

WATER & SOIL

TECHNICAL PUBLICATION

No.

9

RESEARCH AND SURVEY

ANNUAL REVIEW 1977



NATIONAL WATER & SOIL CONSERVATION ORGANISATION



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TECHNICAL PUBLICATION NO 9**

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ANNUAL REVIEW 1977**

**Review of activities
of the Research and Survey group
of the Water and Soil Division,
Ministry of Works and Development.**

WELLINGTON 1978

RESEARCH AND SURVEY ANNUAL REVIEW 1977

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

Water and Soil Technical Publication No 9, 1978, pp 51

PUBLISHED BY THE WATER AND SOIL DIVISION, MINISTRY OF
WORKS AND DEVELOPMENT, P O BOX 12-041, WELLINGTON, NEW
ZEALAND FOR THE NATIONAL WATER AND SOIL CONSERVATION
ORGANISATION

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Page 31, Col. 2, Para. 6 Line 3
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INTRODUCTION

Science Centres

The past year has seen continuing progress in the establishment of the three national science centres at Christchurch, Aokautere and Hamilton. Christchurch has national responsibility for water quantity, erosion processes and sediment transport and the South Island sector of land resource survey; Aokautere is the national centre for land stability, plant materials for erosion control and the North Island sector of land resource survey, and Hamilton is nationally responsible for water quality including estuarine and coastal studies.

New accommodation has been leased for the Christchurch Science Centre and the first group moved into its new quarters at the beginning of August. Final occupation is awaiting subdivision of the building and provision of specialised furniture, fittings and services.

At Aokautere, tenders are about to be called for an additional building to house land stability and land resources staff.

The key requirement at the Hamilton Science Centre is seen as the development of

laboratory facilities to the necessary level of proficiency. To this end it has been necessary to divert technical and scientific effort from existing projects which consequently have had to be run at a largely maintenance level. This has, however, provided the opportunity to concentrate on establishing a pattern of work in which data are processed, interpreted and worked up into a publishable form as expeditiously as possible. It is hoped to have the analytical laboratory fully operative by September 1978.

Staff recruitment is continuing at a cautious rate, with the calibre of applicants being high.

Logotype

The National Authority recently approved the design of a logotype for the Water and Soil Organisation. Work is now underway to incorporate the logo into a noticeboard for the Water and Soil Science Centres and to adapt it for use on letterheads, doorsigns and for general administrative purposes.

THE NATIONAL HYDROLOGICAL NETWORK AND SURFACE HYDROLOGY PROGRAMME

The National Hydrological Network is the complete network of water level recording stations operated for surface water resource assessment purposes. In March 1977 it consisted of 622 water-level recording stations, together with 230 recording rainguages and 82 automatic recorders on groundwater bores. Of the water-level recording stations, 355 are operated by Ministry of Works and Development, 249 by catchment authorities and 18 by other agencies.

The success of the total network and the data bank (Tideda) is reliant on the co-operation of all organisations involved in data acquisition.

The objectives of the National Hydrological network are:

(a) "To be able to provide streamflow data at any point on any stream" (Lystrom 1970). An important corollary of this is that "the streamflow data programme should no longer be considered in terms of a network of observation points, but rather as an

information system in which data are provided by both observation and synthesis" (Carter and Benson 1970).

(b) To be able to provide streamflow data for any purpose in advance of the need.

Multiple-use of hydrological data is of increasing importance in operating a national hydrological network. Data from a particular station may be used in a research project, for power station investigations, for engineering design purposes and for water supply investigations.

Data for one or more purposes are eventually required on virtually every stream in the country and "the data system must be designed to produce the information in advance of the need" (Carter and Benson 1970).

(c) To ensure that continuity of water-level recording is achieved. At some stations very long run records need to be collected.

(d) "To develop accuracy goals which should be stated in quantitative form. This will

permit evaluation of the existing stream-flow data to determine which accuracy goals have been obtained and provides guidance on how the data collection programme should be modified" (Collings 1971).

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. In 1977, 79% 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. A major objective of the national surface water hydrology programme is to provide data for design, planning and management purposes. Data collection for these purposes is routine but absolutely essential because of the great value of the information to the community.
- (b) MAJOR RIVER STATIONS. These are largely existing stations which will be operated as permanent stations primarily to assess long-term trends in water yields from New Zealand's major catchments. Seventy stations will be operated as part of this network.
- (c) REGIONAL STATIONS. Representative basins or regional stations were established during the International Hydrological Decade (1965-74). At present 58 regional stations are being operated in 55 hydrological regions. In all, data are available from 74 catchments in 71 regions. A new regional station has been established in the Makohine catchment, in the Rangitikei hydrological region.
- (d) RESEARCH PROJECT STATIONS. Some hydrological stations are established to provide data for specific research projects. For example:
- (i) Stations established to monitor the inflow into Lake Rotorua and Lake Taupo.
 - (ii) Stations established to assess the water resources of the Rakaia catchment.

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, operational and research objectives to be met with greatest efficiency.

Publication of Data

To improve the availability of hydrological data, a station index for all water-level re-

coding stations (either operational or closed) where more than 3 years of stage data and their appropriate site ratings are available, has been produced. This listing covers stations operated by all agencies.

In addition, a listing of all rainfall monitoring stations not operated as part of the regular meteorological office observation programme has been drawn up. This is dominantly a listing of sites operated by Ministry of Works and Development and catchment authorities.

Draft copies of both these listings for 1977 have recently been circulated.

Catchment Register

A catchment register of all catchments being monitored for hydrological purposes, is being prepared. This will be a loose leaf publication, subject to regular updating, and will include the following information:

- (a) catchment map, showing location of rain-gauges and water-level instruments;
- (b) land inventory map of the catchment;
- (c) a description of the catchment land use, soils, geology and topography;
- (d) a summary of hydrological data.

Other forms of readily accessible data publication are being examined.

National Hydrological Data Bank

The major source of hydrological data in New Zealand continues to be the Tideda system operated by Water and Soil Division of Ministry of Works and Development. This national hydrological data bank contains data from 338 of the 622 stations in operation. Data from 92 closed stations are also available. Arrangements are in hand to extend the number of stations included in the system.

In total, some 4,127 years of hydrological data are now stored in the Tideda system, and are available for use by water and soil staff, catchment authorities, universities, local bodies and consulting engineers.

Crest-Stage Gauging Programme

Crest-stage stations provide a simple and relatively inexpensive means of gathering data on annual maximum discharges. Such data are required for the specific engineering problem of estimating design floods of ungauged catchments for such purposes as bridge or culvert construction. In general, overseas experience has shown that these maximum water-level recorders are best used on small catchments, particularly where culverts allow a synthetic stage-discharge relationship to be established. At present crest-stage stations have been established to provide data for bridge design purposes at

locations on the 10-year National Roads Board bridging programme, in Auckland and Hamilton Works District.

A crest-stage gauging programme is now being established in one Ministry of Works and Development district to assess more fully the technique and its manpower requirements.

Raingauge Network

Analysis of existing networks (particularly those in representative basins) shows that the number of gauges in each network can be reduced. However, the reduction is not a constant factor as each network varies depending on the size of the catchment, the number of existing gauges and the relative topography of each catchment.

Land-Use Catchment Programme

Throughout New Zealand land management and water resource management and planning problems arise which involve an assessment of the effect of specific types of land-use or changes in land-use on the water resource. To date, there is very little hydrological data available from catchments in this country which would permit one to assess whether the effects of a particular land-use in a given locality are large or small.

As a result, a national network of land-use catchments is being established on selected key climatic — lithologic units throughout New Zealand to:

- (a) provide data for water resource management purposes and to guide planning and policy formulation;
- (b) provide data for specific land management problems.

The land-use catchments are being established to monitor the effect of specific land uses on:

- (a) streamflow;
- (b) sediment yield;
- (c) water quality parameters.

Catchments being established, and existing catchments judged suitable for inclusion in the programme are as follows:

- (a) NORTHLAND on northern yellow-brown earths
 - (i) On greywacke rocks (Whangarei hydrological region).

CATCHMENT	LITHOLOGY	LAND-USE
Glenbervie	Greywacke	Mature pine forest
Ngunguru	"	Native forest and pasture
Waipapa	"	Native forest (including kauri)
Mangere	"	Native forest (including kauri)

- (ii) On claystone and related sedimentary rocks (Hokianga hydrological region).

Puketurua	Claystone	Pasture, sheep and cattle
Kokopu	"	Pasture, dairying
Topuni	"	Mature pine forest
Opahi	"	Pasture and scrub
Waiwhiu	Waitemata sandstone	Native forest, pasture planted with pines.

(b) CENTRAL NORTH ISLAND

Purukohukohu (In cooperation with Forest Research Institute)	Pumice-rhyolite	Native forest, pasture, pine forest
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(c) NELSON "MOUTERE GRAVELS" AREA

Moutere (12 catchments)	Moutere gravels	Six in pasture, six planted in pines
Roughn's Creek	"	Young pine forest
Hunter's Gully	"	Beech forest
Kikiwa Station	"	Pasture
Graham Creek	"	Pasture planted in pines
South Pigeon Creek (proposed)	"	Mature pine forest

(d) SOUTH CANTERBURY (with South Canterbury Catchment Board)

Opihi catchments	Greywacke	Snowgrass (2 catchments)
	"	Tussock oversown and topdressed (2)
	"	Depleted and eroding (2)
Kakahu catchments	"	Tussock (2) To be planted in pine forest (2)

(e) MACKENZIE BASIN (being investigated)

(f) URBAN CATCHMENTS

Several catchments in varying stages of urbanisation are being monitored in the Auckland area and at Rotorua.

Wairau Creek	Auckland	Near-fully urbanised
Glenfield (proposed)	"	Modern housing
Puhinui	"	Partly developed
Pakuranga	"	Partly developed
Manukau	"	Pasture, to be developed
Fenton St Drain	Rotorua	Commercial urban area
Te Ngae Drain	"	Urbanised (older)
Pomare catchment	"	Recent urbanisation

Moutere Land Use Catchments

The increasingly widespread practice in New Zealand of planting pines in hill country has necessitated an investigation into the effect of water yield of stands of *Pinus radiata*, the most commonly used species. Studies of both afforestation and deforestation

overseas, while indicating that afforested catchments generally yield less water than those in pasture or scrub, cannot be applied directly to New Zealand situations. The importance of climate, soil conditions and geology demand the acquisition of New Zealand experience.

At Moutere, Nelson, a study is in progress to evaluate the effect on water yield of stands of *Pinus radiata*. Although Moutere receives approximately 1,000 mm rainfall annually, yield is usually only 10–25% of this amount. For many purposes the area is regarded as water-deficient. In 1970 and 1971 three experimental catchments were planted in one year old pines. Comparison of the runoff characteristics of these catchments before and after planting and analysis of differences between the hydrologic response of these catchments and others in pasture, are allowing an early insight into the impact of pines on the flow regime.

Involved in this analysis are catchments 2, 5 and 15 which have been in pasture throughout the period for which flow has been

monitored (since 1963); catchments 8 and 13, which were converted in 1970 and 1971 respectively from heavy gorse to pines (1,500 spha) and catchment 14, converted in 1970 from pasture to pines (also 1,500 spha).

Variation of the annual runoff from the three catchments converted to pines relative to that for the grassed catchment 5 is presented in Fig. 1. For catchments 8 and 13 the pattern is dominated by the impact of burning the gorse, cultivation and line-doing which produced the high relative runoffs in 1970 and 1971. By 1975 establishment of grasses, resurgence of gorse and growth of the pines reduced relative runoff below pretreatment levels. Because the pines are still young the present difference in runoff from that when the catchments were in heavy gorse is not large. In contrast, disturbance of the pasture catchment 14 when the pines were planted was minimal and growth has been rapid, producing by 1975–76 a reduction in yield relative to pretreatment levels of 47%. Comparison of the 1975 and 1976 annual runoff data for catchments in pines and pasture shows that relative

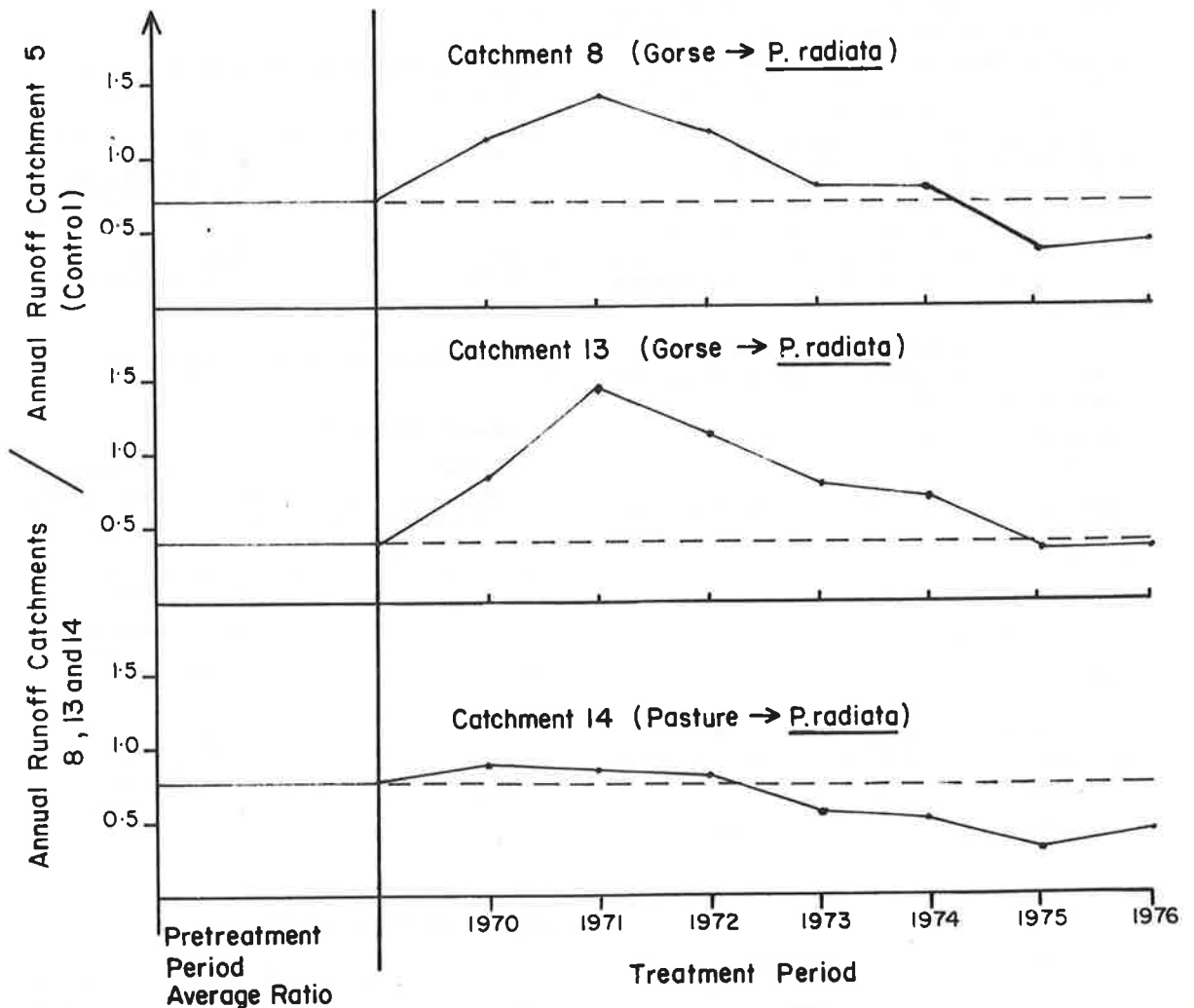


Fig. 1 – Variation of annual runoff of the treated catchments relative to the control catchment 5.

to pasture the young pines reduce annual runoff by 55% (Table 1). A similar analysis of quarterly runoff indicates that this reduction is most marked in the drier summer months (first quarter).

Average cumulative runoff functions (proportion of annual runoff released at specific discharges or stream discharge per unit area of catchment less than any given value) for catchments in pines and pasture are presented in Fig. 2. The curves are based on 1975 and 1976 data and show that for both land uses the bulk of the runoff comes off at low flows but that pines cause a greater proportion of the annual runoff to be released at higher flows. If "low" flow is defined as

specific discharges less than or equal to 20 l/s/km² then it is apparent (Fig. 2) that catchments under 6–7 year old pines release 38% (43 mm) of the annual yield as low flow while the figure for pasture catchments is 42% (105 mm). Figure 3 indicates that the total time for which the flow is "low" is slightly higher for pines catchments and that the average low flow is reduced by half; pine catchments discharge for 80% of the year at flows less than 4 l/s/km² whereas pasture catchments discharge for a similar time at 8 l/s/km². This depletion of the volume of low flow can be expected to become more pronounced as the pines mature. As the annual runoff decreases, a greater proportion of it will be released at higher flows.

Table 1 Runoff data for Moutere Catchments

ANNUAL RUNOFF (mm)				
Catchment	1975	1976	Mean	
Pasture (2	226	231	229	
(5	274	302	288	
(15	245	228	237	
(8	112	147	130	
Pines (13	94	106	100	
(14	90	134	112	
AVERAGE ANNUAL RUNOFF : (1975, 76)				
Catchment in Pines	: 114 mm)	Ratio $\frac{\text{pines}}{\text{pasture}} = 0.45$		
Pasture	: 251 mm)			
MEAN QUARTERLY RUNOFF (mm)				
Quarter :	1	2	3	4
Pines :	10.9	12.5	70.0	20.5
Pasture :	34.4	33.9	132.0	51.4
Pines/Pasture:	0.32	0.37	0.53	0.40

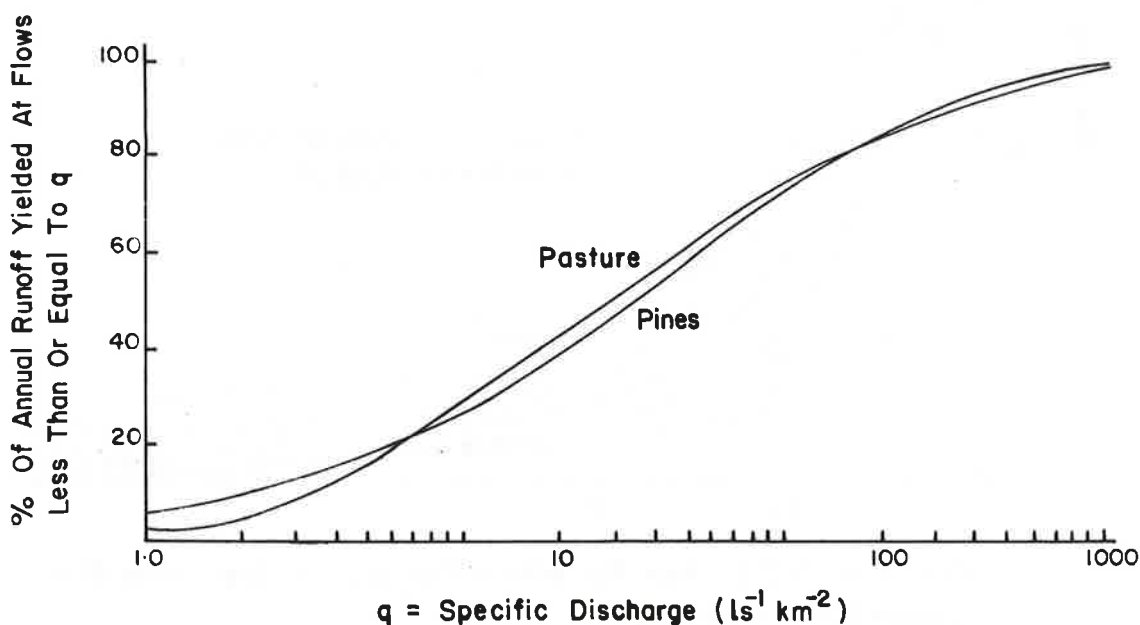


Fig. 2 – Mean cumulative runoff distributions for catchments in pasture (2, 5, 15) and pines (8, 13, 14) – 1975 and 1976 data.

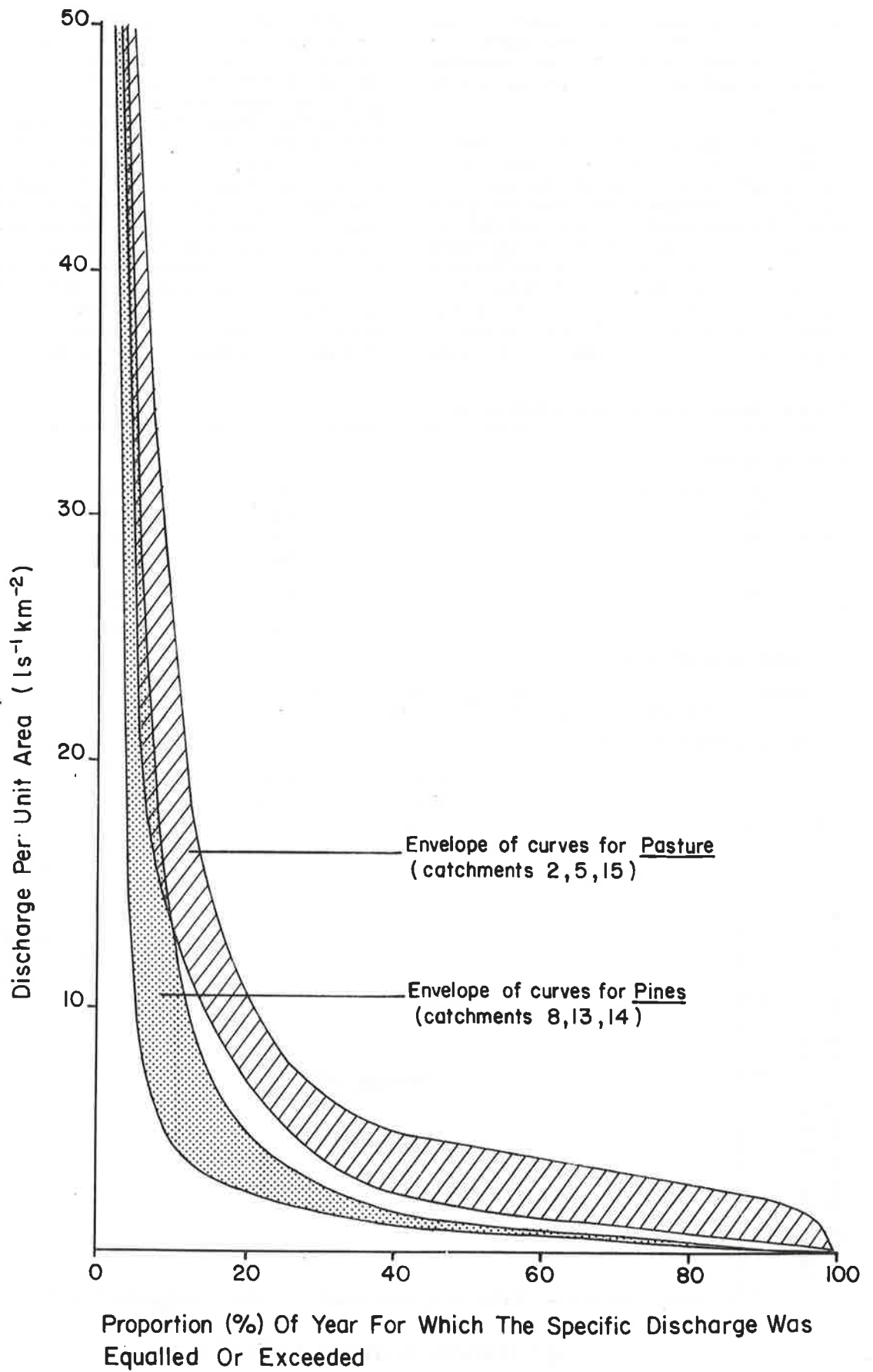


Fig. 3 – Distribution of low flow for catchments in pasture and pines – 1975 and 1976 data.

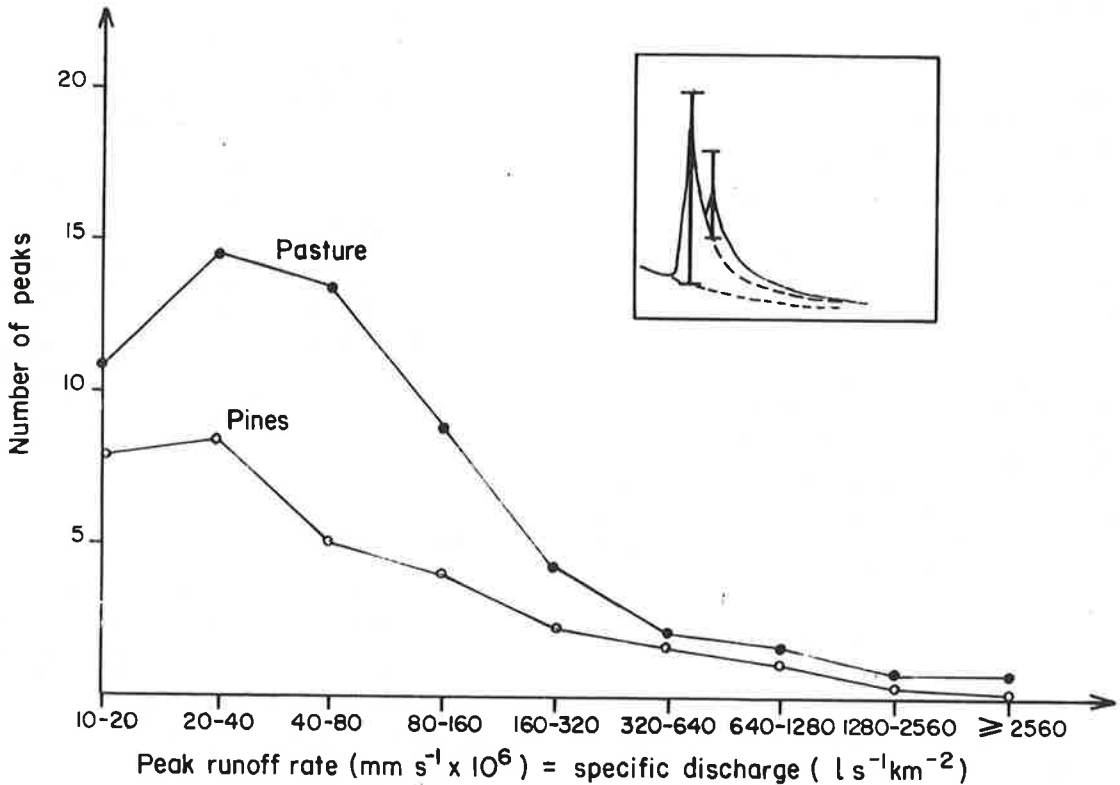


Fig. 4 – Peak height distributions for catchments in pasture (2, 5, 15) and pines (8, 13, 14). Average of 1975 and 1976 data. (Inset: Measurement of peak height).

Peak height distributions averaged for the three catchments in pasture and the three in pines (1975 and 1976 data) are presented in Fig. 4. Peak heights were determined from the annual hydrograph by subtraction of the recession flow extrapolated from the record prior to the peak (Fig. 4, inset). The distribution curves do not cross, reflecting the low degree of overlap of the constituent annual curves for the individual catchments, particularly for specific discharges less than 320 l/s/km². Catchments in pines yield fewer peaks in all magnitude classes.

In conclusion, the studies have shown that after 6–7 years growth, a stand of *Pinus radiata* in Moutere Gravel hill country, previously used as pasture, can be expected to reduce annual runoff by about 55% and summer runoff by about 68%. This reduction is effected by decreasing the volume released as low flow by about 59% and by reducing flow peaks. If confirmed by subsequent data these results have significance for much of the New Zealand water-deficient hill country.

Rakaia Water Resource Studies

The possibility of large scale irrigation development, together with a re-assessment of the hydro-electric power potential of the Rakaia River, has led to proposals for the integrated development of this major water

resource. It has been suggested that up to 80,000 ha of land could be irrigated using water from this river.

A feasibility study of the hydro-electric power generation possibilities on the Rakaia River has been carried out by a group of Christchurch consultants (Southern Energy Group). The feasibility report highlights the considerable potential for multiple-use development of the resource and also the very considerable lack of basic, factual information.

Preliminary discussions have been held with the North Canterbury Catchment Board as to the need for and nature of a detailed catchment study on the Rakaia River. An integrated programme of work balancing the national and local interests in the water resource and utilising to best advantage both board and Ministry of Works and Development staff and resource capabilities, is required.

Within the Alpine Processes study (page) it is proposed to select, for detailed research, about ten small catchments from within a broad transect across the Southern Alps. The transect has been located at the Rakaia River and will thus coordinate with the ongoing studies on the water resources and climate of the region.

Five new gauging stations have been established in the Rakaia catchment to further investigations.

Water and Soil Instrument Service Centre

New arrangements for the purchase of equipment by catchment authorities and regional water boards, and, where possible, the advance supply of that equipment by WSISC, have functioned well during 1977. Notice of 21 orders being placed for a total of 50 digital recorders and 19 other instrument types has been received. WSISC has been able to assist in advance supply of instruments on 13 of these orders. Advance supply was not required on some others as sites were not completed.

During the year, WSISC has continued to service instruments for the Water and Soil Division, catchment authorities and other departments. Servicing included 767 instruments for Ministry of Works and Development, 451 for catchment authorities, 93 traffic counters for Roading Division (MWD) and 49 instruments for other agencies.

In Canterbury and Otago practically all recording sites used for hydro-power objectives have been upgraded from chart to digital recorders.

In addition to servicing instruments, the following work has been carried out:

- (a) Construction of a heat pulse velocity meter for sap flow measurement in trees.

- (b) Development and construction of equipment for studies on the Manukau Harbour:
 - (i) two systems of automatic fixed-time water temperature recorders using integrated circuit sensors;
 - (ii) one system of four pairs of sensors to measure wet and dry air temperature for humidity determination using integrated circuits;
 - (iii) Construction of thirty event rainfall recorders from kitsets or by converting standard recorders.
 - (iv) Manufacture of thirty-three ground-water surface followers. Data from these are recorded on chart or digital recorders.

Electronic Clocks

Failures in mechanical clocks have caused major problems. Recently, electronic clocks with higher reliability have become available but they are very expensive. As a result, the WSISC staff have designed and developed a lower cost prototype electronic clock which has now been tested at the Physics and Engineering Laboratory, DSIR, with excellent results. A programme for the manufacture of the clocks will get underway in 1978.

HYDROLOGY SYSTEMS

A "systems" group is being established, which should rapidly become one of major international standing. Personnel in this group will assemble at the beginning of 1978. The objectives of the group will be to:

- (a) study the pool of New Zealand hydrological information, using established techniques and new techniques now being developed internationally, to determine how information available can best be used in meeting a range of national objectives in the field of policy planning and engineering design;
- (b) formulate and implement specific projects that will achieve segments of these objectives.
- (c) suggest how the country's hydrological network might be improved to better fulfil its objectives.

From this, in appropriate consultation with the Research Director, a specific programme of work will be established.

Organisation of the group will be flexible and functional, and oriented toward project requirements. A healthy balance between immediate and long-term objectives and be-

tween basic and applied research needs will be sought.

One introductory study being undertaken by the systems group is concerned with flood estimation. The study objective is to develop a design flood estimation procedure for ungauged catchments based on recorded floods in New Zealand. This is to replace the present use of empirical formulae, believed to be open to major error.

The method proposed is to collect records of annual flood peaks for as many stations as possible. To date annual maximum data for 125 catchments throughout the country representing 1155 station years of record have been collected and are being checked for consistency and correctness.

Catchment parameters for these catchments have been extracted from the 1:63360 (NZMS 1) map series and two rainfall parameters (mean annual rainfall and the 2-year return period 24-hour storm rainfall) have been estimated for each catchment. Regional regression equations under development use these parameters to estimate the mean annual flood. In six regions tentatively defined, catchment area, mean annual rainfall and storm rainfall appear to be the most important

parameters for estimating the mean annual flood.

The fits of extreme value frequency distributions are being examined to find which will be most suitable for developing the regional dimensionless frequency-magnitude curves.

Dr R.A. Rao, Associate Professor of Hydraulic Engineering at Purdue University, Indiana, has joined the Christchurch hydrology group of Water and Soil Division on a National Research Advisory Council Fellowship.

Dr Rao is engaged principally in three areas of work. The first involves statistical analysis of New Zealand hydrologic data, including correlation and spectral analyses, analysis of rescaled range characteristics and some elementary statistical analyses of data. Daily, monthly and annual data are being analysed. The results of this work will be useful in providing an understanding of the nature of the hydrologic processes and

the correlation structures, enabling stochastic models to be developed and the hydrologic processes to be simulated or forecasted.

The second area of work is concerned with the development of stochastic forecasting and simulation models for New Zealand hydrologic data. Models useful in simulating or forecasting hydrologic information at a single station or at a number of stations, are being developed. These models are designed to utilise all available information and update the parameters on the basis of the latest information.

The third area of work covers the development of a methodology to evaluate the hydrologic characteristics of basins with different land uses. This will involve a literature review to compile a set of characteristics which are important in evaluating the performance of different watersheds and also watersheds which are undergoing change. Based on this review, appropriate models will be developed to characterise the hydrologic responses of different basins.

GROUNDWATER

Heretaunga Plains Groundwater Quality Project

Following nine months of intensive investigation of the Heretaunga aquifer a report was produced in June entitled "Movement of Contaminants into and through the Heretaunga Plains Aquifer".

The study was designed to provide information to guide planning decisions on wise land use in the area, and specifically to answer the questions as to whether urban expansion over the unconfined aquifer, as desired by Hastings City, would result in unacceptable pollution of the groundwater system.

Results showed that the potential level of pollution from residential urban development is not high, and the existing municipal and industrial water supplies are well protected against future potential pollution.

Tracer studies conducted to determine the groundwater flow direction, velocity and dispersion characteristics, show that at the Roy's Hill site, close to the Ngaruroro River and in the major recharge zone, the gravels overlying the aquifer have little or no capacity to prevent nitrate, chloride, bacteria or petrol from reaching the water table. Rates of vertical filtration were between 15 and 24 metres/day.

Peak velocities measured within the groundwater on the centreline of the tracer plume at Roy's Hill ranged up to 200 metres/day over a distance of 125 metres at a piezometric gradient of 7×10^{-3} . Bacteria appear to

travel somewhat faster than do rhodamine and bromine tracers. The behaviour of bacteria in the gravel aquifer has been most unexpected both in the fact that they have travelled faster than the dyes and also because they were detectable in large numbers at a distance of 125 metres.

At the Flaxmere site the aquifer is overlain by a stratum of silts but is still technically unconfined. The piezometric gradient is much lower, 1.6×10^{-3} , and the groundwater velocities, measured over a distance of 75 metres, were 20–25 metres/day.

Pump tests at both sites gave very high transmissivities of $0.29 \text{ m}^2/\text{sec}$ at Roy's Hill and $0.35 \text{ m}^2/\text{sec}$ at Flaxmere. Storage coefficients were markedly different, reflecting the different confining conditions. At Roy's Hill, in what should have been a completely unconfined aquifer, the storage coefficient was 2.7×10^{-2} which is an order of magnitude less than the measured porosity of 0.22. Thus even in this environment where the lenses of fine material are discontinuous or absent there does appear to be some confining effect. By contrast, at Flaxmere the storage coefficient measured was 4.62×10^{-4} , confirming the fact that there is no phreatic surface.

Dispersivity values measured showed marked variation between longitudinal and lateral dispersivities.

Longitudinal	0.30 – 11.5 metres
Lateral	0.10 – 3.3 metres

The vertical dispersivities values were much more consistent i.e. 0.04–0.10 metres.

The values of dispersivity were required to enable the numerical simulation of pollutant dispersion, in order to predict the effects on groundwater quality of residential urban development over the unconfined aquifer. The simulation was deliberately based on a worst case example of the development being serviced entirely by septic tanks.

The overall result from the simulation study was that the level of contamination arising from residential urban development would be low. Nitrate was adopted as being the contaminant of most concern. The maximum concentration of nitrate in the confined aquifer under the above conditions was about 1.5 gm.m^{-3} which is well below the WHO limit of 10 gm.m^{-3} . Chloride would occur in greater concentrations than this, but is not regarded as a health hazard. Other chemical constituents would be at lower concentrations.

The second major concern apart from chemical contamination is bacterial pollution. In conjunction with the use of special strains of *E. coli* bacteria as tracer, some die-off experiments were conducted, with bacteria suspended in dialysis sacs down the boreholes. These tests indicated that the life span of this strain of bacteria in the aquifer is of the order of a month.

Further results showed that the existing municipal and industrial water supply is well protected from chemical and bacterial contamination that may arise from existing or future housing development on the unconfined aquifer. However, private wells drawing from the unconfined aquifer or from the confined aquifer within 2 km of the confined/unconfined aquifer boundary would be at some risk from urbanisation.

A study of the water quality confirmed the generally high quality of water in the major recharge area, but pointed up some high nitrate levels in the groundwaters of the Ngatarawa Valley which is the minor recharge zone of the unconfined aquifer. As this is the area of a proposed irrigation development which could lead to an increase in nitrate input from a greater intensity of agricultural development and leaching of soils, there is a need to examine the flow characteristics within the aquifer and at the junction of the major and minor recharge zones. This will clarify whether the Ngatarawa waters are likely to pass anywhere near the major urban abstraction points.

Yaldhurst Groundwater Quality Project

The study area is a relatively densely populated rural area at Yaldhurst on the western boundary of Christchurch. The project is designed to determine whether or not septic tanks in the study area are polluting the

groundwater. Possible sources and extent of contamination are being investigated.

The study area has been mapped and all wells and septic tanks located. The wells have been classified according to depth and, using North Canterbury Catchment Board piezometric data, the approximate flow direction has been determined. All suitable wells within the project area have been analysed over a period of 5 months for coliform, faecal coliform bacteria, faecal streptococci, conductivity and nitrate nitrogen.

Results to date show that there is a tendency for both nitrate nitrogen and conductivity to increase along the assumed direction of flow. In addition, marked increases in both these parameters have occurred during periods of high rainfall.

Preparations are underway for detailed tracer studies on two properties to determine whether contamination of the domestic bores by septic tank effluent is occurring. Preparatory work has centred on the use of both bacterial and chemical tracers. Although initially promising the thermophile *Bacillus stearothermophilus* has proved to be unsuitable for use as a tracer organism because large numbers of spores of this organism have been found to occur naturally in Canterbury groundwater. Investigations are now underway to determine the suitability of other species, particularly $\text{H}_2\text{S} + \text{ve } E. \text{Coli}$ (used successfully in the Heretaunga project). Experiments are also being conducted into the use and detection of the fluorescent dye, rhodamine W.T.

Canterbury Plains Groundwater Quality Survey

A baseline survey of groundwater quality in the area bordered by the Rakaia river and State Highways 1 and 75, commenced in June 1977. Approximately 80 well locations have been mapped and water samples from these analysed.

The investigation is an extension of the Templeton/Burnham project baseline groundwater quality survey. The two surveys cover a major groundwater-using district and together with complementary work being undertaken by the North Canterbury Catchment Board will enable groundwater quality modelling for the Waimakariri-Rakaia region to be undertaken.

Water quality data will be analysed in order to determine water patterns and an assessment made as to whether any major land use/water quality patterns exist. In addition, any relationship between observed groundwater quality in the study area and the water quality status of Lake Ellesmere will be considered.

Two separate, arbitrarily selected "blocks" of wells have been sampled to date. A summary of results is presented below.

	Killinchy-Brookside	Southbridge-Rakaia River
No. of wells	48	29
Nitrate Nitrogen	3.45	1.8
Conductivity	20.20	11.6

Although no detailed analyses of the results have been attempted at this stage, a

tentative comparison of the two areas is of interest. Both nitrate and conductivity levels appear to be lower in the Southbridge-Rakaia block. Landowners in this area report that a recent change of course in the Rakaia River had the effect of raising groundwater levels in the area. The main channel of the river now passes to the north-east of Great Island and bores in the Southbridge-Rakaia block may possibly fall within a "zone of influence" of the river.

SEDIMENT TRANSPORT

Activities of this group during 1977 include: the construction of a Helley-Smith sediment sampler for measuring bedload transport rates on gravel bed streams; the updating of suspended-sediment gauging procedures and the analysis of available data to determine long-term sediment yields on a national scale; the construction of a vortex-tube bedload sediment collector for measurement of low bedload transport rates – a joint project with Wallingford Hydraulics Research Station, England and the University of Canterbury; the preparation from flow gauging data of a predictor chart for hydraulic roughness in gravel bed streams; the analysis of cross-section data to determine aggradational and degradational trends in rivers during the past 50 years and the construction of a tank for modelling the evolution of drainage systems.

Sediment Transport in the Upper Clutha River System

The development of a multi-dam hydro-electric power generation system in the Upper Clutha river system is compounded by the very high sediment transport rates within the upper reaches of that system. This project aims to further define the comparative contributions of the river tributaries to the total Clutha sediment load and to obtain information on the composition of the tributary sediments such that the sediment deposition rates in the dam lakes may be determined.

Erosion and Sediment Transport in the Upper Waipawa River Basin, Ruahine Range

The drainage area (125 km²) of the upper Waipawa River comprises the four major basins; Mangataura, Upper Waipawa proper, Middle and Smith. In 1955 indications of major channel changes were observed in the Mangataura and Upper Waipawa proper and in that year three permanent channel cross-sections were established on one reach of the upper Waipawa. In 1960 another three sections

were added. Remeasurement of those sections has produced the pattern of change on that reach since 1955. In later years several other sections were established on other reaches of the upper Waipawa and subsequently remeasured. Records from these permanent sections supplemented by measurements from aerial photographs taken since 1950 and from oblique ground photographs made possible estimates of channel changes since 1920 on numerous reaches of the upper Waipawa River.

Dominant trends since 1955 were increasing active bed width (ABW), rising mean bed level (MBL), steepening of channel slope and an increase in the size and frequency of occurrence of riparian landslides on greywacke. All four major basins were similarly affected.

In the Upper Waipawa proper, at Waipawa Fork, from 1961 to 1975 North Branch MBL rose 8 m and South Branch MBL rose 7 m. From 1950 to 1975 the vegetation apex at their confluence receded 117 m upstream as a result of lateral erosion and vegetation drowning by bed material transported down the steeper North Branch. Nearby reach ABWs increased up to 113%.

Downstream of the Fork, at McCullough's mill reach (583 m long) the reach MBL rose 1.1 m from 1960 to 1975. From 1950 to 1975 the reach ABW increased 43 m or 146%, channel slope increased from 0.033 to 0.036 and the channel sinuosity index declined from 1.07 to 1.00.

Farther down stream rise of MBLs has been general. Between 1950 to 1975 along a channel length of 6.9 km average ABW increased from 71 m to 116 m – an increase of 61%.

Recorded channel morphology trends have resulted from increase of sediment transport rates. An estimate of periodic sediment transport was derived for each site using change of channel cross-sectional area as the chief criterion, supplemented by rates of change of MBL and ABW. From these patterns an average

pattern of sediment transport rate was estimated. Using rate indices which represent the periodic average relative rates of coarse sediment transport the broad pattern was:

PERIOD	RATE INDEX
c. 1920 – early 1930s	1
mid – late 1930s	4
late 1930s – c. 1949	1.5
c. 1949 – c. 1955	4
c. 1955 – c. 1960	2
c. 1960 – c. 1965	10
c. 1965 – 1973	3
1973 – 1976	20

This shows that the channel average rate of sediment transport for 1973–76 was 6 to 7 times that for 1965–73 and double that for 1960–65. The periods 1920 – early 1930s and late 1930s – mid 1940s were relatively very tranquil.

Overall the indications are that the same trends are still operating and seem likely to for some time ahead.

To monitor more adequately the trends and rates of change, the establishment and measurement of a total of 75 channel sections

on 16 reaches was completed during 1976/77. On these measurement reference reaches photographic records will be made, bed material sampling will be undertaken and other observations carried out. This work will serve as a basis for:

- (a) determining causal factors;
- (b) studying rock source areas;
- (c) assessing possibilities for management techniques;
- (d) improving prediction for downstream effects;
- (e) understanding sediment transport processes;
- (f) refining methodology for translation to other basins.

Complementary to these activities on the modern period of erosion (since the 1930s – 1940s) work is well advanced but further field work is proposed to produce the history of previous major erosion periods on the Ruahine Range. These will place the current trends in a broader perspective and give a fuller understanding.

ALPINE PROCESSES

The study in its various facets aims to determine quantitatively how individual watersheds of the Southern Alps react to the forces of nature and to land use. It aims 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. It is intended as a quantitative study to enable past and future studies of isolated small 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.

A major gap in knowledge of our mountainlands is revealed by our inability to evaluate and compare policy and management options in terms of their quantitative effects upon the land, its vegetation cover, and the water and sediment that it yields.

The gap is twofold. In the first place, we know little of the quantities of materials in-

involved in the condition of our mountain catchments. We do not know how much of the Southern Alps is truly permanently covered by snow and ice, or how much is bare rock, scree, devegetated soil, or barren river bed. We do not know how much rain and snow falls over most of the alps nor much else about the climate. And we know little of the high and low flows of our mountain rivers, and even less of how much sediment they transport. Although we know that some catchments differ from others in their responses to similar events, and to a large extent we know why, we do not know by how much they differ, nor by how much their responses could or should be altered.

In the second place, our knowledge of the processes that change the condition of mountain catchments and determine their water and sediment yields is almost entirely descriptive. Even if we could be given numerical data on the geology, soils, vegetation, and climate of an alpine catchment, because we cannot relate the data quantitatively, we could not begin to calculate the possible effects of alternative proposed policies or land uses, or even to calculate the effects of natural events.

These two deficiencies lead to an inability to solve objectively controversies arising over

our high country policies and management practices. It is impossible to reach an objective resolution when the policies, of necessity for the present, must be founded on subjective assessments of qualitative hypotheses and unknown quantities.

Programmes within the national hydrology network, including past representative and experimental basin programmes, already are significant steps towards closing the gap in the areas of hydrology.

The National Land Use Capability Survey allows us for the first time to quantitatively assess the extent of our mountainland resources but it is only a beginning, being too crude a tool for use in quantitatively assessing the condition of our mountains. Quantitative small catchment studies such as those being undertaken by the Forest Service, and the Torlesse programme of TGMLI are also slowly closing the gap, but, like the representative and experimental basins programmes, they cannot yet be put in the context of the larger catchment or of the Southern Alps and cannot themselves ever fill the gap. On the other hand, studies of larger catchments such as the Shotover sediment survey, and the Waimakariri catchment study are insufficiently quantitative to be put in the context of our present knowledge of small catchments.

What is proposed here is a programme of coordinated studies of small and large catchments in the Southern Alps aimed at establishing the connecting links between our quantitative knowledge of the two scales. The programme will also measure in detail a substantial sample of the environments of the Southern Alps for use in numerical assessments of high country policy and management options, and the planning and design of engineering works.

It is proposed to select, for detailed research, about ten small catchments from within a broad transect across the Southern Alps. The transect has been located at the Rakaia River to coordinate with our ongoing studies of the water resources and climate of this region, and to utilise existing knowledge of the Rakaia River and of the Ivory Glacier and Hokitika Representative Basins, which are parts of the transect. A compact and logistically practicable transect can be maintained in this region. The more or less concurrent small catchment studies are to be undertaken simultaneously with a similar but less detailed survey of the major catchments making up the transect.

The programme of studies will assess the erosion status of the Southern Alps, quantitatively through measurement of sediment yields, rates and processes of erosion and recovery from erosion, across the transect of study catchments. Already it is known qualitatively that these are determined by catchment condition and climate and that they are

altered by land use. Through quantitative study of how they react to land use and the forces of nature, this programme aims to predict the extent that mountain catchments are altered by 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.

One of the aims of the project is to determine the magnitudes at which events, such as for example storms, droughts, fires or revegetation, become significant in the alteration of catchment condition. At present there is only sparse quantitative knowledge of what constitutes a significant event in mountainlands; of how much "condition" affects catchment response in terms of water and sediment yields, peak and base flows, and water quality; or of how much, or for how long, one event alters a catchment's condition for future events. These things cannot be deduced from casual observations and cannot be gained for large catchments from studies of isolated small catchments; an integrated small and large catchment study is needed. Among the things we need to know for efficient land management are: what damage to expect from the one, ten, and hundred-year storms; how different land uses change this damage; and whether an area has the potential to recover from the damage before the next such storm. When an event occurs, we need to know if it is a significant one for the catchments involved, and we need to be able to assess quickly and precisely the damage done, and its likely consequences. We need to know whether immediate appropriate remedial action is needed, and we also need to know what action is appropriate. These are the sorts of information that the project will gather.

The programme will develop techniques of catchment analysis that utilise the existing data to the fullest extent possible. Good maps of the Southern Alps already exist for topography (1:63,360), geology (1:250,000), and land use capability (1:63,360), for examples, but we presently lack the knowledge of how these might be used quantitatively to assess such things as catchment condition, and water and sediment yields. This study aims to provide this knowledge, and to determine what other information must be directly measured in order to determine the reactions of the many other watersheds of the Southern Alps. This will be done by comparing existing data for the Rakaia transect with the specialist data to be collected during the project, to determine the suitability of existing maps for the new purposes that they are being put to. The techniques will then be tested on other catchments such as the Clutha system where such data as sediment yield are also available.

Although the data are to be gathered from the Rakaia transect, the information will be

applicable to wider areas of the Southern Alps. In particular, the information of how rates and processes of erosion and sediment transport change with increasing rainfall and rainfall intensity, from east to west across the transect, can be used to estimate rates and processes in regions of different rainfall. And the survey techniques which must be developed during the project will be universally applicable in numerically assessing the status of mountain catchments.

Individual projects which have been established are as follows:

Alpine Climatology

The project is a study of processes controlling the distribution of rain over the Southern Alps. The objective is a reliable isohyetal map of the alps for erosion and water resource research. Rain is being sampled at 40 storage and 11 automatic raingauges in a transect across the alps from Mt Hutt to Waitaha River. Although the pattern of rainfall was previously thought to be quite complex with substantial differences between amounts falling on individual peaks and valleys, a simple pattern of distribution is now emerging.

From 3,000 mm at the western coast the annual rainfall rises to 10,000 mm within 25 km. The peak of precipitation is quite narrow and lies about 10 km west of the Main Divide. The decrease in rain east of this peak is equally dramatic; within 20 km east of the Main Divide, it has dropped to around 1,500 mm. East of this region annual rainfall is apparently within 300 mm of 1,200 mm. Distance from the western coast may be the dominant control of the location of the high rainfall zone. Altitude and proximity to the Main Divide do not seem to be important, or the effects are masked by the very strong regional gradient. In the dry eastern high country, altitude and proximity to the eastern foothills are significant.

A frequently made criticism of the measurement of New Zealand rainfall is that there are too few gauges above 1000 metres. In the list of rainfall normals for New Zealand for 1941 to 1970 published by the New Zealand Meteorological Service, only 2 of 1853 stations are listed as being above 1000 metres.

The Ministry of Works and Development index of water and soil and catchment authorities gauges lists 1560 stations with 212 (13.5%) above 1000 metres. Most of these gauges were installed under the Representative Basins Programme. An additional 25 gauges recently have been installed above 1000 metres as part of this project.

A worrying statistic, from a comparison of the two listings, is the lack of overlap. In essence, the most recent isohyetal map of New Zealand, produced from the 1941 to 1970 rainfall normals, used only 54% of the readily

available stations. In addition, during the duration of the Rakaia transect, eight records each of approximately 10 years duration, that are not listed in either index have come to light. This has increased the number of stations in the transect by 25% in addition to adding a record-length that we do not even hope to match. Provided this same statistic holds true for the remainder of New Zealand there would be some 300 more rainfall records that could be used if they were sought out.

Alpine Erosion and Sedimentation Studies

The very low level of Lake Hawea permitted measurement of the volume of the delta of Little Hopwood Burn. From this, the erosion rate has been estimated, and the sediment yield for each size grade in the sediment calculated. The rate for this schist catchment is about that estimated for the Shotover Catchment (1500 tonnes/km² per an). The watershed of Little Hopwood Burn is in good condition; it is not grazed by domestic stock or burned and it has had low levels of feral grazing for most of the last 20 years. The erosion rate confirms the conclusions of the Ministry of Works and Development Shotover survey that geological erosion rates of schist are naturally high.

In winter 1976 the sediment in the bottom of Lake Ballance was cored to estimate the erosion rate from a glaciated schist basin. Because of the failure to find layering in the cores a sedimentation rate of more than 15 cm depth a year was inferred. In winter 1977 a line of soundings was repeated from which a sedimentation rate of 3 m depth a year is apparent. Suspended sediment rating of the lake outlet, and a repeat of this year's more detailed sounding, are needed to calculate the very high erosion rate for this basin.

Rock Avalanche Studies

The frequency and magnitudes of major landslides ($>10 \times 10^6 \text{ m}^3$) in the Southern Alps are being compiled. They occur throughout the alps, associated with major faults. The largest noted is about $500 \times 10^6 \text{ m}^3$. Locally they are the dominant geomorphic process since the disappearance of ice from the last ice age, often profoundly affecting the hydrology of catchments through the formation of lakes, such as Lochnagar, Constance and McCrae. Some avalanches, such as at Lochnagar, are beneficial as sediment traps and buffers to flooding. Others, such as one on the Arthurs Pass-Otira highway, are constant major problems in road maintenance. On the Mathias River, a tributary of the Upper Rakaia, a rock avalanche has been a major point source of sediment, supplying an average of $50,000 \text{ m}^3$ per year for the past 1,500 years. The unvegetated scar of a very recent one (about 500 years ago) in the Craigieburn Range has been used wrongly, as an example of poor agricultural practice.

Weathering-rind Dating

When rock is exposed to the weather for a very long time, a series of complex time dependent chemical reactions termed weathering occur. As weathering progresses deeper into the rock, a visible rind of discoloration appears and the thickness of this rind is a function of time. The growth of rind thickness with time for the Canterbury greywackes has been measured and is being used to date important geological events in the Southern Alps.

The technique has been used overseas to date events in the range 10,000 to 1,000,000 years, but it was found to be useless in New Zealand for events in this range. Mr T. Chinn found that it could only be used for events in the range 100 to 10,000 years, a time range of great interest in studies of catchment status as it covers the time interval of development of much of the present land surface in our high mountains.

A paper entitled *Holocene Glacial History from the Waimakariri Watershed, New Zealand* was presented by T.J.H. Chinn at the Tenth International Quaternary Association Congress,

Birmingham, England. Dates in this history were by weathering-rind dating. The work has aroused considerable interest in New Zealand and overseas and the paper was well received at the conference.

Alpine Catchment Condition and Trend Studies

An initial study of the use of aerial photographs for evaluating catchment condition was completed. Colour photography, both true and false colour infra-red, provides a useful though expensive aid to ground investigation.

Old and new aerial photographs are being compared to detect changes in condition over intervals as long as 30 years.

Copies of very old photographs of the Canterbury high country were obtained and a programme of locating and re-photographing the sites is beginning. Some erosion scars, attributed to a particular storm about 25 years ago, have not changed in 60 years. Some sites have changed very little, others have experienced remarkable recovery in the last century.

LAND RESOURCE SURVEYS

In 1970, the need for a standardised survey to provide basic land resource data was recognised. This would bring together available resource data and, with further work, complete a New Zealand wide coverage. Forums such as the National Development Conference and Physical Environment Conference highlighted the obvious deficiencies in physical resource data for regional and national planning.

In response, the Soil Conservation and Rivers Control Council authorised the present National Land Resource Survey. Its objectives were to provide a New Zealand-wide inventory of land resource data to provide a sound basis for land use planning at regional and national levels.

More recently, as the demands of planners have been recognised, emphasis has been placed on the production of 1:63360 land resource inventory worksheets. Continued high standards of discrimination between inventory units have been adhered to.

To obtain national coverage within a reasonable time period (3 years), a streamlined approach has been developed. This is briefly:

(a) collection and assimilation of basic resource data, i.e. geology, soil maps, catchment authority plans;

- (b) detailed aerial photograph interpretation;
- (c) preliminary integration of photo interpretation data and available resource data;
- (d) field work and discussions;
- (e) compilation;
- (f) worksheet check procedures
 - internal staff
 - catchment authority staff and others
 - final national standards and correlation;
- (g) printing (low cost and quickly printed layout).

In compiling the worksheets, full use is made of the best available geology and soil information from published or unpublished maps supplied by other organisations or from personal consultation.

Water and Soil staff check the location of boundaries on the existing geological and soil maps and where necessary, draw new sets of boundaries. This occurs when worksheet compilation places different emphasis on these features or where geological and soil mapping is at such a generalised scale that complete redefinition of boundaries is necessary to make the units delineated compatible with the worksheet scale of mapping (1 inch to 1 mile). Units are then categorised according

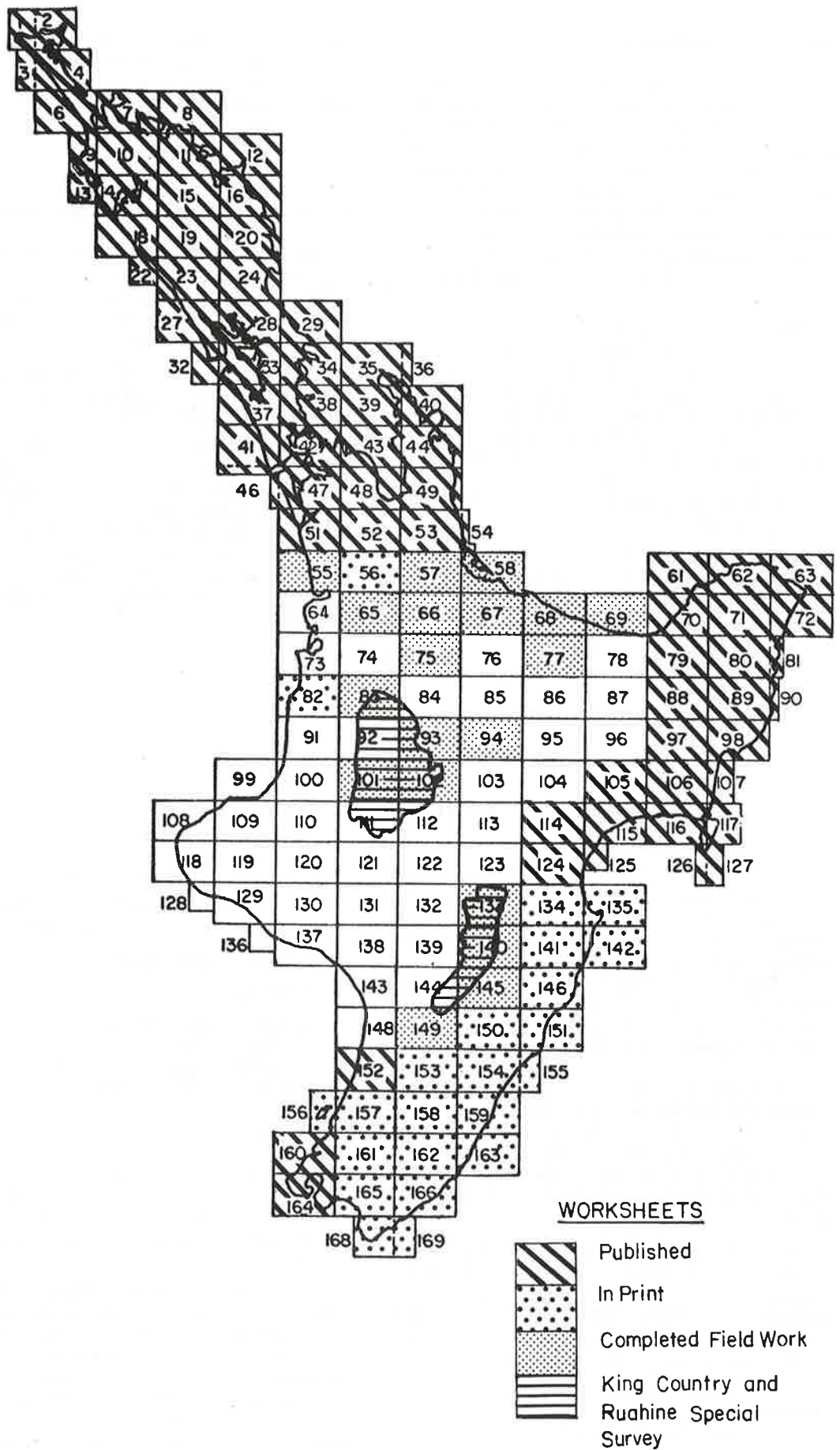


Fig. 5 – North Island land resource survey coverage as at 31.12.77.

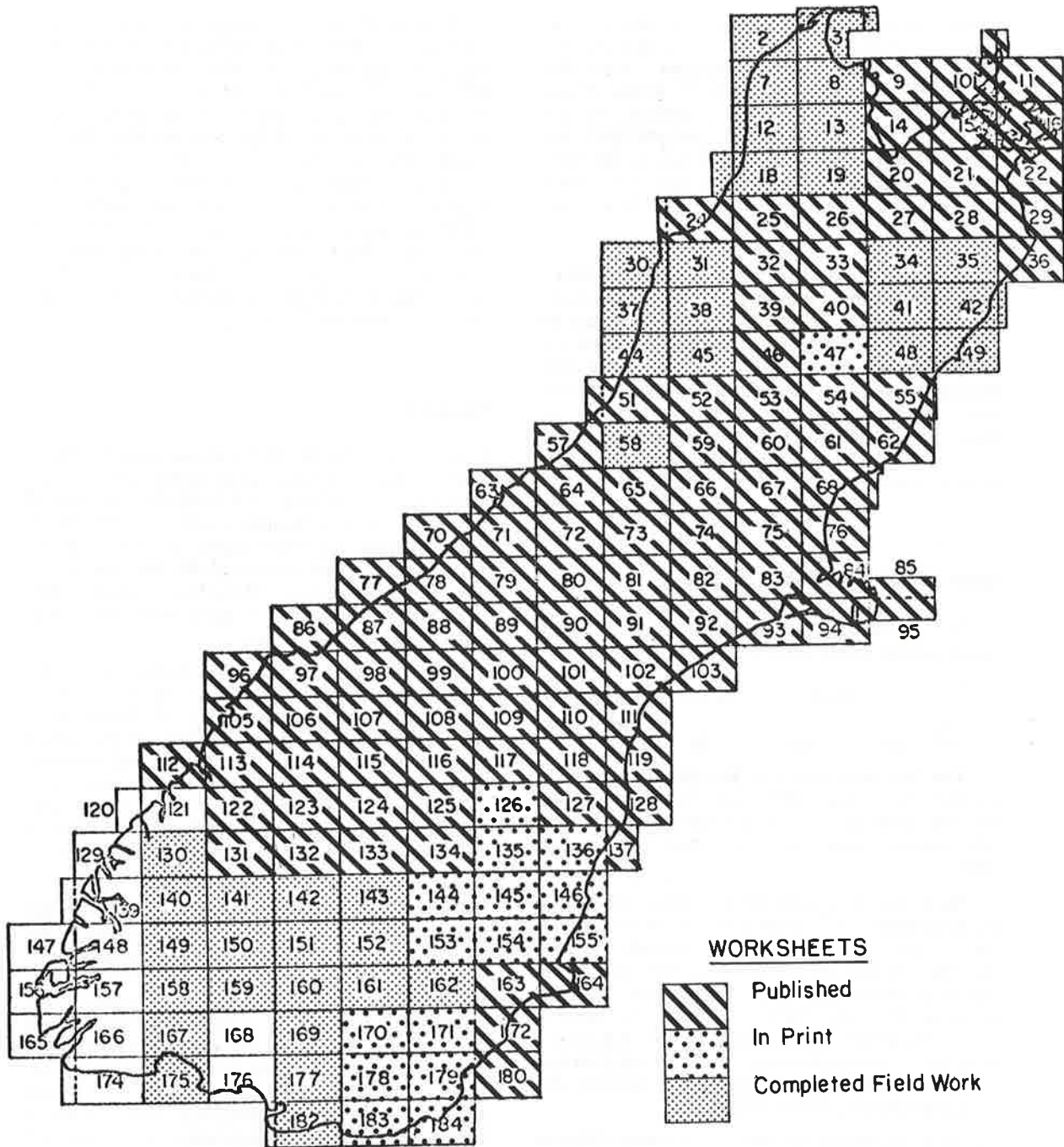


Fig. 6 – South Island land resource survey coverage as at 31.12.77.

to the Water and Soil rock type classification and the latest available soil type classification for that area.

As an alternative service to users, the land inventory data is also being put into an electronic data storage system, with the ability to reproduce this data in terms of any combination of the inventory factors. As the basis of storage is the New Zealand grid, the data are fully compatible with any other data stored in that fashion. Data can be made available in either tabulated, graph or map form.

As an integral part of worksheet utilisation, a bulletin is being prepared which sets out in a simple and straightforward manner by reference to a range of examples how the information should be used. Preparation of this bulletin has also necessitated the updating and upgrading of the *Land Use Capability Handbook*, to bring it into line with current techniques. The publications will be available by early and mid-1978 respectively.

North Island Land Resource Survey

The following summarises progress for the North Island as at December 1977 (Fig. 5).

	Published	In Print	Completed Field Work
No. of maps	63	20	19

The Northern Hawkes Bay Region was completed in August 1976 but, due to hold-ups in the printing of the extended legend, the worksheets were not available until early 1977.

Work recommenced in the Waikato Region in November 1977 after a break of 10 months and is progressing well. The extended legend for this region was printed in October 1977. All field work was completed for the southern Hawkes Bay and Wairarapa areas by August 1977. However some areas of the Wairarapa will be resurveyed to include new information and a greater degree of detail. The region will be completed by April 1978.

Mapping began for the Bay of Plenty Region in June 1977 and to date field work on three worksheets has been completed. Programmed completion time for the region is April 1978.

South Island Land Resource Survey

The following summarises progress for the South Island as at December 1977 (Fig. 6).

	Published	In Print	Completed Field Work
No. of maps	182	39	62

With the completion and printing of the land use capability extended legend, printed worksheets are now available for distribution. Although the extended legend is South Island

wide, the classification is comprehensive and is done to broad capability unit level. Completion of all worksheets is due by mid 1978.

As part of the Soil Conservation and Rivers Control Council's continuing policy of ensuring that inventory information is drawn to the attention of, and fully explained to, all prospective users, a further series of seminars has been held in the Canterbury and Waitaki areas. The seminars follow the release of a block of worksheets which cover a particular region. Widely representative audiences totalling approximately 150 people from 70 separate organisations, including central government, local government, universities and consulting firms, attended. Further seminars are planned for 1978.

Special Projects

KING COUNTRY REGION: From July to December 1976 selected staff were involved in preparing a Land Resource Inventory survey of the King Country Region as part of the inter-departmental land-use study of that region. This was prepared as part of the National Land Resource Inventory Worksheet programme. Vegetation and erosion maps were also prepared from the basic data.

The completed printed worksheets and legend for the whole area, were supplied to the steering committee early in March. Had they been used then as a basis for the other derivative studies, it is a reasonable expectation that the whole survey could have been completed on schedule by the end of July. Instead, only about one third was finished in time, with the remainder awaiting completion in 1978.

Both as follow-up to the King Country Survey, and on a national basis, checks and tests are being made to ascertain how well the basic information on the worksheets can be adapted to meet the needs of various departments. Excellent cooperation has been obtained to date and the quality of the basic land resource inventory has proved excellent. Bearing in mind the major effort staff have made to meet tight schedules, the manner in which they have simultaneously maintained standards of assessment fully comparable with those other survey organisations, is a matter for congratulation.

PAUATAHANUI LAND RESOURCE SURVEY: Land Resource Inventory, Land Use Capability Assessments and Erosion maps of this area were mapped at a scale of 1:25000 and a brief report prepared as part of the Pauatahanui Environmental Programme.

RUAHINE RANGE LAND RESOURCE SURVEY: This survey comprising a Land Resource Inventory and Land Use Capability Assessment was completed in 1976 (at a scale of 1:63360). The range was surveyed at the request of the Ruahine Range Control Scheme

Committee. The survey data are being incorporated into the southern Hawkes Bay – Wairarapa region worksheets.

National Erosion Map Series

This series, derived from the 1:63360 worksheets, presents data on present and potential erosion. The base for these maps is the NZMS 18 series (1:250,000). Progress for the North Island is as follows:

NZMS 18 sheet	1 North Cape	In print
	2 Whangarei	In print
	3 Auckland	Printed
	4 Hamilton	Printed
	6 East Cape	Printed
	7 Taranaki	Printed
	9 Gisborne	Printed
	10 Wanganui	Printed

It is hoped to have the remaining 4 completed within the next year. Progress for the South Island is as follows:

NZMS 18 sheet	13 Golden Bay	Printed
	14 Marlborough Sounds	In prep.
	15 Buller	Being printed
	16 Kaikoura	Printed
	17 Hokitika	In prep.
	18 Hurunui	In prep.
	19 Haast	In prep.
	20 Mt Cook	In prep.
	21 Christchurch	Printed

The remaining 5 are programmed for completion in 1978.

Remote Sensing Techniques and their Application to Catchment Condition Surveys

Remote sensing techniques are being developed to aid rapid and accurate assessments of catchment condition where these are required prior to erosion control works.

Initial research in 1974–76 indicated that colour, false colour infra-red and multispectral aerial photographs were superior to conventional panchromatic coverage for photo-interpretation of catchment condition. It showed that aerial photography from light aircraft was a feasible technique for catchment condition surveys requiring further evaluation and development.

It is advantageous for Water and Soil Division to have its own aerial photographic capability, while developing and evaluating different techniques. Commercial firms have high commitments to existing users, and have not been able to meet the division's research requirement for repeated coverage of small experimental catchments at short notice. Therefore, four Hasselblad 500 EL 70 mm cameras, four Zeiss Planar 150 mm lenses, and a Wild RC8 camera mount have been purchased, to form a flexible 4-camera system capable of both multispectral photography and other film-filter combinations. A Cessna 206

aircraft has been specifically modified to take the camera system, and test flights commenced in November 1977.

Current Projects include:

- (a) Multispectral photography of the Raparapa-wai Catchment (Ruahine Range), West Tamaki Catchment (Ruahine Range) and Puhokio Catchment (southern Hawkes Bay) was obtained during 1975–77, using cameras owned by the DSIR and Lands and Survey department, and operated by commercial firms on their behalf. This photography is currently being evaluated.

The basic theory of multispectral photography is that reflected radiation, instead of being recorded on photographic film as a single, broad-waveband image, is split into several narrow waveband images by interference filters. Certain features become more apparent in these narrow-band images than in the broad-band image.

Interim findings are:

- (i) features associated with moisture eg. drainage channels, seepages, soil moisture differences, lithological weaknesses, are more easily detected on multispectral than on other forms of coverage;
- (ii) vegetation patterns and erosion scars can be detected equally as well on multispectral, as on colour and false colour infra-red photography, and considerably better than on conventional panchromatic coverage;
- (iii) simultaneous projection of single-band positive transparencies through coloured filters on to a common projection screen ('additive colour viewing') is an effective interpretation technique which enables some features (e.g. vegetation) to be mapped more easily than from the single-band images alone.
- (b) Photogrammetric mapping of streambeds has commenced to establish whether this technique can measure volume changes in streambeds and monitor shingle resources. Hand-held vertical photography of the West Tamaki stream channel was taken in April 1977 with a non-photogrammetric Asahi Pentax 4 x 5 camera. Lands and Survey Photogrammetric Branch produced a 1:500 scale plot with 1 metre contours from the photography. The accuracy of this plot has been validated by a subsequent field check, and is extremely encouraging in view of the original photography's non-photogrammetric nature.
- (c) LANDSAT earth resources satellite images are being evaluated for potential use in resource surveys. While few lithological, soil and erosion features can be recognised, broad vegetation associations can be accurately identified and mapped. Evaluation is continuing, bearing in mind

that improved resolution and regular, sequential coverage will be necessary before earth resources satellite data can be put to practical use.

Future aerial photographs research will be directed towards:

- (a) development of suitable photographic, processing and interpretative techniques, to enable multispectral photography to be used as a practical technique for catchment condition survey;
- (b) establishment of the radiance character-

istics of various features, and the best wavebands for their detection;

- (c) establishment of the accuracy with which streambeds may be measured, from non photogrammetric photography;
- (d) cost, time, and efficiency comparisons between aerial photography and alternative ground survey techniques.

In view of its potential investigation of satellite imagery will continue but will be subordinate to the aerial photographic research.

LAND STABILITY

Development of this work, the importance of which has been highlighted by events of the past year, has awaited the availability of appropriate staff and accommodation in which they can work. These limitations will be substantially removed during 1978-79 and the programme of work is being developed accordingly. At the same time the completion of the North Island sector of the Land Resource Surveys will allow staff who have been concentrated there to become more directly involved with land stability issues.

Emphasis will be on studies of the basic processes combined with investigations of the practicalities of how best to combine plant materials and engineering techniques to achieve stabilisation under rural and hence low loading conditions. Work on mass earth-movements and the effectiveness of certain remedial treatments is already underway in the Gisborne area.

Wairarapa

For the Wairarapa the Aokautere Science Centre is coordinating research into land instability with particular reference to the serious landslips which occurred during 1977. Cooperating organisations include DSIR (Soil Bureau and Geological Survey), Victoria University of Wellington (Geography Department), Auckland University (School of Engineering), Wellington District Office MWD, the Wairarapa Catchment Board and the Aokautere Science Centre. This research will include studies of what happened, why it happened, how the chances of a recurrence may be minimised and what are the most sensible things that can be done immediately. The results of these studies will have relevance beyond the Wairarapa, in particular to areas further north in Hawkes Bay.

The Aokautere Science Centre is providing not only overall coordination but also:

- (a) plant materials expertise to study the effectiveness or otherwise of existing plantings, to advise on immediate remedial planting and to investigate by trials or otherwise possible improvements in types of plants and patterns of planting;
- (b) slope stability analysis studies — to be conducted by the Scientist-in-Charge in collaboration with Auckland University School of Engineering staff — which will focus on the parts played by soil dilatancy and progressive failure in the onset of landslides in these and similar soils;
- (c) aerial surveys to:
 - (i) study the type, distribution and extent of landslip, including measurements of volumes of displaced material;
 - (ii) study the effectiveness or otherwise of existing plantings;
 - (iii) monitor the effectiveness of over-sowing in autumn 1978.

These studies will provide valuable opportunities for staff to develop their expertise with newly acquired aerial photographic equipment.

Port Hills

Initiatives were taken to promote the setting up of a Port Hills Scientific Coordinating Committee. This committee, now set up by the North Canterbury Catchment Board, is to coordinate and advise on research into the occurrence, control and prevention of erosion on the Port Hills, in both the rural and urban situations. This committee comprises representatives of the catchment board, Research and Surveys MWD, DSIR, University of Canterbury, civil engineering consultants, territorial local bodies and drainage boards.

Wellington Region

The Scientist-in-Charge, Aokautere has been actively involved in urban slope stability studies and meetings relating to the Wellington-Hutt Valley areas. At some of these meetings, time has been given to constructive comment on what can be done immediately to reduce the incidence of instability.

Field Stability Studies

Projects are currently being set up to measure the rates and distributions of movements within selected creeping earthflows with the aim of quantifying the beneficial effects resulting from:

- (a) graded banks;
- (b) planting;
- (c) the installation of bored-in underdrains.

Mass Earthmovements Study, Gisborne

This project was established to study the mechanisms involved in earthflow movement and to test the effectiveness of certain remedial treatments. The treatments are intended to reduce pore water pressure within the earthflow and consist of surface and subsurface drainage techniques combined with a

vegetative cover of poplar varieties or *Pinus radiata*.

Currently instruments are being installed and data collected to define groundwater conditions of eight earthflows as they exist before the remedial treatments are applied.

Simple tests have not indicated a particularly high bentonite content although this has commonly been thought to be the cause of the instability. Additional and more accurate tests are proposed.

Installation of a simple form of piezometer commenced in February 1977. Forty-six of these have now been installed in a total of 18 boreholes. Where possible three piezometers are being installed in each borehole at different depths to allow the hydraulic gradient to be determined.

Four water surface followers, after modification, are now providing a continuous record of pore pressure in selected piezometers. Two movement recorders have been installed.

Sufficient data have not yet been collected to allow the overall pattern of water movement to be determined. There are, however indicators of an upward flow of water in 7 of the 18 boreholes. Pore pressure fluctuations appear to be related more closely to rainfall duration than rainfall intensity.

PLANT MATERIALS

The revised policy for plant materials for erosion control and revegetation initiated last year on behalf of the National Water and Soil Conservation Organisation was further implemented and consolidated during the period under review.

Research, selection, initial testing and propagation for field testing is being centralised at the Aokautere Science Centre. Propagation at the nursery of the Christchurch Science Centre or at Lincoln will be terminated. Nursery and test areas have been closed at Waerenga-o-kuri and Tangoio Soil Conservation Reserves and at Black Birch, and reduced at Kauri (Whangarei).

At Alexandra a 2 ha site is being obtained as a base for plant materials studies for the Upper Clutha and Upper Waitaki basins – two areas with a high priority as regards erosion control and revegetation and with a large community involvement.

Experimental sites for field testing are being established as required in association with catchment authorities and farmers.

Willows

Investigations have continued into methods of overcoming the incompatibility between tree willows and bitter shrub willows in an attempt to produce opossum resistant tree willows. Chemical and irradiation treatments have been used with some limited success. Some 25 combinations were attempted last winter.

In pole tests, material of the *Salix matsudana* hybrid clones released last year outperformed the parent clones by 100% under field conditions. A further 82 tree willow clones are under elimination tests in order to select a multi-clonal range to reduce disease risk and to cope with clone x site interactions.

The selection of improved, drought resistant, bitter shrub willows is continuing. About 100 clones (out of 400) have been retained for further testing. These are mostly clones with a prostrate or spreading habit.

Material of 33 willow clones has been introduced from Europe and Chile. This in-

cludes 11 species imported from Czechoslovakia for mountainland revegetation. Some of these are reputed to spread by suckering and may be particularly valuable for erosion control planting.

Poplars

With the arrival of poplar leafspot disease (*Marssonina brunnea*) the poplar breeding and selection programme for disease resistency has become more complex. *Melampsora* rust resistant clones developed over the last three years now need to be reselected for *Marssonina* resistance.

A series of 2-year clone trials to obtain data on the early growth of 100 new *Melampsora* and possible *Marssonina* resistant clones has been established on six sites. The first pole trials to determine survival and growth from poles of 16 *Melampsora* and possible *Marssonina* resistant poplar clones have been established on farms in Northland and Hawkes Bay.

This year's poplar breeding programme is concentrating on clones resulting from hybridisation between aspen (*P. tremula*), silver poplar (*P. alba pyramidalis*) and grey poplar (*P. x canescens*) using the n. hexane technique to break incompatibility. This project is aimed at obtaining vigorous, less site demanding, disease resistant material with a high suckering capacity.

Ninety-three clones representing a wide range of disease resistant material selected in Japan, Argentina, Australia, Italy, Turkey, Yugoslavia and USA were released from quarantine this year and will provide a valuable contribution to the poplar gene pool.

Accelerated propagation is in hand for the release of a disease and opossum resistant poplar clone in 1978. It is intended to release a further eight new clones in 1980.

Grasses, Legumes and Herbaceous Material

The inter-departmental committee, established to assess how best to use existing skills and resources for development and use of grazeable grasses and legumes for erosion control, has carried out its initial review. Its recommendations have been forwarded to the research director.

Consultation on revegetation measures for the Maui Pipeline project continued. The Aokautere Science Centre supplied thirty-two tonnes of *Phalaris* plants and 10,000 wands of bitter shrubby willows, for planting on earthworks along the pipeline route, and 4,000 willow cuttings for the establishment of a project nursery.

A severely eroding and extremely acid highway batter near Whangarei was success-

fully rehabilitated by construction of a series of cut-off drains across the slope, application of lime and anaerobically stabilised sewage sludge, and oversowing and planting of *Pennisetum clandestinum*.

Shrubs and Alternative Tree Species

A large number of tree and shrub species is under investigation at the nursery stage and under field conditions. These include species of *Eucalyptus*, *Acacia*, *Robinia*, *Casuarina*, *Platanus*, *Gleditsia*, *Ceratonia*, *Cistus*, *Atriplex*, *Kochia*, *Cornus*, *Elaeagnus* and *Erythrina* genera.

Research into the protection of tree seedlings in the presence of stock is continuing. Plastic net-sleeves to protect container grown seedlings of *Acacia*, *Eucalyptus*, *Sequoia*, *Casuarina* and *Pinus* are being tested intensively in Hawkes Bay. The sleeves are proving successful barriers against sheep damage.

Grazing trials have been carried out to determine the relative palatability of seventeen shrub species to sheep and opossum. Results show that these animals have different preferences, *Cistus ladanifer* for example being moderately palatable to opossum but not at all palatable to sheep while the situation is reversed with *Symphoricarpos orbiculatus*.

Pathology

During the year the establishment of *Marssonina brunnea*, (poplar leafspot disease) was confirmed. Artificial inoculations with two levels of *Marssonina brunnea* inoculum to test susceptibility of some 200 clones have been carried out in the laboratory. A new agar leaf-disc technique was developed for these tests and proved very useful in distinguishing the very susceptible and the most resistant clones. These tests indicated that many of the clones, including the new clone 'Flevo', which are resistant to *Melampsora* (rust) are also resistant to *Marssonina* leafspot, but the intensity of the infection depends largely on climatic conditions.

Other diseases under study are *Marssonina salicifolia* which is causing damage to willows in Northland and *Agrobacterium tumefaciens* (crown gall infection) which is affecting rooted stock in nurseries.

Tissue Culture

The method of micropropagation of poplars developed at the Plant Physiology Division (DSIR) makes it possible to produce rapidly large numbers of certain clones. A pilot production unit is now being established at the Aokautere Science Centre and staff are being trained. It is intended to produce 1,000 plants of two to three poplar clones this year for field planting and to gain practical experience.

Plant Growth and Water Relations

The heat pulse velocity method developed to measure transpiration rates of trees in situ was further improved with the development of double acting probes, and verified in trees in which the trunk was cut under water and the transpiration stream fed directly from the cut end. For a *Populus* 'Flevo' tree (3-yr-old, 7.3 m high and 12 cm basal diameter) on a sunny February day, typical peak heat pulse velocities were of the order of 70 cm/hour in the fastest-conducting vessels, peak water uptake was 8.2 l/hr and daily water use was 64.5 l.

Ruahine Range Investigations

Results of the 1976 trial planting along streams and on riparian slips and gullies in the Kumeti Catchment were encouraging. In particular the willow layering trials, using a number of new 'bitter' shrub and osier willows to provide barriers to material moving down-slope, were very promising. Assisted by favourable weather a good strike and subsequent growth was obtained while opossum damage was minimal. Only the more palatable willows were completely stripped and most of these died.

Of the shrub species planted *Acacia melanoxylon*, *Robinia fertilis*, *Symphoricarpus* spp., *Cytisus proliferus* and *Lupinus polyphyllus* were the most promising. Considerable damage occurred on some sites through opossum browsing. A further series of trials was established on six sites this winter.

Shotover Investigations

Notwithstanding damage due to soil movement and flooding and occasional severe browsing by goats, hares and opossum, several species and clones in the upper Shotover catchment trials showed promising results.

Of the willows, the bitter shrub willow clones (*S. pupurea*, *S. incana* x *S. daphnoides*) performed best while *Symphoricarpus orbicula-*

tus proved the best shrub for sandy or gravelly soils. *Cornus* spp. (and *Alnus* spp.) are promising on wetter soils. *Lupinus* spp., *Hippophae rhamnoides*, *Robinia fertilis* and *Tamarix* spp. are promising where animals are controlled.

Semi-arid Country Revegetation

The four trials in Central Otago and the Upper Waitaki Basin were extended. These tested shrubby and herbaceous species for restoration of severely depleted areas, for additional browse for livestock and for cover as a nursecrop and stability of eroding sites under low rainfall and high evapo-transpiration conditions.

Moderate success has been achieved with tubed stock of *Cistus* spp., *Atriplex* spp., *Dorycnium hirsutum* and some *Acacia* and *Eucalyptus* plants. *Sanguisorba minor* appears particularly adaptable to the extreme conditions and is spreading freely from self sown seeds. This year a further 1,600 shrubs were planted in these trials while sowings of several annual and perennial *Lupinus* spp., *Dorycnium* and *Sanguisorba* were made.

Selection of woody species for gully control in droughty pumice loess and argillite soils is continuing in the Taupo, Wairarapa, Blenheim and North Canterbury areas. Some 3,500 shrubs and trees (*Alnus*, *Acacia*, *Robinia*, *Salix*, *Populus*, *Eucalyptus*, *Gleditsia*, *Cornus*, *Eleagnus*, *Symphoricarpus*) were planted together with oversowing with *Lupinus polyphyllus*.

Mini-rotation for Fibre Production

Currently there is considerable interest in the utilisation of short-rotation crops for fibre production and in the use of plant material for conversion into energy. Preliminary data indicate that willows may be capable of producing 25 tonnes/dry matter/ha/year on a coppicing system.

WATER QUALITY

Until recently, water quality research and survey work in New Zealand has been confined to specific local problems, and only now is a formal framework of organisation for national activities being established.

To enable adequate coverage of all types of water regime, it is proposed to set up three main research groups at Hamilton covering:

- (a) lake systems and the relation between land use and water quality;
- (b) river systems;
- (c) coastal and estuarine waters.

It is also proposed to set up specialist sections to provide services in the fields of:

- (a) chemical analysis;
- (b) bacteriology;
- (c) bioassay and productivity;
- (d) mathematics and statistics;
- (e) instrumentation.

The National Water and Soil Conservation Authority would look to other agencies with specialist skills to carry out investigation required in other fields, such as fisheries, aquatic weeds, etc, merely functioning in a coordinating role to ensure that requirements for work in these fields are brought to the attention of the appropriate agencies.

LAKES/LAND USE WATER QUALITY

The two major projects (Lake Rotorua and Lake Taupo) with which this group is involved are overextending the resources of the group. Also, looked at from the national viewpoint of establishing general understandings, there is a great deal of overlap in the objectives of the two studies. If both are to be carried out at the existing level, greater resources will be needed.

At the same time there are a number of aspects of nutrient cycling in lakes which need to be studied but which are being neglected at present. The Freshwater Section, Ecology Division, DSIR, are investigating some of these, notably nitrogen fixation and nitrogen loss, but certain key aspects such as deoxygenation mechanisms and nutrient loading models are not being covered.

In the effects of land use on water quality field, there is also a need for wider involvement by the group. At present studies are largely restricted to pumiceous areas. These need to be extended to other situations, and to link more closely with other sectors of the land-use catchment studies which are presently being developed, especially in the area of urban hydrology.

Lake Rotorua

In continuation of the 1976 programme, samples were collected twice weekly from 10 inflow streams of Lake Rotorua and from the outfall channel, until March 1977. After studies carried out to optimise sampling procedures, samples are now only being collected monthly, with the exception of the outlet channel.

The data from these samples have been used to calculate nett inputs of phosphorus and nitrogen to the lake, and a paper on the especially detailed measurements over the summer period 1975-76 has been submitted to New Zealand Journal of Marine and Freshwater Research. The main conclusion is that there is more phosphorus and nitrogen flowing into the lake than out of it, sufficient to raise the concentration by 0.06 mg/m³ per day for phosphorus and 0.92 mg/m³ for nitrogen. These figures are much greater than observed changes in the outflow waters, showing that internal processes remove over half of the soluble nutrients (both P and N) reaching the lake, as well as most of the particulate nutrients.

Three catchments have been examined to see how nutrient concentrations vary between the tributaries within a catchment. There has been a generally consistent pattern which shows that streams passing through swamps have very low nitrate concentrations, those with urban areas have very high nitrate concentrations, and those with pasture or native forest land use have a wide range between these extremes, i.e. from 200 to 1200 mgN/m³. There is a preponderance of low nitrate concentrations in the south of the catchment. Other nutrients measured show no discernable patterns at the moment. The nitrate data formed the basis of a paper presented at a colloquium of land use and water quality sponsored by the New Zealand Committee for Water Pollution Research in Dunedin in August 1977.

Over 30 floods have now been sampled by automatic sampler and both discrete and composite samples have been analysed for various

forms of phosphorus and nitrogen. A paper was presented to the 1976 Hydrological Society conference on the nitrogen and phosphorus content of flood waters of the Lake Rotorua Catchment, the main points being that, although the soluble nutrients did not greatly change in concentration, the nutrients in particulate material increased to such an extent that the total amount of particulate nutrients from floods in a 6-month period approached the amount of soluble nutrients in the base flow. This is not to say that the particulate nutrients and soluble nutrients are of equal importance to plant growth. A further paper in preparation shows that the total transport of phosphorus by a flood is well correlated with the peak flow, even though the correlations between instantaneous concentrations and flows vary markedly from one flood to another.

There have been other minor investigations in conjunction with other organisations. During the 1976-77 summer, profiles of dissolved oxygen were measured twice weekly in the lake at two locations in order to find out whether the lake was anoxic in its bottom waters, the idea being that if the lake did show this phenomenon then the various interested groups could undertake immediate extensive sampling. However, it was found that very little stratification occurred that summer, and the dissolved oxygen seldom went below 2 mg/l. Even the deep hole near the south side of the lake was continuously well-mixed.

Lake Taupo

This project has been operative for just under two years and the first results were written up for presentation at the Colloquium of the New Zealand Committee for Water Pollution Research in August 1977. The network of flow and rainfall stations is operating successfully and the first attempts at water balances have been made for each of the flow recorder sites.

The existence of relatively large areas of native vegetation in the Lake Taupo catchments provides the opportunity for establishing a base-line for water quality to which the used catchments can be compared. The natural differences between the various landscape units must be understood before the impact of land use on any one can be assessed.

The water quality data have been collected in such a way that, as far as possible, the final data pool is seasonally unbiased. Flood sampling was always carried out in each of the land use categories at any sampling opportunity.

The real catchment areas of streams draining catchments both in andesites and rhyolites are difficult to establish and often have no meaning during base flow. Nearly all of the northern catchments are losing water to

an outside source, probably to the Waikato River valley further north. Although it is preferable to use estimates of total mass when comparing the outputs of catchments the phenomenon described above makes it impossible to use any parameter other than concentration.

Notably higher mean ionic matter, suspended matter, total phosphorus and total nitrogen concentrations were recorded in the streams draining agricultural and exotic forestry catchments than in streams draining catchments in native vegetation.

Ionic matter concentrations are generally highest in the andesitic volcano region, being more than double those draining greywacke and rhyolite (more than 30 compared with less than 15 mg/l). Lithological differences and the occurrence of hydrothermal activity with mineralised water are considered to cause the higher concentrations.

Vegetation differences, especially the occurrence and frequency of tutu (*Coriaria arboreum*) and various exotic legumes (gorse, broom and lupins), may explain the large differences in natural nitrate levels. These may be as high as 300 mg/m³ during base flows and up to 700 mg/m³ during flood flows in lowland catchments rich in tutu and scrub including gorse and lupins. There is a strong seasonal cycle in nitrate concentrations with a maximum reached during midwinter high flows and a minimum in midsummer base flows. In the greywacke ranges and the andesitic volcano region the nitrate concentrations rarely exceed 50 mg/m³ and are often below 10 mg/m³.

The Kuratau River system, which is in an area of high nitrate, is one in which agricultural development has been established for a long time. Nitrate concentrations measured here are on average twice those from similar catchments in native bush, ranging from 40 to 70 mg/m³.

The Waihaha Stream surrounded by relatively unmodified vegetation has nitrate concentrations ranging from 5 to 50 mg/m³. The soils and the original vegetation of the Kuratau system are comparable to those in the Waihaha Stream. Adequate data have now been collected from the Waihaha to allow prediction of nutrient species content, under different flow conditions.

Ammonia concentrations during baseflows follow the same general pattern shown for nitrate, and rarely exceed 20 mg/m³. Higher concentrations are measured occasionally in streams draining hydrothermal areas.

The highest suspended matter concentrations are always measured in catchments modified by human activity. Differences between agricultural and forestry land use types cannot be established from the limited flood data available at present, but the higher concen-

trations in both are very obvious when a comparison is made with the data from unmodified catchments.

During floods in agricultural and forestry catchments, the nutrients associated with suspended matter (particulate P and N) are removed from actively eroding areas concentrated along the stream channels, roads and access tracks. Management techniques which minimise bank erosion and gullyng, as well as erosion of roadsides and tracks,

may assist if nutrient loadings are to be reduced to low levels. The greater concentrations, especially of ionic species, from streams draining agricultural land and exotic forests are evidence of a less stable environment.

Around Lake Taupo no great water quality problems are envisaged in the near future as the intensity of land use is still low, and the effects modest when compared with other areas in the world.

RIVERS WATER QUALITY

Sufficient data are being accumulated on river systems to enable this group to start studying the general applicability of some of the mathematical models available. Such a study would greatly extend the assistance the division could offer to regional water boards. Several oxygen-regime mathematical models have indicated that the oxygen demand of the sediments is a significant factor. Experimental work is needed to link the observable sedimentary oxygen demand with the sedimentary demand coefficients of the mathematical model.

Waikato River

Reconnaissance water quality surveys were carried out between Taupo and Karapiro and between Taupo and Tuakau during the 1976-77 summer to provide planning information for future work and to obtain a picture of the water quality in the entire river below Lake Taupo. The Auckland Regional Authority, Auckland University, Cawthron Institute, DSIR, New Zealand Electricity Department and the Waikato Valley Authority assisted with these surveys.

The surveys showed that between Taupo and Lake Ohakuri there were large increases of turbidity, BOD₅, nutrients and metals.

Increases of mass flows of lithium, a constituent of geothermal waters, in this stretch of the river suggest that geothermal inputs are important. These include the Waiotapu Stream, which is the largest tributary to the Waikato River in this area and has several geothermal and agricultural inputs. Total algae mass flows were approximately constant between Taupo and Lake Ohakuri, then increased 10-fold in this lake and remained relatively constant to Tuakau.

Other major inputs into the Waikato River include the Whirinaki Arm which discharges algae into Lake Ohakuri; the Waipa River which enters the Waikato River just below Ngaruawahia (turbidity, nitrate-N); swamp

discharges, e.g. Whangamarino River (turbidity); and some major industries which discharge partially treated wastes into the Waikato River, e.g. Kinleith Paper Mills (BOD₅, colour, turbidity), Auckland Farmers Freezing Company Meatworks (BOD₅, bacteria).

Mass flows (March 1977) at sites on the Waikato River are given in Table 2.

Considerable work has been carried out on flow records from lower Waikato River sites. Water level recorder charts have been edited, adjusted to the Moturike datum, certified and added to the computer data bank. Flow ratings have been checked and constructed where necessary, and are now also stored in the computer file. The earlier phases of the work are now being written up.

Mathematical Modelling (Waikato River)

A mathematical model, which has given some success in predicting DO, was developed for the Waikato River Project. It was used mainly as an analytical rather than a management tool and has not been transferred to the central MWD computer.

The present model predicts dissolved oxygen concentrations for the lower Waikato River. As it is envisaged that the Waikato River will serve as a test-bed for the assessment of other types of model, e.g. hydraulic, colour and turbidity, biological, it is proposed that the modelling approach be extended to these throughout the middle Waikato as well as the lower Waikato River. These models will serve as analytical tools, and should also be developed as management tools.

Tarawera River

The combined effects of waste discharges from Kawerau Borough, Caxton Paper Mills Ltd. and Tasman Pulp and Paper Company into the Tarawera River often cause classified standards (class D) of the river to be breach-

Table 2 Mass flows at sites on the Waikato River (March 1977)

Station	Taupo	Ohakuri Dam	Karapiro Dam	Horotiu	Ngaru-awahia	Mercer
Turbidity (FTUmm ³ /sec)	247	513	535	581	532	1129
BOD ₅ (g/sec)	112	391	206	91	319	128
Total P (g/sec P)	2	8	7	9	11	17
Nitrate (g/sec N)	4	2	7	17	19	27
Arsenic (g/sec)	<10	22	<10	<10	<10	<10
Lithium (g/sec)	20	59	39	35	34	37
Total algae (No./sec x 10 ¹²)	0.29	2.9	1.5	1.6	1.7	2.6
Total Bacteria at 37°C (No./sec x 10 ¹²)	0.01	0.1	2	0.1	1	0.4

ed in terms of dissolved oxygen, colour and odour. The Bay of Plenty Regional Water Board has therefore set up the Tarawera River Technical Committee to make recommendations on the appropriate allocation of the assimilative capacity of the river.

To assist the committee in this task the Hamilton Science Centre has been involved in regular water quality monitoring surveys, three additional intensive surveys, and modelling studies.

Mathematical Modelling (Tarawera River)

The data collected have been used to verify and calibrate a steady state DO – BOD computer model of the river. Good agreement between model predictions and survey data has been obtained. The principal conclusions of the modelling show that a significant portion of the oxygen depletion of the river water occurs in the bed of the river, whilst the remainder of the deoxygenation (occurring

through biological processes in the river water) has been described by assuming that the BOD is comprised of three different fractions. These fractions (sugars, organic acids and sewage) are each assumed to deoxygenate at a different rate. The input of oxygen from tributary inflows downstream of the paper mills is significant; at low summer flows the absence of these tributaries would mean that the minimum river DO would be approximately 1 g/m³ less than actual value.

Minimum values of river DO commonly occur at the Awakaponga site situated 15 km downstream of the paper mills. Data for this site obtained from the intensive surveys are tabulated in Table 3.

Under the aegis of the Technical Committee discussions have been held with Caxton and Tasman Laboratory staff and regional water board staff to standardise analytical methods for DO, BOD₅ and suspended solids. Comparative checks of the various methods used

Table 3 DO and BOD at Awakaponga

Survey Date	River Flow (m ³ /s)	River Temperature (°C)	River DO (g/m ³)	River BOD (g/m ³)
26 August 1976	35.2	14.9	3.8	4.9
14 September 1976	33.0	14.4	4.5	4.8
15 December 1976	28.4	18.5	2.8	6.0

at present by these organisations have shown such standardisation to be necessary.

Further river surveys may be needed from time to time, especially as developments in the treatment of effluents discharged to the river are carried out.

Upper Waitaki Dye Dilution Gauging

Dye dilution gaugings were carried out for flows up to 120 m³/sec at three sites in the Upper Waitaki Power Scheme in June and July 1977. These flow gaugings were carried out by staff of the Hamilton and Christchurch Science Centres at the request of Power Division, Ministry of Works and Development, as part of the commissioning of the Tekapo B Power Station.

Flow measurements were made at:

- (a) Tekapo A Power Station, situated at the upper end of the Tekapo Canal;
- (b) Tekapo B Power Station, situated at the lower end of the Tekapo Canal;
- (c) the radial gate controlling augmentation flow from the Tekapo River to the Tekapo Canal.

A fluorescent dye, rhodamine WT, was injected into the penstocks of the power stations

and at the radial gate, and downstream dye concentrations measured with a fluorometer. Two methods were used to calculate the flows, these being based on:

- (a) the dilution of the injected dye in the receiving water;
- (b) the travel time of the dye through the penstocks (at the two power stations).

Current meter gaugings (in duplicate at Tekapo A) were also carried out by the local Water and Soil Division hydrological field party to provide a check on the accuracy of the measured flows and as a comparison with the dye dilution method. Further estimates of flows were obtained from measured volume changes in the canal.

The duplicate meter gaugings agreed to within 1% at Tekapo A, and also agreed closely with the nominal flows as determined by turbine ratings and power station load. The dye dilution results showed less agreement with nominal flows due to poor mixing of the dye during some runs and variable water turbidity (Table 4).

A formal report is in preparation in Power Division in which the fully processed results will be analysed and compared.

Table 4 Some Flow Measurements at Tekapo A and B Power Stations (Preliminary Results)

Date	Site	Pen-stock	Turbine Flow From Theoretical Rating (m ³ /s)	Gauged Flows (m ³ /sec) By		
				Dye Dilution	Dye Travel Times (mean)	Meter (Mean)
19.7.77	Tekapo B	II	30	25.3	30.8	} 59.7
		III	30	29.4	31.6	
22.7.77	Tekapo B	II	30	28.7	31.1	} 30.2
		II	20	22.8	24.9	
		III	40	39.9	42.9	
23.7.77	Tekapo B	III	50	50.9	48.5	} 60.7
		II	10	—	13.6	
27.7.77	Tekapo B	II	40	39.7	41.1	} 80.3
		III	40	40.1	42.3	
27.7.77	Tekapo A	I	80	84.4	75.4	81.2
1.8.77	Tekapo A	I	120	133.1	130.7	122.5
		I	120	122.0	—	122.5

ESTUARINE AND COASTAL WATER QUALITY

The increasing pressures for diverse use for industrial and urban, development and recreational purposes being placed on estuarine and coastal areas and the complex interaction between these is seen to the greatest extent in the Auckland metropolitan region.

Accordingly emphasis is being placed on assessing the situation there. Work from the Hamilton Science Centre is being organised to provide appropriate support to field studies which will be selected according to areas of most pressing need.

LABORATORY SUPPORT SERVICES

Analytical Chemistry Laboratory

This services the various field projects (Rotorua, Taupo, Waikato, Tarawera etc) which are in progress from the Hamilton Science Centre.

Since August 1976 the laboratory has carried out some 16,000 analyses, with the Rotorua project providing the majority of samples.

Project	No. of Analyses Performed
Rotorua	12,250
Taupo	2,000
Waikato	1,720
Tarawera	

Most of the routine methods have been revised and written up to form a laboratory manual and a supporting methodology reference file has been set up.

Data recording and quality control of analytical tests have been updated, and a central laboratory data retrieval system has been established.

Some time was spent in developing the analytical repertoire, e.g. mercuric thiocyanate method for chloride, and in modifying or investigating existing methods e.g. anomalies in the hypochlorite ammonia method. The setting up of the auto-analyser system has also been started.

Bacterial Tracer Studies in Groundwater

The Hamilton Science Centre provided a bacterial tracer service for the Heretaunga groundwater project. For this, three bacterial tracers, *E. Coli* ($H_2 S^+$), *Bacillus stearothermophilus* and *Serratia marsescens* (pigmented strain) were evaluated although the latter was not used in the actual experimental programme.

E. Coli ($H_2 S^+$) strain is not common and was thought to be easily identifiable. A specially modified MacConkey agar was used which enabled both good recovery (more than 90%) of the organism and its differentiation from any similar naturally occurring organisms

which would otherwise interfere in the test. Special precautions were taken in the use of this organism because of its possible pathogenicity and its transferable antibiotic resistance.

Bacillus stearothermophilus (non pathogenic) is a commonly used tracer. It was recovered by growth at 55°C on nutrient agar. After growth in broth the organism did not survive in groundwater, presumably because it did not produce spores. Further use would require the development of techniques to ensure sporulation in broth culture. Preliminary tests suggest that this will be possible.

Serratia marsescens (pigmented strain) also is a commonly used tracer. The techniques available for its isolation and enumeration did not permit it to be differentiated from indigenous organisms. This limited its usefulness in these studies. Also *Serratia marsescens* is not compatible with *E. Coli* ($H_2 S^+$) as the medium used for detecting the latter also encourages growth of the *Serratia* which interferes with H_2S production and hence detection of *E. Coli* ($H_2 S^+$). Some strains of *Serratia marsescens* are pathogenic.

Horizontal tracer studies were carried out at Roy's Hill in May and July 1977. In the first experiment *E. Coli* ($H_2 S^+$) and *B. stearothermophilus* were injected with good recovery of *E. Coli* ($H_2 S^+$) and poor recovery of *B. stearothermophilus*. In the second experiment *E. Coli* ($H_2 S^+$) was mixed with rhodamine WT (20% solution) and injected. Horizontal flow rates for bacteria, estimated from time taken to reach peak concentration at distances greater than 50 m from the injection well are given in Table 5.

Bacteria were subject to less "dilution" than dye.

A vertical tracer study was undertaken at Roy's Hill in June 1977 when *E. Coli* ($H_2 S^+$) was mixed with well water containing nitrate and injected through a simulated "leaky sewer". Both *E. Coli* ($H_2 S^+$) and nitrate moved vertically at rates of from 15 to 24

Table 5 Horizontal flow rates at Roy's Hill

Depth (m)	Flow rates (m/day)		
	E. Coli (H ₂ S ⁺)		Dye
0.5	Expt 1 142-153	Expt 2 116-165	Expt 2 103-132
3.0	—	150-185	136-154
5.0	138-200	—	—

m/day through 5 m of unsaturated material above the water table.

To test the underground die-off rate of *E. Coli*(H₂ S⁺), a well water sample containing bacteria at well water temperature, was held in a plastic container in the laboratory. At the time of the second horizontal tracer experiment, dialysis tubes tied at each end and containing bacteria in incubated well water samples were also suspended in the

actual wells. An average T50 of 2.2 days (range 0.8 - 3.7) was observed in the dialysis sacs. In the wells, bacteria were detectable up to 26 days after injection.

It was concluded that movement at a rate of 150 m/day in the groundwater could continue for up to 14 days over a distance of 2 km, by which time dilution and die-off would have reduced the population to small but detectable concentrations.

RESEARCH CONTRACTS

This activity continued to be developed into a major programme in accord with the new policy and procedures adopted by the National Authority in 1976.

Under this scheme applications from universities for grant assistance are called for once a year and in doing so emphasis is given to two principle policy issues viz. proposals must be relevant to the National Authority's fields of interests and responsibilities, and should involve advanced student training. The policy also provides for entering into special purpose contracts which require the use of special skills, above the student level, which are available in the university system.

Upon receipt each proposal is subjected to a rigorous internal assessment not only in respect of the policy issues stated above but also in terms of:

- (a) whether similar studies are already known to be in progress;
- (b) how far and well the proposed study is likely to add to or fill in gaps in existing knowledge;

(c) the adequacy of the details given in the proposal, particularly as to whether the nature and standard of the methodology is such that there is a reasonable chance of the study objectives being attained;

(d) whether the knowledge to be gained is commensurate with the cost of the proposed study.

As a reflection of the introduction of the scheme on an organised basis and the opportunity it has given for increasing contact and development of understandings between the organisation and universities the manner of presentation and the quality of the information contained in this year's proposals showed a considerable improvement on proposals received in previous years. Similarly proposals were more directly relevant to problems within the organisation's field of interest.

Nineteen contracts approved in previous years continued or were under offer to commence in 1977/78. Five of these were completed during the year. The National Authority during the year approved the negotiation of contracts for 15 new proposals and extensions to two existing contracts.

CONTRACTS UNDERWAY

Slope Stability in Relation to the Soil Types, Rock Types and Geologic Structures of the Waimarama – Elsthorpe Valley, Tukituki River, Southern Hawkes Bay: University of Auckland, Department of Geology

This project 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 structure and physical parameters in the rock mantle.

Problems associated with bentonitic and other soft rock terrain are well known, control measures far from certain and most difficult to achieve and base information on parameters and processes which contribute to movements is very sparse. Findings from the study will have particular relevance to catchment authorities in the southern half of the North Island and some territorial local authorities.

Detailed geological mapping (300 sq km) of the area has been completed and maps and cross sections are being drawn up. Hitherto unrecorded sets of structures in the coastal sector, have been elucidated. Of special note are thrust wedges and crush zones both involving bentonitic clays.

Some pedological mapping has been completed and in combination with geological mapping is allowing an appraisal of controls on slope failures. Two recent large landslides in the Makara Formation have been studied. The controlling features are rock structure (bedding, fractures, faults) and rock type (alternating mudstone – sandstone). The material in the slips has been severely disrupted and crushed, forming a typical debris mantle. This is prone to continuing failure and removal by sliding and earth flow movement.

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 proposed aim of this research project is to establish standard bioassay techniques for the assessment of algal growth potential in the Waikato and Rotorua Lake and River systems, and to complement a study which has already been carried out on the Waikato River.

Preliminary procedures have been set up with two algal species. *Anabaena oscillarioides* and *Selanastrum capricornutum*, and a duckweed, *Spirodela oligorrhiza*.

As a nitrogen-fixing blue-green alga, *A. oscillarioides* is a useful organism to test the phosphorus status of test waters. Its growth requirements in the laboratory such as culture medium, temperature, light and pH have been

standardised. Methods have been devised to assay the biomass of this alga by measurements of dry weight, cell volume, cell count, chlorophyll-a and protein content. Its nutrient requirements in the Waikato waters, phosphorus requirement and its interaction with other algal species have been delineated.

Selanastrum capricornutum has been widely used in standard bioassay procedures. It was grown in membrane filtered water samples collected from various sites along the Waikato River in March 1977. Low growth of the alga was obtained, but different sites with various capacity to support algal growth were discerned. However it has proved difficult to associate the change of water quality along the river with a definite pattern.

Two experiments were performed using *Spirodela oligorrhiza* which also possesses the qualities of a test organism. Different results were obtained probably due to the differences in water quality at different sampling times. However there is evidence that *Spirodela* is not as sensitive as *Selanastrum* since its growth in water samples, collected from different sites along the river in February 1977, did not show a significant difference.

National Peat Resources Survey: University of Waikato, Department of Earth Sciences

Professor J. McCraw, Department of Earth Sciences, University of Waikato, has been convenor, co-ordinator and advisor to this co-operative project with the University employing students for field survey and map compilation work. This arrangement has been efficient and economic – Professor McCraw and others associated with him have done an excellent job.

The students, with assistance from Water and Soil Division and catchment board staff, facilities etc completed the field survey during the 1976–77 university summer vacation. Subsequently, maps and accompanying description of the nature and extent of over 60 peat areas (including such features as location, classification, present status, area, surface vegetation and land use, peat thickness and composition, highest point and outfall level and climate) have been compiled and the manuscript is now with the printer.

Nutrient and Water Conservation by Peatland Systems: University of Waikato, Department of Biological Sciences

Research will investigate peat soils and vegetation ranging from the natural to fully developed situations. Soils will be evaluated for oxidation susceptibility, moisture and nutrient retaining characteristics and status, and vegetation for nutrient composition,

nutrient utilisation efficiency and degree of adaptations to peat soil characteristics. Studies will also include the dynamics of selected whole peat land ecosystems (eg Moanatuatua, Hauraki) to assess water and nutrient budgets to define progressive changes and as the basis for preparing recommendations for preservation and/or management. The rationale for the study relates to the history of peatland development, and current problems of development versus preservation. On the one hand peatlands require to be used efficiently and conserved as effectively as possible; on the other, there is a need to understand their importance in terms of nutrient and water conserving properties – which will lead to more informed planning decisions in their future use.

The Influence of Particulate Matter on Coliform Counting of River Water: University of Waikato, Department of Biological Sciences

This study is aimed at ascertaining how far the very high variability of coliform counts on water can be ascribed to "clumping" of the bacteria onto particles in the water. The variability of bacterial counts is a well known drawback to their application as a criterion of water quality and has caused difficulties in the attempts made to mathematically model bacteriological behaviour in the Waikato River.

In work done to 31 March 1977 *Escherichia coli* 1103B was grown on nutrient broth at 30°C/24 h and filtered through membranes of different pore size in order to determine the effectiveness of the membranes in the retention of *E. coli*. Results showed that membrane filters of pore size 0.45 μ m retained significantly more *E. coli*, than did those of pore sizes 3.0 μ m and 8.0 μ m. However, results from further experiments indicated that the *E. coli* in river water, in contrast to pure cultures, are associated with particles of such a size that they are retained to a significant extent on filters of pore size 8.0 μ m.

It is proposed to investigate the possibility of increasing the efficiency of coliform counting by dislodging the bacteria absorbed to particles with the use of sonication. It is also proposed to make coliform counts of the sediments in the river in order to estimate the extent of sedimentation of particles with coliforms adhering to them and to estimate the viability of coliforms under such conditions.

Preparation of Annotated Bibliography of the Effects of Urban Land Use on Water Quality: University of Waikato, Department of Earth Sciences

The aim is to assemble information which will assist and guide staff in setting research priorities and making land management decisions.

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 the 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. This involves:

- (a) measurement of the proportion of rainfall which can be harvested from drainage waters and stored in dams;
- (b) investigation of water requirements of pasture in dry periods and the effect of applying harvested water on herbage yield, nutrient composition and fertiliser requirements;
- (c) evaluation of movement of plant nutrients (particularly N and P) in tile drainage as influenced by irrigation and fertiliser use and the impact of these on water quality and fertiliser requirements. Results would be applicable to a large area of soils in an environment where seasonal soil moisture deficits of 25 mm or more occur in at least 5 out of 10 years.

Following is a summary of the work during 1976/77.

The year 1976 was comparatively wet, with 1,366 mm of rainfall measured at the water harvesting site as opposed to a long term average of 1,002 mm at Grasslands Division, DSIR. On irrigated plots flow started from the tile drains on 8 May and, through until 13 October, yielded 490 mm. On unirrigated plots the first significant discharge occurred on 4 June, and the total discharge measured was 430 mm. Discharge indicated that over 80% of total runoff appears as harvestable tile drainage, and that surface runoff and deep percolation beneath the mole-tile drainage system are minor components of the water balance.

Since mid-November 1975 the non-grazing treatment has been discontinued and all plots have been grazed by sheep resulting in an increased loss of nitrate from the previously ungrazed plots.

High nitrate nitrogen ($\text{NO}_3\text{-N}$) concentrations (24 mg/l) were recorded in the drainage water during the early part of the season, but these soon fell to much lower levels as the winter progressed.

Dissolved inorganic phosphorus (DIP) concentrations were affected by the application of phosphate fertiliser in mid-June. This temporarily increased the DIP concentrations in the drainage waters, but the effect was short lived, and concentrations soon fell

close to pre-fertilizer levels. Losses of DIP were not so greatly affected this year as previously by irrigation or 'grazing' but losses due to superphosphate application were increased. This was probably due to the fertilizers being added in mid-June rather than April and thus having less time to equilibrate with the soil before drainage flows. On a per hectare basis the range of DIP and $\text{NO}_3\text{-N}$ losses occurring in subsurface drainage amounted to 0.2 – 1.0 KgP/ha/annum, 8 – 32 kgN/ha/annum, and the range of total P and total N losses was 1.0 – 1.9 kgP/ha/annum, 17 – 42 kgN/ha/annum.

From an agronomic standpoint there is a negligible loss of P but the drain on the soil N pool under some treatments may be significant, and for both nutrients the concentrations in the drainage waters could cause concern in "sensitive" waterways.

The effect of irrigation and fertilizer additions on pasture yield and its nutrient composition was measured. The 1976–1977 dry matter yield effects allow the following tentative conclusions to be drawn:

- (a) To obtain maximum benefit from irrigation, the nutrient status of the soil must be adequate.
- (b) In an average year of summer rainfall, such as 1976–1977, pasture yield responses to irrigation increase the yearly production by 40%. Over the summer period the increase in pasture production due to irrigation, is almost five fold.
- (c) Comparison with the dry matter yield data from previous years, indicates that irrigation markedly reduces the year to year fluctuations in annual pasture yield.

Grazing compared with mowing resulted in pasture with higher phosphorus levels while nitrogen levels remained relatively unchanged. This interpretation is confounded by differences in the species composition of pasture between the two treatments. There were general increases in pasture total P levels, through topdressing. However further analyses of pasture TP and TN levels are now underway to enable fuller interpretation of the effects of grazing, irrigation and fertiliser treatments.

Disposal of Dairy Shed Effluent in Soils: Massey University, Department of Soil Science

Land disposal of animal wastes is regarded by many to be the most economical and effective method. However it should not be permitted to enhance the nitrogen and phosphorus enrichment of surface and subsurface waters entering natural waterways or groundwaters used for domestic and animal consumption. The research aimed to develop and evaluate an efficient, economic and environmentally sound method for disposal of dairy-shed effluent in soils by developing under-

standings of the physical properties of soils, the ability of plants to use nitrogen and phosphorus in effluent, and the movement of nitrogen, phosphorus, soluble organic compounds and microorganisms within the soil.

The report presents the major findings of a research effort carried out over three years to evaluate the effectiveness of sprinkler irrigation of untreated dairy-shed wastes onto permanent pasture in the Manawatu. Dairy-shed wastes from 250 cows were pumped to spray equipment irrigating a 1.6 ha area of permanent pasture grazed by sheep and yearling steers.

Drainage water during the non-milking period of 60 – 80 days in winter accounted for large losses of nitrogen and phosphorus from the soil because of leaching by water from heavy rainstorms. BOD's were undetectably low and faecal coliform numbers less than 200 per 100 ml of drainage water during this period of the year.

During the milking season drainage of water was dependent on irrigation of shed waste water morning and night. Even under the most adverse conditions (in spring) 90% of waste nitrogen and 95% of waste phosphorus are estimated to have been removed. Actual removal of BOD was about 90% on average while it is estimated that 99% of faecal coliform bacteria were removed leaving 10^5 per 100 ml. It must be borne in mind that these results may be influenced by a higher standard of management practice than may normally be found on a dairy farm. Thus the faecal coliform count of the untreated effluent was a mere 107 per 100 ml whereas values of 10 times this figure are not uncommon. Similarly the BOD of the effluent was 800–900 mg/l, indicating that these results are affected by high water use during shed cleaning operations.

Analysis of phosphorus and nitrogen in pasture herbage showed that net quantities applied to the soil were greater than could be utilised by the pasture, suggesting a build up in the soil profile. Soil phosphorus levels over the three year period did increase approximately 2-fold in the surface 5 cm but apparently no similar nitrogen increase occurred. It is possible that gaseous losses (as N_2 , NH_3 , N_2O) are involved.

Results of the research show that disposal of dairy shed wastes in soils can be an effective method of waste treatment under suitable management conditions and with suitable soils in the disposal area. The method has an added advantage of returning nutrients to the soil-plant system, while the very high level of bacterial removal is particularly significant from a water-treatment/water-management viewpoint. The data and discussion of management implications presented in the report will be of assistance to designers of dairy

shed effluent spray irrigation disposal systems, provided due account is taken of the differences in management procedures between the experimental and the farm situation.

Geological Erosion in the Southern Ruahine Range: Massey University, Department of Soil Science

The research provides for mapping the basement geology in the area with particular emphasis on relating rock units and faulting to erosion potential and patterns. The study will have value as a portion of long term research on interrelationships between structure of greywacke ranges and their erosion potential and may help to guide planning and implementation of catchment control schemes presently being developed for the area.

So far, work has been concentrated on collection of literature and base maps relevant to the study area and reconnaissance field work with the aim of elucidating the broad patterns of rocks present. From the latter it appears that detailed studies will probably begin in the West Tamaki - Delaware Ridge area and the Raparapawai Catchment area where Water and Soil or Manawatu Catchment Board staff have or are carrying out relevant and related resource survey work.

Coastal Erosion Survey: University of Victoria, Department of Geology

Coastal erosion problems are becoming more acute and the information from this study will be important for understanding the mechanism causing the erosion and the likely trends. Information is being compiled for both the North and South Island on shoreline changes over the last 6,500 years, longshore drift directions, tectonics and historic coastal erosion and/or accretion.

A progress report lists the locations of 130 sediment sampling stations together with physical and petrographic data of samples taken at these stations.

Groundwater Computer Modelling: University of Canterbury, Department of Civil Engineering

A steady state computer model is to be constructed and calibrated for use as a groundwater predictive tool in South Canterbury covering the area between the Rakaia and Ashburton rivers. The proposal is very topical as the South Canterbury Catchment Board has already gathered a substantial body of piezometric information and has begun a programme of pump tests designed to measure aquifer characteristics which are necessary for model building.

The ultimate objective in groundwater management is to build such a model which

can be used to predict changes in groundwater level under various future patterns of demand.

The Movement of Coarse Bed Material by Flood Waves in Rivers: University of Canterbury, Department of Civil Engineering

With the growing shortage of good gravels for industrial purposes in many parts of New Zealand and the over exploitation of some of the rivers for this commodity there is an obvious need for better knowledge of our reserves of gravel. In part this requires extensive survey to determine the amount and whereabouts of present resources, but it also requires a knowledge of how the resource is replenished from the mountains.

The project involves a theoretical and laboratory study of the response of an alluvial reach to non-steady water inflows, both transporting and not transporting bed load, with the aim of providing results from which conclusions concerning transport mechanisms can be drawn and which may lead to a viable method of predicting the sediment yield to be expected from a given flood.

A Survey of Chlorinated Organic Matter Present in the New Zealand Aquatic Environment and the possible Toxic Effects of these on Phytoplankton: University of Canterbury, Department of Botany

This contract assists an extension of studies made overseas using an electron microscopic technique which can demonstrate cellular damage to phytoplankton brought about by exposure to chlorinated organic matter such as PCBs (polychlorinated biphenyls and DDT).

This study is of interest in New Zealand despite the present rarity of industrial discharges of this type because, in their endeavours to meet the bacteriological standards required by water classification, several municipalities are chlorinating sewage before discharging or contemplating doing so. This results in chlorinated organic products of which little is currently known as to their toxicity, although it is known that they are responsible for taste and odour problems in drinking water.

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

Provides for access to and covers incidental costs incurred in training Water and Soil staff for use of a special photogrammetric plotter on such projects as catchment condition.

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, Department of Botany

Research recently completed has demonstrated that the presence of a good snow tussock cover in a catchment can have a marked beneficial effect on water yield in the dry Otago environment. The present proposal extends this work to different altitude levels on the Rock and Pillar Range and begins a similar study in the Deep Stream Catchment which is being developed as part of the water supply system for Dunedin City.

Progress to date has been concentrated on the setting up of research equipment. Seven lysimeter sites have been established, four in the Deep Stream - Deep Creek catchments and three on the Rock and Pillar Range. Each site consists of twelve non-weighing lysimeters containing three different treatments i.e. bare soil, blue tussock turf and snow tussock. The highest site on the Rock and Pillar Range has four additional lysimeters with a cover of *Celimisia viscosa* turf, while the lowest site in Deep Stream has four extra lysimeters with a cover of pasture grass.

Soil moisture blocks, soil thermometers, hygro-thermographs, porous pot evaporimeters, pyranometers and non-recording raingauges measure a range of environmental factors. Water analyses to determine calcium, potassium, sodium, magnesium, chloride, iron, nitrate, ammonia, phosphate and sulphate levels are underway.

Two series of raingauges have been placed in altitudinal sequences. One series runs up the east face of the Rock and Pillar Range; the other has been placed up the Calsa Craig access track. Soil samples are taken at 10 and 20 cm depth at each site when the raingauges are serviced. These data will correlate rainfall with altitude and determine altitudinal zones in which soil moisture deficiencies may occur.

Response of a Trout Population to Water Abstraction: University of Otago, Department of Zoology

A major problem concerning water management is how much water can be abstracted from a river without substantial damage to the fish population. The study investigates the changes in numbers and population structure of trout in a stream where high and low flow conditions succeed each other. This study, together with a complementary study in progress in Deep Stream, should provide information of assistance in multiple-use water resource management.

Progress has been good and useful information has been obtained, despite adverse

weather conditions. Sixteen monotypic sampling sites were set up, eight in the abstracted section and eight in the lower control section, enabling any response with respect to habitat type to be detected. There was no evidence of a general downstream movement by the population, suggesting that there is no well marked behavioural mechanism for removing a population from an abstracted area. Results show that with decreasing discharge, current velocity decreases most rapidly while depth and width decrease less rapidly. This suggests that velocity could be the environmental clue for any behavioural response to abstraction.

Wind Erosion: New Zealand Agricultural Engineering Institute

The objectives of the contract (now completed) were:

- (a) to establish values of wind erosiveness;
- (b) to determine rates and amounts of topsoil movement by wind over agricultural land;
- (c) to study cultivation practices compatible with wind erosion control.

Reporting on (a) above values of wind erosiveness, prevailing wind erosiveness direction and preponderance of that direction have been established for 21 key sites in New Zealand. It has been shown that wind erosiveness is high, and that values vary markedly with time of year and site. (Wind erosiveness is defined as the ability of wind to transport dry cultivated soil.) This preliminary network of sites at key locations is sufficiently scattered so as to make uncertain interpolation between the sites. This is because of localised effects such as topographic effects.

Reporting on (b) above background rates of transported wind-borne sediment are typically a few grams of soil per day per metre width of arable land in a rural area such as the Canterbury Plains. This is of no concern. However extreme events measured during the contract period have resulted in the loss of many tonnes/hectare of topsoil in a single day. This is of concern.

At this time of reporting there are no specific findings on (c) above which can be mentioned, as these are contained in a monograph currently under preparation which will outline the problem of wind erosion on arable land in New Zealand, and control practices likely to be effective in combating it. This publication will be completed shortly, and while partially satisfying the objective will be still some way removed from being translated into effective practices that the National Water and Soil Conservation Organisation may require.

Fencing: New Zealand Agricultural Engineering Institute

Between September 1972 and December 1973 eight major fence durability trials were installed throughout New Zealand. These have shown the incompatibility of multi-salt treated wooden fence posts and zinc galvanized wire. It is now suggested that if wooden posts and zinc coated wire are to be used in combination in environments conducive to rapid corrosion of exposed steel, that the posts be treated with PCP. The trials have also confirmed that very rapid corrosion of zinc takes place when galvanized wire is placed underground. Aluminium clad wire-samples in the trials show no sign of deterioration, but these wires are easily damaged and there is the possibility of ensuing corrosion. It is suggested that, at least until a more economically viable alternative is found, stainless steel wire should be used for footing wire.

A number of high country fence trials have been installed in collaboration with catchment boards. Arising out of observations to date and bearing in mind the few years that the fences have been erected the Institute has suggested guidelines for the design of high country fences.

Biological Studies of the Waikato River: University of Waikato, Department of Biological Sciences

(1) INTERACTIONS BETWEEN *ESCHERICHIA COLI* AND ALLOPHANE

Bacteriological counts are notoriously variable in water microbiology. A thesis reports on studies of one mechanism which may be involved in this variability, the tendency of some particulate matter, allophane in this case, to adsorb bacterial cells and hence give low counts.

Escherichia coli cells were directly observed using fluorescence techniques. Bacterial adsorption was found to obey chemical equilibria theory sufficiently well for equilibrium cell concentrations relations to be determined for ranges of pH and the presence of different saturating anions and cations. Adsorption isotherms above pH 5.0 obeyed a single term Langmuir equation but at lower pHs (rarely met in nature) the Al_2O_3 component of allophane solubilised and produced aggregation effects. The interactions between allophane and the bacterial cells could be explained in terms of surface change phenomena. The iso-electric point for *E. coli* is about pH 2.5, for allophane about pH 6. At pHs between these two values, the two components have different surface charges and attract strongly.

A literature review provides an excellent summary of the interaction between colloid

chemistry and microbiology in natural waters. The results show that adsorption of bacteria onto allophane could markedly affect the accuracy of bacterial counts. Further studies are now required to see whether there is any possibility of overcoming the problems which this study has pointed out.

(2) BENTHIC STUDIES ON THE WAIKATO RIVER

The study reported covers the benthic macrofauna in the Hamilton section of the river and studies on sediment oxygen uptake rates and carbon content.

The benthic fauna studies are interesting as they appear to show a decrease in diversity of species related to the existence of sewage discharges. However significant differences in species and distribution and number were only recorded between muddy and non-muddy substrata. The benthic fauna studies were valuable, as no other information is available on this aspect of the river system. They suffer however from inadequate statistical testing.

The sedimentary oxygen demand studies together with associated studies were used to show that 28% of the oxygen consumption over a 5 km reach could be attributed to the BOD of the water, and 23% to the sediment. The unaccounted-for 49% was attributed to epiphytes and macrophytes. This study used great enterprise in the development of techniques for studying sedimentary oxygen demand. These will need to be followed up as the picture which they give of the mechanism of oxygen demand differs from that deduced from modelling studies.

The total carbon content of the sediments was low, being highest at the edges of the river.

(3) THE GROWTH OF *CERATOPHYLLUM DEMERSUM*

Ceratophyllum demersum is a rootless aquatic weed which has caused major problems in hydroelectric power stations.

It was found that the growth rate of this hydrophyte was proportional to the light intensity up to 8,000 lux. The upper limit of response to light was not determined.

Response to nitrate and phosphate was linear over the range 0–93 mg P/m³ and 0–336 mg N/m³ respectively. Interaction occurred. The maximum growth rate of *C. demersum* was at 220–250 mg P/m³. Growth inhibition occurred at higher phosphate levels. The plant was found to be unable to use bicarbonate directly for photosynthesis.

Interestingly, despite its lack of roots, the plant was found to grow more rapidly under low nutrient conditions if planted in mud. The plant accumulates nutrients when these are available, enabling it to continue to grow during periods of dearth. This makes it difficult to predict plant

growth responses to natural situations.

The work described proves an advance in our knowledge of the physiological requirements of *C. demersum*. Unfortunately, because of this plant's characteristics, they do not provide any obvious lead to management techniques.

CONTRACTS BEING NEGOTIATED

Slope Stability in Relation to the Soil Types, Rock Types, Clay Mineralogy and Geologic Structure in the Ohingaiti-Mangaweka-Utiku-Hihitahi Region, Rangitikei Valley: University of Auckland, Department of Geology

The aim of the study is to carry out detailed geological and pedological mapping, in situ field testing and laboratory analytical work on an area subject to serious and widespread slope failures in order to establish relationships between slope stability and rock type, soil type, clay mineralogy and detailed rock mass structure. Also to be investigated is the relationship of selected physical and mineralogical parameters in the rockmass and overlying soil to slope stability including measurement of in situ shear strength, field compressive strength, density, porosity, moisture content and permeability in near-surface layers.

Dispersion in Natural Rivers: University of Canterbury, Department of Civil Engineering

The question of how much pollution can be accepted by a river is largely unanswered. Dispersion is one of the processes whereby a pollutant is reduced to harmless concentrations in a river. When effluent is dispersed in a natural stream, roughness in the bed and embayments on the sides of the river cause existing theories of dispersion to be inapplicable for a considerable distance downstream. Also lower velocities in embayments lead to higher effluent concentrations in these embayments than in the main stream. This contract will study the effects of the above. The establishment of understanding for these will greatly aid the mathematical modelling of the dispersion processes.

Investigation into the Pollutational Contribution of Surface Water Drains in Christchurch: University of Canterbury, Department of Civil Engineering

There is overseas evidence that pollutational load contributed to receiving waters by storm water is of considerable importance but much of that evidence is conflicting because of frequent failure to differentiate

between combined and separate sewage systems. There is little information available in New Zealand on water quality aspects or urban hydrology. The proposal aims to estimate approximately the total likely pollutational loads of the drains in the Christchurch Drainage Board area.

Eutrophication of Lake Ellesmere – Investigation of Phytoplankton: University of Canterbury, Department of Botany

It is proposed to regularly sample, identify, and describe the phytoplankton population of Lake Ellesmere over a period of two years and carry out complementary bioassay studies to develop a better understanding of eutrophication processes in the lake. Lake Ellesmere was accorded a high research priority by the Officials Committee on Eutrophication. A lake research committee was set up under the aegis of the North Canterbury Catchment Board and both the committee and the board support this proposal.

Eutrophication of Lake Ellesmere – Preliminary Appraisal of Nature of Lake Sediments: Lincoln College, Department of Soil Science

The study proposes to sample and analyse sediments from selected areas and analyse these for physical and chemical characteristics with particular emphasis on the amounts and forms of phosphorus and other nutrients likely to affect the eutrophication of the lake. The aim of this preliminary study is to provide background information for decision on whether a more detailed study is warranted.

Nutrient Status and Primary Productivity of Hawkes Bay – Poverty Bay Coastal Waters with Particular Reference to Sewage Disposal from Marine Outfalls: University of Canterbury, Department of Zoology (Estuarine Research Unit)

The objective is to determine a nutrient budget for the coastal waters and to estimate the relative nutrient contribution from sewage outfalls and the rivers along the coast. Methods employed will assess hydrology, water chemistry, heavy metal concentrations,

chlorophyll, and primary productivity. The study will have relevance to future siting of marine outfalls and the degree of treatment that might be required.

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, Department of Soil Science

A preliminary survey has indicated that high groundwater nitrate levels in the Central Canterbury area may be significantly affected by leaching losses from agricultural land. This study will extend the survey to investigate nitrate – N, ammonium – N, and phosphate movement through deep soil profiles under four management systems on two soils of contrasting drainage status. It will also evaluate the extent of nitrate – N and phosphate movement through the soil profile to groundwater from an effluent disposal point source of high N and P content.

Methods of Enumerating and Identifying Coliform Bacteria with Special Reference to their Survival and Significance in the Assessment of Water Quality: Lincoln College, Department of Microbiology.

The work done on coliform organisms is very extensive but difficulties in arriving at dependable methods for identifying and enumerating them in relation to assessment of water quality still need to be solved. An effective study of this problem requires the development of techniques to enable the population being studied to be enumerated not merely to species but also to strain, and to investigate how far mutation or "training" adaptations are involved. The study proposes to examine some aspects of this problem.

Investigation of Water Flow and Sediment Movement in Step-pool Streams: Lincoln College, Department of Agricultural Engineering

The ability of streams in upper catchment areas to erode their banks is postulated as a fundamental factor in the processes of hill slope stability, sediment supply to streams, and river instability. The aim of the proposal 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 unsteady flows of both sediment laden and clear water. This will be supplemented by observations on a prototype stream in the field.

Soil Physical Properties Associated with Slip Erosion in Loess on Banks Peninsula: Lincoln College, Department of Soil Science

The aim of the study is to determine the physical properties of soils and develop

understanding of the causal factors for mass movements and tunnel gully erosion being predominant on west and east facing slopes of Banks Peninsula respectively. With pressures to extend urbanisation on to the area, development of causal factors will assist in better definition of areas at high risk. Present stability problems have led to the setting up of the Port Hills Scientific Co-ordination Committee to evaluate past and present research and to identify future research needs. This project will be of value to that committee and the local agencies.

The Regional and Economic Impacts of Government Irrigation Schemes: Lincoln College, Agricultural Economics Research Unit

Large scale irrigation schemes are currently evaluated in a narrow cost-benefit framework which does not recognise nor quantify either the effects such schemes may have on regional income or employment, or their potential contribution to the national economy. The study aims to identify and quantify the economic impacts of irrigation schemes (in the Lower Waitaki region) beyond the farm gate in terms of such parameters as gross output, employment, household income and overseas exchange.

Monitor Flows in the Kowai River and Groundwater in the Torlesse Catchment: Lincoln College, Department of Range Management

This contract is assisting a project designed to develop a predictive flood model for alpine catchments in particular. The value of the study will be enhanced if it can be extended out of the small Torlesse Catchment which is already being studied, into the larger Kowai River system. Manual measurement of groundwater in the Torlesse stream channel has indicated rapid changes in groundwater storage and that valuable information is being lost by the present observational programme. A continuous record of groundwater changes will be made to enhance the study.

Evaluation of Simple Biological Indices for Assessment of Water Quality and Organic Pollution of Streams and Rivers: University of Otago, Department of Zoology

This study derives from recommendations made to the Biological Standing Working Party of the Water Quality Research Committee. The objective is first to assess the value of three simple biological indices as indicators of water quality in a wide variety of streams and rivers throughout New Zealand. Secondly to derive the simplest, most easily repeated and standardised methods for sampling which yield results capable of interpretation for water quality assessments. The results will be of great assistance in establishing pro-

cedures for characterising the water quality status of streams and rivers.

Effects of Land Development and Fluctuations in Water Level on the Phytoplankton Productivity of Lake Mahinerangi: University of Otago, Department of Zoology

Lake Mahinerangi is a power supply reservoir. It was formed in 1923 and raised to its present level in 1946. A pine forest was

planted around the lower half of the lake more than 30 years ago and some logging has been done since 1970. The Department of Lands and Survey propose to develop about a third of the lake catchment for agricultural use, this to represent a 7-fold increase in area cultivated and a 14-fold increase in area oversown and topdressed. The objective is to study the relationship between land development and eutrophication of the lake as measured by phytoplankton productivity, chlorophyll, transparency, zooplankton and phytoplankton species, and concentrations of inorganic nutrients.

RESOURCE SURVEYS BY CATCHMENT BOARDS AND REGIONAL WATER AUTHORITIES

The resource survey programme commenced late 1975 with 1976/77 being its first full financial year. The surveys are to make quantitative assessment of resources or to measure response to treatments of resources. Catchment boards and regional water boards propose survey projects. Research and survey staff are responsible for the final decision as to whether they should be financed and hence initiated.

The following proposals are all ongoing surveys. Maximum survey duration is five years but many are for a shorter time.

Northland Catchment Commission

- (1) West Coast Dune Lakes
A water resources survey to establish a typical water balance for Lakes Taharoa, Kai Iwi and Waikare such that they can be managed as a water resource.
- (2) Public Water Supplies and Northland Catchment Commission Resource Data Collection
A water resources survey assessing low flows in drought conditions and base-flow recession to establish the potential for future public water supplies.
- (3) Water Quality Monitoring
A survey of fresh and saline water quality throughout the catchment commission area.
- (4) Northland East Coast Beach Surveys
In Bream Bay work is underway to determine the stability of the beach where development has occurred, to assess the dune and beach system for future development and to determine safe extraction rates for beach sand and shingle. Further work will involve surveying other east coast beaches. This is a joint project with Ministry of Works and Development, Auckland District.

Auckland Regional Water Board

- (1) Hoteo Water Resource Study
A water resource survey to evaluate the potential of the Hoteo Catchment for major urban and rural water supplies. It includes the evaluation of flood flows and the assessment of land capability for implementing soil conservation schemes.
- (2) Kaipara River System Water Resources Survey
A survey to assess the water resources of this catchment for future management.

Hauraki Catchment Board

- (1) Mamaku Water Resources
A survey to determine the resources of the Upper Waihou River and to determine what effect forestry operations have on the water resource.
- (2) General Hydrology
A continuing general program of hydrological data collection which will assist the Hauraki Catchment Board in managing the water resources of its district.
- (3) Water Quality Sampling
A survey to sample the quality of all the major waterways in the catchment board district.
- (4) Fluctuations in Ground Surface Levels and Drainage Patterns with Peat Mining Land Use.
A survey to determine the effect of peat mining on ground levels.

Bay of Plenty Catchment Commission

- (1) Investigation of Otakiri Artesian Basin
A survey to assess future management of the groundwater resource.

- (2) Coastal Erosion Survey
A survey to identify the areas of coastal erosion with a view to future development.
- (3) Whakatane River Channel Efficiency
To test efficiency and performance of major scheme works in the Whakatane River.
- (4) Underground Water Resources Bay of Plenty Coastal Area
To determine the resource of the underground water for management purposes.

Waikato Valley Authority

- (1) Peat Resource Assessment Survey
A survey to classify peat in the authority's area.
- (2) Maui Pipeline
Assessment and prediction of instability zones during the pipeline construction and site restoration difficulties between Mokau and Huntly.
- (3) General Hydrology
An on-going programme monitoring all major and some minor rivers in the authority's area.
- (4) Six projects evaluating catchment resources for catchment control and regional planning. The catchments are the Upper Waipa, the Paeroa Range, Lake Arapuni from Waipapa Dam to Arapuni Dam, Whangapoa, Upper Mangawara and Waitomo upstream of Waitomo Caves.

Poverty Bay Catchment Board

- (1) Catchment Monitoring Surveys
A study of the effect of changed land use, from pastoral to exotic forest, on channel morphology. The aim is to forecast the short and long term effects of changing land use on river control and roading structures.
- (2) River Shingle and Land Resource Assessment
A survey to determine the sand resources and the quantity of renewable river shingle in northern East Coast rivers.
- (3) Three land resource surveys to produce a recommended land use map for each of the Waingaromia, Ihungia and Waipiro catchments.

Hawke's Bay Catchment Board

- (1) Ahuriri Lagoon Development Scheme
A survey to determine resources for development in the lagoon area.
- (2) Wairoa Coastal Catchments Water Resources Survey
An assessment of the water resources available for soil conservation and flood control schemes between Wairoa and

Opoutama, including the control of Lake Whakaki.

- (3) Upper Tukituki River Channel Survey
To assess changes since the last survey in 1951 so that a catchment control scheme can be designed.
- (4) Ngaruroro River Channel Survey
To assess changes since the last survey in 1951 so that the effects of the Here-taunga Plains flood control scheme can be determined and also to assess available gravel resources.
- (5) Tutaekuri River Channel Survey
To assess changes since the last survey in 1951 with a view to gravel extraction management.

Taranaki Catchment Commission

- (1) Onaero-Mohakato Catchment Assessment Survey
To assess land use and erosion patterns by land use and land capability survey. Initiated after storm damage to the catchment in 1975.

Rangitikei-Wanganui Catchment Board

Two surveys are being carried out on the Rangitikei and Wanganui Rivers to prepare an integrated river works maintenance and water management plan, to protect the recreational and other values of the rivers.

Manawatu Catchment Board

Four surveys are underway, all with similar objectives. These are on the Upper Manawatu, Pohangina, Oroua and Otaki rivers. Each survey assesses the amount of bed material moved and the lateral and longitudinal variations in bed material composition. Suspended sediment movement as an indicator of catchment condition is being measured and the effect this has on control and/or channel training works is being analysed.

Wairarapa Catchment Board

- (1) Greytown Shallow Aquifer Investigation
This survey is investigating the quantity, quality and extent of the aquifer to assess its potential as a water supply for market gardens and orchards in the Greytown area.
- (2) Awhea and Opouawa Bed Surveys
This survey is measuring changes in the river channels using surveyed cross sections.
- (3) Ruamahanga River Water Quality and Quantity Surveys
These surveys are assessing the quality and quantity of the water resources of the Ruamahanga River for future management.

- (4) Wairarapa Water Region Pollution Monitoring
A survey to identify pollution problems in the Wairarapa region.

Wellington Regional Water Board

- (1) Whakatiki Catchment Water Resources
An assessment of the resources available in the Whakatiki catchment so that a proposed water supply/Hutt River low flow augmentation dam can be planned.
- (2) Orongorongo River Water Resources Survey
A survey of a catchment still in its natural state to enable the assessment of the water resources for future water supply purposes.
- (3) Mangaroa Black Swamp
This survey is studying the relationship between rainfall and runoff in swamp conditions and is also monitoring the water quality, with a view to possible future development.
- (4) Plimmerton Flax Swamp
This survey is monitoring the inflows and outflows of the swamp. The object is to provide management guidelines for urban development on land bordering the swamp. The effects on wildlife are also being studied.

Nelson Catchment Board

- (1) Brooklyn Catchment Requirement Survey
A full land inventory scheme is being carried out to assess erosion problems and identify requirements for the preparation of a catchment control scheme.
- (2) The Nelson board has five water resource surveys in action on the Motueka, Takaka, Waimea, Aorere and Moutere rivers. These are to measure the water resources available for multipurpose uses such as water supply, irrigation, recharge of underground water and flood control.

Marlborough Catchment Board

- (1) Mountain Lands Priority Assessment
The objective of this survey is to make a priority assessment of sub-catchments of the Wairau River in terms of conservation remedial treatments and the possible effect these treatments will have on the whole catchment. This is the final year of the survey and a full report is expected in mid-1978.
- (2) Wairau River Water Resources
This survey is being carried out in conjunction with a water allocation plan to determine the quantity and quality of the Wairau River for future management of the resource.

North Canterbury Catchment Board

- (1) Multi-purpose Hydrology Survey
A general data collection survey covering all aspects of hydrology in the North Canterbury Catchment Board area.
- (2) Lake Ellesmere – Eutrophication
This survey is the initial resource assessment of a much larger on-going proposal to determine the eutrophic status of the lake. The aim is to provide long term management measures necessary to prevent deterioration in the quality of the lake. The survey is measuring inflows and outflows, both saline and fresh, both underground and surface.
- (3) Port Hills Land Resource Survey
The survey has mapped (within the North Canterbury Catchment Board's area of the Port Hills) soil types, parent material, erosion and relative soil stability, to indicate to the various territorial local authorities (e.g. Christchurch City, Paparua County) areas where soils are likely to be unstable. This was done to a scale of 1:15840.
- (4) Amuri Range Land Resource
A survey to assess erosion problems and provide a land capability plan. It has also defined accurately the spread and extent of the noxious weeds gorse and broom and certain self sown species such as *Pinus nigra*, *Larix decidua* and *Pinus pinaster*.

Westland Catchment Board

- (1) Kongahu Swamp Scheme
This is a land use capability survey required for the preparation of farm plans. The plans will be used for the development of drainage schemes.
- (2) West Coast Forest Investigation
This survey is mapping logging operations and measuring sediment yields from areas where gravels and soils overlie sedimentary rocks.

South Canterbury Catchment Board

- (1) Tussock Country Trials
This survey is assessing long-term trends in the condition of tussock grasslands by comparing bare ground/vegetation relationships under present stocking methods and the effects of complete destocking. Results to date show that of 11 sites under study 6 show significant increases in the percentage cover of tussock and subsequent decrease in bare ground, four show an increase in litter with a decrease in bare ground and only one site shows a decrease in living vegetation. These sites are fenced enclosures within the stocked tussock areas. It is suggested that the

results are variable due to rainfall and that the increase of bare ground at the one site is due to local effects of stock movement and conglomeration.

(2) Sources of Sediment of Waihao River

The survey is assessing the type, magnitude and severity of sediment source (suspended and bedload) within the upper Waihao River. It will attempt to determine patterns of erosion and to define those areas with a high potential for future erosion.

Waitaki Catchment Commission

(1) Waitaki Catchment Land Resource Assessment

This survey is a land inventory, land capability and debris source survey in selected sub-catchments e.g. Diggers Gully, Awamoko, Elephant Hill catchments, to allow for full integration of land use with proposed river control works.

Otago Catchment Board

(1) Molyneux Bay Coastal Observations

An investigation survey on the sand movement and wave patterns of the Molyneux Bay to assess how the bay is formed.

(2) Lower Taieri River Multiple Use Survey

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

(3) Water Quality Monitoring

A general survey to cover all smaller catchments in the Otago Catchment Board's district not included in water allocation plan proposals. This includes Otago Harbour, coastal beaches near Dunedin, and the Lower Tokomairiro.

(4) Two land inventory surveys for the control or prevention of erosion on retired land. The ultimate aim is a management plan for the Makarora/Hunter Valley and the West Wanaka catchments.

(5) Condition and Trend Surveys

This survey is monitoring changes on areas of retirement or restricted grazing e.g. Ben Nevis, West Wanaka, Deep Stream, to obtain information concerning the rehabilitation of retired lands and the per-

centage increase in ground cover following recovery after severe burning or overgrazing.

Southland Catchment Board

(1) Pollution Survey Mataura River

A monitoring of pollution levels with particular reference to the location of dissolved oxygen sag points and BOD levels in the river. The aim is to evaluate recovery parameters of the river at summer low flows. Model data were supplied to Water and Soil Division, Ministry of Works and Development for dissolved oxygen concentrations. Flow in the 1977 low flow period was 50% higher than in 1976. Bacterial parameters for this period did not reach 1976 levels.

(2) Peat Resources Survey

This survey has mapped the location and extent of peat in Southland such that information is now available for development on the peatlands.

(3) Sand and Gravel Resource of Oreti River

This survey is determining the extent of the sand and gravel resource in the lower river and monitoring the rate of depletion and renewal. The survey has shown that the average bed level of the lower river has been degraded by 2 metres during the past 35 years.

(4) Beech Forest Erosion Survey

The survey is identifying areas of erosion and potential erosion under both virgin beech and logged conditions. It is mapping such parameters as slope, aspect, altitude, geology and existing erosion to provide guidelines for future forestry management.

(5) Makarewa and Oreti Rivers Pollution Survey

A survey to determine the extent and sources of pollution on these two rivers.

(6) Hamilton Burn Water Resources Survey

A general water resources survey with the particular objective of creating some form of water retention for water deficient periods of the year.

(7) Ground Water Survey

This survey is collating all known information on the location, depths, drawdown, geology and quality of existing wells in the Southland Plains. Once this information is obtained the resource will then be managed.

INTER-AGENCY CO-OPERATION

This is being steadily developed with particular emphasis on pooling of skills where particular problems or new lines of development have to be considered. Ad hoc groups who come together to do a particular job and then disband can be particularly effective and establish a basis for long term co-operation.

Water Quality Research Committee

The Water Quality Research Committee was established to co-ordinate and review water quality research and ensure there was effective dissemination of information concerning that research. There are currently representatives from the New Zealand Manufacturers' Federation, Catchment Authorities Association, New Zealand Electricity Department, Ministry of Agriculture and Fisheries, Chemistry Division of DSIR, the universities, Water and Soil Division, and the Department of Health. The committee is responsible to the Water Resources Council and also reports to National Research Advisory Council through the Water Resources Council.

The committee has examined the questions of microbiological water testing in New Zealand; research requirements on the water quality needs of freshwater fisheries and the role of the universities in research contracts. It has also considered the financing of conferences relating to water quality, and a number of other proposals relating to water quality research such as data archiving and multiple use classifications of New Zealand lakes. An ad hoc interdepartmental committee also met to discuss the habitat requirements of freshwater fish.

Two standing working parties of the committee – biological and chemical – have been established.

(a) Biological standing working party

This working party has representatives from the universities, the Ministry of Agriculture and Fisheries, Water and Soil Division, and the Department of Health. Members have prepared a series of reports on biological aspects of water quality. A survey of microbiological water testing has also been carried out. It is intended that the working party should formulate a handbook of biological methods relating to water quality.

(b) Chemical standing working party

This working party has representatives from Water and Soil Division; Chemistry Division; Soil and Field Research Organisation, MAF; Institute of Nuclear Sciences, DSIR; New Zealand Forest Products; and Ecology Division, DSIR. The committee

has recently been concerned with laboratory surveys, reference methods for the analysis of chemical species in water, water quality parameters and sampling techniques.

Joint Working Party on Land Use and its Effects on Water

This working party is jointly sponsored by the Officials Committee on Eutrophication and the Water Resources Council. Members include representatives from Water and Soil Division, MAF, Soil Bureau of DSIR, Tussock Grasslands and Mountain Lands Institute, Forest Research Institute, Ecology Division of DSIR, and the universities.

The working party was set up to collect information of a technical nature which would be used by organisations responsible for research and management of land and water resources to set research priorities and guide land management decisions.

Members of the working party have prepared papers on the various aspects of land use and its effects on water – particularly relating to agricultural, forestry and urban land use. It is intended that the working party will produce a publication detailing current knowledge, which would be of use to management.

Waikato River Technical Study Group

Members of the group include representatives from Water and Soil Division, Waikato Valley Authority, Auckland Regional Authority, and Auckland and Waikato Universities. The group is currently engaged in 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.

Lake Rotorua Scientific Co-ordinating Committee

This committee was established under the auspices of the Water Resources Council and reports to the Bay of Plenty Catchment Commission. The manager of water quality, Water and Soil Division, is the chairman. Representatives of DSIR – Freshwater Section of Ecology Division, MAF – Fisheries Research, Health Department – Public Health Engineer, MWD – Public Health Engineer, Bay of Plenty Catchment Commission – Engineer, and of Internal Affairs – Wildlife Division, are members.

The committee's activities for 1977 include: deoxygenation, denitrification and algae nitrogen fixation studies by Fresh Water Sect-

ion of Ecology Division, DSIR; looking into the possibility of setting up a pilot plant to investigate the effect of harvesting aquatic weeds on nutrient stripping by the Bay of Plenty Catchment Commission; fish studies, algal productivity studies, monitoring Lake Rotorua at fixed stations for various parameters by Fisheries Research Division, MAF; monitoring dissolved oxygen levels, catchment mapping and regular chemical sampling by Water and Soil Division.

Tissue Culture for Propagation of Poplars and Other Woody Species with Potential for Erosion Control

The working party under the chairmanship of Mr I J Warrington, Plant Physiology Division, DSIR, presented its final report early in 1977. The working party comprised representatives of Water and Soil Division, Plant Physiology Division, Rangitikei-Wanganui and Wairarapa Catchment Boards and the Horticulture Department of Massey University.

After consideration of the report the Soil Conservation and Rivers Control Council approved the establishment at the Aokautere Science Centre of a pilot tissue culture unit. This will have an initial capacity of 200,000 plantlets per annum. Until such time as full facilities and staff are available only a limited amount of material produced by this method will be available. Provision is also being made for the development of appropriate nursery handling procedures, plant container technology and field establishment techniques for rooted saplings in the programme of the Aokautere Science Centre.

It is also planned to arrange for complementary work to be carried out under contract by appropriate university departments and for co-operative trials to be established with adjacent catchment boards as soon as possible.

It is anticipated that close contact with the tissue culture group of Plant Physiology Division will be maintained and that this group will operate in an advisory and supervisory role for the propagation unit at the Aokautere Science Centre. It is hoped that Plant Physiology Division will also continue and preferably expand its research and development work on tissue culture propagation of those species for which the technique has yet to be fully developed or tested.

Grazeable Grasses and Legumes for Erosion Control

A group under the convenorship of Dr B.J. Molloy, Botany Division, are examining the requirements for development of grazeable grasses and legumes on various sites throughout the country. Representatives are from the Botany and Grassland Divisions, DSIR; Soil and Field Research Organisation, MAF; Forest Research Institute; Tussock Grasslands and Mountain Lands Institute; Water and Soil Division. The first meeting of the group was held in October 1977.

Hydrological Instrumentation

The working party, chaired by Mr M Collins, a Divisional Head at Physics and Engineering Laboratory, DSIR, comprised representatives of Water and Soil Division, other Ministry of Works and Development divisions, catchment boards and DSIR.

The working party set up in 1976 has now presented its final report. Major recommendations of the report centre around the need to move to fully telemetered hydrological data acquisition accompanied by automatic data processing systems. The report is being studied by Water and Soil Division staff.

PUBLICATIONS

To ensure that papers prepared by research and survey staff are of a high standard of presentation and quality, new arrangements for the internal refereeing and editing of these prior to submission to an outside journal or publication in the organisation's publication series were implemented during the year.

Papers published with research and survey staff as authors or co-authors are listed below. In addition to these a further 18 papers have been approved for submission to nominated journals.

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