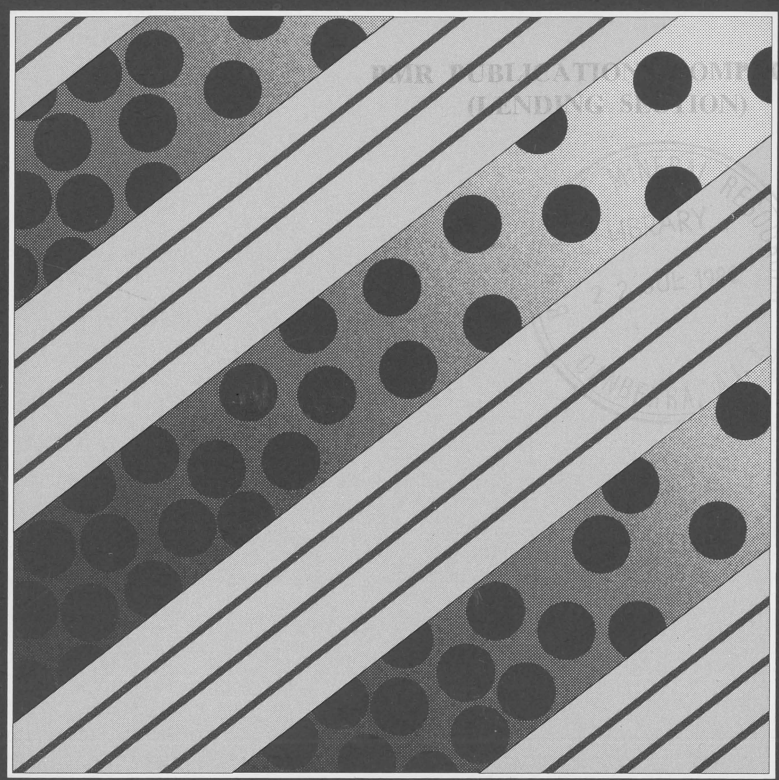
GROUNDWATER 14

Studies in Hydrogeology

AUSTRALIA

MURRAY BASIN HYDROGEOLOGICAL PROJECT PROGRESS REPORT 18 FOR HALF YEAR ENDING 30 SEPTEMBER 1987



BUREAU OF MINERAL RESOURCES, GEOLOGY & GEOPHYSICS

DIVISION OF CONTINENTAL GEOLOGY

RECORD 1988/24

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MURRAY BASIN HYDROGEOLOGICAL PROJECT

PROGRESS REPORT 18

for half year ending 30 September 1987

compiled by

G.E. Wilford

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SOUTH AUSTRALIA

by

S.R. Barnett

Department of Mines and Energy

Monitoring and sampling is continuing throughout the basin. Three new observation wells were drilled in the unconfined limestone aquifer (SWL 10-15 m) to monitor any rise in the water table due to clearing and to complete a transect from areas of salinisation near Cookes Plains (SWL 1 m) to the remainder of the regional Mallee network on higher ground (SWL 25 m). A replacement observation well (MNT 2) was drilled at Maggea to the Renmark Group confined aquifer. A salinity of only 2 900 mgL was obtained which is interesting considering that salinities of 15-20 000 mg/L occur at Waikerie 30 km to the north. Two different flow systems - high salinity from the north and east and low salinity from the southeast, are postulated.

Levelling of several outstanding private and mineral exploration wells north of Renmark is about to commence. A re-sampling programme of Departmental observation wells using the new slimline Mono pump (inside 76 mm. casing) is underway.

Heavy mineral exploration by Aberfoyle Resources Ltd. is being carried out in six EL's in the Mallee region south of the River Murray. About one hundred holes have been drilled in the Pliocene sands to an average depth of 18 metres.

Petroleum exploration activity within the Murray Basin and infrabasins has been occurring in PEL 16 (5767 km2) and PEL 37 (9263 km 2). Both are held by International Mining Corporation NL and Satima Pty. Ltd. Within PEL 16, reprocessing of all previous seismic data as well as 72 line kilometres of seismic recording have been completed. Cooltong No. 1 is to be drilled to economic basement at about 1370 metres in November 1987. Work carried out in PEL 37 has been restricted to source rock analysis together with palaeontological and palynological sampling.

CSIRO Division of Water Resources Research

Drilling has been proceeding beneath areas of localised recharge in the Mallee. Chloride and suction profiles were taken beneath areas which have been cleared for 6, 15, and 22 years with an average rainfall of about 320 mm. Preliminary data suggests initial recharges rates soon after clearing are very high (25-50 mm/yr). Further drilling is planned at another site to verify these results.

Investigations using chlorine-36 profiles in the unsaturated zone are encountering difficulties. A paper has been prepared on the use of the EM technique to delineate areas of higher than normal recharge.

Samples for chemical and isotopic analysis have been taken in the Woolpunda area from the Renmark Group confined aquifer and from three levels in the overlying Murray Group limestone water table aquifer in an attempt to quantify upward leakage between the two aquifers.

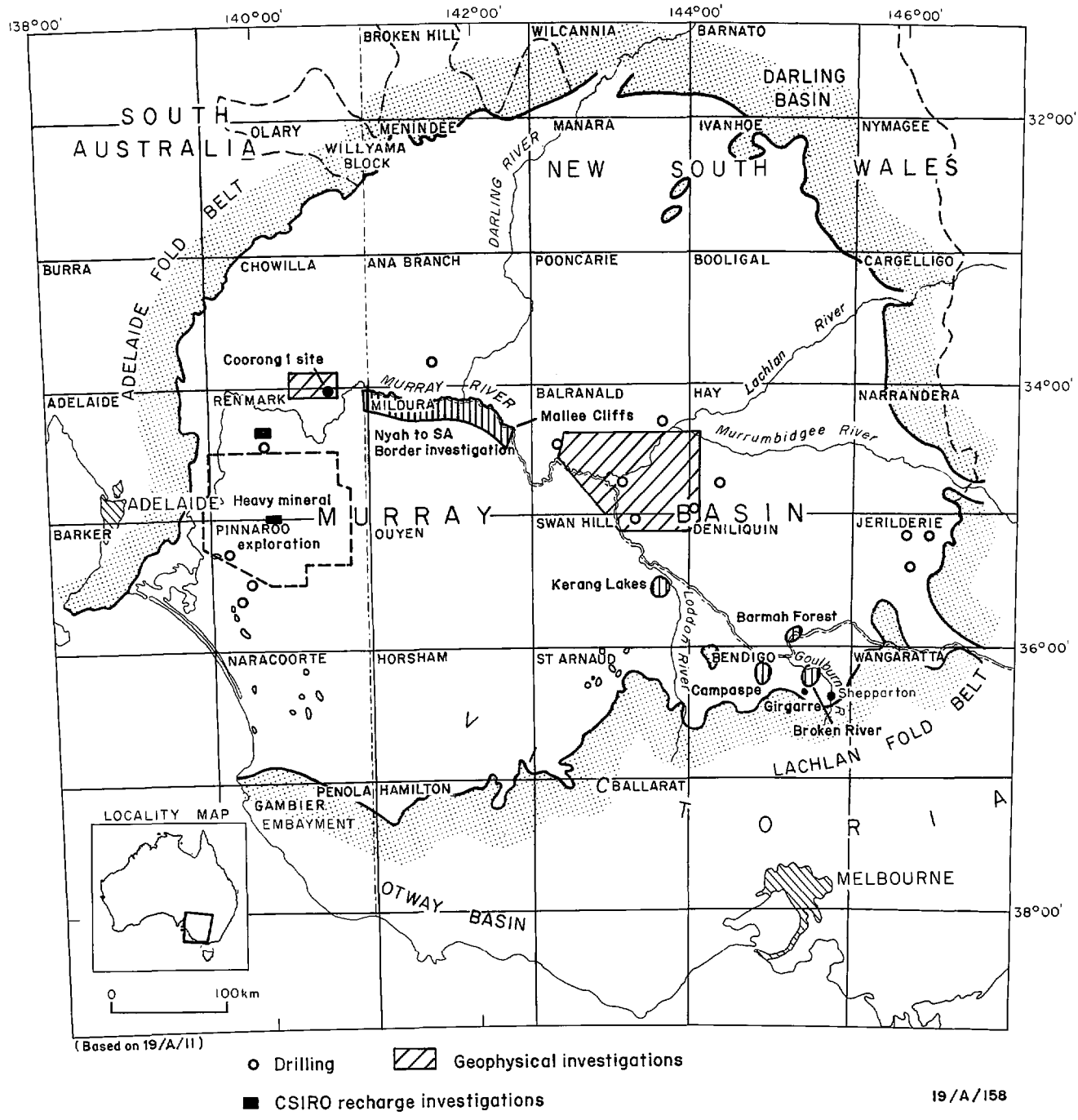


Figure 1. Locality Map

Water Resources Branch, E&WS Dept

Woolpunda Interception Scheme investigations have shown that density contrasts between groundwater (20 000 mg/L) and the river (400 mg/L) directs groundwater flow toward the deeper parts of the river. Salinity profiling indicates accessions from 'trenches' in the river bed associated with sharp bends, contribute 2 to 3 times greater than average accessions. The conceptual design will be finalised and presented to the RMC in early December. At the same time, a submission will be forwarded to the Public Works Standing Committee.

A feasibility study of a scheme to intercept saline accessions to the River Murray from water table mounds beneath the Waikerie-Golden heights Irrigation Areas has been carried out by Coffey and Partners. An estimated 160 tonnes/day enters the river. Three options have been considered, incorporating interception, sealing of drainage wells and pumping from the mound itself. The preferred interception option is predicted to reduce salinity at Morgan by 22 EC units.

NEW SOUTH WALES

Geological Survey of New South Wales

1. Coal Exploration - Oaklands Basin

The joint venture between Coal Cliff Collieries Pty Ltd (CRA) and Mitsubishi Developments Pty Ltd has been granted a further Exploration Authorisation (No. 388) in the Oaklands Basin. In their existing Authorisations (Nos. 207,250 and 345) nine boreholes were drilled in the period March to September, 1987. Mine planning and data acquisition for an Environmental Impact Statement are continuing.

2. Petroleum Exploration

No petroleum exploration has taken place since the completion of three wells by Claremont Petroleum (PEL 212) in the half year ended March 1986.

The only petroleum exploration activity proposed within the next twelve months is a 75 km seismic survey planned by Meekatharra Minerals Australia Pty Ltd in PL273 in the Oaklands Basin.

3. Mineral Exploration

CRA is continuing to explore for heavy mineral sands in an area mainly to the east of the Darling River. A large area has now been relinquished and a relinquishment report including drill logs and ground magnetic traverses is available on open file. An application has been made for a further exploration area to the southeast of the previous areas.

Several isolated Exploration Licences held by CRA for Group 1 (metallic) minerals have been relinquished. A relinquishment report for one of these, a base metal target to the north of Robinvale, is now on open file.

BHP Minerals Ltd has applied for four Exploration Licences for Group 1 minerals adjacent to the South Australian border between "Ennisvale" and "Tarrara".

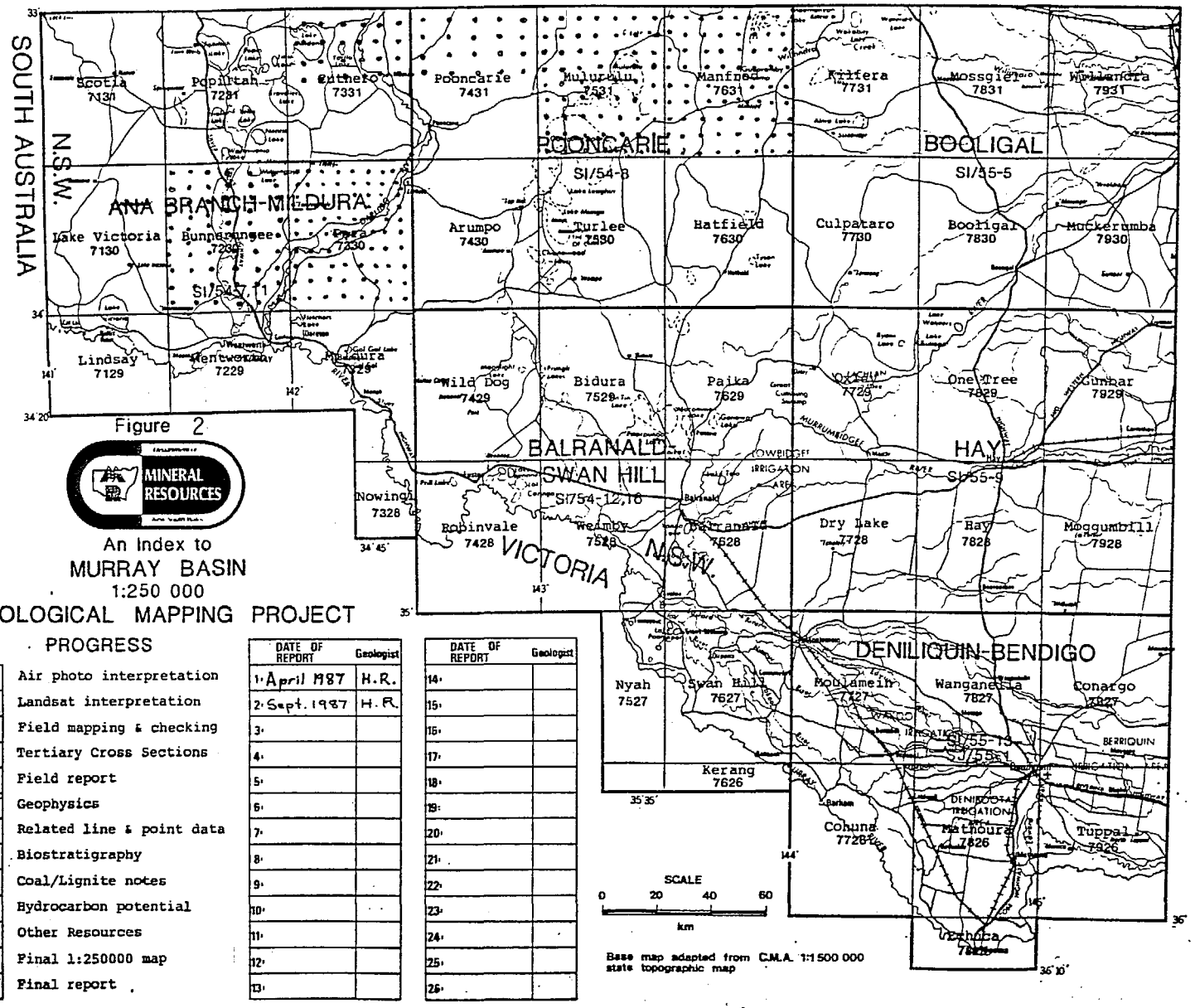


Figure 2

MINERAL RESOURCES

An Index to
MURRAY BASIN
1:250 000
GEOLOGICAL MAPPING PROJECT

PROGRESS

		DATE OF REPORT	Geologist		DATE OF REPORT	Geologist
	Air photo interpretation	1. April 1987	H.R.	14.		
L	Landsat interpretation	2. Sept. 1987	H.R.	15.		
	Field mapping & checking	3.		16.		
XS	Tertiary Cross Sections	4.		17.		
Fr	Field report	5.		18.		
	Geophysics	6.		19.		
R	Related line & point data	7.		20.		
B	Biostratigraphy	8.		21.		
C	Coal/Lignite notes	9.		22.		
H	Hydrocarbon potential	10.		23.		
O	Other Resources	11.		24.		
FM	Final 1:250000 map	12.		25.		
FR	Final report	13.		26.		

4. Geological Mapping (Figure 2)

1:250 000 scale mapping of the New South Wales portion of the Murray Basin is continuing. Air photo interpretation and field checking of the Manfred, Mulurulu, Para and Bunnerungee 1:100 000 sheet areas in the Pooncarie and Ana Branch 1:250 000 sheets have been completed. Dyeline copies of the Manfred and Mulurulu sheets are now available and those of the Para and Bunnerungee areas will be available shortly.

Notes on the Manfred-Mulurulu area are being prepared as an unpublished report. Air photo interpretation of the Cuthero and Pooncarie 1:100 000 sheet areas has commenced.

Department of Water Resources

Drilling

Western Murray Basin

Seven (7) bores were constructed in the second phase of the joint Department of Water Resources/Bureau of Mineral Resources Drilling Program. A number of piezometers were constructed at each site to enable long term monitoring of water levels and water chemistry.

Preliminary results of the drilling indicate:

- The eastern and western Murray Basin are divided by Iona Ridge to immediately north of Balranald and an extension of the Tyrrell Fault immediately east of Euston/Robinvale.

- There are significant artesian heads associated with the Renmark Group west from about Barham.

Jerilderie

Three (3) bores were constructed east of Jerilderie in the northern extension of the Ovens Valley Graben. Problems were experienced distinguishing the Triassic Jerilderie Formation from the Tertiary sediments due to low geophysical response of both sediment groups and lithographic similarities.

The groundwater investigation in this area is nearly 90% complete and a preliminary data report is being prepared. A draft should be available in early 1988.

Mallee Cliffs

A preliminary report "Tertiary Foraminifers from WRC 36465, Mallee Cliffs, Murray Basin" by V. Scheibnerova has been received from the Department of Minerals and Energy.

The bore hole was drilled as part of the Mallee Cliffs/Lambert Island investigations and is about 6 km north from the Murray River. Sediments between 39 and 241 m were examined. They are assigned to the Winnambool Formation and the Geera Clay and were deposited in a high energy inner to middle shelf environment.

Geophysics

A total of 56 km of seismic refraction traverses were shot and have been interpreted. Eighteen resistivity soundings were also carried out on the traverses for control purposes.

The results have been used to:

- provide an understanding of the geological structure and refractor stratigraphy;
- aid in the interpretation of hydrogeological conditions sampled by the bores drilled as part of the joint DWR/BMR drilling program.

The main refractors found are the water table, the top of the Murray Group, the calcarenite units of the Murray Group and pre-Tertiary basement. Problems of unit or layer equivalence has been a problem in some instances although subsequent to drilling reinterpretation has provided good interpreted correlations. By this method a fair reliance on the seismic refraction interpretations for the region can be made.

Long-Term Monitoring

Piezometric levels and water quality are currently being measured over most of the NSW part of the Basin although there are significant gaps in even the regional coverage in some areas.

Measurements range from continuous to six monthly depending on the likely changes to the hydrogeological system.

Reports

Several reports were prepared during this period:-

Shettigara, K.V. and Odins, J.A. (1987) - Application of NOAA-AYHRR Images for Structural Studies related to Groundwater Flow in the Murray Basin. 4th Australian Remote Sensing Conference Adelaide

Odins, J.A. - Wemen Seismic Refraction Survey. DWR 1987/5 (Unpubl.)

O'Neill, D.J. - Balranald Resistivity Survey. DWR 1987/1 (Unpubl.)

VICTORIA

Rural Water Commission of Victoria

1. NYAH TO SOUTH AUSTRALIAN BORDER HYDROGEOLOGICAL PROJECT

- Field work completed
- 2 pumping tests carried out
- Interpretation of older shallow drilling data in study area
  - RWC (Merbein-Colignan) approx 800 bores
  - WRC (Paringi-Euston-Swan Hill) approx 200 bores
- Full chemical analysis of groundwater from 34 bores
- Collation of groundwater chemical data
- Preparation of project data base

- Numerical modelling well underway. Results expected within several months.

2. SHEPPARTON REGION SALINITY OPTIONS STUDY

A two layer quasi 3D finite element flow model of the Upper Shepparton Formation has been developed over a 30 000 ha irrigated region in the Toolamba -Tatura - Mooroopna - Ardmona area. The model is being used to establish combinations of recharge and discharge values which will satisfy the observed groundwater behaviour. The model incorporates two layers in the Upper Shepparton Formation and allows for seepage from the underlying aquifers. Calibration of groundwater flows has been completed for the period 1981-1986. Work has commenced on a coupled solute transport model to allow changes in groundwater salinity to be studied.

Basic data has been assembled for the Shepparton study to enable definition of the areas where different management approaches will be required. This role will be undertaken by the local community group.

3. GIGARRE SALINITY INVESTIGATION

- Construction of an evaporation basin at Girgarre has been completed and commissioning is well advanced. No significant problems have yet been identified.

- Monitoring of existing pump performance continued including the effects of disposals to the drainage system.

4. BARMAH FOREST

Monitoring of water table levels continued with the aim of establishing the relationship between tree health and groundwater levels. Eight holes were completed as part of the monitoring grid. Total drilling completed was 179 metres.

5. SHEPPARTON REGIONAL INVESTIGATIONS

- Drilling work continued on the Punt Road - Arcadia - Broken River Section to examine the Shepparton Formation sequence as it overlaps Siluro-Devonian bedrock, south east of Shepparton. Nine holes were drilled for the period, for a total of 244 metres.

- Drilling work was commenced on the Waranga Basin investigation. For the period 22 holes were completed for a total of 433 m drilled.

- Draft report on the stratigraphy, lithology and hydrochemistry of intermediate level Shepparton Formation aquifers in the Rochester area has been completed.

- Hydrogeological maps at a scale of 1:100 000 of the Upper Shepparton Formation covering the Murray, Goulburn and Campaspe Valleys have been completed. A draft report to accompany the maps is in preparation. The maps will be produced in colour at 2 scales - 1:250 000 and 1:100 000.

- Groundwater flow models of the Upper Shepparton Formation have been or are being developed for two small areas (1 000 to 5 000 ha) within the region. A single layer finite difference model

has been calibrated over a 3 year period for an area at Girgarre. A two layer model has been developed for an area at Tongala and calibration for the period 1981-1986 is well advanced. Bore data have been collected for a similar model for an area at Katunga but present indications are that it will be impossible to establish acceptable boundary conditions because of the large number of private groundwater pumps in or adjacent to the study area. The areas modelled include some parts which have high uncontrolled water tables and others which have water tables effectively controlled by groundwater pumping.

- A map of depths to water table throughout the Shepparton Region is being prepared for August 1987. Similar maps have been produced in August of 1982, 1984 & 1986. The basic map is prepared at a scale of 1:100 000 and provides a good regional picture of water table levels and allows broad regional trends to be identified. Projections of bore hydrographs are being used to map the likely spread of high water table areas in the years 2000 and 2020.

- Major long term pumping trials are in progress in the Campaspe Irrigation District and at Girgarre.

6. FARM EXPLORATION DRILLING SERVICE

Assistance is continuing to be provided to farmers to locate shallow aquifers which could be pumped to supplement surface water supplies and also assist in lowering water tables.

Proposals were prepared for investigation programmes on 19 properties in the Shepparton Region, and field work carried out on 16 properties. Only one site with an aquifer cable of yielding more than 1 megalitre/day of water of a quality less than 3 500 EC, was delineated. The final report detailing field work for the north-west Mooroopna area was presented to the associated landholders group. Two proposals for similar regional E.M. surveying and drilling were prepared for landholder groups in the Echuca West area and the Stanhope area.

7. ACCESSION PROJECT

Techniques for assessing rates of water table accession are being evaluated. A borehole induction probe (EM 39) was hired to test whether it can be used in monitoring changes in salinity profiles and hence measuring accession rates.

Approximately 200 bores have been logged using the EM39 induction probe. Bores in areas where groundwater pumping occurs will be logged again in a year. Although assessment of the initial data is still in progress it is considered that an adequate evaluation of the probe's usefulness may take several years. It has therefore been purchased and is being used for routine logging of bores. Work has also commenced on a trial site at north west Mooroopna where a joint project is being developed with the Department of Agriculture and Rural Affairs. A number of techniques, including the use of tracers, will be tried out.

8. SUBSURFACE DATABASE MANAGEMENT SYSTEM

The Water Commission has begun the development of a comprehensive

computer based groundwater data base. Currently data is stored in a variety of forms. The proposed system will systematise all storage procedures and, most importantly, allow ready access to all data. Data on the RWC 7 000 bores and 27 000 private bores will be stored. Over the previous 6 months, Stage 1 software development has been underway and data preparation, into a computer compatible form of high priority data, is continuing.

9. KERANG LAKES STUDY

The objective of this study is to develop a land and water management plan for the area around the Kerang Lakes and the Torrumbarry Irrigation System, having regard to agricultural production, water quality and quantity, conservation values, recreation and tourism. A consultant has been reviewing the most appropriate surface water and groundwater modelling programmes available, and some of the technical issues to be addressed in the study. This report has been completed in draft form. Preliminary field work and data compilation has commenced.

10. MALLEE CLIFFS GROUNDWATER INTERCEPTION INVESTIGATION

A stage 2 consultancy was let by DWRNSW to further investigate possible evaporation basin sites and other aspects of the hydrogeology of the interception scheme. This is under the control of an RMC steering committee. This work involved several months of drilling and associated field testing. Extensive modelling has also been undertaken.

11. SOUTH AUSTRALIAN/VICTORIAN BORDER GROUNDWATER SHARING AGREEMENT

Two more meetings of the Boarder Review Committee have been carried out. This legislation establishes a legal framework for the equitable distribution of the groundwater resources of a 40 km wide zone running along the S.A./Vic. border. A number of studies are being planned which will be used to refine the most appropriate groundwater management policy for the region. Geological and hydrogeological terminology used by Victorian and South Australian agencies has been agreed to.

Department of Industry, Technology and Resources

Over the last three years joint funding of salinity related research and investigations by the Victorian and Federal Governments has resulted in a rapid expansion in the Departments Murray Basin works programme.

Within the Riverine Plain, DITR's accelerated drilling programme has resulted in the drilling and construction of approximately 100 groundwater observation bores screened in either the Deep Lead (Calivil Formation and Renmark Group) or bedrock. Shalllow observation bores drilled adjacent to the deep bores supplement the monitoring network. During drilling lithological samples are taken every two metres and water samples for every water-boring zone. Water samples are analysed for major ions, and the following minor ions; Iodide, Boron, Lithium, Bromide and Strontium. Analysis for Deuterium, Oxygen 18 and Carbon 14 isotopes are being carried out by the BMR, and the CSIRO Division of Soils. Concurrent with the drilling programme, DITR has collected and compiled a comprehensive Riverine Plain hydrologic and hydrogeological computerized data base which includes the NSW portion south of Billabong Creek.

Salinity Mangement Plans are now being prepared for the Shepparton Region, the Kerang lakes, and Tragowel Plain, and the Campaspe Irrigation District by interdepartment project teams in conjunction with community based working groups.

DITR are assisting with the evaluation of management options by predicting the depths of watertable under the range of potential management options and climatic conditions using numerical models. Interaction between aquifers is accomodated by leakage relationships obtained from vertical slice models.

A numerical model of the Shepparton region which includes the Campaspe Irrigation District is in the final stages of calibration. As groundwater usage is a major water balance component, a comprehensive survey of 860 licensed irrigation bore owners has been undertaken to obtain a more accurate estimate of historical groundwater usage. The anticipated completion date of the survey is in late April this year.

Within the Loddon & Avoca Region two models of lake-groundwater interaction are currently in the early development stage. In addition a model of the Loddon-Avoca region is also under development. These models will assist with the development of Management Plans for the Tragowel Plains and the Kerang Lakes.

In the Mallee thirteen holes have been drilled over the past two years as part of DITR's deep drilling programme. Twelve of these bores being constructed as permanent observation bores are within the basal Tertiary Renmark Group aquifer. Aquifer pressures are high with artesian conditions at the following three bores; Mildura 320, Walpamundah 4 and Markalla. Environmental heads have yet to be calculated. DITR is currently drilling several shallow bores in the Duddo Limestone and Parilla Sand to determine vertical hydraulic gradients.

Water chemistry results are incomplete, however TDS tend to range from 11000 to 30000 mg/l. Guramolarg 2 is an exception having remarkably "Fresh" water of 1600 mg/l. Variations in thickness of Tertiary and post-Tertiary sediments indicates the basin has had minor tectonic activity.

With respect to groundwater resource management there is continued advance in the establishment of a comprehensive observation bore network for the South Australian/ Victoria Border zone. Monitoring is being synchronised between S. Australia and Victoria and there's currently a joint sampling exercise for all observation bores for detailed chemical analysis.

BUREAU OF MINERAL RESOURCES

by

J.R. Kellett & W.R. Evans

HYDROGEOLOGY

Joint BMR - DWR Drilling Program:

Nested piezometers were installed at seven sites as part of the joint BMR-

DWR drilling project in the western Murray Basin in N.S.W. The bores are located in the western Riverine Plain, Tyrrell Basin and Tararra Trough.

The Riverine Plain bores were designed to investigate the effects to the regional hydrogeology caused by the marked decrease in aquifer permeability and storage at the Geera Clay-Renmark Group boundary. The TCHELERY drillhole, 45 km to the east of the Geera Clay, intersected 418 m of Tertiary continental sediments on Devonian sandstone; the major aquifers are thick coarse sands in the Renmark Group (366m thick) characterised by high yields of waters of salinities ranging from 1500 mg/l to 2000 mg/l TDS. Electric logs indicated practically uniform groundwater salinity throughout the Renmark Group aquifers but there is a strong potential for upwards leakage since standing water levels in the Lower Renmark aquifers are over seven metres higher than those in the overlying Upper Renmark sediments.

The PEREKERTON drillhole, 10 km east of the Geera Clay, intersected 361 m of Tertiary continental sediments on Ordovician metasediments; again, the major aquifers are in the Renmark Group (300m thick) but the sands are not as well sorted and are more carbonaceous than those at the Tchelery site. Groundwater salinities range from 12000 mg/l in the Parilla Sands to 2000 mg/l in the flowing artesian bores in the Renmark Group.

The KYALITE drillhole lies 25 km to the west of the Geera Clay boundary and intersected 369m of Tertiary continental and marine sediments on Ordovician metasediments; the Geera Clay here is about 100 metres thick. Groundwater salinities range from 16000 mg/l TDS in the Shepparton Formation and Parilla Sands to 4000 mg/l in the flowing artesian bores in the Renmark Group.

The WEIMBY drillsite, at the confluence of the Murrumbidgee and Murray Rivers, bottomed on fresh granodiorite at 316m. Most of the Tertiary sequence is marine, with Geera Clay - Winnambool Formation sediments (190m thick) of glauconitic fine sands and clays forming a prominent low permeability barrier to westerly transmission of groundwaters in the Middle Renmark Group. Groundwater salinities range from 500 mg/l TDS in some thin sands in the Shepparton Formation which are hydraulically continuous with the Murray River, to 23000 mg/l in the Parilla Sands.

The CUMBUNG SWAMP drillhole, in the Great Cumbung Swamp at the terminus of the Lachlan River, intersected 432m of Tertiary continental sediments on Ordovician? bedrock. The Great Cumbung Swamp therefore lies in a basement depression at the toe of the Lachlan Fan, and the entire Tertiary sequence is characterised by lacustrine sedimentation with very fine - grained aquifers throughout. The Renmark Group is 354 metres thick and is highly ligneous with the thin brown coal brands. The groundwater salinity in the Calivil Sands is 10,000 mg/l TDS and in the upper Renmark Group it increases to 19,000 mg/l; electric logs indicate that the salinities in the lower Renmark Group Aquifers are significantly lower but it was not possible to successfully install a piezometer in this sequence.

The EUSTON drillhole lies in a small infrabasin, the Tyrrell Basin, on the downthrown (eastern) side of the Tyrrell Fault. Drilling revealed 371 metres of Tertiary sediments consisting of 200m of Geera Clay - Winnambool Formation enveloped by upper and lower Renmark Group ligneous silts. The entire Tertiary sequence contains large volumes of highly saline groundwaters. TDS values vary from 22,000 mg/l in the Parilla Sands to 30,000 mg/l in the upper Renmark Group. The Geera clay contains several sand interbeds with water of salinity 27,000 mg/l TDS.

The WARWICK drillhole, on the eastern flanks of the Tararra Trough, intersected 421m of Tertiary sediments on Cretaceous carbonaceous siltstone. There are no Warina Sands in the Tertiary sequence, however, the lower Renmark Group contains a ten metre thick basal gravel aquifer. The upper and lower Renmark Group aquifers produced flowing artesian bores with TDS values of 19,000 and 21,000 mg/l respectively. The overlying Parilla Sands contain waters of salinity 83,000 mg/l TDS. The Murray Group sediments consist entirely of low permeability marls and calcareous clayey silts of the Winnambool and Ettrick Formations.

BMR DRILLING

Three sites were drilled to investigate the northerly extension of the Tyrrell Fault into NSW and the possible southerly extension of the Ivanhoe Block into Victoria. A drillhole at WILD DOG TANK, 50 km north of Robinvale on the upthrown side of the Tyrrell Fault, intersected 250m of Tertiary sediments overlying highly fractured and faulted Devonian sandstone. The Geera Clay directly overlies Devonian basement and contains several shelly sand interbeds of low permeability with waters in excess of 50,000 mg/l TDS. Groundwater salinities in the overlying upper Renmark group aquifers also exceed 50,000 mg/l TDS. The Parilla Sands are highly permeable with TDS values of 37,500 mg/l in the basal Pliocene sand beds.

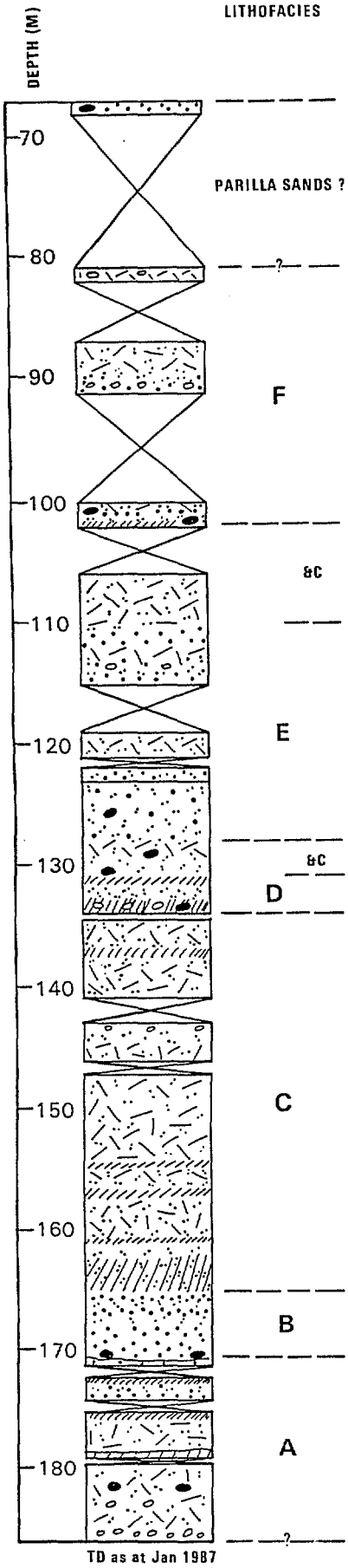
Twenty km to the south, and on the downthrown side of the Tyrrell Fault, a drillhole at BIG GULTHUL TANK revealed 303m of Tertiary sediments on Ordovician basement. A 158 metre - thick sequence of Geera Clay is enveloped by 25m of upper Renmark Group micaceous fine sands at the top and by 41m of lower Renmark Group sands and lignites at the base. Groundwater salinity of 25,000 mg.l TDS is uniformly distributed throughout the Tertiary aquifers.

The KUNGIE bore, 50 km east of the Euston drillhole, bottomed on granodiorite at 241m. Again, the Geera Clay - Winnambool Formation is enveloped by upper and lower Renmark Group sediments. Groundwater salinities vary little between 30,000 and 35,000 mg/l TDS from the water table in the Shepparton Formation to the base of the Winnambool Formation at 192m. Thereafter, electric logs indicate a pronounced decrease in dissolved salts to 6,000 mg/l in the lower Renmark Group. There is a ten metre head differential (flow direction upwards, uncorrected for density differences) between the lower Renmark Group and the unconfined aquifer.

GEERA AQUITARD STUDY

In conjunction with DITR and Prof. J. Hanor (Louisiana State), formation waters obtained from squeezing cores from the PIANGIL drillhole were analysed for isotopes and major and minor elements. The distribution of elements in the pore fluids indicate that hydraulic connection exists between the Renmark Group and Parilla Sands through the Geera Clay at Piangil. The two most important mechanisms of solute transport at Piangil are probably hydraulic advection of water and dissolved salts driven by differences in fluid pressure and density, and diffusional transport of dissolved salts downwards from the Parilla Sands to the less saline Renmark Group. The linear variation in salinity across the Geera Clay suggests the unit is not behaving as a semi - permeable membrane and that upward osmotic flow of water is insignificant. Estimates of the diffusive flux of salts from the Parilla Sands through the Geera Clay are of the order 1 to 5 g NaCl/sq.m sediment/year. Using measured physical properties from the cores, and knowing the present salinity profile in the Geera Clay, it has been possible to assess the palaeohydrogeological regime of the Geera - Parilla sequence at Piangil. It appears that the Parilla Sands have

LITHOSTRATIGRAPHY



LITHOLOGIES

Light to medium olive grey, fine to very fine quartzose sand with minor mica, feldspar, lithics; well sorted; dolomitic concretions; minor pyrite.

Mottled grey and olive black, pebbly sandy clay.

Grey to olive black mud, sandy, pelletal, skeletal and burrowed; pyrite infill foraminifera. Mud grades down to burrow-mottled green-grey silt. Dark olive grey gravelly sand over erosional surfaces.

Rythmic gradational alterations of dark olive grey sand, mud, and sandy silt; burrowed, fossiliferous, pyritic; calcareous concretions.

Olive black clayey silt; burrowed, fossiliferous, pyritic, glauconitic.

Burrow-mottled light and dark olive grey, quartzose, glauconitic sand; pyritic; intergradational with burrowed silt and minor gravelly sand. Faint relict lamination and ? flasers.

Dark brown to olive grey burrow-mottled silt, clayey inpart, fossiliferous, pyritic.

Weathered ? crumbly slickenslided, olive black sandy silt

Dark olive grey - black burrowed silt and sand

Dark olive grey finely burrowed pyritic silt.

Brown black - olive black clayey silt, mud, silt and minor sand interbanded; burrowed, fossiliferous, pyritic and slickenslided; carbonate concretions.

Gradationally interbedded clay predominant; pyritic; cherty dolomitic concretions have fractured and resin coated centres. Minor gravelly clay.

Olive black - dark olive grey clayey silt, minor mud and clay, burrows increasingly smaller down sequence - large burrows are pyrite and resin part-occluded.

Dark olive grey burrowed silt; gradational down to burrowed, faintly laminated mud and clayey silt; pyritic, glauconitic

Dark olive grey-light olive grey burrow mottled clayey silt and minor mud; fossiliferous, faintly laminated, pyritic.

Monotonous gradational alternations of dark olive grey - light olive grey and olive grey - yellow grey burrow-mottled clayey silt, mud, and minor clay; pyritic but with goethitic haloes in places.

Pyritic *Ophiomorpha*-like burrows increasingly abundant down to underlying sands.

Dark olive grey - yellow grey burrow-mottled, fine, sorted quartzose sand, glauconitic, shelly, locally indurated and dolomitic; glauconitic and muddy firmgrounds. Separate sandy muddy silt and flasered silt carbonate concretions.

Dark yellow brown - light olive grey laminated foraminiferal micaceous silt, clayey to top, sandy to base; abundant graded laminae and flasers

Olive grey - yellow grey (laminated) sandy silt, clayey silt; minor micaceous quartzose sand at base, clay at top, flaser structures.

Dark olive grey - yellow grey burrow-mottled and laminated clayey silt, minor mud, clay, and sandy gravelly clay; fossiliferous, pyritic; oxidized firmgrounds.

Yellow orange - yellow brown oxidized cobbly gravel.

II/154-16/3

Record 1987/25

Fig. 3 Lithostratigraphic log of Piangil West 1 borehole.

contained saline to hypersaline waters of meteoric origin for at least the last 300,000 years.

GEOLOGY

As part of an investigation of the Geera Clay aquitard, a detailed report by B.M. Radke on the sedimentology and diagenesis of cored sediments encountered by Vic. D.M. Piangil West 1 was prepared for publication in the Division of Continental Geology Groundwater Series. The interval examined was between 81.5 and 185.88 m and is characterised by dark and carbonaceous semi-consolidated silts and muddy silts (65%), unconsolidated and partly indurated sands (15%), mud (14%), and black plastic clays (only 6%). Detailed logs of lithologies, sedimentary structures, depositional events, general macrofauna, general ichnofauna, mineralogy, diagenesis and paragenesis are presented. A generalised lithology log is shown on figure 3. Five lithofacies were recognised on the basis of cyclical lithological patterns, sedimentary structures, ichnofauna, ichnofaunal cyclicity and fauna. Deposition was by micro-progradational cycles (shoaling-upward cycles) during a rise in sea-level to produce up-sequence shallow intertidal flat, shallow estuarine channel, subtidal-intertidal restricted marine and supratidal facies in a convoluted bay configuration. As the rate of sea-level rise diminished these transgressive environments were subjected to reworking and a simpler subparallel coastal configuration developed with more open-marine, supratidal and finally paralic conditions being established. Bioturbation in the fine siliclastic sediments enhanced the original porosity of the sequence. Early porosity ranged from 0% in the clays to about 5-10% in the silts, and up to 30% in the sands. Burrow interparticle porosity predominated, with additional interparticle porosity in sorted coarse silts and sands. The combined effect of early diagenetic cementation by clays, carbonate and pyrite, and subsequent compaction of the sequence reduced porosity to an existing range of 0-7% as interparticle and burrow interparticle porosity types. Clays, glauconite, pyrite, calcite and dolomite precipitated in the sediment at an early stage. Carbonate and minor pyrite precipitation continued as both replacement and porefill during compaction to very late diagenesis when pyrite, resinous organic matter and traces of arsenopyrite occluded remaining porosity.

Reference

RADKE, B.M., 1987 - Sedimentology and diagenesis of sediments encountered by Vic. D.M. Piangil West 1, Swan Hill area, Murray Basin, southeastern Australia. Division of Continental Geology Groundwater Series, 3, Bureau of Mineral Resources, Record 1987/25.

APPENDIX

MURRAY BASIN HYDROGEOLOGICAL PROJECT

Description

This project is a long-term study which is being undertaken jointly by South Australian, Victorian and New South Wales geological surveys and water authorities and by the Commonwealth Bureau of Mineral Resources, Geology and Geophysics. It is coordinated by a Steering Committee comprising members of those organisations.

The Murray Basin is a geological structure with an areal extent of some 300 000 km^2. In each of the three States, the basin sediments contain very large groundwater reserves. Where the groundwater has a low salinity it is increasingly being used for irrigation and town water supply purposes. In much of the basin, the water is suitable only for stock use and is extensively used for this purpose. In other parts of the basin, the groundwater is too saline for any use. There is a complex interaction between groundwater and surface water which may be beneficial, as in recharge areas in some parts of the basin, or harmful as in areas of saline groundwater discharge to rivers. In recent years, the states involved have stepped up the rate of assessment of the groundwater regime in the basin.

The primary aim of the Project is to improve the understanding of the groundwater regime of the basin by examining it as a single entity, unencumbered by State boundaries. Since a knowledge of the geology of an area is basic to the understanding of groundwater occurrence, a geological study of the basin is an essential part of the Project and, as a consequence, it will also be possible to make an assessment of other mineral resources.

Hydrogeological Objectives of the Basin-wide Study.

The major long-term objective of the Murray Basin Project is to develop a computer-based simulation of flow dynamics and solute transport in the groundwater systems of the basin, in order to allow prediction of future hydraulic heads and groundwater salinities in response to changes in land use. It is anticipated that the groundwater model will allow future salinity problems, and proposed solutions, to be assessed in a basin-wide context. In order to achieve this major aim a three-fold strategy has been adopted, involving collation and assessment of existing hydrogeological data, identification of areas of necessary research, and development of the model itself. Within this framework a number of limited objectives and products have been proposed. The data assessment involves development of computerised hydrogeological databases, identification of areas of data deficiency, and the preparation of 1:250 000 hydrogeological datamaps and 1:1 000 000 scale basin-wide maps. The research topics are mainly concerned with the examination of stratigraphic and structural influences on groundwater flow and related investigations of the systems which have contributed to salinity.

There are three main strands to the current activities:-

I. Data Review and Map Production
II. Research Projects
III. Development of Regional Groundwater Model

I. Data Review and Map Production - involving verification, entry and manipulation of hydrochemical, hydrodynamic and geological data into

computerised hydrogeological databases. The long-term objective is to enable the systematic preparation of 1:250 000 scale hydrogeological maps, in addition to 1:1 000 000 scale basin-wide maps. A limited number of maps are nearly completed (POONCARIE & DENILIQUIN 1:250 000 hydrogeological datamaps). The short-term strategy is to develop innovative presentation techniques using relational databases linked to output from an interactive Intergraph graphics workstation. This requires data entry and the linking of microcomputers, main-frame and graphics workstation. It is proposed that the short-term requirement for data entry and development of the necessary software and hardware procedures required to achieve these aims be undertaken by contract specialists.

II. Research Projects (BMR) - Recent investigations of present-day and fossil saline groundwater discharge features have highlighted the importance of interactions between fluctuating groundwater tables and surface geomorphic processes. Therefore, in order to develop an understanding of the systems in which salinity problems have developed there is a need to investigate the relationship between aquifer geometry, groundwater flow patterns, and the distribution and character of surface discharge features. In particular, aquifer geometry has been partly influenced by the structural configuration of shallow basement features and partly by stratigraphic and lithofacies relationships within the concealed Tertiary succession. Current research objectives have therefore been targeted to investigate the relationships between stratigraphic and structural influences on regional groundwater flow, and to further relate these to the distribution of groundwater discharge sites in the Murray Basin. This currently involves investigation of the Renmark Group aquifer, Geera Clay aquitard and basement features such as the Ivanhoe Block.

III. Development of regional groundwater model - A regional steady state finite difference model has been developed to simulate groundwater potentials and is currently being upgraded to allow improved definition of inflows and outflows. The model will ultimately be used to predict groundwater salinities. In this way various management options to alleviate the salinity problem can be simulated, and high risk areas can be delineated with confidence. It will also be possible, by adjusting the constant head cells, to simulate prior variations in climate and rises and falls in sea-levels and thus gain some understanding of palaeohydrological regimes.

The objective is to predict groundwater salinities throughout the basin, particularly those discharging to the Murray River, in response to perturbations to the system.

The strategy is to develop a fully three-dimensional model which permits significant leakage between layers. Calibration of the model will permit quantification of the major groundwater recharges and discharges. When the model adequately simulates hydraulic heads, the above will be incorporated as subroutines to calculate fluxes in the solute transport model.