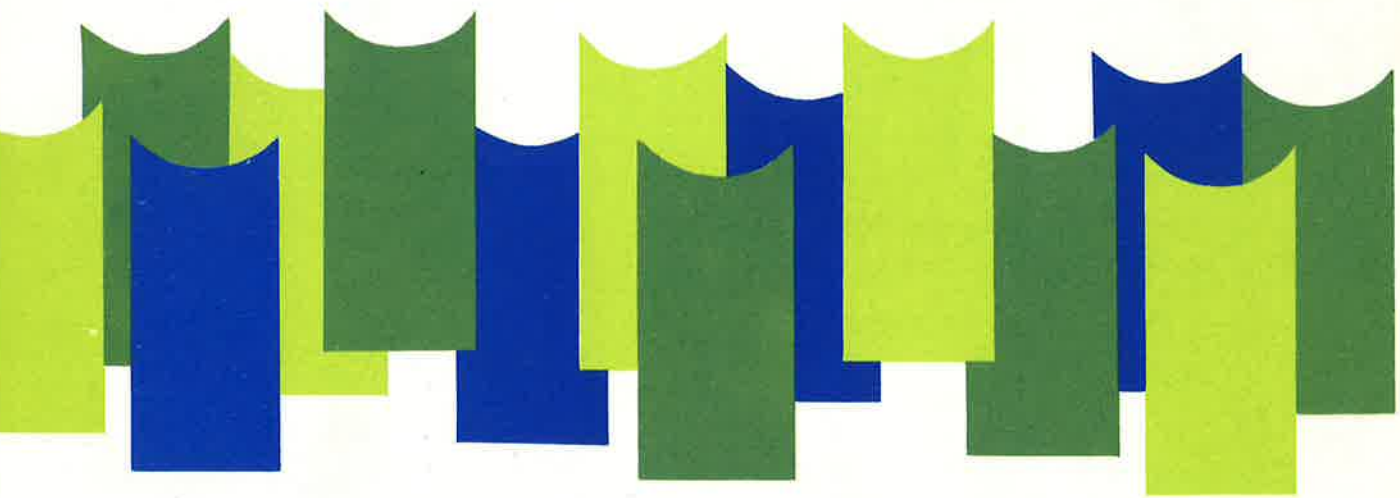
WATER & SOIL

TECHNICAL PUBLICATION

NO. 16

Research and Survey Annual Review 1978



NATIONAL WATER AND SOIL CONSERVATION ORGANISATION

ISSN 0110-4144

Multispectral colour composite aerial photograph, Dry Acheron Catchment, Canterbury, taken in February 1978. Scale 1:3500.

This was produced by successive projection and registration of three narrow-band black and white transparencies (Fig 9) onto the same piece of colour print paper. Blue light is projected through the band 1 transparency, green light through band 2, and red light through band 4.

The photograph shows a large scree, approx 800 metres long, which extends from the tussock covered 'tops' to the valley bottom. This colour composite enhances the differences between 'greywacke' mudstone (**A**) and 'greywacke' sandstone (**B**). Partly vegetated areas (**C**) on the scree reflect reddish tonings. The vivid red tones of the beech forest (**D**) contrast sharply with the light reddish yellow tones of the tussock associations (**E**) and the distinctive purplish red tones of regenerating scrub and dracophyllum (**F**). Individual dead or dying beech trees (**G**) can be easily discriminated. Sheet and wind eroded sites (**H**) are scattered throughout the tussock areas. Their distinctive irregular pattern aids in their photo identification.

Photo: Catchment Condition Group, Aokautere Science Centre

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Research and Survey Annual Review 1978

Compiled by staff of the
Water and Soil Division,
Ministry of Works and Development

WELLINGTON 1979

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Water & Soil Technical Publication No. 16. 1979. 89 p. ISSN 0110-4144

The National Water and Soil Conservation Authority has statutory functions for water and soil resource surveys and research. This review presents annual reports of 149 resource surveys undertaken by New Zealand's 20 catchment authorities (33 pages); reports on 18 research contracts placed with universities, now under way, and 12 contracts being negotiated (9 pages); research and surveys by the Water and Soil Division of the Ministry of Works and Development (MWD) (31 pages); brief descriptions of the work of 7 inter-agency committees, and a list of publications by the research and survey staff of the Water and Soil Division, MWD.

National Library of New Zealand
Cataloguing-in-Publication Data

NATIONAL WATER AND SOIL CONSERVATION ORGANISATION.
Research and survey annual review . . . -
1977- . - Wellington : Water and Soil Division, Ministry of Works and Development for National Water and Soil Conservation Organisation, 1978- . -30cm. - (Water & Soil Technical Publication, ISSN 0110-4144)
Annual. - Supersedes: National Water and Soil Conservation Organisation. Research and survey annual report for National Water and Soil Conservation Organisation, ISSN 0110-1897. - 1977 has subtitle: review of activities of the Research and Survey group of the Water and Soil Division, Ministry of Works and Development. - Research undertaken by members of the Organisation.
ISSN 0110-5183 = Research and survey annual review
National Water and Soil Conservation Organisation : gratis
I. New Zealand. Water and Soil Division.

Published for the National Water and Soil Conservation Organisation by the Water and Soil Division, Ministry of Works and Development, P.O. Box 12-041, Wellington, New Zealand.

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Water and Soil Division

INTRODUCTION

It is the policy of the National Water and Soil Conservation Organisation that the water and soil resource surveys and research which are needed for matters in which it has statutory responsibility are broad based. It encourages them to be undertaken by a wide range of organisations, none of which dominates the overall effort and all of which are complementary and have equivalent standing. In accord with this philosophy of approach the highlighting of various sections of work and their order of presentation in the annual review is being varied from year to year.

As most research and survey projects require several years from initiation to completion this can also assist in avoiding the general danger of an annual report becoming repetitious.

A significant development during the year was the establishment early in 1978 of a research and survey committee as one of four committees set up to assist and advise the National Water and Soil Conservation Organisation in carrying out its statutory functions. The duties of the research and survey committee are to make recommendations to the Water Resources Council and the Soil Conservation and Rivers Control Council on matters concerning research and survey in terms of existing policies and legislation, and to advise councils where existing research and survey policy needs revision or where new policy is required. In doing so it shall have regard to the need for providing a sound basis for and co-ordinating research and survey work carried out by the Water and Soil Division of the Ministry of Works and Development, by catchment and regional water authorities, and by other agencies in those water and soil areas with which the National Water and Soil Conservation Organisation is involved.

Members of the research and survey committee, who were appointed because of their personal knowledge and experience in one or more aspects of water and soil affairs, are:

M.S. Carrie (Chairman)	National Water and Soil Conservation Authority member. Meat Industry Research Institute representative on the Water Resources Council.
H.W. Hayward (Deputy Chairman)	Soil Conservation and Rivers Control Council member. Dairy Farmer. County Chairman.
R.G. Norman	Soil Conservation and Rivers Control Council member. Civil Engineer. Assistant Commissioner of Works.
R.G. Calvert	Water Resources Council Member. Dairy Farmer. Member of the N.Z. Dairy Board.
H.E. Connor	North Canterbury Catchment Board member and Chairman of its Water Committee. DSIR Scientist.
J.H. Young	Chief Executive Officer Waikato Valley Authority. Soil Conservator.
J.D. McCraw	Professor of Earth Sciences and Dean of Sciences, University of Waikato.
I.R. Wood	Professor of Civil Engineering, University of Canterbury.
A.J. Ellis	Director, Chemistry Division, DSIR. Water Chemist.
I. Inkster	Assistant Director of Research, Ministry of Agriculture and Fisheries. Soil and plant responsibilities.
A.L. Thorstensen	Department of Health. Public Health Engineer.
D.G. Butler	Technical Manager, Southland Frozen Meat Company.
J. Bull	Multiple Enterprise Farmer. Recent County Chairman. Chairman of Food Processing Companies.
J.T. Kneebone	Soil Conservation and Rivers Control Council Member. Former president of Federated Farmers. Farmer.

To explore effectively the issues involved in 'what water and soil research and survey is worth doing' and 'how best it is done' the committee, because it recognised that the specialist expertise and time required to explore effectively issues would go beyond the committee's available time and numbers, has set up three working parties. These are water quantity, water quality and land resources into which most of the areas of National Water and Soil Conservation Organisation's involvement conveniently fall. Each working party will consider and report to the research and survey committee on such issues that the committee refers to it. These working parties would be expected to contribute a substantial amount of the innovative thinking.

Memberships of the working parties are:

WATER QUANTITY RESEARCH AND SURVEY WORKING PARTY

H.E. Connor (Chairman)	North Canterbury Catchment Board member and Chairman of its Water Committee.DSIR Scientist. Research and Survey Committee member.
G.N. Martin (Secretary)	Manager, Research and Survey (Water Quantity) Water and Soil Division.
G. Barnard	Senior Water Resources Engineer, Auckland Regional Authority.
J. Bull	Multiple Enterprise Farmer. Recent County Chairman. Chairman of Food Processing Companies. Research and Survey Committee member.
T.F.W. Harris	Scientist-in-Charge, Hamilton Science Centre, Water and Soil Division.
J.A. Hayward	President of New Zealand Hydrological Society.
D.R. Maidment	Group Leader, Hydrosystems, Christchurch Science Centre, Water and Soil Division.
J.R. Waugh	Group Leader, National Hydrology Network, Christchurch Science Centre, Water and Soil Division.
I.R. Wood	Professor of Civil Engineering, University of Canterbury. Research and Survey Committee member.

WATER QUALITY RESEARCH AND SURVEY WORKING PARTY

E.H. Simpson (Chairman)	Farmer. Former chairman of Water Quality Research Committee. Former member of Water Resources Council.
M.E.U. Taylor (Secretary)	Manager, Research and Survey (Water Quality), Water and Soil Division.
M.H. Bauer	Investigating Engineer, NZED.
D.G. Butler	Technical Manager, Southland Frozen Meat Company. Research and Survey Committee member.
K. Currie	Water Resources Officer, Manawatu Catchment Board.
R.L. Earle	Head of Department of Biotechnology, Massey University.
A.P. Mulcock	Professor of Agricultural Microbiology, Lincoln College.
J.N. Parle	Assistant Director (Station), Soil and Field Research Organisation, Ruakura Agricultural Research Centre.
C.D. Stevenson	Chemistry Division, DSIR.
J.K. Syers	Head of Department of Soil Science. Massey University.
R.H. Thornton	Director of Cawthron Institute.
A.L. Thorstensen	Department of Health. Public Health Engineer. Research and Survey Committee member.
G.D. Waugh	Director, Fisheries Research Division, Ministry of Agriculture and Fisheries.
E. White	Officer in Charge of Freshwater Section, Ecology Division, DSIR.
G.R. Williams	Director, Wildlife Service, Department of Internal Affairs.

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LAND RESOURCE RESEARCH AND SURVEY WORKING PARTY

J.D. McCraw (Chairman)	Professor of Earth Sciences and Dean of Sciences, University of Waikato. Research and Survey Committee member.
G. Howard (Secretary)	Manager, Research and Survey (Land Resources), Water and Soil Division.
B.J. Allison	Forest Manager, New Zealand Forest Products.
R.W. Cathcart	Planning Officer, Northland Catchment Commission.
N.A. Cullen	Director of Soil and Field Research, Ruakura Agricultural Research Centre.
G.O. Eyles	Group Leader, Land Resource Surveys Aokautere Science Centre, Water and Soil Division.
J.G. Hawley	Scientist-in-Charge, Aokautere Science Centre, Water and Soil Division.
H.W. Hayward	Soil Conservation and Rivers Control Council member. Dairy Farmer. County Chairman. Research and Survey Committee member.
J.T. Kneebone	Soil Conservation and Rivers Control Council member. Farmer. Former president of Federated Farmers. Research and Survey Committee member.
M.J. McSaveney	Group Leader, Alpine and Erosion Processes, Christchurch Science Centre. Water and Soil Division.
I.G. Speden	N.Z. Geological Survey, DSIR.
J.P.C. Watt	Soil Physicist, Soil Bureau. DSIR, Havelock North.

The past year has seen further consolidation of the programmes operating out of the three national science centres at Hamilton, Aokautere and Christchurch and the provision of improved laboratory and office accommodation. In September 1978 the Minister of Works opened the Christchurch Science Centre's new quarters which accommodates all that centre's staff, except for those at the Instrument Servicing Centre which still remains at Kaianga. Construction has commenced on additional office and laboratory facilities at Aokautere and upon completion early in 1979 will allow staff at that centre to be brought together to work as a much more unified group. For the Hamilton Centre a new office block adjacent to the University of Waikato campus has been acquired to supplement accommodation on the campus. This will allow for the Centre's laboratory facilities to be expanded and rearranged for greater proficiency.

Staff of high calibre have been recruited at a cautious rate consistent with needs for implementing that part of National Water and Soil Conservation Organisation's approved research and survey programme being undertaken by the Water and Soil Division.

Resource Surveys by Catchment Authorities

INTRODUCTION

The resource survey programme of the National Water and Soil Conservation Authority became operative as from 1 April 1976. The programme provides for catchment authorities to carry out the survey assessment of, or gauge the response to treatment of, land and water resources. The catchment authorities generally initiate the surveys and set the priorities. These can be surveys in their own right, surveys for evaluating resources for water allocation, or surveys to provide data for scheme design. Research and survey staff provide technical advice and guidelines for each survey. Emphasis is placed on the development of uniform standards and on defined times for reporting results. The objectives are not only to provide the data required for designing schemes but also to build up a body of data and staff skill which becomes a substantial contribution to regional and national planning requirements.

The groupings of survey activity are:

Land resource surveys

(1) Land resource inventory and capability.
(2) Sand and shingle resource.

Water resource surveys.

(1) Water quantity surveys.
(2) Water quality surveys.
(3) Coastal and estuarine surveys.

Catchment monitoring surveys

(1) Catchment condition surveys.
(2) Channel efficiency surveys.
(3) Erosion and sedimentation surveys.

Programmes are set out in terms of realistic targets on an annual basis up to a maximum of five years total. Progress and data summaries, in the form of an annual report for each survey, are submitted by each authority. On completion of a resource survey a comprehensive report must be prepared and submitted to the Director.

A total of 166 resource surveys have been supported technically and financially in the two financial years to March 1978. The majority of these surveys are on-going in that they are programmed to run for up to five years. As a result only 24 surveys have been completed.

The following reports are based on annual survey reports from each authority, as at March 1978.

NORTHLAND CATCHMENT COMMISSION

[1] **West Coast dune lakes water resource survey**

This survey investigates the hydrology and water quality of the lakes including a water balance for a typical lake to establish criteria to be used in the management of the lakes as a water resource.

Rainfall records, collected by local residents, are available as follows:

Kanono, Kahuparere	1957 to date
Waikare, Taharoa, Kai Iwi, Spectacle and vicinity, Pouto	1970 onwards
Parawanui, Swan, Humuhumu, Rotokawau	1976 onwards

Lake levels records available are:

Taharoa, Kai Iwi	1970 onwards
Parawanui	1976 onwards
Kanono, Kahuparere	1977 onwards
Spectacle, Kanono	poor record

Some records of levels of Lake Rotokawau were kept for January and February 1978.

As a result of what seemed like diurnal fluctuation in lake levels barometric pressures were recorded during May and June 1977 at Lakes Kanono and Kahuparere, and from November 1976 to the present at Lake Parawanui. Some correlations were also attempted between lake levels and phases of the moon. Indications are that there is a relationship between lake level fluctuations and barometric pressure, but the data have not yet been analysed in sufficient detail.

Lakes Kanono, Waingata, Parawanui, Taharoa and Waikere were sampled in April and December 1976, and in May and September 1977. Based on the results of this preliminary survey it appears that the waters of these lakes are of a fairly high quality; indeed they seem to be oligotrophic.

The nutrient levels are usually very low, mostly in the trace range, and oxygen levels are high. With the exception of the first visit to Lake Taharoa, little stratification appears to be present, indicating good mixing. Coliform bacteria numbers are very low indicating little contamination by stock etc.

The above conclusions seem to be supported by algal determinations carried out by Dr Cassie, Botany Division, DSIR, Auckland, as part of this survey.

[2] **Potential public water supply water resource survey**

Because of changes in staff, pressure of other survey work and the drought conditions experienced, the number of sites where base flow recession gaugings were carried out was reduced in 1977/78. However the information obtained was of special value, having regard to the severity of the 1977/78 summer drought. Investigations were concentrated on streams which had highest water supply priority.

Table 1 compares the specific discharges from the catchments in the different years gaugings were carried out.

Table 1 Comparison of specific discharges for various years in which discharge measurements have been made. Early and latest summer drought discharges recorded used in this comparison.) All figures are specific discharges in 1 s^{-1} km^{-2}.

Catchment and site	**1977-78 drought** *early Jan – early Feb*	*late Mar – Apr*	**1976-77 drought** *early Jan – early Feb*	*late Mar – Apr*	**Other years low flows** *Year*	*early Jan – early Feb*	*late March – Apr*
Falls Creek							
West Trib	8.1	5.6	11.1	8.5			
East Trib	9.3	6.7	11.6	7.5			
Steep Walk	6.2	–	11.6	8.8			
Hakaru River							
Totara Berry	10.5	6.0	13.9	12.9	*1975–76*	13.4	10.0
Langs Beach							
' Pine Straight"	3.6	1.5	3.6	3.2	*1972–73*	–	1.8
					1973–74	2.3	1.8
					1974–75	1.5	1.0
Mangawhai Hbr							
"Silver Stream"							
High Culvert	2.3	0.4	–	2.6			
3 Lob Bridge	3.6	2.1	–	2.5			
Cave-In	6.5	3.3	–	4.9			
Binder-Twine					*1975–77*	5,9	4.7
					1976–77	5.0	2.5
Otaika Stm							
Roadside St	3.5	2.4	–	–			
Petaka Stm							
H/S Intake	3.5	2.4	5.2	3.5			
Trib	–	2.0	3.2	2.9			
Piroa Stream	9.6	6.3	11.5	9.3	*1974–75*	7.2	6.9
					1975–76	12.9	11.2
Raumanga							
City Weir	2.1	1.8	–	2.9	*1973–74*	4.8	2.8
					1975–76	–	1.9
Rockell Bay	–	–	–	–	*1975–76*	19.5	15.0
Ruakaka River							
Flyger Rd	–	–	–	–	*1961–62*	3.5	1.1
Tahopanui							
Kauri Mtn Stream	–	–	3.9	3.4	*1972–73*	–	2.6
					1973–74	4.6	3.7
Taihu Stream	–	1.9	5.3	3.2	*1967–68*	–	2.4
					1972–73	–	1.3
					1973–74	3.2	2.3
					1974–75	–	2.4
Tarawhaturoa							
Bull Roar	–	–	–	–	*1975–76*	7.5	3.9
Sewer Duct	–	–	–	–	*1975–76*	7.2	–
Tauroa Stm	–	–	2.4	1.5	*1972–73*	–	1.7
					1973–74	1.9	1.6
Tee Hihi Stm							
Health Camp	–	1.7	–	–	*1970–71*	7.0	3.9
Te Wairoa							
Clements	–	–	–	7.0	*1972–73*	–	2.5
					1973–74	2.9	2.5
					1974–75	4.2	–
Waikaraka	–	1.7	–	3.1	*1972–73*	–	2.3
Waionepu							
Bint Rd	–	5.7	–	2.2	*1975–76*	–	7.6
Waiotama							
Crawford Rd	–	4.9	–	11.7	*1972–73*	–	4.6
					1973–74	4.9	2.8
Waiotoi	–	–	–	6.6	*1974–75*	4.7	–
					1975–76	–	7.7
Waiparera	–	–	9.4	6.8	*1972–73*	–	2.4
					1973–74	4.9	3.7
					1974–75	–	4.2
					1975–76	–	6.9
Waipu Cove	–	1.5	–	–	*1972–73*	–	1.4
					1973–74	3.6	2.6
					1974–75	1.9	1.1
Waitangi R							
Ngunguru Rd	–	1.8	–	–	*1973–74*	–	3.4

[3] Kerikeri water resource survey for a Water Allocation Plan

Data collected over the past eight or so years in the Kerikeri Region is probably sufficient for the preparation of a water resources report adequate to meet practical requirements for the operation of a water allocation plan.

The preparation of the detailed water allocation plan is inseparable from, and will have to take into account, any crown water right which may be applied for in respect of the proposed irrigation scheme for the area. As soon as the water resources report is available and the irrigation scheme proposals are crystallised the final preparation of the water allocation plan will proceed. In preparation for the water allocation plan the Fisheries Management Division of Ministry of Agriculture and Fisheries has reported on species and fishery aspects and associated minimum flow requirements following their survey on 16-20 March 1977.

A critical tool in the management of the resource will be the three compound crump weirs and recorders now installed in the Kerikeri, Rangitane and Waipapa Catchments. Another key control will be the weir and recorder on the Puketotara River near its confluence with the Kerikeri River. This is being constructed by the Bay of Islands County Council in accordance with requirements imposed on a water right for public water supply for Kerikeri.

Ten sites on the main rivers draining the Kerikeri inlet were sampled during December 1976 - March 1977 and February - March 1978. The parameters used to assess basic water quality were temperature, pH, dissolved oxygen, the soluble nutrients NO_3^-, NH_3, PO_4^{3-}, and the coliform bacteria count. In addition an estimate of colour, turbidity and flow (discharge) were made at each sampling point. Preliminary findings are that there are very consistent values for nutrients and coliform bacteria counts and that, while the rivers are classified B or D, there is an apparent fairly high class C standard throughout.

[4] Kaihu water resource survey for a Water Allocation Plan

Work is proceeding with preparation for publication of a water resources report for the Kaihu River catchment. This follows a concentrated effort over the 1977/78 low flow period to collect adequate flow, water quality and existing water use data. This work has involved a great deal of collaboration between technical staff of Ministry of Agriculture and Fisheries (Fisheries Division), Ministry of Works and Development, Hobson County Council and Engineering Consultants to the North Auckland Electric Power Board.

Considerable effort has also been expended by commission staff in construction, maintenance and preparation of a stage-discharge rating at a new level recorder site at Rotu.

Available reports with some relevance to the water allocation plan are:

(a) Geology of the Mangakahia Subdivision – R.F. Hay, NZ Geological Survey Bulletin 61. 1960
(b) NZ Geological Survey Map Sheet 2A, Whangarei – B.N. Thompson. 1961
(c) Soil Conservation Survey of the Kaihu Catchment – B.E. Burridge, Northland Catchment Commission. 1966 (Superseded in part by (h) below)
(d) Preliminary Report on Development of Power Resources of the Upper Kaihu Catchment – Tonkin-Muir Venture Group. 1970
(e) Investigation Report on Development of Water and Power Resources of the Kaihu and Mangakahia Catchments – Tonkin-Muir Venture Group. 1974
(f) Horticultural Development - Dargaville District – W. Stacey, Ministry of Agriculture and Fisheries. 1974
(g) Hydrology of the Upper Kaihu, Mangakahia and adjacent catchments – Tonkin-Muir Energy Group. 1975
(h) NZ Land Resource Inventory Worksheets – Water and Soil Division, Ministry of Works and Development. 1975
(i) The Ecological Implications of the Kaihu Hydroelectric Scheme – Bio-researches Ltd. 1978
(j) Kaihu Hydroelectric Scheme, Multipurpose Aspects – Tonkin and Taylor. 1978
(k) Preliminary Summary of Water Quality of the Kaihu River and Upper Tributaries – Northland Catchment Commission. 1978

Seven sampling sites have been established on the Kaihu system for the purposes of assessing water quality. Sampling and analysis were carried out between April - May 1977 and December 1977 - January 1978.

Water quality varied greatly with flow, weather, season, time, etc. and, with only two sets of data available to date, generalisations must be of a preliminary nature only. These indicate a fairly close correlation between land use and water quality. On the whole, the area is fairly intensively farmed with most of the catchment in a more or less developed stage.

Values of pH (6.5-7.4) show almost neutral conditions. The 1978 summer Kaihu site was exceptional with a pH of 7.95.

Ammonia varied between a trace and 0.16 mg l^{-1} but generally was about 0.05 mgl^{-1}. Dissolved phosphate varied between a trace and 0.08 mg l^{-1}, being generally about 0.04 mg l^{-1}. Little variation was noted of these nutrients between the autumn and summer series. Nitrate levels however varied between 0.97 and 2.5 mg l^{-1} in autumn and 0.14 and 0.65 mg l^{-1} in early summer. This seasonal variation in nitrate is as yet unexplained but seems fairly consistent throughout the Northland region.

Both presumptive (total) bacteria levels and faecal coliform bacteria levels were slightly up in the summer series, but the waters tested all conformed to an "attained standard" (these waters are not classifiedd) of either B or C based on the criteria used in the schedules to the Water and Soil Conservation Act 1967.

[5] Maunu/Whatitiri water resource survey for a Water Allocation Plan

The objective is to determine the groundwater resources in the region with respect to availability limits and locations of optimum yield so that the exploitation of the resource can be planned to best advantage and allocated accordingly. This water allocation plan although well advanced is still in the "resource determination" phase.

The Department of Lands and Survey has surveyed 16 photo-identifiable control points so that with suitable conditions being available for aerial photography a photogrammetric map at 1:25 000 can swiftly be prepared. Meanwhile old existing maps and aerial photographs are having to be used.

The Auckland University Geology Department was engaged using Auckland University Geology and Engineering Department instruments in a specially adapted Cessna aircraft to undertake a geomagnetic survey of the area. Following the flight all the magnetic punch tape data from the magnetometer survey was converted to computer punch tape for analysis. Surface contours were also digitised for computer analysis and a map of observed total force magnetic anomalies was prepared. The effect of the visible volcanics down to 152.4 m elevation was then removed and a map of residual magnetic force anomalies was prepared. Following this a preliminary assessment of the catchment boundaries of the concealed sedimentary basement material was made by Professor Hochstein.

The third stage of the project (carried out December 1977 - February 1978) was a preliminary interpretation of the residual magnetic anomalies in terms of thickness of basalt flows beneath 152.4 m evaluation. Also, as a check against these, gravity measurements along three profiles to obtain independent confirmation as to the thickness of the volcanics was carried out by a BSc(Hons) geophysics graduate assisted by commission field staff. Following the field survey the data was computer processed and the concealed less-permeable sedimentary basement was summarised in map form.

A final report and interpretation of the geomagnetic survey, together with follow-up test pumping from bores to be sunk at optimum sites, will ensue after Professor Hochstein returns from sabbatical leave in June 1978. In the meantime summer low flow gaugings have been carried out of all streams having their origins in this volcanic region, weekly readings of groundwater level are being kept at two bores in the region, and all 65 existing water supply bores in the area have been located and bore logs summarised.

In correspondence with Professor Hochstein he emphasised the need for drilling holes and carrying out pump tests and level observations "to get a good control as to the future management of the Whatitiri Catchment area by observing the water level." He has suggested two sites in the centre of the extrapolated basement valley. The sinking of test holes and carrying out of pumping tests as a means to testing the predictions of the geomagnetic survey method has been the subject of some discussion between the Commission's water resources officer and Ministry of Works and Development water and soil staff. The carrying out of pumping tests as a resource determination and future management guide to the ground water is considered wise and lies within the stated objectives of the management plan. It is proposed to sink one bore and test hole in 1978-79 and one in 1979-80 and concurrently to obtain good stratigraphic columns.

[6] **Water quality monitoring - Northland**

Over the past two years, the commission staff have undertaken a water quality monitoring programme over the Northland region. The general aim of this survey has been to establish existing quality data for both saline and non-saline resources in the region in relation to classified and unclassified waters.

Eighteen representative sampling areas comprising approximately 200 separate sampling sites have been established. The parameters used to assess basic water quality are temperature, pH, dissolved oxygen, the soluble nutrients NO_3^-, NH_3, PO_4^{3-}, and the coliform bacteria count. In addition, an estimate of colour, turbidity and flow or tidal state is made at the sample point.

Each area is sampled five times (usually within a 30 day period) and from this data a water quality monitoring summary sheet (the result of taking the median value) is prepared. It is intended that a given area will have a summary sheet for each season of the year. Also indicated on the summary sheets are the attained, and where applicable, classified standard of quality, as set down in the schedules to the Water and Soil Conservation Act 1967.

Testing to date has shown in general that the waters of Northland, when considering nutrient and bacterial content, are of high quality. Exceptions occur in the vicinity of some primary industry processing plants, in minor streams and drains in some communities, and occasionally adjacent to dense concentrations of dairy farms.

During the summer the contamination levels of waters in these areas rise. This is due to the associated high temperatures and low flows, coupled with the greater influx of holiday makers and tourists to some coastal resorts and beaches.

Another notable trend in the results is the increase in nitrate concentration during the early autumn months. Values tend to remain relatively high over the winter and start to taper off at the onset of the following summer.

[7] **Bream Bay - Ocean Beach, East Coast, North Auckland**

In April 1976, the Commission in conjunction with the Water and Soil Division, Ministry of Works and Development, Auckland, began beach process studies on the Bream Bay - Ocean Beach coastal stretch as part of resource survey work in the Auckland Works District. The survey is being undertaken to provide information on coastal processes that can be used to enable effective planning and management of the coastal zone These data will have special application towards:

(a) determining the stability of the Bream Bay - Ocean Beach coastal stretch where there is high capital investment in power station sites and an oil refinery;

(b) wise management and development of beach and dune systems in the area and in determining a safe coastal buffer zone in areas where future coastal development may take place;

(c) determining the effect of commercial sand removal from the beaches and offshore areas.

To monitor beach changes along the coast, survey sites are established at approximately 1.5 km intervals, the site spacing varying slightly to avoid river mouths and rocky outcrops at the beach ends. At present, 22 sites are surveyed, 6 on Ocean Beach and 16 on Bream Bay. At any particular site, the survey line consists of an onshore profile from the hind-dune area to a short distance seaward of the low water mark (approximately 120 m) and an offshore profile from the shore end of the onshore profile through the offshore bar zone (when present) to approximately 450 m seawards of the dune face.

The onshore profiles were to be surveyed at one-monthly intervals and the offshore profile at three-monthly intervals. Additional surveys were to be carried out once or twice a year after major north to easterly storms. To date, however, offshore surveying was done on a less frequent and more irregular basis as techniques were experimented with and developed One survey was carried out after a major storm.

Commission staff have been employed in the levelling of the onshore profiles while the surf zone and offshore profiles have been levelled simultaneously by Ministry of Works and Development staff. The beach profiles were levelled on eight occasions in May, June, July, September, October, November and December 1977 and February 1978. In the months of May, October, December and February the offshore profiles were also levelled. During the year trials with the use of a helicopter to transport the levelling sledge through the surf zone instead of using a boat have proved reasonably satisfactory. During 1977-78 the final tying-in of the profile bench marks was completed.

[8] **Waiarohia Stream survey**

The objectives of this survey are to check and update the information which was used for designing the Whangarei City flood protection scheme. Conditions in the catchment have changed considerably and reliable information on flows etc. is necessary before any further accurate design work can be done. The survey was approved recently and only site inspection and investigation has been carried out.

AUCKLAND REGIONAL WATER BOARD

[1] **Franklin water resource survey for a Water Allocation Plan**

This survey which is being carried out jointly with the Waikato Valley Authority is aimed toward the production of a water allocation plan to ensure sufficient use is made of a limited groundwater resource. In was initiated following a request from the Franklin County Council in April 1974.

In September 1977 a report entitled "A Study of the Water Resources in Franklin County" was received by the board. The report summarised the work to date, came down with guidelines to assist decisions on water right applications and indicated the directions of further study.

In line with the report the 1978-79 programme will aim to improve data and evaluations already made in the Pukekohe Plateau area and to extend the study into the remainder of the central Franklin County. Important aspects will be to:

(a) sink four bores to verify and monitor the lower volcanic, shellbed and upper aquifers and the south side Pukekohe Hill;
(b) construct a permanent weir on the Mauku Stream;
(c) regularly measure low and high stage flows in a network of approximately six stream sites, with Ministry of Works and Development continuing to measure flows in major catchments;
(d) construct and analyse performance of a lysimeter for the purpose of more accurately determining evapotranspiration, currently the most significant unknown in determining the water balance;
(e) carry out water quality testing.

[2] **Omaha/Leigh water resource survey for a Water Allocation Plan**

This survey commenced in January 1977 with the aim of producing a water allocation plan. The conflict between potential horticultural development and urban development on the Mangatawhiri Spit is the main reason for implementing this survey.

Flow data has been obtained at a permanent weir on the Tamahunga Stream and at three temporary weirs on other streams, and it is supplemented by low flow gauging data from sites elsewhere. Twenty-three bores were located and levelled, water levels measured and a piezometric map produced. Two wells were monitored continuously. The water quality of legal and illegal waste discharges and ground and surface water has been assessed.

A preliminary report has been prepared (A Preliminary Assessment and Interim Water Management Plan, Omaha Leigh Water Resources Study: ARWB, Tech. Pub. No. 4) which in terms of a general assessment of the water resource in the area comments as follows:

"Based on the data obtained over the last two years (1976-77), a general assessment shows that the Omaha-Leigh study area consists of two separate regions of differing hydrological characteristics. The northern region is dominated by a short range of steep greywacke hills coated with sandstone rocks. As a result, rapid runoff after rainfall is the norm. Stream flows are exceedingly low in summer but can be very high in winter and spring. Groundwater supplies are generally scarce and unpredictable.

"The southern region, referred to loosely as the Omaha Basin, is notable for a significant but again somewhat unpredictable groundwater supply from the fractures in buried Waitemata Group sandstones and siltstones. The most important stream in the basin, the Tamahunga Stream that flows in the Big Omaha Valley, may be the major source of water to the Omaha aquifer, via its shingle bed to fracture zones in the sandstones. Another small recharge zone may exist immediately south of the Omaha Sandspit at the base of the Takatu hills.

"The extreme hardness of the Waitemata Rocks in this area makes it extremely unlikely that any significant quantities of water can enter the confined aquifer by infiltration over exposed rock surfaces. The exact extent of the recharge zone in the Tamahunga Stream is not known and therefore no reasonably-based estimate of annual recharge from the stream can be given at this stage of the study."

It seems so far that the abstraction of groundwater on the Omaha Spit has no discernible effect on static water levels in bores on the Omaha Flats. What is not known is the influence of such abstractions on the horizontal position of the saltwater-freshwater interface, which presumably occurs somewhere east of Omaha Beach, but towards the sea.

The study has not as yet obtained sufficient reliable data for the formulation of a full water allocation plan hence the 1978-79 programme will comprise updating of some of the water use data and a continuation of monitoring hydrological data. The final report is expected in 1979-80.

[3] **Parakai water resource survey for a Water Allocation Plan**

A rapid decline in thermal groundwater levels in Parakai bores during 1975 was brought to the attention of the board which agreed to carry out a study to determine the extent of the hot water resource and to produce a water allocation plan to facilitate its efficient management.

All bores, both used and unused, have been located, plotted and levelled. Water levels in five of these bores are measured weekly. Two full pieziometric surveys have been carried out.

One pump test was carried out by the DSIR on the County Bore with inconclusive results. Assessment of the potential volume of water available from the resource has been delayed by the slow ordering and delivery of water meters and by the breakdown of most meters that have been installed.

The programme for 1978-79 will be to:

(a) analyse the continuous water level recordings and identify the influence of each surrounding bore on the observation bore;
(b) carry out further pieziometric surveys to monitor changes in the water surface and to establish the effects on this surface of pumping bores;
(c) periodically survey water temperature to determine the extent of the hot water field, to monitor changes in the hot water field and to establish the relationship between drawoff and and temperature;
(d) survey water quality to assist in the assessment of subsurface conditions.

As soon as reliable water usage figures are available an assessment of the potential resource will be made.

[4] **Waiwera water resource survey for a Water Allocation Plan**

The purpose of this survey is to prepare a water allocation plan for the most efficient recreational usage and equitable sharing of the finite water resource.

To date all the known thermal water bores have been located, plotted and levelled and an estimate has been made of all water usage. An automatic water level recorder has been installed on a disused bore and the records from this are being collected for analysis. A network of five bores are monitored on a regular basis. Some bore logs have been obtained from the local driller and from N.Z. Geological Survey files.

In 1978-79 changes in groundwater level will continue to be monitored manually and by automatic instruments, and the

effects of pumping on groundwater levels will be examined. Periodic water temperature measurements to monitor changes in the hot water supply and a water quality survey to assist aquifer studies will be taken.

[5] **Hoteo water resource survey for a Water Allocation Plan**

The main reason for including this survey at this early stage of the board's long term programme is not because there is any known shortage or heavy demand on the water resources of the Hoteo Catchment but mainly because it is the largest single catchment area within its region and there is a lack of hydrological and water use data within the area.

This survey was started in 1976-77 with the purchase of a recorded and preliminary investigations for a permanent gauging site(s) (low and flood flows) on the lower reaches of the main river. A site was finally selected and the recorder installed in 1977-78. Instrument malfunction and flood damage to the support structure prevented early collection of useful data but these problems have been overcome. Ten sites have been selected throughout the catchment for stream flow gauging and more than twenty gaugings have been carried out at these sites. Twenty-one manual raingauge sites have been selected and installed. Water quality observations are being made monthly at the continuous flow gauging station.

Regular gauging at high stage to rate the continuous flow station, intermittent gauging at the ten other gauging sites, review and completion of the raingauge network as necessary and continuation of the monthly water quality monitoring will be carried out in 1978-79. Land capability mapping, initial appraisal of geology and groundwater potential and preliminary water usage assessments will also be undertaken.

[6] **Kaipara water resource survey for a Water Allocation Plan**

Increasing demand by localised urban growth and horticultural development on the water resources in this area, in what appears to be a low yield system, has necessitated the early preparation of a water allocation plan. Other peculiar characteristics of this catchment related to river and land management require that this survey be extended to land use practices (e.g. sand drift control, stop bank control) and that a thorough study of the flood characteristics of the river be made.

This survey was commenced in 1976-77 with the purchase and installation of a water level recorder on a tributary at the particle board factory. To date flows on the tributary have been continuosly recorded and four manual raingauges have been installed. A long term observation site on the main river at Waimauku, just upstream of the tidal influence, has been selected and surveyed and the recorder structure has been designed. Tidal influence was recorded continuously through two tide cycles, one of a neap tide, the other a spring tide. Levels were recorded at sixteen sites and the flow gauged at three. This data is currently being analysed. A post-graduate student was commissioned in 1977-78 to produce a mathematical model of tidal characteristics of the lower sections of the river.

During 1978-79 a permanent recorder station will be constructed at Waimauku, three deep penetration groundwater investigation and monitoring bores will be drilled, the rainfall network will be reviewed and extended as necessary, and a post-graduate student will be commissioned to produce a mathematical model of high flow characteristics of the river (to be superimposed with the tidal model). Land use mapping, land capability mapping and the assessment of existing water use will be initiated. Water quality monitoring and a physical survey of the flood plain in the lower reaches of the catchment will also be undertaken.

HAURAKI CATCHMENT BOARD

[1] **Mamaku Range water resource survey**

This survey has been in progress since June 1976 with the data collected to the present time representing flow conditions in the lower end of the spectrum, viz. base to moderate for the waters in the survey area.

Samples taken within the Waipari and Kuhatahi Catchments show that the water is of high quality and has low sediment concentration. On only two occasions to date has the suspended load as sampled exceeded 100 ppm with the mean load being around 25 ppm. A similar trend has been noted for the Waihou River system between Tunnel Road (upper site) and Whites Road (lower site).

The Oraka Stream system differs in appearance from the first two catchments but although volumes of flow and transported sediment are greater, concentrations have been relatively low, exceeding the 100 ppm level on only two occasions during the sampling programme.

During the construction of road works upstream of the Tunnel Road gauging site a maximum suspended sediment concentration of 430 ppm was recorded but this appears to have been an isolated occurrence. Flood and high flow data is scarce in the study to date and this situation is very largely due to the lack of automatic equipment. Invariably events have almost always taken place before personnel can cover the distance between base and the sites. Hence data collected for higher levels of concentrations of sediments at high flows have only been spot checks.

Data collected from the Debris Stream in the Waipari Catchment has shown high concentrations of sediment, up to 2400 ppm but with a corresponding drop to around 100 ppm at 100m downstream of the confluence. This suggests that there is a high percentage of finer sediment settling out between the two sampling stations. Isolated samples were taken on the Waipari at Capricorn Road with a suspended sediment concentration of 4545 ppm at a flow of 550 $l\ s^{-1}$ being recorded on one occasion.

Basically the data outlines the baseline state of water quality and quantity over two seasons in the catchments under study. More data are required to accurately establish the sediment loads during floods and high flows.

[2] **Hauraki routine hydrology investigations**

These have been operated only at a basic data collection level and no detailed analysis of results has been carried out. Two recorder sites have now been connected to Leopold and Stevens digital recorders as part of the board's radio telemetering system.

There were no significant flood flows during 1977-78 and the summer period was marked with a period of low rainfall. November was below average, December average and January to March below average. The dry spell broke in mid-April. A programme of low flow gaugings was initiated. In several areas the lowest flows on record were gauged with other areas approaching minimum levels.

It would appear that this routine data collection has too wide a coverage and it will be split into a resource survey, a water allocation plan and a scheme for works.

[3] **Fluctuations in ground surface levels and drainage patterns with peat mining land use – Hauraki**

This involves annual surveys of ground surface levels and the taking of cores to establish extent, depth and type of peat.

Three survey benchmarks were installed and a single set of levels to establish present ground level was taken in 1977. No further levels have been taken as yet and consequently no qualitative conclusions as to surface levels can be drawn at this time.

Borings to establish depth and extent of peat will be carried out in the near future when the board's drilling rig is completed.

[4] **Whiritoa Beach sand removal survey**

The board, primarily with the assistance of the University of Waikato, has surveyed the beach sand removal from Whiritoa Beach. The objectives were to examine if the beach could sustain further removal of beach sediment without causing erosion of the frontal dunes.

It appears that the beach has receded during the past 20 years and with continued sand mining will continue to do so. Sand mining at the present rate will deplete the existing supplies of sand in approximately 12 years. The result will be that during a normal winter recessionary phase the frontal dune will undergo severe modifications. Public outcry will occur sooner as already storm swash reaches within 10 to 15 m of property boundaries.

A report to the board based on the thesis of a student working on the survey in summary states:

(a) Whiritoa Beach apparently follows the classical equilibrium beach model.

(b) The sediment grain size apparently increases at either end of the beach.

(c) The mineralogical analysis of the heavy mineral components indicate that Whiritoa Beach is related to the Minden Rhyolites which outcrop to the north of the beach rather than to the Beesons Island Volcanics group which outcrop to the south, and that large scale sediment flux along this sector of coast is unlikely. The evidence therefore points to the liklihood that Whiritoa Beach is more or less a "closed system" or "pocket" beach in the short term.

(d) Severe erosive events are most likely to occur in April - July, especially in response to waves generated by storms of tropical cyclone origin. Such storm waves possess a significant wave height of 1.5-1.8 m with a period of 8-11 secs.

(e) Onshore-offshore movement of sediment can be extremely rapid with as much as 40 m^3 per metre of beach being moved within a tidal cycle.

(f) Maximum sand loss from the beach (recorded in 1974) was 112 000 m^3. The difference between the 'average' summer and winter conditions was about 50 000 m^3.

BAY OF PLENTY CATCHMENT COMMISSION

[1] **Routine hydrology records – Bay of Plenty**

Recorders were maintained and serviced during 1977-78 at sites on the Kopuaroa Stream, Atuaroa Stream, Ohineangaanga Stream, Kaituna River at Fords Cut, Ohiwa Harbour at Wharf (tidal record), Whakatane River at Valley Road, Waimana River at Gorge and Waitahanui River. The four recorders in the Kaituna area were originally installed to collect information to be used in the design of the Kaituna River major scheme. The information is now also of use in water resource surveys in this area where irrigation is becoming increasingly important.

The Commission maintained and serviced three Lambrecht rainfall recorders at Grant Road (Galatea), Matahi (Matahi School in Waimana catchment) and Tarapounamu (Waikaremoana Road on watershed of Whakatane and Rangitaiki catchments) and four storage raingauges elsewhere in the commission's area.

River and stream gaugings were carried out as required, rather than on a regular basis. The Water and Soil Division's field hydrology group in Rotorua is carrying out gaugings and servicing of recorders at the main gauging sites in the commission's area.

[2] **Tauranga Harbour water resource survey for Water Allocation Plan – preliminary investigations**

The Mt Maunganui and Bowentown entrances of Tauranga Harbour were gauged on 8 February 1978. The gauging was organised by consultants with the majority of the actual gauging work being carried out by the staff of the Ministry of Works and Development. The Bay of Plenty Harbour Board also provided advice and assistance.

The gaugings were done at a series of stations located along a gauging line across each of the entrances. It was intended to buoy individual gauging stations along the line but this proved impractical because of the strong tidal currents. The gauging stations were therefore defined either by rangefinder distances from the shore or by cross bearings from remote survey stations. The gauging boats were then directed onto their station by radio. Three boats were utilised at each entrance. Current velocities were recorded at 10%, 40%, 60% and 90% of the depth at each station successively, with all stations being gauged at 45-60 minute intervals during the 13-hour gauging period which covered a high-low-high tide cycle. The report on these gaugings is being prepared.

[3] **Underground water resource, Mt Maunganui and Ohiwa for Water Allocation Plans**

An initial appraisal of each area was made by consultants (engineering and geological), and a detailed proposal prepared for investigation work during the year. It was also recommended that the board's current programme of water level recording at Mt Maunganui be augmented by installing an automatic recorder in one bore. The scope of the study was also extended to provide a preliminary assessment of underground water resources at Papamoa.

During the year field trips were made to each area and information was obtained on existing water usage. Problems with bores and deficiencies in water quality were also noted.

This information is now being analysed and an interim report is being prepared which will include recommendations for more detailed field studies at Mt Maunganui and Papamoa, including the sinking of additional observation bores in each area and a number of pump tests.

Although only limited investigations were carried out on the Ohiwa sandspit these have indicated that there is little likelihood of adequate resources being available to support any substantial water supply scheme. It is proposed that this investigation be terminated. The data collected to date may, however, be of use to a consultant geologist who is carrying out an investigation into groundwater resources at Ohope Beach for the Whakatane District Council under a separate commission.

[4] **Bay of Plenty coastal erosion survey**

The Commission, in conjunction with Waikato University, has been identifying, mapping and measuring areas of coastal erosion throughout the Bay of Plenty. The objective is to identify areas for adequate foreshore reserves that can be excluded from development. A very comprehensive report was published in July 1977. In brief it states:

(a) that 51 beach profiles were established for intermittent long term monitoring betweeing Opape and Waihi Beach;
(b) the causes of beach erosion and dune recession are complex and related to a number of factors and sedimentary processes, some natural and others man-induced;
(c) sand extraction activities from the beaches have caused localised dune recession and should be carefully monitored to check for permanent dune damage and recession;
(d) sedimentological and mineralogical analysis point to the central volcanic plateau as the likely source of the littoral sediment;
(e) net littoral drift is in a south-eastward direction;
(f) the majority of the beaches have only a limited area of back beach development.

The work is to continue in 1978-79 with monthly monitorings of the beach profiles for those areas susceptible to erosion-accretion cycles. Particular watch is being kept on the Waihi Beach and Pukehina areas.

[5] **Whakatane River channel survey**

This survey includes the re-survey of all river sections, the plotting of these and comparison with earlier surveys, new aerial photography and bed material analysis. The report prepared on completion of the survey will give special consideration to the effectiveness of channel training works and the shingle resources available in the river.

The 69 river cross-sections have been surveyed and plotted. Previous cross-section information has been converted to metric units and plotted on the same plans. Detailed bench-mark finder-diagrams have been drawn and these should ensure that all may be found with the minimum of trouble. A new series of aerial photographs of the river have been taken and one set of these has been assembled as a mosaic.

In 1978-79 it is proposed to obtain representative samples of the river bed material and carry out standard grading analyses. On completion of this a report covering the full survey will be made.

WAIKATO VALLEY AUTHORITY

[1] **Upper Mangawara land resource survey**

The Authority has completed a land use capability survey over some 10 000 ha of the southern Hapuakohe Range, and this indicates the Upper Mangawara to be the main problem area.

A committee was established, representative of government departments and local authorities, and it agreed that an element of forestry was required in the catchment. This report proposes the establishment of 1722 ha of exotic protection/production forest within the Mangawara catchment immediately north of Hoe-o-tainui, Piako County. The proposals are based on an extensive examination of physical catchment characteristics, including detailed land use capability assessments, geo-hydrological behaviour, land ownership and land valuation and they are in response to the concern of the Taupiri Drainage and River Board over the impacts of upstream land use on the security and efficiency of its downstream flood control investments.

Progressive forest removal and grassing of the upper catchment has increased susceptibility to hillside instability and has increased rates and amounts of runoff, with impacts on stream channel stability and the capacity of streams to accommodate the products of erosion. Consequently there are detrimental effects downstream. It is considered that a strong element of controlled forest establishment and management is the most efficient and appropriate technical land treatment measure available to complement immediate downstream capital investments which are integral with the Lower Mangawara flood control scheme as a whole.

The catchment of the Mangawara upstream of Hoe-o-tainui is predominantly under pastoral land use and either all, or parts of, 12 farm units are affected by the proposals. The proposals will alter the land use pattern as follows:

Commercial production /protection exotic forest	1722 ha
Restructured farm units (4)	520
State indigenous forest	311
Scenic reserve	497
Total study area	3050 ha
Total area upstream of Hoe-o-tainui	3431 ha
Commercial production/protection forest, Hauraki catchment	483
Indigenous retention, Waiti Valley	263

The proposals attempt to achieve a long term land use balance through the promotion of forestry on erosion susceptible hill country and the retention of higher class arable lands for farming purposes. The concern of environmental conservation interests is also acknowledged.

The approach toward implementing proposals acknowledges the shortage of public funds for the promotion of new water and soil conservation works and is therefore one of coordination and cooperation with willing parties in a free market situation within the regulatory constraints of public policies. Accordingly staff from the Authority and the Fletcher Timber Company have cooperated in preparing complementary reports for the Authority and the board of Fletcher Holdings respectively.

[2] **Whangapoa Catchment regional water and soil management scheme survey**

The objective of this survey is the evaluation of the land and water resources for a costed regional water and soil management scheme, to be implemented through catchment control financing and town and country planning. Field work has been completed and a draft report has been prepared.

[3] **Upper Waipa/King Country land resource survey**

This project has involved authority staff assistance to Ministry of Works and Development in the preparation of the Upper Waipa portion of the King Country Land Use Capability Survey.

Present information is being more closely evaluated and mapped at a 1:20 000 scale. A catchment control scheme report is to be prepared.

[4] **Paeroa Range regional water and soil management scheme survey**

The objective of this survey is the evaluation of land and water resources for a costed regional water and soil management scheme to be implemented through catchment control financing and town and country planning.

Based on a 1:20 000 land use capability survey a comprehensive catchment control scheme for an area of some 80 940 ha is in preparation.

Work proposals for erosion control are currently 75% completed. Water quality and quantity work is also proceeding in association with work being done on geothermal development (Broadlands) and general water quality monitoring in the Waiotapu basin to aid in the development of an overall management scheme.

[5] **Lake Arapuni regional water and soil management scheme survey**

A comprehensive report on this survey summarises physical data relating to Lake Arapuni and sets out recommendations to establish and secure a coordinated water and soil management plan for the land area draining to Lake Arapuni downstream of Waipapa Dam. Proposals acknowledge the water and soil, scenic, recreational, industrial and regional community significance of the catchment and its waters.

Lake Arapuni is formed behind the Arapuni Hydro-electric Dam and extends 19 km upstream to Waipapa Dam. Lake Arapuni is the seventh in a series of eight hydro-electric impoundments on the middle Waikato River extending from Aratiatia to Karapiro. Between the Waipapa and Arapuni Dams 25 900 ha drains into Lake Arapuni. Catchment ownership is predominantly freehold with approximately one-third in private exotic forest tenure. The territorial counties of Matamata, Otorohanga and Waipa are responsible for local administration.

The New Zealand Electricity Department has a major interest in the lake and this is expected to be consolidated should approval for Arapuni B be obtained.

The report recognises three areas of general input and responsibility. These are:

(a) a water and soil conservation input and responsibility being the primary concern of the Authority;
(b) a hydro-electric input being the interest of the New Zealand Electricity Department;
(c) a recreational and local administrative input being the concern of the territorial councils.

The scheme offers an administrative and financial format through which these responsibilities can be shared. The water and soil conservation responsibility is contained in the following proposals:

(a) the retirement of pastoral lands and retention of undeveloped cover adjacent to the lake shore and within the catchment for the control of erosion and eutrophication processes, with conservation planting being compatible where possible with wildlife, recreational and landscape requirements;
(b) the encouragement of forest management policies and practices in line with the forest operations guidelines but with special regard for the environmental sensitivity and community significance of Lake Arapuni;
(c) the administration of water rights within the catchment having special regard for Arapuni waters;
(d) the initiation of a water resources survey to establish the need, or otherwise, for a formal water allocation plan.

[6] **Maui Pipeline land route evaluation**

The Authority is a member of a liaison committee responsible for developing and promoting a programme for restoration work. Authority staff have continued monitoring the construction and restoration work over the past year and produced reports to illustrate their shortcomings.

While most of the total length of the line in the Authority's area has responded to restoration, points along the section between Mokau and Mahoenui have exhibited the problems predicted by the Authority in 1976. In this latter section the restoration work has not been adequate for the magnitude of the problem, indicating the need for constant specialist attention.

[7] **Waitomo Catchment water and soil management scheme survey**

The objective of this survey is identical to the surveys of the Whangapoa Catchment and Paeroa Range as listed above. Land use capability data at a scale of 1:20 000 has been completed. The draft report and scheme proposals are in preparation.

In addition water quality data and flow data are being collected for an overall management scheme in order to protect the reserves at Waitomo Caves.

[8] **Franklin water resource survey for a Water Allocation Plan**

(See Auckland Regional Water Board, page 19)

[9] **Waikato routine hydrological measurements**

Stream discharges within the catchment were measured continuously throughout 1977-78 at 31 stations fitted with recorders. Four new recorder sites were established on the:

(a) Waipa River at Pirongia providing base-flow data. (this recorder replaces a system of manual readings);
(b) Mangapiko Stream at Te Awamutu providing base-flow data important to water quality assessment;
(c) Opuatia Stream at Pukawa providing data pertaining to groundwater investigations;
(d) Rotongaro Canal at Rangiriri providing data related to groundwater investigations.

Two automatic raingauges have been maintained to provide rainfall coverage over the catchment supplementary to normal NZ Meteorological Service instrumentation and to that provided by Ministry of Works and Development for special investigations.

In addition to sites at which routine low-flow gaugings have been carried out for several years 35 new low-flow gauging sites were established and monitored throughout 1977-78. At each site quantity and quality of discharges were monitored. Water quality monitoring has included colour, temperature, dissolved oxygen and pH. Additionally in 1977-78 conductivity and suspended solids were monitored.

481 low-flow gaugings (quantity and quality) and 50 routine stream gaugings (half of these included water quality) were carried out at non-long term sites in 1977-78. Included within these were routine runs at:

(a) Mangaonua Stream (quality and quantity) – 5 sampling runs, each run involving sampling from 12 sites, 6 of which were gauged;
(b) Mangapiko Stream (quality and quantity) – 13 sampling runs, each run involving sampling from 11 sites, 2 of which were gauged;

(c) Raglan Harbour (quality) – 10 sampling runs, each run involving triplicate samples from 7 sites;
(d) Lake Karapiro (quality) 18 sampling runs, each run involving duplicate samples from 4 sites.

Specific sampling samples studies have included the following:
(a) Raglan Harbour in respect of sewage outfall;
(b) Mangapiko Stream related to effluents;
(c) Lake Karapiro related to sewage and recreation;
(d) Lake Arapuni related to catchment management and recreation;
(e) Mangaonua Stream related to water quality;
(f) Taupo-Wairakei-Broadlands thermal area related to heat inputs;
(g) Lake Taharoa (near Kawhia) related to water balances into and from the lake.

From January to April 1977 low flow gaugings were undertaken by the Authority in association with water quality measurements. It was considered that the extreme low flow conditions were partly responsible for poor water quality found in the streams, which generally speaking were grouped as follows:

(a) those affected by industrial discharges, particularly dairy factory effluents;
(b) those draining mainly peat swamp;
(c) those draining small catchments with no apparent natural causes of poor water quality but with low flows, particularly in summer.

Further quantity and quality gauging of these streams was undertaken during higher winter flows in an endeavour to identify the causes of poor quality found during low flow conditions. This evaluation is proceeding and is intended as a continuing programme of study.

POVERTY BAY CATCHMENT BOARD

[1] **Upper Waipaoa Catchment land resource survey**

A detailed land use capability and land inventory survey has been carried out in the Waipaoa catchment upstream of its confluence with the Mangatu River, but not involving land owned by the New Zealand Forest Service. In addition, the properties on the true right of the Mangataikapu Stream were surveyed.

This survey was programmed for 1978-79 season but was brought forward to accommodate the planning of erosion control on Waipaoa Station, a large part of which had been surveyed with the adjoining Waingaromia catchment in 1976-77.

The land inventory and land capability information has been transferred onto aerial mosaics and some field checking has been carried out. Percentage areas in land capability classes III to VIII are: 2, 0, 1, 56, 34 and 7 respectively.

The final report will contain a legend describing each land capability unit, but for general purposes they conform with the Gisborne - East Coast legend of the New Zealand Land Resource Inventory Worksheets.

The survey information will be discussed with the property occupiers before a report on recommended land use is prepared for the board.

[2] **Poroporo Catchment land resource survey**

The objective of this survey is to produce a recommended land use map on a scale 1:15 840. The Poroporo is a sub-catchment of the Waiapu River.

Data for 95% of the area has been transferred onto aerial mosaics and the land use capability assessment completed. The other 5% (the flat land) will require some more intensive field work to assess the capability of the soils. Once the flat area has been completed, the areas will be measured and the assessment will be discussed with land occupiers, prior to a recommended land use report being prepared and presented to the board.

[3] **Mata Catchment land resource survey**

The objective of this survey is identical to that of the Poroporo Catchment listed above.

The part of this catchment surveyed in 1977-78 included the Whakoau Stream and the true left side of the Mata above its confluence with the Whakoau Stream (Huiarua, Hauturu and Wairangi Stations).

Field information is now being transferred to aerial mosaics, and areas in each capability unit will be assessed. The findings will be discussed with land holders and a recommended land use map will be prepared.

[4] **Ihungia Catchment land resource survey**

The final report on the recommended land use of this catchment has been completed. This is the result of land use capability and land inventory surveys carried out similar to the Poroporo, Upper Waiapoa and Mata surveys listed above.

A review of the possible productive use shows the whole catchment is capable of sustaining a forest vegetation, while only parts are capable of supporting farming in perpetuity. It is hoped to reduce the amount of pastorally farmed land requiring afforestation to a minimum.

In formulating a land use policy a map has been prepared showing requirements for erosion control. The requirements in order of severity are:
(a) no erosion control treatment;
(b) slight treatment under pastoral cover;
(c) moderately intensive treatment under pastoral cover;
(d) intensive treatment under pastoral cover;
(e) afforestation.

Small areas may, with intensive treatment, be able to move up one grouping but on the experience of the September 1976 wet period it can be fairly confidently assumed that large areas will only get worse if the appropriate treatment is not applied.

Land group (e) would involve about 30% of the surveyed land but by the time stable fence lines are established it will probably increase to about 40%. These figures, if land group (d) is added, will be 38% and 50% respectively.

Discussions with land owners are continuing and the board is drawing up a 10 year scheme plan which will indicate the speed with which the land use recommendations can be implemented.

[5] **River shingle and sand resource survey: East Coast**

This survey is determining the sand resources and the quantity of renewable river shingle in the northern East Coast river catchments of Waiapu, Mangaoporo, Tapuaeroa, Awatere and Karakatuwhero. As the East Coast Project is implemented sand and gravel will be required for the development of forestry roads, highways, industry, housing and harbour works. Because beach sand resources are limited in the East Coast region it is expected that washed and screened river sand will be the major sand source for the district. This survey is in year two if its four year programme. The Ministry of Works and Development, Gisborne, are preparing a report on the results of the survey and laboratory tests to date.

[6] **Forestry development regions water resource survey for a Water Allocation Plan.**

This survey is now in its fourth year. Three years of observations have been analysed to provide various data summary formats. The data has already been of considerable use to the East Coast Planning Council and does not detract from the siting of any timber processing mill and related township in the Hicks Bay – Te Araroa region.

Flow data for the Mangatutu, Tangihanga, Waiapu and Hikuwai sites have been analysed for total flow, flow with less than 500 ppm and 100 ppm sediment concentration, lowest mean discharge for 1, 7, 15, 30, 60 days, base flow recessions, flow durations, listings of peak flows, and sediment discharge. Concurrent gaugings at Mangatutu and six nearby sites yielded very good low flow correlations. These suggest that water requirements for a pulp mill at Hicks Bay could be supplied by the Mangatutu, Waitaukakari, Nukutaharua and Waimate Streams at the design rate of 12250 m^3/day. Additional water may be required from the Wharekahika River during dry periods if the mill requirement is increased to 25920 m^3/day, thus more emphasis has been placed on gaugings of this river.

Correlation of Mangatutu with the Parinui, Tawatoa and Pukeamaru Streams suggest that a projected township of 10 000 near the Karakatuwhero River could be easily supplied by these streams.

Preliminary work on rainfall data has been carried out. Some correlation between a Lambrecht automatic raingauge at Mangatutu and four daily manual gauges at Whakaangiangi, Lottin Point, Matarau and Te Araroa has been found. The correlation between these four raingauge sites and the Mangatutu flow record is better than any corresponding correlation between flow and the Mangatutu raingauge. This appears to be due to the stream catchment originating in 900 m plus country in which the rainfall is better approximated by the four manual gauge sites than the low altitude Mangatutu recorder. This indicates a strong need for another recording raingauge at higher altitude, preferably at Hovell's Watching Dog.

[7] **Waimata River water resource survey for a Water Allocation Plan.**

This survey is in the initial stage and no positive results are available at present.

[8] **Te Arai River water resource survey for a Water Allocation Plan**

This survey is in its initial year. Although continuous flow recording has not commenced low flow gaugings and water quality tests have been continued on the Te Arai, particularly during the summer dry weather when flow once more approached a critically low level. A programme to gather and collate all existing data has commenced.

[9] **Channel measurements East Coast: Mangatu and Ruatoria Forests**

This survey is monitoring the effect of change in land use from pastoral to exotic forest on channel morphology from which to forecast short and long term effects on river control works and roading structures on the rivers in the district. Eight small streams and creeks in the Mangatu Forest, and seven in the Ruatoria Forest, are monitored for development of meander pattern, changes in suspended sediment, changes in discharge for given rainfall, changes in vegetation, and changes in transportation of bed load.

Surveys of the selected cross-sections are proceeding as planned and analysis of the data is up to date. The NZ Forest Service have also contributed extra data on bridge cross-sections and have offered further information in future. Some degrade is noticeable on the Raparapaririki and Mangaraukokore Streams. Changes in other sections are indeterminate at this stage.

HAWKES BAY CATCHMENT BOARD

[1] **Waipukurau coastal catchments water resource survey**

Because this survey was approved late in the financial year permanent recorder sites have yet to be instrumented. However, numerous low flow gaugings were undertaken throughout the survey area during the drought period from November 1977 to April 1978, as part of a combined effort with the Ministry of Works and Development staff to cover the whole of the board's district with low flow gaugings. The data was included in a recent unpublished Ministry of Works and Development report on low flows for the Napier district.

During 1978-79 it is proposed to install the Porangahau Stream stage recorder and pluviograph, and to upgrade the existing stage recorder and intensify suspended sediment sampling in the Upper Makara Stream. The land resources group from Palmerston North has been doing a catchment condition and trend study on the Pouhokio catchment and it is proposed that the board undertake a land use capability survey in this catchment as part of the planning necessary for a proposed catchment control scheme.

The board recently completed four of the five flood detention dams in the Upper Makara catchment control scheme. However, before completion of the last and by far the biggest dam, it is essential that sediment yields be quantified. It is proposed to re-survey the cross-sections within the lake formed by the Ponui slip on the Kairakau Stream and determine the volume of sediment trapped over the past two years.

[2] **Wairoa coastal catchments water resource survey**

A river stage recorder and pluviograph have been installed in the Waiatai Valley and these were in operation during the high flood in February 1977. The stream was outflanked at the recorder site and it is now realised that the gauging site is only suitable for measuring floods up to about a 5-10 year recurrence. A new site has been selected upstream and it is proposed to relocate the stage recorder during 1978-79.

The estimated peak discharge during the February flood was 47.0 $m^3\ sec^{-1}$ or 3.85 $m^3\ sec^{-1}\ km^{-2}$. Higher specific discharges occurred in other catchments closer to the storm centre. Preliminary estimates are 6.8 $m^3\ sec^{-1}\ km^{-2}$ for the Tawhara Stream (3.73 km^2) and 9.4 $m^3\ sec^{-1}\ km^{-2}$ for the Kiwi Valley Stream (8.86 km^2).

During the current year it is also proposed to extend the network of raingauges along the coastal strip towards Mahia and to enhance the programme of suspended sediment sampling by the installation of an automatic single point sampler at the Waiatai gauging station. It is also proposed to undertake a land use capability and erosion assessment survey of the Nuhaka catchment.

[3] **Ruataniwha Plains water resources survey for a Water Allocation Plan**

Work for 1977-78 comprised routine servicing of recorders,

and the installation of stage recorders on the Kahahakuri Stream upstream of its confluence with the Tukituki River and on the Waipawa River upstream of State Highway 50. The latter site is upstream of the point where losses to groundwater commence and it will be a permanent site for the purpose of monitoring the Waipawa River flows for management purposes. An evaporimeter was installed at the Takapau Research Station towards the end of 1977.

A comprehensive programme of low flow gaugings was undertaken throughout the survey area during the recent drought period and this data has been incorporated with the Ministry of Works and Development data in the preparation of their recent report on low flows 1977-78.

The Soil Bureau DSIR has begun a resurvey of the soils in the area with the intention of preparing maps showing intensity duration and frequency of soil moisture deficits for various soil groups and these data will be used as a basis for water allocation.

The board is now undertaking a survey for levelling to selected bores in the area. This is essential to obtain a more quantitative assessment of the shallow groundwater resource.

During 1978-79 it is proposed to complete the groundwater investigations and to prepare the interim report on water resources and water allocation for the area.

[4] Heretaunga Plains water resource survey for a Water Allocation Plan

No water resources report is available at present. Work has concentrated on the collection of data for a report on the Ngaruroro River resources, the main considerations being proposed hydro-electric power development and fisheries, recreation and irrigation requirements.

Other water resources work has involved:

(a) preparation of cross-section plots of bore logs in the Karamu and Haumoana zones;
(b) installation of a water level recorder in the Irongate Stream and site works for recorders in the Karewarewa and Tutaekuri-Waimate Streams;
(c) collection of water quality and low flow data for the Karamu Stream and its tributaries;
(d) collection of water use data from industries and municipalities.

It is hoped to complete the water allocation plan for the Ngaruroro River and unconfined aquifer areas of the Plains in 1978. With the collection of further surface water flow data, further monitoring of underground water quality and processing of water demand data, substantial progress should be made in 1978/79 with the preparation of water allocation plans for the Karamu and Hastings zones of the survey region.

[5] Esk Valley water resource survey for a Water Allocation Plan

Stage recording and pluviograph equipment has been purchased for this survey and it is aimed to have the installation completed before winter 1978.

Work has concentrated on a comprehensive programme of stream gauging on various tributaries, particularly during the 1977-78 summer drought. The results of this work were incorporated in the Ministry of Works and Development report on low flows 1977-78.

[6] Ahuriri Lagoon catchment investigations

The steering committee for this study comprises representatives from the Napier City Council, Napier Harbour Board, Hawke's Bay County Council, Ministry of Works and Development, Department of Lands and Survey and Hawke's Bay Catchment Board. A technical committee convened by the chief engineer, Hawke's Bay Catchment Board, held two meetings during the year and at its last meeting considered a number of reports by the various technical organisations involved.

Hawke's Bay Catchment Board

(a) Land inventory, land use capability, catchment condition

The report concluded that soil erosion in the 13 000 ha catchment was slight to moderate with no significant off-site effect, except for one local area affected by quarrying operations. No recommendations were warranted for change in land use.

(b) Sedimentation

There had been comment that the lagoon bed was silting up. This report, which dealt with the results of comparative surveys taken in 1963 and 1978, concluded there was:

(i) a small net accretion from Pandora Bridge to the low level bridge adjacent to the Lands Department pump outlet—maximum rise in mean bed level of 0.2 m;
(ii) a net degrade from low level bridge to Whararangi Stream outfall—maximum lowering of mean bed level of 0.32 m;
(iii) a trend towards accretion along upper contour channel adjacent to the hills;
(iv) an insignificant total loss of storage over 15 years.

(c) Hydrology

This report gave preliminary data on mean rainfall, mean discharges and estimated minimum and maximum inflows into the lagoon. The report was based on observations from two full flow gauging stations and three partial record stations.

(d) Water quality

Water quality samples were taken periodically at 12 sites over a 14 month period. Samples were taken of the surface and bottom flows at high and low tides. Parameters measured were pH, temperature, dissolved oxygen, suspended solids, conductivity, salinity, phosphate, nitrate and ammonia. No interpretation was put on the data, which was supplied to the Estuarine Research Unit, University of Canterbury.

Ministry of Agriculture and Fisheries

Technical Report No. 153, "Fish and Invertebrate Macrofauna of Ahuriri Lagoon" by A.R. Kilner and J.M. Akroyd, dealt with the various types of fish and macrofauna in the estuary and the effects of possible modifications to the estuary on these. Modifications discussed were dredging (for deep water port in the lower estuary, for winning of fill material and for flood control), reclamation, motorway crossing, effluent discharges, disturbance effects of various recreational uses, alternative areas for breeding, and fish farming.

Department of Internal Affairs — Wildlife Service

"Investigation of Wildlife Values" by M.J. Imber, described the birdlife in the estuary and lagoons, and labelled the area as one of national importance from the birdlife point of view. The report commented on the effect of various uses of the estuary.

Estuarine Research Unit, University of Canterbury

(a) "Fertility of the Estuary, Ecology of the Westshore Ponds" by Professor G. Knox covered all forms of life in the ponds, compared them with other New Zealand lagoons, commented on the impact of possible developments, and gave recommendations for future management.

(b) A thesis by A.J. Voice titled "Resource Evaluation and Management Alternatives" discussed the importance of the estuary, outlined many possible physical development alternatives, and suggested alternatives for future management.

The technical committee members are to forward comments on the above reports to Professor Knox who will prepare a final comprehensive report before the end of 1978.

[7] **Upper Tukituki River channel measurements**

Data from the 1941–44 and 1974–77 cross-section surveys are being converted from imperial to metric units, the earlier survey cross-sections are being adjusted to be compatible with current bench mark locations, and hydraulic parameters and changes in mean bed levels are being calculated.

A number of cross-sections have been selected for 3-monthly surveys to monitor short term fluctuations in overall trends.

[8] **Ngaruroro River channel efficiency and gravel resource survey**

This survey covers 56 km of the Ngaruroro River from the sea to the Whanawhana. Work during the year mainly comprised the plotting of cross-sections. A number of key cross-sections were selected for 3-monthly surveys to determine short term fluctuations in long term trends. Work in 1978–79 will concentrate on bed material recording and analysis and entering survey data in the board's minicomputer.

[9] **Tutaekuri River channel efficiency and gravel resource survey**

This survey involves the Tutaekuri River over 24 km from the Ngaruroro River confluence to Dartmoor. Progress is similar to that for the Ngaruroro River.

TARANAKI CATCHMENT COMMISSION

[1] **Onaero-Mohakatino catchment assessment survey**

This is a land inventory and land capability survey of approximately 700 km^2. The survey commenced in late 1976 and at present the total area has been mapped at a scale of 1:25 000, with special areas mapped at 1:10 000. The final report should be published in late 1978.

Steep hill country forms a large part of the area surveyed. It is covered by native forest except for those farmed areas alongside the river valleys and a few large areas of scrub. The steep hill country is mostly Class VII and VIII because of the erodible nature of the underlying sandstone, siltstone and mudstone. Soil slip is the dominant erosion type in the hill country and is most severe where Urenui siltstone and sandstone are the underlying rocks. Slump erosion occurs to a lesser extent, usually on mudstone rocks. Soil slip erosion is more severe under grassland than under native forest and has led to the reversion of much land to fern and manuka scrub.

The river flats in the area have more fertile soils than the steep hill country and are affected by flooding. The river flats are mostly Class III and IV. The mantle of volcanic ash on the coastal terrace and inland terraces forms fertile soils which are only slightly susceptible to erosion and support good pasture. The flat to rolling land of the coastal terrace is Class II and III with some Class IV land immediately adjacent to the coast.

The coast has discontinuous precipitous cliffs. These cliffs are Class VIII and are subject to cliff erosion of varying rates. The few sandy beaches along the coastline are suffering from net erosion and are Class VIII.

[2] **Patea River water resource survey**

This is a survey to assess the quality and quantity of the river with special emphasis on the effects resulting from the construction of a dam for hydro-electric purposes in the lower portion of the catchment.

To complement the established site at Mangamingi, gauging stations were installed at Skinner Road and at Mangaeku. Rating of these sites has commenced.

[3] **Lake Rotokare water quality survey**

This is a survey to determine a nutrient budget for the 17.8 ha lake, monitor the effects of recreational activities on the wildlife and monitor the fluctuations in the storage volumes due to sediment accumulation and macrophyte growth.

The bed contour has been determined, a staff gauge installed in the lake outlet and dissolved oxygen, temperature, phosphorus and nitrogen determined on four occasions in the past two years. It is intended to survey the lake fauna and flora in 1978–79.

[4] **Waingongoro River water quality survey**

This is one of the major rivers in South Taranaki, with an apparently uncommitted quality capability. Eltham freezing works discharges to the river, the river mouth is used for recreation, and the flows in the lower reaches could be used for irrigation, rural water or community water supply (Hawera). To date only limited water quality data have been collected.

[5] **Farm oxidation pond survey**

As the Commission has had to licence a considerable number of farm dairy oxidation ponds, it became obvious that ponds were being installed in all manner of shapes and sizes.

Investigations carried out during the summers of 1976–77 and 1977–78, involved the field survey of 37 oxidation ponds. Parameters measured were dimensions, type of solids trap, oxygen, temperature, BOD, COD, turbidity, suspended soilds and, on a smaller number, ammonia. Counts of *Chlorella* sp., *Euglena* sp., *Chlorogonium* sp. and bacteria were also taken.

The final report is in preparation and a "Farms Guide to Oxidation Ponds" booklet has been prepared.

RANGITIKEI–WANGANUI CATCHMENT BOARD

[1] **Rangitikei River channel survey**

This survey was originally submitted as a channel efficiency, evaluation of river control works, past and future works requirements and gravel resource survey with the aim of determining continuing river control works requirements within integrated river and gravel resources management plans. The main activity over the past two years has been the assessment of the shingle resource within the Rangitikei River system, the other activities mentioned being of low key or funded from an alternate source.

A comprehensive network of cross-sections has been established along the river. These are more concentrated over the lower 60 km of the river but have also been established at other important tributary sites and sites where metal extraction takes place. Three full surveys of these cross-sections have been made to date and mean bed levels calculated. Results indicate that the surveys will have to continue for a number of years before any accurate statements on long term aggradation or degradation trends can be made.

Bed load sieve analyses and hardness testing have been carried out on samples taken at strategic points along the river system. The results indicate obvious trends throughout the river system and therefore will be used as a basis of measuring any changes that may occur in future years.

It is intended to continue repeat cross-sectional surveys on a biannual basis and to collect further bed load samples for comparative analysis. An interim report on the shingle resources of the river, based on information measured to date is planned for 1978–79.

[2] **Wanganui underground water resource survey for a Water Allocation Plan**

This survey, by identifying bores, collating available bore log data and monitoring selected bores for yield and pressure variations, aims to determine the boundaries and the existing and potential use of the artesian aquifers in the area. All groundwater bores within the Whangaehu, Turakina, Wanganui and Kai Iwi valley systems are to be surveyed. Because of the poor quality of the available surface water, aquifers (especially in the Wanganui City area) are the source of almost all industrial, irrigation and urban water supplies.

Over 100 artesian bores have been located in an area bounded by a line joining Wanganui City to Kai Iwi (including a Kai Iwi stream catchment), to Upokongaru, to Okoia and back to the Wanganui River mouth. Those accessible have been pressure tested and a water sample taken for quality analysis. At this stage there appears to be three confined aquifers and ten representative bores were selected to be sampled and pressure tested every three months. Three repeat tests have been carried out to date. A continuous pressure recorder was installed on one bore but it has been found to be subject to tidal influence, the extent and boundaries of which will have to be determined before accurate pump tests can be made.

Data collection and monitoring of bores will contine through 1978–79. It is intended to augment the one automatic pressure recorder with two more automatic pressure recorders to obtain more comprehensive information on the aquifer systems. Three-monthly pressure testing and sampling on other selected bores will continue.

[3] **Rangitikei River water resource survey for a Water Allocation Plan**

This is a water quantity and a water quality survey of the main Rangitikei River and the principal tributary system. The objective is to produce a water allocation plan that will accommodate the known and potential demands for power generation, irrigation, water supply and waste disposal while maintaining the fisheries and recreational values of the river systems.

Progress on this survey has been slower than anticipated due mainly to other works priorities. Nevertheless sufficient data related to low flows and water quality have now been collected and placed on computer to allow a start to be made on data analysis.

Apart from flow data available from twenty automatic water level recorder sites within the catchment (70% of these have been established for ten years or more), the board has logged some 700 gaugings that are mainly related to low flow conditions. Four comprehensive low flow gauging runs were made of the entire catchment in 1973, 1974, 1976 and 1978.

Weekly monitoring of DO, temperature, BOD_5, hardness, alkalinity, chloride, turbidity, suspended solids, faecal coliforms, pH and conductivity was carried out from August 1975 until May 1977. Since then monitoring has been fortnightly. The Kawhatu River has been monitored fortnightly since April 1977.

Catchment survey runs have been performed as follows:

Rangitikei River: 29.4.75 (low flow), 5.3.76 (low), 9.3.76 (low), 7.3.78 (low).

Hautapu River: 6.5.75 (med), 15.3.78 (low).

Maowhangao River: 14.1.76 (med), 17.2.76 (low), 9.3.76 (low), 2.3.78 (low).

Porewa Stream: 2.12.74 (low) and monthly at 6 sites since November 1975.

The water resources report should be completed by March 1979.

[4] **Wanganui River water resource survey for a Water Allocation Plan**

The original objective of this survey was to prepare an integrated river works maintenance and water management plan for maintaining and protecting the recreation and other values of the river channel system. This entailed a survey of the main channel system including the effects of the Tongariro Power Development diversions, and identification of the community interests in the river and the extent of controls that may be required to protect those interests.

Because of increasing interest in the river related to future power development and the multiplicity of recreational uses the original survey has been broadened to cover assessment of the water resources of the whole river system and prepare a water allocation plan.

Complementing the long term flow records from Ministry of Works and Development hydrological stations along the Wanganui River system, board's staff have carried out two intensive low flow gauging runs. In the summer of 1976–77 low flow gaugings were done in the headwaters of the river and during the low flow conditions in the summer of 1977–78 a comprehensive overall catchment low-flow gauging run was carried out.

Water quality data has been collected essentially at 2-monthly sampling intervals since at least July 1977 for:

(a) Upper Wanganui River – 14 sites (as far as Te Maire and including Whakapapa River);

(b) Ongarue River – 13 sites, including two on Wanganui river;

(c) Ohura River – 9 sites;

(d) Retaruke River – 9 sites, including one on Wanganui River;
(e) Manganui-a-te-ao River – 4 sites;
(f) Matarawa Catchment – 8 sites (including Upokongaro and Makirikiri Streams);
(g) Lower Wanganui River – 5 sites (from Upokongaro to Cobham Bridge).

One full catchment water quality survey was performed under low flow conditions at 49 sites on the river and major tributaries in February 1978.

[5] **Whangaehu water resource survey for a Water Allocation Plan**

This initially involved a water quality and quantity survey of the upper tributary catchment of the Whangaehu, together with a survey of the middle catchment soil conservation requirements and lower river protection works requirements. The overall aim now is the preparation of a water allocation plan and the formulation of a whole catchment control scheme.

Activity to date has related solely to the collection of water resource data and its analysis.

Two reports and one water allocation plan have already been completed for subcatchments of the Whangaehu where power development, industry and irrigation have required early interim assessment of the water resource.

These documents are:

(a) *Basic water resources of Upper Mangawhero and Whangaehu River Catchments*
This report includes a basic appraisal of the water resources in the upper catchment area based on data available at the time. The results of this appraisal indicated that further data was necessary in the area to allow a full assessment of the water resource leading to a comprehensive water allocation plan for the whole Whangaehu catchment.

(b) *The Makaranui Stream - a Water Allocation Plan*
Due to the excessive demand of water from the Makaranui Stream for irrigation, vegetable washing and stock and domestic use it was necessary to prepare a water allocation plan for this stream as an interim step in the overall Whangaehu Water Allocation Plan. This plan has operated successfully since its inception in summer 1976–77.

(c) *The Whangaehu River – predicted effects of the Wahianoa Aqueduct Diversion on the water resources of the Whangaehu River*
Because of the imminent commissioning of the Tongariro Power Development works priority was given to the preparation of this report which is a comprehensive assessment of the effects of the Wahianoa Diversion on the flows in the Whangaehu proper.

It is intended to produce (by March 1979) an overall water resource report for the Whangehu catchment which will comprehensively combine all plans, reports and data collected to date. This includes various partial catchment quality runs which have been performed to assess effects of lahars and crater lake overflow on the river, and numerous spot samples which have been collected from the Tangiwai and Aqueduct sites to provide comparisons of qualities to assess Tongariro Power Development diversion effects.

Catchment surveys will be required to assess post-Wahianoa diversion effects particularly under contaminated conditions. The land capability survey which was deferred due to other commitments now has high priority.

[6] **Tutaenui catchment condition survey**

This was originally submitted as a survey of land and water resources within the Tutaenui catchment, but is now restricted to a survey of the water resource.

Sufficient water quantity resource data has been collected to date to allow the preparation of a water resource report as other priorities allow. Monthly monitoring of 13 water quality parameters at four sites representative of features of the catchment, has continued since June 1974. Complete catchment runs (28 sites) were performed on 26–27 September 1973 (medium flow) and 6–7 November 1973 (low flow) and a limited run (at seven sites) 9 November 1976 (low flow).

Sufficient water resource data has been collected to date to allow the preparation of a water resource report but because of other priorities this may not be possible until 1979–80 at the earliest.

[7] **Kai-Iwi catchment condition survey**

This consists of a land use capability survey to determine the requirements for a catchment control scheme to control severe erosion of unconsolidated sands. The Kai-Iwi catchment of 20 000 ha has a long history of ineffective attempts at gorse eradication with each attempt initiating a new cycle of soil erosion.

The land inventory survey of the catchment has been completed and from this land use capability maps have been prepared, showing the classification to unit level at a scale of 1:16 000. The survey shows that the catchment consists of 6% Class I, 5% Class II, 4% Class III, 7% Class IV, 18% Class VI, 59% Class VII and 1% Class VIII. The area of unconsolidated sandstones with a high erosion potential has been identified as extending in a 5 km wide band across the middle of the catchment and covers 27% of the catchment area.

The survey report has been completed and a catchment control scheme based on this is in the final stages of preparation.

[8] **Porewa Valley Control Scheme works extension survey**

The aims of this survey are to prepare a land use capability classification for the catchment to determine requirements for additional soil conservation works, and to collect and analyse some additional information on the water resources of the catchment.

The land inventory survey has been completed and a land use capability classification to the unit level prepared. At present the maps at a scale 1:16 000 require field checking, the report is in a draft form, and areas of land capability units have still to be calculated. It is intended to complete the land use capability survey during 1978–79.

No water resource work has been accomplished since it has been given a low priority in relation to water resource studies elsewhere in the board's district.

[9] **Kawhatau-Mangatera Catchment Scheme survey**

This is for the purpose of determing the requirements for a catchment control scheme.

The land inventory survey has been completed and a land capability classification to the unit level prepared, with maps at a scale of 1:16 000. Field checking and final draughting of the maps remain to be completed while the text of the report is still in a draft form, but should be completed in 1978–79.

[10] **Matarawa catchment condition survey**

This survey aims to produce a land use capability survey for the catchment, and also to undertake initial studies of water resources related to flood flows as initial investigations into a flood control scheme. The land use capability studies were completed in 1976 and sufficient flow data have been collected over the last three to four years to allow basic analysis of infiltration rates and runoff to assist with design aspects of the

flood control scheme. The resource surveys part of the Matarawa Catchment Control Scheme has basically been completed and further activity in the catchment will be more related to actual soil conservation or engineering works.

[11] **Turakina Catchment condition survey**

This involves a full and comprehensive land use capability survey of the whole catchment related to existing soil erosion problems and a comprehensive survey of the water quantity and quality resources.

The land use capability survey has not proceeded because of other works priorities. Water resource data are being collected and placed on computer for future water resource analysis.

MANAWATU CATCHMENT BOARD

[1] **Pohangina shingle resource survey**

During 1977, five critical control sections were re-surveyed to establish whether any significant changes had taken place. Comparison with the original sections showed that little movement had occurred. Indications are that much of the additional material moving within the control reach is derived from bank erosion. Over the period April–June 1977 a pulse of fine gravel (particle size of less than 15 mm) moved approximately 60 m. The size of the pulse was approximately 10 m long × 20 m wide × 0.5 m average depth. This movement occurred during normal winter flows without any significant freshes during the period. There are several of these pulses within the control reach and they all appear to move independently of the armoured bed.

All cross-sections for the original 1967 bed survey were relocated and re-surveyed during the 1977–78 summer. This involved 48 sections over 39 km of river. Work is continuing on assessing the changes in relation to bed movement.

Studies have been made to locate the major sources of suspended sediment. Indications are that bank erosion and high cliff erosion are major contributors of the suspended load. Major slips within the catchment on tributaries take a considerable period of time to reach the main channel. An interesting observation was that Beehive and Coal Creeks (which drain catchments with a sand lithology) although yielding considerably less concentrations of suspended solids than the tributaries of the Oroua, produced much higher total sediment contributions to the main river channel during higher flows. Also the Pohangina River has a greater capacity to transport sediment than the Oroua. The suspended solids tend to be transported through the river system. This effect is reflected in the particle size analyses by lesser fraction of fines compared with the Oroua particle size analyses.

[2] **Oroua shingle resource survey**

During 1977–78 all sections in the control reach were visually monitored several times and four critical sections were re-surveyed. The results of the re-survey confirmed the findings of the visual inspections, namely that during the 1977 winter little change occurred in the bed configuration and coarse bed material, and that bed material movement into and within the control reach was very limited. However, there were no significant high flow events during the year.

Aerial photographs were taken and surveys made of vertical cliffs within the control reach to assist in determining the source of the suspended load. The importance of measurement of the suspended load has been established in relation to total sediment movement and the particle size distribution of the shingle resource.

A stage-height recorder was installed in Goulters Gully to assist in the assessment of sediment movement from sand gullies. Indications are that although the sand gullies under certain conditions produce high sediment yields (in the order of 200 000 ppm) for a discharge of 1 $m^3 s^{-1}$ the contribution from high cliff erosion in terms of total sediment yield is equally important.

The licensing of shingle removal established during 1977 will assist in more accurately determining gravel extraction rates and amounts.

[3] **Upper Manawatu shingle resource survey**

This is aimed at determining the full extent of the resource and the rate of movement of the input from the Ruahine system through the Upper Manawatu River system. Suspended load, as an indicator of catchment condition, is being measured and the effect this has on control and/or channel training works is being analysed.

During 1977–78, 34 bench marks were established at approximately 1 mile intervals from river mileage 68 to 96. Additional bench marks were placed at tributary inflows. Cross-sections were taken at all the bench mark sites but, because of lack of significant events, the sections were not re-surveyed during the year.

A reasonable estimate of inflow of bed material from the Ruahine Range into the Upper Manawatu system has been obtained from the investigations for the South-east Ruahine Management Scheme.

[4] **Otaki River shingle resource survey**

During 1977–78 all sections in a control reach established in 1973 were visually monitored several times. The results obtained from the earlier surveys were checked and included, where appropriate, in the Otaki Scheme Review. No re-surveys of critical sections were carried out due to lack of significant high flow events during the year.

A shingle management policy has now been implemented in an attempt to control rate and areas of extraction. The licensing system established during 1977 for shingle removal will help considerably in more accurately determining shingle extraction rates and amounts.

It is proposed to re-survey all cross-sections within the control reach in 1978 and to carry out an assessment similar to that completed in 1975 and reported in "Report on the Otaki River Scheme Bed Survey & Shingle Resources 1975".

[5] **Mangatainoka shingle resource survey**

During 1977–78 40 bench marks were established at 1500 m intervals under the Mangatainoka Catchment Works Survey. Cross-sections were taken at all bench mark sites. Due to lack of significant events, the sections were not re-surveyed during the year.

One control reach was selected between Stirling Bridge and Redpath Bridge. The reach is 2200 m long with 23 sections established and surveyed within it. The reach was visually monitored throughout the year. Four critical sections were re-surveyed four times, another four three times, and the remainder twice during the year. The results from the re-surveys confirmed the results from visual monitoring in the Upper Manawatu and investigations on rivers on the western side of the Ruahine and Tararua Ranges, namely that during 1977–78 there were no significant river flow events to cause any great movement of bed material within the river system. Within the control reach in the Mangatainoka it was found 800 m^3 entered the reach from bank erosion with 600 m^3 of this remaining within the reach. There was negligible nett input of bed material from above the control reach.

[6] **Oroua Downs water resource survey for a Water Allocation Plan**

The objectives are to produce a water allocation plan that will resolve the present conflicts between demands for farm water supply, land drainage and preservation of the wildlife habitat in the Pukepuke Lagoon and Lake Kaikokopu.

The water quantity and quality of all groundwater resources within the area, the limits of safe extraction from the artesian ground waters, and the affects of land drainage and other extractions on the phreatic groundwater are being assessed. The resource survey has proceeded satisfactorily and at present a draft of the final water allocation plan is being prepared.

[7] **Otaki/Waitohu/Mangaone water resource survey for a Water Allocation Plan**

This survey involves hydrological and geohydrological investigations, water quality monitoring and assessment of existing uses in the area. A water allocation plan will be prepared for three catchments.

A draft water resources management plan was prepared and advertised for public comment in late 1976. This plan will be reviewed in 1978–79 in the light of the comments received and additional data collected during 1977.

During December 1977 and January, February and March 1978 considerable time was spent measuring low flows in the area. A total of 21 gaugings were carried out at each of four sites. This extended drought period has enable sufficient data to be collected to derive excellent base flow recessions for the three catchments. Over the balance of the year another 12 gaugings were carried out.

The back log of stage-time data for Otaki at Gorge (1953 to 1972) has been entered on the computer. Along with Ministry of Works and Development water resources investigations in 1973 and 1974 this new data will enable assessments in the draft report to be reviewed and refined.

Water quality investigations continued as part of an overall background water quality survey at eight sampling sites. Investigations into temperature variations, particularly in the Otaki, were made. A temperature recorder was installed in the Otaki during the summer. An attempt is being made to correlate temperature with flows.

Three shallow test bores were drilled in the vicinity of Otaki Township and aquifer tests carried out. An aquifer test was also carried out on the Otaki Borough well at Rangiruru Road. Levelling of additional bores in the area for an extended piezometric survey was carried out. In the light of the preliminary evaluation of the groundwater resource data additional test bores may be required. The water use assessment in the area was completed.

[8] **Waikawa/Manakau water resource survey for a Water Allocation Plan**

The objectives of this survey are to determine the quantity and availability of groundwater and to provide data for a water allocation plan.

The extended drought period of 1977–78 enabled excellent low flow data to be collected for both streams. Thirteen gaugings were carried out during the period. Design for a monitoring weir on the Manakau Stream was completed and will be constructed in 1978–79. Water quality monitoring continued at three sites as part of an overall background water quality survey. Water use assessment in the area continued.

[9] **Ohau water resource survey for a Water Allocation Plan**

The aim of this survey is to assess the water resources and flow characteristics of the river system and to provide data for a water allocation plan. Water use in the area is also being assessed.

During the 1977–78 summer twelve flow gaugings were carried out, mainly to establish a baseflow recession. Background water quality data was collected at four sites as part of an overall base water quality survey. Geological information was obtained from drillers operating in the area.

[10] **Oroua River water resource for a Water Allocation Plan**

The availability and allocation of water in the Oroua River is becoming a major problem with increasing abstraction by local authorities, industries and individuals. The problem is compounded by the fact that a decrease in the amount of water in the river below Feilding would require dischargers in the area to provide additional treatment facilities to maintain a satisfactory water quality. Some $1–2 million has been, or is about to be spent on effluent treatment by the two major dischargers.

The extended drought period in 1977–78 enabled excellent low flow data to be collected for the Oroua River. Nineteen gaugings were carried out at three sites during the summer period. Design for a control weir on the Oroua at Kawa Wool was completed. Water quality monitoring continued at four sites as part of an overall background water quality survey. These results have been summarised in a report on the "Baseline Water Quality of the Manawatu Water Region 1977–78".

It is proposed to have the provisional water allocation plan completed by mid–1979.

[11] **Mid-Manawatu water resource survey for a Water Allocation Plan**

The objectives of this survey are to provide data for upgrading the floodway system, flow data for a water quality investigation and data for a water allocation plan.

During 1977 a report on "Water Quality Management, Manawatu River Below Palmerston North" was completed. Since this was released a technical committee of all interested parties has been set up to discuss the implications of the report and the allocation of water for waste assimilation in the Mid-Manawatu. A report on the "Low Flow Assessment in the Lower Manawatu 1949–1978" was completed in 1978.

The extended drought period in 1977–78 enabled excellent low flow data to be collected for the Manawatu River. Nine gaugings were carried out at two sites during the summer period. Water quality monitoring continued at five sites as part of an overall background water quality survey.

Recommendations contained in the Urban Growth Study for Palmerston North have provided a more definite base to assess requirements and, together with results of discussion from the technical committee, it is hoped that a specific allocation plan can be prepared.

[12] **Kiwitea Stream water resource survey for a Water Allocation Plan**

This survey investigates the water resources of the stream and should provide data for the preparation of a water allocation plan.

The extended drought period in 1977–78 enabled excellent low flow data to be collected and 18 gaugings were carried out over the summer period at three sites. Water quality monitoring is continuing at two sites, and water use assessment within the catchment is underway.

[13] **Pohangina River water resource survey for a Water Allocation Plan**

This survey involves water use assessment and an overall background water quality survey, and it should provide data for the preparation of a water allocation plan.

The 1977–78 summer drought enabled some excellent low

flow data to be collected and 16 gaugings were carried out at three sites during the period.

[14] **Upper Manawatu water resource survey for a Water Allocation Plan**

The extended 1977–78 drought period enabled excellent low flow data to be collected from the Upper Manawatu River system. Ten gaugings were carried out during the summer period.

Water quality monitoring continued at four sites as part of an over-all background water quality survey. These results are now presented in a report on "Baseline Water Quality of the Manawatu Region 1977–78". This water quality survey will provide a base for water allocation planning.

Water use assessment is continuing in the area. Background bore hole information was collected for the area. Bore hole levelling was carried out in the vicinity of Oringi.

[15] **Mangatainoka/Makakahi water resource survey for a Water Allocation Plan**

As for the Upper Manawatu, the extended drought period enabled excellent flow information to be collected for the Mangatainoka River. Twenty four gaugings were carried out at eight sites during the period.

Water quality monitoring continued at four sites as part of an overall bore water quality survey. A detailed water quality survey is planned for the 1978–79 summer.

Water use assessments in the Mangatainoka catchment have been completed and a re-survey for future demands has commenced.

[16] **South-east Ruahine Streams water resource survey for a Water Allocation Plan**

The hydrology of these streams is discussed in the report "South-eastern Ruahine Investigation – Report on Hydrology".

Water quality monitoring is being carried out at 22 sites in the South-east Ruahines as part of an overall base water quality survey, and water use in the area is being assessed.

During 1978–79 these activities will continue, future demands on water use will be assessed, and the data collected during 1977–78 will be analysed and assessed.

[17] **Mangahao River water resource survey for a Water Allocation Plan**

This survey involves surface water resource and water use assessments and geohydrological and water quality investigations. It will provide data for a water allocation plan.

Low flow information was collected for the river during the 1977–78 drought period, during which twelve gaugings were carried out at the control site at Ballance.

During 1978–79 the data collected to date will be analysed and assessed, and the monitoring of water quality and quantity at established sites and water use assessment will also continue.

WAIRARAPA CATCHMENT BOARD

[1] **Wairarapa sand and gravel assessment survey**

This is a survey to determine the sources of sand and gravel to the Ruamahanga, Waingawa, Waiohine and Tauherenikau Rivers and to attempt to determine the amounts of sand and shingle carried by these rivers.

A photographic survey of tributary catchments of the Ruamahanga and Waingawa Rivers in the Tararua Ranges was carried out. The area of active scree slopes was plotted on aerial mosaics and transferred to a 1:25 000 map. A comparison between the 1968 and 1978 aerial mosaics indicated a considerable increase in the eroded area over this period.

The only primary source of the gravel carried by the Tararua feed rivers is a relatively small area within the Tararua Ranges. Thus, to obtain some idea of the amount of gravel entering the river system, a number of retaining dams are proposed for small representative catchments within the Tararuas. Sites to determine the threshold of motion have not been set up yet but it is hoped to do this in 1978–79. Bed sediment samples have been obtained at various points throughout the Ruamahanga, Waingawa and Waiohine Rivers.

In view of the relatively late start made on these investigations and the importance of a greatly increased knowledge of the resource for both safe exploitation and river control purposes it is intended to increase the input to this study considerably in 1978-79.

[2] **Greytown shallow aquifer investigation**

This survey measures the quantity, quality and extent of the aquifer with a view to assessing its usefulness as a water supply for further market garden and orcharding operations in the area.

Work is still in progress on this survey. A network of 26 private wells has been chosen so as to give an even coverage of spot water levels over the area thought to underlay the aquifer. The height above sea level has to be fixed at each point before water level measurements can be analysed.

A water surface follower has been installed over one of the wells, and the board now has chart records of water level from August 1977.

[3] **Ruamahanga Basin water resource survey for a Water Allocation Plan**

This report covers the continuing survey on the Waingawa, Upper Ruamahanga, Tauherenikau and Waiohine Rivers.

Flow gaugings have been carried out on all rivers, with an extended programme being done during the extreme low flow conditions pertaining over the 1977–78 summer months. This in turn led to the gauging of various creeks and streams which are not normally gauged, since it was felt that the drought would lead to an increase in applications for irrigation water from all sources. A more accurate base-flow recession curve has been obtained for the Waingawa which is the source of the Masterton Borough water supply. Drought flows on the main rivers were the lowest so far recorded.

A comprehensive water resource survey has been completed for the Kopouranga and Whangaehu catchments and a report on the Whangaehu representative basin is being compiled.

[4] **Ruamahanga River water quality survey**

The uses of the Ruamahanga River are many and varied, ranging from recreational to discharge of treated effluents. All uses have some effect in regard to water quality. The board is endeavouring now to promote the rational use of water particularly where competing uses exist. Unless effectively controlled these are likely to lead to reduction in water quality.

The river commences in the Tararua Range on the western side of the valley, and meanders through the plains until discharging into the sea at Palliser Bay. Important tributaries from the Tararua Range are Waipoua, Waingawa, Waiohine and Tauherenikau. Some smaller eastern hill catchments occur and limited investigations of the Taueru and Huangarua were made.

The investigation commenced in November 1977 and continued until April 1978, later than was earlier anticipated due to the prolonged dry summer. River flows streadily receded and presented a unique opportunity to obtain invaluable data. Temperature, pH, dissolved oxygen, bacteriological, conductivity, biological, biochemical oxygen demand and turbidity parameters were assessed by board staff. Chemical analyses of water samples were done by Cawthron Institute.

Where possible gaugings were done in order to relate water quality to flow conditions. One important aspect of water use management is the setting of minimum flows to ensure that environmental parameters are not exceeded and that adverse conditions are not created. The setting of minimum flows in rivers appears to be attracting considerable interest in all spheres of water management at present and the information obtained during the survey will certainly provide data for the determining of such flows.

To account for variations in diurnal cycles and corresponding changes in water quality particularly in reference to pH, O_2 and temp, 24-hour surveys were done. Initial observations indicate that, despite the extreme drought of the recent summer and the low flows that resulted, the Ruamahanga and its tributaries stood up extremely well. It should be emphasised that 'freshes' in these mountain catchments occur frequently such that in the past considerable frustrations have been experienced in monitoring water quality at low flows.

[5] **Pollution survey monitoring – Wairarapa**

The objective is to investigate and record the effects of effluents, land run-off etc. on receiving waters.

The survey covers the Castlepoint and Riversdale areas and the Ruamahanga River Basin. In the Castlepoint area data on existing water quality relative to recreation use are being obtained for the setting of standards for future development in the area. In the Riversdale area the quality of water in the Motuwaireka Catchment and 'Lagoon' is being investigated. Enough data are now to hand for an interim report. The investigations in the Ruamahanga Basin are complimentary to the Ruamahanga water quality survey with the emphasis here being on effluent treatment facilities and the effects of their discharges on receiving waters. In particular the performance of lagoon systems which are being established on some dairy farms and at piggeries are being monitored.

The survey is continuing through 1978–79. In the past monitoring of effluent treatment systems has been limited to the survey period November-March. The effects such outfalls have on receiving waters during winter months, when slow down in biological activity of such systems occurs. is to be investigated

[6] **Awhea and Opouawe river bed surveys**

Twenty-six cross-sections are to be surveyed and compared with previous surveys to measure the change in bed levels. and to assist in the evaluation of extensive catchment control works.

The cross-sections at established bench marks on only the Awhea River have been surveyed. and work is in progress to compare them with previous surveys. In 1978–79 it is intended to complete the Opouawe River bed survey.

WELLINGTON REGIONAL WATER BOARD

[1] **Porirua Basin study**

The objective of this survey is the evaluation of flood discharges and their frequency of occurrence as a basis for determining the extent to which flood control measures should be carried out through the catchment.

During 1977 two water level recording stations were constructed at intervals along the main river channel and one at a substantially urbanised tributary to supplement the already established station near the stream outlet to the Porirua Harbour. Rating of the three new stations has commenced.

[2] **Hutt River Catchment water resource survey**

The objective of this survey is the assessment of the surface water resource within the catchment at and above the Silverstream Bridge at the following five sites:

(a) Headworks Catchment at Kaitoki Weir – flow data is available from 1968;
(b) Birchville on main river channel – data from August 1970;
(c) Silverstream Bridge on main river channel – data from September 1962;
(d) Pakuratahi Catchment at confluence with Hutt River at Kaitoke Forks;
(e) Akatarawa Catchment at confluence with Hutt River at Birchville.

Installation of recording stations at the latter two stations is programmed in 1978–79.

Flow records have been processed and brought onto the Ministry of Workds and Development's TIDEDA storage.

[3] **Hutt Valley groundwater survey for a Water Allocation Plan**

This survey is concerned with the continuous monitoring of inflows and this data, together with well data and mathematical model studies, will be used in an attempt to determine inflow variation into the Lower Hutt Valley artesian system with high river stages.

Detailed water balance gaugings over the recharge zone of the Hutt River have been carried out since 1969, to determine exact river losses. The measurements were taken during "dry weather flow" periods when generally maximum draw off from artesian supplies occurred.

An evaluation of the available data in relation to model studies is now necessary to determine the future of this programme and this is proposed for 1978–79.

[4] **Whakatiki Catchment water resource survey**

The survey objective is to compile a complete water and land resources inventory of the catchment to assist water supply design and to provide data for the Hutt Catchment Water Allocation Plan.

In 1976–77 a temporary Foxboro chart recorder and low level staff gauge were installed. Nineteen gaugings were carried out and a low level rating from 0.400 m to 1.000 m was established. In 1977–78 a digital recorder replaced the Foxboro and a high stage staff gauge was installed. A further twenty gaugings were carried out and the rating extended to 2.700 m.

It is proposed in 1978–79 to complete the ratings and then to determine preliminary correlation of the flow at this site with the flow at the Kaitoke Weir site.

[5] **Orongorongo River water resource survey**

A water quantity survey of the catchment, (which is still in its natural state) is being undertaken to assist long term planning of this water resource, particularly for water supply purposes. The upper catchment is used for water supply purposes with a weir and water intake (run of the river scheme) on the Big Huia Stream and the Orongorongo River.

In 1976 a continuous water level recorder was installed on the upstream side of each concrete intake chamber and a slackline cableway was erected some 400 m downstream of the Orongorongo intake. Preliminary ratings have been established at both recording sites. Sufficient data has been collected for a regression correlation between the two stations and a preliminary printout of mean daily flow has been produced for the Orongorongo station. Rainfall/runoff correlation and generation of mean daily flows between the Orongorongo River and Pakuratahi River have been carried out.

In 1978–79 flow and rainfall data collection and processing, completion of ratings and, because of the bed changes just above the concrete weirs, continued check gaugings of ratings will be carried out. A land survey of the catchment will be undertaken and the animal possed.

[6] **Mangaroa Black Swamp water resource survey**

This swamp was initially earmarked for future urban/light industrial development. An environmental and water resources assessment would be necessary before development could commence. Since the inception of this survey development has been deferred but, because of the uniqueness of this swamp, this survey is continuing on a reduced scale.

In 1977–78 a Foxboro chart recorder and staff gauge were installed at the swamp outlet. The site has been rated and a total of twelve gaugings carried out. To facilitate higher flow gaugings a temporary slackline cableway was installed 10 m downstream of the recorder site.

In 1978–79 a preliminary unit hydrograph study and a limited land resources study will be undertaken with the view of producing a preliminary report within the framework of the Mangaroa Water Resources Survey (see below).

[7] **Plimmerton Flax Swamp environmental study**

This involves an evaluation of the possible effects of urbanisation of neighbouring land on the quantitative and qualitative parameters of the swamp.

A preliminary area survey and some inflow and outflow measurements of the swamp were done during 1977–78, but further work has been deferred due to priorities elsewhere.

[8] **Wainuiomata River water resource survey for a Water Allocation Plan**

The water and land resources in this catchment are to be assessed for the formulation of a water allocation plan in which particular attention is to be given to water supply requirements, water quality and recreational use.

The catchment above Morton Dam is classified as a water collection area for water supply purposes and replacement of this dam with a larger one is contemplated. The land between Morton Dam and the Wainuiomata Sewage Treatment Plan is rural/urban. Flow data are available at Morton Dam since 1928, and a gauging site was constructed in 1977 just above the sewage treatment plant. This latter site has been rated and some ten gaugings carried out there. In addition three correlation gaugings between it and five secondary sites have been done.

[9] **Waikanae River water resource survey for a Water Allocation Plan**

By accurately determining the available water (and land) resources it is hoped to formulate a water allocation plan for this catchment. It consists of approximately 25% farmland and 75% native and exotic forest and scrub, and is used as a water collection catchment for water supplies for the 'Golden Coast' area.

A new water treatment plant was completed in 1977, incorporating an intake weir in the Waikanae River. A waterlevel recording station was built in 1975 just upstream of the intake area and waterlevel recording data collection commenced in March 1975. Prior to this period, flow data was collected by the Ministry of Works and Development at a Foxboro recording site, approximately 3 km upstream. Two additional recording raingauges were placed in the catchment adjacent to manual gauges.

Extensive field and published data on soils, land use, rainfall and flows were collected in 1975–76. A preliminary water resources report was produced for the board.

Flow and rainfall data collection and run-off analysis from selected catchments is continuing as a follow up to the preliminary report.

[10] **Mangaroa River water resource survey for a Water Allocation Plan**

Land use in the catchment, of which about 55% is classified as steep to very steep, is quite diverse involving some intensive cropping, dairying, and some sheep and beef farming. There are 19 water rights issued in the area and seven users of groundwater. Water flow data has been inadequate in the past, but some series of waterbalance and "dry weather" flow measurements were taken. A waterlevel recording station and a standard slackline cableway were constructed in the Te Marua Gorge, being operational since August 1977.

In 1978–79 waterlevel data will continue to be collected and processed for the Te Marua Gorge site. Correlation gaugings of five secondary sites with this station and ten tertiary sites for "dry weather" flow balance, particularly taking water rights into account, will be undertaken. Updating of the interim water resources report with a view to producing a preliminary water and soil management plan for the catchment is also proposed.

MARLBOROUGH CATCHMENT BOARD

[1] **Wairau River water resource survey for a Water Allocation Plan**

Data collection for the groundwater survey has been substantially completed and different types of pump tests have been carried out. Aquifer recharge data is written up and a groundwater contour map, including data from over 100 bores, is in the course of production. The line of monitoring wells across the plain was used in 1977–78 for level prediction and levels on all five wells were plotted at weekly intervals. A preliminary assessment which did not contain quantitative data was prepared in November 1977.

Surface water resource data collection is also largely completed, with the exception of certain areas where instrument installation has been delayed. Full quantitative details of all river and stream gauging work, rainfall and water level recording is stored in the Ministry of Works and Development TIDEDA computer system. Work remains to be done on the installation of the new recorders at the Goulter and Wash sites.

Apart from the general work on water quality in the catchment, such as baseline data on stream sediment loads (also on computer), chemical analyses and bacteriological work, specific attention has been paid to problem areas such as the

Taylor/Opawa system and the Tuamarina River.

Sufficient data is available, analysed, and written up for the majority of the report. There are delays in the fields of land-use related water usage, the preparation of background and introductory sections and in plan and map production.

The principle activities in 1978–79 will be:

(a) More sediment sampling will be done and follow up work carried out in problem areas. Baseline information will be obtained on water quality in areas such as Six Mile Creek where possible ski-field development may cause water quality changes.

(b) The groundwater contour map will be completed. Some work will continue with the DSIR on the areas where water dating has shown up apparent anomalies, in order to determine the likely flow patterns. One or more additional pumping tests may also be needed to determine aquifer constants in fringe areas.

(c) Groundwater quality is fairly well known, except for certain areas. For example, it has recently been found that a manganese problem exists in some areas and so it will be necessary to delineate these areas more accurately. Also, there are a number of land and industrial uses which have potentially damaging results to groundwater and, as baseline data has been obtained, it will be necessary to continue monitoring to ensure that groundwater is not affected.

[2] **Groundwater investigation for a Water Allocation Plan**

Apart from a very few cases, all investigation into groundwater in Marlborough has taken place on the Wairau Plains as part of the data collection process for the Wairau Valley Water Allocation Plan. Groundwater is by far the most important source of water for domestic and agricultural use on the Wairau Plains. Almost all irrigation takes place from wells or spring fed streams and the Blenheim Borough water supply is entirely based on groundwater.

Bearing in mind the low summer rainfall and the otherwise high agriculture potential of the plains, the importance of underground water cannot be over emphasised. The board has operated an underground water by-law since 1975, which controls the sinking of and alterations to wells and boreholes. In the work, the board has been assisted by the DSIR, particularly Mr L.J. Brown (NZ Geological Survey, Christchurch).

Mr Brown, in an as yet unpublished paper submitted to the board for inclusion in the water allocation plan and entitled "Notes on Geology and Groundwater for Wairau Valley Water Allocation Plan," describes the geohydrology, groundwater flow and groundwater availability. The data for the paper was derived from several unpublished reports of the board and Geological Survey and Mr Brown's own published sources.

Specific investigations have included:

(a) drilling test bores to establish aquifer width and thickness;

(b) pump tests to establish aquifer constants at various places;

(c) isotope studies;

(d) tidal fluctuation studies in the low plains area;

(e) groundwater inflow-outflow studies from river flow measurements;

(f) monitoring groundwater level;

(g) groundwater quality assessment with particular reference to general baseline information and to areas of potential problems adjacent to rubbish dumps, industrial areas etc.

Work in progress is as follows:

(a) further investigation into aquifer recharge and outflow at low river levels;

(b) extending the well level monitoring system to extend and fill in the groundwater contour knowledge;

(c) establishing a series of observation wells for water quality sampling;

(d) weekly water level monitoring of a series of wells across the mid-section of the plains to assist with level prediction;

(e) establishment of a few short term observation wells adjacent to wells used for irrigation to continuously record water level reaction to pumping at an approximately known rate.

[3] **Wairau mountain lands priority assessment survey**

This survey was to be completed during 1977–78 but the resignation of the principal survey member has delayed the programme considerably. A new co-ordinator was appointed in June 1977.

The new co-ordinator has spent the year observing the land and water systems and relating these to the field data collected by his predecessor during the previous three years. The past and present approaches are similar and maintain that an understanding of the process at work is of equal importance to the static quantitative description of erosion and other features in the high country. Thus, observation in the field has been combined with perusal of literature and discussion with appropriate personnel concerned with mountain building/soil erosion factors.

The whole catchment has been divided into regions on the basis of logical convenience: Upper Wairau (St Arnaud to headwaters), Waihopai-Spray, Branch-Leatham, etc. Each of these has been divided into smaller areas (generally small sub-catchments in themselves) and each of these has been examined in detail, using standard land use capability survey methods and modifications where necessary. Information on slope, aspect, soils, geology, areal erosion, scree, detritus, vegetation, etc. has been obtained from these small areas and a synthetic picture has been built up.

A simplified example of the type of quantitative data obtained is recorded below where Upper Wairau is a major sub-catchment, and Stockyard Face a small portion of this:

	Upper Wairau	Stockyard Face
Total area (ha)	61 700	2 505
> 1540 m altitude	21 761	534
< 1540 m altitude	40 039	1 971
Background (sheet and scree)	19 476	798
> 1540 m altitude	12 550	369
< 1540 m altitude	6 926	429
Detritus units	4 621	32
Bare ground recoverable by AOSTD, tree planting etc. (ha)	2 760	175

Field work including collection of quantitative data on erosion and other factors has been completed.

[4] **Kaikoura East Coast land resource survey**

The land use capability survey is completed. The percentages of total area in classes I-VIII are 0, 1, 5, 25, 1.5, 41, 35.5 and 13.5 respectively.

All 116 streams within the survey area were inspected to determine those which constitute a hazard to communications and farmlands. Detritus levels were recorded on a 1–5 scale to indicate the increasing order of seriousness. The source of detritus, whether slips, gullies, streambank erosion or bed reworking, was also recorded, together with priorities for treatment on a 1–3 scale.

Of the 116 streams, 85 are proposed in the report for treatment: 8 in detritus level 2, 18 in 3, 11 in 4, and 48 in 5

Plans completed at a scale of 1:25 000 for office use and planning purposes are land inventory, land use capability - stream conditions, potential land use, and recommended land use - recommended works/treatments

In the course of preparation of the recommended land use - recommended works/treatment maps the New Zealand Railways, Ministry of Works and Development, Canterbury University (Geography Department), DSIR (Botany Division and Soil Bureau, Christchurch), Ministry of Agriculture and Fisheries (Blenheim), Lands and Survey Department (Blenheim), Tussock Grasslands and Mountain Lands Institute, and New Zealand Forest Service (Christchurch) were consulted.

The first draft of the report is almost completed and base maps (1:50 000 scale) of land use capability, stream condition, and recommended land use-works are presently being prepared by Lands and Survey Department.

[5] **Wairau Diversion development survey**

This survey is monitoring the physical development of the Wairau Diversion Channel (which was opened in 1963) and the amount of flow (in particular flood flows) carried by the diversion and the lower Wairau River Channel.

[6] **Benhopai Dam sedimentation survey**

This dam was used as a water storage dam for hydro-electric power generation. It is full of gravel and is effectively providing a base level from which the Waihopai River is gradually aggrading, thus providing an opportunity to study the interactions between sediment size, grade and stream behaviour, as well as monitoring future aggradation.

Cross-sections at approximately 61 m intervals near the dam, extending some 4 km above the dam will be surveyed at 10 to 15 year intervals.

The relationship between bed slope and material size on the bed will be determined by material size analysis of grab samples of the bed surface taken along the survey area at similar flow rates.

[7] **Wairau River and tributaries channel efficiency survey**

The objective of this survey is to determine changes in river bed shape and efficiency caused by natural changes, catchment works and river control operations. The rivers were surveyed and cross-sections benchmarked at about 0.4 km apart during 1957–59. Since then regular surveys have been carried out at 5 or 10 year intervals. Gravel deposits and the effects of removal of these are also being measured.

[8] **Awatere River water resource survey for a Water Allocation Plan**

The objectives are to assess the water resources for the Awatere and its tributaries for irrigation, for domestic and stock water and for future local authority supplies, and to provide data for the preparation of a water allocation plan.

Water level recording, low flow analysis, sediment sampling (at the time of gauging) and chemical sampling are being undertaken. During 1978–79 there will be an intensification of river and stream flow gauging.

[9] **Pelorus River water resource survey for a Water Allocation Plan**

The objectives of this survey are to obtain data for the preparation of a water allocation plan and a proposed flood warning system.

In 1978–79, in addition to the gauging and water quality work, it is intended to install a water level recorder on the Rai and to increase the raingauge coverage by the addition of three raingauges.

[10] **Marlborough Sounds water resource survey for a Water Allocation Plan**

This survey, by data collection and evaluation, will identify areas that need special attention. Primary sites are to be set up,with digital recorders possibly being installed on these sites. Particular emphasis will be given to areas which require water for development purposes, and the effect of present discharges on water quality in particular areas will be evaluated. It will provide data for the production of a water allocation and water management plan. It will also provide data for use by the Oceanographic Institute and Ministry of Agriculture and Fisheries with respect to freshwater and Sounds fishing and shellfish farming.

Stream gauging and water quality work has commenced. Freshwater and seawater testing includes that for suspended solids, total solids, dissolved oxygen, pH and conductivity.

NELSON CATCHMENT BOARD

[1] **Lower Motueka sand and shingle resource survey**

This survey of the Lower Motueka River is evaluating the current resource and rate of replenishment of the shingle resource of the river. With the restriction on extraction from the Waimea River the Motueka River has become one of the major suppliers of sand and shingle in the region.

A river cross-section network over 13 750 m from the sea to Alexander Bluff Bridge has been established. This involved the installation of 110 bench marks and marking posts, the surveying in of these to mean sea level datum, the clearing and surveying of the 55 cross-sections and the preparation of plans.

Work proposed for 1978–79 involves the analysis of gravel samples for size distribution and quality, aerial photography of the river for record purposes (to enable later stereo plotting), the traversing of the bench mark network to fix their locations in geodetic terms and to see if a gravel movement of significant size occurs, and the re-photography and survey of the cross-sections.

[2] **Moutere Valley water resource survey for a Water Allocation Plan**

This survey is being carried out to determine the quality and quantity of the water resources to provide the basis for an irrigation scheme design. A groundwater survey is being carried out at the same time.

A river flow recorder has been installed on the Wills Road Stream, Central Road, Moutere and a recording raingauge has been installed in the catchment. These are now fully operational.

[3] **Waimea Inlet flora and fauna study to produce a Water Allocation Plan**

This survey aims to determine the present condition of the Waimea Inlet which is subject to man introduced stresses, namely reclamation and effluent discharges. It is proposed to introduce a regional scheme to discharge effluent at one site to replace the many existing point discharges. The regional scheme may be more detrimental than the present system. Hence the inlet requires surveying to monitor existing discharges, and to study the hydrological patterns to find a suitable discharge site for the regional scheme.

During 1976–77 the hydrology of the inlet has been studied with particular emphasis on the tracing of tidal currents using rhodamine dye. The general distribution of benthic inverte-

brates has been studied in detail and a programme for studying the aquatic flora, particularly the *Zostera* fields, is underway in conjunction with the Botany Department, University of Canterbury.

A tidal recorder (tower installation) has been established in the main channel adjacent to the proposed outfall site of the Nelson Regional Sewage Scheme. This now provides the facilities for accurately plotting biological species distribution in terms of tidal exposure.

It is proposed that this study concentrate on the intertidal zone to the west of Saxtons Island this year to provide baseline data on sediments and flora and fauna species diversity prior to the commissioning of the regional sewage scheme.

[4] Waimea Plains water resource survey for a Water Allocation Plan

Two pump tests of the lower confined aquifer undertaken in August 1977 along the line of Richmond Borough supply wells gave a comparable storage co-efficient/transmissivity ratio with that for the recorded tidal oscillations. The tests suggest that the extractions from the lower confined aquifer may be approaching the upper allowable limits, hence more stringent management policies are being formulated with regard to water right approvals.

All wells to the upper confined aquifer were located and their usage determined. A detailed potentrometric survey was undertaken in mid-summer to relate water levels in the two confined and the unconfined aquifers. These were also related to river levels.

Since 1974 the board has conducted a sampling programme for oxygen isotopes aimed at identifying sources of recharge. The samples have been analysed by Institute of Nuclear Sciences, DSIR and a preliminary report is available.

An intensive chemical study of the Waimea groundwater was undertaken to provide baseline data, particular emphasis being on the concentrations of nitrate nitrogen. In addition there has been intensive monitoring of chloride concentrations in the vicinity of the coast.

A water resources report is currently being assembled which assesses the knowledge available to date for the catchment. This report also outlines proposals to augment the naturally available resource.

The main works proposed for 1978–79 are:

(a) potentrometric survey during August to provide data for a winter water level contour map;

(b) three pump tests to compare permeabilities of the confined and unconfined aquifers with postulated values and to investigate artificial recharge of both aquifers;

(c) well logging and sieve analysis of samples from new wells drilled by farmers to provide aquifer characteristics;

(d) collection of irrigation water use data and determining areas and crops under irrigation;

(e) drilling of an exploration bore towards the western extremity of the lower confined aquifer and probable recharge area.

[5] Motueka Plains water resource survey for a Water Allocation Plan

Water levels in three wells drilled in 1976 and two drilled in 1977 are recorded continuously. Bench marks were installed at most of the intersections of roads over the plains for levelling in the wells used for a potentrometric survey in March 1978.

From gaugings conducted in March 1978 down the Motueka River to locate recharge it appears there is little, if any, recharge to the Motueka Plains during drought conditions.

In 1978–79 two further exploration holes will be drilled to provide further information on aquifer thickness and hydrogeology of the Motueka River delta. A potentrometric survey is proposed during July–August 1978 to provide an overall view of highest water table levels and these will be compared with the March 1978 potentrometric survey.

[6] Brooklyn Catchment land resource survey

The survey objectives are to establish a land use capability classification, and to assess work type requirements This basic information will be the justification of and the priority rating within district requirements for considering implementation of comprehensive schemes.

Field work, with the exception of lower plains detail, is completed over the total catchment (21.5 km^2). The main river work requirements and economics have not been included as these are complex, inter-related with the Riwaka River and would be more appropriately included under a regional catchment scheme.

The survey shows that the upper catchment is moderately steep to steep. Soil erosion is minimal at present. It is on the granite derived soils which cover approximately a quarter of the catchment that the potential for erosion is high. Gully and stream stability is a normal feature of the Brooklyn, the upper reaches of the main river being particularly stable. The middle and upper catchment consists of indigenous scrub and forest, exotic forest and medium to low intensity hill farming. The river plain is fertile producing highly valued crops.

Work planned for 1978–79 is to complete maps at 1 30 000, complete the lower plain detail and determine soil conservation requirements, costs and priorities.

[7] Wai-Iti Catchment land resource survey

The objectives of this survey are to establish a land use capability classification, to assess erosion problems and to identify and assess work type requirements. This basic information will be the justification of and the priority rating within district requirements for considering implementation of comprehensive schemes.

WESTLAND CATCHMENT BOARD

[1] **Kongahu Swamp land resource survey**

This land use capability survey was carried out to assist in the formulation of farm plans necessary as a pre-requisite for the development of an overall drainage scheme for the swamp. The total area surveyed was 80 ha.

[2] **Styx Catchment water resource survey**

This hydrological investigation is being carried out at the request of the West Coast Electric Power Board to assess the feasibility of the Styx Catchment (65 km^2) providing water for a small hydro-electric scheme.

This small hydro-electric scheme entails carrying water from the Styx via tunnels and water race to Lake Kaniere, then through a further series of tunnels and water races to the power station and eventually discharging into the Hokitika River.

A water level recorder was installed in early 1977 at the Lower Styx bridge and its rating will be calculated when enough gauging data are to hand. Rainfall/runoff relationships will then be derived.

[3] **Routine water quality sampling**

Baseline sampling for the setting of synoptic levels on water rights is carried out at some 70 sites in the board's area. Sampling and analysis is for general parameters such as temperature and pH. Most sites are also sampled for bacteriological parameters

The board at present uses the Cawthron Institute for analysis but in the near future is planning extensions to its offices which will include a water quality laboratory. It is hoped to expand water quality sampling once this facility is available.

NORTH CANTERBURY CATCHMENT BOARD

[1] **Port Hills land resource survey**

This is a land use and land capability surves of the Port Hills part of the Halswell catchment to determine relative soil stability on the hill portion of that catchment within the Paparua County.

The hill catchment of the Halswell River within the Paparua County is 5 500 ha. Field investigations on 5 075 ha have been complete. The report together with maps should be completed by the end of 1979.

[2] **Hurunui Catchment water resource survey for a Water Allocation Plan**

A water resources report has been prepared, from which a water allocation plan will be drawn up. The main features of the report are as follows.

The seasonal flow pattern of the river is typical of eastern South Island rivers north of the Rakaia i.e. high spring flows decreasing to a minimum in later summer. The lakes influence this pattern by extending the recession downstream causing a half life of 98 days (c.f. Waiau 43 days). Also, there is very little diffierence in the 70, 80 and 90 per cent flows, especially in the summer months.

The annual mean discharge of the Hurunui is 49.3 $m^3 s^{-1}$ at the Mandamus site and 59.1 $m^3 s^{-1}$ at the No. 1 State Highway site. The two major reaches in the headwaters of the catchment, the South Branch and the Hurunui, contribute 12.8 $m^3 s^{-1}$ and 27.4 $m^3 s^{-1}$ respectively at their confluence.

Irrigation is potentially the greatest consumitive use of Hurunui water. Fishing and recreation are currently the most important non-consumptive uses of water. However, hydro-electrical generation could become a dominant consideration in the management of the resource.

The continuation of the programme of mapping the average annual water resources is an important feature of the report. Unfortunately there is insufficient information available at secondary sites to permit that available to be extended to mapping flows. However, by maintaining the flow recorders established during this investigation, more detailed mapping will eventually be possible.

The use of flow records available for the Mandamus and Lake Sumner sites has permitted a number of analyses of data which should enable the board to assess the effect of abstraction more accurately, and potential water users to assess restrictions which may be imposed. These include the calculation of return periods for low flows and the likely duration of those flows.

Groundwater, on the evidence available, is not significant in the total water resource of the catchment. Its use for irrigation is extremely limited and it is likely to remain only a supplementing source of domestic requirements. When planning water allocation for the Hurunui it will be necessary only to consider the surface supply.

The major resource development possibility within the catchment is to control the effective storage of Lake Sumner.

[3] **Canterbury Plains underground water investigation**

The objective of this survey is to collect all data relevant to the determination of the source, quantity, quality and safe potential yield of the underground water in the region.

Water level recorders have been installed and data is recorded continuously. Piezometric contour maps are drawn up at six monthly intervals and pump tests have been undertaken at Lincoln and at Travis Swamp. Groundwater hydrograph analysis is being undertaken and work has been done on stratigraphy and well log interpretation. Computer models are being used for management analyses.

[4] **Ashley water resource survey**

This report surveys the quantity and quality of water in the catchment and is the first stage of the preparation of a water allocation plan. adata is being collected on physical and hydrological aspects of the catchment and raingauges and flow monitoring sites have been installed. A stream-flow gauging sequence has been established and a programme to monitor the Lower Ashley groundwater resources is being designed.

SOUTH CANTERBURY CATCHMENT BOARD

[1] **Opihi River water resource survey for a Water Allocation Plan**

Proposals for flow regulation by means of storage have been initiaed and data is being collected for design purposes. The data collected involves flow rates and precipitation and suspended sediment sampling, and will continue at and above the two telemetered water level recorders. Because surface water losses are apparent downstream of the recorder sites, a continuation of flow measurement (at 20 sites) is required to establish amounts and locations of these losses.

[2] **Ashburton River water resource survey for a Water Allocation Plan**

The objective of this survey is to assess the water resource of the river in preparation for a proposed water allocation plan.

The daily mean flows from the two automatic water-level recorders and the data from the two automatic and the 26 daily manual precipitation stations are being analysed. Flow measurements are being carried out at 33 sites.

[3] **Orari River water resource survey for a Water Allocation Plan**

The objective is to assess the water resource of the river in preparation for a proposed water allocation plan.

Data are being collected at one automatic water-level recorder site, 15 precipitation stations and 12 flow measurement sites.

[4] **South Canterbury groundwater survey for a Water Allocation Plan**

The objective is to establish baseline data on groundwater levels, to determine areas of recharge and outflow, and generally to provide data for analysis with respect to existing and potential withdrawals.

The levelling in of all known well heads has been completed and in 1978–79 a programme of more frequent and selective water level measurements will be undertaken.

[5] **Routine baseline water quality sampling.**

The objective is to monitor water quality at selected sites where pollution is likely to occur.

Routine sampling is being carried out on 11 runs within the boards district. Each run has up to 11 sample sites which are sampled each month. The samples are analysed for BOD, dissolved oxygen, pH and faecal coliform levels. Temperature is also measured at each site at the time of sampling. Areas of high pollution are identified and where necessary further sampling is being carried out.

[6] **Influence of vegetation and catchment condition on catchment hydrology**

The lack of qualitative and quantitative data on the influence of catchment condition and type of vegetation cover on downstream values is a serious problem for water resource managers and planners.

The survey is located in water-short catchments, such as the Opihi, not only to determine if river flows can be increased by land management but to ensure that existing flows are not further reduced by incorrect land use. It commenced in 1977 with the selection of six catchments in the Mt Nessing area. Catchment details are given in Table 2.

It is proposed to accelerate the development of differences in land use between the short and the tall tussock catchments by oversowing and top dressing catchments three and five and a total of twenty-eight hectares of bare ground in catchments four and six. Catchments four and six will then be de-stocked and satisfactorily fenced.

Weir sites in all catchments have been selected. The owners of Shenley have agreed to de-stock catchments four and six for five years. Access to all six recorder sites has been constructed and siting and bulldozing of fence lines has been completed. In 1978–79 all weirs will be constructed and fencing completed, and oversowing and top dressing carried out.

A further four catchments in the Kakahu forest region have been selected for a comparative study of the effects that forestry (two catchments) and tussock cover (two catchments) have on the hydrological cycle. Investigations will commence as manpower permits.

Table 2 Details of Mt Nessing catchments

	Eroded	*catchments*	*Well covered*	*Short tussock*	*Well covered*	*Tall tussock*
Catchment no	1	2	3	5	4	6
Area (ha)	115	190	159	190	87	129
Mean elevation (m)	1100	1100	940	880	950	790
Average slope (°)	32	32	31	29	31	29
% bare ground	31	20	9	9	10	6
% tall tussock canopy cover	40	45	36	45	61	52
Principal vegetation	Snowgrass assn.	Snowgrass assn.	Snowgrass – Hard – Silver Tussock assns.	Snowgrass – Hard – Silver Tussock assns.	Snowgrass – Hard – Silver Tussock assns.	Snowgrass – Hard – Silver Tussock assns.
Property	Mt. Nessing	Mt. Nessing/ West Hills	Shenley	Shenley	Shenley	Shenley
Main soils	Kaikoura	Kaikoura, Hurunui	Hurunui, Kaikoura, & intergrade of the two	Kaikoura, Kaikoura – Hurunui Intergrade, Hurunui	Kaikoura, Kaikoura – Hurunui Intergrade	Kaikoura, Hurunui

[7] **Sources of detritus to South Canterbury's major rivers**

A survey was commenced in 1975 to analyse the sources of detritus in the upper catchments of the Ashburton, Orari, Waihao and Rangitata Rivers. The survey scope proved too large to adequately cover all aspects required and subsequently the survey has been split into four separate catchment surveys.

The type and objectives of each survey are identical, these being to:

(a) assess the distribution, extent and severity of detritus sources within the catchments and compare this information with each major catchment in the board's area;

(b) relate the distribution and severity of detritus producing erosion to environmental factors such as rainfall, slope, elevation, landscape position, aspect;

(c) identify areas of high potential risk for any specified type of erosion;

(d) establish priority areas for treatment of detritus sources and to indicate the type and ease of treatment required;

(e) relae land use capability patterns, soil patterns and water yields to catchment environmental factors (precipitation, catchment condition, vegetation, etc).

The report on the Upper Ashburton catchment was conpleted and published in 1978 (SCCB Publication No. 15).

Field work for the Upper Orari catchment was completed in 1976 and survey data and background catchment data was computer stored during the same year. Computer programming and checking of survey data was undertaken in 1976–77 and the initial comprehensive analysis of results was done in 1977. Results include calculations of numbers, density, total and relative ratings and average severity (see p.8 of SCCB Publn. No. 15 for definition of these t erms) for each type of erosion mapped versus: catchments, elevation, class, landscape position, rainfall class, soils, percentage bare ground and vegetation. One result shown in the analysis is that density and relative rating of gullies get greater with increasing bare ground above, i.e. there could be a relationship between areal erosion (sheet and wind) and the occurence and/or risk of gully erosion. Analysis of results has been delayed through difficulties in getting access to the computer but the majority of work should be completed by mid- to late- 1978.

The field work for the Upper Waihao Catchment/Lower Eastern Hunters Hills survey is nearing completion. Inventory and capability maps will be produced mid-1978.

The Upper Rangitata River Land Use Capability Survey was completed in early 1977 and the Lawrence Catchment Report was completed in late 1977. Further land use capability surveys of other major tributaries of the catchment are continuing. The Lawrence survey will be used in the preparation of a catchment management plan of the area by the Lands and Survey Department and in considering a request for zoning of the catchments as a game management area.

[8] **Vegetation trends and catchment condition monitoring**

This work has been in progress in various ways for many years, mainly using two methods of line transects. From 1977 all new monitoring work uses either close-up stereo-pairs of photographs (10 pairs per site) or general panoramic photographs.

Eleven stereo-photo transects were established during the year, their locations being:

1-4 South Opuha catchment, adjacent to long term line transects;

5-8 Turtons Stream, North Ashburton catchment on Class VIIe land; some grazed, some de-stocked;

9-10 Dalzell, Upper Pareora catchment on Class VIIe land due to be destocked this year;

11 Cloudy Peaks, Opihi catchment; a retired area which has been oversown and topdressed for revegetation purposes under the Opihi Catchment Control Scheme.

Four permanent panoramic photographic benchmark sites had been established prior to 1977. Over the past year, another 13 sites have been established. The number of photographs taken at each site varies but averages about 14. The 17 sites established to March 1978 are located as follows:

1,2,4,5 Turtons Stream, North Ashburton River;
3 South Opuha catchment Opihi River;
6-10 Dalzell, Upper Pareora River, Upper Waihao River;
11-17 Cloudy Peaks, Opihi River.

Panoramic photographs provide a comprehensive coverage of large tracts of land and are complementary to the stereo-photo transects. Photographs taken with the 300 mm lens generally show sufficient detail to readily identify individual tussocks and small erosion scars. Any changes with time will be readily observed.

Certain of the line transects (which date back to 1952) were re-read during the year.

WAITAKI CATCHMENT COMMISSION

[1] **Waitaki Catchment land resource survey**

The objective of this survey is the completion of land inventory and capability mapping for the Waitaki Catchment. To date, 15% has been completed, 50% has been mapped but requires office revision and 29% of the catchment requires new survey. The remaining 6% of the catchment is waterways.

Management decisions resulting from this survey include the preparation of ten run plans, either completed or pending. Catchment management plan reports have been completed for Kyeburn, St Marys Range, Ohau Range and Ruataniwha.

[2] **Waitaki Catchment water resource survey for a Water Allocation Plan**

The objective is to assess the water resources of the river's tributaries, in preparation for a water allocation plan.

A number of flow measurements have been carried out and discharges have been calculated. This data collection is continuing, and flow quantity and variability is being determined. A water resource report publication for the lower river tributaries is 75% complete.

[3] **Waitaki Catchment condition survey**

The survey, which has just commenced, is to assemble and analyse an on-going photographic record, including stereo-pairs, of selected sites in the Waitaki catchment in order to:

(a) assess trends in vegetative cover under various regimes of use, including retirement;

(b) provide a basis for determining the improvement in the condition of sites that have had 2:1 subsidy on fencing for recuperative spelling and depleted sites that have been oversown and topdressed;

(c) assess effectiveness of revegetation measures;

(d) monitor sites known to be eroding to establish erosion rates and trends.

The locations surveyed include the Diadem Range (Ribbonwood Station), St Marys Range (Kyeburn, Lone Hill and Rugged Ridge Stations), Haldon Station and Te Akatarawa Station.

OTAGO CATCHMENT BOARD

[1] **Sawyers Creek land resource survey**

Field work has been completed, data are being draughted onto maps, and the text and recommendations are being prepared.

[2] **Makarora/Hunter Valley land resource survey for a Catchment Management Plan**

The survey has been carried out by the board in conjunction with officers from Department of Lands and Survey, New Zealand Forest Service and Ministry of Works and Development. All land inventory and land use capability data has been recorded and draughted onto maps. A text has been prepared and forwarded to the Department of Lands and Survey for inclusion in the catchment management plan proposal.

From the detailed survey, the requirements for water and soil management were set out under the following headings:

(a) Protection of Class VIII and eroded Class VIIe land
(b) Revegetation and rehabilitation of eroded areas
(c) Vegetation management
(d) Fire hazard
(e) Tracking
(f) Noxious animals
(g) Problem weeds
(h) Recreation
(i) Vegetation condition and trend
(j) Zoning
(k) Rationalisation of boundaries and the need for a total catchment approach

It was estimated that a total cost of $40 000 would be required initially to carry out erosion control and rehabilitation measures on areas which it is considered can be successfully treated.

[3] **West Wanaka land resource survey for a Catchment Management Plan**

This survey was carried out in a similar manner to the Makarora/Hunter Valley survey, with the exception that the New Zealand Forest Service did not take part as it owned no land within the area being surveyed. The data collected has been recorded in map form, and a text prepared and forwarded to the Department of Lands and Survey for inclusion or consideration in the catchment management plan

Soil and water management requirements recommended for inclusion in the plan are:

(a) Protection of Class VIII and eroded Class VIIe land
(b) Revegetation and rehabilitation of eroded lands
(c) Vegetation management
(d) Fire hazard
(e) Tracking
(f) Noxious animals
(g) Problem weeds
(h) Recreation
(i) Vegetation condition and trend
(j) Zoning

These recommended requirements are seen as essential for inclusion in the catchment management plan if the soil and water values of the area are to be protected.

[4] **Vegetation condition and trend studies - Otago**

Studies to monitor the effects on vegetation and bare ground of subsidised works within Soil and Water Conservation Plans have been established on nine properties.

(a) *Scabweed country which is subject to restricted grazing to encourage recuperation*

Studies have been established on two properties in the Lindis catchment, one on the Pisa Range and one on the Dunstan Range. Plots will be assessed every two years to provide quantitative and photographic information of the recovery of these recuperative spelled scabweed blocks.

(b) *High altitude short tussock grasslands and snow tussock grasslands*

Studies have been established on one property on the Hector Mountains, two on the Pisa Range, and two in the Wanaka area. In each case the objective is, using stereo-photographic techniques, to monitor changes in vegetation and ground cover on blocks which are being grazed on a restricted basis to encourage rehabilitation. The data will be used to establish stocking rates as well.

(c) *Grazing exclosures on the Block Mountains*

In order to gauge the long-term effects of animal grazing of high altitude short tussock grasslands on the Block Mountains six trials were established: two on the Pisa Range, two on the Old Woman Range on two on the Dunstan Range. At each site two adjacent 20 m × 20 m fenced plots were constructed, one to exclude all animals and the other to exclude only domestic stock. A stereo-photographic plot was established inside each plot, and one outside a pair, to provide quantitative data to complement visual observations.

[5] **Routine baseline water quality monitoring**

The objective of this resource survey is to provide baseline water quality data throughout the board's district as a basis for eventual classification and resource management, particularly in those catchments and coastal waters not at present covered by a water allocation or management plan.

Since the commencement of this survey in 1976 an expanding programme of water quality data collection has been under way. The appointment of a full-time qualified chemist to the board's staff to manage the board's water quality laboratory (which became fully operational during the year) means that most of the normal water quality testing can now be carried out at very reasonable costs.

Efforts to date have been concentrated on known problem areas, in particular the Otago Harbour, the coastal beaches near Dunedin, the lower Tokomairiro River system and the Kaikorai Stream, but excluding the Silverstream, lower Taieri and Clutha which are included in water allocation plan projects. Attention is also now being focussed on coastal estuaries, in particular the lower Waikouaiti River and estuary system. As information is collected, particular problems have been pin-pointed, for example the dispersal of heavy metals in the Otago Harbour, but so far the scope of the survey has not been extended to examine such problems.

All of the board's water quality data is now stored and indexed on a separate computer file in addition to the standard filing system. This permits the rapid sorting and analysis of data and enables it to be presented in a suitable form for resource management purposes.

The following is a brief summary of the findings from the survey to date:

(a) *Otago Harbour and coastal beaches near Dunedin:*

No. of sites tested	36
No. of analyses:	
chemical and physical	621
bacteriological	20

In general, mainly those areas adjacent to wharves and industrial or other (e.g. sewerage or stormwater) outfalls, the waters of Otago Harbour near Dunedin would, from the tests so far conducted, appear to be capable of meeting a Class SC

standard or higher most of time. Two areas of particular concern in Otago Harbour are at Ravensbourne and Sawyers Bay. An extension of the scope of the survey to allow sampling and analyses of bottom sediments in these areas would help in understanding the dispersal mechanism of pollutants in the harbour and assist in the framing of special conditions on water rights to discharge.

The faecal coliform tests of the coastal beaches near Dunedin indicate high counts in areas close to major sewerage outfalls.

(b) *Lower Tokomairiro River:*

No. of sites tested		7
No. of analyses:	chemical and physical	190
	bacteriological	22

These waters are subjected to industrial and local body waste treatment plant effluents as well as natural run-off from intensively farmed pastures. Stream channel efficiency also is threatened by the rank growth of acquatic weeds, the accelerated growth of which no doubt is encouraged by the nutrient enrichment of the waters. It appears that the deposition of organic and inorganic wastes on the river bottom may be associated with dissolved oxygen (DO) deficit problems in the lower reaches of the river. The board is currently planning for a water quality predictive model for this river system in order to better understand possible management options, especially since it is obvious that there is a high potential for the downgrading of water quality at times of low river flow.

(c) *Kaikorai Stream and Estuary:*

No. of sites tested		7
No. of analyses:	chemical and physical	70
	bacteriological	0

This stream runs through a relatively heavily industrialised area of Dunedin and because of this is subject to frequent accidental industrial spillages. More importantly, the estuary has suffered over a number of years because of the discharge of effluent from a major freezing works and domestic sewage overflows from a grossly overloaded system. Consequently, present water quality is low with high biochemical oxygen demand (BOD), total suspended soilds and faecal coliform levels, low DO concentrations and anaerobic sulphide bearing bottom sediments. Upgrading of the freezing works and domestic sewage disposal and treatment systems have since ameliorated much of the organic pollution entering the estuary, but a close monitoring watch needs to be keit on the stream and estuary to ensure improvement in the water quality.

(d) *Other localities (i.e, Leith, Waikouaiti, Oamaru):*

No of sites tested		13
No. of analyses:	chemical and physical	216
	bacteriological	15

[6] **Lower Taieri multiple use survey**

The objective of this survey is a resource evaluation for multi-purpose usage. This involves comprehensive data collection in respect to water quality and quantity to enable the evaluation of the dynamics of saline inflows and of storage in the lower river system, incorporating Lakes Waihola and Waipori.

The following is taken from a report received by the board covering the work carried out on the water quality aspects of this survey concerning the Taieri River downstream from Outram, the Silverstream, the Waipori River and Lakes Waihola and Waipori.

The whole lower Taieri River and lakes system is important because of sustained low flows and its promixity to large centres of population. Information collected by the bard indicates the general quality of the waters in this area is low at present, almost wholly due to thee discharge of domestic and industrial wastes from a local authority's, partially completed treatment plant in both the Silverstream and the lower Taieri River. This is confirmed by marked sags in dissolved oxygen levels, high biochemical oxygen demand, faecal coliform, ammoniacal nitrogen and phosphate levels in samples taken below the outfalls, and visual evidence in the form of gross solids and eel kills during low flow periods. Table 3 gives an indication of the quality of the water as it enters the lower Taieri system and its quality near the end of the system.

Compounding these problems is the tidal nature of the lower Taieri and the possibility that during extreme low flow conditions polluted water from the Taieri can enter Lakes Waihola and Waipori. Algae blooms and high nutrient concentrations have been observed in these lakes which are subject to heavy recreational use and suffer the additional problems of siltation. Another, but minor, discharge into the lower Taieri is from a cheese factory – a small volume discharge but with very high BOD concentrations.

The board has been working on a water quality predictive model for the lower Taieri and the programme of data collection has been orientated to this purpose. On 19 and 20 January 1978, a major survey of the river was carried out from Outram to Henley Ferry Bridge for the purposes of model calibration. DAta measured included river flow, velocity, temperature, DO, and river BOD_5 (BOD measured over a five day period). All major effluent discharges were also monitored. Concurrently with this calibration survey, a diurnal survey was carried out. Results of this survey and its application to the computer model have yet to be appraised. The board is receiving assistance in this work from Mr G. McBride, Hamilton Science Centre, Water and Soil Division.

Table 3 Water quality of the Silverstream and Taieri River

	DO (mg l^{-1})		BOD_5 (mg l^{-1})		FC (MPN/100 ml)		TP (mg l^{-1})		NH_3 – N (mg l^{-1})	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
Silverstream										
(a) Black Bridge	13.3	7.5	5.1	1.0	420	9	0.028	0.001	0.575	<0.001
(b) Riccarton Rd	14.0	8.5	169	2.5	>110 000	220	0.459	0.014	12.25	<0.001
Taieri										
(a) Outram	14.2	8.5	6.3	1.0	> 1600	4	0.046	<0.001	0.963	0.010
(b) Allanton	13.5	1.1	11.4	2.5	900 000	120	0.170	0.008	1.741	0.024

Note:

DO (mg l^{-1}) dissolved oxygen expressed in milligrams per litre.
BOD_5 (mg l^{-1}) five day biochemical oxygen demand at 20°C, expressed in milligrams per litre.
FC (MPN/100 ml) faecal coliforms, expressed as the most probable number in 100 millilitres.
TP (mg l^{-1}) total phosphate expressed in milligrams per litre.
NH_3-N (mg l^{-1}) ammoniacal nitrogen expressed in milligrams per litre.

[7] **Lower Clutha River survey**

This is a general channel survey and related gravel resource survey carried out by establishing cross-sections at varying intervals up to 500 m apart, at each significant change in river geometry. The region of river covered under this survey is Tuapeka to Barnego. Gravels are to be sampled at specified locations.

[8] **Molyneux Bay coastal observation survey**

The objective of this survey is to observe sand movement and the coastal climate for the Molyneux Bay coast from Kaka Point in the south to a northern limit at Summer Hill.

[9] **Clutha River Catchment water and land resource surveys for a Water Allocation Plan**

An abridged version of the allocation plan, sub-titled "A Land and Water Resource Inventory of the Clutha Catchment", was published in October 1976. It gave a broad survey of the entire catchment's land and water resources (both as to availability and quality), an assessment of present and potential future needs and development opportunities, and identified areas where conflicts may arise in allocating the catchment's resouces. The final stage in the planning process, namely that of decision-making on the allocation of resources, had not been undertaken, the chief reason being the degree of uncertainty as to how much attention should be given to current dominant (or single purpose) development and how much consideration should be paid to optimising land and water resource development of the catchment.

Since publication of the abridged version efforts have been concentrated on the preparation of the first volume of the plan. Considerable delays have occurred in preparing the final chapters of this volume, principally because of the need to investigate more closely the probable magnitude and frequency of low flows in the main river and lake system.

The content of the abridged version of the allocation plan has been considerably expanded in order to embrace a full review of the land, water and population resources of the catchment. Chapters 2-7 have been completed. The remaining chapters are in the process of being completed and edited.

Apart from the current objective which is to complete and publish Volume I as soon as possible and continue with Volume II which is concerned with allocation *per se*, the statutory requirements of the board oblige it to continue and constantly update its work in this field of regional planning. The Clutha catchment is large and has many complex issues relating to the management of its land and water resources. Volume I of the plan is a basic survey of the overall resources and requirements of the catchment, but essentially concentrates on the resources of the river system below the three glacial lakes. Many of the larger tributary systems, e.g. Arrow, Shotover, Manuherikia, Fraser, Lindis, Cardrona, have water allocation or land and water resources management problems which are particularly pertinent to those catchments. It is also apparent from investigations to date, that extensive revision of rainfall, hydrological and water resource maps is already required, particularly in view of the consistent pressures for development of the water resources. Proposed Scheme F developments are large, even by world standards. It is therefore considered essential that the board continues with, if not intensify, the planning work already undertaken in this catchment if it is to keep pace with the requirements placed upon it.

[10] **Taieri River water resource survey for a Water Allocation Plan**

A great deal of preparatory work was done on the Taieri Water Allocation Plan during 1977–78. Progress on the preparation of the plan was accelerated following the decision by the Otago Electric Power Board to make detailed studies of the plan in conjunction with the intake to the Maniototo Irrigation Scheme. Other aspects on which work has been carried out are water quality surveys, water resource mapping, extension of run-off records and an inventory of water rights.

Mapping of the basic water balance components, namely precipitation, evapotranspiration and specific yield, is the first step in any water resource inventory. Initial attempts to produce a specific yield map for the Taieri catchment met with little success due to anomalies in the rainfall map (mainly underestimation of rainfall) and the method which had been used for estimating evapotranspiration.

The rainfall map was redrawn using all available raingauges and a more refined method for estimating evapotranspiration was introduced. The problem of under-estimation of precipitation was then isolated in a manner similar to that used in work done overseas and the rainfall map was adjusted accordingly. Subsequently a mean annual evapotranspiration map has been produced. Further maps derived from the rainfall and evapotranspiration maps include the mean annual specific yield map (precipitation minus evapotranspiration) which agrees well with recorded flows, the mean annual run-off ratio map (the ratio of specific yield to precipitation), and the mean annual dryness ratio map (the ratio of the energy needed to evaporate all precipitation to the potential amount of energy available).

Most of this work could not have been undertaken without the assistance of a computer. The programmes developed for the work will be of assistance in any future work of this nature.

Work has commenced on assembling daily mean flows from Ministry of Works and Development TIDEDA records onto the board's computer, and some simple correlations between water level recording sites have been attempted. Because of the scarcity of long-term flow records in this catchment, attempts will be made to extend the data record using synthetic modelling techniques. It is also intended to convert other long-term records that exist (e.g. Dunedin City Council's continuous stage record in the Deep Stream catchment) into a form useful for water resources planning.

A complete inventory of water rights in the Taieri catchment is required to assess the quantities of water which have been allocated to private and Crown water users. All water rights in the Taieri catchment are being collated for filing onto the board's computer system to enable processing and recovery in a manner suitable for resource assessment and management purposes. The programme for this processing and recovery is at present being developed.

A broad programme of baseline water quality data collection is in operation in the Taieri catchment and some work has been concentrated on water quality modelling in the lower Taieri River in conjunction with the Lower Taieri Multiple Use Survey. It will be necessary to considerably extend the coverage of water quality data collection in this catchment in the near future.

It is very apparent that a considerable amount of additional time and effort will be required to complete this plan. There are considerable pressures on the board, particularly from other local authorities in the area, to accelerate the publication of the plan. Currently there are proposals for a joint hydroelectricity/irrigation development in the upper catchment, associated with the Maniototo Irrigation Scheme, for which new Crown water right applications have been applied for. In the Strath Taieri region, the Ministry of Works and Development is currently investigating proposals for large scale irrigation. In addition, there is the possibility of future diversions from the lower catchment for electricity generation.

[11] **Kakanui River water and land resource surveys for a Water Allocation Plan**

The objective of this survey is to assess the water and land resources of the Kakanui and Waiareka River catchments, in

preparation for an allocation plan.

Since carrying out a preliminary water resources inventory some three years ago in conjunction with investigations for the catchment control scheme, work on the allocation plan has mainly centred on updating information on droughts in North Otago and evaluating the probable frequency of occurrence of droughts of a specified severity. Collection and processing of water resource data is continuing, but this task is especially difficult in the Waiareka and Island Stream tributaries because of the variable nature of the yields and the lack of suitable gauging sites with the necessary sensitivity for automatically recording stream flows.

In February 1978 a re-assessment of all applications for water rights was made to update current water use requirements. This review indicated that the assessed requirements for irrigation had been reduced to 0.64 $m^3 s^{-1}$ (26.6 cusecs), and that 37 applications only were outstanding, whereas previously there had been 48 with an assessed requirement of some 1.77 $m^3 s^{-1}$ (62.6 cusecs).

A water-level recorder for the Kakanui River at Clifton Falls has been in operation since January 1969. The records derived from this recorder show that during an average summer, the flow in the river at Clifton Falls can be expected to be in excess of 0.36 $m^3 s^{-1}$ (12.7 cusecs) 98% of the time or 176 days out of 180, and in a very dry season this level could drop to 0.21 $m^3 s^{-1}$(7.42 cusecs). The lowest recorded flow at this site was 0.150 $m^3 s^{-1}$(5.3 cusecs) on 21 February 1973. Measurement of flows further downstream can be affected either by abstractions, by natural losses through streambed gravels, or by evapotranspiration.

The problems of water allocation on the Waiareka Stream are compounded by extremely low water yields and the difficulty encountered in measuring stream flows.

A rather broad estimate of the mean annual yield from the catchment of Enfield made some three years ago, indicated that runoff, expressed as a ratio to rainfall, could be less than 2%, which is equivalent to an average annual flow of 42.5 $l s^{-1}$ (1.5 cusecs). This is an extremely low yield and could be caused by geological as well as climatological and hydrological factors. This figure is supported to some extent by flow gaugings carried out since. A recent survey indicates that there are some twenty firm applications for water rights on this tributary, having a total assessed requirement of 508 Ml per month (6.92 cusecs equivalent). Of these, four totalling 61 Ml per month (0.83 cusec) are on tributary streams and do not appear to have any significant effect on the water resources of the main creek.

Balanced against a requirement of some 198 $l s^{-1}$ (7 cusecs), it is obvious that an average annual flow of 42.5 $l s^{-1}$ (1.5 cusecs) would be insufficient to supply requirements on a straight withdrawal basis, even if rostering was considered. In a situation such as this, pumping to off-river storage reservoirs during times of relatively high flows in the creek is one means of providing water for irrigation later in the season. However, if the storage reservoirs are not of adequate size, problems are likely to arise over competition for what water may subsequently become available in the creek, particularly once these supplies are exhausted and extensive areas of crops are at risk.

The immediate need is to complete the water resources inventory, which is still in draft form, and prepare the associated water resource maps. It is also considered necessary to continue the programme of stream flow measurement, particularly in the Waiareka catchment. A broad appraisal of the underground water aquifers in the Waiareka catchment is also required, since there has been some recent interest shown in the possibility of using these underground supplies for irrigation and possible industrial uses in the area. However, the quality of this water may be a limiting factor, especially for irrigation. Underground sources are used extensively in the Awamoa area for horticultural purposes.

Completion of the land resource inventory which is being undertaken under a separate resource survey, is another essential requirement of the resources inventory. Basically, the problem in this catchment is one of resource management rather than water allocation *per se*. The present work appears to be more appropriate to the production of a regional management plan for the area than merely a water allocation plan. The board's publication "A Development Blueprint for the Kakanui Catchment" (August 1975) has already given a strong lead for regional planning in North Otago.

[12] Shag River water resource survey for a Water Allocation Plan

Over the last few years there has been consistent pressure by local residents, and particularly the Waihemo County Council, for the board to examine the water resources of the Shag River catchment with the object of preparing a water allocation plan for the catchment so designed to conserve the water runoff to augment the low level of summer flows.

During the summer considerable demands are placed on the water resources of this catchment, especially in the lower reaches where losses of water through stream bed gravels aggravate the shortage of water for irrigation, rural water schemes and township water supplies. This problem of water shortage is compounded by the need for a residual flow into the estuary to safeguard against saline intrusion into the groundwater and to maintain surface water quality.

The Shag River has a catchment area of 54 390 ha. Flow data for the river at Dunback has been recorded by the board since 1971. These records indicate a mean annual yield of 2.60 $m^3 s^{-1}$, but a monthly mean flow as low as 0.03 $m^3 s^{-1}$ has been recorded (February 1973). The lowest measured flow at Dunback is 0.022 $m^3 s^{-1}$ (18 February 1971). Below Dunback river flows are lost through stream bed gravels during extremely dry conditions. During the periods of restrictions in 1976 and 1978, the board's hydrological staff regularly carried out flow traverses to monitor the loss and recharge of water to the river channel. In both instances there was a delay of several days after significant falls of rain in the catchment before flows increased in the river at Dunback.

Although detailed studies on flow variability have yet to be carried out, it is possible that on an annual basis there is sufficient yield to meet presently indicated water requirements in the lower catchment, provided sufficient storage can be economically created in the river system with sufficient catchment above it to fill it with some reserve for years when yields are lower than average.

As at August 1978, the board's records indicated there are 24 abstractions for irrigation from the main river and tributaries, totalling some 686.3 Ml per month (9.35 cusecs equivalent). In addition, the Goodwood and Dunback rural water supply schemes and the Palmerston County town supply scheme require 14.10 Ml per month (0.20 cusecs equivalent). The Goodwood and Palmerston supplies draw their water from gravel based wells alongside the river, in its lower reaches. The board has constituted a local water allocation committee to ensure that withdrawals upstream do not prejudice these supplies at any time.

The area at present under irrigation by private irrigators has been assessed at approximately 560 ha (1380 acres), and the future potential in the lower catchment has been estimated by the board's staff to be in the order of 2240 ha (5530 acres).

Priority of work in the Clutha and Taieri catchments, particularly the former, has delayed progress with the Shag River catchment plan and work to date has mainly been confined to data collection and processing.

SOUTHLAND CATCHMENT BOARD

[1] **Oreti River sand and gravel resource survey**

The aim of this survey is to determine the extent of the sand and gravel resource in the lower river and to monitor the rate of depletion and renewal.

To date five re-surveys have been carried out on this reach. Since the last re-surveys during July 1977 there have been two major flood discharges; one (May 1978) appears to have been the greatest in the last 65 years.

The July re-surveys appear to show that the trend of the previous years is tending to continue. That is, that aggradation continues in the reach below the Oporo Railway Bridge where gravel extraction has been prohibited since November 1975. Upstream of the railway bridge to the upper limit of this resource survey degradation continues indiciating that the annual volume extracted by the gravel contractors is greater than the river's ability to replace.

[2] **Oreti River water resource survey for a Water Allocation Plan.**

The objective is to collate information on stream flows and groundwater for the preparation of a water allocation plan.

Work continued during 1977–78 on the computer filing of river levels recorded in the catchment, including the upper Oreti River and Irthing and Winton Streams. Flow duration curves for water allocation requirements have also been obtained from the data. Water right takes, discharges and diversions have been recorded between gauging sites in relation to computer returns to allow an update of demands on river sections. Some data on groundwater have been obtained from lignite survey drillers in the catchment. To date no water quality data have been obtained on the main or tributary rivers.

[3] **Mataura River pollution survey**

The aim of this survey is to evaluate recovery parameters of the river at summer low flows. The survey commenced late in 1975. Field work was on a limited scale and early emphasis was directed towards oxygen sag determinations and the need to supply information for the report on water availability for industries associated with the utilisation of beech forests in Southland.

In late 1976 the South Island Council of Acclimatisation Societies set up the Mataura River Supervisory Committee to oversee a number of research projects on the river under the Chairmanship of Dr D. Scott, Associate Professor of Zoology, University of Otago. Since then the Board has tailored data collection to the water quality data requirement of this project while at the same time sustaining the original aim of the survey.

Since July 1977 good use has been made of the opportunities created by a relatively dry summer, particularly in the measurement of oxygen related parameters.

Series of chemical and bacteriological samples are being taken from seven sites on the river. The sites are from Gorge Road in the lower tidal reach to Cattle Flat upstream of the main population centres. The feature of all results, winter or summer, is the increase in bacterial pollution below Gore and more particularly Mataura. Levels of nitrate-nitrogen, ammonia-nitrogen and phosphorus all show a similar increase. In general terms nitrogen and phosphorus levels downstream of Mataura are ten times greater than above Gore and this is reflected in the profuse growth which occurs on river bed material and the part this growth plays in the overall oxygen demand on the river.

On each river sampling run dissolved oxygen and BOD_5 is measured. In addition three separate 24-hour surveys have been conducted. A maximum of 12.5 mg (BOD_5) l^{-1} was measured at Mataura. Below this site results are in the range 2–4 mg (BOD_5) l^{-1} and above this site, less than 1.5 mg (BOD_5) l^{-1}.

An important part of the survey has been the analysis of samples from seven of the major discharges to the river. The recent commissioning of effluent treatment facilities by Southland Frozen Meat and Produce Export Company at Mataura has reduced their BOD_5 loading on the river by nearly 90%.

[4] **Lower Makarewa and Oreti Rivers pollution survey**

The aim of this survey is to determine the extent and sources of pollution on these two rivers.

In March 1976 testing revealed levels of ammoniacal nitrogen approaching those reported as being toxic to fish and some simple captive trout experiments resulted in fish deaths.

Data collected in 1976–77 were reduced in comparison with the previous summer because of higher flows and an especially diligent approach by effluent discharges which did not produce the high levels of ammonia encountered in the previous year. In 1977–78 attention has been given to the effect of discharges to this river system on the bacteria and chemical quality of the tidal recreational reach and the neighbouring estuary. The levels of faecal coliforms detected in the Oreti River above the Makarewa confluence is high. This level is sustained until dilution and die-off occurs in the estuary and sea. Although yet to be confirmed it appears the upgrading of effluent discharges by the freezing companies has lead to an improvement to bacterial quality of the river and that the contamination which exists, even upstream, is due to land use and river activity in the catchment.

There are indications of oxygen suppression in the lower Makarewa in particular. However on the occasion a 24-hour survey was carried out supersaturation of the river was noted. One kilometre below the Alliance Company outfall up to 15.7 mg (O_2) l^{-1} was measured at the peak and 7.6 at the sag. Upstream of the discharges the peak was 11 mg (O_2) l^{-1}. At the former site BOD has been up to 8.0 mg l^{-1}.

It is proposed to complete this survey in 1978 with a sampling programme designed to show up or contrast the levels of bacteria, ammonia and nutrients with the period when anaerobic discharges are being made to the river.

Research Contracts

INTRODUCTION

The policy and procedures of the National Water and Soil Conservation Authority's research contract scheme provide for the calling of applications from universities early in each year. In doing so they are advised that proposals must be relevant to the National Authority's fields of interest and that preference will be given to funding those which involve advanced student training. The policy also provides for entering into special purpose contracts which require special skills above the student level which are available in the university or public sector. These are negotiated with appropriate groups as the need arises.

This year 25 proposals were received from universities and the National Authority approved the negotiation of contracts for 13. For some proposals the National Authority supported research in the field proposed but indicated that there was a need to negotiate towards a more specifically defined involvement before a contract was to be offered. One proposal was negotiated with a civil engineering consultant.

Most research contracts have a provision to remain open for a period of two years from the time they are offered to a university. This is to give the university flexibility in establishing satisfactory arrangements for the commencement of the research and in selecting a suitable student. If the contract has not commenced within two years a new proposal has to be submitted or specific application made for its reconsideration, otherwise the contract lapses.

Of the 29 contracts approved in previous years 21 were underway in 1978. The following seven contracts did not commence because no suitable students were available:

(a) Nutrient and water conservation by peatland systems (University of Waikato);
(b) Dispersion in natural waters (University of Canterbury);
(c) Investigation into the pollutional contribution of surface water drains in Christchurch (University of Canterbury);
(d) Influence of management systems and soil type on the movement of nitrate-N, ammonium-N, and phosphate through deep soil cores in central Canterbury (Lincoln College);
(e) Methods of enumerating and identifying coliform bacteria with special reference to their survival and significance in the assessment of water quality (Lincoln College);
(f) Effects of land development and fluctuations in water level on phytoplankton productivity of Lake Mahinerangi (University of Otago);
(g) Evaluation of simple biological indices for the assessment of water quality and organic pollution of streams and rivers (University of Otago).

A contract with the Univeristy of Canterbury on Groundwater Computer Modelling was cancelled at the university's request. This was because of the non-availability of a student and the fact that Christchurch Science Centre staff are now covering the proposed research.

Of the 21 contracts underway the first progress reports for the following are not yet due:

(a) Eutrophication of Lake Ellesmere: investigation of phytoplankton (University of Canterbury);
(b) Nutrient status and primary productivity of Hawke Bay and Poverty Bay coastal waters with particular reference to sewage disposal from marine outfalls (University of Canterbury);
(c) Monitoring flow in the Kowai River and groundwater in the Torlesse Catchment (Lincoln College).

The remaining 18 contracts are reviewed in the next section.

CONTRACTS UNDERWAY

Contracts provide for at least annual reporting on progress and for most this is for the year ending 31 March. Hence, except where specifically noted, the summaries that follow are for the period up to 31 March 1978.

[1] **Slope stability in relation to soil types, rock types and geologic structures on the Waimarama–Elsthorpe Valley, Tukituki River, Southern Hawkes Bay**
University of Auckland, Department of Geology

This study aims to identify the relationship between slope failures in a structurally complex area of soft rock strata (in particular bentonitic mudstones) and rock type, soil type, bedrock mantle and physical parameters in the rock mantle.

Detailed geological mapping of the area has been completed at a field sheet scale of 1:10 000. The area mapped has increased during the course of the study from the 300 km^2 originally proposed to approximately 500 km^2. The latest addition has been the area north from Waimarama to Ocean Beach and inland to Mt. Erin thus completing the coverage of the geologically complex coastal belt from Kairakau to Ocean Beach. Also it has allowed the examination and more detailed understanding of a number of large landslides in that area. The preparation of the final geological maps at a scale of 1:15 000 for the coastal belt and 1:25 000 for the remaining area has commenced. The complex stratigraphy and structure along with instability data of the coastal belt from Waimarama south to Taupata is being draughted on to an aerial photo half tone base at a scale of 1:5000. The preparation of the soil, slope failure and slope failure susceptibility maps is nearing completion.

An extensive programme on *in situ* shear vane testing has been carried out in both wet and dry ground conditions but it was found that for best results field testing should be conducted in the wet season. A further problem encountered with the shear vane was the blocky nature of almost all colluvial material. This either prevented penetration of the shear vane or, due to the clast being

hit by the blades of the vane, affected the shear strength readings. It was also found that where the colluvial debris was appreciably sandy very anomalous readings were obtained suggesting the vane is of little value in such frictional soils.

The relationships of geological parameters to slope failure have now been examined in detail. There have been five important conclusions reached concerning the Cenozoic mudstones and sandstones. These are: low angle to moderately dipping bedding planes provide the basal failure for large bedrock block-slides; major joints and fault plane fractures provide the tensional head scarp boundaries; joints and bedding planes provide side shear plane boundaries; initial instability is considered to be promoted by permeability differences and probably excessive pore pressures created in sandstone beds; the nature of the bedrock material is such that once disturbed and disrupted it assumes soil properties and is prone to continuing failure by sliding and/or flowing. Investigations of slope failures in the bentonitic clays of the 'tectonic slices' and crush zones indicate that shallow debris slides are the common form of failure.

There has been good liaison between those involved on this study and staff at the Aokautere Science Centre. This has led to joint cooperation on a project evaluating the use of black and white multispectral photography as a guide to identifying geological formations in the Waimarama region.

[2] **Slope stability in relation to soil types, rock types, clay mineralogy and geologic structures in the Ohingaiti-Mangaweka-Utiku-Hihitahi Region, Rangitikei Valley**

University of Auckland, Department of Geography

This study involves detailed geological and pedological mapping, *in situ* field testing and laboratory analytical work on an area subject to serious and widespread slope failure.

Detailed geological mapping in the Utiku-Mangaweka area has now been carried out. In mapping, Opoitian-Nukumaruan rocks in five formations have been recognised overlain by an alternating sandstone and siltstone sequence of a further nine units. Clay seams have been identified in several of the formations and range in thickness from 2 mm to 2 cm. High and low level terrace gravels and lahar deposits overlie the sequence and appear to have little if any direct bearing on slope stability.

The structure of the area has proved more complex and faulting more common than previously shown. Faulting has a predominant NE-SW (030°-070°) trend together with lesser N S (000°-020°) and W-E (080° -090°) trends. Small scale faulting and jointing is also common.

A landslide map prepared for the region indicates the location and direction of small scale failures ie. earth flows and earth slides, but does not record rock falls or rock slides which are features caused by spalling or slabbing and are not readily mappable. Large scale failures (often deep-seated slides) are mapped in the categories of debris slides or flows, block slides and slumps. Areas of active movement and one known location of 'imminent' failure are mapped. Also indicated are the positions of probably ancient slides. exhumed glide planes and oxbow induced slumps.

The relationship of slope failures to geology is being examined and it has been found that small scale earth slides are common in the region and occur over all lithologies. Most of the large scale slides however, occur over two formations. The predominant trend of slope failure is to the S-SE and to a lesser degree to the S SW. There are few slides with a northerly component of movement. Most of the slides thus appear to be influenced, in part at least, by the dip direction of the beds. In some cases (e.g. the Utiku Slump) the slide plane on which the failure moves is found to be a clay seam, but this is unlikely to be the mechanism for all slides. Pore-water pressures built up at a permeability barrier between porous sandstone and underlying less porous siltstone may become high enough to promote failure.

[3] **The influence of particulate matter on coliform counting of river water.**

University of Waikato, Department of Biological Sciences

This study aimed to ascertain how far the very high variability of coliform counts on water can be attributed to 'clumping' of bacteria onto particles in the water.

Initial studies showed that *E.coli* 1103B which had been grown on broth when filtered through different sized membranes were not retained in significant numbers by filters having a pore size greater than 0.45 μm. By contrast *E. coli* in river water were retained on filters larger than 0.45 μm indicating that some coliform bacteria were associated with large particles. It is possible that more than one coliform bacterium is associated with a trapped particle but would show up as only one colony. Attempts were made to increase the efficiency of coliform counting by dislodging the bacteria absorbed to the particles using sonication but it caused very high mortality of the bacterial cells, resulting in lower and not higher coliform counts. Other desorption processes such as changes in pH, increasing salt concentration or use of ion exchange resins could be equally detrimental because they have an inherent bacteriocidal effect.

The University has submitted a revised proposal the principal aim of which is to develop a procedure for direct coliform counting using autoimmunofluorescent techniques. For this a specific polyvalent antisera against cultures of faecal coliforms isolated from the Waikato River will be developed after labelling with a fluorescent dye the sera will be used on samples of particulate material from the river water and the number of absorbed coliform organisms determined using a high quality incident light fluorescent microscope. The results will be compared with faecal and total coliform counts determined by standard methods. The contract now will not be completed until March 1981.

[4] **Bioassay techniques in the assessment of water quality in the Rotorua and Waikato lake and river systems**

University of Waikato, Department of Biological Sciences

The objective of this project is to establish standard bioassay techniques for assessing algal growth potential in the Waikato River and Lake Rotorua. Three test organisms have been chosen with the hope that they will represent a good range of responses to the nutritional status of test waters. They are two algal species, *Anabaena oscillarioides* and *Selanastrum capricornutum*, and a duckweed, *Spirodela oligorrhiza*. Physical conditions of the bioassay procedures using these organisms have been standardised rather arbitrarily rather than based on the optimal requirements of the individual organisms. However the basic aim was to achieve good growth of organisms under reliable conditions which were simple and convenient to set up. A test tube culture method which is economical to produce, easy to handle and requires only a small working space has been developed for the standard test organism *Selanastrum capricornutum* thus making this bioassay more readily available to smaller laboratories.

Since the aim of the bioassay procedures is to provide a number of organisms which, under standard culture conditions, will give a range of responses to the physical and nutritional status of test waters, the project concentrates on the study of the responses of the three chosen organisms and their specific use for certain purposes in testing water quality. The three organisms have been tested in field applications to test the water quality of Lake Rotorua inputs and the Waikato River. All organisms have shown good growth response indicating the applicability of the methods. A range of responses was also evident toward different water samples. Attempts have been made to correlate the growth responses to the annual mean nutrient concentrations.

Anabaena oscillarioides has strong growth responses to phosphorus additions, indicating that it is a good test organism for detection of phosphorus limitation and phosphorus fer-

tilising capacity in natural waters. Higher growth of *Anabaena* was found in the following Lake Rotorua inputs: Utuhina, Waingaehe and Waiohewa. The latter two samples were found to have high annual mean inorganic phosphorus contents.

Selanastrum capricornutum has significant differences in growth at different concentrations of nitrate-N indicating that the organism is very responsive towards nitrogen nutrition. However a nitrogen concentration of above 1 ppm is required for good algal growth which suggests that the alga might not be sensitive enough for detecting nitrogen in natural waters which are usually below this. The organism may be a suitable species for effluent testing, though. The organism is less responsive to phosphorus than nitrogen. Good growth was found with the following Rotorua inputs: Waiohewa, Awahou, Waingaehe, Utuhina, and low growth with Purenga and Kaituna.

Spirodela oligorrhiza was found to be most sensitive to a deficiency of calcium, nitrate, magnesium, iron, phosphorus and potassium (in descending order). Changes in frond size, nature of colony, colour of fronds, root length, presence of dead fronds and the appearance of roots were found to accompany changes in nutrient deficiency and can therefore serve as a guide to detect the limiting nutrient in natural waters. Significant increases in growth were found with increases in nitrate–N concentration. If nitrogen was not limiting growth, significant changes were found within the range of 0–1 ppm P, indicating that the organism is sensitive for the detection of phosphorus status of test water samples. Tested on Waikato River samples *Spirodela* has shown that plant growth was enhanced by nitrate addition. The enhancement of growth was higher with the addition of both nitrate and phosphate. Good growth was found in the following Lake Rotorua inputs: Waiohewa, Waingaehe, Waiteti, Utuhina and Awahou, and low growth with Purenga.

In general, the results indicate that *Selanastrum* and *Spirodela* are more sensitive to phosphorus than *Anabaena*. These results are in good agreement with the physiological characteristics of these organisms.

[5] **Preparation of an annotated bibliography on the effects of urban land use on water**

University of Waikato, Department of Earth Sciences

Under this contract information on the above topic has been assembled and is available to assist and guide staff in setting research priorities and making land management decisions. The bibliography which is stored on the university computer comprises over 1100 entries of which over 90% have accompanying abstracts. The printout is approximately 400 pages. Because the number of references is considerably in excess of that originally anticipated the contract has been extended to enable the university to key word index the bibliography.

[6] **Water harvesting, storage and irrigation of a yellow-grey earth soil — implications to the hydrology of the system, herbage yield and composition, and nutrient movement in soils and drainage waters**

Massey University, Department of Soil Science

The aim of this research is to evaluate the harvesting, storage and irrigation of tile drainage waters as related to the hydrology of a catchment and plots, pasture yield and composition and the movement of plant nutrients. The research extends an earlier three year programme on the same study area by considering in more detail the water balance, predictive modelling of the system, the effects of applying harvested water, and the effects of applying N and P fertilizers. Following is a summary of the work during 1977–78.

Rainfall in 1977 at 1020 mm was about normal but in the first three months of 1978 it was only 42 mm as compared to the long term average of 227 mm. Evapotranspiration from the irrigated pasture, measured using 'bucket lysimeters', was 856 mm, almost identical to the 848 mm measured in 1976. Calculated potential evapotranspiration (from temperature and sunshine data) was 841 mm in 1977. Aside from a single application of 18 mm in December 1977 irrigation commenced in mid-January and continued at approximately weekly intervals to the end of March by which time total application was 340 mm Actual deficit on 18 March 1978 measured by neutron probe on the non-irrigated plots was 227 mm whereas the computed soil water deficit relative to field capacity, assuming evapotranspiration could have continued at the potential rate, was 404 mm. From early February the actual evapotranspiration from the non-irrigated plots diverged from the potential evapotranspiration. Even towards the end of March the actual remained at approximately 1 mm/day, or approximately 30% of the potential.

Pasture yield in response to irrigation was increased by 44% (from 8380 to 12090 kg DM/ha/annum), close to the 40% average for the four years of this project. The mode of occurrence of drought conditions varies markedly from year to year, the 1977–78 year being characterised by extreme dryness commencing late in January. Thus on the non-irrigated plots the mean of the average daily yields for January was 56 kg DM/ha with virtually no production during February and March. The irrigated plots mean average daily yields were 60, 46 and 50 kg DM/ha in January, February and March respectively.

A new feature reported is data relating to an application of nitrogenous fertilizer (120 kg/ha urea) in August 1977 during the drainage season on two irrigated and two non-irrigated plots. Dry matter yield on the non-irrigated nitrogen fertilised plots averaged 8560 kg/ha from the time of application until late January 1978. The non-irrigated control plots averaged 7510 kg DM/ha. However this response requires further confirmation since it could be the result of one control plot having a low yield. Yield following the time of N addition was higher on the irrigated plots than on the non-irrigated plots which was evidence for the persistence of the irrigation treatment in the previous summer. Fertilised plots produced approximately 20% more than unfertilised plots, a relative differential almost the same as that which existed during the pre-N period. Therefore it is unlikely that N-fertilizer produced any major yield response on the irrigated plots.

After fertilizer-N addition both pools of inorganic N (NH_4 and NO_3^-) increased in the 0–10 cm soil depth but this increase was barely detectable 28 days after fertilizer addition. A similar increase was noted in the 10–20 cm depth for a period of 17 days. The rapid decline in soil N was not accompanied by a compensating increase in organic soil N at lower depths as would be expected if N was being leached in percolating waters. The decline is probably related to the incorporation of N into plant or microbial N.

Losses of nitrogen in tile drainage waters of individual plots varied between 5.8 and 23.3 kg/ha/annum. The overriding effect of irrigation is shown by an average loss of 17.4 kg/ha/annum for the irrigated plots and an average loss of 6.9 kg/ha/annum for the non-irrigated plots. Only 1% of the amount of N fertiliser applied was lost in the tile drainage waters within 30 days of its application, an unexpected result in view of the time of the year when it was applied.

1977–78 results also produced additional information on drainage losses of phosphorus, indicating the persistence for up to 63 days of elevated P concentrations and loadings in the drainage waters following P topdressing on July 1. Not only were the losses of P in the drainage increased by fertiliser addition, but they were more pronounced for plots which had received previous irrigation treatment. Soil data indicated an increase in the pool of dissolved inorganic and total dissolved P following P-fertiliser addition in the 0–10 cm depth but after 60 days no detectable differences were found. Similar trends were noted in the 10–20 cm depth.

It is suggested that, as well as highlighting the difference in persistence of fertiliser effects on N and P contents of soil and

drainage water, the results indicate that tile drainage losses of N and P may be predictable from soil measurements prior to the commencement of a drainage season. This possibility will be further explored using the accumulated data from several years of soil and drainage monitoring on the water harvesting site.

[7] **Geological erosion in the southern Ruahine Range**
Massey University, Department of Soil Science

The project provides for the geological mapping and interpretation of the greywacke basement of major catchments of the southern Ruahine Range. Particular emphasis is being placed on relating lithologic units to erosive potential and relating faulting to erosion patterns.

Detailed structural and lithological bedrock mapping has now been completed in 8 out of a proposed 11 catchments. Two distinct lithological sequences have been recognised and are lateral equivalents of similar sequences recognised in the northern Ruahines and to the south in the Manawatu Gorge. One specific objective of the project is to carry out an examination of the prevalence of mass movements and surficial erosion and their relationship to these lithological belts. Relationships between fault zones and patterns and the lithologic belts are also being examined. To date the Mohaka and Ruahine fault zones is defined in most catchments by a very wide crush zone. Coinciding with this zone are a number of large slumps, rock slides and slips. Elsewhere erosion scars are common along minor faults or where faulting has induced bedding plane movement.

[8] **Interactions of waste water and a river system**
Massey University, Biotechnology Department

The intensity of waste loading from sources such as meat works and city sewage is increasing for many New Zealand rivers. This study aims to characterise effluents entering the Oroua River near Feilding, and to determine their effects on this river. Over the 1977–78 summer period weekly sampling of the river and effluents took place, and chemical and bacteriological tests have been carried out. During this period the river flow was average to very low, the range recorded being 1.8–6.3 $m^3 s^{-1}$. Initially the river was fairly algal free but later in the summer immense algal growths developed in the less turbulent areas.

A preliminary appraisal of the results show the river to be significantly affected by Feilding sewage discharges, with high BOD/COD levels immediately below the discharge, and a change in the aquatic biota was noticeably more 5 km downstream early in November but by late summer only pollution resistant forms were present, indicating the pollution zone had moved downstream.

The sewage effluent had high levels of organic material, suspended solids and coliform bacteria, and a low dissolved oxygen level. The phosphate level in the river was the only factor to be noticeably affected by an abbatoir effluent. Effluent characterisation studies, and identification of biotic samples will take place in May–November 1978. Data will also be analysed for possible application of suitable models prior to completion of the contract in December 1978.

[9] **Mass movement erosion in the Wairarapa**
Victoria University of Wellington, Geography Department

A series of research and survey projects to determine cause and effect aspects of hill slope instability are being coordinated by the Aokautere Science Centre. As part of that the University is bringing together information on the extent of mass movement erosion and channel changes which occurred in the Wairarapa in 1977 and relating these to geology, soil, slope, vegetation and land use. In-depth studies are being made of the erosion processes within two instrumented catchments on different rock types (mudstone and loess-covered sediments).

As part of the regional survey of 1977 mass movement erosion an air photo interpretation study has now begun. From the post-winter 1977 air photo coverage a mosaic representing about 250 km^2 was assembled and sample units randomly selected for stereographic analysis. In the initial stage 100 units each 0.25 km^2 in area are being examined to assess the degree of slip erosion, slope position, aspect preference and terrain conditions.

The two instrumented sites selected are Clifton Grove Road catchment which is a mudstone, SE oriented, scarp slope basin and Pakaraka Road catchment which is a loess-covered, NW oriented, dip slope basin. Detailed field surveys of landslip location, volume, material and other characteristics within each basin have commenced.

In the Clifton Grove catchment a flow measuring station and a climate station have been established. A large active earthflow has been instrumented with inclinometer tubes with which to measure movement of the flow.

In the Pakaraka catchment two sites for climatological measurements were chosen on opposite aspects and equipment installed. A concrete weir has been constructed and a water level recorder installed.

[10] **Photogrammetric mapping at medium scale and very large scale, with particular reference to non-metric cameras and non-standard conditions both at photography and plotting**
University of Canterbury, Department of Civil Engineering

The initial objective of this project was the presentation of a base map of the Kowhai and Torlesse Streams and environs from existing 300 mm photography. It was planned to prepare three stereoscopic models; the Upper Kowhai River, the confluence of the Kowhai and Torlesse Streams areas and the ridge between these. To date the first model of the Upper Kowhai River at a scale of 1:2000 has now been plotted and contoured and is ready for draughting. It is aimed to have the three models traced out into a single map of 1–2 sheets.

[11] **The influence of chlorinated organic compounds present in the NZ aquatic environment and the possible toxic effects of these compounds on phytoplankton**
University of Canterbury, Department of Botany

Recent findings on PCBs and DDT have shown that these chemicals are extremely toxic to a large number of phytoplankton and furthermore, that these stable pollutants could have long term effects on the composition of natural phytoplanktonic communities which constitute the basis of aquatic food chains. This contract gives support to research which aims to:

(a) assess PCB levels in selected aquatic environments, using bioassay and gas chromatographic techniques.
(b) survey the sensitivity of locally occurring marine and freshwater phytoplankton to PCBs and DDT and their derivatives;
(c) determine the physiological basis of observed differences in sensitivity;
(d) study the adsorption of PCBs to environmental surfaces, and the factors controlling their subsequent re-release;
(e) determine the reasons for variations in sensitivity to various PCBs.

Experiments to date have indicated that the pattern of resistance and susceptibility of algal species to DDT differs from that for PCBs. Those species which exhibited resistance to PCBs exhibited no particular resistance to DDT. Experiments are being conducted to compare the DDT and PCB responses.

The effects of PCBs on photosynthetic activity of five species of freshwater unicellular algae (*Chlorella vulgaris*, *Chlorella fussa*, *Sceudeornus quadricauda*. *Scenedesmus obliqus* and *An-*

kistrodesmus angustus) are being examined. They were grown in the dark on a medium supplemented with glucose and the response to PCBs compared with light grown material. When *C. vulgaris* was grown in a minimal medium (without glucose) in the light, PCBs at 200 ppm completely inhibited growth. However, when the medium was supplemented with glucose, growth was not affected by PCBs either in the light or the dark. It thus appears that in *C. vulgaris* the effect of PCBs centres on either the photosynthetic apparatus or mechanism. Experiments are continuing with the other above species of algae to establish whether this effect is universal.

Diatoms appear to be much more susceptible to PCBs than are algae. The causes of this differential susceptibility are being studied, and it appears that because PCBs bind strongly to silicon particles they may affect diatom cell wall synthesis.

Samples have been taken from the lower Heathcote River, in the area of a rubber processing plant, and have been sent to La Trobe Univeristy in Melbourne for PCB analysis.

[12] **Movement of coarse bed material by flood waves in rivers**

University of Canterbury, Department of Civil Engineering

The aim of this project is to measure and ultimately to predict the variation in bedload transport rate in a non-equilibrium, non-steady flow situation e.g. the region of a scour hole during the passage of a flood wave. A detailed review of numerous papers dealing with problems of non-equilibrium degradation has been completed. It appears that the normal method of analysing these problems has been to apply steady state equations even when the water phase is definitely non-steady. The application of such a method is questionable but has been justified in many instances because of the lack of experimental data upon which a more realistic model can be built.

Experiments have been conducted in a small flume using sand as bed material to observe the longitudinal profile of the scour and to compare the shape with that predicted by existing numerical models. Observations have been most useful in planning the main experimental programme to be done in a large flume.

An existing general, non-steady model has been modified to simulate the experimental situation proposed. Further development will occur once some non-steady bedload distributions within the scour hole are obtained during the main experimental programme.

[13] **Investigation of water flow and sediment movement in step-pool streams**

Lincoln College, Department of Agricultural Engineering

The aim of this study is to clarify the hydraulic processes which occur in steep mountain streams. A laboratory study will systematically record the behaviour of an idealised step-pool stream under steady and non-steady flows of both sediment laden and clear water. This will be supplemented by observations on a prototype stream in the field. To date a small flume has been used to define the probable extent of the study laboratory work and to decide on the significance of the phenomenon of roll waves which, though prominent in artificial channels, is apparently absent from naturally formed step-pool channels.

[14] **An investigation of slip erosion in the Port Hills, Canterbury**

Lincoln College, Soil Science Department

The main objective of the research is to determine the physical properties of soils and develop understandings of the causal factors for mass movements which are predominant on west facing slopes and tunnel gully erosion predominant on east facing slopes.

The primary cause for major slip erosion on the west facing slope of the study area has now been established. This slope is formed on a series of westerly dipping basaltic lava flows. Water moves downslope between the lava flows and where it seeps to the surface it initiates loess movement. The loess moves virtually along the bedding planes of the lava flows.

On the east facing slopes the lava flows dip into the hill away from the slope. Water percolating through the solum of the east facing slope can move into the hill along the porous rock between the flows and therefore reduce the risk of high pore water pressures developing in the regolith of this slope. Also, basaltic chips fallen from the bluffs have mixed with the loess on the slope and the incorporation of this coarse fraction into the loess matrix probably gives the material a greater shear strength.

[15] **Eutrophication of Lake Ellesmere – preliminary appraisal of the nature of lake sediments**

Lincoln College, Department of Soil Science

The work to be done under this contract was completed and a final report submitted in July 1978.

Nineteen sediment cores were obtained in December 1977 along a series of transects leading into the lake from the mouths of the major rivers flowing into it. Physical and chemical parameters and the crystalline clay minerals present in layers of the cores were determined. Minerals present in selected silt samples were also determined.

Considerable variations in texture occurred in the lake sediments and these appeared to be related to fluvial deposition. The textures tended to be sand or sandy loams closest to shore and silts or silt loams furthest from shore.

Clay contents were usually low (<5%) and increased with distance from the shore. Organic matter contents were low (mean 2%; only 4% of samples contained more than 4% OM) and decreased with depth and increased with distance from the shore.

Total nitrogen ranged from 0.015–0.25% with a mean of 0.076%. This is less than the levels of 0.2–0.3% commonly found in the surface horizons of soils in the vicinity of the lake. Nitrogen values increased with increasing organic matter and clay contents.

Total phosphorus ranged from 160–970 ppm with a mean of 530 ppm (c.f. greywacke sandstone of the Southern Alps of about 750 ppm), and, with the exception of one transect, values increased with increasing distance from the shore. Most of the P was in inorganic forms (mean 89%). The measured P retention values had a mean value of 15% indicating that the sorbing power of the sediments for inorganic P should be low. This would be enhanced by the below average values (mean 10%) for the uppermost layer of each core. Mean value for oxalate-extractable iron and aluminium were 0.06 and 0.13% respectively, values that indicate low levels of strongly sorbing components.

Clay mineralogical analyses show mica to be the major component present, with smaller amounts of smectites, vermiculites and primary and pedogenic chlorites present in most samples. Only trace amounts of quartz and feldspar were present. No oxides of iron or aluminium were identified. With the possible exception of pedogenic chlorite, none of the minerals present are likely to sorb phosphate strongly. The quantities of smectite present were greater than those likely to be found in soils in the vicinity of the lake or in soils of the areas drained by rivers flowing into the lake. This indicates that mineral genesis has occurred in the sediments since their deposition.

The silt samples examined were dominated by quartz and feldspar. Minor amounts of mica and primary chlorite were also present.

Using its own resources the College intends to do further work on the clay mineralogy of the sediments. This will involve the examination of selected samples by differential thermal analysis, and, following dissolution of chlorite, by X-ray diffraction. These determinations will provide the most direct evidence as to

the presence or absence of inorganic components known to sorb inorganic P strongly. A study aimed to determine the proportion of inorganic P that may be brought into solution, and the equilibrium P concentration of a disturbed solution in contact with the sediments has commenced.

[16] **The regional and national economic impacts of the Lower Waitaki irrigation schemes**
Lincoln College, Agricultural Economic Research Unit

This study which effectively commenced in February 1978 aims to identify and quantify the economic impacts of irrigation schemes beyond the farm gate in terms of such parameters as gross output, employment, household income and overseas exchange. Data on the schemes and the regional economy, mainly from Ministry of Works and Development and Ministry of Agriculture and Fisheries, are being collected and collated. Some preliminary steps have been taken towards developing a theoretical framework for quantifying the regional impacts of the schemes.

[17] **Response of a trout population to water abstraction**
University of Otago, Department of Zoology

This programme aims to provide answers to the problem of determining how much water can be abstracted from a river without substantial harm to the fish population. The study is located on the Silverstream, a tributary of the Taieri River.

The compensation water put into the lower half (control area) of the Silverstream in 1976–77 was terminated on request so that this area was low in 1977–78. The upper area was given more water in 1977–78 but not enough apparently to change the behaviour of the fish (see below) so this area must be counted as being abstracted for two consecutive years.

Electric fishing, trapping, cover, width, depth, velocity and temperature measurements at specified sites were carried out. It was found that fish behaviour patterns showed marked changes at lower flows from aggressive territoriality to shoaling behaviour. However no mass movement out of the abstracted (Upper Silverstream) zone was observed, the only movement probably being local to the nearest deep water, either upstream or downstream. It appears that the fish shoal at a fairly precise velocity above which they maintain territories and below which they shoal.

[18] **Yield and macronutrient content of water in relation to plant cover from the snow tussock grasslands zone of Eastern and Central Otago**
University of Otago, Botany Department

This study extends previous work which demonstrated that the presence of a good snow tussock cover could have a beneficial effect on water yield in the dry Otago climate. Study sites cover an altitudinal range on the Rock and Pillar Range together with four sites in the Deep Stream catchment.

Mean water yield for the period February to October 1977 shows that snow tussock yielded significantly more than the other cover treatments except for the highest site on the Rock and Pillar Range and the lowest (and driest) site in Deep Stream. The former appears to be due to the duration and depth of snow cover in winter modifying the catch yield in the lysimeter so that *Celmisia viscosa* here shows the greatest yield. It is believed that below-snow canopy morphology is directing snow melt water into the localised *Celmisia* plot. At the lowest Deep Stream site the low fog duration and dry conditions provide a situation where the snow tussock plants lose more water due to their greater aerial surface exposed to evapotranspiration. It appears the greater yield of snow tussock at the other sites is due to gains from fog interception and low evapotranspiration. However, it may be due to greater catches of precipitation in the form of rain hail and snow due to the aerial morphology of the snow tussocks providing a greater catch area. Unfortunately fog duration data are patchy and poor due to automatic-data-recorder breakdowns. Yields from blue tussock and bare soil did not differ. Steps have been taken to safeguard against loss of fog data.

A floristic survey of the Deep Stream catchment was begun in the 1977–78 summer. Associated with this survey soil and snow tussock canopy characteristics have been determined at over 200 sampling points in the higher upland portion of the catchment. For the canopy study an indirect biomass system was developed to assess canopy variation and interception potential.

CONTRACTS BEING NEGOTIATED

[1] **Erosion of cohesive soils**
University of Auckland, Department of Civil Engineering

Substantial areas of New Zealand are covered by cohesive soils yet little is known about the physics of erosion of such soils. Research efforts worldwide have been devoted almost exclusively to the problems of alluvial sediment transport. It is the erosion of cohesive soils which is associated with a large proportion of soil losses, with wash load of streams, siltation of estuaries and water quality.

The research proposed aims to develop methods of *in situ* testing of the erosion properties of various cohesive soils and estuarine deposits, and to extend the theoretical formulation of the erosion process of cohesive soils, as developed, to include the effect of rain drops on a very thin sheet flow. The study will be a follow on from previous PhD research which essentially has been concerned with reviewing the state of the art. It will assist in covering an important area relevant to the National Water and Soil Conservation Organisation's interests and would relate to work at both the Christchurch and Aokautere Science Centres.

[2] **Upper Waitemata Harbour**
University of Auckland

The Waitemata Harbour Plan of the Auckland Regional Authority and the Auckland Harbour Board noted that the Hobonsonville Inlet and Lucas Creek are sensitive to pollution and there is a need for more study to ascertain whether or not further land development in the catchment is likely to lead to serious environmental degradation. In April 1977 the Water Resources Council gave approval in principle to the study of the problems in the Upper Waitemata Harbour. Subsequently an interdisciplinary group from various organisations established the following study objectives:

(a) to assess quantitatively the sensitivity of the waters of the Upper Waitemata Harbour to pollution and to identify suitable preventative measures;
(b) to determine the hydraulic charactersitics of the catchment to facilitate sound planning and design development;
(c) to formulate guidelines for the development of the Upper Waitemata Harbour catchment (and for urban develop-

ment of sensitive catchments generally) with the aim of minimising erosion, flooding, silting and water quality problems resulting from development;

(d) to carry out studies to assess the effectiveness of these guidelines.

During the initial planning of the overall study programme it was foreseen that contributions could be made by way of research contracts to the University of Auckland. This was discussed with the University following which provisional proposals were submitted. Steps have been taken to appoint a study coordinator for the overall study but until this is done the defined involvement of the University cannot be finalised and following on from that detailed study programmes cannot be formulated. However NWASCA has given its support in principle to the University being involved in sectors of the overall study, with the University's study programmes being determined and contracts being negotiated subsequent to the appointment of the study coordinator.

The provisional proposals were in the fields of:

(a) *Freshwater hydrology*: Department of Civil Engineering. This entails the study of the hydrology of catchments draining into the Upper Waitemata Harbour to develop working models for further predictive use.

(b) *Estuarine hydrology:* Department of Civil Engineering. The hydrology, hydrodynamics and sedimentation characteristics of the Upper Waitemata Harbour are to be studied and from that a predictive working model of the dispersion and distribution of substances released into the harbour is to be developed.

(c) *Community hydrology*: Departments of Botany and Zoology. The aim would be to determine the effects of changes in water characteristics resulting from urbanisation of the Upper Waitemata Harbour catchment. Much of the work will involve baseline surveys of the freshwater and estuarine flora and fauna. Aquatic organisms are very sensitive to small changes in their environment. Since it is fairly certain urbanisation will cause changes in the community these changes would be monitored to ensure that efforts being made to minimise environmental deterioration are effective.

[3] **A study of mechanics and dynamics of storm runoff producing regions in some lower order channels**

University of Waikato, Department of Earth Sciences

Divergent views exist as to the mechanisms by which water makes its way to a stream channel. It is considered that in permeable soils in humid regions, such as in the Hapuakohe Range proposed for the study, throughflow and the partial area concept are the principal mechanisms involved rather than the traditional Horton Model. The Horton Model is based upon the concept that for storms with intensities greater than the infiltration rate overland flow occurs uniformly over the catchment. However overseas evidence suggests that the storm runoff processes, particularly in forested areas, are much more complex, variable and dynamic such that the Horton concept is inadequate to model the processes. In so far as New Zealand steeplands both under forest and pasture are concerned the rainfall excess concept of Horton has not been validated.

The study aims to define the mechanisms of storm runoff production on forested and pasture sites, to measure quantities of flow contributed by each runoff form, to determine the factors affecting the relative contribution of each flow type, and to determine the contributing source areas and define indicators that may be used in the field to predict runoff producing zones.

[4] **Nitrogen budget in forest communities**

University of Waikato, Department of Biological Sciences

There is a generally held view that drainage water from undisturbed forest ecosystems is low in released nutrients but that when a forest is disturbed it will release large quantities of soluble and insoluble nutrients. However there is increasing evidence, both from overseas and from New Zealand, that nitrogen output from established forest may be large and not necessarily be related to disturbance or disequilibrium. Nitrogen in forest ecosystems is usually contained in the biomass as organic nitrogen and in soil as humus. A small proportion is mineralised and some of this enters groundwater and waterways. Once nitrogen is transformed to nitrate it moves unimpeded along with drainage water. Once in an open waterway nitrogen contributes to the productivity of rivers and lakes and is at least partially responsible for increasing enrichment and productivity of New Zealand freshwater systems.

The study aims to ascertain the nitrogen fixation inputs into forest catchments by symbiotic (including lichens) and free living organisms, to identify the organisms involved, the conditions under which they operate, to produce a quantitative budget of the separate inputs, and investigate the form and rate of transformation of mineral nitrogen constituents of litter and soil. One student will study litter and symbiotic organisms, one the lichens and phyllosphere and one the soil transformations. The proposal states the sites likely to be concerned are ideally those currently producing hydrological and chemical data under the Hamilton Science Centre's Taupo and Rotorua Lakes projects.

[5] **An evaluation of the effects of subsurface drainage on soil physical and chemical propoerties, and plant production**

Massey University, Department of Soil Science

Despite increases in subsurface drainage practices in recent years it is estimated that approximately 40% of the cultivable land in New Zealand remains poorly or imperfectly drained.

Although many farmers and Government recognise that expenditure on land drainage is a necessary part of land development there are very few quantitative data available in New Zealand on the likely depression in crop yield and animal performance due to waterlogging, on the magnitude of the benefits to be gained by a drainage system, or on the comparative effectiveness of different drainage systems. At present drainage design decisions are based largely on empirical information most of which is derived from overseas investigations. Many of those criteria still need to be validated in New Zealand because of it's unique climate and soils.

The study aims to evaluate subsurface drainage systems (pipe, mole, combined pipe-mole) as they affect the physical properties of the soil with special emphasis on gravitational water movement, water table levels and stock trafficability, the root distribution, nutrient uptake and drought susceptibility of plants, and pasture production and composition.

[6] **A study of the effects of benthic algae on the water quality of the Manawatu River**

Massey University, Biotechnology Department

Substantial growths of benthic algae have been observed in the Manawatu River. Their photosynthetic activity causes severe diurnal fluctuations in the dissolved oxygen and pH of certain river reaches. Above Palmerston North, prior to any point discharges, they cause a diurnal change of 3 mg l^{-1}. In the lower reaches below three major point discharges, diurnal fluctuations of up to 6.2 mg l^{-1} have been recorded. Their presence also lowers the aesthetic quality of the water and restricts the recreational use of the river.

The project proposes to study the standing crop and rates of photosynthesis and respiration of the benthic algae in the Manawatu River, to assess the nutrient limiting the growth of

these algae, and to provide baseline data concerning these algae.

By quantifying the algal problem and indicating causes for its growth this project would assist the Manawatu Regional Water Board in further understanding the processes occurring in the river. This is particularly important as the Board is intending to restrict organic discharges into the river severely. As present indications are that the nocturnal oxygen demand of the algae may limit the ability of some river reaches to adsorb organic effluents further research is regarded as necessary and would complement work of the Hamilton Science Centre on floating algae.

[7] **An engineering evaluation of alternative systems of dairy waste treatment**

Massey University, Department of Agricultural Engineering

This study aims to compare the engineering problems associated with the design and construction of spray disposal systems and anaerobic/aerobic lagoons and to monitor the performance of lagoons. It also aims to develop equipment which will overcome present cost, reliability and operational difficulties associated with spray disposal and to achieve improved distribution. In 1977 NWASCA provisionally supported the proposed study and referred it to the Dairy Wastes Committee of the Water Resources Council for its consideration and comment. The committee recommended that the study be supported and a contract was recently offered to and accepted by the University.

[8] **Sand and gravel**

Victoria University of Wellington, Department of Geology

Sand and gravel are important economic minerals but no comprehensive national survey of these resources has been undertaken. A considerable amount of information is known to be indirectly available but widely scattered. Research and survey staff of the Water and Soil Division have initiated a search for and collation of the information and are determining the needs for, the survey techniques and the programming of a national survey. As part of that survey it was seen that facets of the programme could be undertaken through the research contract scheme and preliminary discussions were held with Victoria Univeristy. The University submitted a proposal the objectives of which are to produce maps and three dimensional diagrams of sand and gravel resources in New Zealand, to assess the qualities and characteristics of each deposit, particularly grain-size, grain shape and lithologic type with reference to weathering characteristics, and to assess the amount of mineral that should be extracted from each deposit and the effect such extraction may have on water and soil management and planning issues as they may relate to the surrounding environment.

At the present stage the proposal as submitted could not be supported. However provision has been made that, once the overall national programme has been formulated by the Water and Soil Division, negotiations will take place with the Univeristy for detailed proposals to be prepared for specific studies that the Univeristy could undertake.

[9] **Investigations into nutrient inputs and cycling of nitrogen and carbon into Lake Ellesmere with particular reference to microbiological transformations**

Lincoln College, Microbiology Department

The productivity of lakes is usually considered to be limited by low levels of some nutrient such as nitrogen or phosphorus or some physical factor such as light penetration. A study of algae in Lake Ellesmere which is currently being carried out under a research contract with the University of Canterbury may help to elucidate the nature of the limiting factor or factors. Since the lake has a largely agricultural catchment, a large bird population and a fluctuating water level which causes inundation of land used for grazing, inputs of many chemical species could be large.

It is proposed to determine the magnitude of nitrogen inputs into the lake and to study the rates of nitrification, denitrification and nitrogen immobilization, together with associated aspects of the carbon cycle. In particular the lake margins and the lake sediment and suspended sediment will be examined

Lake Ellesmere was accorded a high research priority by the Officials Committee on Eutrophication and a Lake Ellesmere Scientific Co-ordinating Committee was set up under the aegis of the North Canterbury Catchment Board. Both the committee and the Board support this proposal.

[10] **High country fencing**

N.Z. Agricultural Engineering Institute, Lincoln College

Under a previous contract the Institute assessed the then design and effectiveness of different high country fences. Based upon the findings a fence design of cheaper material and labour costs was devised and has been tested in a series of comparison trials at seven sites to determine its compatibility to the special conditions in the high country. The trials were established in 1976–77, most being in co-operation with catchment authorities. The Institute has requested further funding to cover the costs of inspecting the trials to give information on their longer term effectiveness.

The National Water and Soil Conservation Organisation has been the principal supporter of fencing research and wishes that that should continue. However it is considered that further support should primarily be to significant new fencing issues and NWASCA asked for this to be discussed with the Institute with a view to bringing forward a research programme meeting that criterion.

[11] **Survival and detection of enteric viruses in water and waste water**

University of Otago, Microbiology Department

The field of waterborne viruses is one which has been identified by the Water Quality Research Committee as being a major gap in New Zealand work on water quality. Little is known of the types of enteric viruses or their survival patterns in New Zealand waters and waste waters. One enteric virus, hepatitis, which has a high incidence in New Zealand is believed to be transmitted by faecally contaminated water. It cannot be cultured in the laboratory and only detection of other enteric viruses can give any indication of its possible presence.

Bacteria are usually used as indicators of faecal contamination but their absence does not preclude the presence of viruses since viruses can resist chlorination. Methods for detecting enteric viruses in relatively clean or finished waters are available. Detection of viruses in wastes and treated wastes present problems using currently described methods.

The project which will be the first intensive study of viruses in New Zealand waters and wastewaters covers two studies the objectives of which are:

(a) to use the tentative standard method, proposed by the American Public Health Association, to detect viruses in rivers, streams and drinking water supplies in the Otago area and to carry out experiments on the survival of viruses under different conditions;

(b) to establish a method for detection of viruses in waste water on precipitation, centrifugation and pH adjustment (note: the method has been in part established in previous university research) and, following its establishment, to use it to determine viruses present in a variety of effluents.

[12] **Stabilisation of loessial soils with chemicals**

G.L. Evans, Consulting Civil Engineer, Christchurch

Erosion of Port Hills loess has been a feature of the landscape

for at least as long as there has been any photographic record of the hills: this is a time period of about a hundred years. The relatively recent urban development work on the hills has, in some areas, increased the risk and severity of erosion occurring whereas in other areas the erosion has become less noticeable or has not occurred at all. Research on the loess material in recent years (since about 1970) has revealed more clearly the nature of the erosion problems and the variability of the loess material. Although there is now a better understanding of the erosion processes, practically no research work has been done to improve the stability of the soil and alleviate the erosion problems. In most instances with erosion problems, standard solutions are applied such as drainage and retaining walls etc. But in many cases there is no way of controlling subsurface water flows and, with dispersive and erodible loess, erosion continues unabated.

Recent research has focused attention on the possible use of phosphoric acid (in very small quantities) and hydrated lime as two alternative chemicals which may have some worthwhile stabilising effects on loessial soil.

The study will involve:

(a) laboratory tests to investigate the effects of phosphoric acid and hydrated lime on loess from a site known to have erosion problems and compare changes in erosion resistance and other characteristics such as shrinkage and chemical composition, and strength gain;

(b) field trials using optimum quantities of the two stabilisers as determined in the laboratory tests to examine the effectiveness of field mixing and erosion resistance, density and strength of field mixed and placed materials.

Water and Soil Division

INTRODUCTION

Hamilton Science Centre

1978 has been a period of consolidation at the centre. An important development was the appointment of Dr T.F.W. Harris as scientist-in-charge, who took up his position in August. Programmes of work on inflows to Lakes Taupo and Rotorua have continued as in the past, while work on the Waikato River is moving into a new phase directed towards particular process studies rather than the comprehensive river length surveying conducted previously.

New programmes of work are being formulated, including studies of phytoplankton dynamics, nutrient transformation and oxygen exertion in stream sediments, construction and validation of mathematical water quality models, kinetics of oxygen demand, sampling programme design, regional comparison of water quality related to land use, riparian strip studies, and between-catchment nitrate variations.

Most staff are now located in an office block immediately adjacent to the campus of the University of Waikato, while the laboratory will remain in one of the university science block buildings.

Aokautere Science Centre

During 1978 the campus at Aokautere changed from being solely the National Plant Materials Centre to being a more broadly based centre: the Catchment Condition Survey and Land Stability Groups moved to Aokautere, together with the first of a small group of hydrologists. The completion of the new office/laboratory building will allow the Land Resource Survey Group to move in early in 1979. This will complete the gathering together onto the one campus of staff with the full range of skills and disciplines needed to tackle land resource, slope stability, and soil conservation research and survey issues for the National Water and Soil Conservation Organisation.

The centre has become conspicuously involved in co-ordinating research, within its range of responsibilities, on behalf of the National Water and Soil Conservation Organisation. A notable example has been the setting up of a joint research programme for the Wairarapa hill country.

A notable achievement was the near completion of field work for the North Island Land Resource Inventory Worksheets. Compilation and printing of the last sheets is expected to be accomplished early in 1979 and storage on computer will be completed later in the year.

In plant materials tissue culture facilities and techniques able to propagate large numbers of plants have been successfully established.

The centre was successful (after a worldwide search) in obtaining quantities of *Sanguisorba* seed. This promises to make a very significant contribution to the revegetation of the Mackenzie country and similar areas. Trials and seed multiplication projects are underway.

Christchurch Science Centre

The most noteworthy event during 1978 was the official opening of the Water and Soil Division's Christchurch Science Centre by the Minister of Works and Development, the Honourable W.L. Young on 5 September 1978.

The establishment of the Centre has allowed a concentration of professional and technical staff to develop. Research and survey staff began to move into the centre in Westminster House (Cashel Street) on 10 April 1978 and on 17 July 1978 the laboratory commenced operation. On 15 May an IBM 2741 interactive typewriter terminal was installed at Westminster House giving direct access to the Vogel Computer Centre.

Research and survey staff together with district staff have arranged a series of displays depicting water and soil conservation activities. The displays have been mounted in the Bank of New Zealand, Cathedral Square, and also at a meeting of the South Canterbury Catchment Board held in Ashburton. The displays were also on view at the Science centre during the visit of National Water and Soil Conservation Authority members on 5 September. Overall they have attracted considerable public interest.

Dr A.R. Rao, National Research Advisory Council Senior Research Fellow, concluded his research activities at the science centre on 29 June 1978. His year with the Water and Soil Division was most fruitful and a number of papers are in press. Dr Rao's presence and involvement in the science centre was a considerable stimulus to the other hydrologists at the centre.

THE NATIONAL HYDROLOGICAL NETWORK AND SURFACE HYDROLOGY PROGRAMME

The National Hydrological Network has continued to develop during 1978. At 1 January 1978 there were 669 water-level recording stations operating in New Zealand (622 in March 1977). Of these, 361 are operated by Ministry of Works and Development (MWD), 273 by catchment authorities and 35 by other agencies.

The success of the total network and the national hydrological data bank (TIDEDA) depends on the co-operation of all organisations involved in hydrologic data acquisition and water resource assessment. The assistance and co-operation of all agencies working in the hydrological field is gratefully acknowledged. The Water and Soil Instrument Service Centre (WSISC) continues to fulfil an important national function by servicing hydrologic equipment from all the agencies operating in New Zealand. To a considerable extent the successful operation of the hydrologic network depends on the high standard of servicing maintained by the WSISC.

A notable feature of hydrologic data collection during 1978 has been the marked increase in the use of digital water-level recorders. At 1 January 1978, 293 stations (44% of the total) were equipped with digital recorders, 41 of these being operated by catchment authorities. The installation of digital recorders continued during 1978 and by 1 October 1978 a further 22 digital recorders had been installed at new stations (11) or had replaced older chart recorders (11). Further progress in this direction is in hand with both MWD and catchment authorities purchasing standard digital recorders recommended by WSISC.

Components of the hydrological network

(a) Data for Current Use (Planning and Design). The majority of hydrological stations in New Zealand are operated to provide data for the design or for the operational control of specific projects. At 1 January 1978, 69% of stations were associated with projects such as power investigation, power operation, flood control (design and operation), flood warning (telemetered), irrigation (design and operation), water supply and underground water investigations.

(b) Major River Stations. These permanent stations are operated to assess long term trends in water yield from New Zealand's major catchments. Since the programme commenced five new stations have been established on major rivers and five existing stations have had their recorders changed to digital recorders, mostly replacing circular chart Foxboro recorders.

(c) Regional Stations. The regional station network is now relatively static but considerable use has been made of the available data in a regional flood estimation study (refer page 57). At present 60 regional stations are being operated in 57 regions, with a new station (Rosy Morn) established on the Kaikoura Coast during 1978. In all, data are available from 76 stations in 73 regions.

(d) Research Project Stations. Some hydrological stations are established to provide data for specific research projects. For example, stations have been established to assess the water resources of the Rakaia catchment. Where research project requirements have been met numbers of short term stations may be closed. For example, of the stations established to assess the inflow into Lake Rotorua and Lake Taupo, eight around Lake Rotorua were closed in 1978.

Data from these stations form part of the national hydrological data bank. However it should be clearly understood that the entire station network is organised to meet multipurpose research objectives. Such organisation allows management, operatiional and research objectives to be met with greatest efficiency.

Publication of data

To assist users in locating sources of basic hydrological data, an "Index to Hydrological Recording Stations" for all water-level recording stations has been published by the National Water and Soil Conservation Organisation for 1978. This index covers all stations operated by agencies working in hydrology in New Zealand. The published index is taken from a computer-based index which has been developed at the Christchurch Science Centre, and is updated using information supplied by the various agencies.

Catchment register

A catchment register of all catchments being monitored for hydrological purposes is being preapred. This will be a loose leaf publication, subject to regular updating, and will include the following information:

(a) catchment map, showing location of raingauges and water-level recorders;
(b) a description of the catchment land use, soils, geology and topography;
(c) a summary of hydrological data.

National hydrological data bank

A major advantage of digital recorders is the relative ease with which the 16-track punched tape can be processed into the computer-based hydrological data bank (TIDEDA). During 1978 National Hydrology staff at Christchurch Science Centre developed a fully-operational, data input and editing system using a Hewlett-Packard 9825A mini-computer. This data handling system permits hydrological technicians to process digital tapes and chart records immediately they come in from the field recorders. Editing, checking and compression of the data is carried out in a continuous single operation with visual checks by means of graph plots. The edited data are then transferred to the TIDEDA data bank in Wellington by means of a punched paper-tape.

Use of this data handling facility has greatly decreased the time between field recording of data and their availability on the national hydrologic data bank. It has also given the hydrological technicians more direct control of data editing and considerable insight into the effects of various processes.

The national hydrological data bank (TIDEDA) operated by the Water and Soil Division of the Ministry of Works and Development (MWD) now contains records from 424 stations (338 in 1977). During 1978 a major effort has been made by MWD staff to load all the data from stations not included in TIDEDA. In April 1978 TIDEDA held 5300 station-years of water-level record and 2226 years of rainfall data.

Crest-stage gauging programme

Crest-stage stations provide a simple and relatively inexpensive means of gathering data on annual maximum discharges. The objectives of establishing a New Zealand pro-

gramme are firstly to obtain a much larger data base of annual maximum discharges to supplement the data available from water-level recorder stations and secondly to carry out flood frequency analysis on the data collected in this programme, with a view to revising flood estimation procedures in use in New Zealand. The third objective is to obtain these data at low cost and miminum effort.

During 1978 extensive networks of crest-stage stations were installed in the Auckland and Hamilton Works Districts but as yet there are insufficient data available from which conclusions can be drawn.

Land use catchment programme

In 1978 considerable progress has been made in establishing land use catchments to monitor the effect of specific land uses on streamflow, sediment yield and water quality parameters. This network of land use catchments provides data for water resource management purposes and guides planning and policy formulation as well as providing data for specific land management problems.

New stations have been established in the Moutere Hills (Nelson), in South Canterbury (Opihi Catchment) and in East Otago.

Water and Soil Instrument Service Centre (WSISC)

The arrangements for the purchase of equipment by catchment authorities and regional water boards, and where possible the advance supply of equipment by WSISC, have continued to function during 1978. Notice of 24 orders being placed for a total of 92 digital recorders and 13 other instrument types has been received. WSISC has been able to assist in advance supply of instruments on 19 of these orders. Technical advice was supplied by WSISC for all orders.

During the year WSISC continued to service instruments for the Water and Soil Division of the Ministry of Works and Development, catchment authorities and other agencies. Servicing included 764 for the Water and Soil Division, 422 for catchment authorities, 99 traffic counters for the Roading Division (MWD) and 67 instruments for other agencies.

In addition to servicing instruments the following work has been carried out:

(a) 25 electronic time units designed at WSISC have been constructed and a further 200 are programmed for assembly and fitting to instruments during 1979;

(b) a multiple well-level monitoring system for Canterbury groundwater studies has been constructed, to be used by the Groundwater Group at the Christchurch Science Centre;

(c) a pitot tube high wind velocity recorder has been manufactured for the Alpine Processes Group at the Christchurch Science Centre;

(d) Troxler nuclear density meters for Waitaki power development and the Water and Soil Division have been serviced;

(e) event rainfall recorders have been modified to replace clockwork drive and timekeeping with a stepping motor operated by a solid state timer – this appears to be a most promising modification giving increased reliability to the event raingauge;

(f) event rainfall recorders have been constructed for the Water and Soil Division and other authorities as required

HYDROSYSTEMS

The Hydrosystems Group was formed early in 1978 and is being brought up to strength by recruitment and transfer of specialist staff. A work programme has been established and is being implemented. This programme is aimed at analysing the pool of New Zealand hydrological data to understand better the underlying physical processes, and to generate information for management decisions in such fields as water allocation planning, waterway design, hydropower production and irrigation development. Established systems analysis techniques and new methods now being developed internationally are employed. Computers are used extensively in these studies.

The Hydrosystems Group collaborates with the National Surface Water Hydrology Group to recommend how the country's hydrological data gathering network can be improved, and advises on techniques for the analysis of the data from the national hydrological data bank.

Regional flood estimation

A nation-wide flood frequency study has been carried out over the past two years in collaboration with the Planning and Technical Services Group, Water and Soil Division, MWD, Head Office. The study objective is to develop a design flood estimation procedure for ungauged catchments based on recorded data in New Zealand. Flow records from more than 200 stations have been used. The procedure developed represents the first major advance in flood estimation on ungauged catchments in New Zealand since the introduction of Technical Memorandum No. 61 some 25 years ago.

Using this procedure, the maximum flood which will occur on average once during a specified period of years is estimated in two steps. First, the mean annual flood, $\overline{Q}$, is calculated by means of a regional equation containing rainfall estimates and catchment area. Following this, the design flood flow, Q_T, is found from a regional curve relating the ratio $Q_T/\overline{Q}$ to the flood frequency, or return period, T. Separate equations and curves have been defined for each region of the country having homogenous flood characteristics. The mean annual flood equations have been developed at the Christchurch Science Centre and the regional frequency curves by the Planning and Technical Services Group. The results for the South Island are now available and those for the North Island are close to completion.

Regression analyses have demonstrated that the mean annual flood for a catchment may be estimated from catchment area and estimates of rainfall statistics with a precision comparing well with that of similar studies in other countries. Figure 1 gives the estimating equations derived for four South Island regions. Where used, the rainfall statistics are either the mean annual rainfall or the 24 hour duration rainfall of 2 year recurrence interval. Other catchment parameters such as channel slope, channel length, percentage forest, etc, were shown to be of lesser significance for estimating $\overline{Q}$.

Comparisons of estimated $\overline{Q}$ with observed $\overline{Q}$ are given in Table 4 for four South Island catchments not used in deriving the equations. In three of four cases the observed $\overline{Q}$ is within a range of one standard error about the estimated $\overline{Q}$. A final report on this project is in preparation.

Flow characteristics of major rivers

Effective management of water and land resources in major river systems frequently requires:

(a) streamflow characteristics at ungauged locations;

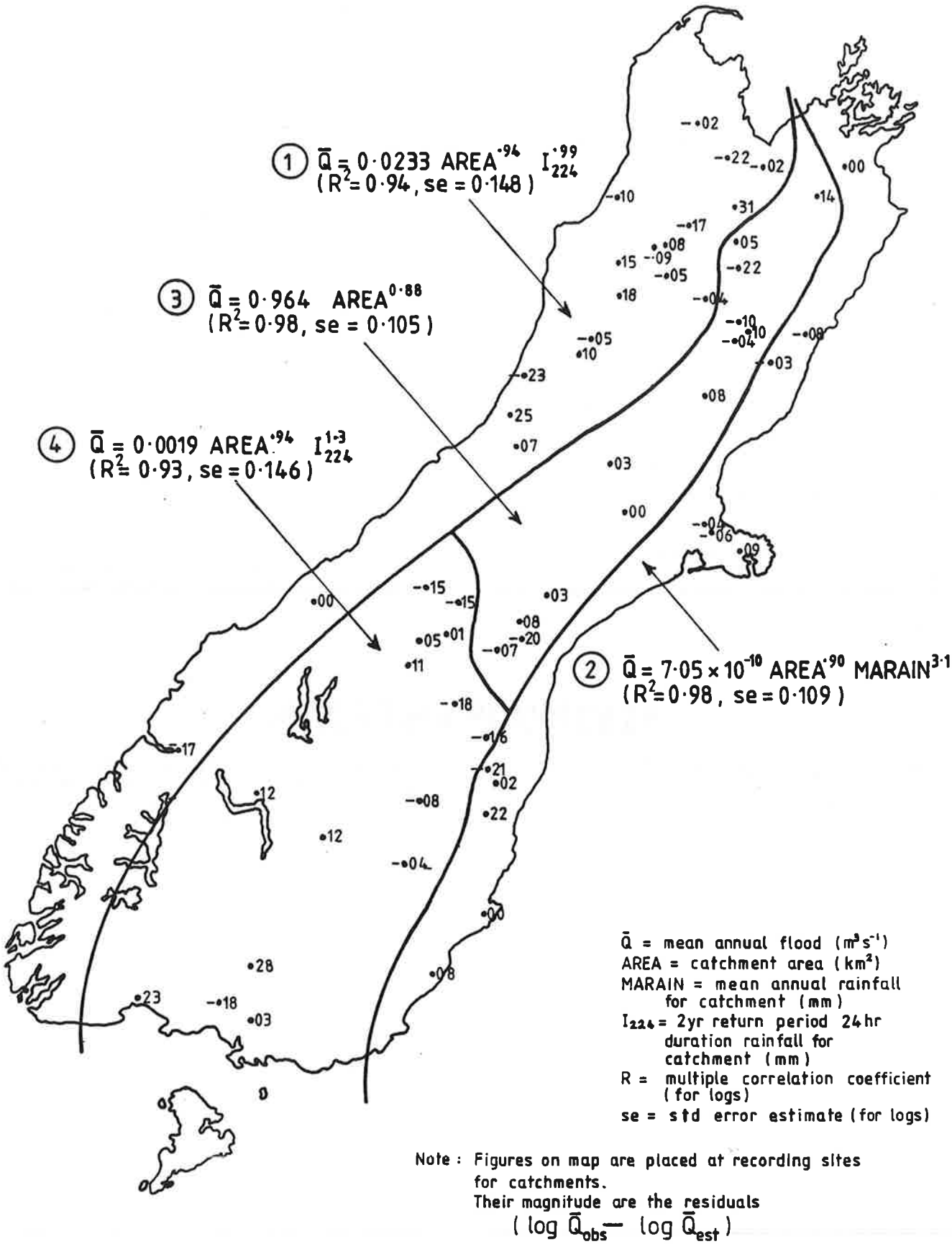


Figure 1 Regional equations for mean annual flood.

Table 4 Comparison of observed and estimated $\overline{Q}$

Station number	*River name*[a]	*Observed* $\overline{Q}$ $(m^3 s^{-1})$	*Length record (yrs)*	*Area* (km^2)	*Marain* [b] *(mm)*	*I224*[c] *(mm)*	*Estimated* $\overline{Q}$ $(m^3 s^{-1})$	*Range for 1 standard error*		*Region*[d]
58301	Collins	43	16	17.6	–	104	34	24	48	1
74337	Kyeburn	45	8	376	–	46	72	51	101	4
74352	Deep Stm	133	7	190	1000	–	158	124	201	2
78633	Makarewa	216	9	1040	–	41	162	116	227	4

Note:
a These catchments were not used in deriving estimating equations
b Marain: mean annual rainfall
c I224: rainfall depth for 24 hour duration and 2 year recurrence interval
d Regions are as specified in Fig. 1

(b) extension of flow records at gauged locations;

(c) optimal design of the hydrological measurement network;

(d) estimation of the hydrological effects of land management changes.

This information can be generated from mathematical catchment models which have rainfall as an input and simulate the various flow processes in the catchment. To give precise results these models require detailed information on the catchment conditions including area, shape, slope, soil type, vegetation, geology, stream pattern and channel characteristics. To extract this information manually from the various map series available is a large task for a major river system covering several thousand square kilometres. The magnitude of this task has restricted the application of catchment models in New Zealand to a few special investigations involving relatively small catchments.

A new approach to catchment modelling is now becoming feasible with the availability in computer-compatible form of nationwide data on catchment conditions from land resource inventory maps and NASA satellite photographs. Utilizing these computerized data bases it may be possible to develop catchment models which are capable of wide application without extensive manual data preparation.

Preliminary investigations have focused on the interpretation of land features from LANDSAT satellite photographs. The data from which these photographs are made have a resolution of about 78 m. By comparing light intensities reflected from the land surface some ridgelines and stream channels have been successfully identified in a test area near Lake Rotoiti in Nelson. However, there are parts of the test area in which land features cannot be reliably recognised from the available data, and it has been concluded that the LANDSAT data base would not be suitable as the primary data source for catchment models at present. Investigations are now proceeding into the use of the National Land Resource Inventory Worksheets for this purpose.

Rakaia River water use

Rakaia River water is used for fishing, irrigation, power generation and recreation. Further abstractions from the river for irrigation and power generation are being proposed. The project aims to set these proposals against the background of the potential options for multipurpose use of the Rakaia River water to ensure that as far as possible present proposals do not limit future options. Particular attention is being paid to the time pattern of water withdrawals for irrigation and how these withdrawals might affect the fish population of the river.

An irrigation water use model based on a large climatic data bank is being assembled which enables the precise calculation of the amounts of water needed to irrigate crops for a variety of weather conditions, soil types, cropping patterns and irrigation strategies. Once completed, this model will allow for the examination of different proposed irrigation schemes and calculate the time pattern of water which would be withdrawn from the river for these schemes.

Application of advanced techniques

The application of new hydrological analysis techniques being developed internationally to New Zealand data was considerably stimulated by Prof. A.R. Rao who spent a year on sabbatical leave from Purdue University, USA, at the Christchurch Science Centre, from July 1977 to July 1978. Prof. Rao is an expert in stochastic models describing the relationships between these data and using these models to forecast streamflows for period of a week to a month ahead.

The analyses revealed:

(a) the existence of weak seasonal and non-seasonal correlations;

(b) the existence of a weak 2-4 year oscillation which is related to observed atmospheric circulation oscillations in the Southern Hemisphere;

(c) large variability in the correlation characteristics of the data from different regions of the country.

The last finding is of considerable importance as it implies that the variability in New Zealand hydrological characteristics is such that it demands continued data acquisition and careful analysis, more so than for comparable regions situated in some continental land masses where the hydrological characteristics are more consistent from one region to another.

The wide variations in New Zealand hydrological data were also revealed by the high "noise-signal" ratio in the line spectra of their seasonal data, compared with data from Indian rivers which are strongly periodic.

Autoregressive-moving average models were fitted to weekly, monthly and annual data for forecasting purposes. Because the water storage is small in many of the catchments studied, streamflows could not be forecast with any accuracy for periods of even a week ahead by using only the preceding stream flow values. Hence, good rainfall forecasts are essential for forecasting streamflows a week to a month ahead.

GROUNDWATER

Heretaunga Plains groundwater quality

This project has continued during 1978 with attention being focused on the possible effects that irrigation in the Ngatarawa Valley may have on groundwater quality therein and also on the main Heretaunga Plains area. Background water quality sampling has shown that nitrate levels of 5–15 g m^{-3} exist within the valley under the existing pastoral farming system which is largely dry-land. Chlorides range up to 30–50 ppm but other chemical species are at low concentrations.

Vertical tracer tests at one site showed that pollutants will readily reach the aquifer, although it is known that in some other areas a hard pan exists. The gravels are generally older and contain more clay than in the main Heretaunga Plains area.

Generally groundwater velocity as measured at the Ngatarawa site was 5–7 m/day although tracer tests using bacteria gave some local velocities up to 40 m/day.

The piezometric gradient at the Ngatarawa study site is 1.1×10^{-3} but is much steeper than this at the head of the valley. A comprehensive piezometric survey was done in the valley and integrated with the main aquifer area.

A desk study comparing the nitrate and water balance under dry-land and irrigated farming indicates that, although under irrigation the nitrate loading on the groundwater will increase by a factor of 3–5 depending on the annual rainfall and its distribution, the concentration of nitrate in the water will rise very little, if at all. This is because the drainage to groundwater under irrigation also increases by a factor of 3–4, thus keeping the leachate well diluted.

Well to well tracer studies using seawater have revealed some interesting information on the structure of these recent gravel aquifers. Intensive measurement in time and depth at an array of wells using a conductivity meter showed that paths of higher permeability exist within these gravels with lateral dimensions of the same order of magnitude as river channels presently existing in the nearby rivers.

Groundwater resources between the Ashburton and Rakaia Rivers

This project is designed to provide information for future irrigation development in the lower Rakaia area. Initial work has concentrated on improving knowledge of piezometric conditions and recharge of the groundwater system. A reasonable piezometric map of the area now exists. It has been established that both the North and South Ashburton Rivers lose a substantial amount of water in the reach below the Rangitata Diversion Race. Under low summer conditions this amounted to about 1.5 $m^3 s^{-1}$ for each branch. Recorders have been installed on wells close to both the Ashburton and Rakaia Rivers, and as these wells respond rapidly to river freshes recharge of groundwater will also be occurring in these reaches although the quantities are unknown.

All the borelogs which contain some hydraulic data have been analysed and positions mapped. From this the areas which produce best groundwater discharges have been broadly defined. All the water level data, some of it deriving from the 1940s, have been computer-filed.

Evaluation of downhole logging equipment

This downhole logging equipment is, as far as is known, the first of its type in the country. Such equipment is regarded as an invaluable tool in obtaining qualitative and quantitative information on lithology of aquifers.

To date this equipment has only been tested in cased holes in greywacke alluvium using the natural gamma sonde. Results show that natural gamma radiation levels in clays derived from greywacke are low and it is not possible to differentiate between clays and gravels on this basis. A gamma source is now to hand and gamma-gamma logging will be attempted in the near future.

Nitrates in groundwater

Nitrate leaching from agricultural land has not been studied in detail in New Zealand despite the increasing concern being expressed about the health problems associated with nitrates in drinking water. Nitrates in water supplies in concentrations about 10 g m^{-3} have led to numerous cases of infant methaemoglobinaemia and have been linked with the formation of carcinogenic nitrosamines and the incidence of gastric cancer in adults.

An attempt has been made to quantify the effect of non-irrigated grazing on groundwater quality and to predict the effect of large-scale irrigation on the future groundwater quality.

Ashburton-Rakaia

The purpose of the study is to define the existing source(s) of nitrate contamination of groundwater prior to the development of the Rakaia irrigation scheme (57 000 ha). The ratio Cl/NO_3–N was found to be an effective method of classifying areas of groundwater by their source (ie. river water, irrigated drainage, non-irrigated drainage, etc).

This method of groundwater classification which was developed with Dr B. Quin (Winchmore Irrigation Research Station) allowed the groundwater of mid-Canterbury to be divided into the following quality zones:

Zone A — Low nitrate (0–3 g m^{-3}), low chloride (0–6 g m^{-3}), Cl/NO_3– N ratio 2–10

Zone B — Medium nitrate (8–12 g m^{-3}), medium chloride (5–10 g m^{-3}), Cl/NO_3–N ratio 0.6–1

Zone C — Variable nitrates (5–20 g m^{-3}), high chloride (10–30 g m^{-3}), Cl/NO_3–N ratio 1.5–2.

In areas beneath or immediately downstream of the Ashburton–Lyndhurst irrigation scheme NO_3–N concentrations in the shallow groundwater (30m) were in the range 8–12 g m^{-3}. However, NO_3–N concentrations beneath non-irrigated pastures were in the range 5–9 g m^{-3}.

Ngatarawa, Hawke's Bay

Groundwater quality within the Ngatarawa Valley can be divided into similar zones to the mid-Canterbury area. Away from the Ngaruroro River NO_3–N concentrations are in the range of 8–20 g m^{-3}, in most cases well above the WHO limit.

A nitrate leaching simulation using climatic and agricultural data for Ngatarawa indicated that drainage from non-irrigated pastures would produce groundwater NO_3–N concentrations of up to 12 g m^{-3} at the foot of the valley and that widespread irrigation could raise the NO_3–N level beneath a large part of the valley to about 20 g m^{-3}.

Waiau Plains

About 50 percent of the wells sampled on the Waiau Plains in North Canterbury had NO_3–N concentrations in the range of 10–20 g m^{-3}. Monthly sampling of these wells indicated that nitrate levels at the surface of the groundwater fluctuate seasonally with the highest NO_3–N values being recorded in the relatively wet months of June, July and August. However, the NO_3–N concentrations remain close to or about 10g m^{-3} at greater depths.

Clearly, alluvial aquifers overlain by stony or relatively thin soils are contaminated by pasture grazing and irrigation. While not increasing the NO_3–N concentrations above about 20 g m^{-3} a much larger volume of groundwater would be contaminated

with irrigation. It appears to be general practice in other countries that when NO_3–N concentrations in public water supplies exceed 10 g m^{-3}, as they do in all of the three New Zealand areas studied, the health authorities are automatically notified and may issue warnings to parents of young infants to use bottled water. Based on local findings, a similar approach in New Zealand may be justified.

Baseline surveys of groundwater quality

Baseline groundwater quality surveys are necessary to define a quality datum for an area and to identify localised sources of contamination. Two areas close to Christchurch City have been studied.

Yaldhurst

Yaldhurst overlies an unconfined aquifer which is thought to feed into the confined aquifers underlying Christchurch City. The area has neither sewage nor water reticulation. The purpose of the study was to evaluate the potential for contamination of domestic wells by nearby septic tank disposal systems. Approximately 120 wells were sampled over a three month period and 25 of those were selected for more intensive sampling over the following nine months. The samples were analysed for conductivity, nitrate-nitrogen, coliform bacteria, faecal coliform bacteria and faecal streptococci.

The data from the first sampling programme of 120 wells did not reveal any clearly recognisable zones of contamination by septic tank effluent. Although levels of conductivity, nitrate-nitrogen and chloride varied with well location and depth, in all the wells they were well within the maximum permissible WHO limits for drinking water. However, WHO standards for coliform bacteria and *E. coli* were exceeded in several wells on a number of occasions. Faecal coliform bacteria and faecal streptococci were also detected in wells within the study area.

The 25 wells in the second programme were divided into two groups: Group I wells were situated in the southern half of the study area in a zone of relatively deep soils and Group II wells in the northern half of the study area in a zone of relatively shallow stony soils.

Group I wells exhibited slightly higher nitrate nitrogen levels than did Group II wells. This phenomenon may have been influenced by the more intensive forms of agricultural land use in the southern half of the study area. In addition, an increase was noted in conductivity and nitrate-nitrogen levels from west to east along Buchanan's Road in the assumed direction of groundwater flow. However, no corresponding increase in numbers of indicator bacteria was recorded.

Although significant numbers of bacteria indicative of faecal contamination were detected in several wells close to septic tank soak pits, this contamination was of an intermittent nature and the source(s) could not be positively identified.

Significant increases in both conductivity and nitrate-nitrogen were recorded in all wells in the study area following periods of high rainfall. No similar trend in numbers of indicator bacteria was found.

Rakaia

Ninety-six wells were sampled in an area bordered by the Rakaia River and State Highways 1 and 75. The survey covers a major groundwater-using district and together with complementary work being undertaken by the North Canterbury Catchment Board will establish a quality datum and will eventually enable groundwater quality modelling for the Waimakariri-Rakaia region to be undertaken.

Nitrate-nitrogen levels ranged from 1–7 g m^{-3} in the Irwell and Brookside-Killinchy areas and from 1-4 g m^{-3} in the Southbridge-Rakaia River area. Water levels in wells in the Southbridge-Rakaia area fluctuate with the river flow suggesting that the groundwater is affected by seepage from the Rakaia River. Consequently the NO_3–N concentrations are relatively low. Clearly, the NO_3–N levels are lower than in the mid-Canterbury area where the ratio of drainage water to river water entering the groundwater is probably higher.

SEDIMENT TRANSPORT

The main objectives of the Sediment Transport Group are to study transport in lowland river channels with main emphasis on bedload transport in gravel river beds where the material supply is greater than the transport capacity. The group at the Christchurch Science Centre has been mainly occupied with setting up field installations for measuring sediment transport rates, implementing sediment data collection programmes and producing operational procedures for sedimentation investigations in rivers and streams.

Sediment transport in the Upper Clutha River system

In conjunction with the Power Division, MWD, an extended sediment data collection programme was instituted in the Upper Clutha Catchment. The aim of the programme is to provide data for assessment of possible changes in the sedimentation regime as a consequence of installation of dams of the Upper Clutha Hydroelectric Scheme, and to provide a rational basis for choice of control options should they be required. Sampling sites have been established on the Upper Clutha, its main tributaries and at the outflow to Lake Roxburgh. Results obtained so far strongly indicate that the Shotover River is the predominant sediment contributor to the system and investigations are being made to determine sediment source areas within this catchment.

Erosion and sediment transport in the Upper Waipawa River Basin, Ruahine Range

From 1973–76 the relative rate of coarse sediment transport in the upper Waipawa River channel was very high – six to seven times that of 1965–73. Since 1976 only small quantities of extra rock detritus have been supplied to the channel system. Consequently in the upper steeper reaches degradation has been the dominant process. During 1976–78 degradation proceeded intermittently but persistently, so that by July 1978 the mean bed level was down to the low level of 1964. This process results in the downstream transport of large quantities of alluvium.

Although 1976-September 1978 was a tranquil interval with a relatively low rate of sediment transport (as was 1966-73) large quantities of the finer alluvium were transported to the lower reaches about Pendle Hill where two new replacement bridges are well under way.

There are no real indications that the modern erosion period is near its end; hence management planning and operations should be based on the hypothesis that the Ruahine Range is still under the influence of an erosion regime, and is likely to be so for some years to come. The probability is very high that there will be recurrence of the 1973–76 storm and high sediment transport rate situation.

Bedload transport in shingle rivers

Many New Zealand rivers flow in alluvial channels draining eroding catchments that are often supplying more detritus for stream transport than the stream is capable of transporting. Because of the value now placed on the sand and shingle resources of these streams, there is a need to quantify the amount and the rate at which bed load is being transported. This is of particular importance for the planning of river training programmes and the possible future use of the water resources of the stream.

Projects that are being implemented at present in relation to this topic include:

Recent sedimentation of the Waimakariri River

An analysis has been made of suspended sediment, cross-section survey and hydrologic data collected in the Waimakariri River over the past 45 years. It was shown that gravel supplied by river bank erosion and channel bed degradation possibly moves downstream as channel sediment waves; but at any rate material so derived can pass through a river reach leaving it substantially unaltered in width, bedmaterial size, slope and mean bed level. This is in opposition to established notions. A method was given for estimating the bedload yields in this situation. Hypotheses were put forward, concerning the mechanics of these waves, based upon a mathematical model and further evidence from another river. It was also clearly demonstrated that most of the gravel causing aggradational problems in the lower reaches is derived locally from the bed and banks of the river. The upper catchment channel is very stable and contributes little bedload gravel to the problem reaches. Moreover most of the problems result from man's unfortunate but necessary interference in the lower channel.

Sediment yield estimation methods

A report was compiled dealing with the estimation of sediment yield in New Zealand rivers and streams. Recommended procedures were detailed. Established direct methods of yield estimation, including nearly continuous, frequent and intermittent streamflow sampling and reservoir surveys, were reviewed: indirect methods such as regional estimation of washload and suspended load yields and prediction of bedmaterial load transport rates from equilibrum transport formula were similarly treated. Two new procedures were given for determining bedload yield. One has a stochastic basis and can be applied to mountain catchments for which no hydrologic information is available. The other is a quick but accurate method of estimating bedload yield in stable lower reaches of gravel bed rivers. A procedure was also given for the unstable case.

Hydraulic roughness of gravel bed rivers

The first part of a study into this topic was completed. It dealt with water flows where no bedload transport is occurring; the second part will deal with the mobile bed situation. Data were obtained and analysed from about 40 New Zealand rivers together with some data from overseas.

It was found that the Darcy-Weisbach friction factor f could be expressed as

$$1/\sqrt{f} = 0.23 + 2.43 \log_{10} (R/d_{50})$$

in which R = mean hydraluic radius; d_{50} = mean size of surface bed material. The equation applies to more or less regular channels relatively free of streambank vegetation. A base value of hydraulic roughness is therefore provided and further allowance can be made for other flow-retarding effects by using already published information.

Bridge pier scour

A field test rig was designed and installed at the Waimakariri Gorge Bridge to estimate scour depth around a bridge pier. The maximum depth scour that occurs during a particular flood can be ascertained using the rig and an instrument provided by the University of Auckland. The project is a co-operative one involving the Railways Department and the Scour Committee of the National Roads Board. Further field installations are planned.

ALPINE PROCESSES

Studies in this sector in their various facets aim to determine quantitatively how individual watersheds of the Southern Alps react to the forces of nature and to land use. They are aimed to measure and later to predict with precision, the ways in which catchments are altered by land use and the vagaries of weather and to determine how these alterations are expressed in changes in water and sediment yield, in water quality, and in soil and vegetation cover. They are intended as quantitative studies to enable catchments to be put in the contexts of the larger catchment and of the spectra of catchments and climates of the whole of the Southern Alps. The ultimate objectives are the gathering of knowledge and the development of survey techniques to assist the understanding, utilisation, and conservation of our mountain lands through the numerical assessment of policy and management options and the planning and design of engineering works. Within the overall objectives a series of individual projects have been established.

Alpine precipitation

The project is a study of processes controlling the distribution of rain over the Southern Alps. A simple pattern of annual rainfall has been found to exist for the whole of the Southern Alps, with the dominant control emerging as the mid-altitude topography along the Alpine Fault. This control persists in the rainfall distribution well across the Main Divide into the eastern high country.

The annual rainfall regime across the Rakaia transect now is beginning to emerge from its driest period in over ten years. For the period 1 to 15 August 1977 the Tuke Hut site recorded 10 841 mm of rain, and this may be as much as 15% below the 10 year average.

The distribution of annual rain across the Southern Alps appears to begin increasing from an "open ocean" value of about 1 100 mm, some 60 km west from the Southern Alps. About 2 km out from the foot of the Alps, annual rain has risen to around 4000 mm, and begins a spectacular increase to perhaps 12 500 mm over a distance of only about 7.5 km. From this peak, well west of the Main Divide, the annual rainfall decreases exponentially into the eastern high country, reaching as low as 500 mm in Central Otago.

Rainfall intensities also appear to follow a very similar distribution, ranging more than an order of magnitude across the Alps.

Alpine wind

Data on wind speeds in the Southern Alps are sparse, yet increasing numbers of structures are being built in alpine situations. To improve design data for wind loading, new instruments are being designed to record the very high winds of the Southern Alps. In the past two years, 3 Lambrecht anemomographs have been worn out over the summit of South Peak, Mt Hutt (2 075 m). From a meagre 28% record, an hourly wind run

Figure 2 Sediment retention rock dam in Dry Acheron Catchment.

of 160 km (100 mph) can be expected to be exceeded once in 20 days, and the daily average probably exceeds 180 km hr^{-1} (113 mph) once a year. On one occasion, an hourly wind run of 250 km was recorded. An aircraft airspeed indicator is now being used in an attempt to obtain a better record.

Alpine erosion

Study of the variation in suspended sediment concentration with discharge is confirming that precipitation is the dominant control over regional variations in erosion rates over the Southern Alps. Empirical relations suggest that total specific sediment yield varies with nearly the cube of annual precipitation. Where annual rainfall varies more than an order of magnitude, erosion rates can be expected to vary by more than four orders. No other erosion inducing parameter is known to cause such variation in the Southern Alps.

Continuing soundings and coring of Lake Ballance are yielding data on erosion rates under very high annual rainfall (about 10 000 mm), but no survey yet has been detailed enough to provide an annual sediment volume. The sedimentary environment in Ballance Lake is a vigorous one with depositional features with a relief of more than 15 m forming and being destroyed from one year to the next. Very much more detailed surveys than expected are required to assess volume changes in this dynamic environment.

Alpine catchments study

Development of this major study to assess quantitiatively how individual watersheds of the Southern Alps react to the forces of nature and to land use is progressing as equipment comes to hand. Flow and rainfall at present are being monitored for three major catchments (Rakaia, Hokitika and Waitaha Rivers) and at five sub-catchments within these. Further subcatchments are to be instrumented. Total sediment yield presently is being monitored at two of the subcatchments, at Ivory Glacier and at Dry Acheron Stream. Good progress is being made in obtaining base information on catchment condition, geology and soils.

Dry Acheron Experimental Basin, Rakaia Catchment

In mid April a large storm occurred over the catchment and the resulting flood infilled the sediment retention dam. The recurrence interval of this event, in the sediment yield sense, was estimated as greater than ten years, whereas the design life of the dam's storage was five years. However much valuable information was obtained regarding sediment supply and yield from both the Dry Acheron and the Torlesse catchments.

A second, larger, porous sediment retention rock dam was constructed about 150 m downstream of the original dam (Fig. 2). The storage capacity of the new structure is 6000 m^3.

The function of the dam is to trap all the material moving downstream as bedload as well as some of the suspended load. The actual amount of suspended load will be determined by standard sampling procedures at a site upstream of the dam near the weir. This information coupled with a knowledge of the relevant particle size distributions will allow accurate computation of the total sediment yield of the basin.

A Futuro Unit dwelling was transported to the area to provide accommodation during field work and the road into the basin was upgraded to ensure all-weather access. A Crump Profile weir was designed and should be constructed by December 1978. It will give a continuous and reliable record of water outflows from the basin. This is necessary information for the hydrological and sedimentologic research programmes being carried out in the Dry Acheron catchment.

Shotover River Catchment geomorphology

This study aims at examining the recent geomorphic history of the Shotover River catchment as an aid to understanding the present catchment sediment output. Possibly as much as a third of the annual sediment yield from this catchment is from depletion of sediment stores such as one behind a major landslide dam, downstream of Branches Flat. An offshoot of this study has been the proposition of several little used avenues of sediment control that may offer more effective remedies than currently are available. The economics of these are yet to be evaluated.

Rock weathering rind thickness

During the course of a study of alpine moraines in the Waimakariri River catchment to establish a climatic sequence for the Holocene, it was confirmed that the weathering rinds on rocks of the "greywacke" suite show a systematic thickening with age. This enables moraines, screes and other boulder-covered surfaces to be dated by employing a weathering rind growth curve constructed from radio-carbon dates obtained from landslides.

During the year Prof. P. Birkeland, Boulder, Colorado, USA, one of the world's leading workers in the field of relative age dating visited New Zealand to study Holocene moraines. Opportunity was taken to work in the field with Prof. Birkeland,

where as part of his studies he checked the Waimakariri River sequence. It was pleasing to find that Birkeland's findings agreed completely with the established chronology.

The weathering rind dating method could not be applied to the schist rock of Shotover River glacial history studies, but will be applied to a proposed study of the Rakaia River headwaters.

New Zealand glacier inventory

In addition to documenting the extent and distribution of alpine water resources, a glacier inventory provides data on: both present climatic patterns and changes from snowline elevations and glacier fluctuations; on past climatic trends from moraine positions; and provides a basis for historic and future alpine studies. Complete sets of instructions have been collected on compiling an inventory compatible with the UNESCO World Glacier Inventory system. In addition, samples of inventories have been obtained from four different countries.

Work on the NZ glacier inventory was initiated in 1977 when a reconnaissance study was made of the glacial snowlines of the Southern Alps. A more comprehensive end-of-summer study was made in April 1978 and is summarised separately below. UNESCO sponsored a visit to Switzerland to present the results of this and Antarctic glacial studies at a World Glacier Inventory Workshop held during October 1978.

Glacier snowline variations in the Southern Alps for 1978

End-of-summer glacial snowline elevation estimates have been made on several hundred glaciers over some 400 km of the Southern Alps. From oblique aerial photographs the snowline positions were plotted on 1:63 360 contour maps and the snowline elevations estimated. Snowline-elevation contour maps were constructed.

The snowlines descend from the extreme west to a trough parallel to, but somewhat east of, the zone of maximum precipitation. With decreasing precipitation the snowlines rise eastward across the main divide. Imposed on this general pattern are variations due to large mountain masses lying normal to the prevailing north-west winds and west of the Main Divide which generate precipitation shadow areas of higher snowlines, and to low passes which allow the moist air masses to penetrate east of the main divide and give lobes of depressed snowlines.

Hydrology Glaciology, Dry Valleys Area, Antarctica

A party of two spent the first half of the summer field season monitoring the Onyx River, enclosed lakes and glaciers of this area to gather data on climatic conditions. The flow of the Onyx River is continuously recorded at two sites, but early in the 1977–78 summer season an unusually heavy snowfall increased the albedo of the normally bare ground surface sufficiently to inhibit summer melting drastically so that the Onyx River did not flow its full course into Lake Vanda.

Measurements of enclosed lake levels were continued and most of the lakes showed a fall in level over the year, indicating a lower energy input into the area. On Lake Vanda continuous records of the lake level were made together with ablation, ice thickness and temperature measurements.

An analysis of glacier mass balance measurements made on a number of glaciers over the past six years has shown that the glaciers are very close to being in a state of equilibrium, hence these studies were continued on one glacier only. Measurements of glacier snout ablation rates were continued on threee glaciers.

LAND RESOURCE SURVEYS

Major emphasis for the Land Resource Group has been on the completion of the New Zealand Land Resource Inventory Worksheet series. Once coverage of the North Island is completed, this series will be increasingly involved with back-up work of implementing improved techniques for assessing erosion and land stability condition of catchments and river systems together with trends in these.

A bulletin titled 'Our Land Resources' has been prepared. This will accompany the worksheets, giving details about the information they contain and the many uses to which they can be put. It is expected to be available in 1979. Updating the Land Use Capability Survey Handbook has continued.

North Island land resource survey

Field work for the North Island land resource survey is near completion. Progress for 1978 was as follows:

	No of worksheets
Published	31
In print	9
Completed field work	35

Coverage as at 31 December 1978 is shown in Fig. 3.

The Southern Hawke's Bay–Wairarapa region was completed in July 1978. All worksheets except those bounding the Taranaki-Manawatu region have been printed.

The Bay of Plenty-Volcanic Plateau regional extended legend is in the final stages of compilation. This legend has been extended to include present average, and potential stock units per hectare, and estimates and potential site index values for *Pinus radiata* in each land use capability unit. These values have been provided by professional staff of the Ministry of Agriculture and Fisheries and the New Zealand Forest Service.

Work was completed in the Waikato region in October. The rate of coverage was increased by Waikato Valley Authority staff preparing five worksheets in the area under contract.

Mapping began in the Taranaki-Manawatu region during June 1978. The accompanying regional extended legend is in preparation.

Worksheets of the Wellington region are being reprinted incorporating lithologies in the rock type section of the land resource inventory (time stratigraphic symbols were previously used).

South Island land resource survey

The survey was virtually complete by December with all worksheets published except for 7 which were in print, and 10 where only field work was completed. Coverage as at 31 December 1978 is shown in Fig. 4.

During the year, 42 sheets were submitted for printing, 23 of these covering a large part of North Westland, Buller, Northwest Nelson and Kaikoura, and 19 sheets covering South-east Otago and Southland. The South Island extended legend is undergoing revision. Published worksheets have been distributed to over 70 user organisations.

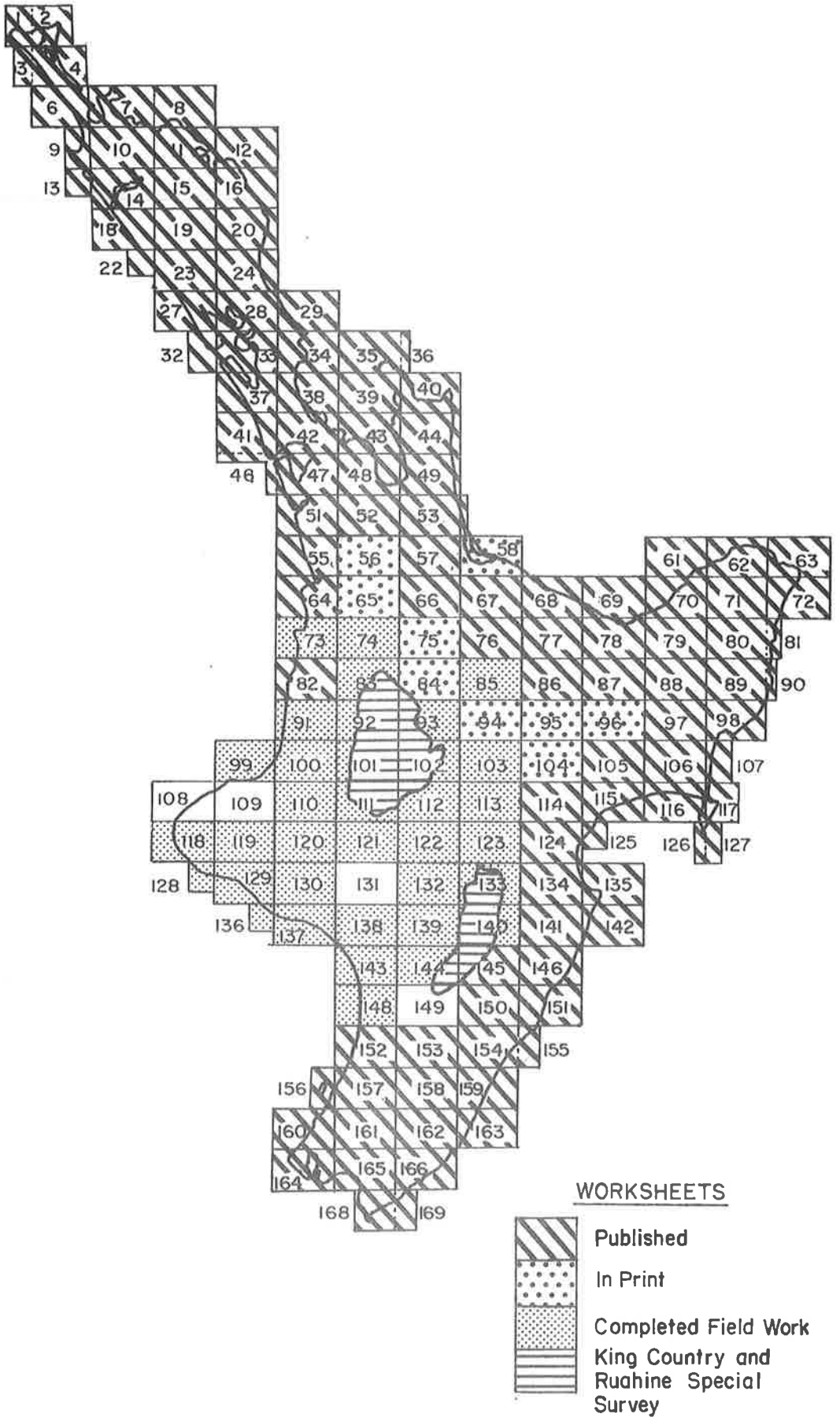


Figure 3 North Island land resource survey coverage as at 31 December 1978.

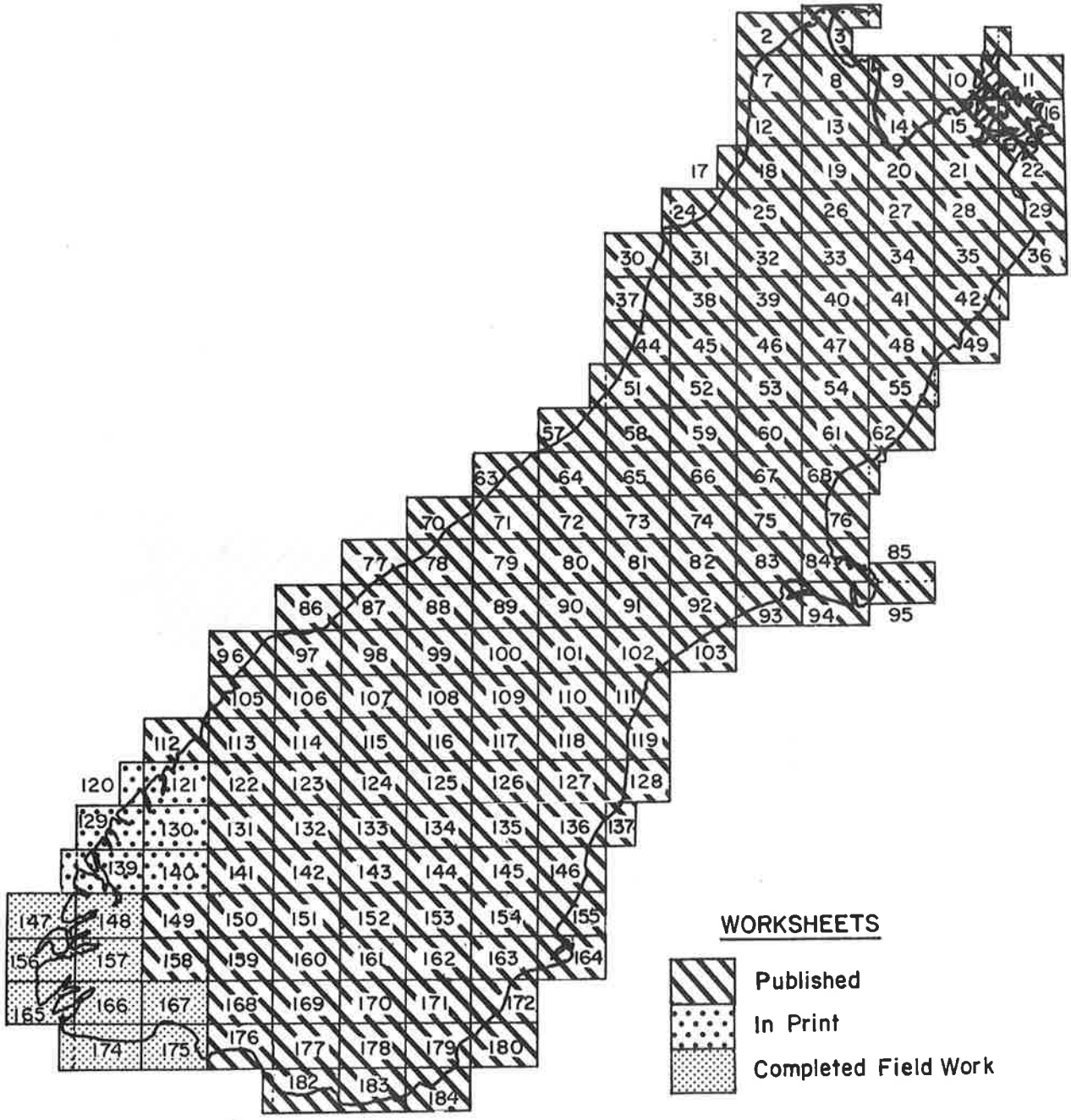


Figure 4 South Island land resource survey coverage as at 31 December 1978.

Special projects

King Country Region

Following the completion of the King Country Land Resource Inventory Survey, checks and tests were carried out to ascertain how well the basic information on the worksheets could be adapted to meet the needs of various departments. These checks indicated that the technique would have been suitable for the requirements of most departments.

Taumarunui County

As an aid in the preparation of the Taumarunui County District Scheme the King Country Land Resource Inventory Survey was extended to cover the whole county during the period January–March 1978. Information was placed on computer so that it could be supplied on request to the consultant planner and to other interested groups. The programme for this was separate from that used in the National Land Resource Survey and illustrated the effectiveness of the resource data base storage system.

National Erosion Map Series

Preparation of this series has been delayed until the completion of the New Zealand Land Resource Inventory Survey. The series will be completed in 1979.

The following sheets were printed in 1978:

NZMS 18	Sheet 1	North Cape
	Sheet 2	Whangarei

National land resource data storage, retrieval and sorting system

A Hewlett Packard 9825A calculator and automatic planimeter has been installed at each of Christchurch and Aokautere Science Centres. These acquisitions enable the establishment of a national computer data base for land resource surveys. The system electronically stores, retrieves and then represents physical land resource data in any combination.

Already land resource information from a large proportion of the New Zealand Land Resource Inventory Worksheets has been entered. Queries for information have been received from a large number of organisations such as New Zealand Forest Service, Ministry of Agriculture and Fisheries, catchment authorities, and divisions of Ministry of Works and Development. These requests have largely been for information in the King Country, Taumarunui County, Gisborne–East Coast region, and the Waitaki Catchment.

Figures 5 and 6 show the state of data storage of the New Zealand Land Resource Inventory Worksheets.

CATCHMENT CONDITION SURVEYS

The development of remote sensing facilities and expertise by the Catchment Condition Survey Group has been a very visible, and potentially important, feature of the year. This group is now beginning to demonstrate the value of remote sensing not only for catchment condition surveys but also as a supporting facility for the work of other groups.

Remote sensing techniques and their application to catchment condition surveys

Since November 1977 many test flights have taken place in a specially modified privately owned Cessna 206. The modification includes a large bubble that can be attached to the outside of the aircraft. Inside this bubble aerial cameras in a mount are housed. The Hasselblad camera mount is hinged so that the mount can be swung up into the aircraft to enable filter changes, camera and lens adjustments and magazine changing (Fig. 7). A special tube has been inserted through the floor of the aircraft so that a navigational drift sight can be slid into it. These modifications have been approved by the Department of Civil Aviation, Ministry of Transport. On top of the camera mount is an intervalometer and a command unit (Fig. 8). The purpose of these is to set the time interval between successive camera firings (to enable 60% overlap) and to ensure that the four cameras are fired simultaneously.

For the initial test flights the four Hasselblad camera system belonging to the Remote Sensing Section, Physics and Engineering Laboratory, DSIR was used. Since May 1978 the Catchment Condition Survey Group camera system (Figures 7 and 8) has been used. The purpose of these test flights which are still continuing, is to determine the correct shutter speed and aperture settings of each camera for a range of conventional and multispectral aerial film/filter combinations for a wide variety of ground and water targets. These flights are also used to develop the precise navigational skills required for small format research aerial photography. The ground targets occur in a variety of physiographic regions throughout New Zealand.

To ensure rapid, consistent, and repeatable film processing and printing it has become necessary for the Catchment Condition Survey Group to load, process and print its own imagery. Facilities to enable this are being developed. Because of the time involved in setting up the darkrooms and the research aerial photographic survey unit, no detailed interpretation and analysis of photographs has been possible.

Examples of multispectral imagesfrom some of the successful surveys are illustrated. Figure 9 shows four black and white multispectral photographs taken in the Dry Acheron catchment, Canterbury. Preliminary results indicate that in this mountainous area, multispectral photography is generally more suitable than false colour infrared photography because of the critical exposure characteristics of the latter broad-band film type. Using colour composites of multispectral imagery, areas comprising 'greywacke' sandstone could be easily distinguished from 'greywacke' mudstone areas. An example of a colour composite photograph is shown in the Frontispiece.

Figure 10 shows four multispectral aerial photographs taken in the 'Wairarapa 1977 storm-damaged area'. The rectangular plot in the centre of the photographs has been laid out, spot sprayed and planted by the National Plant Materials Centre, Aokautere Science Centre. The difference between the four narrow band images is clearly evident. Multispectral colour composite photographs of the Waimarama area, Hawkes Bay, have shown areas of 'high' soil moisture and seepage areas that were not visible on conventional black and white photographs.

Figure 11 shows four multispectral aerial photographs of an oxidation pond near Masterton. Sewage being discharged is most clearly visible in the two visible bands, particularly Band 1. Figure 11 shows the versatility of aerial photography for acquiring information about land and water resources. Further water quality photography will be taken in 1979, in conjunction with staff of the Hamilton Science Centre, to determine to what extent aerial photography can be used to detect dispersion rates of pollutants in water bodies.

More detailed interpretation of recently acquired multispectral aerial photographs will be done in the near future.

To date all colour composite images have been prepared using equipment of the Remote Sensing Section, Physics and Engineering Laboratory, DSIR. General liaison with this section has continued on a range of technical matters of interest to NWASCO. Liaison with the Central Photographic Unit, Ohakea Air Force Base has continued on aerial photographic matters.

Text continues on Page 72

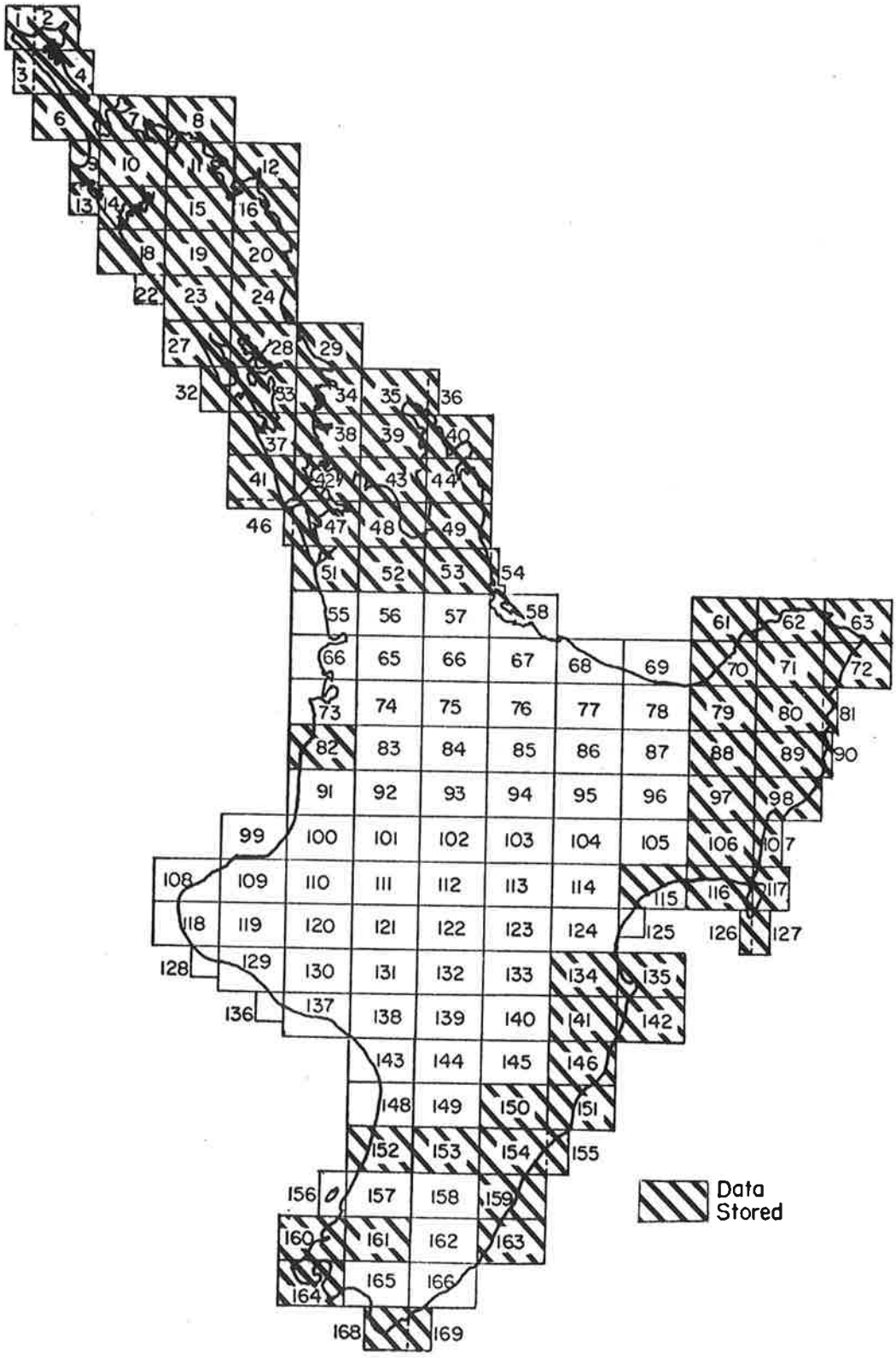


Figure 5 North Island land resource data storage as at 31 December 1978.

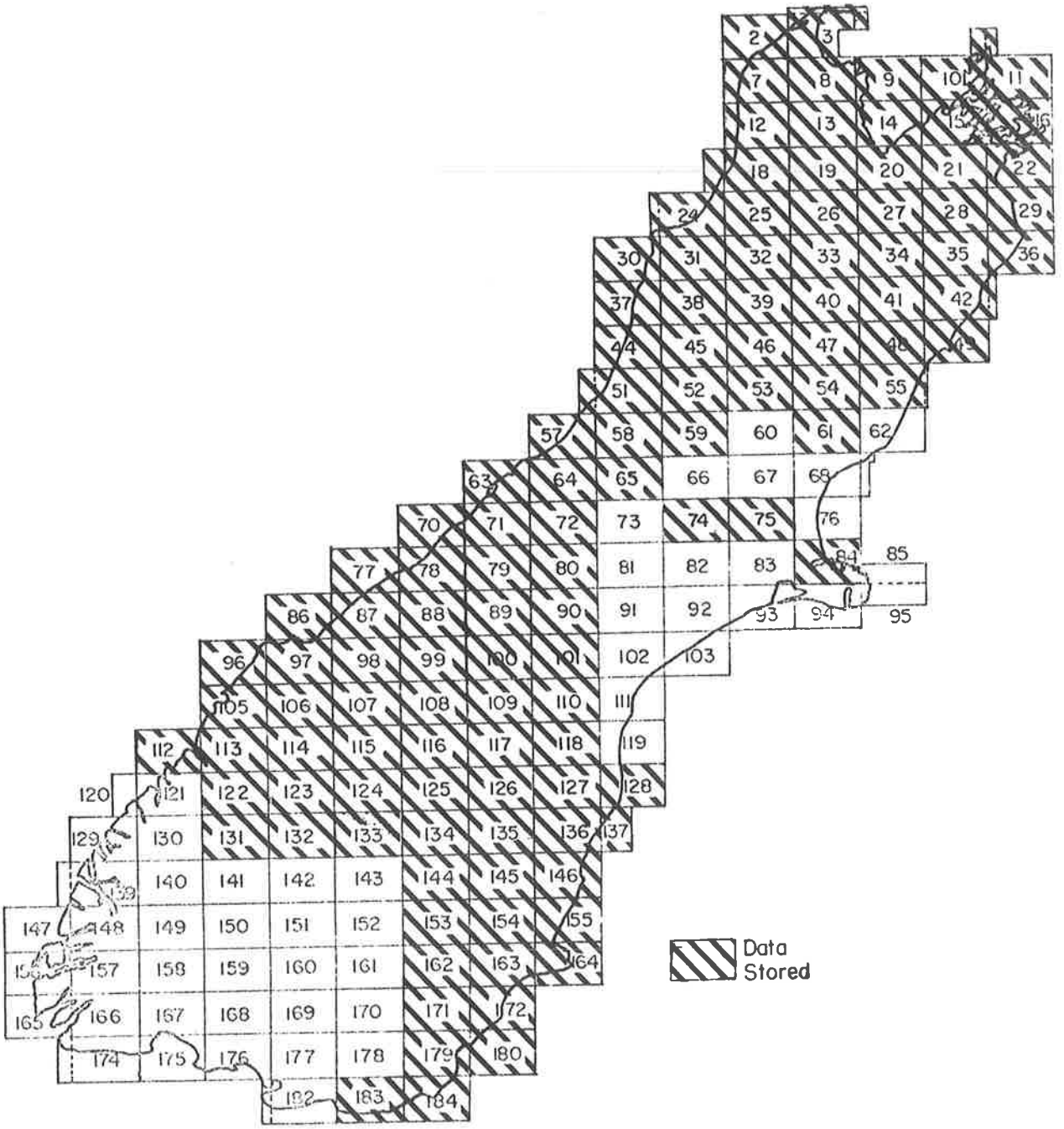


Figure 6 South Island land resource data storage as at 31 December 1978.

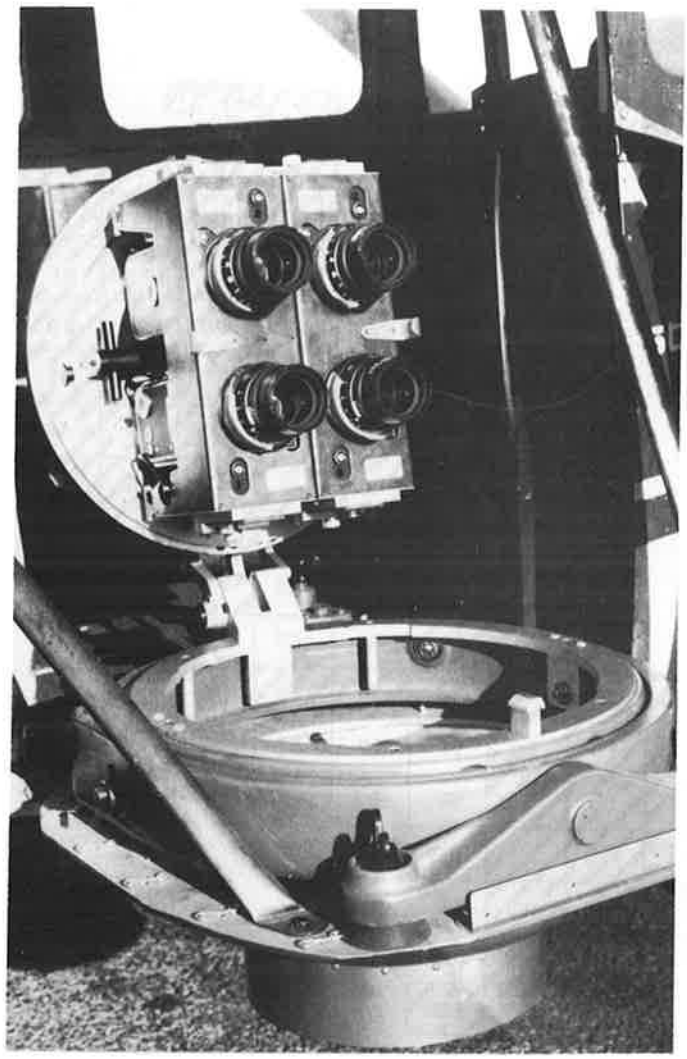
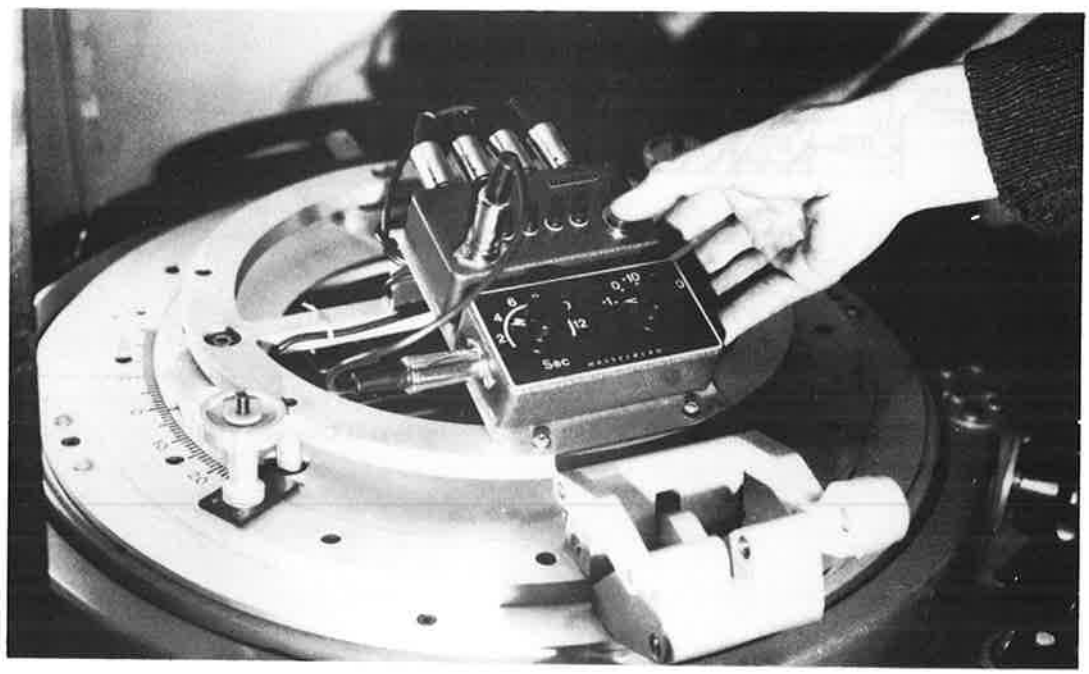
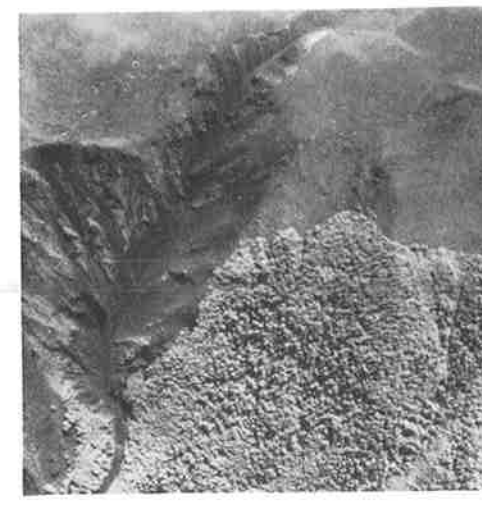


Figure 7 Four hasselblad cameras in hinged mount (see text, page 67).

Figure 8 (below) Hasselblad camera system in firing position. Intervalometer and command unit are seen on top of camera mount.

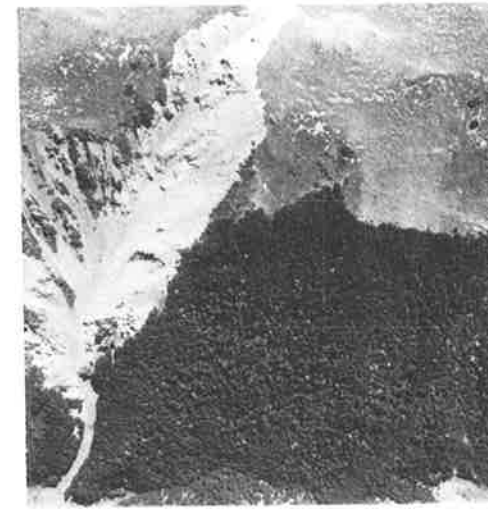


Band 3



Band 4

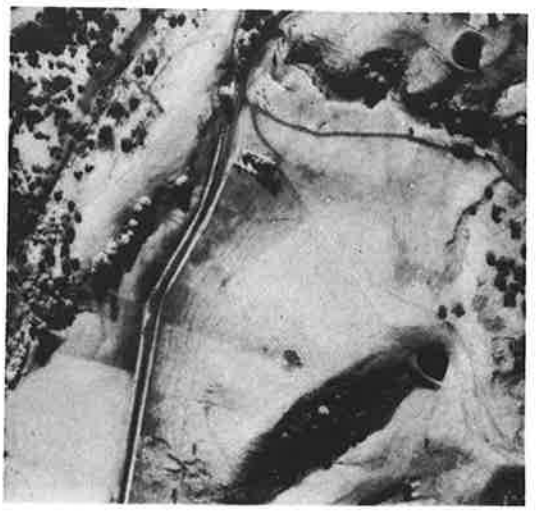
Band 1



Band 2

Figure 9 Black-and-white multispectral aerial photographs of a large scree in the Dry Acheron Catchment, Canterbury. Mountain beech vegetation shows up darkly in Bands 1 and 2. Above the timberline are tussock associations. Colour composites of these images can be used to enhance resource features that can not necessarily be seen on any single black-and-white print. Band 1 is sensing green light reflectance (500-600 nm), Band 2 red light reflectance (600-700 nm), Band 3 infrared reflectance (700-800 nm), and Band 4 infrared reflectance (800-950 nm). Scale is approximately 1:10 000.

Band 3



Band 4

Band 1

Band 2

Figure 10 Multispectral aerial photographs of an area in the Wairarapa. Erosion damage is most clearly seen in Band 2. The revegetation trial area that has been spot sprayed and planted by the National Plant Materials Centre and the difference in water quality in the two stock dams are also most clearly seen in Band 2. Scale is approximately 1:8000.

Photogrammetric mapping of river channels

The theoretical accuracy and cost of photogrammetric measurement, as an alternative to conventional field survey of river channels, has been investigated. Results are contained in a draft report 'NWASCO photogrammetric requirements: a background and recommendations' (September 1978). In brief, this report finds that photogrammetry is likely to be cheaper than, and as accurate as, conventional field survey in exposed gravel channels, but is not applicable to deep water-filled sand or silt channels (Fig. 12).

It is anticipated that a research programme will commence in early 1979, to adapt photogrammetry to the specific requirements of river channel survey and demonstrate the technique to catchment boards. Adequate aerial photographic facilities for this research are now available at Aokautere, and negotiations are under way to ensure adequate photogrammetric facilities for the research programme and for subsequent operational use of the technique.

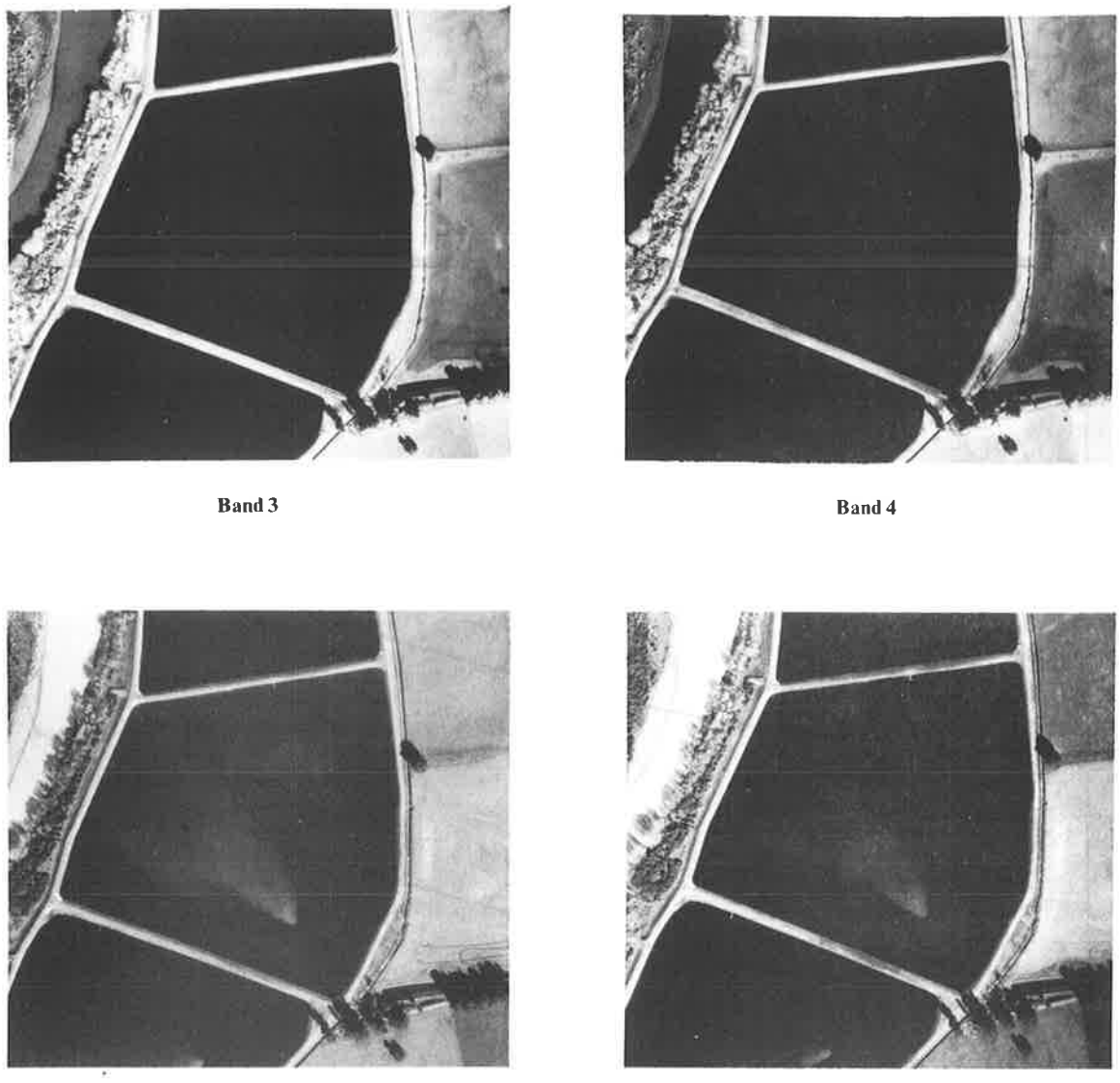


Figure 11 Multispectral photographs of oxidation ponds near Masterton. The position of the outlet pipe and the distribution of sewage is most clearly seen in Bands 1 and 2. The difference between the relatively clear oxidation pond waters and the very turbid waters of the Ruamahanga River (top left of each photograph) is most clearly seen in the visible bands (Bands 1 and 2). Scale is approximately 1:8000.

Evaluation of earth resources satellite information

Proposals to evaluate LANDSAT information for a range of land resource and water resource surveys (for example, to aid up-dating of land resource inventory worksheets and to build up a body of images showing the direction of sediment-transporting coastal currents) were drawn up in April and forwarded to NASA as part of an overall New Zealand evaluation programme.

Evaluation of computer mapping programmes in co-operation with the Physics and Engineering Laboratory re-commenced in June 1978 after a pause of several months. These programmes, in the long term, will be applicable to a wide range of remotely sensed data in addition to that from satellites. Currently a maximum-likelihood-classifier modification is under development and this is expected to improve feature classification accuracy substantially.

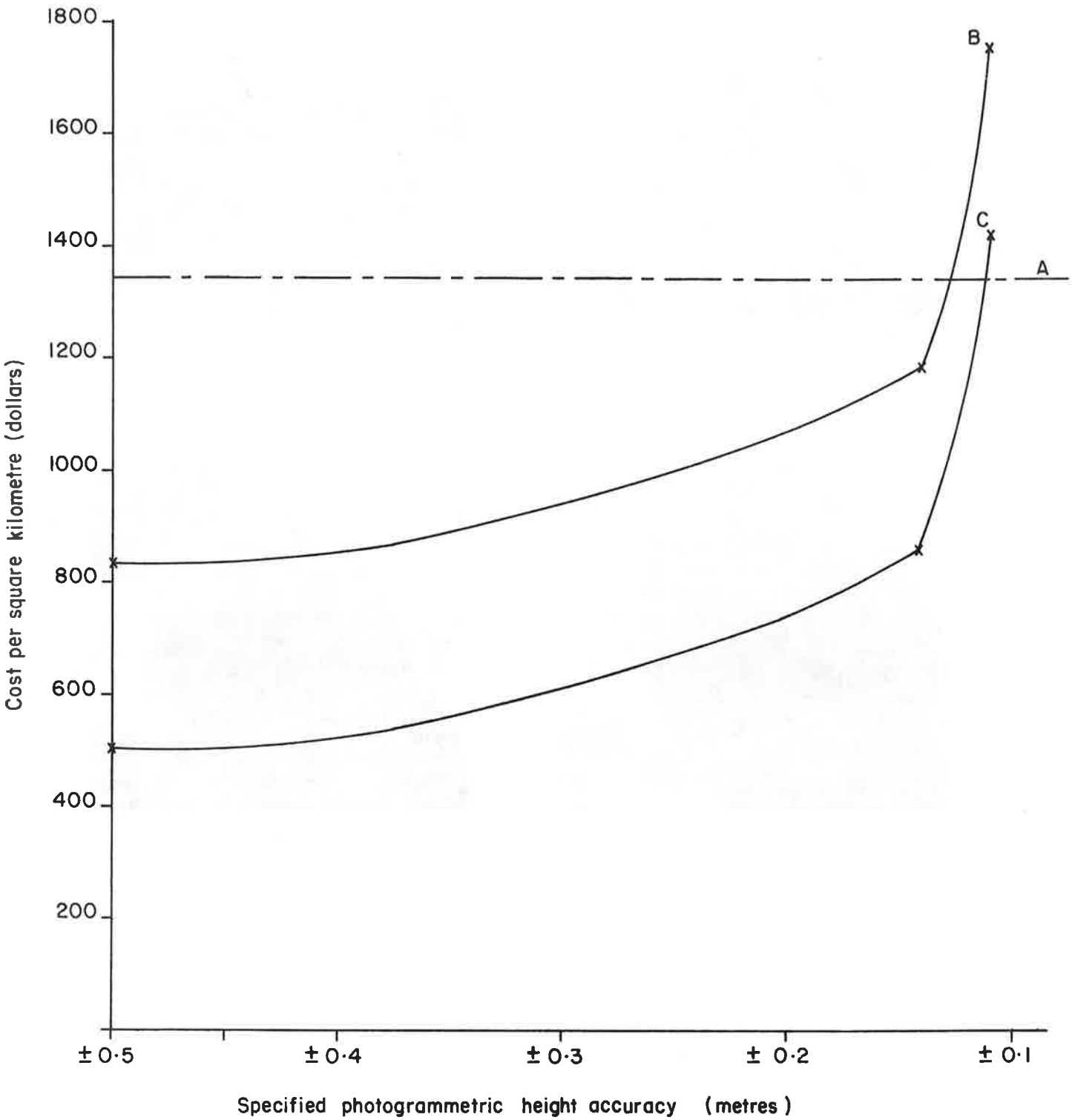


Figure 12 Estimated costs of river channel survey.

LAND STABILITY

The recruitment of staff into the Land Stability Group has enabled further development of land stability work during the past year.

Measuring rates and patterns of movement of creeping earthflows

The Aokautere Science Centre acquired an inclinometer during the year. Access tubes have been installed in earthflows near Taumarunui, in the Wairarapa, and near Gisborne.

The results being obtained are already giving accurate quantitative information on depths, rates and types of earth movement in these situations. It is expected that quantitative information on reductions in rates of movement following the establishment of plant materials, and/or graded banks, and/or bored-in underdrains will be given by this technique as readings are repeated in successive years.

Mass earthmovements study, Gisborne

At eight earthflow sites a total of 185 piezometers have been installed in 61 boreholes with the final 90 scheduled for placement in the summer of 1978–79. In most cases three or more piezometers have been placed in each borehole to allow the determination of vertical hydraulic gradients. Surface followers provide a continuous record of pore pressure on eight piezometers. Inclinometer tubes designed to detect the extent and depth of earthmovement have been installed in five earthflows.

Drilling boreholes up to depths of 9 m has necessitated the development of a portable drilling rig, the components of which can be carried by two men over rough terrain. This allows piezometer installation to proceed without vehicular tracks having to be made with their resultant hydrological effects. By using an 80 mm drill bit it has been possile to install inclinometer tubes without the normal truck-mounted drilling rig. This has enabled inclinometers to be installed in previously impassable locations and at a fraction of the normal cost. A simple grout pump, operated by water pressure enables the grouting of both piezometer and inclinometer tubes through a 15 mm tube. To transport this equipment over rough terrain, a three-wheeled motorcycle and trailer unit with low pressure tyres has been used and found to be entirely satisfactory.

As the earthflows are still being calibrated results relating to the main purpose of the project are not yet available. The most obvious feature of the results obtained to date is that pore water pressure fluctuations are related more closely to rainfall duration than rainfall intensity. This is in contrast to observations made on shallow slips in which pore pressure in these more permeable soils appears to be related to rainfall intensity.

A further aspect that has been highlighted by field observations is the rapid reduction in shear strength that occurs in these mudstones under certain cyclic wetting and drying conditions. The relevance of this to earthflow development is being investigated.

Data have not yet been analysed for secondary aspects such as the location of zones of different permeability and patterns of subsurface movement.

Hill country land stability

As parts of the integrated search for ways of reducing the incidence of rural hillslope instability two land stability studies have been started. The first of these, an examination of basic mechanisms of this type of instability, has led to:

(a) the beginnings of an analysis of the dominant mechanisms involved which will allow incorporation of the seasonal roles of different plant materials;

(b) a re-thinking of the role of laboratory testing to support these studies, with more emphasis being planned for sophisticated field instrumentation. It is now appreciated that it is the subtleties of the outdoor environment (rainfall, temperature, wind and sunshine) which produce the failures and that the complex patterns of these weather factors cannot be modelled satisfactorily in the laboratory. Laboratory studies will be needed to characterise the soils at particular experimental sites so that the results obtained in the field studies at those sites can be extrapolated to other sites.

The second land stability study is being carried out in the Wairarapa by staff and students of the Geography Department, Victoria University of Wellington under contract to the National Water and Soil Conservation Organisation. Aokautere Science Centre staff are also involved as are staff of the Wellington District Water and Soil Division and the Wairarapa Catchment Board. This project will provide a very complete and detailed record of the events of 1977, including good quantitative records of volumes and areas of material moved on the different slope aspects, soil types rock types etc This record will also include a collation of all available information on previous occurrences of widespread instability in the Wairarapa

Urban slope instability

The scientist-in-charge of the Aokautere Science Centre has presented papers at conferences and seminars on the subject of urban slope instability and has entered into public correspondence. This has placed the Centre in a position where it can, with some confidence, identify what steps need to be taken (or at least debated) if the incidence of urban slope instability is to be reduced.

A project proposal "Development of Techniques for Urban Land Resource Surveys" has been drafted. The results of this project should provide guidance to local bodies at the District Scheme stage of urban development.

LAKES/LAND USE WATER QUALITY

The major objective of the water quality studies initiated for Lakes Rotorua and Taupo has been the definition of the manner in which land use within a lake catchment influences the character of the inflows and hence the quality of the lakes. Following the successful establishment of this programme and the commissioning of the national system of land use catchments it is appropriate to broaden the scope of involvement of this group into studies on a nation wide basis of the interactions between the type of use made of the land in a catchment and the water quality characteristics of the flow emanating from it.

Table 5 Estimates of annual specific outputs of streams draining the Lake Taupo Basin (the streams draining areas of native vegetation have catchments still largely unmodified by man)

Stream	Dominant vegetation	Runoff (mm)	Susp. matter (tonnes km^{-2})	Major ions* (tonnes km^{-2})	NO_3-N (kg km^{-2})	Diss. react. P (kg km^{-2})
Waipakihi	beech forest	2300	250	35	75	8
Upper Waimarino	beech forest	2300	70	40	220	13
Waihohonu	scrub	2300	400	80	15	26
Waihaha	podocarp forest	1500	65	35	350	24
Kuratau	agricultural grassland	1150	60	30	520	12
Whanganui	pine forest	1450	35	35	575	9
Waitahanui	pine forest	1150	25	35	225	60

*$Na + K + Ca + Mg + Cl + SO_4 + HCO_3$

Lake Taupo

Adequate data on water chemistry, suspended matter and flow have been collected from streams in the Lake Taupo Basin to produce estimates of outputs. Much recent effort was put into gauging and sampling streams in the southern part of the basin. For a number of streams draining key areas, the estimates of annual outputs are presented in Table 5.

While it had previously been observed (at an early stage of the investigation) that the average concentration of nutrients in streams draining exotic forestry and agricultural catchments were notably higher than in those draining areas of predominantly native vegetation, recent work has shown that this is not necessarily a result of the land use practices in those catchments. Although the average concentrations of nutrients in the streams draining the alpine regions to the south and the podocarp forest covered mountains to the west are generally lower than those in other streams in the Taupo catchment, their specific outputs are similar or even higher than streams draining exotic forests and agricultural land (see Table 5).

Rainfall and geological differences explain most of the output differences of flow, suspended matter, major ionic components and dissolved phosphorus. Only in the case of nitrate-nitrogen is there a strong indication that both the vegetation-soil complex and differences in land use play a major role. Nitrate concentrations and outputs are generally higher in streams draining agricultural and exotic forestry land than in native vegetation draining streams. A special point of interest is the streams draining the poorly vegetated Tongariro National Park volcanoes. Nitrate concentrations and outputs of these streams are extremely low by world standards and only the special local soil and vegetation factors explain this phenomenon.

Several publications on the results of the Lake Taupo investigations are now in preparation. The first summarises the data collected on concentrations separated for base flow and flood conditions and estimates of average annual outputs for each of the sampling sites. The next publication will attempt to build a regional picture from these results.

Lake Rotorua

The main task has been to study the data collected in 1975-77, although 10 river sites and the Rotorua city sewage are still being monitored monthly to determine whether long-term trends are occurring. A nutrient budget for 1976 is presented in Table 6. 1977 values, although based on fewer data, were almost identical.

Table 6 Lake Rotorua nutrient budget 1976 (tonnes).

	N	P
Soluble input from streams	365	25
Particulate input from streams	110	17.0
Sewage	68	7.5
Rainfall	31	1.2
Total	574	50.7
Total excluding particulate	464	33.7
Outflow from lake (Total N & P)	185	17.0

It is clear that far more total N & P enters the lake than leaves it. More importantly, the amount of soluble N & P entering the lake is more than the amount of total N & P leaving it. In fact, most N & P leaves the lake as organic compounds, reflecting the growth of algae and other plants in the lake.

In order to use the above information to calculate the effects of the nutrient inputs on the lake it is necessary to have an implicit or explicit model of in-lake processes, so some effort is being devoted to clarifying the concepts involved in such models. The major difficulties are associated with defining the ways in which the particulate nutrient inputs affect the plant growth. Closely associated with this is the whole question of nutrient exchange between the lake waters and the lake bed sediments, most of which are derived from deposits of dead diatoms (siliceous algae). Further work is required in this area.

In order to facilitate understanding of the lake as a whole, some of the data handling skills and equipment of the Hamilton Science Centre are being used to collate and examine the correlations in the data collected on the lake by the Ministry of Agriculture and Fisheries, and the Department of Internal Affairs since 1967. This will help the Centre guide the Bay of Plenty Catchment Commission in its continuation of this lake monitoring programme.

The data obtained from the outfall of the Rotorua City Sewage Treatment Plant have been examined in detail. Large changes occur in the concentration and mass flow of phosphorus in the sewage, and these changes have been shown (by reference to plant operating data) to be due to changes in the phosphorus stripping efficiency and general process control of the sewage treatment plant. Mass flows of phosphorus ranged from 3 kg/day to 60 kg/day, the latter reflecting conditions where the activated sludge was not growing in a desired fashion. The 1976 and 1977 total outpus of phosphorus were 7.5 t and 8.0 t, the difference being statistically insignificant.

Sediments in the lake bed have been examined by a student working at Waikato University and in close cooperation with the Hamilton Science Centre. The sediments have proved to be mostly composed of siliceous diatom frustules, rather than the clays and carbonaceous organic material often expected.

About half of the particulate matter transported by streams in the Lake Rotorua catchment is transported under base flow conditions, in marked contrast to the usual situation where high flows are all important to sediment transport. The annual deposition of siliceous sediments derived from biological processes in the lake amounts to about 40 000 t yr^{-1}, while the amount of sediment entering the lake from streams is 35 000 t yr^{-1}.

Internal reports have been prepared on various topics some of which will be incorporated into future publications. A report on bedload of three tributaries shows that bedload is insignificant in these streams. A report on the use of automatic samplers to obtain estimates of nutrient transport during floods shows that some errors are introduced by sampling at one point near the bed of the stream, but that these are small and restricted to particulate nutrients. A report on the hydrology of the lake shows that the streams recorded during the study accounted for 67% of

the estimated amount of water leaving the lake, rainfall directly into the lake accounted for 22%, and the remaining 11% can be accounted for by rainfall minus evaporation on those parts of the catchments which show no recordable flow.

Land use effects on water quality

A start has been made in preparing a list of catchment and stream properties that are to be taken into consideration before inclusion of sites into the national network of sampling sites for water quality land use studies. Distance from the sea, geology and average rainfall are deemed to be extremely important factors to be considered and it is probable that in many cases they may completely over-rule any effects of land use and vegetation. It will be very important for this study to obtain suitable catchments with relatively undisturbed native vegetation within each region to provide some information on the regional natural background concentrations and outputs of nutrients. Some preliminary sampling for this project has been carried out in Northland (Glenbervie, Topuni and Puketurua) and the Waikato Region (Lake Taupo inflows and Pokaiwhenua Representative Basin) and in some Taranaki streams.

RIVERS WATER QUALITY

A number of projects have been adopted for research into particular rivers, and for research into processes that affect river water quality These include projects for: Waikato River and tributaries: benthic and aquatic oxygen demand; models for river dissolved oxygen prediction; exploratory study of river appearance models, models for river temperature; and participation in the Global Water Quality Monitoring Project. Substantial work has already been carried out, over some years, on the Waikato River and its tributaries and some dissolved oxygen models have been developed and validated. Work on the other projects is beginning.

Waikato River

Up to 1977 a substantial amount of water quality survey and laboratory analytical work had been carried out for this river. Most surveys had been carried out below the Karapiro Dam, with only limited work between Lake Taupo and Lake Karapiro. The Waikato Valley Authority will continue water quality monitoring work in the river, whilst the Hamilton Science Centre's activities will be concentrated in a few particular areas of the river – inflows of organic and inorganic material between Lakes Taupo and Karapiro; phytoplankton dynamics and the effect of phytoplankton metabolism on water quality, especially downstream of Huntly; behaviour of significant tributary inflows (Waiotapu Stream, Waipa River).

A substantial effort has been made on the interpretation and publication of results obtained to date for the Waikato River. A major report is in preparation in conjunction with the Waikato Valley Authority Auckland Regional Authority, Ministry of Agriculture and Fisheries and University of Waikato.

The regular monthly surveys carried out below Karapiro Dam down to Tuakau, particularly in the 1975–76 period, coupled with some intensive short term surveys have afforded a description of an annual budget and daily and seasonal variations of various water quality characteristics. These surveys included measurement of tributary and waste inflows, which enabled a mathematical DO-BOD_5 model of this section of the river to be calibrated and verified. An example of this budget for measures of oxygen demand is shown in Table 7.

Limited surveys have been carried out in the 1978 year. These included a dispersion study downstream of the proposed Ohaki Geothermal Power Station (which suggested that effects of an emergency discharge of geothermal water from the field would be localised near the point of discharge) and a winter survey of the Waiotapu Stream. This latter survey produced results that showed little difference in concentrations of constituents characteristic of geothermal waters (Cl, Na, Li etc) from those measured in the summer of 1977. These geothermal constituent concentrations are an order of magnitude higher than those obtained in the river. Results also imply that there is significant deoxygenation occurring at the stream bed, at least in summer. This phenomenon has been noted in other rivers (notably the Tarawera). Algae counts were low for this survey and the flora appears to be very different to those in the river.

Mathematical modelling – Tarawera River

Two mathematical models for river DO-BOD_5 have been constructed and validated in the past. One was for the Waikato River and has been reported in the literature: Rutherford, J.C. 1977: Modelling effects of aquatic plants in rivers. *Journal of Environmental Engineering Division, Proc. ASCE 103 (EEA):* 575–91.

The other is for the Tarawera River, details of which will be published as a Water & Soil Technical Publication. This model

Table 7 Average annual BOD_5 and COD concentrations and massflows measured on MWD surveys at Karapiro, in major tributaries and waste inflows, and at Tuakau for the October 1975 -September 1976 year.

	River	Tributary inflow				Waste inflow			River
	Karapiro	Waipa	Komakorau and Mangawara	Whangape	Whangamarino	Hamilton City Pollution Control Plant	Te Rapa Dairy Factory	AFFCO Meatworks	Tuakau
BOD_5 ($g\ m^{-3}$)	1.0	1.2	4.2	1.8	2.3	140	2100	1100	1.5
Massflow BOD_5 ($g\ s^{-1}$)	260	130	27	21	100	20	13	230	670
COD ($g\ m^{-3}$)	7.4	15	50	19	28	210	4200	1700	9.8
Massflow COD ($g\ s^{-1}$)	1960	1400	440	230	920	31	21	350	4800

is being used to predict the effects on river dissolved oxygen of changes in waste treatment by pulp and paper mills in the Kawerau region. The model has demonstrated that substantial benthic oxygen demand occurs in this river, and experimental work on this aspect will continue under the 'benthic and aquatic oxygen demand' project. This will involve the use of electrolytic BOD equipment.

In order to calibrate and verify this model three water quality surveys of the river below Kawerau, including measurements of waste and tributary inflows, were carried out in 1976. From this exercise it was concluded that under present waste loading on the river at low flows, a benthic oxygen demand of about 12 g m^{-3} d^{-1} occurs in the river.

A further survey was carried out in April 1978, during the period of the major strike at the Tasman Pulp and Paper Mills plant in Kawerau. The river was therefore in a state when only a minimal inflow was being made from the largest waste discharge to the river. This enabled the model to be used to determine the magnitude of the benthic oxygen demand in the absence of Tasman's discharges and hence to determine values for this parameter to be used in predicting future distributions of dissolved oxygen in the river.

Survey results showed that an appreciable dissolved oxygen depletion occurs in the Tarawera River below Kawerau, even when only minimal waste discharge is made from the Tasman Mill (waste discharges were being made from Kawerau Borough, and Caxton Paper Mills Ltd, during the period of the survey). It appears that relatively low levels of waste discharge, whatever their source, are sufficient to sustain this demand (BOD_5 loading in the river during this survey was 4500 kg d^{-1} whereas it is normally in the region of 15 000–20 000 kg d^{-1}). It was inferred from use of the model that a benthic oxygen demand of about 10 g m^{-3} d^{-1} occurred during this survey.

WATER QUALITY MATHEMATICAL MODELLING

Exploratory studies on lake modelling

The study has to date concentrated on Lake Rotorua, a choice based on there being some field data available and on the need to investigate implications of adopting or rejecting various aspects of the proposed Upper Kaituna Catchment Control Scheme. Data collected between March 1967 and June 1978 by Fisheries Research Division, Ministry of Agriculture and Fisheries, have been stored on the MWD computer in Wellington. Time series analysis has shown that these data exhibit monthly and seasonal fluctuations, as might be expected. When these are removed by numerical filtering, fluctuations with a period of about five years are apparent. There is, however, no evidence of overall increases or decreases in either total nitrogen, total phosphorus, seechi disc, or chlorophyll concentration over the 12 year period. Attempts to identify the causes of the five-year fluctuations using correlation techniques have to date not proved to be very successful (which suggests that the relationships between parameters are dynamic) but further investigations will be made.

In parallel with time-series analysis, simple conceptual models have been developed to predict mean total phosphorus, total nitrogen, and chlorophyll concentrations from forecast nutrient loadings. These models have been calibrated using data from the lake itself, and have been used in connection with Rotorua City Council's application to increase the volume of treated sewage discharged into the lake. They complement the use of 'loading plot' models but have the considerable advantage of furnishing estimates of the changes which are likely to be measured in the lake as a result of the various control measures.

Attempts will be made to refine these conceptual models, for example by considering the role of sediments in more detail. These models should find application in other lakes as the need arises.

Dissolved oxygen modelling

This work is continuing in collaboration with the Rivers Group at the Hamilton Science Centre (see page 77).

Dispersion Handbook

The first draft of this document, which is intended to summarise the fundamental concepts of dispersion and the techniques used for making an initial estimate of the impact of an effluent on water quality, has been prepared. Mini-computer programmes are being developed in order to test and gain experience with one and two dimensional techniques.

Contact with regional water boards will provide valuable information on how best to present techniques and results and will strongly influence the form of the final document.

Dispersion studies

A study of the dispersion of geothermal effluent from the proposed Ohaki Power Station has been undertaken jointly with the Rivers Group. The effects of a routine field test discharge of geothermal fluid were monitored in the river.

The resulting increases in geothermal pollution were found to be minor and local compared with the background of pollution from natural sources and the Wairakei Power Station.

Design study for water quality data archive system

A PDP 11/34 minicomputer has been installed and brought into operation to support the development of automated analysis techniques in the Hamilton Science Centre laboratory.

A considerable study has been undertaken to plan the further resources required for this project. This has resulted in a report 'Computing Needs of the Hamilton Science Centre' which included recommendations that local magnetic data storage capacity should be considerably expanded to provide for adequate management of the data produced in the laboratory. It is hoped to develop supporting software for this purpose in the coming year.

ESTUARINE AND COASTAL WATER QUALITY

Auckland Thermal No. 1 Power Station Investigations, South Manukau Harbour

From 1975 to 1978 hydrological and meterological studies have been carried out in the southern Manukau Harbour as part of investigations for Auckland Thermal No. 1 Power Station. The proposed station was to operate using cooling towers and freshwater for cooling, or to be a closed-cycle system utilising saltwater from a 560 ha cooling pond sited on intertidal flats.

Hydrological studies were undertaken to determine the availability of fresh and saltwater, to ascertain the limitations governing thermal discharges, to check on selected aspects of the suitability of marine waters for cooling water, and to provide information for water right applications and environmental impact reporting. Marine hydrological studies included investigations of tide levels, waves, currents and water quality.

Tides, waves and certain water quality parameters were recorded using instruments sited at three offshore platforms situated in the southern Manakau Harbour. Additional surveys determined the magnitude of temporal fluctuations in sea water temperature, including temporal fluctuations due to the heating of shallow harbour waters by hot sand banks. Surface and subsurface currents were measured under a variety of wind and tide conditions using surface floats, drogues and current meters. Tidal currents were measured in shallow tidal channels and over shallow intertidal banks of the southern harbour.

Meteorological studies were undertaken to determine cooling system design and predict its effect on the environment, to compare on-site records with those of other meterological stations in the Auckland area, and to provide information for environmental impact reporting. Climatological parameters monitored were air temperature, evaporation, humidity and wind. Automatic recorders were sited on a platform situated on the intertidal Poutawa Bank.

Wairoa River study

This study is being undertaken to determine the characteristics of the Wairoa River system with the ultimate aim of determining the feasibility of utilising water from the lower tidal reaches for irrigation purposes.

The Wairoa River system drains a large catchment (3900 km^2) extending almost from the west to the east coast of Northland. The estuarine lower reaches of the river merge with the northern arm of the Kaipara Harbour. Field measurements show that the freshwater-saltwater boundary (fsb) does not show a classical salt wedge structure but is a rather diffuse zone extending over many kilometres. This is probably the result of considerable mixing produced by highly variable fresh water input, high tidal current flows and the shallow and irregular bottom morphology of the Wairoa River channel. For the purpose of this study the fsb is set at 2‰ salinity as overseas work has shown that water having a salinity of less than this value is suitable for most irrigation purposes. Two parts per thousand corresponds with a chloride concentration of 1.09% and a conductivity of approximately 310 mS m^{-1}. Investigations to date show the 2‰ fsb is about 1-3 km long and that the fsb position ranges from 24 km downstream to 30 km upstream of Dargaville depending largely on freshwater inflow. Daily mean discharge from the contributing catchments varies from 10 $m^3 s^{-1}$ in summer to 250 $m^3 s^{-1}$ in winter. Tidal range is also an important factor in determining the position of the fsb.

Studies are being made to determine the nature of the fsb and the factors which control its nature; for example, freshwater inflow, tidal range, channel geometry etc. Measurements are being made of the position of the fsb for various freshwater inflows from surrounding catchments and for varying tide conditions. These data will then be used to develop a model that describes the position of the fsb for nominated freshwater inflows and tidal ranges and enables determination of volumes of freshwater reservoir at nominated freshwater inflow and tidal range. Analysis of Wairoa River waters for selected ions and suspended solids will further determine their suitabiliy for irrigation.

East Coast beach survey, Northland

This project has been operative since April 1976 and is being carried out in conjunction with the Northland Catchment Commission. Investigations are being undertaken to determine the stability and magnitude of coastal change at Bream Bay and Ocean Beach, Northland, and to provide information on which to base future management and development decisions concerning this coastal zone.

To monitor beach changes along the coast. survey sites were established at intervals of approximately 1.5 km. Twenty two sites are being surveyed: 6 at Ocean Beach and 16 at Bream Bay. At each site the dune-beach profile is surveyed at monthly intervals and once every three months the dune-beach-offshore bar profile is measured. Additional surveys have been carried out after major storms from the north. north-east and east. Standard survey methods are used to monitor the onshore profiles.

To overcome some of the hazards and data inaccuracies involved in measuring sea floor profiles through the surf zone. a sea sled technique has been developed. The profiling sled has a frame, mounted on a pair of parallel steel runners, that supports an aluminium pole 11.4 m tall. The pole graduations are colour-coded to facilitate recognition at a distance and under a variety of light conditions. A helicopter takes the sled out to sea. the sled is then winched back to shore with distance and level being measured on its return using a level. The system allows profiling to 7 m below chart datum which is about 450 m offshore from mean high water mark.

Beach observers record daily wave and beach state parameters. Meteorological and tidal information is available from local New Zealand Meteorological Service stations and the Northland Harbour Board respectively. Historical beach changes are being determined from air photographs.

Prior to May 1978 the beaches remained relatively stable with minor erosion and accretion occurring during storms and periods of swell respectively. In May and July 1978 the coincidence of north, north-east and east winds, low barometric pressures and spring tides produced erosive waves and tidal surge causing significant erosion along both beaches. The May storm produced tides 0.5 m above those predicted and 0.3 m greater than the highest predicted for the year. The July storm resulted in tides 0.8 m above those predicted and 0.4 m greater than the highest predicted for the year.

LABORATORY SUPPORT SERVICES

Analytical chemistry laboratory

The past year has seen both permanent laboratory staff and technical officers from rivers and lakes groups concentrate on establishing analytical techniques for a range of water quality parameters and for approximately 20 chemical species anticipated to be of continued concern. With this task essentially complete, seconded group members are returning to their permanent tasks and laboratory staff are occupied with clearing the backlog of water samples accrued during this period of emphasis on method-development.

The Hamilton Science Centre hosted a week long analytical workshop from 16-20 October 1978. This was a cooperative venture between staff of DSIR, regional water boards and the Hamilton Science Centre in examining the analytical methods for dissolved oxygen, oxygen demands (chemical/biochemical), and speciation of nitrogen and of phosphorus suggested by the Standing Chemical Working Party of the Water Quality Research Committee.

Microbial tracer experiments

In many area of the Canterbury Plains, micro-organisms of sanitary significance appear to be able to percolate through the soil profile and enter the underlying groundwater systems. Micro-organisms indicative of faecal contamination have been detected in wells downstream of border-dyked effluent disposal areas and septic tank soak pits. However, it has not been possible to identify positively the source(s) of contamination in these cases. Highly distinctive organisms or 'tracers' which can be readily distinguished from normal sewage biota, including the standard indicator species, are required for use in areas where microbial contamination of groundwater is known to occur. Accordingly, experiments on the use of bacterial species *Bacillus stearothermophilus* and *Escherichia coli* (H_2S^+) as microbial tracers in groundwater were conducted at the Water and Soil Division experimental site at Burnham.

Techniques were developed to enable both tracer species to be recovered and identified using membrane filtration, a method which allows the recovery of a single bacterial cell from at least 100 ml of water. Ten litre batch cultures of *B. stearothermophilus* and *E. coli* (H_2S^+) were injected into a well at Burnham and were subsequently detected in four downstream wells. The furthest well was 920 m from the point of injection and this appears to be the longest recorded distance for an injection/recovery operation for microbial tracers in groundwater. The speed of travel was approximately 200 m/day. *B. stearothermophilus* exhibited the better rate of recovery from groundwater samples and superior survival characteristics in dialysis tubes suspended in groundwater. This was probably due to the spore-forming ability of the species.

Groundwater samples collected from the well array at Burnham in the 12 months prior to the main tracer experiment indicate that *B. stearothermophilus* exists naturally in Canterbury groundwater and concentrations tend to increase following long periods of rainfall. It is important therefore to establish 'background noise' levels of *B. stearothermophilus* before using the species as a tracer in a groundwater system.

Neither *B. stearothermophilus* nor *E. coli* (H_2S^+) are considered suitable for use as tracers in sewage polluted water. Both species were isolated from sewage samples at Lincoln and Burnham, although *E. coli* (H_2S^+) appeared to be present only intermittently.

The Christchurch Water and Soil Division microbiology laboratory is investigating several non-pathogenic strains of *E. coli* carrying non-transferable antibiotic resistance factors as microbial tracers in sewage polluted groundwater. In addition, host-specific bacteriophages are being investigated as potential tracers. These organisms may better represent the behaviour of viruses in groundwater systems than the standard bacterial indicators.

PLANT MATERIALS

Work has been directed towards implementation of the policy adopted previously by the Soil Conservation and Rivers Control Council. To achieve this the range of shrub and tree species being worked with is being broadened, tissue culture is being developed as an operating tool for propagation, and necessary support work is being concentrated at two centres only — Aokautere and Alexandra.

To achieve a greater integration with other aspects of work at the Aokautere Science Centre attention is being focused on basic studies to define the manner in which plant materials, trees, shrubs etc., achieve stabilisation of land. Such studies will aim to achieve better selection of species and increased choice in planting layouts.

River protection work is a major source of expenditure. To publicise methods available, field trials and demonstrations are the most effective and are being initiated.

Poplars

Emphasis has been placed on developing a range of improved disease resistant poplar clones for soil conservation, farm forestry and horticultural shelter, and also on establishing a gene-pool for future breeding and selection work. Selection has been from introduced seedlots, which have all been subjected to stringent testing for resistance to *Melampsora larici-populina, M. medusae* and recently to *Marssonina,* and from introduced clonal material which also has been screened for rust and *Marssonina* resistance. One hundred and fifty sufficiently rust-resistant clones from these have been included in a two-year nursery test programme. Ten clones from the introduced clonal material appear particularly promising and are being multiplied for more intensive nursery and field testing.

Work has also concentrated on developing special purpose poplars possessing characters such as unpalatibility to opossums, drought and wind resistance, high suckering ability, early development of rough bark, and increased length of growth period.

Although poplar seed and cutting imports are providing a large number of disease-resistant vigorous clones, most of these have one or more characteristics which render them unsuitable for erosion control plantings on pasture sites where they may be exposed to high winds and cattle and sheep grazing during establishment.

To provide clones with the desired combination of characteristics a poplar breeding project has been in progress using clones available in New Zealand. Two hundred and five crosses

were attempted between 1973–77. Most of these have been difficult interspecific crosses and because of the scarcity of rust-resistant clones have been restricted to parent clones with one or two highly desirable characteristics but low combining ability. Normal compatible crosses have been supplemented by crosses using hexane treatment of the stigma to break incompatibility and 47 successful crosses have produced 13 000 seedlings. After selection for rust-resistance and rooting ability of stem cuttings, 19 seedlings have been cloned and included in two-year nursery clone tests, and 140 seedlings retained for further observation. Of the 19 clones, one, a hybrid between *P. deltoides* and *P. Simonii,* has proved to be resistant to *Melampsora* and *Marssonina* and has shown an excellent growth rate. This clone has been multiplied for intensive nursery testing and for early field trials along with the 10 imported clones referred to above.

Poplar clones resulting from nursery selection have also been field tested to evaluate their use in erosion control and farm forestry plantings over various soil and climatic conditions occurring throughout New Zealand.

Aspen poplars being developed at the Aokautere Science Centre have an extremely high ability to sucker from disturbed root systems but cannot be propogated from stem cuttings. Establishment of these requires the use of small rooted trees and this necessitates some form of tree protection from rabbits, hares and domestic stock. Trees of the aspen poplars *P. tremula* and *P. tremuloides* were included with *P. trichocarpa* and other tree species in tree protector trials in Hawkes Bay and Wairarapa during 1978. Initial trial plantings of *P. tremula* and *P. tremuloides* have also been made in the southern Ruahine Range, Marlborough, North Canterbury and in the Shotover River catchment where their high-suckering ability is being tested for river bank stabilisation.

Pole trials of five years duration have been established in Northland, Hawkes Bay and Otago to test the growth from poles of 24 rust-resistant clones selected from the first two-year nursery tests. Additional pole trials will be carried out as new clones become available from current nursery tests.

Willows

Development, selection and field testing of tree willows has continued to provide, by breeding and introduction, a range of improved fast-growing tree willows for hillside stabilisation, river control and farm shelter.

The *Salix matsudana* × *alba* hybrids released to catchment authorities in 1975 have performed well in the field, and over 200 000 stools have been established in nurseries to date. In order to provide a range of similar clones of this type of willow a further 17 clones have been selected, on the basis of their performance in two-year nursery tests, for bulking up. From these, approximately five will be selected for release in 1980. Field trials including all 17 clones were established at Gisborne, Mangaweka and near Masterton in 1978.

Of the 14 tree willows released from quarantine in 1977, two clones (*S. alba* F16/63/281 introduced from Yugoslavia, and *S. alba* SI 75/62 introduced from Italy) are reasonably fast growing and appear to have potential for further hybridisation with *S. matsudana*.

Lower growing shrub and osier willows with more flexible branches are being developed to replace large tree willows (especially crack willows) where heavy bank protection is not required. These require less maintenance, and their flexible shoots and multi-stemmed habit are ideally suited for river bank protection. Many hybrid clones have been produced from material available within New Zealand and introduced from overseas. From the range of unpalatable, male (non-seeding) shrub and osier willow clones developed over the past five years, four single clones and four clonal mixes have been selected for release in 1980. Further trials have been established in the southern Ruahine Range, the Mangaatua Stream, and lower Manawatu River. A stoolbed of 8000 plants has been established at Aokautere which will provide stock material for distribution to catchment authorities, as well as heavy material for further trials and demonstration plantings.

Work is also continuing on breeding and introducing low-growing, unpalatable, non-seeding and cold tolerant clones of shrub willow clones for controlling debris movement in mountainlands.

A demonstration trial involving 5000 plants of recently developed shrub and tree willows has been established with the assistance of the Manawatu Catchment Board on an 800 m reach of the lower Manawatu River. This demonstration is to develop river protection species and techniques.

Alternative species of trees and shrubs

Much work in this area has been centred on selecting trees and shrubs suitable for revegetation of dry, exposed and eroded sites. A range of 32 species of *Eucalyptus* was selected for open planting on dry exposed sites in the Wairarapa hill country. A species trial established in 1970 on a droughty loessial soil at Wither Hills was evaluated, with results being similar to those obtained in 1975. *Eucalyptus bosistoana* was the best performing species closely followed by *E. camaldulensis*.

Seed samples of some 75 Australian *Acacia* species were obtained and sown at Aokautere. A collection of seed trees will be established from the most promising species for future seed supply. *Acacia melanoxylon, A. longifolia, A. mearnsii* and *A. parramettensis* have successfully been established in the Ruahine and Shotover catchments.

Selections have also been made of improved clones of *Robinia pseudoacacia* and *Gleditsia triacanthes* while *R. fertilis* a low growing nitrogen-fixing suckering shrub which has proved to be very adaptable on both moist and droughty sites in many districts, is now being bulked up at Aokautere for release next year.

An increased effort is being made in the selection of other three species with the potential for rehabilitating eroded sites, in particular those sites which are subject to more extreme soil and climatic conditions. Species of the *Alnus, Betula, Acer* and *Platanus* genera, and *Erythrina sykesii* are being evaluated.

Low shrubs, legumes and herbaceous species

Lupin species are being evaluated for ground cover, soil improvement and as a nursecrop in erosion control. *Lupinus polyphyllus* has been established successfully in the Ruahine Range and in a hydroseeding trial along the Mangaweka Railway Deviation. Work with the annual lupin, *L. pubescens*, is continuing in the South Island.

Aokautere Science Centre now has 60 accessions of *Sanguisorba minor* for evaluation for erosion control on dry, sunny faces and stony riverbeds. Screening is continuing at Aokautere, Wither Hills and in the Mackenzie Basin. Accessions tend to be highly variable in vigour and growth form. Superior lines will be selected from two-year old plants, especially of the subspecies *muricata* which tends to be the most productive.

Atriplex species are being evaluated for revegetation of eroded semi-arid country. Accessions have established successfully on two sites in Central Otago where soil salinity is higher than on similiar semi-arid sites in the Mackenzie Basin.

Besides *Lupinus, Sanguisorba* and *Atriplex*, a further range of low shrubs and herbaceous plants is being evaluated for summer-dry eroded sites. Seed of species from the most promising genera, *Dorycnium, Hedysarum* and *Cistus* is being collected.

Tissue Culture

During the year a plant tissue culture laboratory has been established using the rapid propagation procedures developed by the Plant Physiology Division, DSIR, Palmerston North. The laboratory has 12 m^2 of illuminated shelf space, capable of

producing 200 plantlets per day (Fig. 13). Rooted plantlets are produced in easily handled culture tubes which allow unrestricted vertical growth of the shoots (Fig. 14).

Root initiation on plantlets has been improved by the use of different growth factors. By exposing the plantlets to glasshouse conditions for three days prior to removal from the culture tubes, visible hardening of tissues takes place. This has increased the number of plantlets successfully transferred to a soil-less potting mixture to 90% (Fig. 15). Plantlets are potted up (Fig. 16) and grown on for a further two months until ready for despatch at 30-60 cm height.

More than 3000 poplar plants have been produced in this way for field and nursery investigation projects. Four Korean *Populus alba* × *glandulosa* clones are being increased to have 20 000 rooted plants available for evaluation and catchment authority planting in May 1979. Other plant materials with soil conservation uses are being investigated for tissue culture multiplication.

The sterile culture of plant materials provides a unique opportunity to import new selections of plants with minimal risk of disease introduction. The plant quarantine requirements of imported plant materials can be met more readily with tissue culture than with cuttings.

Figure 13 Illuminated shelves in incubation room showing a range of growth stages in different culture containers.

Plant diseases

Melampsora larici-populina and *Marssonina* species are the two most serious diseases of poplars in New Zealand. Their pathogenicity to important clones is being studied. Variation within the pathogens is also being investigated.

Rust caused by *Melampsora larici-populina* was widespread throughout the country in late summer 1977–78. In general, rust attack was less severe than in the previous year, due to the dry summer.

Marssonina leaf spot disease occurred in a restricted area in the lower half of the North Island where it caused some early leaf fall in suceptible clones. The organism apparently over-winters in the asexual state in this climate as conidia were produced in spring from infected fallen leaves, but no sign of apothecia was found. It appears that viable *Marssonina* conidia can survive on apparently 'clean' seed, and was almost certainly introduced into New Zealand in this way.

With the rapid increase in the use of willows since 1973 and with the establishment of large willow nurseries, the incidence of diseases is also increasing. Two diseases *Marssonina salicicola* and *Stereum purpureum* are causing concern. Trials have been set up at Aokautere and Whangarei to assess the relative suceptibility of 50 *Salix matsudana* × *alba* hybrids to *M. salicicola*. Clones vary in suceptibility and the severity of the disease is influenced by climate and level of inoculum. Trials have also been set up in five nurseries to assess the effectiveness of biological control of *Stereum purpureum* in stoolbeds using suspensions of *Trichoderma* spores sprayed on stumps after poles have been cut, compared with the current practice of painting stumps with fungicide.

Crown gall investigation is now completed. In the Centre's nursery, all willow and poplar cuttings are now routinely treated with a commercial preparation of *Agrobacterium radiobacter* var. *radiobacter* strain 84 ('Dygall') for biological control of crown gall.

Young plants propagated by tissue culture have shown high susceptibility to seedling diseases such as *Pythium* and *Botrytis* when transferred from sterile culture to greenhouse conditions, and require a careful schedule of protective fungicides.

Establishment techniques

Investigations have been carried out into improved techniques for nursery propagation and field establishment of plant materials for erosion control.

Most plants for field planting are grown in 8 cm peat pots, or for slower growing deeper rooting plants 17 cm long 7 cm diameter plastic bags are used. The Spencer-Lemaire 'rootrainers' are being evaluated as an alternative as they prevent root spiralling and facilitate 'air pruning'. Potting mixes having different ratios of peat, polystyrene and perlite are being evaluated with a view to reducing freight costs. At the same time the tendency of these mixes to dry out rapidly must also be considered.

In field trials, various forms of slow release fertilisers are being evaluated e.g. Magamp, Osmacote and Agriform tablets. The fertilisers are added to the planting hole, or added later. Where soil fertility is low, the addition of these fertilisers improves growth. For example, the use of Osmocote 8-2.6-10 and

Figure 14 Plantlets of *P. alba* × *glandulosa* 'PN895' in culture tubes.

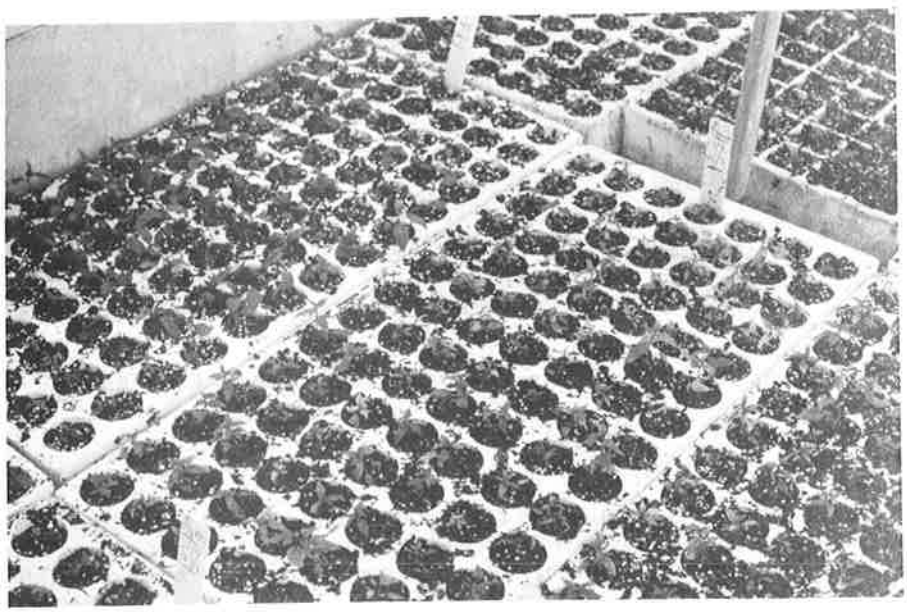


Figure 15 Hardening-off of tissues cultured *P. tremula*.

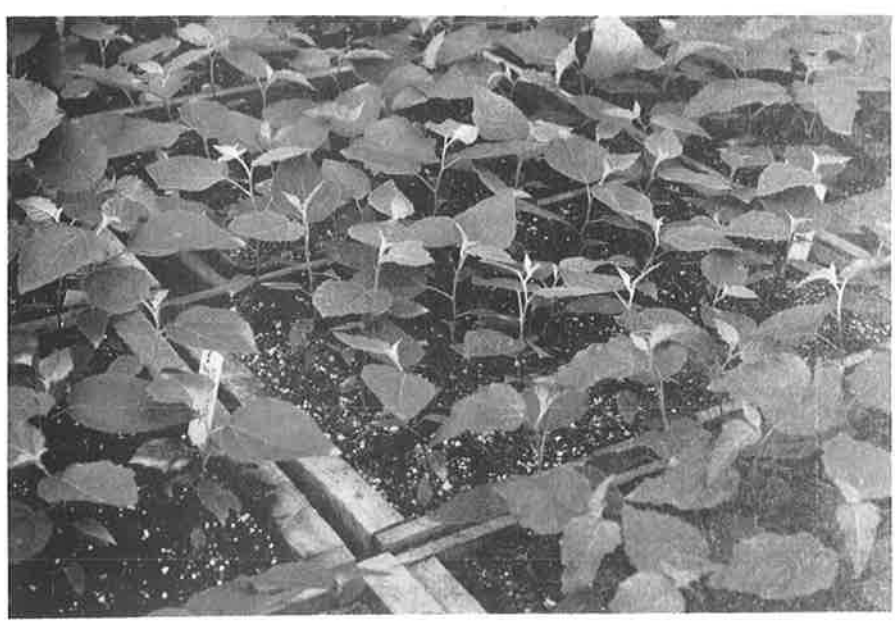


Figure 16 *P. alba* × *glandulosa* 'PN894' one month after hardening-off.

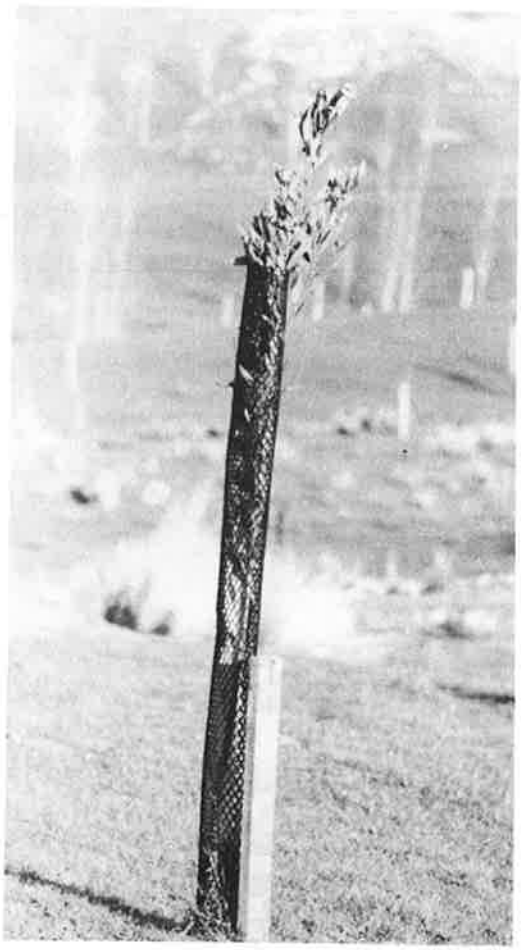


Figure 17 (left), Netlon sleeve giving protection from grazing animals.

Figure 18 (right), Electric wire tree protector provides protection against sheep browsing.

Agriform 28-8-4 in a pot trial with *Corokia cotoneaster* in a Ruahine Steepland Soil gave a 50% increase in growth over nil fertiliser. However *Acacia melanoxylon* gave no significant response to any of the fertiliser treatments applied.

Grass and weed competition must be avoided to ensure satisfactory plant establishment and growth. Spot spraying with simazine/paraquat before planting in the field is common where weed competition can be expected. Other chemicals being evaluated include 'Caraguard' and glyphosate.

For weed control in soil conservation nurseries, a range of chemicals has been evaluated on *Populus* (two clones), *Salix* (two clones), *Symphoricarpos orbiculatus* and *Atriplex halimus*. Simazine was the safest effective material used, even at 3 kg/ha.

Poplar and willow cuttings can be stored for three months at 1-4°C to facilitate spring planting in areas with pronounced winters, provided they are stored in plastic bags and temperatures are not allowed to fluctuate beyond that range. The cuttings should be stored as soon as possible after dormancy has commenced.

Protection techniques

Techniques are being developed to protect rooted plants from damage by sheep and cattle. These will reduce the need for fencing off grazeable but eroding hillsides during tree establishment.

The Netlon sleeve developed successfully by the Aokautere Science Centre for poplar and willow pole protection from grazing animals can also be used to protect seedling trees. This increases the range of trees which can be used for soil stabilisation on dry hill country.

Seedling trees of *Eucalyptus, Acacia, Casuarina, Robinia* and *Pinus radiata* have been established successfully in sleeves 1-4 m long with a lie flat diameter of 160-170 mm (Fig. 17). A stake 1.8 m long by 50 × 35 mm is driven 0.6 m in the ground to support the sleeve. The stake has to be free of knots and treated with preservatives. As sheep use the tree protectors as rubbing stakes, a shorter second stake is driven in front of the sleeve. The stake supporting the sleeve must be vertical to prevent the terminal shoot from growing through the sleeve. Seedling trees have been protected with this method in spite of Romney, Coopworth and Perendale sheep grazing at up to 350 animals per hectare.

Trials at Aokautere have shown that small tree seedlings can be protected from sheep grazing with single wire loops of 50 cm diameter, 20 cm above the ground, electrified by a 'Grassfence' energiser (Fig. 18). The loops are connected to single electrified wires, supplied by an overhead leadout wire. It is desirable to accustom sheep to the electrified loops before establishing one-year old trees.

The system is now being evaluated in a farm situation for the stabilisation of tree seedlings for hill country stabilisation and for farm shelter. A trial with 200 *Acacias* and *Eucalyptus* has been implemented on a Wairarapa farm. Here no mishaps have occurred in four months except for when a mob of sheep was driven through the trial too quickly.

Shotover investigations

Work is being undertaken to determine which plant materials are suitable for erosion control and riverbank protection in the Shotover Catchment and to determine the most suitable establishment techniques.

Shrubby willow clones continue to be the most promising over the greatest range of sites. Over 90 clones have been evaluated and 15 selected for further testing.

Other shrub species have shown much more variable results than shrubby willows. *Robinia fertilis* and *Hippophae rhamnoides* were poor for the first two years but subsequently have started to grow well and are now very promising on sandy and gravelly sites. Good initial results have been obtained from *Symphoricarpos orbiculatus*, with quick ground cover being obtained. *Cornus baileyi, Alnus viridis* and *A. glutinosa* are promising on wetter sites, and *Populus* I–154 and *Salix* NZ1002 are growing well where opossums are not present.

Lupinus pubescens, an annual, provides a very rapid ground cover and will reseed freely below about 550 m. *Lupinus arboreas* and *Lupinus polyphyllus* establish more slowly but being perennial provide long term cover.

Along river channels only wands of willows have been used. Heavier material needs to be used to reduce damage caused by high floods.

Ruahine Range investigations

Trials established in 1978 again concentrated on riparian slips and gullies in the Kumeti Catchment, particularly in the 'valley throat' area just upstream of the forest margin. In this area 12 000 shrub and osier willows were planted between pole and netting retards for bank protection purposes. Four thousand plants of other trees and shrubs including *Acacia* (3 spp.), *Albizzia lopantha, Alnus* (13 spp.), *Betula* (7 spp.), *Ceonothus americanus, Chaemoneles* spp., *Cistus* (2 spp.), *Coriaria arborea, Corokia cotoneaster, Hoheria sexstylosa, Phormium* (3 clones), *Populus* (3 spp.), *Robinia fertilis, Symphoricarpus* (2 spp.), were planted on riparian slips.

The most promising species from the 1976 and 1977 plantings include many shrub willow clones of *S. purpurea, S. incana, S. glaucophylliodes* and hybrids from these, *Acacia melanoxylon, Populus trichocarpa, Robinia fertilis, Symphoricarpus orbiculatus, Lupinus polyphyllus* and *Cystisus proliferus.*

Tree establishment and species selection, Wairarapa hill country

This project is being undertaken as a result of severe erosion of north-west slopes in the Wairarapa during the winter of 1977. The objectives are:

(a) to select tree species capable of growing on and stabilising dry, exposed upper slopes which occur throughout much of the east coast of New Zealand, and where the traditional soil conservation species of poplars and willows are unsuitable;

(b) to determine suitable establishment methods for these species.

During the winter of 1978, species and establishment trials were established at four sites representative of the more severely damaged loess-covered north-west slopes. The species trials include 32 *Eucalyptus* spp., two *Populus* spp. and six *Acacia* spp. involving approximately 4200 plants in both fenced-off plots and as space-planted individually protected trees. The establishment trials are designed to determine the effects of time of planting, fertiliser treatments and different weed control methods on establishment, and to determine suitable methods of protection against stock. The protection methods being studied include various types of plastic sleeves, wire mesh cages, and electric wire tree protectors. Further trials are to be established in 1979.

Roadside stabilisation

An area of exposed limestone rock near Pakipaki (Hastings) has been revegetated effectively with *Lotus* spp. (especially *L. corniculatus*), *Medicago sativa, Hedysarum coronarium, Onobrychis viciifolia* and *Coronilla varia*. Plant establishment was disappointing for the first 15 months after plantings but from then on ground cover improved. As the legumes started to enrich the limestone rock with nitrogen, grasses invaded and became well established. The most important grasses were *Vulpia* spp., *Bromus* spp., and *Dactylis glomerata.*

A range of legumes has been hydroseeded onto road batters in the Gisborne Residency. Extensive treading damage to the batters from wandering cattle has seriously affected plant survival in the trial areas. Continuous fretting of exposed siltstone to mudstone soils tended to bury those plants which had established unless their morphology enabled them to grow through the accumulated debris. The most suitable plants in these soils were *Phalaris aquatica* and *Medicago sativa*. Of the experimentally sown plants, only *Melilotus* spp. and *Coronilla varia* show any promise at this stage.

Further trials were hydroseeded on batters in the Mangaweka SH 1 road realingment. The trials included a range of legumes and also *Sanguisorba minor*. Probably because of the rather dry winter, only grasses which had survived after the original vegetation had been killed off formed a reasonable plant cover on the very hard mudstone. Of the experimental plants only *S. minor* had established to some extent. If these plants survive the summer they may seed and thicken the sward.

Further selections have been made of *Coronilla varia* and *Lotus tenuis* with particular emphasis on early spring growth. Seed of these species is being increased for more extensive trials. Steep road batters present particular problems to plant establishment because of poor moisture holding capacity , poor aeration and other soil physical and chemical characteristics. Root growth is often severely limited. Major emphasis will have to be placed on plants which can tolerate the extreme Mediterranean summer dry conditions of many road batters.

Semi-arid and drought-prone areas

Several species are showing great promise in the semi-arid areas of Central Otago. *Atriplex* species show greatest promise on the solonetz soils of Central Otago but fail in the MacKenzie Basin. Natural reseeding was recorded for all provenances of *A. semibaccata* and *A. vesicaria.*

On the non-saline soils, *Dorycnium* species are promising. This sub-shrub is showing good regrowth at the base of the plant in autumn, early winter and early spring.

Several *Cistus* species are very promising but they will not tolerate salty soils and have not grown well on heavy clayey soils. The best plants are growing on soils ranging from loess to semi-arid gravelly sandy silts.

All the above plants have only been successfully established from tubed seedlings – open rooted plants have failed. All show varying degrees of unpalatability. Most unpalatable are the *Cistus* species.

Inter-Agency Co-operation

Water Quality Research Committee

Following on from the activities of last year, a review of the habitat requirements of freshwater fish in New Zealand and suggestions for developing in-stream uses of New Zealand streams has been prepared for publication.

Biological Standing Working Party

Reports on biological aspects of water quality and microbiological water testing have been prepared for publication. A handbook of standard methods for sampling of biological aspects of water quality is also being prepared.

Chemical Standing Working Party

The working party has recently been working on standard methods for water analyses, a checklist of substances of concern to water quality in trade wastes, a survey of laboratories performing water analyses, wastes from timber treatment plants, parameters for baseline water quality surveys, chlorophyll concentrations in surface waters of some New Zealand lakes, nutrient loading in relation to trophic status of lakes and biological availability of phosphorus.

Reorganisation of Water Quality Research Committee

Following the restructuring of the National Water and Soil Conservation Organisation servicing committees, and the formation of the Research and Survey Committee, the Water Quality Research Committee is to be reorganised to strengthen its technical role. It will then be known as the Water Quality Research and Survey Work Party (WQRSWP).

The standing chemical and biological working parties are completing existing briefs and will then be discontinued. Working groups will be established under the WQRSWP to deal with specific issues as they arise. It is anticipated that the WQRSWP will be operational by early 1979. This working party will be responsible to the Research and Survey Committee.

Joint Working Party on Land Use and its Effects on Water

Members of the working party have prepared papers on various aspects of land use as it affects the movement of chemical and biological materials into water – particularly land clearing for agriculture and forestry, agriculture, indigenous vegetation and forestry land use, agricultural and silvicultural chemicals, and the urban situation and transport network. These papers will be published as a single report and will be of considerable use in management.

Waikato River Technical Study Group

The group has completed a major review of work done on the Waikato River. Areas covered include hydrology and land use, physico-chemical conditions, biological features, and mathematical modelling. A publication is being prepared.

Lake Rotorua Scientific Coordinating Committee

The committee's activities for 1978 include: algal assay studies by Freshwater Section of Ecology Division, DSIR; monitoring Lake Rotorua at fixed stations for various parameters by Fisheries Research Division, Ministry of Agriculture and Fisheries, and the Wildlife Service, Department of Internal Affairs; regular chemical sampling of tributaries, lake modelling studies, dredging feasibility studies, macrophyte nutrient stripping studies, and sediment studies (in collaboration with MAF and Waikato University) by Water and Soil Division, Ministry of Works and Development; and macrophyte surveys by the Wildlife Service, Department of Internal Affairs.

Lakes Ellesmere Research Committee

A committee has been set up to manage and coordinate research into the present condition of Lakes Ellesmere and to provide information to assist the future management of the lake.

Dr H.E. Connor of the North Canterbury Catchment Board and Regional Water Board is chairman of the committee. Representatives are from the Botany Department, Univeristy of Canterbury; Soil Science and Microbiology Departments of Lincoln College; Wildlife Division, Department of Internal Affairs; Fisheries Division, Ministry of Agriculture and Fisheries; Chemistry Division, DSIR; Ellesmere County Council; Water and Soil Division, MWD; and Officials Committee on Eutrophication.

Research contracts approved to date are:

(a) investigation of the nature of the sediments in Lake Ellesmere and their influence on the state of eutrophication of the lake;

(b) investigation of phytoplankton – to identify species or groups of species which may allow monitoring of future changes in the trophic structure of the lake;

(c) investigations into nutrient inputs and cycling of nitrogen and carbon into Lake Ellesmere with particular reference to microbiological transformations.

Current or on-going activities in support of the above research investigations include chemical analyses of the samples, hydrological gaugings on inflow streams and temperature monitoring of the lake waters.

Port Hills Erosion Research Co-ordinating Committee

The committee was constituted by resolution of the North Canterbury Catchment Board in October 1977 and is chaired by Mr R.D. Dick of that board. Other respresentatives are from the Water and Soil Division, MWD; Soil Bureau, DSIR; Soil Science Department, Lincoln College; Geology Department, University of Canterbury; Christchurch Drainage Board; Christchurch City Council; and a consulting engineering firm.

The committee has the following terms of reference:

(a) to co-ordinate and advise on research on the Port Hills into the occurrence, control and prevention of erosion, the effects of construction works, and minimising soil instability;

(b) to evaluate the results of previous research and other relevant data;

(c) to consider and recommend to the North Canterbury Catchment Board what further research is required and who might undertake it;

(d) to recommend to the Board ways and means of financing

or otherwise assisting recommended research projects to be implemented;

(e) to make recommendations to the Board as to how results of research could best be translated to rural management and urban construction work practices;

(f) to report to the Board at six-monthly intervals, or more frequently if the Board so requests.

The committee has initiated two research projects. One is to undertake comparative testing of the stabilising effect of two chemicals, phosphoric acid and hydrated lime, on the highly erodible loessial soils on the Port Hills. The work involves laboratory testing and field trials and is being carried out by a consulting engineer under contract to the National Water and Soil Conservation Organisation. The second involves processing and interpretation of rainfall and weir flow charts from the Cashmere and Hoon Hay catchments to predict the runoff patterns for storms of various intensities, and their return periods. The work is being carried out under the supervision of the Board's regional water engineer. Staff are engaged in preparing a computer programme for statistical analysis and correlation of the rainfall and weir flow data.

Technical Committee on Tarawera River

This committee is under the chairmanship of Mr E.D. Revington of the Bay of Plenty Catchment Commission and Regional Water Board, and includes representatives of that; the Water and Soil Division, MWD; Ecology Division, DSIR; Tasman Pulp and Paper Company Limited; the Borough Council of Kawerau; and Caxton Paper Mills Limited.

The terms of reference of the committee are to report on:

(a) the individual waste loads now being discharged into the Tarawera River (this has been reported upon but requires continual up-dating as Tasman Pulp and Paper Company Limited, and Caxton Paper Mills Limited carry out further improvements to their waste treatment facilities);

(b) the total acceptable waste assimilative capacity of the Tarawera River (the subject of mathematical modelling work, see page 77);

(c) its planned allocation of the assimilative capacity and the basis for the plans;

(d) the conditions considered necessary on the rights of all discharges of waste into the river to give effect to the planned allocation of the assimilative capacity.

Publications

Water and Soil Division is currently producing two series of publications for the National Water and Soil Conservation Organisation; *Water and Soil Technical Publications*, and *Water and Soil Miscellaneous Publications*. Of these, the following have been published with research and survey staff as authors or co-authors.

Technical Publications:

No. 1 "Liquid and waterborne wastes research in New Zealand 1976." (1977)
No. 2 "Sampling of surface waters." (1977)
No. 3 "Water quality research in New Zealand 1976." (1977)
No. 4 "Shotover survey." (1978)
No. 6 "Recorded channel changes of the upper Waipawa River, Ruahine Range, New Zealand." (1978)
No. 7 "Effects of domestic wastewater disposal by land irrigation on groundwater quality of the central Canterbury plains." (1978)
No. 8 "Magnitude and frequency of floods in the Northland–Auckland region and their application to urban flood design." (1978)
No. 9 "Research and survey annual review 1977." (1978)
No. 14 "A survey of New Zealand peat resources." (1978)

Miscellaneous Publications:

No. 1 "Rainfalls and floods of Cyclone Alison, March 1975, on the northeastern Ruahine Range." (1978)
No. 2 "Water quality research 1977." (1978)
No. 3 "Liquid and waterborne wastes research in New Zealand 1977." (1978)
No. 6 "Suggestions for developing flow recommendations for in-stream uses of New Zealand streams." (1978)
No. 7 "Index to hydrological recording stations in New Zealand 1978." (1978)

Papers with research and survey staff as authors or co-authors are listed below.

Chinn, T.J.; Whitehouse, I.E. 1978: Glacier snowline variations in the Southern Alps, New Zealand. Presented at UNESCO Workshop on Glacier Inventories, Zurich, October 1978.

Duncalf, I.A. 1977: Plane trees for soil conservation. *Soil and Water 14(2)*: 28-9.

Edwards, W.R.N. 1978: Sand-surfacing, a new technique to prevent bark damage. *Soil and Water 14 (3):* 11.

Edwards, W.R.N. 1978: Effect of salicin content on palatability of *Populus* foilage to opossum (*Trichosurus vulpecula*). *N.Z. Journal of Science 21:* 24-6.

Eyles, G.O. 1977: New Zealand Land Resource Inventory Worksheets and their applications to rural planning. *Town Planning Quarterly 47:* 38-45.

Eyles, G.O. 1977: Land Resource Inventory Worksheets. *Landscape, June 1977:* 8-9.

Gilchrist, A.N. 1978: Herbicides for New Zealand soil conservation nurseries. *Australian Weeds Research Newsletter No. 26:* 24-6.

Hathaway, R.L. 1977: Revegetation research, Ruahine Range. New Zealand Society of Soil Science 25th Jubilee Conference, December 1977. Field Excursion Handbook p.45.

Hawley, J.G. 1977: Physical considerations. Paper presented at Symposium on Urban Development, Lower Hutt. July 1977. Standards Association of New Zealand.

Hawley, J.G. 1977: The measurement of time within the soil mass. *Proceedings of the 9th International Conference of the International Society of Soil Mechanics and Foundation Engineering.* Tokyo.

Hawley, J.G. 1978: Urban slope stability: the way ahead. *Proceedings of the 25th Conference of the New Zealand Association of Soil Conservators, Christchurch, August 1978.*

Hawley, J.G. 1978: The Aokautere Science Centre. *New Zealand Geomechanics News No. 17.*

Hawley, J.G. (In press): Some effects of urban development on risks of slope instability. *Proceedings of Seminar on Slope Stability and Urban Development.* Department of Extension Studies, University of Canterbury.

Hicks, D.L. 1977: Geomorphological development of the southern Aupouri and Karikari Peninsulas. *In* "Soil Groups of New Zealand, Part 2: Yellow Brown Sands". pp. 48-52. New Zealand Society of Soil Science.

Hoare, R.A. 1978: Particulate matter in the tributaries of Lake ROtorua. *Proceedings of the 25th Conference of the New Zealand Association of Soil Conservators, Christchurch, August 1978.*

Howard, G. 1978: Changing perspectives of erosion assessment in South Island high country. *Proceedings of the 25th Conference of the New Zealand Association of Soil Conservators, Christchurch, August 1978.*

Jessen, M.R. 1977: Horotiu and Waihou silt loams as indicators of prehistory. *New Zealand Soil News 25(5)* (Summary only). Paper presented at the New Zealand Soil Society Silver Jubilee Conference, Flock House, December 1977.

Lambrechtsen, N.C. 1977: Roadside flowers. *National Roads Board, R.R.U. Newsletter No. 51.* 20p.

Lambrechtsen, N.C.; Foote, A.G. 1976: Weed control in *Coronilla varia. Australian Weeds Research Newsletter No. 23:* 31-2.

McBride, G.B. 1978: Temporal variations of dissolved oxygen and oxygen demand in the Waikato River. *Proceedings of New Zealand Institute of Engineers Conference, Hamilton, February 1978.*

McSaveney, M.J. 1978: The magnitude of erosion across the Southern Alps. *Proceedings of the 25th Conference of the New Zealand Association of Soil Conservators, Christchurch, August 1978.*

Maguiness, J.A.; McBride, G.B.; Beable, M.E. 1977: FRAN – a computer program for the frequency analysis of extremes. Paper presented at New Zealand Hydrological Society Annual Symposium, Christchurch, November 1977.

Nieuwenhieus, E.; Trustrum, N.A. 1977: Gilgaei in Extremdura, Spain. *International Institue for Aerial Survey and Earth Sciences (I.T.C.) Technial Report No. 4.* Enschede, The Netherlands.

Pittams, R.J. 1977: Maximum intensity rainfall data from Otutira, related to thunderstorms in the northern Taupo area. Paper presented at New Zealand Hydrological Society Annual Symposium, Christchurch, November 1977.

Rao, A.R. 1977: Robust estimation of parameters of time series models in hydrology. Paper presented at New Zealand Hydrological Society Annual Symposium, Christchurch, November, 1977.

Rao, A.R.; McKerchar, A.I. 1977: The use of Kalman Filter in hydrology. Paper presented at New Zealand Hydrological Society Annual Symposium, Christchurch, November 1977.

Schouten, C.J.; Hambuechen, W.H. 1978: The impact of gullying and subsequently applied soil conservation techniques in a Northland mudstone catchment. *Proceedings of the 25th Conference of the New Zealand Association of Soil Conservators, Christchurch, August 1978.*

Sheppard, J. 1976: Studies on shrub species for erosion control. *Proceedings of NZIAS Conference New Zealand Association of Soil Conservators:* 21-7.

Sheppard, J. 1978: Woody plants for soil stabilisation and erosion control. *Annual Journal of the Royal New Zealand Institute of Horticulture 6:* 46-53.

Spiers, A.G. 1976: *Phoma* leaf-blotch of *Populus* species in New Zealand. *Plant Disease Reporter 60 (11):* 981-4.

Spiers, A.G. 1978: An agar leaf-disc technique for screening poplars for resistance to *Marssonina. Plant Disease Reporter 62(2):* 144-7.

Spiers, A.G. 1978: An agar leaf-disc technique for screening the effectiveness and persistence of fungicides for control of *Marssonina* on *Populus. Plant Disease Reporter 62(2):* 148-52.

Spiers, A.G. 1978: Effects of light, temperature and relative humidity on germination of urediniospores of, and infection of poplars by, *Melampsora larici-populina* and *M. medusae*. *N.Z. Journal of Science 21*: 393-400.

Stephens, P.R. 1977: Erosion in the Upper West Tamaki Catchment. New Zealand Society of Soil Science 25th Jubilee Conference. Field Excursion Handbook: 27-36.

Taylor, D.K.; Hawley, J.G.; Riddolls, B.R. 1977: Slope stability in urban development. *DSIR Information Series 122.*

Thorpe, H.R. 1976: Ruahine problem in pictures. *Soil and Water 13(3):* 22-3.

Thorpe, H.R. 1977: Movement of contaminants into and through the Heretaunga Plains Aquifer. Paper presented at New Zealand Hydrological Society Annual Symposium, Christchurch, November 1977.

Thorpe, H.R.; Scott, D.M. (In press) Groundwater – state of the art in New Zealand. *In*: "Physical hydrology – New Zealand experience". (Edited by D.L. Murray and P. Ackroyd). New Zealand Hydrological Society.

Trustrum, N.A.; Stephens, P.R. 1978: Development of remote sensing techniques for erosion assessment in New Zealand. *Proceedings of the 25th Conference of the New Zealand Association of Soil Conservators, Christchurch, August 1978.*

van Kraayenoord, C.W.S. 1976: Plant materials for erosion control. *New Zealand Journal of Agricultural Science 10(1):* 29-33.

van Kraayenoord, C.W.S. 1978: Plant materials for erosion control. *Proceedings of the 25th Conference of the New Zealand Association of Soil Conservators, Christchurch August 1978.*

van Kraayenoord, C.W.S.; Wilkinson, A.G. 1976. The role of *P. deltoides* in New Zealand. *Proceedings of the Symposium on Eastern Cottonwood and Related Species,* Greenville, Mississippi, U.S.A.: 176-88.

Waugh, J.R.; Fenwick, J.K. (In press) River flow measurement. *In:* "Physical hydrology – New Zealand experience". (Edited by D.L. Murray and P. Ackroyd). New Zealand Hydrological Society.

Whitehouse, I.E. 1978: A century of erosion and recovery. *Soil and Water 14(5):* 10-4