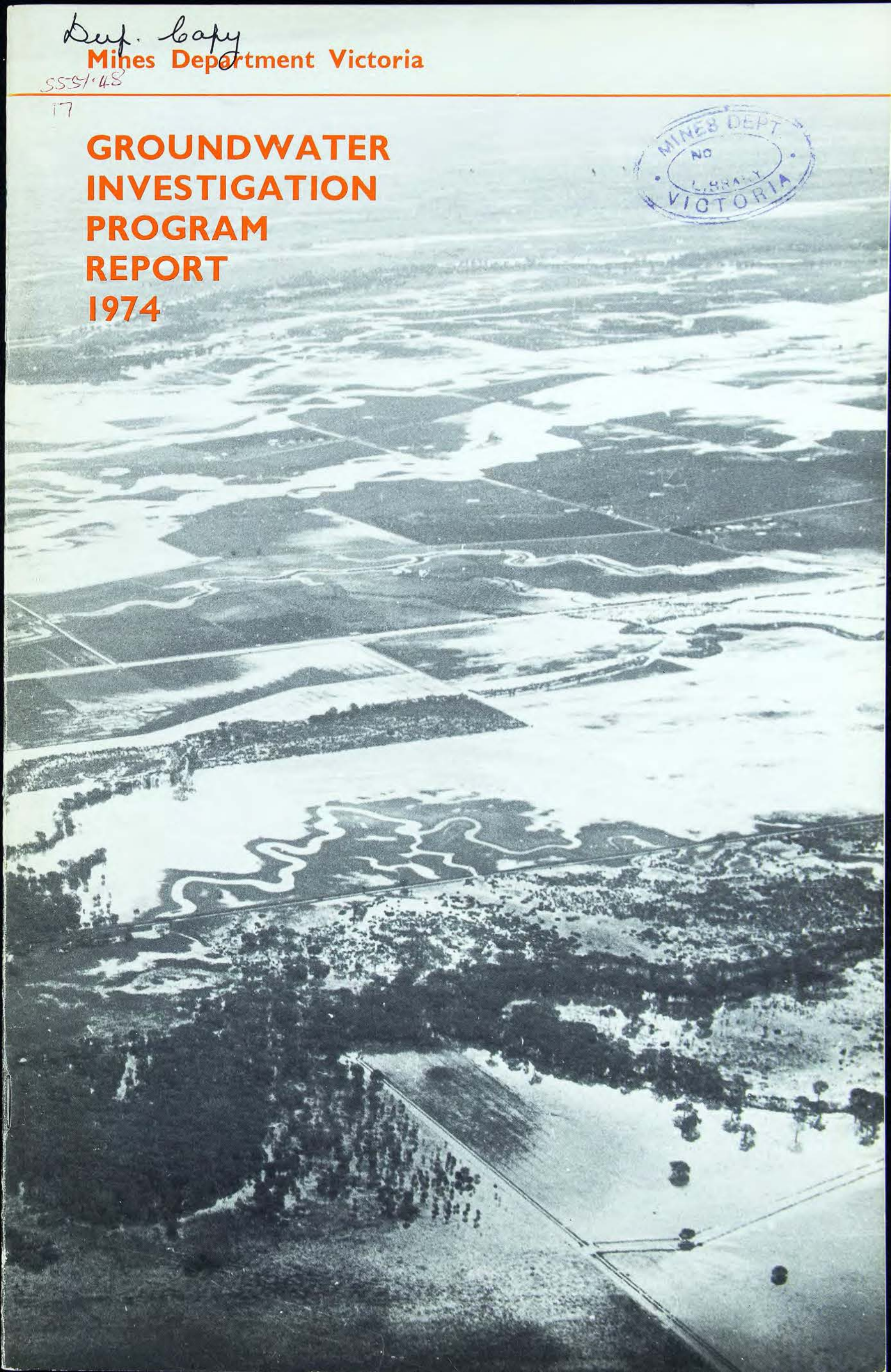
Mines Department Victoria

GROUNDWATER INVESTIGATION PROGRAM REPORT 1974



Cover— Aerial photograph of the 1974 floods along the Murray Valley.
(Picture supplied by the S.R.W.C. Photographic Section.)

Mines Department Victoria

GROUNDWATER INVESTIGATION PROGRAM REPORT 1974

12421/75—PL

Contents

To the
Honourable J. C. M. Balfour, M.P.,
Minister of Mines.

Sir : In accordance with the requirements of section 6 of the *Groundwater Act* 1969 (No. 7849), the Groundwater Advisory Committee has the honour to submit to you for presentation to Parliament its Annual Report covering the Groundwater Investigation Program for the year ended December 31, 1974

E. J. Condon.
R. O. Kefford.
G. Murray.
D. Spencer-Jones.
A. L. Tisdall.

Introduction

During 1974 many of the groundwater investigation programs conducted by the Mines Department, Department of Agriculture and the State Rivers and Water Supply Commission in Northern Victoria were suspended because of concern about widespread salinity in orchards and pasture in the Goulburn Valley caused by abnormally heavy rains in 1973 and again in 1974.

In mid 1974 an urgent program was initiated to provide protection against rising water tables and salinity in major horticultural areas. Finance was made available by the State Government to accelerate construction of surface drains and the installation of water table control works.

Funds for water table control were allocated for three complementary programs

1. $50,000 for hire of existing irrigation pumps which are suitably placed for water table control, if operated continuously. Nineteen pumps have been hired under this program.
2. $300,000 for installation of groundwater pumps by the Water Commission. There are now 14 completed units, and 27 potential sites have been test pumped. Nine of these are being operated with temporary pumps.
3. $150,000 as low interest finance (through Rural Finance and Settlement Commission) to assist orchardists to install pumps to protect their own properties. Where suitable, these will eventually be integrated into a comprehensive network of Water Commission pumps. Forty-eight applications have been received and 31 loans have been approved.

Other areas in the State also suffered from widespread flooding and attempts were made to drain flood waters into bores north of Horsham. This was only partially successful because no suitably porous sands were located.

DISPLAYS

Because of the enthusiasm shown by farmers to the groundwater display exhibited by the Mines Department at the Elmore Field Days in 1973, the Department also exhibited at the Gippsland Field Days held at Lardner in February ; the Wimmera Field Days at Longerenong in March and again at the Elmore Field Days in October.

The displays were arranged in conjunction with V.I.R.P.O. (Victorian Irrigation Research and Promotion Organisation) who coordinated a " farm water display ". The theme attempted to include all water authorities involved with farm water supplies. Farmers could obtain information on irrigation layout, farm dams, groundwater and bore construction, pump information and running costs from State Rivers and Water Supply Commission, Soil Conservation Authority, State Electricity Commission, Mines Department, Department of Agriculture and the Environment Protection Authority.

This report presents a summary of the groundwater investigations undertaken by the Mines Department, State Rivers and Water Supply Commission, and the Agriculture Department for 1974.

The Groundwater Report includes abstracts of the more important reports by government officers on current projects. These projects can be subdivided into seven main types :

1. Systems design for storage and retrieval of groundwater data.
2. Exploration and regional analysis of groundwater resources.
3. Management of groundwater resources.
4. Investigation of problems of shallow water tables.
5. Investigation, design and installation for town supplies.
6. Investigation of groundwater pollution.
7. Determining the quality limits for various purposes.

In planning the program of investigation the Minister of Mines is assisted by a Groundwater Advisory Committee established under the Act. This Committee is chaired by E. J. Condon, LL.B., Secretary for Mines ; the other Members being D. Spencer-Jones, Ph.D., B.Sc., Director of Geological Survey ; A. L. Tisdall, D.Agr.Sc., F.A.I.A.S., Chairman, State Rivers and Water Supply Commission ; R. O. Kefford, B.Agr.Sc., Deputy Director of Agriculture ; and G. Murray, representative of groundwater users.

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ABSTRACTS OF REPORTS ON CURR

HISTORY OF GROUNDWATER EXPLORATION FOR VICTORIAN TOWNS

P. Feehan.

Twenty-one towns in Victoria rely on groundwater as a sole source for their town water supply. Total usage of groundwater for the year 1973–74 was estimated to be in the vicinity of 6900 ml. (See table opposite.)

The Mines Department is actively engaged in assisting local water-supply trusts to locate and develop acceptable sources of water. There is a long history of this type of work. By 1884 the Mines Department had eighteen auger drills engaged in drilling for water to depths of 100′. Deeper holes were drilled with a diamond drill. During the 1890s the Department was systematically drilling in the Wimmera and Mallee in search of " the great underground drainage system, which must make its way seawards from New South Wales somewhere between the Palaeozoic rocks of the Grampians in Victoria and those exposed north of the Murray, in New South Wales and South Australia ". In 1887 two bores were sunk to bedrock near Nhill and further bores were to be sunk on contract.

From 1890 to 1905 the Department of Mines and Water Supply administered the Water Act of 1890, and subsequent acts. The initial act provided for the constitution of Waterworks Trust whose primary function was to supply water for domestic and manufacturing purposes to towns and for stock and domestic purposes to rural districts. By 1903 there were 72 trusts in existence. The State Rivers and Water Supply Commission was formed in 1905 and took over the administering of water supply.

The Department did not drill for water in the 1890s but assistance was given to local government bodies in the northern districts by lending equipment free or on very easy terms, to any wanting to make tests for themselves. Valuable supplies were reported. A chemist attached to the Department analysed water samples supplied from the works under the direct control of the Board of Land and Works, or sent from Trusts.

In 1905 the Sale Borough Council decided to drill for artesian water to fill a depression near the town known as Lake Guthridge. The Department of Mines supplied a drill and the council paid the costs. Two successful bores were sunk but one of these ceased flowing after a short period. The second bore flowed at a rate of 145,000 gallons per day.

During the period up to 1955 the Mines Department was sporadically engaged in drilling for water and in offering geological advice, when required. In 1955 it was decided, in agreement with the State Rivers and Water Supply Commission, that the Department should increase its activities in the investigation of groundwater, and that these activities would be carried out in a more rational manner than previously.

Six heavy duty percussion drills were then acquired. Drilling began on the Mornington Peninsula at the Rosebud High School where a good supply of water was found. It continued on the Peninsula, at Lang Lang, and during 1956 at Balnarring, Bittern and Wangaratta most programes were highly successful. A bore was drilled at Learmonth for the Ballarat Shire Council. This bore (Burrumbeet 12) was to a depth of 455′, with water having a TDS of 300 mg/l and yielding approximately 5000 gph from between 360′ to 370′. It was to be the reticulated supply for the town.

In 1957 the Department purchased at a cost of £150,000 a rotary rig capable of drilling to 5500′. This was an improvement of some 3500′ on existing departmental rigs and enabled deeper formations to be tested. It was immediately put to use drilling two town supply bores at Portland. These bores, Portland 2 and 3, were sunk to 4600′ and 5600′ respectively and each yielded approximately 30,000 gph. In 1969 a further production bore, Portland 11, was drilled to increase supply. Several other observation bores were drilled to provide information on the aquifer fluctuations over long periods.

This large rig operated in the Otway Basin and supplied valuable stratigraphic information as well as drilling water supply bores at Portland, Pt. Fairy, Pt. Campbell, Heywood and Peterborough. Attempts were made to provide a supply for Warrnambool but the waters found were too saline.

In the same area Koroit has had a long history of utilization of groundwater from shallow aquifers. At present its water supply is from a bore sunk in 1962 in Black St. called Warrong 2. This bore taps basalts of the Newer Volcanics and the underlying Pt. Campbell Limestone which together yield 10,000 gph. A deep bore drilled in 1960 to 4000′ struck an artesian supply which proved to be too saline for domestic use.

Timboon once had a town supply bore put down in 1958 but now receives its water via pipeline from a Pt. Campbell bore (Paaratte 1).

Intensive investigation has also been carried out in Gippsland. In 1958 drills explored groundwater possibilities at Pt. Albert,

ENT PROJECTS

Seaspray and Lakes Entrance but the waters encountered were not of acceptable quality. In 1962 a bore was drilled at Briagolong to supply the town with water. A 5″ diameter bore was put down to 345′ and two aquifers were developed between 105′ to 145′ and 245′ to 305′, yielding a safe 7000 gph.

The City of Sale originally relied upon unpredictable water supplies from the Thomson River. It decided in 1969 to investigate groundwater as an alternative source to surface supplies. The city required 1 million gallons per day rising to 2·5 million gpd at peak demand. Three 8″ production bores were sunk 1000′ apart, and each is capable of yielding over 1·5 million gpd. Each bore has 80′ of stainless steel screen between 200′ and 400′ below surface. The cost of these bores was less than $30,000, which only covers the cost of equipping the bores, since the Mines Department makes no charge for footage.

In the past few years surveys have shown that several towns in Gippsland could have their total water requirements met from underground sources. Quite a few bores have been set up as production bores but few are being utilized. Boisdale will soon be using groundwater and feasibility studies for supplying Moe with supplementary water from underground have been undertaken.

In 1926 Nhill's original town bore was drilled tapping the Duddo limestone. In 1961 the town had two supply bores yielding a maximum of 36,000 gph. During January 1961 one of these bores failed and the Department was asked to investigate. Consequently a series of observation bores and one production bore were drilled. Another production bore was sunk in 1972 and Nhill now has four production bores.

In 1918 at Kaniva, an exploratory bore was sunk for preliminary investigations into a reticulated supply for the town. This supply was turned on in 1923. The Department drilled a series of bores in 1964 for town supply purposes. The nearby town of Lillimur and Miram have their water supplied from bores sunk in 1962 and 1967.

At Goroke the Mines Department sank a series of bores in the late fifties but many had to be abandoned because of the water salinity or construction problems. Problems with pre-existing town supply bores had been due to development and the sealing off of certain silts and sands. In the same shire, Apsley had a town supply bore drilled in 1948 to a depth of 58′.

Other water supply trusts have had their own town supply bores drilled by private contractors or the State Rivers and Water Supply Commission. Katunga, Strathmerton, Elmore, Cowangie and Murrayville fall into this category.

In many areas of Victoria groundwater for town supplies can be found more economically than water from a surface system. In years to come this source can be expeceted to be utilized to a far greater degree than at present. Towns or cities which are now nearing their limits of growth due to a finite surface water supply may find new growth possible through the use of groundwater. The Geelong Waterworks Trust in conjunction with the Mines Department has examined the feasibility of gaining additional water from underground in the Barwon Downs area. It has been suggested that Bendigo look at the possibilities of obtaining supplies from deep leads in the Campaspe and Loddon valleys. Trusts facing increased demand from the connection of sewerage could be forced to put in more production bores or make greater use of their present bores.

The Mines Department with its experience in all facets of groundwater exploration development will be greatly involved in this future work.

Waterworks Trust	Estimated Usage (Megalitres/year) (73–74)
Briagolong	30
Elmore	990
Heytesbury Shire Council—	
Timboon, Pt Campbell	240
Heywood	182
Kaniva Waterworks Trust—	
Kaniva	350
Lillimur	2
Miram	2
Koroit	136
Kowree Shire—	
Goroke	91
Apsley	23
Learmonth	32
Murrayville	91
Nhill	500
Numurkah Shire—	
Strathmerton	46
Katunga	18
Peterborough	9
Pt Fairy	705
Portland	1390
Sale	2050
Walpeup Shire—	
Cowangee	14

PROJECT No. R2.
APPROVED ITEM No. 1B.
PROVINCE Central Sunklands
LOCALITY Melbourne Metropolitan Area Pollution Studies

SUITABILITY OF DISUSED QUARRIES IN THE SOUTHEAST METROPOLITAN AREA FOR THE DISPOSAL OF WASTE.

I. F. Harris.

INTRODUCTION

Landfill methods of disposal have been extensively used for waste disposal in the Melbourne area utilizing abandoned quarries. Many of the pits are situated in rock types that are permeable and contain high quality groundwater. Unless care is taken in selecting the type of waste disposal disposed in these pits, the underlying groundwater could be irreparably damaged.

GEOLOGY AND HYDROLOGY

The following rocks are found in the Melbourne area :

(*a*) Fissured Rocks of Early Palaeozoic Age

Palaeozoic sediments, extrusives and granite intrusives form the bedrock of the area, and outcrop in the northwestern and eastern part of Melbourne. Around the granitic intrusions the sediments have been metamorphosed to form hornfels. The sediments are usually deeply weathered and have a low porosity and hydraulic conductivity. The water is usually restricted to joints, fractures and shear zones. Bores sunk on these sediments have generally obtained low yields (less than 0·6 1/sec) and have medium to high salinity, varying from 3000–11,000 mg/1 TDS.

The basement sediments which underlie Cainozoic deposits give high yields (up to 8 1/sec) of water that varies in salinity from 2000 to 4500 mg/1 TDS. The major outcrop of granitic rocks is the Lysterfield Granodiorite extending eastwards from Dandenong. The granodiorite contains groundwater with a low salinity (less than 1500 mg/1) but the yield of individual bores appears to depend on the number of fractures and joints intersected in each bore. Most have low yields. The Dandenong Ranges are composed of acid igneous lavas of Upper Devonian age. These rocks are hard and compact and the groundwater is restricted to joints and fractures. The quality of water is good, but most yields are small.

(*b*) Unconsolidated sediments of Cainozoic age
The Cainozoic sediments are subdivided into several main units:—

1. Werribee Formation and Older Volcanics
Non-marine coarse sand, coal and clay of the Werribee Formation rest unconformably on the Palaeozoic basement. These sediments do not outcrop, and appear to infill valleys in the Palaeozoic sediments. They cover only a relatively small area and reach a maximum thickness of 30 m.

High yields are obtained from this formation (up to 23 1/sec) of good quality water (480 mg/1 TDS). The number of bores tapping this formation is not known, but is probably less than 100. The associated Older Volcanics of probable Eocene age also yield good quality water at Mordialloc and Frankston, but at Carrum they contain saline water. The basalts occur under the Melbourne and Metropolitan Board of Works treatment plant at Carrum and it is intended that a trial recharge program of the basalts will be carried out at this site.

The main intake area of water for this formation and the volcanics is thought to be in the north and east away from the coast where they are not overlain by less permeable silts. No sand pits intersect this formation, but leachates from the filling of pits in the overlying sediments would eventually percolate into these sediments.

2. Newport Formation
The marine sediments of the Newport Formation overlie the Werribee Formation and the Palaeozoic rocks. These are grey or green calcareous silt and clay with lenses of limestone and sand near the base. They reach a thickness of 50 m and cover an area of about $2{\cdot}4 \times 10^4$ ha, but outcrop only at Beaumaris. They are Upper Oligocene to Upper Miocene in age. These sediments are generally fine grained and have a low hydraulic conductivity, except where coarse sand, limestone or gravel are intersected. Most of the higher yielding bores tap this formation, with depths ranging from 30–50 m and yields are typically about 2·6 1/sec, although a yield of 7·0 1/sec has been recorded. The number of bores in production is not known. The quality of groundwater is usually good, the salinity being between 800 and 2000 mg/1 TDS, but appears to become more saline in the Carrum-Chelsea area and under the Carrum swamp. The water in these sediments must be derived from the overlying Brighton Group but movement of water is occurring within these sediments from the north to the coast as indicated by the potentiometric surface.

Some quarries may reach the top of this formation, but in general it has not been mined. Leachate from waste dumped in sand pits would enter this formation, but the rate of movement would depend on the nature of the sediments in the vicinity of each pit. The nature of these sediments varies and although they are always saturated, not all sections yield water in sufficient quantities to be a useful source. They would in all cases act as a reservoir for those bores which tap the coarser sediments near the base.

3. Brighton Group
The sand, clayey sand and gravel that overlie

the Newport Formation are called the Brighton Group. They cover an area of $4 \cdot 8 \times 10^4$ ha extending from the coast to approximately Gardiners Creek and also occur as isolated hill cappings further north. The maximum thickness is about 30 m, but the apparent thickness varies especially as the boundary with the Newport Formation is not always clearly apparent. They often appear to act as a combined hydraulic unit with the Newport Formation.

The water is used almost entirely for domestic water supplies and the bores are rarely deeper than 15–20 m. The water from these bores is mainly used for gardens during the summer. This is especially so when water restrictions are imposed.

Yields are usually less than 0·6 l/sec and the quality of the water varies considerably. It appears that in the inner more highly paved and artificially drained suburbs the salinity is usually high, but even in the more open suburbs the salinity varies considerably. The Brighton Group acts as an intake source for all the aquifers in the southeastern suburbs, and all the sand pits are situated in it.

(*c*) Pleistocene and Recent Deposits

The rivers and creeks in the Melbourne area are flanked by alluvial deposits of silt, gravels and sands. The swamp deposits behind the dune deposits in the Carrum area and between Wells Road and Bangholme appear to contain brackish quality water (4000 to 10,000 mg/l TDS). The dunes that flank Port Phillip Bay from Mordialloc to Frankston contain good quality water due to local recharge. Many hundreds of shallow bores (up to 6–7 m deep) have been sunk and obtain small quantities of good quality water (usually less than than 0·2 l/sec).

Spear points are the most popular method of obtaining this water. The dunes along Wells Road also contain good quality water.

QUARRIES AND THEIR USE FOR DISPOSAL OF WASTE

(*a*) Clay pits

These are situated in the deeply weathered zone of the Palaeozoic sediments. The clay extracted is used for the manufacture of bricks, tiles and pipes. Pits have been excavated throughout the eastern suburbs in Hawthorn, Camberwell, Box Hill, Oakleigh, Mitcham and more recently at Scoresby. Most of these pits would be suitable for dumping of soluble industrial or chemical waste, as leakage in large quantities is unlikely, and any small leakage would not pollute a groundwater resource that has highly beneficial uses. Careful geological investigation would be necessary however before any of these pits could be used for disposal of this type of waste.

(*b*) Hard Rock Pits

Pits used for the extraction of crushed stone are located in the hornfels of the Lysterfield Hills and in the volcanics of the Dandenong Ranges. These pits have not been used for disposal of waste on a large scale. Before waste disposal is commenced each site should be investigated to determine the hydraulic conductivity of the rocks to ascertain the effect the waste would have on the surrounding groundwater. As the quality of groundwater in these rocks appears to be good, and since it is probable that the pits intersect fractures and joints capable of transmitting groundwater, it is thought that restrictions may need to be placed on the nature of wastes dumped in these pits.

(*c*) Sand Pits

The Brighton Group sand of Tertiary age has been widely quarried for aggregate and other products. The greatest concentration of pits is in the South Clayton–South Springvale area. It has been estimated that in 1968, 94% of the concrete sand requirements for the Melbourne area was obtained from this area. Other pits are located at Frankston, Lyndhurst and Cranbourne.

A large proportion of the garbage from the southern and eastern suburbs is dumped in abandoned and operating sand pits. Municipalities that own abandoned, or currently use sand pits, and operate garbage disposal sites include Brighton, Moorabbin, Mordialloc, Oakleigh, Springvale, Cranbourne, and Frankston. Private companies operating or wishing to operate disposal depots in sand pits include Industrial Waste Collectors Pty. Ltd. and Commercial Waste Disposals Pty. Ltd.

The Department has recommended that the dumping of soluble industrial waste or chemical waste be prohibited in these pits. However, some are still used for dumping all types of waste.

Almost all the sand pits intersect the water table and would allow movement of liquid or soluble wastes into the surrounding sand. As the water table is above the bottom of the pits leachants may reach the groundwater either by being carried down by infiltrating rainwater, or by the movement of groundwater through the garbage. It is proposed we carry out an investigation in conjunction with the Environment Protection Authority around a selected garbage depot to determine the effect garbage disposal in sand pits has on groundwater.

It is suggested that the practice of dumping garbage in one end of a pit and mining sand from the other, often using the water that leaches through the garbage for hydraulic sluicing, is undesirable and a potential health hazard for the mine operators. It should be discontinued. The policy of each municipality requiring a disposal depot instead of systematically filling a few abandoned pits at any particular time encourages this practice.

(*d*) Surface Landfill Sites

These are usually located on low lying alluvial flats, gullies or swamp lands. These types of

disposal sites are operated by municipalities which include Chelsea, Croydon, Dandenong, Nunawading and Berwick.

The hydraulic conductivity of alluvial flats is extremely variable. If they are silt covered, they are probably impermeable but if sand lenses outcrop under the garbage depot there may be a direct channel way to bores and/or the stream course. It is also likely that leachants from the garbage may enter the stream through the bank usually constructed to prevent flooding of the garbage depot by the stream. It is undesirable that low-lying land would be used for garbage disposal, but if it is necessary, it should only be used for the disposal of non-toxic putrescible garbage.

RECOMMENDATIONS

It is recommended that only non-toxic putrescible garbage be dumped at any site or in any pit that is situated in rocks that are permeable and might allow movement of liquids to enter any aquifer that contains water capable of being used for human consumption, stock watering or irrigation. It is also recommended that the same restriction apply to sites where the seepage of contaminants may enter any stream or Port Phillip. If adopted these restrictions would then apply to all sand pits, alluvial flats, gullies and low lying lands and possibly pits used for the extraction of crushed rock. They may sometimes apply to abandoned clay pits but this would depend on determination of the permeability of the clay surounding the pit.

Following from this, it is recommended that the above restrictions be applied to any such application to establish disposal depots and also all licences required for existing disposal depots to continue to operate.

It is recommended that the disposal of rubbish and extraction of sand should not be allowed to be undertaken in the same pit.

PROJECT No. R4.
APPROVED ITEM No. C.
PROVINCE Murray Basin
LOCALITY General

SUMMARY OF DRILLING INVESTIGATION INTO SALTING AT LASCELLES.

C. R. Lawrence

AIM

To determine the relationship between hydrogeology and soil salting at Lascelles, northwestern Victoria.

INVESTIGATION

Drilling by the Mines Department commenced on 27 May 1974. Three bores were drilled. Each was located in the swales where salting is occuring, between the ridges of Parilla Sand. These bores indicate that :

1. Up to 17m of alluvial clays, capped by a thin layer of aeolian sediments, rest unconformably on weathered Parilla Sand.

2. That the Parilla Sand is continuous throughout the area and is underlain by the marine, Bookpurnong Beds and Winnambool Formation.

3. The regional water table lies well beneath ground surface at a depth of approximately 29 to 32 m.

4. Groundwater movement within the unconfined aquifer is to the NNE.

5. The hydraulic head within the Winnambool Formation is slightly greater than that in the shallower Parilla Sand hence there is some upward movement of groundwater.

6. The salinity of groundwater in both the Parilla Sand and in the Winnambool Formation is high—lying in the approximate range 25,000 to 27,000 mg/l.

7. Salting in the swales at Lascelles is related to movement of perched groundwater, probably caused by clearing of native vegetation, resulting in increased infiltration, and not to discharge from the regional saturated zone.

PROJECT No. R7.
APPROVED ITEM No. A.
PROVINCE (Riverine Plain)
LOCALITY Murray Basin Plains on the Lower Avoca, Loddon and Campaspe Rivers

CALIVIL PUMP TEST JULY 31 TO AUGUST 23, 1974

P. G. Macumber

AIM

To determine the effects (if any) on shallow observation bores by lowering the pressure levels in the deeper confined aquifer system developed in the Calivil Formation. This project was undertaken in cooperation with Mr H. Smith of the State Rivers and Water Supply Commission.

METHOD.

The area chosen was at Calivil where there is an established history of high pressure levels in the shallow aquifers, and where the hydrogeologic parameters of Loddon Valley deep lead systems are known from previous pump tests (1969, 1970 and 1972), and extensive deep drilling. The deep bores, Calivil 2, 3, 4, 5 and 6, lie between State Rivers and Water Supply Commission 1220 and the proposed discharge bore owned by Mr W. Lea, who agreed to the State Rivers and Water Supply Commission using his turbine pump for the test. Observations were taken from the bores M. D. Calivil 2 and 3 which form part of the Loddon Valley network of deep observation bores. Calivil 2 monitors the deeper Renmark Group aquifer while Calivil 3 is in the Calivil Formation sands, the same aquifer as the discharging bore and occuring at a depth of between 78–96 m below the surface

A series of shallow piezometers was established by State Rivers and Water Supply Commission to measure pressure fluctuations in the shallow aquifers during the pump test.

At the commencement of pumping (3.00 p.m. July 31, 1974) all bores, both deep and shallow, were monitored by a series of continuous recorders. This situation was maintained for ten days, by which time Calivil 3 bore had virtually reached equilibrium, and there was no meaningful movement in the remaining bores. From this time only daily observations were considered necessary and these continued until the test ceased in August 22, 1974.

Recovery was measured on Calivil 3 using a 60-inch Foxboro Recorder over a 24 hour period.

RESULTS

Over a period of 22 days, pumping was carried out at a rate of approximately 50·5 l/sec during which time only one bore (M.D. Calivil 3) showed a reaction. This reaction was totally expected since Calivil 3 taps the same aquifer system as the discharging bore and records the activity of all deep bores in the vicinity.

Calculations based on drawdown and recovery data from this bore indicated a transmissivity of between 790–900 m^2/day and a storage coefficient of 6×10^{-4}.

The reaction of the deepest bore (M.D. Calivil 2) was in line with that previously recorded. It showed no reaction for at least the first 18 days of pumping, then over the following four days showed an overall fall of only 4 cm.

SHALLOW AQUIFERS <30 m

Following 22 days of continuous recording it is clear that there are no visible changes in static level in the shallow aquifers arising from the depressed pressure levels induced in the deeper Calivil Formation aquifer system.

Fluctuations in static levels ranging over 14 cm in State Rivers and Water Supply Commission bore 1220 to 9 cm in State Rivers and Water Supply Commission bore 1217 were recorded . It is certain however that these are reflections on local meteorological conditions which caused general high pressure levels on August 3, 18 and 19, and low levels on August 5, 11 and 12. Two bores, State Rivers and Water Supply Commission 1216 and 1219, showed a continuous rise in static level throughout the test period suggesting that poor development is masking any pressure variations experienced by the aquifer.

PALEOHYDROLOGY AND PALEOCLIMATOLOGY OF THE KOW SWAMP AREA IN RELATION TO SALINIZATION.

P. G. Macumber

Detailed stratigraphic and paleohydrologic interpretation has been undertaken in conjunction with the excavation of skeletons of **Homo erectus** at Kow Swamp, 255 km north of Melbourne, in the Riverine Plain.

The work indicated that there have been wide fluctuations of the hydrologic regime in the past 10,000 years. This has special relevance to an area which has very shallow water-tables and resulting soil salinization.

STRATIGRAPHY

The stratigraphy of Kow Swamp has previously been summarised (Thorne and Macumber 1972). There are three basic units in excavations : the clay plain, the Cohuna Silt, and the Kow Sand, deposited in fluviatile, lacustrine, and aeolian environments respectively.

Clay Plain : This incorporates all Pleistocene argillaceous overbank deposits which cannot be readily differentiated at Kow Swamp. It forms the basal unit in the district. A series of five closely spaced bores (Patho 1–5, Vic. Mines Dept.) drilled across the lunette penetrated the clay plain to a depth of 10 m. Core samples showed it to be a uniform, grey and brown mottled, dense, sticky clay with occasional lime and manganese pellets and small lime nodules. Two bores intersected thin channel sands at depths of 7 and 9 m below the surface.

Cohuna Silt : This denotes the thin narrow belt of silts deposited in a near shoreline environment at the eastern edge of Kow Swamp, and marking the limits of advancement of the late Quaternary Lake Kow. The silts are ideally suited to grave excavation, and their post-depositional history has resulted in an almost perfect preservation environment for skeletal material.

The average thickness of the silts is 7 m, but they widen lakewards to approximately 2 m. South of Taylor's Creek the silts themselves underlie a dune. Between the dune and the lake edge the underlying silts give way to fine gritty sands.

The silts are generally clean, well-sorted quartz silts cemented by authogenic carbonates of groundwater origin. The average grain size is from 0·040–0·041 mm. The silts have a well-developed minimal red-brown earth soil profile where not covered by later dune accretion. Under the fore dune, a slight darkening of the silts immediately below the junction is considered to be a very poorly developed but pollen-rich palaeosol.

Kow Sand are dune sands of the Kow Swamp lunette, formed around the eastern edge of Kow Swamp. The lunette is 2·5 km long and commences south of Taylor's Creek where it rises to a height of 4 m. It always overlies the Cohuna Silt, and the very weak development or absence of the intervening palaeosol, shows no significant gap between the two units.

The dune sands are sub-rounded, well-sorted clean quartz sands. There are small quantities of heavy minerals, consisting mainly of the ultra stable suite ilmenite, zircon, rutile and tourmaline. There is no visible bedding. The medium grain size of 0·085–0·095 mm lies at the lower limits of grain size requirements for dune sands.

The lunette has a soil profile with the development of elluviated and illuviated zones, perhaps best described as a podsol.

Two other geomorphic units of stratigraphic importance, but not met at the main Kow Swamp site, are the Mead Stream ancestral river complex and the Gunbower Creek ancestral river system. Low source-bordering sand dunes are occasionally found along the eastern banks of the channels.

PALEOHYDROLOGIC REGIME OF KOW SWAMP

The paleohydrologic picture is in close agreement with the sedimentologic and pedologic evidence at Kow Swamp, although there may be further refinement as more data becomes available.

A late Pleistocene phase of lake expansion and high lake level is seen in the deposition of the Cohuna Silts well above the present artificially high lake level, in a position now found extending leewards of the Kow lunette. When the initial phase of high lake levels commenced is not yet known. The silt sequence was partly deposited by 12,000 y B.P. when the KS 14 skeleton was buried. However this is in agreement with dates from the overlying lunette, ranging upwards from 9,590 y B.P. High lake levels continued throughout this period with deposition of further silt sequences lakewards of the KS 14 site but still above the present high lake level. An example is to the north of the main burial site there are basal silts by varve-like alternations of thin silt and fine sand laminae, then a quartz fine sand bed, the shell band, and finally more silt. The alternating silt-sand laminae show a regular (? seasonal) fluctuation in sediment input or lake level or both. The sand suggests a lake regression and the overlying silts a further transgression. The whole sequence suggests a fairly dynamic environment at a general high lake level.

A further lake expansion was noted in a trench section opposite the main site where shoreline silts have incised into pre-existing gritty silts. This dated at 9,260 y B.P. There are no lacustrine deposits dated later than 9,260 y B.P. in the narrow band of silts bordering the swamp, and since the former lake bed is submerged it is difficult to examine younger sequences lakewards of the shoreline. However the prolongation of a high water-table regime indicating at least a moderately high lake level is shown by the capillary emplacement of authogenic calcium carbonate in the sequence until well after 9,260 y B.P.

Lunette aggradation rates and pedogenesis indicate a waning in levels after 8,000 y B.P. with the onset of aridity. For the remainder of the Holocene the lake was virtually dry, and only filled at times of exceptionally high seasonal discharge.

The excellent preservation of the Kow Swamp material is largely due to a fortuitous combination of palaeoclimate and hydrology, which together with the favourable grain size of the Cohuna Silt has resulted in a padological environment favourable to the continuing preservation of skeletal material. One influence of this environment is seen in the protective calcium carbonate coatings preferentially precipitated around the bones.

While the initial emplacement of carbonate in the silts is primarily a hydrologic factor,

stemming from high water tables, its later remobilization is a reflection on later pedologic influences. The degree of carbonate infusion has however been enhanced by the grain size of the Cohuna Silt which enables a high rate of vertical capillary movement.

At present very high water tables occur throughout the Kow Swamp district. This has led to a capillary rise of saline groundwater causing widespread soil salinization and surface salt efflorescence. This is an artificial situation arising from over-irrigation of unsuitable soils. Prior to the commencement of irrigation the water tables were well below the surface (deeper than 6 m under the adjacent Loddon Plains), and capillary processes had virtually no influence on soil salinities. The critical depths above which surface salinization by capillary rise from the water table has been determined as at about 1·2 m in the Kow Swamp district. This was not always so and in the Quaternary Period. Major climatically induced cyclic fluctuations in the piezometric surface have led to the hydrologic position now artificially induced at Kow Swamp, and the capillary concentration of salts in the near surface soils. This was the situation at the time of the Kow Swamp burials, and the physicochemical environment of the soil under high water table conditions is a major factor in the preservation of the Kow Swamp material. Where these conditions were not present the skeletal preservation is at best poor, for example in the Kow lunette.

Thus in terms of a fluctuating palaeohydrological equilibrium, the present day (albeit immediately pre-irrigation) regime can be regarded as one of low water tables. High water tables existed in early Holocene times. The latter can only occur under full lake conditions and at times of high stream discharge.

PROJECT No. R10.
APPROVED ITEM Nos. 1J and 1K.
PROVINCE Otway Basin
LOCALITY Gambier Embayment

NOTES ON THE DEEP SAND AQUIFERS OF LOWER TERTIARY AGE IN THE PORTLAND AREA.

W. A. Esplan

INTRODUCTION

Currently the Portland Waterworks Trust is the only user of the waters of the deeper aquifers at Portland. It operates two bores constructed by the Department of Mines. These located respectively at the West Portland Pumping Station (Portland 3) and Bald Hill (Portland 11) are operated as water demand requires.

Any private development of the groundwater in the Portland area must be considered in conjunction with the requirements of the Portland Waterworks Trust.

The predictions made in these notes are based on the results of investigations during 1970–71 by the Department of Mines when the pumping bore (Portland 11) and two observation bores (Portland 8 and 10) were constructed in the Bald Hill area of South Portland.

The aquifers developed in the Portland 11 bore occur in the depth interval of approximately 1143 m to 1219 m AHD. They consist of three separate sand strata with a combined thickness of approximately 42 m. The water is moderately brackish (TDS 685 mg/l) and soft (hardness 20 mg/l as calcium carbonate).

An additional aquifer which was not developed at Bald Hill occurs in the interval of 1401 m to 1448 m. This aquifer, consists of 42·7 m of well sorted sand and appears to contain water of comparable quality to that referred to above.

Below RL 1448 m the wireline surveys indicate that the aquifers contain saline waters in excess of 20,000 mg/l TDS.

CHEMICAL COMPOSITION OF THE WATER DEVELOPED AT BALD HILL

Chemical analyses of this water are given in Table 1 which includes an analysis of the water obtained from Portland 3.

The November 1970 and December 1971 analyses relate to samples obtained during pumping tests. The November 1973 and February 1974 analyses refer to samples obtained after the bore had been in production for some time. The pumping test samples are basically identical whereas the production samples show a slight increase in Na, Cl and CO_3—HCO_3 ions and the absence of SO_4.

The water obtained from Portland 3 is inferior in quality compared with that from the

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Portland 11 bore. The difference in the quality of the waters obtained in the two bores, Portland 3 and 11, should not be regarded as indicative of a change in water quality laterally through the aquifer. It is due rather to the development of different vertical intervals within the one geological formation. This is supported by electric wireline surveys.

It should be noted that water temperatures of 46–53° C have been measured at ground surface during pumping.

THE POTENTIOMETRIC SURFACE AT PORTLAND

Five deep bores have been constructed at Portland but only Portland 8, 10 and 11 are constructed so as to develop the same part of the aquifer system which is recognised currently as the uppermost sands of the Dilwyn Formation. The Portland 2 bore at North Portland in part develops sands of the younger Mepunga Formation.

The measurements of static level in the three localities, North Portland, West Portland and South Portland are as follows :—

Portland 2	24·7 m above sea level (ASL)	1958
Portland 3	32·6 m ASL	1959
Portland 8, 10 and 11	21·9 m ASL	1971

Derived from these figures, the hydraulic gradient is 1 : 200 in an easterly direction. This steep gradient may indicate that there is a discharging boundary to the east of Portland located somewhere in Portland Bay. Alternately, there may be changes in water level over the time interval, due to the number of years of extraction of groundwater from Portland 3.

Little is known of the extent of the aquifer across the continental shelf and virtually nothing is known of the region of outflow from the aquifer to the sea. Little can be said regarding the maintenance of water quality with time after prolonged periods of pumping. It is not too much to anticipate that flushing of the top section of the aquifers of the Dilwyn Formation has been achieved for at least 6 km in a seaward direction. Based on the pumping test results, it was calculated that the transmissivity is 890 m^3/day/m and the storage coefficient is $8{\cdot}0 \times 10^{-5}$. Drawdown in a 304·8 mm diameter bore with 100% efficiency discharging 126 l/sec continuously would be 26·8 m after 27 years of pumping. Therefore, the pumping level would be —4·9 m and at a distance of 6·4 kms seaward the piezometric surface would be lowered 8·2 m to a level of 13·7 m ASL, assuming no slope to the natural piezometric surface.

PROJECT No. R11.
APPROVED ITEM No. 1L.
PROVINCE Otway Basin
LOCALITY Mocamboro (Merino Town Supply).

RESULTS OF HYDROLOGIC TESTING OF THE MOCAMBORO BORE 9

M. Riha

GENERAL

A production bore, Mocamboro 9, and an observation bore, Mocamboro 8, were sunk 52 m apart and 2·2 km to the south of the original production bore. These bores were completed and several pumping tests of the upper and lower aquifers were carried out.

The upper limestone aquifer at the original production bore dips gently to the south forming the lower aquifer in the Mocamboro 9 bore. The impermeable boundary condition of the lower aquifer at the original production bore, discovered during an earlier pumping test, is explained by the limited extent of this aquifer.

The values of the aquifer characteristics have been calculated by " Jacob " analysis of the drawdown data applied to the upper slightly confined aquifer and " Theis " analysis to the lower confined aquifer.

UPPER AQUIFER

Transmissivity = 7·13 m^2 day^{-1}

Hydraulic conductivity = 0·98 m day^{-1}

Storage coefficient = $1{\cdot}42 \times 10^{-6}$. The low value of the storage coefficient is due to the uncompleted gravity drainage. A recharge boundary was reached during the delayed yield period.

LOWER AQUIFER

Transmissivity = $7{\cdot}82 \times 10$ m^2 day^{-1}

Hydraulic conductivity = 2·31 m day^{-1}

Storage coefficient = $6{\cdot}04 \times 10^{-4}$

QUALITY OF THE PUMPED WATER

Upper Aquifer—(unconfined).

Water samples were taken during the pumping tests. This water was found to be suitable for all purposes. The salinity ranges from 192 to 249 mg/l TDS and the total iron content is high, ranging from 13 to 47 mg/l. Because of the slightly low pH (6–6·3), the water would tend to hold iron in solution.

Lower Aquifer—(confined).

This water is suitable for human consumption, irrigation, all stock and for flushing in a septic sewerage system. It is hard water, which would respond to softening by an iron exchange softening unit. This treatment would also remove iron at concentrations up to 10 mg/l. The salinity ranged from 471–648 mg/l TDS.

The higher total iron found in earlier samples was derived from suspended sediment and ranged from 11 to 19 mg/l.

UPPER AND LOWER AQUIFER

(Aquifer 1 and 2). A weir device used in Mocamboro 8 enabled sampling of the mixed water (0·2 1/sec from the upper aquifer and 1·1 1/sec from the lower aquifer). Although this water is lower in hardness and total solids than the lower aquifer water, it would still require softening and iron treatment.

The hardness of the water obtained by blending from production bores is expected to be about 150 mg/l and could be used without softening. Removal of iron by aeration is advisable.

PUMP SETTING

The following data were calculated assuming continuous pumping at $3 \cdot 15 \times 10^{-3}$ m^3 day^{-1} over a three month period free of recharge.

Original production bore 1

Upper aquifer

Yield : $7 \cdot 56 \times 10^{-4}$ m^3 sec^{-1} (600 gph)

Drawdown : 12·30 m (40 ft)

Lower aquifer

Yield : $1 \cdot 13 \times 10^{-3}$ m^3 sec^{-1}

Total drawdown : 55 m

Pump setting at 70 m

Mocamboro 9

Upper aquifer

Yield : $2 \cdot 52 \times 10^{-4}$ m^3 sec^{-1}

Drawdown : 9·14 m

Lower aquifer

Yield : $1 \cdot 01 \times 10^{-3}$ m^3 sec^{-1}

Total drawdown : 55 m

Pump setting at 73 m

CONCLUSION

A submersible pump able to pump $1 \cdot 9 \times 10^{-3}$ m^3 sec^{-1} if set at 70 m below the ground would be capable of yielding the water required from the original production bore. A similar pump yielding $1 \cdot 26 \times 10^{-3}$ m^3 sec^{-1}, set at the depth of 73 m at the Mocamboro 9 bore would also produce the amount of water required. To make the production bores efficient, a gravel pack was used which retained about 30% of the aquifer sand. A pump capable of lifting water containing a small amount of fine sand without causing excessive wear is preferable.

PROJECT No. R12.
APPROVED ITEM No. Otway Basin
LOCALITY Barwon sub-basin

A PRELIMINARY REPORT ON THE GEOLOGY AND HYDROGEOLOGY OF THE BARWON DOWNS AREA

W. J. R. Blake

The geological and hydrological limits to the Barwon Downs groundwater basin have now been reasonably well defined and the data has been used to calculate the maximum sustained yield. Present indications are that the basin could be developed to yield 260–320 l/sec continuously or approximately 9,000 million litres per year. The optimum site for a " well field," if developed by the Geelong Waterworks and Sewerage Trust, is on the Barwon River flats in the vicinity of Mines Department bore—Gerangamete 13. A detailed feasibility study incorporating hydrogeological and engineering data of the site will enable a bore field to be designed and cost estimates made.

During the operation of the bore field, statistical information will be accumulated enabling more precise calculations of the safe yield of the system.

INTRODUCTION

This report is the result of a continuing study of the groundwater resources of the Otway Basin in Victoria. The purpose of this project is to study the feasibility of development of groundwater as a supplement to the water supply of the city of Geelong, following a request by the Geelong Waterworks and Sewerage Trust to assess the groundwater resources of the region.

AIMS

The area is virtually undeveloped in regard to groundwater and hence the investigation was largely exploratory. It was necessary to establish :—

(1) The dimensions of the basin and its relationship to adjoining basins.

(2) The stratigraphic sequence and the structural relationships of the geological formation.

(3) The outcrop distribution of the principal aquifers.

(4) The hydrogeology of the basin (direction of groundwater flow, aquifer characteristics and water qualities).

METHODS USED

Because of the exploratory nature of this investigation it was necessary to geologically map the area. Particular emphasis was placed upon distinguishing the Lower Tertiary Wangerrip Group and the Middle-Upper Tertiary Nirranda and Heytesbury Groups.

To aid the mapping and to establish the subsurface geology a drilling program was carried out. Two mud rotary drilling rigs were employed—a Failing 1500 rig and a Gardner Denver 2500 for the deeper section. A total of 15 bores, totalling 6,623 m, were drilled for this first phase of the program.

Interpretation of magnetic, gravity and seismic data also added to the understanding of the geology of the area. The study area is located at the eastern end of the Otway Sedimentary Basin. The Otway Basin is a complex depositional trough. At the eastern end the subdivisions are delineated mainly by a series of NE–SW trending faults.

THE BARWON DOWNS BASIN

The Barwon Downs Basin is bounded to the north by the Birregurra Monocline and the south boundary is in the Gellibrand township area where two uplifted blocks converge. The eastern end of the Otway Basin is delineated by a major set of NE–SW trending faults. In geological time, the basin assumed its present configuration at the onset of Nirranda Group sedimentation and after the cessation of Wangerrip Group sediments. The basin includes all post-Otway Group sediments.

The use of the term basin is consistent in a hydrogeologic sense as water infiltrates along the flanks of the uplifted blocks and drains towards the centre of the graben.

STRATIGRAPHY

The following geological formations have been recognized in the Barwon Downs Basin :

Stratigraphic Table

Period	Group	Formation
Pliocene		Newer Volcanics
		Moorabool Viaduct
Miocene		Gellibrand Marl
	Heytesbury	
		Clifton
	Older Volcanics	Narrawaturk Marl
	Nirranda	
Eocene		Mepunga
Paleocene	Wangerrip	Dilwyn
Upper Cretaceous		Pebble Point
Lower Cretaceous	Otway	

WANGERRIP GROUP

In the basin the Dilwyn Formation contains a predominance of quartz sands over mudstones with subordinate brown coals and ligneous clays.

NIRRANDA GROUP

The lithology is commonly a fossiliferous, carbonaceous, dark grey silt to silty-marl with worm burrows. In some areas (Yaugher 19) near Gellibrand this grades into silty limestones. In the Barwon Downs basin the Nirranda Group is intermediate in lithology between the Narrawaturk Marl and the Demon's Bluff Formation at the Anglesea area.

OLDER VOLCANICS

Basaltic dykes and plugs intrude the Dilwyn Formation in the Gellibrand township area and are interbedded with the Narrawaturk Marl formation. The basalt was intersected in Yaugher 19.

HEYTESBURY GROUP

Along the faulted margins of the basin the Clifton formation is a well developed cream-white bryozoan limestone up to 30 m thick. Towards the centre of the basin the formation becomes more silty and to the northeast (Karngung 1) there is no limestone present. The formation is represented by marls typical of the Gellibrand Marl.

Following the Clifton Formation is the widespread Gellibrand Marl as a result of the maximum marine transgression in Miocene times.

In the Barwon Downs basin, the Gellibrand Marl is more silty than the typical section on the Port Campbell coast. The Middle Miocene regression from the Barwon Downs area saw the close of marl deposition and no limestones equivalent to the Port Campbell Limestone is present.

HYDROGEOLOGY

The total area of the Barwon Downs basin is approximately 507 sq km. Of this approximately 118 sq km is intake area (or potential intake area) as determined by the outcrop of Dilwyn Formation and approximately 390 sq km is the area of confined aquifer. The Barwon Downs basin is a discrete groundwater basin.

AQUIFERS

Sands within the Dilwyn Formation are the main aquifers in the basin. The sands within the formation are characteristically fine to medium grained, poorly to moderately well sorted micaceous quartz sands. Although the sands are laterally continuous it is difficult to correlate individual sand beds between the bores. The thickest development of Dilwyn Formation was encountered in the Yeo 16 (approx. 183 m) and the sands appeared coarser here than in the Barwon Downs graben. The Dilwyn Formation is thicker and better developed on the north western edge of the graben than on the south eastern edge.

The Mepunga Formation at the base of the Nirranda Group is a minor aquifer. It probably does not exceed 30 m in thickness. In places (e.g. Karngung 1) there is no Mepunga Formation developed at all ; the Narrawaturk

Marl overlies a very thin Dilwyn Formation. Some difficulty was experienced in logging the boundary between the Mepunga Formation and the Dilwyn Formation in bores, though they are lithologically distinguishable. This was largely because of rotary cutting contamination.

The main area of intake is on the Barongarook block. The sands of the Dilwyn Formation in outcrop appear coarser than those observed in any of the bores in the graben.

Intake also takes place in the Barwon Downs—Forrest area, to Gellibrand on the southern edge of the graben.

It is apparent that groundwater flows in two directions :—

(1) Southwest and out to the Gellibrand river in the vicinity of Kawarren East.

(2) East and northeast towards the Bambra Fault. Outflow from the Dilwyn Formation probably takes place along the Bambra Fault from Pennyroyal through Deans Marsh to Wensleydale.

AN ESTIMATE OF MAXIMUM SUSTAINED YIELD

An appropriate calculation can be made of that proportion of the outflow which goes southwest into the Gellibrand River using Darcy's Law.

For the section of the graben between Gerangamete 13 and Gerangamete 11, there is a gradient of approximately 6 m per km. If the average thickness of sands is 60 m, the width of the basin at this point is 12 km and the average hydraulic conductivity is 0·0039 l/sec, then there is approximately 210 l/sec flowing through the aquifer in a south west direction. The volume of water flowing north east to the Bambra area is more difficult to calculate. However the gradients are a lot less than 6 m per km (approximately 1·6 m/km between Murroon 22 and Whoorel 5) and hence a value of 50–100 l/sec may be of the correct order.

Therefore at the present state of knowledge of the basin a natural discharge of 260–320 l/sec may be compared with the intake of water over the catchment area. The average rainfall in the area is between 76 and 101 mm per annum (say 89 mm) and the intake area is approximately 120 sq km. Five percent of rainfall as intake would yield approximately 170 l/sec continuously from the basin (averaged over a year).

WATER QUALITY

The total dissolved solids content in the Dilwyn Formation waters is low in the range 250 to 350 mg/l TDS. The total iron in the waters is high, approximately 20 ppm and mostly in the dissolved state as it issues from the bores.

The water would have to be treated for both iron and pH (aeration would alone not be sufficient to precipitate the iron). The pump equipment should be of a non corrosive material.

The Mepunga Formation was sampled separately from the Dilwyn Formation in Murroon 25 and proved extremely high in iron (34 mg/l in a water of only 201 mg/l TDS). Sampling procedures in the Mepunga Formation proved important as the total iron varied from 34 mg/l sampled after several weeks flowing, to 0·8 mg/l sampled after only a few hours flowing.

RECOMMENDATIONS OF " WELL FIELD " DESIGN

The capacity of the installed well field is not limited to the continuous safe yield estimated for the basin. A safe yield of 260–320 l/sec is equal to a total volume of between 8,700 and 10,000 million litres per year (say 9,500 million litres per year). There is no restriction (within limits) on the time interval over which this water may be used. For example a well field with a total capacity of 570 l/sec could be installed and used only over the six warmer months and allowing the other six months of year for recovery.

It is stressed that careful monitoring of the observation bores, which have been installed, and continuous metering of the water extracted from the well field should be carried out. Data gained after several years operation would enable a more accurate estimate of the safe yield of the basin to be determined.

LOCATION OF WELL FIELD

Because of the small size of this basin (in relation to the volume of water it is desired to extract) the location of a well field is governed by hydrogeological considerations, not the economics of relative sites. The factors which should influence the choice of the location of a well field site in the Barwon Downs area are :—

(1) The area of maximum thickness of aquifer sands.

(2) The area in which the highest pressures are developed.

(3) The proximity to outcrop of aquifer sands (and hence distance to recharge boundaries).

The area along the Barwon River flats in the vicinity of Gerangamete 13 meets each of the above requirements and hence is the optimum site for a well field. In this area it should be possible to intercept both the water flowing south west and north east.

The disadvantages of this well field site are the depth required for production bores (average depth approximately 560 m) and the distance from the well field to the Barwon West—Wurdi Boluc aquaduct (approximately 3 km).

REPORT ON THE PROPOSED DEVELOPMENT OF THE UNDERGROUND WATER RESOURCES OF THE BARWON DOWNS BASIN

W. J. R. Blake

SUMMARY

This report is the result of a decision by the Geelong Waterworks and Sewerage Trust to proceed with the development of groundwater in the Barwon Downs Basin. Details of the design of a production bore and two observation bores, plus recommendations on the location of the well field site, the location of a treatment plant site, pumping test procedures and equipment are included.

INTRODUCTION

The Mines Department has agreed to drill the first of a series of production bores at the proposed " well field " site. Two observation bores will also be required at the site. These bores will provide information to enable the design of the future " well field ".

LOCATION OF THE WELL FIELD

As discussed in the previous report (unpublished report 1974/21), the choice of the " well field " has been governed by the hydrogeological conditions within the basin. The optimum site in the graben is in the vicinity of Gerangamete 13 on the Barwon River flats.

LOCATION OF WATER TREATMENT PLANT

It is apparent from the chemical analyses that a simple treatment from iron removal and pH adjustment is required prior to discharging water into the Wurdi Boluc inlet channel.

DISCUSSION OF THE GERANGAMETE 13 COMPLETION REPORT

In the Gerangamete 13 bore there is a total approximately 85 m of sand of the Dilwyn Formation developed in 12 distinct sand beds. The sands vary from being poorly to well sorted and are fine to coarse.

The Dilwyn Formation can be divided into a predominantly sand section at the top (382·6 m–492·9 m), a predominantly clay and ligreous clay section in the middle (492·9 m–519·5 m) and a sand section at the base (519·5 m–542·4 m).

A major problem when using mud-rotary drilling in bore design, is the obtaining of representative samples of aquifer sands for size analysis. The cuttings samples cannot be considered reliable particularly if fine sands are encountered. In spite of this, cuttings are often the only samples available and a decision on screen apertures must be based upon them.

An example of the unreliability of cuttings samples is demonstrated by comparing a sizing of sand from a core with cuttings from the same depth. One metre of core of the sand from 414·6 m–427·4 m was recovered and sized for comparison with the cuttings at 417·6 m. The core showed a 50% passing size of 0·355 mm compared with 0·812 mm for the cuttings sample. This result is highly significant as the geophysical logs indicate that the sand 414·6 m–427·4 m is the best developed sand in the section and contains the best quality water.

Sizings performed both on bore samples and outcrop samples suggest screen apertures for the production and observation bores will be in the range of 0·381 mm–0·762 mm. The exact values will be determined when the bores are drilled.

PRODUCTION BORE DESIGN

Length of screens required.

The production bore is being designed on the basis of an estimated yield of 96 l/sec. The screens will be of stainless steel and 31·5 mm, heavy pattern, AWW pipe size. To obtain 96 l/sec with an entrance velocity of 0·051 cm/sec and an average aperture of 0·381 mm, approximately 25·91 m of screens are required. This value is considered to be a minimum taking into account the size and the relatively low permeability of the Dilwyn Formation sands.

For meaningful pumping test results, it is accepted practice to screen at least 70% of the aquifer thickness. The total aquifer sands in Gerangamete 13 is 85 m. Therefore, 70% of this would require 77·16 m of screens. This is well in excess of the 25·91 m needed to yield 96 l/sec. Considering the relatively high cost of stainless steel screens, 45·73 m length of screen in the production bore should be a sufficient compromise between pumping test requirements and cost. The screens will be placed in appropriate lengths opposite to the aquifer sands.

PUMPING TEST EQUIPMENT

The considerable head of water above ground level which will be encountered (approximately 25 m at the recommended site) will make pumping tests difficult. Provision will have to be made to seal the pump into the production bore for the period of the pumping tests.

The observation bores will also have to be capped and equipped with mercury manometers to observe the changes of pressure in the aquifer As these will be required for long term water level observation, the manometres should be constructed and installed for permanent recording.

CONCLUSION

The second stage of the development of groundwater in the Barwon Downs basin will be the drilling of a production bore and two observation bores in the vicinity of Gerangamete 13, on the Barwon River flats.

This program will cost the Geelong Waterworks and Sewerage Trust approximately $64,000. A minimum of 2·25 km of pipeline will be required to deliver the water from the recommended production bore site to the Wurdi Boluc Inlet Channel.

It will be possible to plan further development of the basin utilizing the results of the pump tests on the three proposed bores.

PROJECT No. R.12.
PROVINCE Otway Basin

A CONSPECTUS OF MINES DEPARTMENT DRILLING IN THE KOROIT TOWNSHIP AREA, PARISHES OF WARRONG AND YANGERY

A. Shugg

ABSTRACT

The purpose of this report is to summarize Mines Department drilling activities near the township of Koroit. It also gives a brief description of the aquifers that are developed in the area.

INTRODUCTION

Koroit is located about 15 km to the northwest of Warrnambool in southwestern Victoria. The township is situated on the volcanic products of Tower Hill.

DESCRIPTIVE GEOLOGY

Stratigraphic rock units Koroit Area.

Unit	Description
Quaternary—	
Newer Volcanics late stage	tuffs, scoria and ash
Undifferentiated unit	dark clays and sandy clays
Possible inland equivalent of the Bridgewater Formation Newer Volcanics late stage	basalt
Tertiary—	
Heytesbury Group	marl/limestone suite
Naranda Group	marl/limestone suite
Wangerrip Group	sand/shale suite
Mesozoic—	
Otway Group	mudstone/Arkose suite

Descriptions of these units are adequately covered elsewhere and it is considered outside the scope of this report to deliberate any further.

AQUIFER SYSTEMS

The deep sand aquifers in the area are the Dilwyn Formation of the Wangerrip Group. This formation was tested by the Department in Yangery 1, between 553 m and 697 m. Lithologies encountered in this interval include quartz sand, shale, minor dolomitic quartz sandstone and mudstone. The water's quality was 3800 mg/1 TDS, and thus is unsuitable for a domestic supply.

Within the upper part of the Heytesbury Group there occurs the Port Campbell Limestone and the Gellibrand Marl. They are macroscopically porous and may also be cavernous. Rates of extraction achieved from this aquifer vary from between 1·26 to 12·6 1/sec. The lower salinity compensates for the lower yield from the aquifer, and ranges between 600–1000 mg/1 TDS. The groundwater has high bicarbonate concentrations and a high nitrate concentration (10 to 80 mg/1).

The volcanic extrusives that overlie the Heytesbury Group sediments also form a groundwater aquifer. The water quality in the tuff and scoria is strikingly similar to that in the limestone.

PROJECT No. R.12.
PROVINCE Otway Basin

SUMMARY OF AQUIFERS IN THE WARRNAMBOOL AREA

W. J. R. Blake and A. Shugg

Groundwater pumped from aquifers in the Warrnambool area is used for irrigation, stock, domestic, industrial and town water supplies.

There are six separate aquifers in the Warrnambool area. The aquifers vary in rock type, geological age, salinity, yield and depth to water.

The accompanying table lists the aquifer types giving salinity ranges and typical yields, placed in order of geological age from youngest to oldest.

Aquifer Name	Rock Type	Age	Depth (metres)	Salinity Range mg/l TDS	Typical Fields
Tower Hill Tuff	Volcanic ash	Approx. 7,000 y B.P.	0–48	500–1000	1·25–12·5 l/sec
Bridgewater Formation	Cemented calcareous dune limestone	40,000 y B.P. to 500,000	0–48	700–900	⩽1·25 l/sec
Newer Volcanics	(*a*) basalt and (*b*) scoriaceous basalt	0·5–2·5 m.y. B.P.	0–61	(*a*) 1000–6000 (*b*) 500–1000	0·63–6·3 l/sec
Moorabool Viaduct Formation	Sand and clayey sand, red and yellow	2 m.y. to 5 m.y.	0–30	500–2000	⩽1·25 l/sec
Port Campbell Limestone	Limestone—yellow (cavernous)	16 m.y.	0–183	700–1500	⩽25 l/sec
Lower Tertiary Aquifers (Dilwyn Formation) (Mepunga Formation)	Well sorted quartz sands	30–55 m.y.	762–1,524	600–3000	⩽125 l/sec

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PROJECT No. R.13.
APPROVED ITEM No. A.
PROVINCE Gippsland Basin
LOCALITY Woodside–Bairnsdale District

REPORT ON WURRUK WURRUK 12

G. Y. Nahm

INTRODUCTION

The bore under consideration is located at the southwest corner of the Kilmany Recreation Reserve, situated on the south side of the Princes Highway, some 200 km east of Melbourne.

The bore was originally constructed to supply water for the nearby deep drilling operations, and is now reserved for the Kilmany community water supply on the request of the Shire of Rosedale.

HYDROGEOLOGY

The bore intersected the Haunted Hill Gravels and Boisdale Beds. Both are of Pliocene age and consist of sand, clays and gravels.

The principal aquifer in the bore is a 23 m thick sequence at the bottom part of the Boisdale Beds. It contains coarse to very coarse, rounded, light brownish grey sands occurring between the depths of 143·0 and 166·0 m. The grain size distributions of the aquifer sands are shown as follows :

Effective size	:	0·25 mm
Median diameter	:	0·60 mm
Uniformity coefficient	:	3·40
Sorting coefficient	:	1·76

The standing water level in the bore at the completion of developing was 3·13 m below land surface.

AQUIFER TEST

The bore has been developed with slotted casing between the depths of 149 and 164 m. An aquifer test has been carried out for 24 hours without any observation bore. All results referred to in this report are due to the analysis of the date from the pumping bore.

The drawdown at the end of 24 hours continuous pumping at the rate of 927 m^3/day was 12·3 m.

A straight line method of analysis was employed to give a transmissivity of 175 m^2/day. The value of transmissivity analyzed from the data is however much smaller than would be expected from the grain size.

CHEMISTRY OF WATER

Water samples were taken during the pumping test. The results of the analysis indicate that salinity was 143 mg/1 TDS. This water could be used for human consumption. It would be classed as soft for domestic purposes and could be used without treatment for house washing and any type of hot-water service.

Chemical Analysis of Water *Table 1*

Sample No.		3
Report No.		2170/74
Chloride	(Cl) mg/l	55
Carbonate	(CO_3) mg/l	nil
Bicarbonate	(HCO_3) mg/l	24
Sulphate	(SO_4) mg/l	9
Nitrate	(NO_3) mg/l	nil
Calcium	(Ca) mg/l	2·3
Magnesium	(Mg) mg/l	5
Sodium	(Na) mg/l	36
Potassium	(K) mg/l	1
Iron—Total	(Fe) mg/l	0·6
Iron—Soluble	(Fe) mg/l	<0·1
Silicate	(SiO) mg/l	11
Total Hardness (as $CaCO_3$)	mg/l	27
Total Solids in Solution	mg/l	143
pH		7·05
Electrical Conductivity at 25 C (micromhos/cm)		267

CONCLUSION AND RECOMMENDATIONS

A bore 171 m deep, has been drilled in the Kilmany Recreation Reserve for production purposes. An aquifer system consisting of the coarse sands of the Boisdale Beds was encountered between the depths of 143 and 166 m, with a standing water level of 3·13 m. A transmissivity of 175 m^2/day was obtained by an aquifer test. The specific capacity of the bore at the end of 24 hours continuous pumping was 75·4 m^2/day.

However, in the present bore, about 600 m^3/day is recommended as a maximum optimum pumping rate, because of the slotted casing used. If this rate is exceeded, the life of the bore will be shortened by clogging of the slotted casing.

PROGRESSIVE REPORT ON THE CLIFTON CREEK GROUNDWATER SURVEY

G. Y. Nahm

INTRODUCTION

The survey consists of geological and hydrogeological investigations, studies on the existing bore records in the area, test drilling and finally aquifer tests. Actual test drilling was commenced in January of 1973. At the end of 1973, nine test bores including observation bores for aquifer tests have been drilled and three aquifer tests have been completed.

GEOLOGY AND HYDROGEOLOGY

General geology and geomorphology of the area are summarized by J. J. Jenkin (1968), and aquifer characteristics and chemistry of water by G. Y. Nahm (1973).

According to the present study, geological structures of the area seem to be characterised by several monoclines. As shown in the map, those monoclines form two conjugate sets. One runs in NNE direction, while the other runs in NEE direction parallel to pre-Tertiary shorelines. Two parallel structures developed approximately along both sides of Clifton Creek are either a small graben structure or an old valley incised into the granite. Details of the structures are shown in the fence diagram. (Unpublished Report 1974/7).

The structural interpretation is at present based on the inadequate data of test bores.

Principal aquifer systems of the area are sands and gravels of Latrobe Valley Coal Measures. Total thickness of the aquifer attains 61 m. The areal distribution of the aquifer is chiefly controlled by the structures. Aquifer tests of the Bore 5 and 7, in the parish of Wy Yung indicate barrier boundaries, probably coinciding with the monoclinal structures.

CONCLUSION AND RECOMMENDATIONS

Several monoclinal structures appear to control the areal distribution of the aquifer system.

It is recommended to continue this groundwater survey project with an additional seven test bores to trace the continuation of their thickness and the boundary zones of thinning of aquifers.

12421/75—4

MINES DEPARTMENT PROJECTS

PROJECT No. R1.
APPROVED ITEM No. 1A.
PROVINCE Central Sunklands
LOCALITY Koo-wee-rup

AIM

The aim of this project is the quantitative assessment of the groundwater resources of the Western Port Groundwater Basin of the Central Sunklands. This will assist the State Rivers and Water Supply Commission in the rational management of the groundwater resources of the area.

Problems under investigation include the changes of groundwater storage as estimated from regular monitoring of water levels in 50 observation bores, and the possible danger of seawater intrusion.

Parish	Bore No.
Drouin East	1
,, ,,	2
Drouin West	25

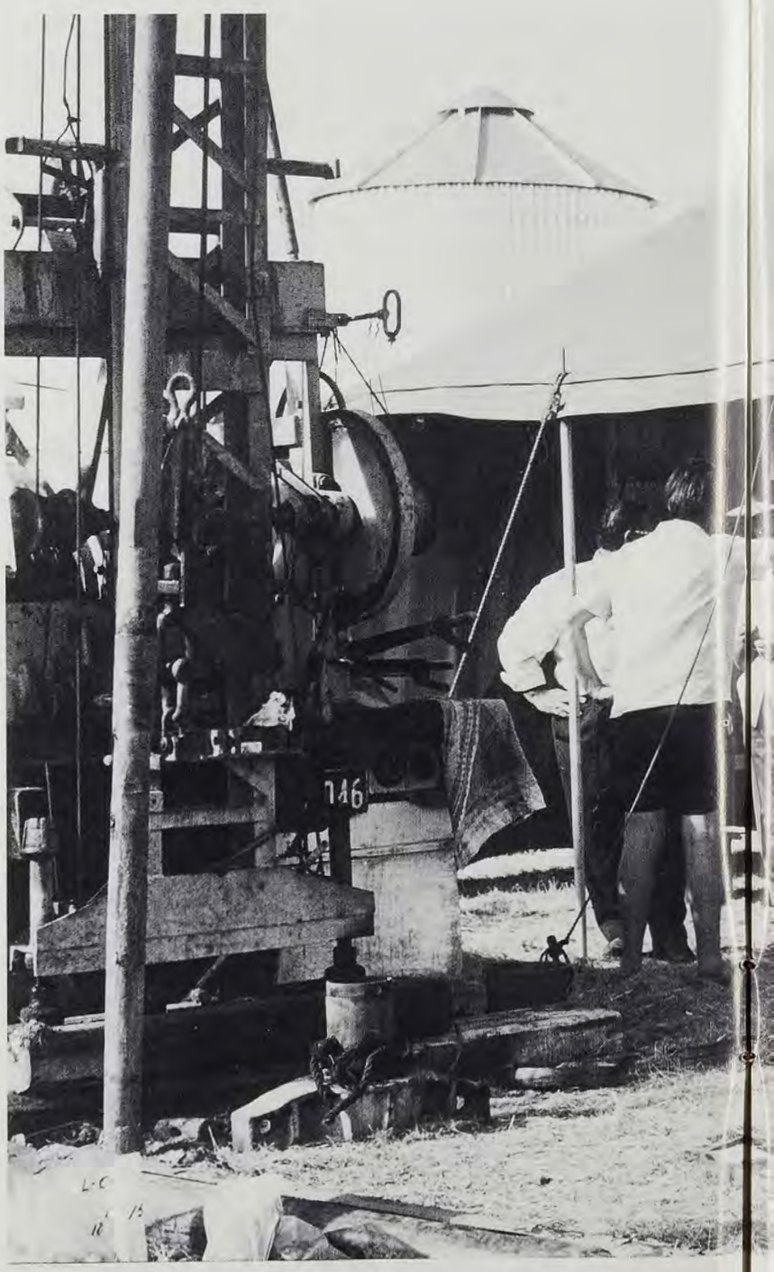
REMARKS

During 1974 three bores were sunk in the outcropping Thorpdale Volcanics in the far northeastern part of the Western Port Basin to determine the significance of this as an intake area. Two of these bores were retained as observation bores.

Four bores sunk previously along the coast for groundwater exploration were developed as observation bores to monitor both salinity and water-level changes.

A set of hydrogeologic maps covering the area has been published, and a report on the aquifer system of the Western Port area has been submitted to the Western Port Environmental Study. A summary of geophysical investigations in the Western Port region was prepared.

Groundwater assessment which would provide a basis for control zones has been undertaken.



PROJECT No. R1.
APPROVED ITEM No. B.
PROVINCE Central Sunklands
LOCALITY Koo-wee-rup

AIM

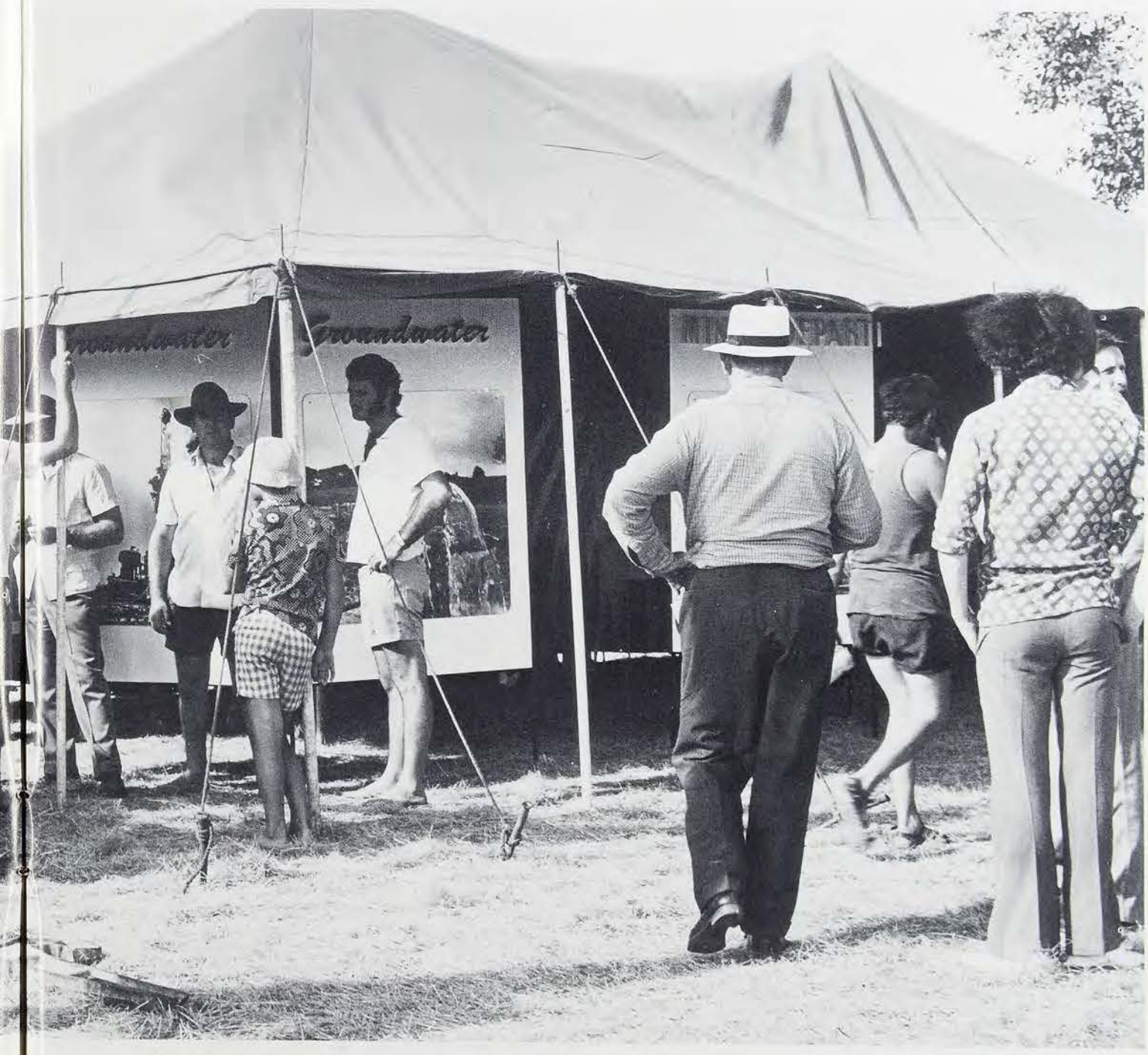
To test for the presence of a subsurface bedrock high, the likely presence of which has been indicated by recent geophysical surveys.

REMARKS

Three bores to basement would be required. Estimated depth in range 90–200 m.

RESEARCH AND INVESTIGATION

Total Depth metres	Water Intersections metres	Water Quality mg/l	Yield l/sec		Lithology
114·0	7·6–7·9		0·1	P	Weathered basalt
	39·6–42·1		0·76	P	
	57·9–58·8		6·92	P	
	72·9–73·2	200 to 350			Hard basalt
	84·5–86·3				
	103·7–112·8		1·77	P	Gravel
45·5	...		Seep		
60·0	27·8–27·9		0·12	B	Basalt
	37·5–40·5	525	6·32	P	



Mines Department Display, Wimmera Field Day, Longerenong Agricultural College.

PROJECT No. R1.
APPROVED ITEM No. 1A.
PROVINCE Central Sunklands
LOCALITY Koo-wee-rup

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Problems under investigation include the changes of groundwater storage as estimated from regular monitoring of water levels in 50 observation bores, and the possible danger of seawater intrusion.

REMARKS

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Four bores sunk previously along the coast for groundwater exploration were developed as observation bores to monitor both salinity and water-level changes.

A set of hydrogeologic maps covering the area has been published, and a report on the aquifer system of the Western Port area has been submitted to the Western Port Environmental Study. A summary of geophysical investigations in the Western Port region was prepared.

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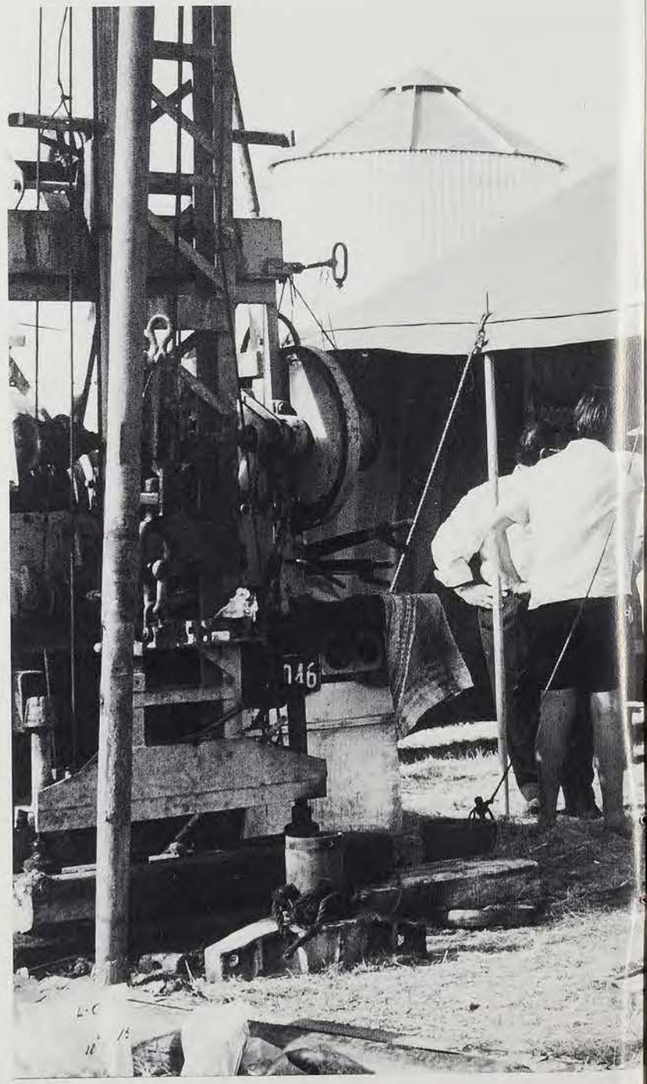
Parish	Bore No.	Total Depth metres	Water Intersections metres	Water Quality mg/l	Yield l/sec		Lithology
Drouin East	1	114·0	7·6–7·9		0·1	P	Weathered basalt
			39·6–42·1		0·76	P	Weathered basalt
			57·9–58·8		6·92	P	Weathered basalt
			72·9–73·2	200 to 350			Hard basalt
			84·5–86·3				Hard basalt
			103·7–112·8		1·77	P	Gravel
,, ,,	2	45·5	...		Seep		
Drouin West	25	60·0	27·8–27·9		0·12	B	Basalt
			37·5–40·5	525	6·32	P	Basalt



PROJECT No. R1.
APPROVED ITEM No. B.
PROVINCE Central Sunklands
LOCALITY Koo-wee-rup

AIM

To test for the presence of a subsurface bedrock high, the likely presence of which has been indicated by recent geophysical surveys.

REMARKS

Three bores to basement would be required. Estimated depth in range 90–200 m.

Mines Department Display, Wimmera Field Day, Longerenong Agricultural College.

PROJECT No. R2.
APPROVED ITEM No. A, B, C, 1B.
PROVINCE Central Sunkland
LOCALITY Melbourne Metropolitan Area—Pollution Studies

AIM

To continue to define the hydrogeology of the area ; to identify pollution centres and to study the migration and dispersion of pollution plumes in the groundwater flow system.

REMARKS

Disposal problems where groundwater could be polluted were investigated throughout the area on behalf of the Environment Protection Authority and Health Department.

(A) Monitoring of observation bores for chemical changes to trace movement of polluted groundwater continued, concentrating on the basalt aquifer to the west of Melbourne and the shallow sand aquifers to the southeast of Melbourne.

(B) In addition, a network of ten observation bores around a disused garbage tip in South Oakleigh was completed during 1974. This project is being undertaken jointly by the Mines Department and the Environment Protection Authority.

(C) Four exploration bores were sunk at the Tullamarine Industrial Waste Disposal Site. One pumping test has been carried out and a preliminary report is in preparation.

(1B) An observation bore was drilled at Collingwood.

PROJECT No. R2.
APPROVED ITEM No. D.
PROVINCE Central Sunkland
LOCALITY Melbourne Metropolitan Area—Pollution Studies

AIM

To test the possibility of recharging deep basalt aquifers with treated sewage effluent at the Melbourne and Metropolitan Board of Works Carrum Treatment Plant.

REMARKS

The Melbourne and Metropolitan Board of Works will cooperate.
An initial exploratory bore would need to be sunk and if this yielded promising results, tests would proceed with observation bores.

Parish	Bore No.
APPROVED ITEM No. A.	
Bulla Bulla	22
,, ,,	23
Darraweit Guim	1
Havelock	6
Kalkallo	12
,,	13
Merriang	2
,,	3
,,	4
,,	5
Yuroke	13
Wallan Wallan	1
,, ,,	2
Derrimut	8
Tharneit	5
Truganina	51
	52
APPROVED ITEM No. B.	
Lyndhurst	141
Mordialloc	308
,,	309
,,	335
,,	336
,,	337
,,	338
,,	339
,,	340
APPROVED ITEM No. C.	
Tullamarine	4
,,	5
,,	6
,,	7
APPROVED ITEM No. 1B.	
Jika Jika	467

Total Depth metres	Water Intersections metres	Water Quality mg/l	Yield l/sec		Lithology
49·25	...				
35·1	...				
74·1	...				
22·3	...				
84·9	...				
85·7	...				
23·5	...				
6·3	...				
71·4	...				
46·0	...				
25·23	...				
37·5	...				
65·2	...				
60·96	...				
80·16	...				
51.81	...				
continued 1975	...				
42·7	4·6–10·7 15·2–40·8	} 1350			Silt, sand Sand marl, gravel
13·7	2·1–12·2	144–317		B	Gravel
29·9	2·1–12·2 24·4–29·3	{ no part. depth— 350, 590			Coarse sand Sandy silty
31·4	27·7–30·2	179		B	Gravel
13·7	3·1–12·2	175		B	Sand
21·3	13·7–18·9	134–228		B	Sand
34·1	27·4–34·2	316		B	Marl and limestone
15·2	9·8–14·6	147		B	Sand and gravel
33·2	12·2–16·8	299		B	Gravel
6·1	0–6·1	oil layer			0–3 m, rubbish
14·0	3·0–14·0	,, ,,			Rubbish
9·1	...	,, ,,			Rubbish
9·75	3·4–9·75	,, ,,			Rubbish
22·25	8·2–8·8	1785	< 1·26		Broken basalt

PROJECT No. R2.
APPROVED ITEM No. E.
PROVINCE Central Sunkland
LOCALITY Melbourne Metropolitan Area—Pollution Studies—Sunshine Quarry

AIM

To aid in the studies of polluted groundwater.

REMARKS

The drilling for this work (2–3 bores) is being financed by EPA and is budgeted for this financial year. Commencement is URGENT.

PROJECT No. R4.
APPROVED ITEM No. A, B, C.
PROVINCE Murray Basin
LOCALITY General

AIM

To carry out a detailed hydrogeological investigation of the Murray Basin in Victoria, including a study of private bore data and the drilling of Government survey and observation bores.

REMARKS

(A) A comprehensive report on the groundwater resources of the Victorian portion is to be published as Memoir 30 in 1975. This report has formed a basis for determining where future exploratory work is necessary, as well as leading to the next phase of transient analysis necessary for the management problems of artificial withdrawal, rising water tables, salting and flooding problems. A transient analysis of the Shire of Lowan has commenced. Over 70 observation bores are being measured at monthly intervals.

(B) Extensive flooding occurred in low-lying areas in the Shire of Wimmera. Investigation drilling was undertaken to drain the perched floodwater into the unconfined sand aquifer. From the low drainage rates down bore holes it was concluded that this was not a feasible method.

(C) Three bores were drilled at Lascelles to determine the shallow groundwater resources there and if there were any relationship with soil sterilization. Drilling indicated that the regional water table was well below the soil zone and that the water was highly saline.

These bores have been retained as observation bores.

Parish	Bore No.
APPROVED ITEM No. B.	
Kewell East	1
,, ,,	2
Longerenong	1
Wallup	1
APPROVED ITEM No. C.	
Chiprick	1
,,	2
,,	3

Total Depth metres	Water Intersections metres	Water Quality mg/l	Yield l/sec	Lithology
49·0	38·0–40·0			Silty sand
40·0	36·0–38·0			Silt
32·0	12·8–14·6 22·0–24·4		15·17 P 13·9 P	Ironstone
137	38·0–39·0 103–106	22 000 18 713		Silt—siltstone Silty sand
86·0	39–45 83	25 000		Sand Sand, clay, coral
36·0	30	28 000		Sand
46·0	38·7–46	27 600		Sand

PROJECT No. R5.
APPROVED ITEM No. A.
PROVINCE Murray Basin
LOCALITY Mallee

AIM

To investigate the relationship between surface lakes and groundwater discharge.

REMARKS

The field investigation for this project is now virtually completed and a report is being prepared.

PROJECT No. R6.
APPROVED ITEM No. A.
PROVINCE Murray Basin (Riverine Plain)
LOCALITY Upper Murray, Kiewa, King, Broken and Ovens Rivers

AIM

To investigate the occurrence and movement of groundwater in the alluviated valleys of the Upper Murray, Kiewa, King, Broken and Ovens Rivers.

REMARKS

No drilling has been carried out in the area during 1974. Observation bores at Kergunyah in the Kiewa River valley are being measured regularly.

There has been a collection and assessment of groundwater data in the vicinity of Albury and Wodonga in collaboration with the NSW Mines Department and the Bureau of Mineral Resources. This is part of the investigations for the projected urban development in that area. It is anticipated that drilling and geophysical work will be carried out in the near future.

A report on the groundwater resources of the Ovens River valley is to be completed in 1975.

PROJECT No. R7.
APPROVED ITEM No. A.
PROVINCE Murray Basin (Riverine Plain)
LOCALITY Plains on the Lower Avoca, Loddon and Campaspe rivers

AIM

The project is principally concerned with the 'deep leads' (channel deposits-paleodrainage system) aquifer system of the ancestral Avoca, Loddon and Campaspe rivers.

Tatura Field Day. Illustration showing problems of high water tables in the Goulbourn Valley.

REMARKS

During 1974 no drilling was undertaken as part of this project.

Over 20 observation bores are being monitored : Pressures in the Loddon Valley Lead responded to infiltration resulting from the high rainfall of 1974.

A long pumping test undertaken with the State Rivers and Water Supply Commission indicated that by pumping the deep Calivil Sand the water table was not lowered.

A report on the groundwater resources of the Loddon and Avoca valley is in progress.

PROJECT No. R8.
APPROVED ITEM No. A, B.
PROVINCE Murray Basin (Riverine Plain)
LOCALITY Shepparton–Cobram Irrigation District

AIM

The program includes the drilling of deep bores to explore aquifer systems and to test various geophysical methods in groundwater exploration. It is also designed to assess the possibility of the combined use of groundwater and surface water, and to determine a water balance for the region.

REMARKS

This program continued under two main lines, approved items A and B. Approved item A was undertaken solely by the Mines Department, whilst approved item B was undertaken with direct participation of the State Rivers and Water Supply Commission with the emphasis on the shallower aquifers.

(A) During 1973 a program was commenced converting previously drilled bores into observation bores tapping two aquifers and this was continued throughout 1974. Drilling continued exploring for deep lead sands (Calivil Sand) of the ancestral Murray and Goulburn rivers. Drilling has been restricted to traverses in the region and has indicated that the deep lead sand aquifer takes the form of a sheet lying at a depth of 60 to 80 m. The sands converging on a point to the immediate south of Cobram represent the ancestral Murray River deposits, and the sands which converge to a point south of Shepparton represent the ancestral Goulburn river deposits. Water quality is excellent towards the margin of the basin, where the salinity is less than 1000 mg/1 TDS, but increases basinward to about 2500 mg/1 TDS. Yields range up to about 50 1/s.

A network of over 30 observation bores is being monitored regularly. These bores tap both the deep Calivil Sand and shallower aquifers.

Parish	Bore No.
APPROVED ITEM No. A.	
Arcadia	1
Barwo	1
,,	7
Cobram	9
Katamatite—45 bores drilled, Total 472m (Continuous auger)	
Katamatite	2
Kyabram—28 bores drilled, Total 318·2m (Continuous auger)	
Narioka	2
,,	3
Nathalia—30 bores drilled, Total 301·8m (Continuous auger)	
Picola	2
,,	3
Shepparton—3 bores drilled, Total 53·7m (Continuous auger)	
Shepparton	2
Tallygaroopna	18
	19
(?) Tallygaroopna	20
Ulupna	8
Waaia—17 bores drilled, Total 257·9m (Continuous auger)	

Total Depth metres	Water Intersections metres	Water Quality mg/l	Yield l/sec		Lithology
80·8	...				
233·5	4·9–5·8	500 to 700			
	10·4–11·6				
	17·6–18·6				
	32·9–34·1				Sands
	38·1–40		1·26	B	
	45·1–46·9	3000			
	53·3–64·6				
170·5	157–170	3900			Sands
100	13·5–14·8	1570			?
	66·0–71·3	627			Sand
126·5	9–16	1925			Sand and gravel
	48–64	410			
	88+	415			Sand
233·0	129–146	4274	1·89	P	Gravel
139·25	...				
7·32	...				
4	...				
233·5	...				
126·75	86–118	3900	2·5	P	Gravel
114·25	85–112				Gravel
114·25	...				
9·14	3·65				Sand

PROJECT No. R8—*continued.*

(B) The investigation of shallower aquifers is continuing. These aquifers offer both a potential source of groundwater and a means of lowering the water table.

Using explosives to develop a pollution observation bore in the western suburbs of Melbourne.

Parish	Bore No.
APPROVED ITEM No. B.	
Cobram	10
,,	16
,,	17
,,	18
,,	19
,,	20
,,	21
,,	22
,,	23
,,	24
,,	25
,,	26
,,	27
,,	28
,,	29
,,	30
,,	31
,,	32
,,	33
,,	34
Picola	2
Shepparton	7
,,	8
,,	9
,,	10
,,	11
,,	12
,,	13
,,	14
,,	15
,,	16
,,	17
,,	18
,,	19
,,	20
,,	21

Total Depth metres	Water Intersections metres	Water Quality mg/l	Yield l/sec		Lithology
7·32	...				
9·5	2·0–9·0		9·1	P	Sand and gravel
9·0	2–8·5		9·1	P	Sand and gravel
9·5	2–9				Sand and gravel
9·5	2–9				Sand and gravel
9·5	2–9				Sand and gravel
9·5	2–9				Sand and gravel
13·0	3–13		9·1	P	Sand and gravel
15·0	4–15	209			Sand and gravel
15·0	4–15	206			Sand and gravel
13·5	4–13·5	198			Sand and gravel
17·0	4–13	212			Sand and gravel
15·0	...				
15·0	...				
25·0	11·0				Coarse sand
16·0	...				
15·0	...				
15·0	...				
15·0	...				
25·0	...				
35	...				
10·0	3·8–5·2	89			Sand
12·0	10·4–11·0	511			Sand
10·0	...				
15·0	9·7–13·2	355			Sand
15·0	9·0–13·2	812			Sand
13·5	8–13	543			Sand
13·0	8·8–12·8				Sand
13·0	8·8–12·0				Sand
13·5	8·7–13·2				Sand
13·0	9·4–12·8				Sand
13·0	8·7–12·4				Sand
13·0	8·8–11·9				Sand
13·0	10·8–12·2				Sand
13·5	12·3–12·9				Sand
13·0	10·6–11·2				Sand

PROJECT No. R8—*continued.*

Parish	Bore No.
APPROVED ITEM No. B.—*continued.*	
Shepparton	22
,,	23
,,	24
,,	25
,,	26
,,	27
,,	28
,,	29
,,	30
,,	31
,,	32
,,	33
,,	34
,,	35
Strathmerton	65
,,	66
,,	67
,,	68
,,	69
,,	70
,,	71
,,	72
,,	73
,,	74
,,	75
,,	76
,,	77
,,	78
,,	79
,,	80
Toolamba	29
,,	30
,,	31
,,	32

Total Depth metres	Water Intersections metres	Water Quality mg/l	Yield l/sec		Lithology
13·0	9·8–12·2				Sand
13·0	9·4–11·2 2·2–4·8	516 320			Sand
12·0	8·6–10·3 1·2–2·6	766 491			Sand
13·0	8·7–10·6				Sand
14·0	8·8–12·8	988			Sand
13·5	9·8–12·7	480			Sand
13·0	9·1–12·4	369			Sand
13·5	8·7–12·8	1191			Sand
13·0	...				
13·0	...				
13·5	2·6–5·7	1073			Sand
13·0	...				
13·5	...				
13·5	...				
13·1	6·2–13	2500			Sand
12·6	6·5–12·5				Sand
3·7	2·5–3·7	1021			Clay
11·0	2·5–3·7	1021			Sand and gravel
10·2	...				
10·0	...				
11·0	...				
11·0	...				
13·5	...				
14·0	9·0–10·5		0·38	P	Coarse sand
11·0	...				
9·5	6·0+				Fine to coarse sand
12·0	6·0–11·5		4·55	P	
12·0	6·0–11–5				
10·5	...				
10·5	6–10·0		5·1	P	Sand
25·0	12·5–15	2206			Coarse sand
25·0	13·2–13·9 14·2–15·0	160			Sand
25·0	12·7–16·9 19·1–21·3	3564			
25·0	11·6–19·5	5219			Sand and gravel

PROJECT No. R8—*continued.*

Parish	Bore No.
APPROVED ITEM No. B.—*continued.*	
Toolamba	33
,,	34
,,	35
,,	36
Ardno	1
,,	(31/74/2)
,,	2
Malanganee	3
,,	4
,,	5
,,	6
Mumbannar	5
,,	6

PROJECT No. R10.
APPROVED ITEM No. A.
PROVINCE Otway Basin
LOCALITY Gambier Embayment

AIM

To study the deep aquifers of Lower Tertiary and Upper Cretaceous sands in the southern and southwestern parts of the onshore Otway Basin in Victoria.

REMARKS

Three bores were completed during 1974. Bores were drilled at Mumbannar, Malaganee and Ardno.

These bores enabled sampling and testing of deep sand aquifers.

PROJECT No. R11.
APPROVED ITEM No. A.
PROVINCE Otway Basin
LOCALITY Mocamboro (Merino Town Supply)

AIM

Investigation of the groundwater resources with a view to providing a reticulated supply for Merino township.

REMARKS

Following a report completed in 1972, an additional pumping bore and observation bore were constructed during 1973. Conclusions made suggest that groundwater resources of the area are adequate to meet the water demand for Merino, and that the extraction of groundwater for this purpose will not materially affect the discharge of springs marginal to the area. These springs form part of water supply of farms.

No further field investigations were undertaken during 1974.

Total Depth metres	Water Intersections metres	Water Quality mg/l	Yield l/sec		Lithology
24·00	11·4–22·8	3131			Sand and gravel
24·0	9·4–23·2	3375	9·1	P	Sand and gravel
24·0	10·4–23·3	3322			Sand
24·0	9·8–22·8	2511			Sand
24·0	7·0–18·0	No part. depth, 628	0·8	Air	Sand and limestone
6·0	Abandoned				Sand and limestone
1071·39	281–321	698–962	17·06	P	Sand
23·0	...				
1719·34	312–347	867	17·01	P	Sand
22·0	7·5+	810	12·64	P	Limestone
22·7	7·5+				Limestone
30·5	2·7–24·7		3·8	Air	Limestone, shelly
1653	3475–3658	850	12·04	P	Sand

PROJECT No. R12.
APPROVED ITEM No. A.
PROVINCE Otway Basin
LOCALITY Barwon Sub-basin

AIM

To investigate by deep drilling the area to the north of the Otway Ranges, east of the Gellibrand River, to obtain data on the intake areas and the potential yield of the Lower Tertiary sand and gravel aquifers.

REMARKS

This project has been given special attention because of the possibility of groundwater from this area supplementing the supply for Geelong.

The field investigation, under approved item A, was completed in January 1974.

Two reports on the geology and geophysical interpretation of structural control were completed. A third report specifically on the groundwater resources was completed.

A fourth report gives details of design, costing and testing of a first production bore to be drilled on behalf of the Geelong Waterworks and Sewerage Trust. (Refer to reports pages 46).

PROJECT No. R12.
APPROVED ITEM No. B.
PROVINCE Otway Basin
LOCALITY Barwon Sub-basin

AIM

As before, but specifically directed to determining " safe yield " with a view to supplying Geelong from a " well-field ".

REMARKS

Four bores required for testing and later to be used as observation bores.

PROJECT No. R13.
APPROVED ITEM No. A.
PROVINCE Gippsland Basin
LOCALITY Woodside–Bairnsdale district

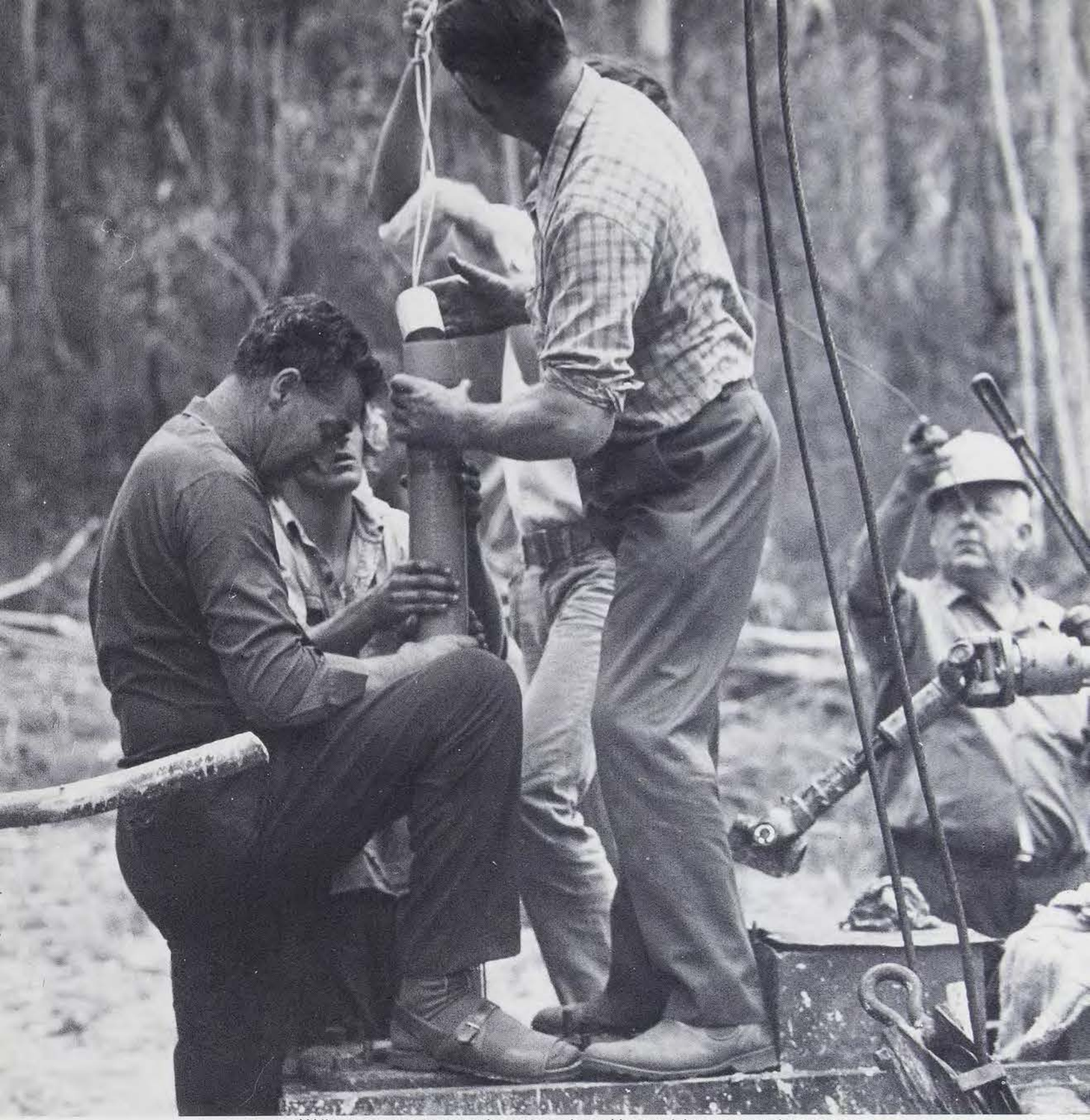
Parish	Bore No.
Woodside	8
Woundellah	9

AIM

The project is to test for groundwater potential of aquifer systems in the Woodside–Bairnsdale district.

REMARKS

During 1973 it was established that the main aquifer is the sands of the Boisdale Beds lying at a depth of approximately 50 m and with a thickness of about 50 m. Both the thickness and depth of the aquifer increase as



Willaura town water supply project. Assembling and lowering explosives into a bore hole. The aim is to fracture the rock and so increase the groundwater flow to the bore.

Total Depth metres	Water Intersections metres	Water Quality mg/l	Yield l/sec		Lithology
216·4	187·5–193·6	1100–1200	14·9	P	Sand bands
168	28–34		0·126	B	?
	31–50·6	160			Clay
	100–168	162	12·6	Air	Fine sand

PROJECT No. R13—*continued.*

it goes south, wedging out a few km north of the South Gippsland Highway.

During 1974 a bore was drilled at Woodside and a pumping test carried out. A completion report on this bore has been prepared.

PROJECT No. R15.
APPROVED ITEM No. A.
PROVINCE Highlands
LOCALITY Grampian Ranges

AIM

The program includes exploratory drilling in Upper Silurian–Lower Devonian jointed sandstone, and the overlying scree deposits of the flanks of the Grampian Ranges, and alluvium within Fyans Creek Valley, Moora Moora Valley and Victoria Gap.

REMARKS

Drilling of four bores was undertaken to test the jointed sandstone. Explosives were used with inconclusive results. The salinity of this water was very low.

The drilling program has stopped for the time being.

Parish	Bore No.
Moyston West	24/74/3
,, ,,	4
,, ,,	5

PROJECT No. R17.
APPROVED ITEM No. B.
PROVINCE Highlands
LOCALITY Dandenong Ranges

AIM

This project aims to determine the safe yield of the aquifer system and the optimum distances between bores.

REMARKS

Increasing numbers of private irrigation bores are being constructed in the Wandin Yallock area.

Drilling by the Mines Department commenced in 1974. Six observation bores have been drilled. A pumping test was conducted at Silvan Recreation reserve.

Wandin Yallock	20
,, ,,	21
,, ,,	22
,, ,,	23
,, ,,	24
,, ,,	25

PROJECT No. R18.
APPROVED ITEM No. B.
PROVINCE Highlands
LOCALITY Daylesford–Hepburn

AIM

To determine and define the distribution, natural state of replenishment and genesis of mineral water in the Daylesford–Hepburn area, with a view of computing the safe

Wombat	32
,,	33
,,	34
,,	35

Total Depth metres	Water Intersections metres	Water Quality mg/l	Yield l/sec	Lithology
16	1+		some water	Sand and boulders
59·4	5·5–6·8 17·7–22·3 31·1–35·7	60	combined, 6·3 to 8·9, P	Sandstone boulders Faulty sandstone
61·0	32·9–37·5 46·9–48·7	? 420 to 470		Coarse sand Faulty siltstone
91·4	22·9–23·8 35·1–36·6 75·6–82·3 84·1–86·3			Weathered and broken basalt Sand
72·0	20–23 47–55	113		broken basalt
86·0	17–31 36–44 53–60 72–74	44 230–340 (no part. depth)	1·84 to 4·6 (no part. depth)	clay—stone broken basalt
83·0	33–35 49–56	256 (no part. depth)		Decomposed and broken basalt
56·0	19–25 34–36 53–54	73 214 191		Clay Decomp. basalt Broken basalt
55·0	16–21 33–35	362 379		Clay Broken basalt
21·5	? 26·0	750		?
74	20 30–34 38·6–42·6 55–57	873 783 735	~ 0·25 P 0·88 Air	Slate Sandstone and quartz Sandstone Siltstone and slate
19·5	15·2–19·5+	243		Slate and shale
83·0	13–16 59–60	279	0·38 B	Grey slate—quartz rock

PROJECT No. R18—*continued.*

withdrawal rates to enable rational management of this resource.

REMARKS

Four bores were sunk in at Daylesford Central Springs to obtain further data on the interrelationship of fractured rock aquifer and water in the nearby lake.

The investigation of the mineral water resources is to be intensified during 1975–76, to culminate in a report upon which to base future development and management.

PROJECT No. R19.
APPROVED ITEM No. A.
PROVINCE Gippsland Basin
LOCALITY Lake Corringle

AIM

To learn of the chemical relationship between the water in Lake Corringle and groundwater in surrounding aquifers.

REMARKS

Drilling for this project was completed in 1973.

PROJECT No. R20.
APPROVED ITEM No. A.
PROVINCE Gippsland Basin
LOCALITY Rosedale–Sale

AIM

To define occurrence of the deep sand aquifers of the Latrobe Group in the Rosedale–Sale area and assess the potential for groundwater development.

REMARKS

Four bores were sunk during 1974, within the range 460 to 862 m.

This drilling program will continue during 1975.

Parish	Bore No.
Denison	51
,,	52
,,	53
Stradbroke	30
Toongabbie South	30
Winnindoo	41
,,	42
,,	43
,,	44
,,	45
Wooundellah	10
Wurruk Wurruk	12

Total Dep metres	Water Intersections metres	Water Quality mg/l	Yield l/sec		Lithology
13·4	8·5–13·4	1080	6·32	P	Coarse gravel
12·19	7·3–10·4	2710	1·26	B	Gravel
833·35	359·8–385·2	340	0·88	F	Med. sand
341·0	...				
34·14	13·7–16·8 25·9–29·9	1400	1·26	B	Coarse gravel Medium to fine sand
26·21	18·3–26·2	2750			Coarse gravel
178·3	ABANDONED—DRY				
31·7	22·9–23·8	419	1·26	B	Gravel
777·6	658·4–676·7 18·3–27·4	250 1107	3·15	F B	Sand and sandstone Coarse sand
460·3	240·8–251·4	682	?	P	Medium sand
804·5	567·1–588·3	400	2·52	F	Fine sand
171·0	29–42 149–164	150	1·26 10·7	B P	Sand Sand

PROJECT No. R21.
APPROVED ITEM No. A.
PROVINCE Gippsland Basin
LOCALITY Clifton Creek

AIM

To obtain information on the aquifer systems in the Clifton Creek area.

REMARKS

Drilling is continuing. It indicates that the aquifer system distribution is very complex due to the effects of monoclines and faults.

In 1974 2 bores were completed and a third bore is in progress. A progress report has been written.

Parish	Bore No.
Sarsfield	8
,,	9
Wy-Yung	14

PROJECT No. R22.
APPROVED ITEM No. A.
PROVINCE Otway Basin
LOCALITY Camperdown

AIM

To study the occurrence and origin of groundwaters of high nitrate concentration.

(Much of the groundwater in this area is of low salinity but its use for town or domestic purposes is precluded by its high nitrate content.)

REMARKS

Eight shallow bores to be constructed. This is to assist with an AWRC Research Project. Commencement of the drilling is URGENT.

PROJECT No. R23.
APPROVED ITEM No. A.
PROVINCE Otway Basin
LOCALITY Allansford

AIM

To study pollution of groundwater caused by effluent of butter factories.

REMARKS

Five–six bores to be used as monitoring bores. This is being financed by EPA and is budgeted for this financial year. Commencement is URGENT.

Total Depth metres	Water Intersections metres	Water Quality mg/l	Yield l/sec		Lithology
151·8	64·6–64·9		0·24	B	Gravel
146	44·2–44·5		soak		Sandstone
114·25	...	abandoned			

Waste disposal at a sanitary landfill site in the western suburbs of Melbourne. The pit was excavated in the Newer Volcanics series.

MINES DEPARTMENT PROJECTS

PROJECT No. S5.
PROVINCE Highlands
LOCALITY Cann River

AIM

To find groundwater suitable for use in the Cann River Township.

REMARKS

Drilling was completed during 1973. A report was completed during 1974.

PROJECT No. S6.
PROVINCE Gippsland Basin
LOCALITY Thorpdale

Parish	Bore No.
Moe	47

AIM

To find a suitable groundwater supply for Thorpdale township.

REMARKS

This project continued from 1973 and was completed early 1974. A production bore and observation bore were constructed. The tapped groundwater within the basalt aquifer lies between the depth of 21 and 40 m.

PROJECT No. S7.
PROVINCE Highlands
LOCALITY Gordon–Mt Egerton

Kerrit Bareet	35
,, ,,	36
,, ,,	37
,, ,,	38
,, ,,	39
,, ,,	40

AIM

To determine the suitability of groundwater as a source of water supply for the towns of Mt Egerton and Gordon.

REMARKS

Six bores were drilled during 1974. One, located 1·6 km west of Gordon, has been subject to a long-term pumping test, and should be suitable for town supply.

PROJECT No. S9.
PROVINCE Gippsland Basin
LOCALITY Boisdale

Wa-De-Lock	10

AIM

To find an adequate groundwater supply for the town of Boisdale.

REMARKS

Drilling is in progress and should be completed early in 1975.

SERVICE

Total Depth metres	Water Intersections metres	Water Quality mg/l	Yield l/sec	Lithology
36·6	1·5–3·4	354	0·13 P	basalt
	27·1–28·6	464	0·065 P	
84·1	33+	1200	6·32 P	Basalt
67·32	11·01+	507	9·2 P for 138 hr.	Basalt
80·76	33·0	900	S=29 m	Basalt
59·34	20·3	489	1·26 P	Basalt
96·47	11·80	534	1·58 P for 75 days	Basalt+sub–basaltic gravels
56·28	15·0	560		Basalt
133·0	2·1–7·2	414		Sand and gravel
	20·5–25	117	1·0 B	Coarse sand
	80·0–85·3	336	1·2 B	Sand
	126–131	615	4·5 F	Sand and gravel

MINES DEPARTMENT PROJECTS PUBLISHED AND UNPUBLISHED REPORTS

Geological Survey Groundwater Reports (Unpublished)

1974–2	Groundwater resources, parish of Samaria, Allotments 99 and 100.	W. Esplan
1974–5	A conspectus of Mines Department drilling in the Koroit township area, parishes of Warrong and Yangery.	A. Shugg
1974–7	Progress on the Clifton Creek groundwater survey.	G. Y. Nahm
1974–8	Possible storage dam at the Public Golf Course, Macrae ; a preliminary report.	J. L. Neilson
1974–10	Proposed mineral spring investigation in the Hepburn–Daylesford district.	P. G. Macumber
1974–11	Summary of groundwater data relevant to the hydrological regime of Swan Bay.	P. R. Kenley
1974–21	A preliminary report on the geology and hydrogeology of the Barwon Downs area.	W. J. R. Blake
1974–23	Geology and groundwater resources of the Cann River flat area, near Cann River township.	G. Y. Nahm
1974–26	Suitability of disused quarries in the southeastern Metropolitan area for disposal of wastes.	I. F. Harris
1974–29	Notes on the geology of the Barwon Downs area (Appendix to 1974–21).	W. J. R. Blake
1974–36	Geology and groundwater resources of the Thorpdale area including aquifer test of bore 46, parish of Moe.	G. Y. Nahm
1974–43	Notes on the deep sand aquifers of Lower Tertiary age in the Portland area.	W. Esplan
1974–44	An initial quantitative study of groundwater flow in the Western Port Sunklands.	P. J. Gunn
1974–49	Hydrology of the Melbourne region.	I. F. Harris
1974–51	Report on Bore 12, parish of Wurruk Wurruk.	G. Y. Nahm
1974–53	Groundwater survey—Calivil pump test July 31—August 23, 1974.	P. G. Macumber
1974–55	Preliminary report on dewatering of the excavations for the Werribee Sewage pumping station.	M. Riha
1974–60	Report on Bore 8, parish of Woodside.	G. Y. Nahm
1974–61	Results of hydrologic testing of Mocamboro testing supply bores.	M. Riha
1974–70	Geophysical investigation of Western Port region.	P. J. Gunn
1974–75	Report on the proposed development of the underground water resources of the Barwon Downs Basin.	W. J. R. Blake
1974–84	Groundwater Investigation, Lyonsville, parish of Bullarto, County of Talbat.	A. Shugg
1974–85	Summary of drilling investigation into salting at Lascelles.	C. R. Lawrence
1974–86	Brief notes on the Aquifers in the Warrnambool area for Warrnambool field day 1975.	W. Blake A. Shugg

STATE RIVERS AND WATER SUPPLY COMMISSION PROJECTS

Groundwater Resources Investigation

PROJECT No. 1.
LOCALITY Koo-wee-rup Basin

REMARKS

The monitoring of observation bores for water table fluctuations and changes in groundwater chemistry continued.

A successful appeal before the Groundwater Appeal Board by an irrigator in the Koo-wee-rup groundwater conservation area indicated a need to re-assess the basis on which applications are dealt with in the area.

Metering of irrigation bores in the conservation area was started and will continue into 1975.

PROJECT No. 2.
LOCALITY Wangaratta–Myrtleford

Investigations continued into the possible interference effects between neighbouring dragline holes, and possible effects on stream flows.

Groundwater (Water Table) Control Programs (Irrigation Areas)

PROJECT No. 1.
LOCALITY Bacchus Marsh

REMARKS

A water table monitoring system comprising installation of six piezometers at depths to 15 metres is required.

PROJECT No. 2.
LOCALITY Sunraysia (Merbein-Mildura).

PROGRESS

This investigation was completed in 1974. It included a piezometer grid to monitor parts of the Merbein Irrigation District and the First Mildura Irrigation Trust adjacent to the River Murray. Contours were plotted and a flow net drawn to estimate groundwater flows to the river. One three-month pump test and fourteen short term tests were carried out to measure aquifer parameters and test the effectiveness of pumping for interception of seepage to the river.

The results were summarised and a report presented recommending the installation of permanent groundwater pumping units for interception of saline seepage. These works would be constructed in two stages at an estimated capital cost of $500,000 and might reduce river salinities by up to 40 mg/l at regulated flows.

FUTURE PROGRAM

Subject to availability of finance, and environmental assessment of the proposed disposal arrangements, works recommended in the above mentioned report should be implemented. The water table monitoring system adjacent to the River Murray should be extended throughout the Sunraysia Region (i.e. Swan Hill to the South Australian border).

PROJECT No. 3.
LOCALITY Swan Hill

REMARKS

A program of drilling supported by pump testing is required to define geomorphic units and water table levels in the Southern Swan Hill Irrigation Area.

PROJECT No. 4.
LOCALITY Shepparton Region

PROGRESS

During 1974 the investigations program was suspended because of concern about widespread salinity in orchards following abnormally heavy rain in 1973 and then again in 1974. The emphasis in early 1974 was on intensive investigations in areas where specific problems existed, with the aim of locating possible pump sites for water table control. As only one drilling rig was available and funds were limited, the investigations were limited to four sites, one each at Tongala, Ardmona, Tatura and Katunga.

In mid 1974 an urgent program was initiated to provide protection against rising water tables and salinity in major horticultural areas. Funds were allocated for 1974–75 to accelerate construction of surface drains to serve horticultural areas, and the installation of water table control works.

$330,000 was allocated for construction of surface drainage. The drains will alleviate water-logging, prevent some accessions to the water table, and provide a reticulation system for disposal of effluent from

groundwater pumps.

Funds for water table control were allocated for three complementary programs :

(1) $50,000 for hire of existing irrigation pumps which are suitably placed for water table control, if operated continuously. Nineteen pumps have been hired under this program.

(2) $300,000 for installation of groundwater pumps by the Water Commission. There are now 14 completed units, and 27 potential sites have been test pumped. Nine of these are being operated with temporary pumps.

(3) $150,000 as low interest finance (through Rural Finance and Settlement Commission) to assist orchardists to install pumps to protect their own properties. Where suitable, these will eventually be integrated into a comprehensive network of Water Commission pumps. Forty-eight applications have been received and 31 loans have been approved.

Progress with Water Commission works to February 1975 is indicated on the plan.

Because drainage effluent from the Shepparton Region flows to the River Murray, the potential impact of drainage works on the river imposes stringent limits on such works. Maximum re-use of effluent within the region is necessary to minimise the effects on the river. Nevertheless some effluent will inevitably reach the river, and investigations are proceeding into means of compensating for this by diverting other more saline flows which enter the river downstream.

PROJECT No. 5.
LOCALITY Kerang Region (Kerang, Cohuna, Pyramid Hill, Boort and Swan Hill)

AIM

The Kerang Region salinity investigation aims to determine what methods would be necessary to overcome the serious damage to productive land by a high water table and salting of the land in the region.

PROGRESS

(*a*) The program of detailed drilling to determine the geomorphology of the region continued. Drilling in ancestral sediments between Cohuna and Kerang was completed, and drilling is now centred west of Kow Swamp.

(*b*) The two long-term pumping tests continued and the results were monitored.

(*c*) Eight short term pump tests were carried out to measure the suitability of certain aquifers for water table control by pumping.

(*d*) A pump test was carried out at Calivil in conjunction with the Mines Department to determine the effects (if any) on shallow water tables caused by lowering the pressure levels in the deep lead aquifer, which is 60 m below surface.

(*e*) An experimental area of sub-surface tile drains was installed in clay soils near Kerang and the performance of the drains is being monitored.

(*f*) Two trials using tile drains to intercept seepage from channels continued.

(*g*) Monitoring of the water levels in observation bores continued throughout the region.

(*h*) The Commission is preparing a comprehensive report on the progress of the investigations so far, and measures which might be implemented for drainage and reclamation of the region.

PROJECT No. 6.
LOCALITY Kerang Region—Tandarra Storage

PROGRESS

This project is concerned with the development of salinity problems adjacent to the Tandarra Storage east of Calivil. Free flowing bores were installed in the worst affected area to intercept the seepage. Monitoring of the new system is continuing, together with investigations in other sections which may require protection.

PROJECT No. 7.
LOCALITY Mitta Mitta Valley

PROGRESS

This project is part of the environmental impact study associated with Dartmouth Dam. Twenty-seven observation bores were installed to establish the water table regime prior to construction of the dam.

PROJECT No. 8.
LOCALITY Nangiloc–Colignan

REMARKS

Private irrigation development in this area is raising water table levels, causing internal drainage problems, and possibly accelerating flows of saline groundwater to the River Murray. Installation of up to 20 observation bores, with pump tests to measure aquifer parameters, is required to monitor water table levels and groundwater movements.

PROJECT No. 9.
LOCALITY Mallee

REMARKS

Salinity increases in low lying areas of dry land in the Mallee is causing concern. The Water Commission will be co-operating with the Soil Conservation Authority to investigate the causes of, and possible remedies for, the problem. The Water Commission contribution will be to investigate the water table and geomorphic situation, but has been postponed due to other commitments.

DEPARTMENT OF AGRICULTURE PROJECTS

PROJECT No. 1. Land drainage by aquifer pumping

LOCALITY Kerang Agricultural Research Farm

Two pumps are now used for this form of land drainage on the Farm. The first pump was installed in 1964 and during 1974 it operated for a total of two months, mostly early in the year and when irrigations of nearby land were in progress. The second pump was installed by S.R. & W.S.C. during 1972 and it operated in 1974 for a total of about five months, mainly in the latter half of the year.

The average salinity of the water from pump one in 1974 was 23,500 mg/l TDS. The minimum water salinity recorded in 1974 was 21,050 mg/l. TDS which is less than half the salinity of the pump effluent in 1964.

A soil salinity survey (112 sites) is conducted on the Farm every three years. Soil salinity decreased markedly (average for all sites) in the 1964–67 period, i.e. the first three years interval after aquifer pumping commenced, and has continued to decrease slowly ever since. The data on soil salinity are summarised in the table.
All figures are chloride expressed as NaCl%

Soil Depth cm	Year					
	1958	1961	1964	1967	1970	1973
0–15.. ..	0·36	0·52	0·51	0·26	0·27	0·16
0–60.. ..	0·61	0·61	0·59	0·37	0·30	0·23

In 1973, the salinity of the 0–15 cm soil was $< 0{\cdot}15\%$ NaCl on 83% of the farm. In 1964, only 39% of the farm came in this category.

PROJECT No. 2. Irrigation of pasture with brackish groundwater

LOCALITY Kerang Agricultural Research Farm

Perennial pasture was established in spring 1971, and irrigated with fresh (channel) water in 1971–72. Four gypsum treatments were applied in the winter of 1972 and irrigations with the various dilutions of bore water commenced in the spring of 1972. Dry matter yields of pasture for 1973–74 are summarized in the tables.

Effect of saline irrigation water 1973–74

Mean water salinity mg/l	Pasture yield, dry matter t/ha
230	11·73
850	12·22
1390	12·75
2130	11·86
3540	9·49
5390	8·25

Effect of gypsum (applied 1972), 1973–74

Gypsum t/ha	Pasture yield, dry matter t/ha
0	9·88
5	10·34
10	11·64
20	12·33

The two highest water salinities have caused a significant depression in yield, whilst the two heaviest gypsum applications have given a significant positive response.

Salt is accumulating in the soil under highest saline irrigation treatments :

Saline water treatment		Soil salinity, Cl^- expressed as NaCl %			
Nominal mg/l	Mean 1973–74 mg/l	November 1973		March 1974	
		0–15 cm	15–30 cm	0–15 cm	15–30 cm
Control	230	0·05	0·10	0·04	0·10
800	850	0·05	0·13	0·06	0·12
1600	1390	0·07	0·12	0·08	0·13
2400	2130	0·06	0·14	0·12	0·17
4000	3540	0·10	0·12	0·17	0·22
6000	5390	0·15	0·21	0·25	0·28

PROJECT No. 3. Pasture irrigation with poor quality bore water

LOCALITY State Research Farm, Werribee

Perennial pasture was established in autumn 1970 under rainfall and has been irrigated each spring to autumn since spring 1970 with bore water containing 2,900 mg/l TDS and having a Sodium Adsorption Ratio of 12·2, Residual Sodium Carbonate Nil and pH 7·2.

The soil is a red-brown earth clay loam developed on basalt and often having basalt floaters within 70 cm of the surface.

Three watering schedules are followed:—

A. Frequent E–R about 30 mm, spring and autumn only.

B. Infrequent E–R about 60 mm.

C. Frequent E–R about 30 mm.

where E–R means excess of evaporation (Australian tank evaporimeter) over rainfall for the period between irrigations.

Pasture yields obtained in the four years of the experiment are—

All yields in kg dry matter per hectare :

Year	Watering Treatments			Gypsum (T/Ha/Year)		
	A	B	C	0	5	10
1970–71 .. (November to March incl.)	3,590	4,570	5,430	4,320	4,560	4,710
1971–72 ..	9,660	9,680	11,470	9,960	9,940	10,900
1972–73 ..	11,210	11,140	14,010	11,840	11,750	12,770
1973–74 ..	12,660	13,530	14,890	12,690	13,790	14,600

Water usage for the A, B and C treatments has been as follows:—

All measurements in mm.

Year	Watering Treatment			Gypsum Treatment (T/Ha/Year)		
	A	B	C	0	5	10
1971–72 ..	283	386	596	419	432	415
1972–73 ..	345	368	654	462	462	442
1973–74 ..	211	374	641	399	436	391

Soil salinity has increased under all watering treatments. The results of analyses of samples taken in 1973 are given—

Soil Chloride as NaCl%.

Date	Soil Depth cm	Watering Treatments			Gypsum T/Ha		
		A	B	C	0	5	10
15.5.73 to 22.5.73	0–15	0·074	0·059	0·090	0·093	0·066	0·065
	15–30	0·166	0·176	0·194	0·230	0·155	0·151
	30–45	0·242	0·281	0·262	0·317	0·240	0·227
	45–60	0·262	0·302	0·267	0·311	0·263	0·256
		Rain between sampling dates 213 mm					
4.10.73	0–15	0·037	0·035	0·047	0·055	0·032	0·032
	15–30	0·124	0·134	0·151	0·181	0·111	0·118

Substantial leaching has occurred due to percolation of winter rains.

Although gypsum (in very large total applications by 1973) has only a modest effect on pasture yield, it does influence the rate of salt accumulation in the soil.

Pasture yields have been quite good, in fact the "C" watering treatment yield for 1973–74 is very good for any irrigated perennial pasture in southern Victoria. Dominant species are lucerne, perennial ryegrass and white clover.

PROJECT No. 4. Location, pressure, composition and movement of groundwater.

LOCALITY Irrigation Research Station, Kyabram

Previous reports on this project have outlined the progressive rises since 1966 in both water tables and deep (9·1 m) pressure levels at the 16 test sites on the Station. Such rises continued in 1974 due to the exceptionally high rainfall. Water table levels (mean of 16 wells) rose from 1·7 m (below ground level) in March 1973 to 0·6 m in October 1974. Deep pressure levels (mean of 16 wells) rose from 2·1 m to 1·0 m over the same time interval.

An associated study on the Research Station has determined changes in soil salinity between 1959 and 1972. These changes have been due to salt movement caused by rain, irrigation and flood waters (movement down) or by groundwater intrusion, capillary rise and evaporation of water (movement up).

The conclusions from the study are :

1. Soil salinity levels on the Station are very low, but have increased slightly between 1959 and 1972.

2. As would be expected, there is a tendency for the salinity of lighter soils and frequently irrigated areas to decrease, whilst the salinity of the heavier soils and the unirrigated areas increases.

A more detailed study commenced late in 1974 to relate groundwater behaviour to salt accumulation in heavy-textured unirrigated soils on the Station in the summer of 1974–75.

PROJECT No. 5. Surveys of orchard salting

LOCALITY Horticultural Research Station, Tatura

Fruit trees on many Goulburn Valley orchards and pear trees in particular showed symptoms of salting during 1972–73. The Research Station is monitoring 120 pear orchards randomly selected through the region and 70 properties with known salt affected trees for leaf chloride and soil salt.

The 1975 figures indicate that salinity is still spreading in Goulburn Valley orchards, but the severity of individual tree damage is not as great as in 1973–74.

PROJECT No. 6. Deep pumping of aquifer

LOCALITY Horticultural Research Station, Tatura

Piezometers were inserted 10–12 m into heavy clay soils at the Research Station, which are typical of salt affected soils in the Goulburn Valley. Coarse sands of the underlying aquifer were intersected at this depth and indicated a water table level of 25–50 cm from the surface. To protect the orchards on the Station and to study the effects of dewatering a spear point system was installed. Water was pumped at 63 l/sec with a salinity of 2200 mg/l TDS.

In less than two weeks of continuous pumping piezometers levels were lowered to about 6 m at the pump, and 1 m over the

whole Research Station. One bore approximately 1 km away was also lowered to 1 m although others did not alter.

The pump has reduced the level of the water table over 6000 Ha. Cessation of pumping allowed levels to rise rapidly, therefore continuous pumping is necessary.

The effectiveness of deep pumping from a suitable aquifer at this site has been clearly demonstrated. Not all sites may be as effectively pumped. The pump is now being taken over by the S.R. & W.S.C.

Some difficulties of saline water disposal have arisen, requiring careful scheduling of pumping periods.

PROJECT No. 7. Survival of fruit trees with high saline water tables

LOCALITY Horticultural Research Station, Tatura and district

Fruitgrowers need to learn the best system of management to adopt whilst they lower the watertable by pumping and leach the salt accumulated in the root zone.

A series of experiments has been set up to investigate the effect of various forms of irrigation (flood, sprinkler and trickle), rates and timing of irrigation, and various soil management methods (mulching, permanent sod, hilling of lands) on tree survival until damaging water tables and salt concentration have been satisfactorily lowered.

A range of treatments appear to be successful in tree survival.

PROJECT No. 8. Leaching of salt from heavy clay soils

LOCALITY Horticultural Research Station, Tatura

Once salt accumulates in the heavy clay soils of the root zone of fruit trees it is extremely difficult to remove. These soils have an exceedingly low permeability which obviates ready removal by normal leaching methods. Means of improving and maintaining the permeability of these soils are being studied.

Results so far indicate that high Na^{+} and Mg^{++} disperse clay subsoils, and the use of Calcium as gypsum, injected into the subsoil to achieve at least 50% exchangeable Ca^{++} will permanently ameliorate the clay and allow leaching.

PROJECT No. 9. Soil salinity and water table survey

LOCALITY Kyabram

A project was commenced in September 1974 to assess the soil salinity and water table status of an area 16 km × 16 km around Kyabram. Test bores were dug and soil samples collected on an approximate 1·6 km grid. A total of 122 bores were involved. The % of bores having water tables within certain limits as in October 1974 are given below.

% of Bores	Water Table Depth (below ground level) cm
14	< 30
16	30–60
11	60–90
15	90–120
34	120–180
10	> 180

Water tables fall considerably during November–December 1974 and by the end of the year height of water table was closely correlated with intensity of irrigation.

The results of analyses of soil and water samples are not yet to hand.

Measurements of water table heights will proceed into 1975 and the area under survey will be increased.

Definitions of commonly used groundwater terms

Aquiclude. A material of such low hydraulic conductivity that it effectively prevents any movement of water through it or reduces water movement to such a low value relative to the surrounding materials that it can be considered a barrier.

Aquifer. Any water-saturated body of geological materials from which enough water can be drawn at a reasonable cost for the purpose required.

Aquitard. A material of low hydraulic conductivity which however on a regional scale allows the passage of groundwater through it.

Groundwater as used here includes all water in the zone of saturation beneath the earth's surface except that water chemically combined in minerals.

Hydraulic conductivity (intrinsic permeability). Ability of a material to allow a fluid, in this instance water, to pass through it. It is controlled by the size and interconnection of the spaces in a rock or soil. In groundwater studies, it is normally expressed as the number of cubic metres of water per day that will pass through a cross-section of one square metre under a hydraulic gradient of one i.e. one metre to the metre. (A hydraulic gradient represents the difference in head in water between any two points). The unit for hydraulic conductivity is metres per day.

Observation bore or **piezometer** is a bore tapping an aquifer, used to measure regularly or continuously, water level, temperature and chemical composition.

Perched groundwater is unconfined groundwater separated from any underlying body of groundwater by an unsaturated zone.

Porosity. The ratio of water-filled spaces in a saturated rock or soil to the total volume of rock or soil. It is usually expressed as a percentage.

Potentiometric surface. A pressure surface or an imaginary surface passing through all points to which water would rise from a given depth or material. It is usually represented by contours. As used here the potentiometric surface has been mapped for a given aquifer.

Storage coefficient is the volume of water an aquifer releases from or takes into storage per unit surface area of the aquifer per unit change in head.

Transmissivity. The measure of the amount of water in cubic metres per day per metre that will flow through a vertical strip one metre wide extending from top to bottom of the material being investigated and under a one metre to one metre hydraulic gradient. The unit for transmissivity is square metre per day.

Water-table is the upper limit of completely saturated material.

Conversion Factors

AREA

acres x 0·4047	hectares (ha)
hectares (ha) x 2·471	acres
square miles x 2·59	square kilometres (km^2)
square kilometres (km^2) x 0·3861	square miles

HYDRAULIC CONDUCTIVITY

feet/second x 26 400	metre/day (m/day)
metre/day (m/day) x 0·000038	feet/second

LENGTH

feet x 0·305	metres (m)
metres (m) x 3·281	feet
miles x 1·609	kilometres (km)
kilometres (km) x 0·621	miles

PUMPING RATE

gallons/hour x 0·001263	litres/second (l/sec)
litres/second (l/sec) x 792·4	gallons/hour
gallons/minute x 0·075	litres/second (l/sec)
litres/second (l/sec) x 13·3	gallons/minute

RAINFALL AND EVAPORATION

inches x 25·4	millimetres (mm)
millimetres (mm) x 0·03937	inches

SPECIFIC CAPACITY

square feet/second x 80 270	square metre/day (m^2/day
square metres/day (m^2/day) x 0·00001246	square feet/second
gallons/day/foot x 0·01491	square metres/day (m^2/day)
square metres/day (m^2/day) x 67·05	gallons/day/foot

STORAGE

dimensionless

TRANSMISSIVITY

square feet/second x 80 270	square metres/day (m^2/day
square metres/day (m^2/day) x 0·00001246	square feet/second
gallons/day/foot x 0·01491	square metres/day
square metres/day x 67·05	gallons/day/foot

VOLUME

gallons x 4·546	litres
litres x 0·220	gallons
acre feet x 1234·0	cubic metres
cubic metres x 0·000811	acre feet

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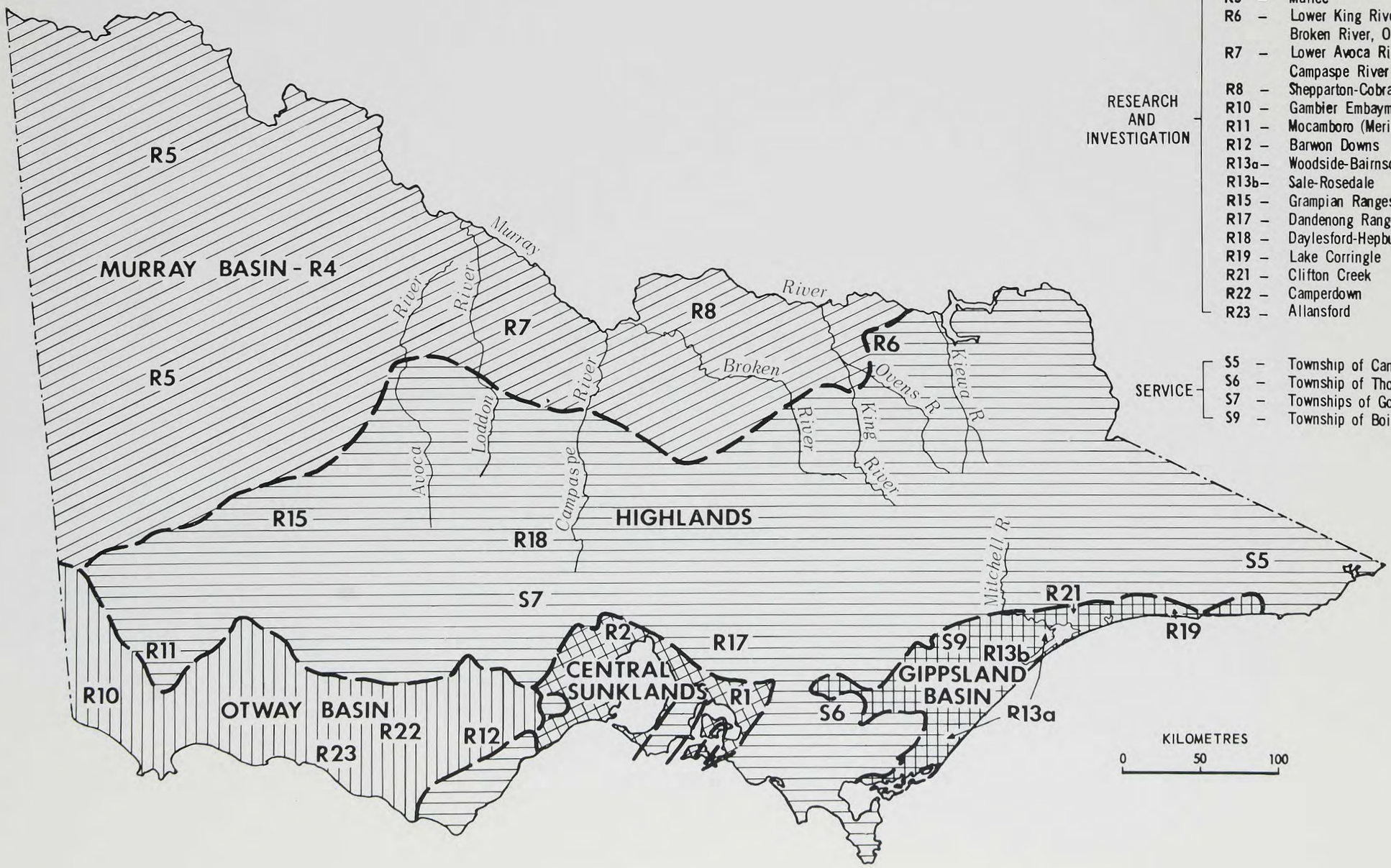
MINES DEPARTMENT, VICTORIA

GROUNDWATER PROJECTS 1974



PROJECT NUMBERS AND LOCATIONS

RESEARCH AND INVESTIGATION

- R1 – Koo-wee-rup
- R2 – Melbourne Metropolitan Area: Pollution studies
- R4 – Murray Basin (general)
- R5 – Mallee
- R6 – Lower King River, Kiewa River, Broken River, Ovens River
- R7 – Lower Avoca River, Loddon River, Campaspe River
- R8 – Shepparton-Cobram irrigation district
- R10 – Gambier Embayment
- R11 – Mocamboro (Merino Town Supply)
- R12 – Barwon Downs
- R13a – Woodside-Bairnsdale
- R13b – Sale-Rosedale
- R15 – Grampian Ranges
- R17 – Dandenong Ranges
- R18 – Daylesford-Hepburn
- R19 – Lake Corringle
- R21 – Clifton Creek
- R22 – Camperdown
- R23 – Allansford

SERVICE

- S5 – Township of Cann River
- S6 – Township of Thorpdale
- S7 – Townships of Gordon and Mt Egerton
- S9 – Township of Boisdale