching effects may occur in irrigated areas if the value is considerably greater than 50.
5. Sodium adsorption ratio SAR = Na / √ ((Ca+Mg) / 2) in meq/*l*. Undesirable soil leaching effects may occur in areas irrigated with medium salinity water (250–750 mg/*l*) if SAR exceeds 10–20.
6. Residual sodium carbonate RSC = (HCO_3 + CO_3) – (Ca + Mg) meq/*l*. Undesirable soil leaching effects may occur in irrigated areas if RSC is higher than about 105.
7. An indication of the accuracy of the analysis. Error should be zero only if all major species have been determined. % ionic difference = 100 × I(difference of cation and anion meq/*l*)I ÷ total.

* Partial analysis by Government Analyst.

Constituent	W88	9.1977 772996		W91	9.1977 772997		W94	9.1977 772999	
	mg/l	meq/l	%meq/l	mg/l	meq/l	%meq/l	mg/l	meq/l	%meq/l
Silica	15	-	-	15	-	-	9.6	-	-
Iron	<0.1	-	-	<0.1	-	-	<0.1	-	-
Aluminium	<0.2	<0.02	<0.8	<0.2	<0.02	<0.8	<0.2	<0.02	<0.8
Calcium	2.1	0.1	4.0	3.2	0.16	6.3	2.3	0.11	4.4
Magnesium	4.2	0.35	13.9	4.1	0.34	13.3	2.7	0.22	8.8
Sodium	20	0.87	34.7	17	0.74	29.0	19	0.83	33.2
Potassium	1.1	0.03	1.2	1.1	0.03	1.2	0.3	0.01	0.4
Carbonate	nil	-	-	6.5	0.22	8.6	nil	-	-
Bicarbonate	6.6	0.11	4.4	12	0.20	7.8	23	0.38	15.2
Sulphate	10	0.21	8.4	12	0.25	9.8	12	0.25	10.0
Chloride	29	0.82	32.7	21	0.59	23.1	24	0.68	27.2
Total dissolved solids	130	2.51	-	110	2.55	-	70	2.50	-
Permanent hardness as $CaCO_3$	17	0.34	-	4	0.08	-	0	-	-
Temporary hardness as $CaCO_3$	6	0.12	-	21	0.42	-	17	0.34	-
Alkalinity	5.4	0.11	-	21	0.42	-	19	0.38	-
pH	5.3	-	-	9.7	-	-	7.4	-	-
Percent sodium	67	-	-	61	-	-	72	-	-
Sodium adsorption ratio	1.8	-	-	1.5	-	-	2.0	-	-
Residual sodium carbonate	nil	-	-	nil	-	-	0.1	-	-
% ionic difference	-	8	-	-	0	-	-	6	-
Conductivity (µS/cm at 25°C)	170	-	-	160 -	-	140	-	-	

Appendix H
SUPPLEMENTARY CHEMICAL ANALYSES OF GROUNDWATER

Constituent	W3[1]	5.1972[2] 722375[3]		W4	5.1972 722377		W11	5.1972 722368		W20	5.1972 722373	
	mg/l	meq/l	%meq/l	mg/l	meq/l	%meq/l	mg/l	meq/l	%meq/l	mg/l	meq/l	%meq/l
Silica	8	-	-	6	-	-	28	-	-	28	-	-
Iron	nil	-	-	nil	-	-	nil	-	-	nil	-	-
Aluminium	nil	-	-	nil	-	-	nil	-	-	nil	-	-
Calcium	7.3			6.5			8.3			9.6		
Magnesium	10			10			8			10		
Sodium	44			38			45			32		
Potassium	1	0.03		0.9			2.1			1.4	0.04	
Carbonate	nil	-	-	nil	-	-	nil	-	-	nil	-	-
Bicarbonate	12			24			85			66		
Sulphate	8	0.17		5	0.10		12			22		
Chloride	74			53			39			49	1.38	
Total dissolved solids	190		-	255		-	220		-	135		-
Permanent hardness as $CaCO_3$	49		-	37		-	nil		-	11		-
Temporary hardness as $CaCO_3$	10	0.20	-	20	0.40	-	70		-	54		-
Alkalinity	10	0.20	-	20	0.40	-	70		-	54		-
pH	5.1	-	-	5.4	-	-	6.4	-	-	6.0	-	-
Percent sodium[4]		-	-		-	-		-	-		-	-
Sodium adsorption ratio[5]		-	-		-	-		-	-		-	-
Residual sodium carbonate[6]		-	-		-	-		-	-		-	-
% ionic difference[7]	-		-	-		-	-		-	-		-
Conductivity (S/cm at 25°C)	-	-	-	-	-	-	-	-	-	-	-	-

Constituent	W21	6.1972 722816		W24	6.1972 722813		W28	6.1972 722815		W30	7.1972 723871	
	mg/l	meq/l	%meq/l	mg/l	meq/l	%meq/l	mg/l	meq/l	%meq/l	mg/l	meq/l	%meq/l
Silica	13	-	-	34	-	-	52	-	-	10	-	-
Iron	nil	-	-	nil	-	-	nil	-	-	0.2	-	-
Aluminium	nil	-	-	nil	-	-	nil	-	-	<0.1		
Calcium	3			7			12			11		
Magnesium	6			13			15			2		
Sodium	50	2.18		56			25			25		
Potassium	0.1			0.4	2.8		0.5			1	0.03	
Carbonate	nil	-	-	nil	-	-	nil	-	-	nil	-	-
Bicarbonate	102			65			96			16		
Sulphate	13			20			13			17		
Chloride	39			77			42			39		
Total dissolved solids	280		-	290		-	245		-	150		-
Permanent hardness as $CaCO_3$	nil		-	18		-	13		-	22		-
Temporary hardness as $CaCO_3$	84		-	53		-	79		-	13		-
Alkalinity	84		-	53		-	79		-	13		-
pH	6.8	-	-	6.8	-	-	7.4	-	-	7.0	-	-
Percent sodium[4]		-	-		-	-		-	-		-	-
Sodium adsorption ratio[5]		-	-		-	-		-	-			
Residual sodium carbonate[6]		-	-		-	-		-	-		-	-
% ionic difference[7]	-		-	-		-	-		-	-		-
Conductivity (S/cm at 25°C)	-	-	-	-	-	-	-	-	-	-	-	-

Notes:

1. Number preceded by W indicates a hand-dug well: corresponds to wells tested – Appendix C.
2. Collection date
3. Department of Mines Registered Number.
4. Percent sodium %Na = 100 × (Na + K) / Na + K + Mg + Ca) in meq/*l*. Undesirable soil leaching effects may occur in irrigated areas if the value is considerably greater than 50.
5. Sodium adsorption ratio SAR = Na / √ ((Ca+Mg) / 2) in meq/*l*. Undesirable soil leaching effects may occur in areas irrigated with medium salinity water (250–750 mg/*l*) if SAR exceeds 10–20.
6. Residual sodium carbonate RSC = (HCO_3 + CO_3) – (Ca + Mg) meq/*l*. Undesirable soil leaching effects may occur in irrigated areas if RSC is higher than about 105.
7. An indication of the accuracy of the analysis. Error should be zero only if all major species have been determined. % ionic difference = 100 × l(difference of cation and anion meq/*l*)l ÷ total.

* Partial analysis by Government Analyst.

Constituent	W33 7.1972			W34 7.1972			W37 7.1972			W38 7.1972			W43 7.1972			W52 7.1972			W53 1.1977			W69 1.1977		
	7238703			723872			723862			723865			723863			723864			770120			770149		
	mg/l	meq/l	%meq/l	mg/l	meq/l	%meq/l	mg/l	meq/l	%meq/l	mg/l	meq/l	%meq/l	mg/l	meq/l	%meq/l	mg/l	meq/l	%meq/l	mg/l	meq/l	%meq/l	mg/l	meq/l	%meq/l
Silica	5	-	-	5	-	-	10	-	-	10	-	-	10	-	-	5	-	-	<5	-	-	8	-	-
Iron	<0.1	-	-	<0.1	-	-	0.2	-	-	<0.1	-	-	<0.1	-	-	<0.1	-	-	<0.1	-	-	<0.1	-	-
Aluminium	<0.1	-	-	<0.1	-	-	<0.1	-	-	<0.1	-	-	<0.1	-	-	<0.1	-	-	<0.2	-	-	<0.2		
Calcium	6			3			7			2			5			9			120			3.5		
Magnesium	3			2			6			3			4			9			200			9.4		
Sodium	22			24			33			37			38			70			1390			48		
Potassium	0.4			0.8			0.8			1.3			1.4			1.2			52			1.6		
Carbonate	nil	-	-	nil	-	-	nil	-	-	nil	-	-	nil	-	-	nil	-	-	nil	-	-	nil	-	-
Bicarbonate	22			38			26			10			38			38			260			4		
Sulphate	5	0.10		12			12			9			19			5			420			<5		
Chloride	39			35			53			56			46			109			2400			92		
Total dissolved solids	120		-	140		-	250		-	225		-	250		-	335		-	5140		-	240		-
Permanent hardness as $CaCO_3$	9		-	nil		-	22		-	9		-	nil		-	29		-	(1120)		-	(49)		-
Temporary hardness as $CaCO_3$	18		-	16		-	21		-	8		-	30		-	31		-	-		-	-		-
Alkalinity	18		-	16		-	21		-	8		-	31		-	31		-	210		-	3		-
pH	7.0	-	-	7.0	-	-	7.0	-	-	7.0	-	-	7.0	-	-	7.0	-	-	8.1	-	-	5.2	-	-
Percent sodium		-	-		-	-		-	-		-	-		-	-		-	-		-	-		-	-
Sodium adsorption ratio		-	-		-	-		-	-		-	-		-	-		-	-		-	-			
Residual sodium carbonate		-	-		-	-		-	-		-	-		-	-		-	-		-	-		-	-
% ionic difference	-		-	-		-	-		-	-		-	-		-	-		-	-		-	-		-
Conductivity (µS/cm at 25°C)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(7600)	-	-	(165)	-	-

Constituent	W82	1.1977		W83	1.1977		W96	11.1977		W98	11.1977		W104	11.1977		W108	11.1977	
	770273			770269			773181			773182			773183			773184		
	mg/l	meq/l	%meq/l	mg/l	meq/l	%meq/l	mg/l	meq/l	%meq/l	mg/l	meq/l	%meq/l	mg/l	meq/l	%meq/l	mg/l	meq/l	%meq/l
Silica	15	-	-	<5	-	-	11	-	-	<5	-	-	<5	-	-	5	,	
Iron	6.7	-	-	<0.1	-	-	<0.1	-	-	<0.1	-	-	<0.1	-	-	<0.1	-	-
Aluminium	0.7	-	-	<0.2	-	-	<0.2	-	-	0.4	-	-	0.2	-	-	<0.2	-	-
Calcium	9			32			3			19			17			14		
Magnesium	64			10			8			7			3			6		
Sodium	49			40			34			51			11			51		
Potassium	1.9			1.4			2.5			1.1			0.4			5.5		
Carbonate	nil	-	-	nil	-	-	nil	-	-	12	-	-	nil	-	-	9	-	-
Bicarbonate	33			130			6.6			9			63			1.3		
Sulphate	8	0.17		10			13			<5			<5			<5		
Chloride	95			64			46			71			21			57		
Total dissolved solids	260		-	270		-	180		-	240		-	110		-	200		-
Permanent hardness as $CaCO_3$	(70)		-	(140)		-	(40)		-	(79)		-	(55)		-	(60)		-
Temporary hardness as $CaCO_3$	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Alkalinity	27		-	110		-	5.4		-	46		-	52		-	31		-
pH	5.7	-	-	7.5	-	-	5.2	-	-	9.7	-	-	6.8	-	-	9.7	-	-
Percent sodium		-	-		-	-		-	-		-	-		-	-		-	-
Sodium adsorption ratio		-	-		-	-		-	-		-	-		-	-		-	-
Residual sodium carbonate		-	-		-	-		-	-		-	-		-	-		-	-
% ionic difference	-		-	-		-	-		-	-		-	-		-	-		-
Conductivity (µS/cm at 25°C)	390	-	-	420	-	-	270	-	-	410	-	-	165	-	-	350	-	-

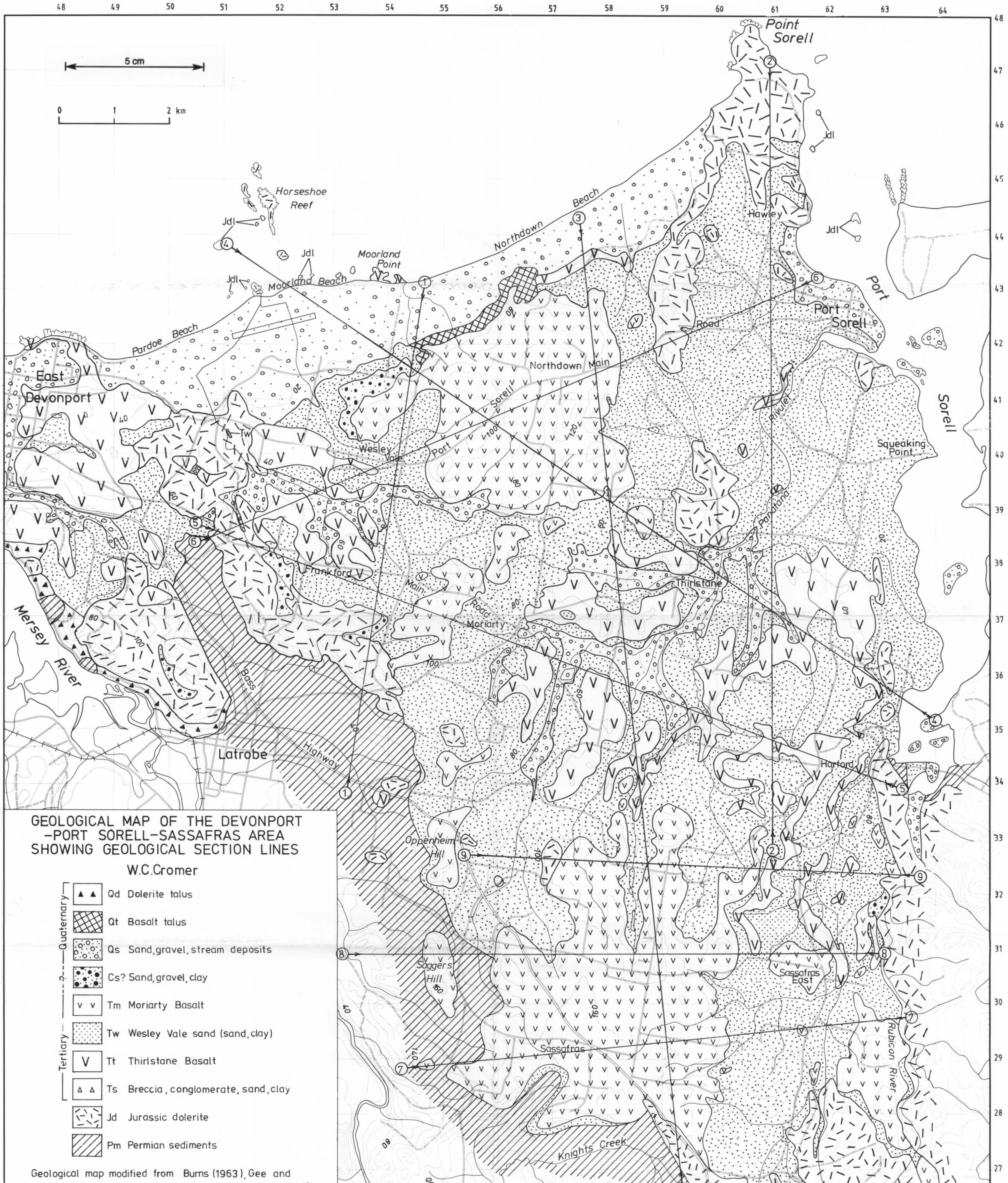
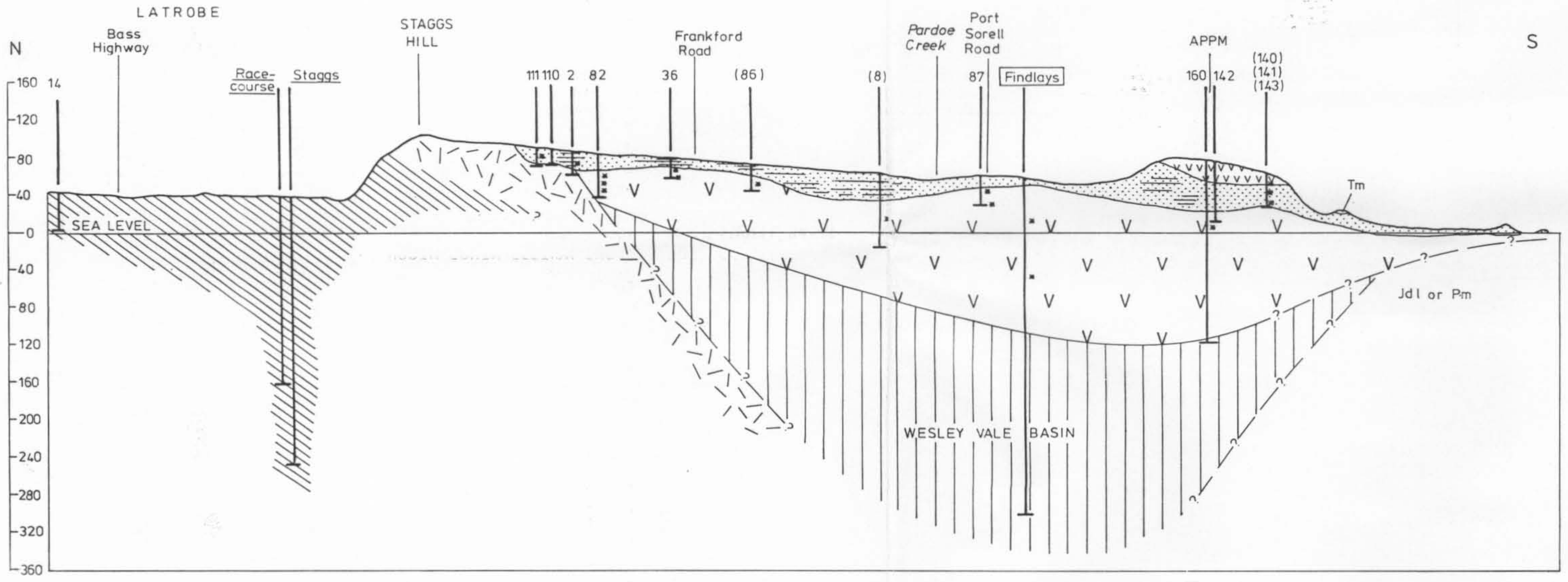
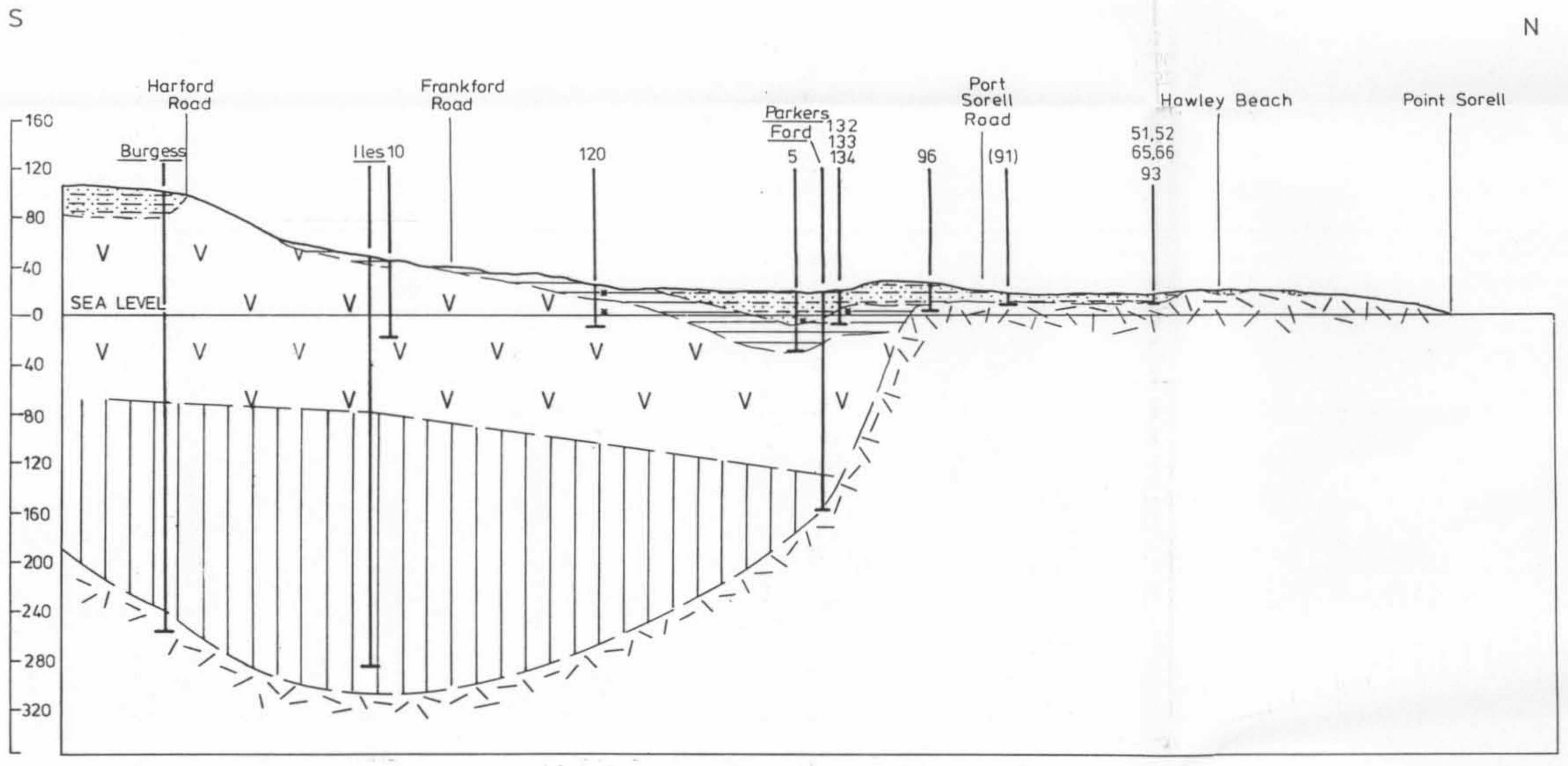


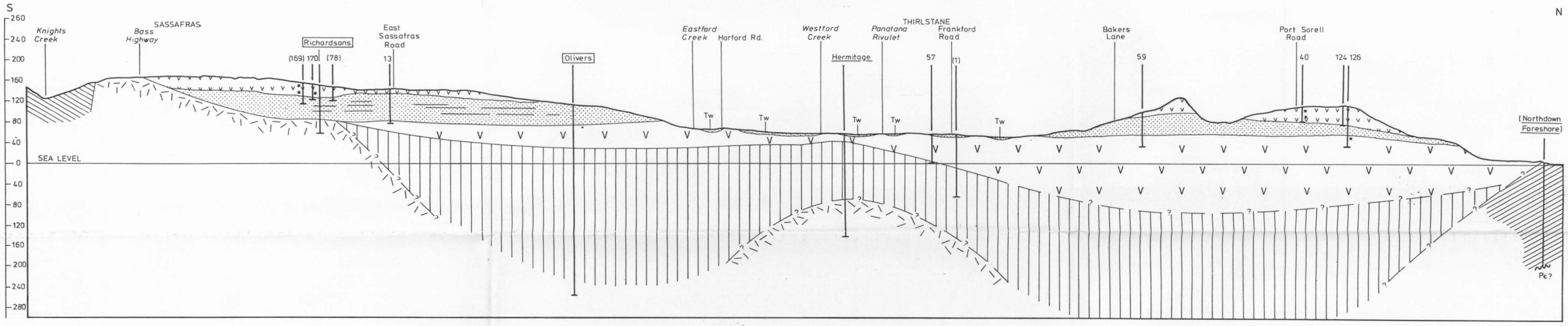
Figure 2A GSB67



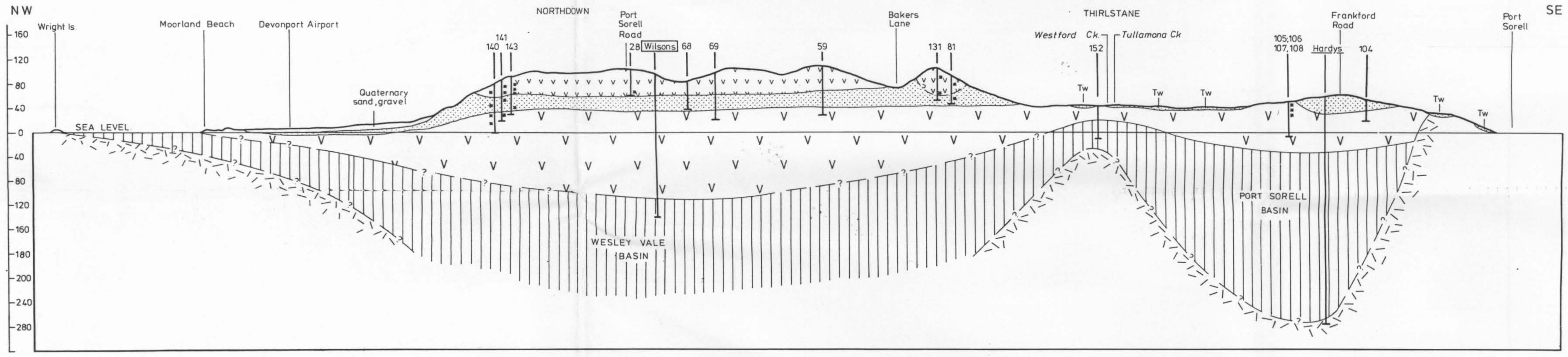
Section 1
NORTH-SOUTH SECTION THROUGH THE WESLEY VALE BASIN



Section 2
NORTH-SOUTH SECTION THROUGH PORT SORELL BASIN



Section 3
NORTH-SOUTH SECTION THROUGH WESLEY VALE AND SASSAFRAS BASINS



Section 4
NORTHWEST-SOUTHEAST SECTION THROUGH MOORLAND BEACH TO PORT SORELL

GEOLOGICAL SECTIONS
DEVONPORT - PORT SORELL - SASSAFRAS AREA

W.C. CROMER 1979

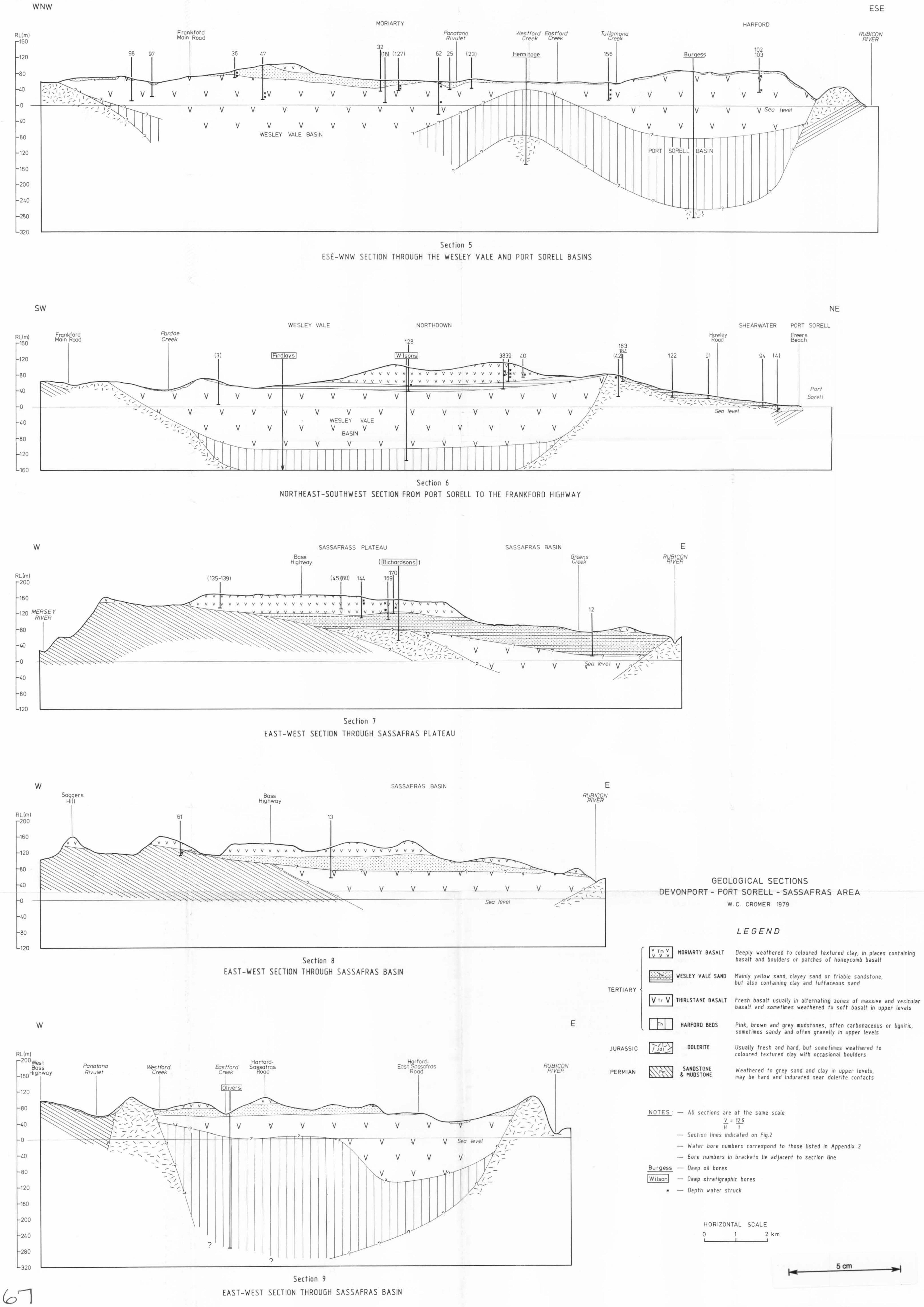
LEGEND

TERTIARY	MORIARTY BASALT		Deeply weathered to coloured textured clay, in places containing basalt and boulders or patches of honeycomb basalt
	WESLEY VALE SAND		Mainly yellow sand, clayey sand or friable sandstone, but also containing clay and tuffaceous sand
	THIRLSTANE BASALT		Fresh basalt usually in alternating zones of massive and vesicular basalt and sometimes weathered to soft basalt in upper levels
	HARFORD BEDS		Pink, brown and grey mudstones, often carbonaceous or lignitic, sometimes sandy and often gravelly in upper levels
JURASSIC	DOLERITE		Usually fresh and hard, but sometimes weathered to coloured textured clay with occasional boulders
PERMIAN	SANDSTONE & MUDSTONE		Weathered to grey sand and clay in upper levels, may be hard and indurated near dolerite contacts

NOTES:
- All sections are at the same scale $\frac{V}{H} = \frac{12.5}{1}$
- Section lines indicated on Fig.2
- Water bore numbers correspond to those listed in Appendix 2
- Bore numbers in brackets lie adjacent to section line
- Burgess — Deep oil bores
- Wilson — Deep stratigraphic bores
- • — Depth water struck

HORIZONTAL SCALE
0 1 2 km

5 cm



GSB67

Figure 2C

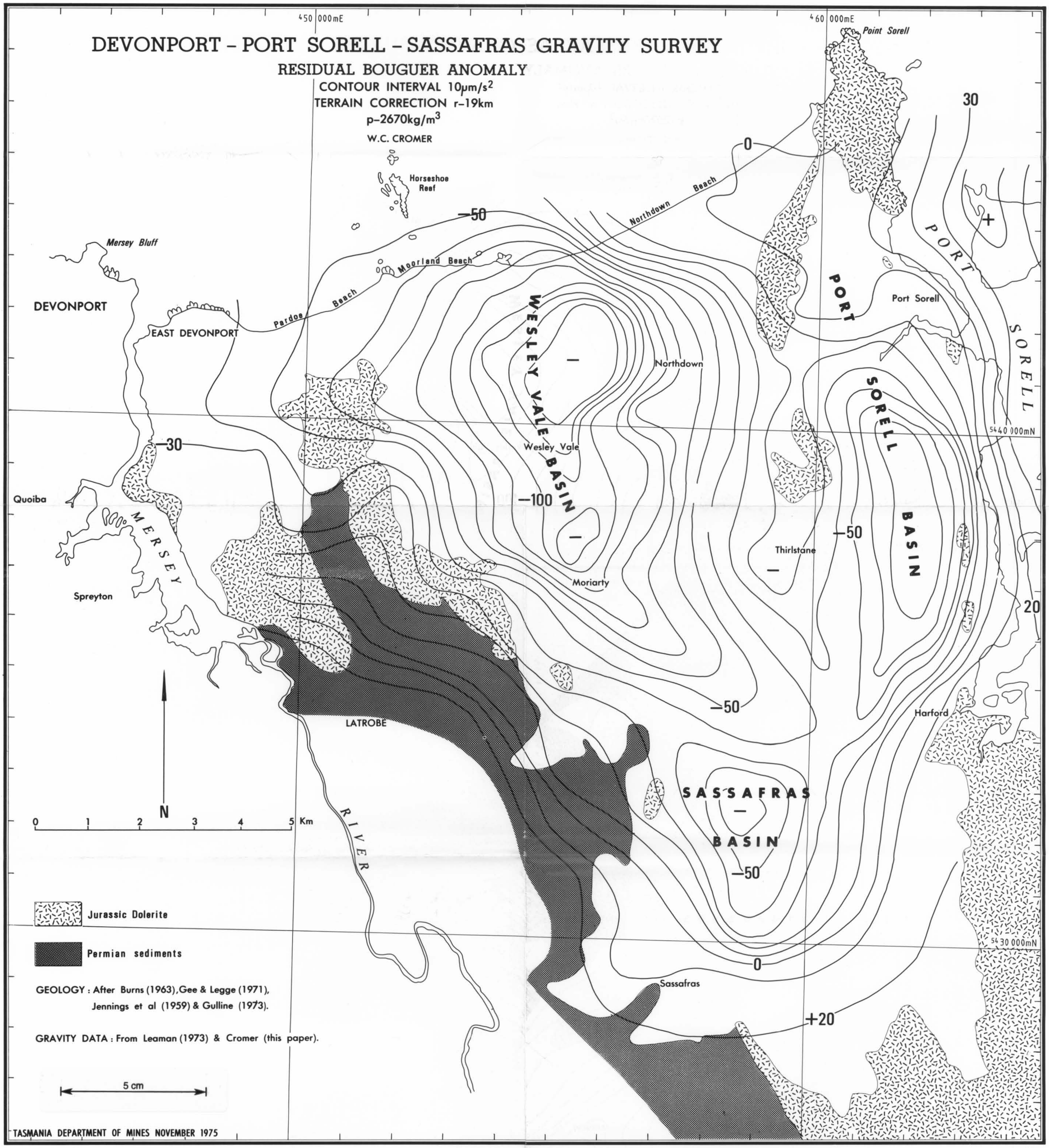


Figure 3 GS867

4041

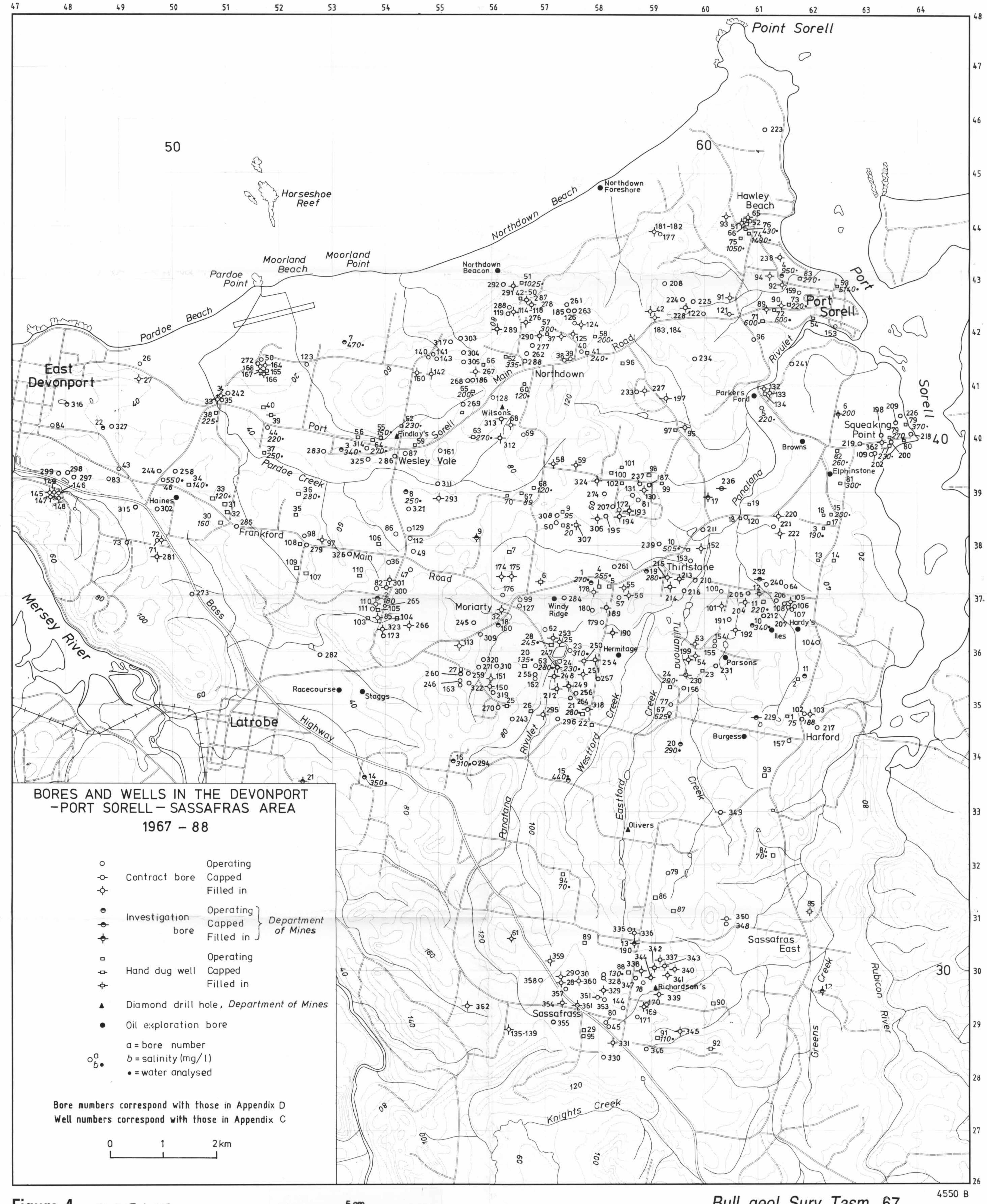


Figure 4 GSB67

5 cm

4550 B

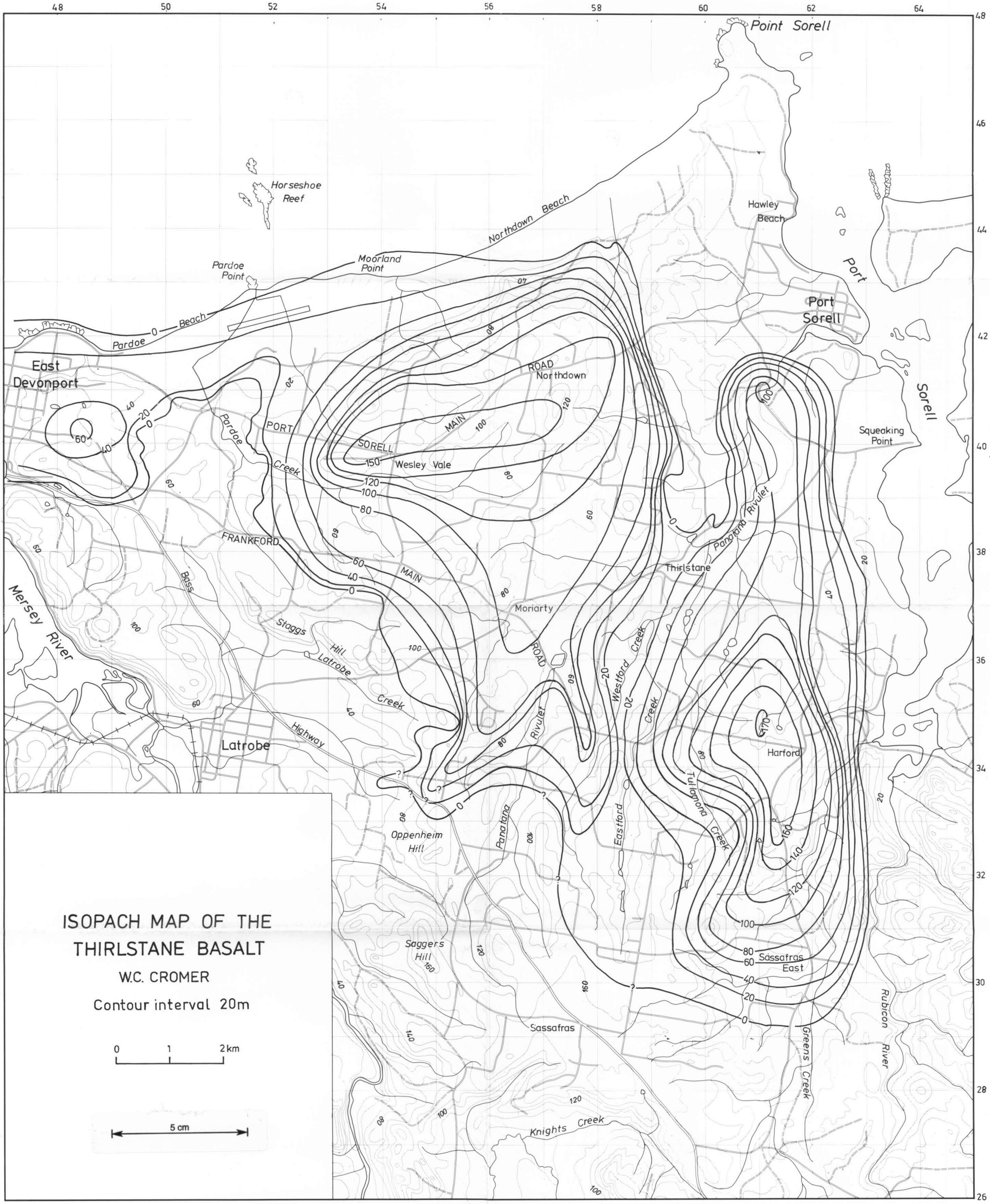


Figure 5 GSB67

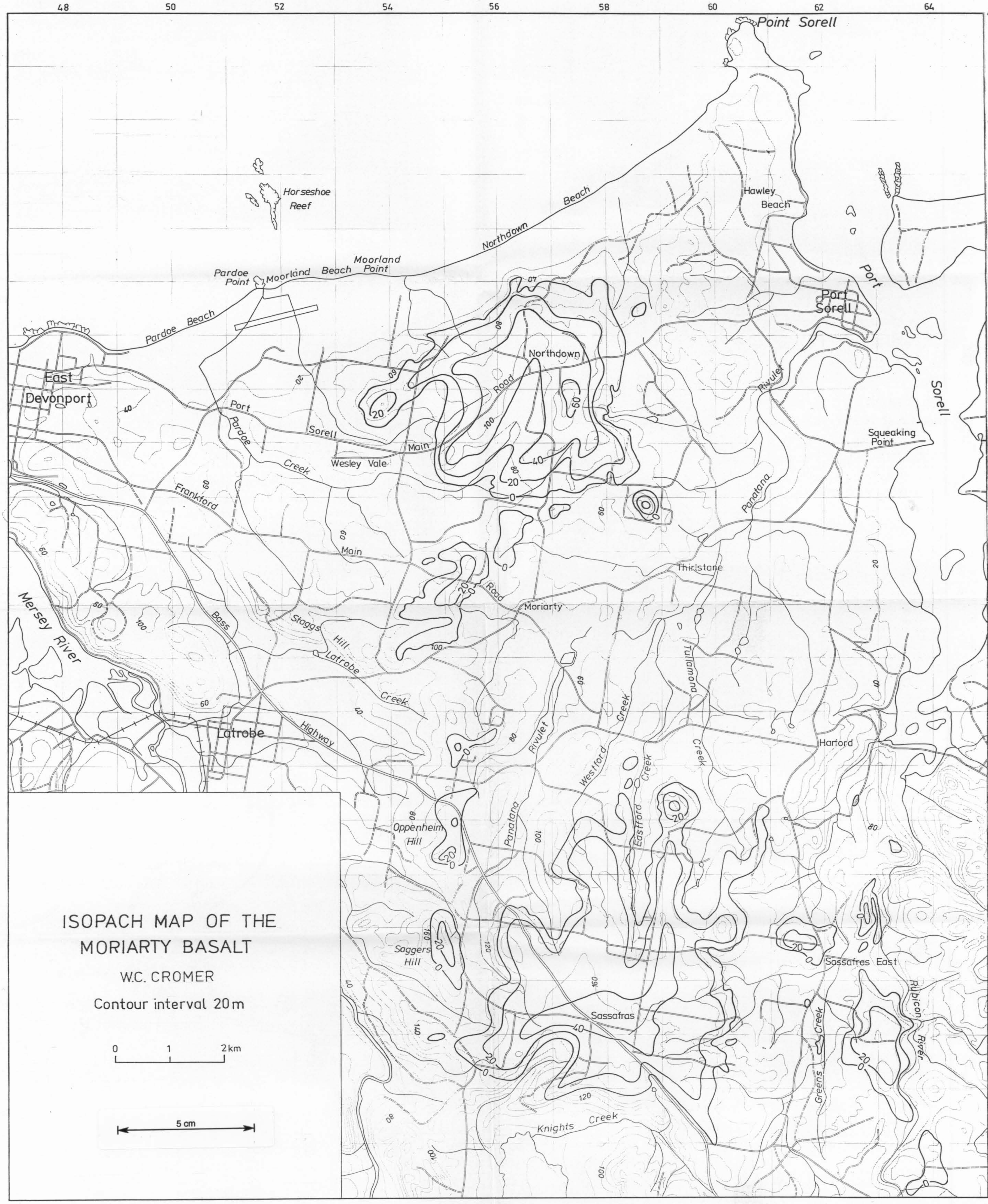


Figure 6 GSB67

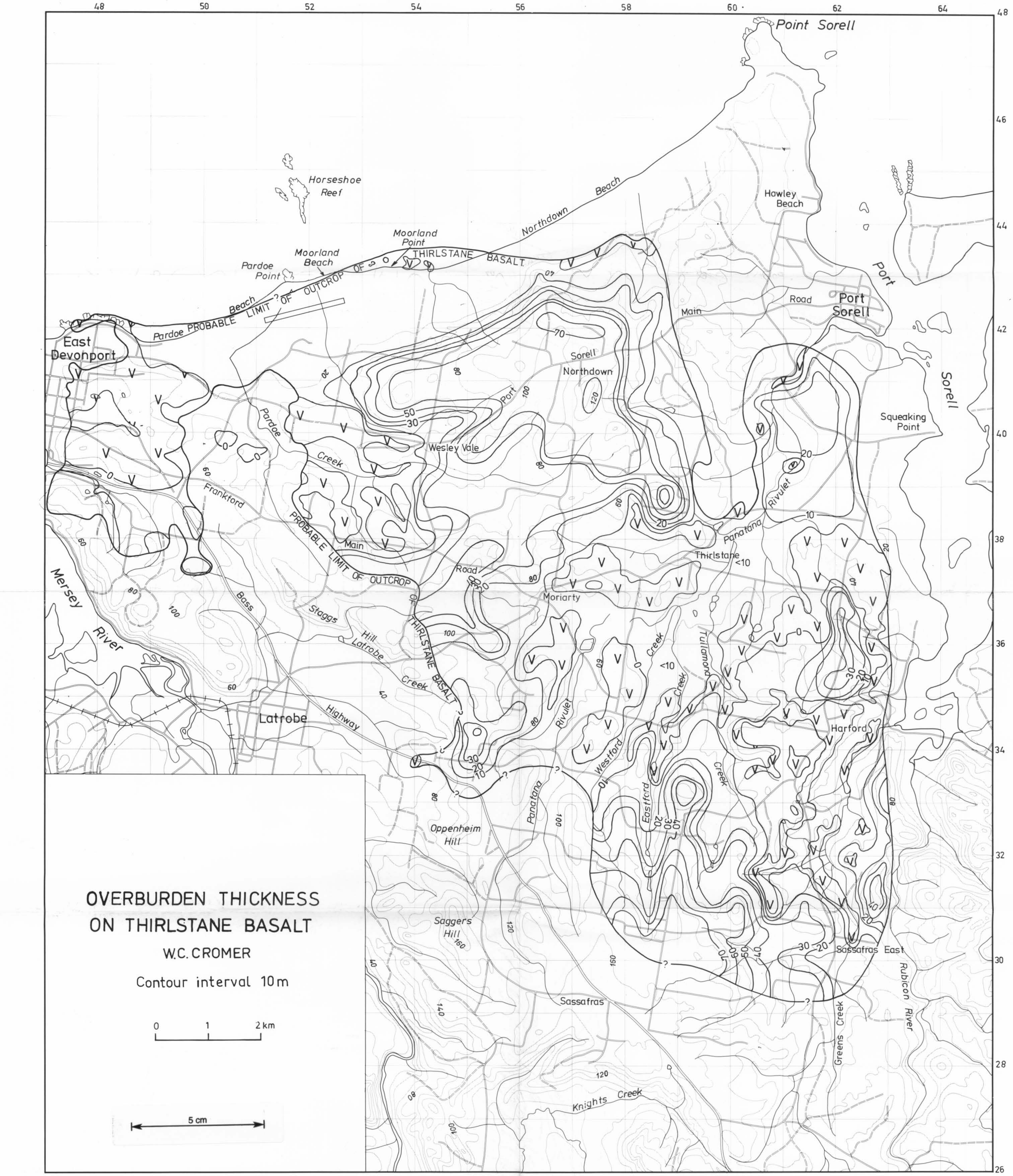


Figure 7 GSB67 *Bull. geol. Surv. Tasm.* 67