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FUTURE GROUNDWATER RESEARCH AND SURVEY IN NEW ZEALAND

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Groundwater working party for
National Water and Soil Conservation Authority

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A groundwater working party set up by the National Water and Soil Conservation Authority reviewed the status of groundwater surveys and research in New Zealand. The working party recommends greatly increased activity in groundwater studies.

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PREFACE

Following a request from the National Research and Advisory Committee, the National Water and Soil Conservation Authority set up a groundwater working group to review the status of groundwater investigation and research in New Zealand. This group consisted of:

Professor I R Wood, Department of Civil Engineering, Canterbury University (Chairman).

Mr G Barnard, Auckland Regional Water Board,

Mr P Simons, Hawkes Bay Catchment and Regional Water Board,

Mr G Martin, Ministry of Works, Head Office, Wellington,

Dr H Thorpe, Ministry of Works Science Centre at Christchurch (with Mr R Burden as alternate).

The group carried out a detailed review of the present situation, pages 1 - 16, and recommends that it is important for the development of our agriculturally based economy that there be a greatly increased activity in the groundwater field. The detailed recommendations which may be read separately from the report are on pages 16 -18.

For the sake of completeness an Appendix is included with some of the data on which the Committees report was based.

INTRODUCTION

Some Regional Water Boards in New Zealand are endowed with ample supplies of surface water but many are finding that surface water resources in parts of their regions, if not already fully allocated, are coming close to it, particularly during long dry periods. Options to provide for an increasing demand for water include either artificial storage of surface water or further abstraction of groundwater.

Since 1950 a substantial effort has been made to evaluate New Zealand's most easily exploitable water resource its surface waters. This is illustrated by the increase in river-gauging stations since 1900 (Figure 1) and this effort is at present paying dividends with more efficient design of irrigation, water supply and hydro electric schemes. In contrast few groundwater studies predate 1975. A review of national research and survey activity (Appendix I) indicates that coordinated groundwater studies are currently at a similar level to that of surface-water studies in the 1950s.

Groundwater assessment is less certain, more costly and difficult than assessing a surface water resource. While it is a simple matter to measure the cross-section, water level and flow velocity of a river, (which leads to a direct and reasonably accurate assessment of the instantaneous size of the resource) groundwater resources can prove exceedingly complex and difficult to assess. The difficulties occur not only in assessing the overall resource magnitude, but also in placing restraints upon localised extraction rates so that the effect of draw-down on adjacent users, the effect of contaminants (eg salt water intrustion) and the risk of damage to the aquifer by collapse can be minimised. At present, approximately 200 man years are devoted annually to surface-water studies whereas only about 40 man years are committed to groundwater resource assessment.

To date speculative drilling by individuals has been primarily responsible for locating new aquifers and defining the boundaries of known aquifers. This speculative drilling currently involves a personal risk of up to $10,000 which may by followed by a further investment of $50,000 - $350,000 for irrigation equipment and on-farm developments.*

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* It is noted that the Ministry of Agriculture and Fisheries is examining the possibility of financing exploratory well drilling by farmers. A predicted significant increase in demand for groundwater following the introduction of this new policy would place considerable pressure on the existing resources of regional water boards.

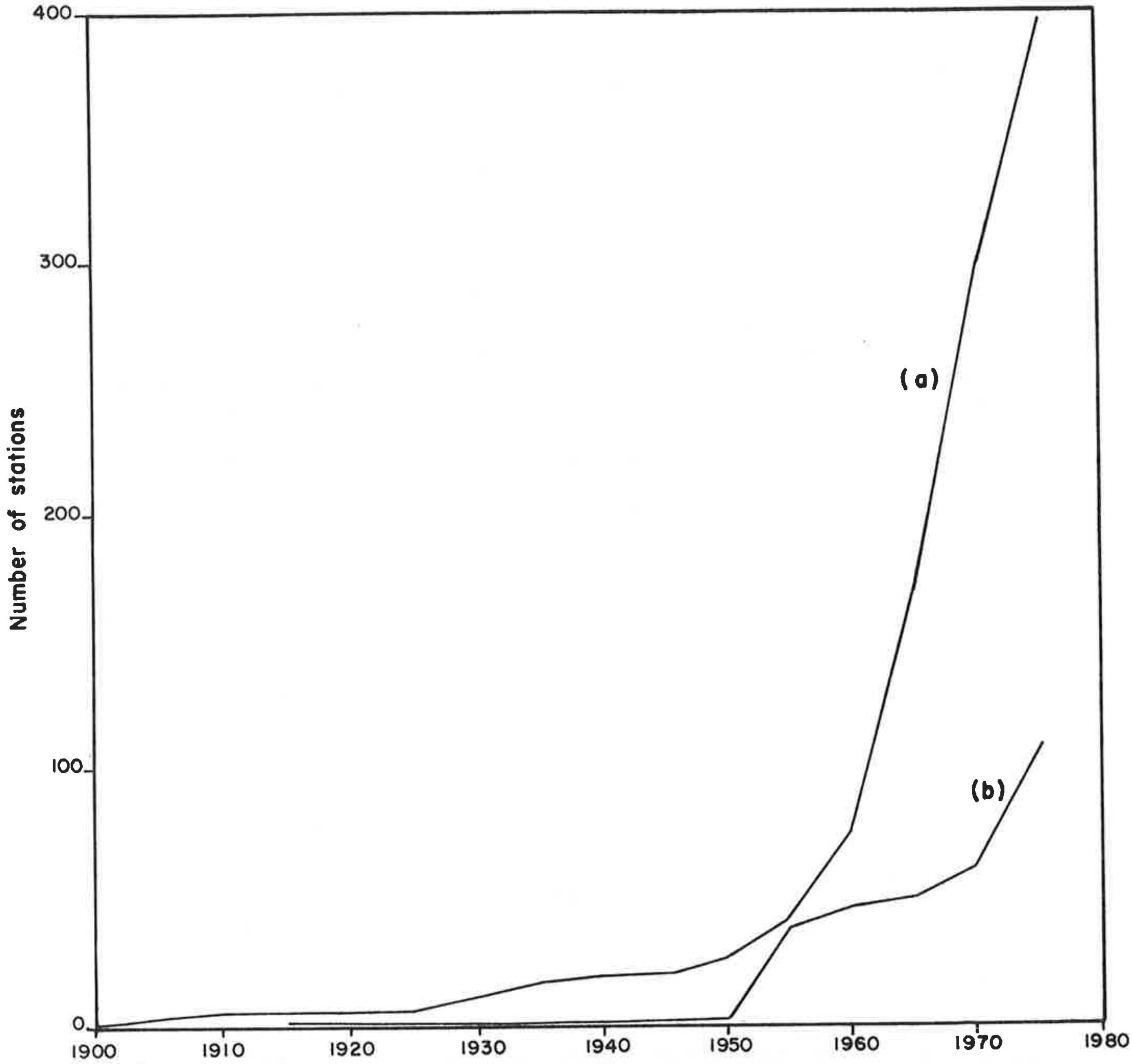

Fig.1 : Comparison of the number of water-level recorder stations (a) surface water and (b) ground water with dated filed on TIDEDA.

Unfortunately, detailed resource evaluation, which is necessary for the ultimate development of an aquifer, has not followed the speculative drilling. There is an urgent need therefore, for systematic groundwater resource evaluation programs of our presently known aquifers in order to protect both the present community investment and future development options.

GROUNDWATER USE

Human activity in some areas of the country has depended upon groundwater since late last century. Subsequent use of groundwater has been controlled only by availability or by the cost of exploitation. Little thought has been given to the possibility and consequences of resource depletion or contamination, or to positive management practices such as systematic well siting and artificial recharge.

1. Consumption

Underground sources of water currently make a substantial contribution to the annual (1977) agricultural (15 x 10^5 m^3/day), domestic (2 x 10^5 m^3/day) and industrial (2 x 10^5 m^3/day) needs of New Zealand (OECD, 1980). Groundwater is utilised in many parts of the country and meets the total water requirements of the major cities of Hastings, Napier, and Christchurch (Table 1).

Irrigation from groundwater for croplands is increasing rapidly in areas such as Canterbury, Marlborough, Nelson, Kerikeri, Pukekohe, Hawkes Bay, and the Wairarapa, and this demand will continue to increase as landuse in these and other areas intensifies.

In New Zealand groundwater is currently the sole source of drinking water for between a quarter and one-third of the national population. Many large townships are entirely dependent upon groundwater for domestic supply (Table 2). At present more than 90 percent of groundwater used domestically does not require treatment for purification.

TABLE 1: Annual groundwater abstraction for domestic industrial and agricultural use (Estimates by Water Board Staff, January 1981)

Water Board	Population	Groundwater abstraction (m^3/day) Domestic	Industrial	Agricultural
Auckland	-	-	-	-
Bay of Plenty	nd	nd	nd	nd
East Cape	-	-	-	-
Hauraki	-	-	-	-
Hawkes Bay	124,000	43,400	80,000	140,000
Manawatu	-	-	-	-
Marlborough	28,100	7,000	>11,200	205,200
Nelson	29,100	6,700	nd	126,000
Nth. Canterbury	265,000	98,000	184,000	2,765,000
Northland	33,000	11,000	19,000	17,000
Otago	nd	nd	nd	nd
Rangitikei-Wang.	35,000	12,400	14,000	11,200
Sth. Canterbury	15,000	3,750	nd	nd
Southland	nd	nd	nd	nd
Taranaki	nd	930	nd	5,600
Waikato	101,900	23,400	37,000	nd
Wairarapa	4,000	1,000	4,000	40,000
Wellington	-	-	-	-
Westland	nd	nd	nd	nd
TOTAL	635,100	207,580	349,200	3,310,000

- No reply received   nd Not determined

TABLE 2: New Zealand Townships (pop. > 5,000) served domestically from groundwater or combined surface/groundwater sources (After Kingsford, 1973)

	Population (1973) served by:	
	Groundwater	Surface/groundwater
Blenheim	13,500	
Cambridge	5,000	
Cashmere	5,000	
Christchurch	165,000	
Dunedin		81,000
Gore	8,500	
Greymouth	8,600	
Hastings	29,000	
Havelock North	6,200	
Heathcote	7,500	
Hornby	10,000	
Howick		10,000
Kaikohe		5,000
Kawerau	5,000	
Lower Hutt	59,000	
Morrinsville		5,000
Mosgiel	8,300	
Napier	28,000	
Onehunga	10,000	
Papatoetoe		20, 000
Petone	10,200	
Pukekohe	5,000	
Putaruru	5,000	
Riccarton	7,500	
Rotorua		20,000
Waimairi	57,600	
Wanganui	37,000	
Wellington		200,000
Whangerai		20,000
TOTALS	490,000	361,000

2. Management

Abstraction from and discharge to groundwater is currently regulated by water rights issued by the Water Boards under the Water and Soil Conservation Act (1967). In many areas water rights are being granted freely because no deleterious effects of the existing management of the groundwater resource have been observed. The limits of exploitation are not known because there is insufficient knowledge of the size and potential for contamination of the underground resource. However, the demand for groundwater is continuing to increase as economic pressures encourage farmers into more intensive land-use, particularly horticulture. The economic benefit to the individual and nation from this intensification of farming will be considerable (Table 3) but the expansion may be frustrated by a lack of knowledge of the availability and quality of groundwater.

TABLE 3: Gross returns per hectare for a range of agricultural options (Ministry of Agriculture and Fisheries estimates 1980/81).

Agricultural Option	Gross Return (Dependent on market conditions)
Dryland pasture (10 stock units)	$180
Irrigated pasture (18-19 stock units)	$414-437
Peas	$680
Potatoes	$1000
Tomatoes	$3000-4000
Blackcurrents	$5000

The lack of warning of the imminent depletion of Waimea Plains groundwater resource (Nelson) has resulted in a delay to the expansion of the local agricultural industry while an additional water supply is sought. If the physical characteristics of the aquifer system had been well understood then strict allocation priorities could have been established several years ago. The predicted rapid expanision in horticulture and cropping and its attendant demand for water may result in similar allocation problems in areas such as the Hawkes Bay, Wairarapa and Marlborough in the near future.

Poorly informed resource management could also lead to extensive groundwater contamination which would be expensive and perhaps virtually impossible to remedy. Seawater contamination of municipal supply bores on the Waimea Plains resulting from rapidly increasing regional groundwater use constitutes a threat to the potability of the water. The problem was heightened by the placement of the bores near the coastline before the aquifer system was properly understood.

Extensive evaluation followed by implementation of soundly-based management strategies has permitted effective control and protection of the important Lower Hutt groundwater system. Without the detailed evaluation program it is possible that the Lower Hutt aquifer could today be over utilised (and perhaps subsiding), contamined by seawater and polluted by industrial effluents.

RESEARCH AND SURVEY

Groundwater research and survey activity may be divided into three categories: (1) resource evaluation, (2) resource management, and (3) fundamental research. Categories (1) and (2) come under the auspices of the National Water and Soil Conservation Authority (NWASCA). As the agents of NWASCA the Water Boards are responsible for evaluation and management of the groundwater resource, and the Christchurch Science Centre is responsible for supplying specialist assistance to the Boards. Private consultants also undertake groundwater investigations but these are generally uncoordinated and quite small. Category (3) is predominantly the domain of the Christchurch Science Centre, Universities, Geological Survey, Institute of Nuclear Sciences, and Chemistry Division, DSIR. Fundamental research at the Christchurch Science Centre has direct relevance to particular problems. Some fundamental research is funded by research grants from the National Water and Soil Conservation Authority. These are administered by the National Water and Soil Conservation Organisation.

1. Groundwater Resource Evaluation

The level of knowledge about a groundwater resource is different for each system. Some Water Boards have virtually no relevant data whereas others have accumulated information for more than a decade. Existing data has, however, generally been collected in a sporadic fashion in response to specific problems. In some regions (particularly those with horticultural potential) the demand for groundwater is increasing rapidly and has now reached the point where planned and coordinated resource evaluations are necessary. Groundwater evaluation may be considered under three headings: (a) geology, (b) hydrology, and (c) quality.

Regional geology may be assessed by geophysical and geological techniques. Geological investigation techniques include bore-hole interpretation and regional stratigraphic mapping. Unfortunately, existing bore-log descriptions, made mostly by drillers, vary widely and are at times virtually useless for geological interpretation. If meaningful information is to be derived from logs in the future it is essential that there is a standard description format and that geologists either from the Water Board or Geological Survey log as many new wells as possible, particularly in areas where geological information is poor or lacking. Surface and downhole geophysical techniques are the most effective methods of rapidly delineating groundwater basin boundaries and regional stratigraphic discontinuities and are usually used to extend our geological knowledge. However, very few systematic geophysical investigations related to groundwater have been made in New Zealand. Geophysical investigations are an essential addition to groundwater studies and specialist personnel and equipment are urgently required. Because of the high degree of skill required in the use of the equipment and the interpretation of the data and the one-off nature of most regional geological investigations the work is best done by specialist teams from the groundwater group at the Christchurch Science Centre or other organisations.

Groundwater use for different purposes (domestic, industrial and agricultural) is governed by the long-term sustainable yield of an aquifer. A hydrological resource assessment is therefore concerned with factors such as aquifer permeability, system inputs and outputs, aquifer response, and groundwater flow pattern. Investigation techniques include water budget calculations, piezometric surveys and aquifer pump tests. Piezometric surveys are one of the most important sources of data because they show the direction of groundwater movement and because they can be used together with the results of aquifer pump tests to estimate groundwater flow rates. They also provide a systematic way of keeping historical records of piezometric levels for purposes of comparisons in later years and are essential for any future modelling purposes. Fundamental hydrological information is lacking for most New Zealand aquifers but until it is available effective resource management is virtually impossible. The main requirement for further geohydrological studies is more trained Water Board personnel and a greater input of specialist assistance from the Christchurch Science Centre.

In many parts of the country knowledge of regional groundwater quality is totally lacking. Investigation programs are urgently required to establish baseline quality, identify potential sources of contamination and clarify links between land-use and groundwater quality. Sophisticated chemical, bacterial and isotope techniques must also be used to identify contaminant sources, recharge and discharge areas and groundwater flow pattern. Boards require specialist assistance from the Science Centres and DSIR to conduct detailed bacterial and isotopic studies and analyse samples associated with complex contamination sources (eg dumps).

2. Groundwater Resource Management

Resource management is the responsibility of the Water Boards who allocate and protect the resource by issuing water rights. In the absence of a detailed resource evaluation most Water Boards have no option but to grant water rights on an ad hoc basis without knowing the long-term collective effect of exploitation of the groundwater resource. Effective management is dependent upon improved knowledge of the resource based on expanded field investigation programmes and implementation of management-oriented computer models. Groundwater quantity models are necessary to assess the short and long-term consequences of existing and planned development options. The effects of various forms of land-use on groundwater quality must also be determined by appropriate models. Numerous management-oriented numerical models exist but these must be adapted by specialists to meet different environmental and planning conditions. Model development requires close liaison between field personnel and specialist so this role is best filled by the Science Centres. Assistance from the Science Centres, is however, limited by existing computer facilities. Considerable expansion of these facilities is required to permit development of effective management models for all Water Boards.

Effective resource management is also dependent upon efficient water use in industry and agriculture. Irrigation is the largest user of groundwater, and, as such, must be carefully controlled to minimise wastage of water while at the same time maximising plant growth. This is an area for cooperative research with agricultural research oganisations.

Regulation of future groundwater use is dependent upon the Water Boards being informed of all proposed bores in advance of drilling. A permit system which would ensure compliance to this management aid could be enforced under an appropriate by-law. Such by-laws have been adopted already by several Boards but there is a need for national coverage.

The management demands made on Water Boards will change with changes in the patterns of land and surface-water use. Boards must periodically review their management needs. A coordinated review could be usefully carried out every 3-5 years under the auspices of a national body such as the Catchment Authorities Association.

3. Fundamental Research in the Field of Groundwater

Fundamental research has a relatively low priority at present because of the more urgent need to establish sound groundwater evaluation and management programmes throughout the country. There are, however, several topics for which fundamental research is currently required. These are to assess: (a) mechanisms of natural recharge, (b) artificial recharge options, (c) standard data storage and retrieval systems, (d) mechanisms of chemical, viral and bacterial discharge from point and non-point sources.

DISCUSSION

It is apparent from this review that a greatly increased activity is justified in the areas of resource evaluation and management in order to enable Water Boards to prepare the groundwater section of a regional water allocation plan. This is necessary to ensure the protection, efficient use and equitable allocation of the resource. Fundamental research, although important, has a lower priority than resource evaluation and management. Indeed, the existing knowledge of research techniques and fundamental groundwater processes is generally sufficient to permit the implementation of effective resource evaluation and management strategies.

The necessary increase in activity in groundwater resource evaluation and management is currently limited by a shortage of: (1) professional and technical staff within Water Boards, (2) staff at the Christchurch Science Centre, (3) computer services and specialist equipment at the Christchurch Science Centre and (4) sufficient finance to implement resource investigations and to initiate and sustain long-term monitoring programmes. The staffing problem for groundwater studies is two-fold. Firstly, there are insufficient staff to implement the necessary groundwater evaluation and management programmes, and, secondly, those staff available or likely to be employed have little or no experience in this field.

1. Staff in the Regional Water Boards

There is a wide variation of staff establishments in Regional Water Boards equipped to study underground water resources. Several have expanded interests inherited from underground water authorities, some have found it necessary to become involved due to severe competition for a particular resource, but many have found it unnecessary to consider underground water resource at all at this stage. The wide variation in interest will continue, but there will be a gradual build up in the need for an assessment of underground water resources throughout the country.

Water Board staff involved in groundwater evaluation and management totals 30 man years/year which is a nominal allocation of 1.5 man year/year/Board. In fact, staff are distributed throughout the different Water Boards approximately in accordance with regional groundwater use (Table 4).

TABLE 4: Regional Water Board Staff devoted to groundwater hydrology (January 1981)

Water Board	Staff man years/year)	Population served domestically
Auckand	3.0	nd*
Bay of Plenty	0.5	nd
East Cape	-	nd
Hauraki	1	nd
Hawkes Bay	1.5	124,000
Manawatu	0	nd
Marlborough	2	28,100
Nelson	1	29,100
Nth. Canterbury	7	265,000
Northland	0.5	17,000
Otago	0	nd
Rangitikei-Wang.	-	35,000
St. Canterbury	1.5	15,000
Southland	0	nd
Taranaki	1	nd
Waikato	3.5	101,900
Wairarapa	3	4,000
Wellington	1	nd
Westland	0	nd
Total	26.5	635,100

nd* not determined

The demand for water right investigations occupies virtually all of the existing staff time leaving little or no time for coordinated resource assessment and long-term monitoring. Therefore in order to carry out this vital assessment task Water Board staff numbers involved in groundwater investigations need to be increased. It would be unrealistic to suggested that all regional water boards should have similar underground-water study groups. In fact it may well be that those already well equipped have greater need for expansion in this field than some who have not yet made a start, and are unlikely to for some years. Certainly in the water short area with a groundwater resource the numbers involved in investigations need to be doubled.

In appointing this staff attention must be paid to the need for a range of expertise necessary for groundwater studies. This expertise includes geology, groundwater, hydraulics and chemistry.

2. Science Centre Staff

Specialist advice and assistance to the Boards is required mainly in the fields of geology (geophysics) and computer modelling. Because of the sophisticated equipment and specialist skills necessary for geophysics and modelling studies staff numbers in the Christchurch Science Centre must be increased. At present, the groundwater group at the Christchurch Science Centre is comprised of five scientists and one technician. The scientists are designated as: group leader, hydrologist, geochemist, numerical modeller, and geophysicist. The group, therefore, has one modeller, one geophysicist, and no geologist, to service the requirements of the regional water boards. Although, specialist staff exist in Universities and DSIR divisions, total numbers would not exceed six for both groundwater modelling and geophysics. In order to meet current resource evaluation and management requirements a further geologist, geophysicist and computer modeller are required immediately for the groundwater group of the Christchurch Science Centre. In the future, pressure on the groundwater resource will continue to increase so that staff numbers in the Boards and Science Centre must increase accordingly. The present staff at the Science Centre has partly been built up by transfer from surface-water activities to fill the growing need in groundwater hydrology. However hydrology staff in the Water Boards and the Ministry of Works and Development are now fully committed on long-term surface-water monitoring programs to provide data for flood control, irrigation, hydro-electric development, etc. It is therefore unreasonable to expect further transfers from the surface water hydrology sections.

The second problem of staffing is one of expertise. Most developed nations have been engaged on groundwater studies for several decades and have accumulated a wealth of knowledge and experience. Because detailed groundwater resource assessment only extends back about five years the pool of experienced personnel in New Zealand is quite small. Many of those working in groundwater hydrology are recent graduates. The build up of professional and technical expertise should be enhanced by the introduction of: (a) technical manuals, (b) technical workshops, (c) a supply of groundwater texts to the Regional Boards and (d) exchanges to and from foreign groundwater research and teaching institutions. Priority topics for manuals are a general groundwater quantity and quality investigation guideline, a standard geological bore-log description format, a document on aquifer test procedures, and details for long-term quality and quantity resource monitoring programmes. Technical workshops should be run as an adjunct to the specific manuals. Exchange of scientists with overseas institutions should be encouraged and sabbatical and research fellowship leaves for foreign groundwater scientists should be sponsored.

3. Specialist Equipment

The need for further equipment for groundwater evaluation and management should follow the appointment of staff for Regional Water Boards and the Christchurch Science Centre and may be divided into: (a) monitoring equipment for the Regional Water Boards and (b) specialist equipment.

(a) Monitoring equipment is necessary on a long-term basis throughout the country and includes adding further automatic water level recorders at a cost of about $1,000 each. All Boards require mini-computers for data storage retrieval and manipulation. A compatible mini-computer network is, among other functions, envisaged as forming the basis for a decentralisted national groundwater data archive.

(b) Considerably improved computer facilities are required for Christchurch Science Centre to permit regional computer modelling. Resistivity and seismic recorders for geophysical surveys should be purchased once suitably qualified staff are available.

4. Finance

Increased finance is required for the evaluation and management of the nation's groundwater resources. Where the size and quality of the resource is unknown and the risk associated with development is high, initial funding should come from central government. To encourage Boards to start evaluation and long-term monitoring funds should be provided, including inflation, for a minimum period of five years. Where the need for knowledge of a regional resource