New Zealand Hydrological Society: the first 50 years, 1961-2011 with reports on New Zealand hydrology through the ages

Compiler: Lindsay Rowe

Preface

President's Introduction

Joseph Thomas

November 2011

It is my privilege to be able to contribute this introduction to this publication to celebrate the 50 year milestone of the New Zealand Hydrological Society. A tremendous amount of work has gone in over the last few years on this endeavour. I would like to acknowledge and compliment Lindsay Rowe on the work in contributing to this, as well as co-ordinating the other contributing authors. A word of thanks also to all the contributing authors, as this would not be possible without you.

The Society can be proud of its achievements over the last 50 years. Our Journal has endured and is a valued publication of the Society. The Society has grown significantly since it was founded, with now close to a total of 600 members in various membership categories. The Society continues to actively promote its mission to 'further the science of hydrology and its application to the understanding and management of New Zealand's water resources'. Our other publication, the newsletter *Current*, continues to be published twice yearly and keeps our membership informed of various issues and happenings in areas of hydrology.

Publication of the journal and *Current* could not be possible without the dedicated efforts of our editor and also the efforts of the contributors. I would like to acknowledge all the editors of the Society from its inception – Pat Grant, Dave Murray, Alistair McKerchar, Tim Davies, Bob Spigel, Mike Stewart, Rick Jackson, Paul Mosley and our current editor Richard Hawke for the efforts – thank you! A special acknowledgment and thank you is extended to Eileen McSaveney, the Society's Assistant Editor since 1979.

Enjoy this publication and hopefully it provides an opportunity to reminisce about our past and also provide newer members an insight to some of the history of the Society.

Editor's Introduction

Richard Hawke

November 2011

It is my pleasure to be associated with this 'special publication' of the New Zealand Hydrological Society. As editor of the Journal of Hydrology (New Zealand) for the past eight years, I have had the pleasure of communicating with a large number of the Society's members and reading manuscripts on a wide range of topics. From relatively humble beginnings through to the end of 50 years (see page 41) the Society has now published well over 500 papers (the recent annual average has been approximately eight). Many more manuscripts have been read, reviewed and returned to authors for their reconsideration.

While technology has made publication easier, technology cannot replace all the hours invested by authors and reviewers before the final product is produced. I still hear authors say publication in the *Journal* can be more difficult than some of the more prominent international journals. Having recently watched as a number of journals, particularly local ones, struggle to survive, the Society should continue to be proud of its *Journal*. Of course, the form of the *Journal* has changed over 50 years and I know change will continue. But, given the Society's mission, I hope production of a *Journal* continues.

Of behalf of all the editors of the *Journal* I would like to thank all the authors and reviewers for their support. I would also like to acknowledge the commitment of Eileen McSaveney and Jo Dickson to continuing the proud tradition of producing a high quality *Journal.* Finally, can I encourage all members of the Society to actively consider contributing to the *Journal* and the Society's newsletter *Current*.

Compiler's Introduction

Lindsay Rowe

November 2011

The New Zealand Hydrological Society was established in 1961 with 8 members and has grown over 50 years to about 600 members. This volume is in recognition of 50 years of achievement by the Society's officers and members. In 2010, the Executive approved the compilation of this book, based on draft papers that were started several years ago (not long after our 40th anniversary) and brought up to date here.

In addition, members were asked to nominate and provide brief portraits of some of the characters who have had an impact on New Zealand hydrology and/or the New Zealand Hydrological Society, and to provide photos of hydrological structures and events. Space constraints meant that not all deserving candidates or photos could be included. As compiler, I made the final selections, so the responsibility for omissions lies with me. Many of these portraits have been paraphrased from articles in the Journal of Hydrology (New Zealand) or *Current* (the Society newsletter) and embellished by contemporaries; others have been specifically written by colleagues.

Acknowledgements

Many people have assisted in this compilation. My grateful thanks go to the authors (Horace Freestone, Lindsay Rowe, Alistair McKerchar, John Waugh and Alasdair Keane) for updating previously submitted material and to those who commented on the papers. I wish to express my thanks to the many people who have contributed to the brief pen portraits of those who have influenced New Zealand hydrology, or provided photos. Eileen McSaveney has done her usual stirling job of editing the contributions, Richard Hawke has coordinated the preparation of the volume, and Jo Dickson put the whole booklet into shape; my thanks to you all.

The New Zealand Hydrological Society: the first 50 years

Horace Freestone[1] and Lindsay Rowe[2]

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Introduction

While hydrological measurements were first collected back in the 1890s (lake level for Lake Coleridge) and hydroelectric and irrigation investigations were undertaken through to the 1930s (Waugh and McKerchar, this volume), hydrology in New Zealand started to be identified as an entity with the introduction of the Soil Conservation and Rivers Control Council Act in 1941. However it was not until 1949 when the first Hydraulic Survey Parties were established that any specialist national activity got underway. By 1961 there was a growing group of people, working in Ministry of Works Hydraulic Survey Parties and in Catchment Boards/Commissions, who practised hydrology.

Also in 1961, Horace's boss at the time, Herman Drost (the leader of the Whangarei Hydraulic Survey of the Ministry of Works (MoW)) headed south for a mysterious technical meeting. Prior to that meeting there had been correspondence between Kees (Cornelis) Toebes and Pat Grant about the formation of an association of hydrologists. A note from Kees to Pat dated 6/6/61 (Fig. 1) included:

> *The course is going to be at Ardmore – no change is possible. We should discuss an ass. of hydrologists then. Most if not all clients will be there.*

The course was to be on 23 August to 1 September. A follow-up letter dated 15/8/61 (Fig. 2) includes:

> *Dear Pat.*
> *'Hydrology Association'*
> *I have had some further thoughts on this matter and I think we should just have a meeting of the established hydrologists – viz –*
> *P. Grant.*
> *H. Drost.*
> *G Ridal (sic)*
> *Ian Simmers.*
> *C. Toebes.*
> *A.C. Hopkins.*
> *W.B. Morrissey.*
> *E.J. Speight (John)*

So, it was at that meeting at Ardmore that the Society was born on 25 August 1961 with those eight hydrologists as the founding members (Grant, P. 1971: Editorial: The New Zealand Hydrological Society. *Journal of Hydrology (New Zealand) 10(2)*: 97-99).

The 'awakening' of hydrology in New Zealand in 1961 was therefore two-fold, with the New Zealand Hydrological Society being formed and the first formal technical procedures in hydrology being used in New Zealand as part of 'The Handbook of Hydrological Procedures'.

The Society was formed as a means of pulling together the various practitioners from several organisations. In this form it was intended that a specialist hydrology environment would be developed. The objectives of the new Society were simple, but the undertaking ambitious. Initially just

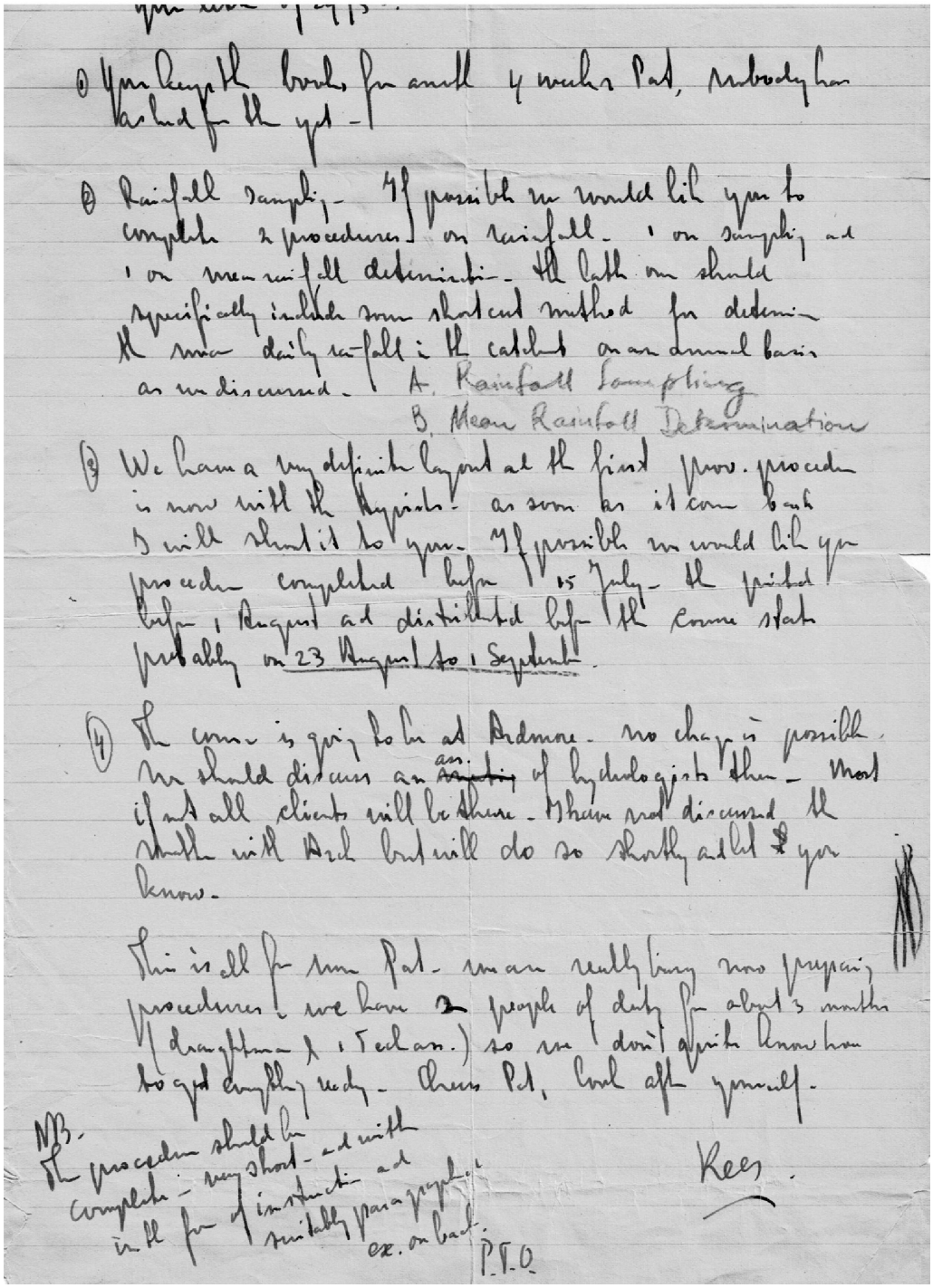
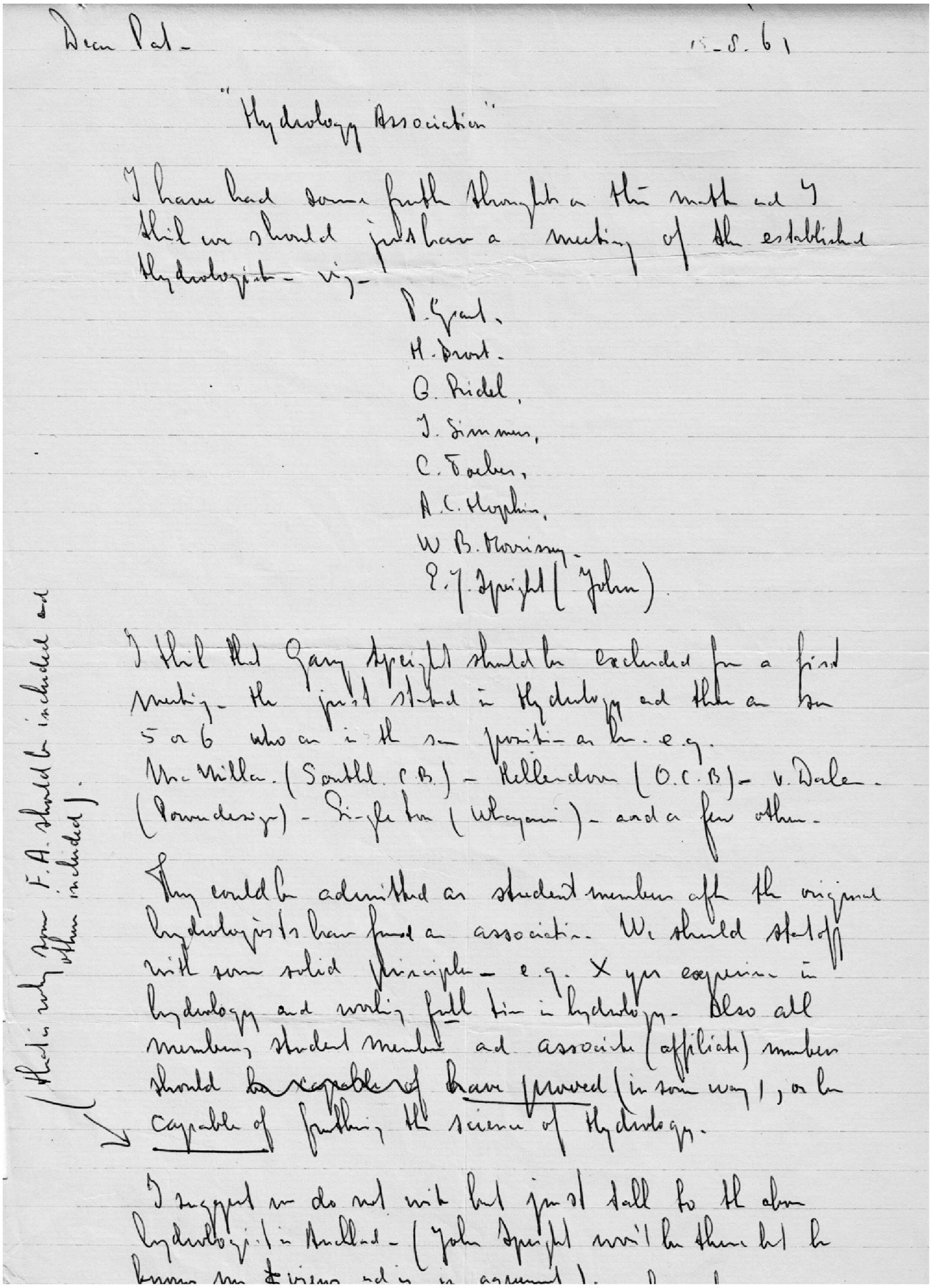


Figure 1 - Part of a letter from Kees Toebes to Pat Grant dated 6/6/1961. Item 4 refers to the formation of an association of hydrologists.


Dear Pat - 15-8-61

"Hydrology Association"

I have had some further thoughts on this matter and I think we should just have a meeting of the established hydrologists - viz -

P. Grant,
H. Drost -
G. Ridel,
I. Simmers,
C. Toebes,
A.C. Hopkins,
W.B. Morrison -
E.J. Speight (John).

I think that Gary Speight should be excluded for a first meeting - he just started in Hydrology and there are some 5 or 6 who are in the same position as him. e.g.
McMillan (Southl. C.B.) - Hellendoorn (O.C.B.) - v. Dale - (Roundesign) - Singleton (Whangarei) - and a few others.

They could be admitted as student members after the original hydrologists have formed an association. We should start off with some solid principles - e.g. X years experience in hydrology and working full time in hydrology. Also all members, student members and associate (affiliate) members should ~~be capable of~~ have proved (in some way), or be capable of furthering the science of Hydrology.

(That is why you F.A. should be included and others included).

I suggest we do not write but just talk to the above hydrologists in Auckland - (John Speight won't be there but he knows ...

Figure 2 – Part of a letter from Kees Toebes to Pat Grant dated 15/8/1961 suggesting who should be involved in the initial meeting.

eight people set out to build a society, hold symposia and produce a journal. All this on a voluntary basis! In his first presidential address via the journal, Kees Toebes noted that '*Hydrology is not always considered a science*'. In the years to come the Society would place a lot of emphasis on establishing a platform for creating excellence and promoting hydrology as a science.

It is often said that many things start with small beginnings. While the New Zealand Hydrological Society started with eight members, the first list published in the first issue of the Journal of Hydrology in June 1962 contained 75 names within three categories: members, affiliate members and student members. As of 31 May 1963 the number of members stood at 123. The Society was still a fledgling, but momentum was growing and membership reached the high 400's in the 1970s. It stayed fairly steady until the late 1980s when there were major changes to New Zealand's research organisations and catchment authorities. These changes resulted in a significant loss of jobs and a subsequent drop in Society membership. From about 2000, there has been a resurgence in membership, with numbers climbing to 580 in 2010, showing the importance of hydrology in all its facets in today's world (Fig. 3). It is fair to say that those original members would probably be more than a little surprised to see what the small beginnings in 1961 has led to in 2011 and the range of activities undertaken in the years in between. They would also be surprised to see that three members they recruited in 1962, George Caddie, Jolyon Manning and Peter Thompson, were still members 49 years later.

Allied, and more tightly focussed, societies such as the Meteorological Society of New Zealand (MetSoc) and the New Zealand Limnological Society (LimSoc, now The New Zealand Freshwater Sciences Society, NZFSS) have been formed since the New Zealand Hydrological Society started and we have cordial relationships with them, as demonstrated by joint conferences.

The new Society

As noted above, the Society was established on 25 August 1961. At further meetings that month, the eight founders determined rules

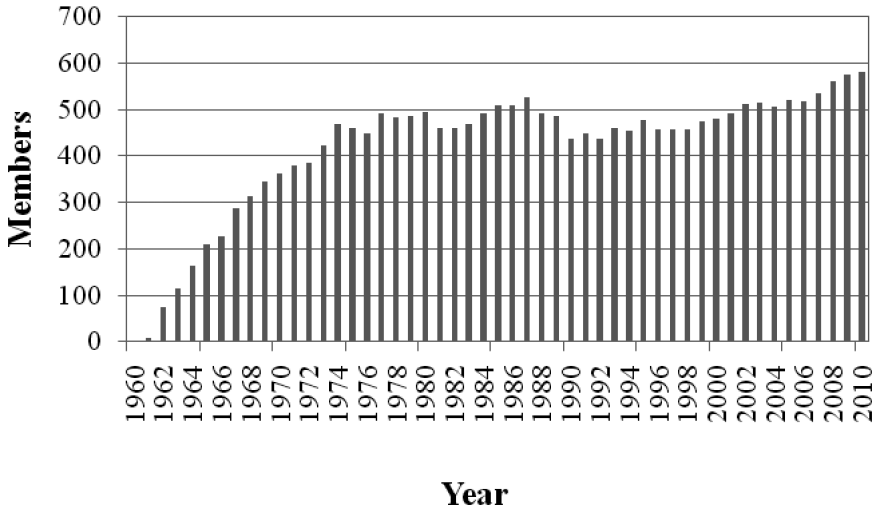


Figure 3 – Society membership numbers

on membership, and decided to publish a journal or newsletter (Grant, *loc. cit.*). The first AGM was held in Christchurch on 9 December 1963 when the first set of rules was adopted; 20 members were present. These rules provided for the following:

- Officers to be president, secretary/treasurer, editor, assistant editor;
- Committee of six members;
- Four membership classes: members, affiliate members, corporate members and student members;
- The committee to provide a balance sheet and statement of accounts;
- An honorary auditor (not a member of the Society);
- The holding of at least one general meeting each financial year.

This proper structuring of the New Zealand Hydrological Society with an Annual General Meeting and the election of officers has ensured that the Society was not born of a whim, only to die out as the initial wave of enthusiasm passed by. The wisdom shown by original founding members has ensured that the society is as strong as it is today.

Initially, members had to be actively involved in the science of hydrology; affiliate membership covered most others. As time has gone on, this differentiation has been relaxed so that an ordinary member shall be a person with an interest in hydrology and in furthering the science thereof. The rules were later modified to allow for branches of the Society to be formed. We do not intend to cover a history of branches here, except to note that branches in Christchurch and Hamilton were formed in the late 1960s and operated until the mid-1970s. The rules have changed little since, just tweaked to cover changes in procedures as society has changed.

When the Society began, the President had to be a hydrologist. This was changed in 1970 to allow non-hydrologists to take office. At the same time the term of office was extended to two years, with half of the officers being replaced each year, as still happens today. In November 1976, new rules were adopted to enable the Society to become The New Zealand Hydrological Society Incorporated, this being approved on 5 January 1977. The new category of Honorary Life Membership was created in 1980, a year in which a logo was designed for the Society. The Secretary/Treasurer position was split in 1995.

As the workload of the Committee grew, there has been a progression towards paying for administrative work. 1994 was the first year in which an honorarium was paid to the secretary/treasurer's assistant and in 1999 a part-time administrative position was established. Editorial assistance and compilation of Current have also been remunerated.

The Society's officers

Kees Toebes was the first president of the New Zealand Hydrological Society, Ian Simmers the first secretary/treasurer and Pat Grant the first editor of the Journal. These three, together with Barry Morrissey, Herman Drost, A.C. (Hoppy) Hopkins, Geoff Ridall and John Speight, were the first committee of the Society (1961 to 1963). Toebes, Grant and Simmers held their positions for at least 12 years and served on the committee for more years after relinquishing their offices. A full list of presidents, editors, secretaries, treasurers and committees has been compiled from available minutes, annual reports and the Journal (Tables 1 and 2).

The Society has had a stable officer base throughout its 50-year history; 12 presidents, 12 secretaries, 8 treasurers (all of whom held the secretary positions in the era to 1994 after which the roles were split) and 9 editors. The

longest serving member on the Committee has been Lindsay Rowe, 22 years with 21 as secretary/treasurer and then as treasurer. Horace Freestone (18), Ian Simmers (17), Kees Toebes (14), Pat Grant (14), Maurice Duncan (14), Andrew Fenemor (13), Jack Coulter (12), Barry Fahey (12), Paul Mosley (12), Gillian Crowcroft (11) and Charles Pearson (10) have been other long-serving members. All of the 85 committee members have contributed as unpaid voluntary workers. There has, however, been support from employers over the years and this has allowed the Society to help maintain its influence on New Zealand hydrology.

The first three presidents have passed away but their legacy is a Society that is being run today with the same enthusiasm with which it started.

Journal of Hydrology (New Zealand)

One of the aims of the Society's founders was to publish a scientific journal. The first issue of the Journal of Hydrology (JoHNZ), Volume 1 (1), consisted of 20 pages and was published in June 1962. It contained papers from the Hydrology Symposium held as part of the Annual Conference of the Meteorological Service in November 1961. It was printed by Photolithox Printing Ltd, Hastings at a cost of £17.10. Issue 2 expanded to 58 pages and cost £33, which was of concern for a fledgling organisation with limited members and budgets. The editor, Pat Grant, also expressed concerns about material arriving late, being poorly presented with the need for severe editing, and meeting publishing deadlines. He also noted

> '*that no one editor could, on his own, satisfactorily cope with more than two numbers per year – the time demanded is too great*'

– views no doubt held by subsequent editors.

In 1963, the North-Holland Publishing Co. Amsterdam published the first issue of their 'Journal of Hydrology'. Although the Society's Journal of Hydrology was the first to be published, the Committee decided to add 'New Zealand' to the title from Volume 3 (1) to avoid confusion when referencing papers. This year also saw an improvement in quality, with the change from low-standard offset printing to letterpress printing on high quality paper. This was a fairly logical upgrade, given the illustrative material used in hydrological papers. Volume 3 (1) also contained the first International Hydrological Decade Bulletin.

A number of special or theme issues have been produced:

- Volume 6 (2) 1967: Papers from 'Symposium on catchment characteristics and streamflow'.
- Volume 9 (2) 1970: This issue carried papers from the International Association of Scientific Hydrology symposium on 'The results of research on representative and experimental basins' held in Wellington during December 1970 that were not in the symposium volume.
- Volume 20 (1) 1981: Extra papers from the International Association of Scientific Hydrology Symposium on 'Erosion and sediment transport in Pacific rim countries' held in Christchurch during January 1981.
- Volume 26 (1) 1987: Bedload transport in gravel channels. M.A. Carson and G.A. Griffiths.
- Volume 35 (2) 1996: Hydraulic modelling of braided river-bed rivers. J. Warburton (Editor).
- Volume 50 (1) 2011: Sediment flux, morphology and river management. S. Coleman and G. Brierley (Editors)

Producing 100 issues of JoHNZ represents a huge effort by hardworking editors, assistant editors and, of course, the authors and the many reviewers who help maintain

Table 1 – Officers of the Society

AGM year	President	Secretary	Treasurer	Editor
1961	Kees Toebes	Ian Simmers	Ian Simmers	Pat Grant
1962	Kees Toebes	Ian Simmers	Ian Simmers	Pat Grant
1963	Kees Toebes	Ian Simmers	Ian Simmers	Pat Grant
1964	Kees Toebes	Ian Simmers	Ian Simmers	Pat Grant
1965	Kees Toebes	Ian Simmers	Ian Simmers	Pat Grant
1966	Kees Toebes	Ian Simmers	Ian Simmers	Pat Grant
1967	Kees Toebes	Ian Simmers	Ian Simmers	Pat Grant
1968	Kees Toebes	Ian Simmers	Ian Simmers	Pat Grant
1969	Kees Toebes	Ian Simmers	Ian Simmers	Pat Grant
1970	Kees Toebes	Ian Simmers	Ian Simmers	Pat Grant
1971	Kees Toebes	Ian Simmers	Ian Simmers	Pat Grant
1972	Kees Toebes	Ian Simmers	Ian Simmers	Pat Grant
1973	Geoff Ridall	Ian Simmers	Ian Simmers	Dave Murray
1974	Geoff Ridall	Lew Wells	Lew Wells	Dave Murray
1975	Geoff Ridall	Graeme Martin	Graeme Martin	Dave Murray
1976	Geoff Ridall	Graeme Martin	Graeme Martin	Dave Murray
1977	John Hayward	Graeme Martin	Graeme Martin	Dave Murray
1978	John Hayward	Judy Lawrence	Judy Lawrence	Alistair McKerchar
1979	John Hayward	Wayne Russell	Wayne Russell	Alistair McKerchar
1980	John Hayward	Wayne Russell	Wayne Russell	Alistair McKerchar
1981	Graeme Martin	Wayne Russell	Wayne Russell	Alistair McKerchar
1982	Graeme Martin	Wayne Russell	Wayne Russell	Tim Davies
1983	Dave Murray	Dave Brash	Dave Brash	Tim Davies
1984	Dave Murray	Dave Brash	Dave Brash	Tim Davies
1985	Andy Pearce	Dave Brash	Dave Brash	Tim Davies
1986	Andy Pearce	Tony Dons	Tony Dons	Tim Davies
1987	Ian Owens	Tony Dons	Tony Dons	Tim Davies
1988	Ian Owens	Tony Dons	Tony Dons	Tim Davies
1989	Ian Owens	Lindsay Rowe	Lindsay Rowe	Bob Spigel
1990	Paul Mosley	Lindsay Rowe	Lindsay Rowe	Bob Spigel
1991	Paul Mosley	Lindsay Rowe	Lindsay Rowe	Bob Spigel
1992	Paul Mosley	Lindsay Rowe	Lindsay Rowe	Bob Spigel
1993	Paul Mosley	Lindsay Rowe	Lindsay Rowe	Mike Stewart
1994	Paul Mosley	Lindsay Rowe	Lindsay Rowe	Mike Stewart
1995	Paul Mosley	Barry Fahey	Lindsay Rowe	Mike Stewart
1996	Andrew Fenemor	Barry Fahey	Lindsay Rowe	Mike Stewart
1997	Andrew Fenemor	Barry Fahey	Lindsay Rowe	Rick Jackson
1998	Andrew Fenemor	Barry Fahey	Lindsay Rowe	Rick Jackson
1999	Andrew Fenemor	Christina Robb	Lindsay Rowe	Mike Stewart
2000	Paul White	Christina Robb	Lindsay Rowe	Mike Stewart
2001	Paul White	Christina Robb	Lindsay Rowe	Paul Mosley
2002	Paul White	Christina Robb	Lindsay Rowe	Paul Mosley
2003	Paul White	Christina Robb	Lindsay Rowe	Richard Hawke
2004	Paul White	Christina Robb	Lindsay Rowe	Richard Hawke
2005	Paul White	Gil Zemansky	Lindsay Rowe	Richard Hawke
2006	Tim Davie	Gil Zemansky	Lindsay Rowe	Richard Hawke
2007	Tim Davie	Joseph Thomas	Lindsay Rowe	Richard Hawke
2008	Tim Davie	Joseph Thomas	Lindsay Rowe	Richard Hawke
2009	Tim Davie	Joseph Thomas	Lindsay Rowe	Richard Hawke
2010	Joseph Thomas	Gil Zemansky	Mike Ede	Richard Hawke

Table 2 – Committee/Executive of the Society

1961	Barry Morrissey A C Hopkins	Herman Drost	Geoff Ridall	E J Speight
1962	Barry Morrissey A C Hopkins	Herman Drost	Geoff Ridall	E J Speight
1963	Barry Morrissey A C Hopkins	Joe Finkelstein Geoff Ridall	Brian Douglas Arved Raudkivi	E J Speight
1964	Barry Morrissey A C Hopkins	Joe Finkelstein Geoff Ridall	C Warner	J Darwin
1965	Barry Morrissey A C Hopkins	Joe Finkelstein Geoff Ridall	C Warner	J Darwin
1966	Barry Morrissey A C Hopkins	Joe Finkelstein Geoff Ridall	A Pritchard Gary Blake	J Darwin
1967	Barry Morrissey A C Hopkins	George Caddie Jane Soons	Rick Jackson Jack Coulter	A Pritchard
1968	Barry Morrissey A C Hopkins	George Caddie Gary Blake	Rick Jackson Jane Soons	Jack Coulter A Pritchard
1969	A C Hopkins Rick Jackson	Gary Blake Geoff Ridall	Jane Soons	Jack Coulter A Pritchard
1970	John Hayward Rick Jackson	Gary Blake Geoff Ridall	Jane Soons A C Hopkins	Jack Coulter A Pritchard
1971	John Hayward Dave Murray	Gary Blake Geoff Ridall	Herman Drost Jane Soons	Jack Coulter A Pritchard
1972	John Hayward Geoff Ridall	Dave Murray Gary Blake	Herman Drost Jane Soons	Jack Coulter A Pritchard
1973	John Hayward Kees Toebes	Pat Grant Gary Blake	Herman Drost	Jack Coulter A Pritchard
1974	John Hayward Kees Toebes	Pat Grant Gary Blake	Ian Simmers M Willcocks	Jack Coulter A Pritchard
1975	John Hayward John Waugh	Jack Coulter	Ian Simmers Pat Grant	A Pritchard M Willcocks
1976	John Hayward John Waugh	Jack Coulter	Ian Simmers C Hovey	M Willcocks
1977	John Waugh Geoff Ridall	Frank Scarf Jack Coulter	Ian Simmers C Hovey	M Willcocks
1978	John Waugh Geoff Ridall	Frank Scarf Jack Coulter	Dick Martin Graeme Martin	Horace Freestone Pete Smith (Co-opt)
1979	John Waugh Paul Williams	Andy Pearce Frank Scarf	Dick Martin Graeme Martin	Horace Freestone
1980	John Waugh Paul Williams	Andy Pearce Frank Scarf	Brian Kouvelis (Knowles) Graeme Martin	Horace Freestone
1981	Maurice Duncan Paul Williams	Andy Pearce Hugh Thorpe	Brian Kouvelis (Knowles) Paul Mosley	Horace Freestone
1982	Maurice Duncan Paul Williams	Andy Pearce Hugh Thorpe	David Hamilton Dave Murray	Horace Freestone
1983	Maurice Duncan Paul Williams	Andy Pearce Hugh Thorpe	David Hamilton Derek Goring	Horace Freestone
1984	Maurice Duncan Paul Williams	Andy Pearce Hugh Thorpe	David Hamilton Derek Goring	Horace Freestone
1985	Maurice Duncan Paul Dell	Tony Dons John Waugh	David Hamilton Derek Goring	Horace Freestone

1986	Maurice Duncan Paul Dell	John Waugh	Dave Stewart Barry Fahey	Horace Freestone Dave Brash
1987	Maurice Duncan Paul Mosley	Andrew Fenemor	Dave Stewart Barry Fahey	Horace Freestone Dave Brash
1988	Maurice Duncan Paul Mosley	Andrew Fenemor	Dave Stewart Barry Fahey	Horace Freestone Lindsay Rowe
1989	Maurice Duncan Paul Mosley	John Waugh Andrew Fenemor	Dave Stewart Barry Fahey	Horace Freestone
1990	Maurice Duncan Mike Stewart	Andrew Fenemor	Jack McConchie Barry Fahey	Horace Freestone Earl Bardsley
1991	Maurice Duncan Mike Stewart	Andrew Fenemor	Jack McConchie Barry Fahey	Horace Freestone Earl Bardsley
1992	Maurice Duncan Mike Stewart	Andrew Fenemor	Jack McConchie Barry Fahey	Horace Freestone Earl Bardsley
1993	Maurice Duncan Jim Price	Michelle Keyte Andrew Fenemor	Jack McConchie Barry Fahey	Horace Freestone
1994	Jim Price Michelle Keyte	Andrew Fenemor	Jack McConchie Paul White	Horace Freestone Maria Greer
1995	Jim Price	Andrew Fenemor	Jack McConchie Paul White	Horace Freestone Maria Greer
1996	Gillian Crowcroft Jim Price	Paul Mosley Mark Stringfellow	Charles Pearson Paul White (co-opt)	Viv Smith
1997	Gillian Crowcroft Mark Stringfellow	Paul Mosley	Charles Pearson Paul White	Viv Smith
1998	Stephanie Bowis Gillian Crowcroft	Bettina Anderson	Charles Pearson Paul White	Viv Smith
1999	Stephanie Bowis Paul White	Bettina Anderson	Charles Pearson Gillian Crowcroft	Carolyn Ingles
2000	Martin Doyle Richard Little	Bettina Anderson	Charles Pearson Gillian Crowcroft	Carolyn Ingles
2001	Martin Doyle Richard Little	Bettina Anderson	Charles Pearson Gillian Crowcroft	Geoff Wood
2002	Martin Doyle David Leong	Phoebe Loris	Charles Pearson Gillian Crowcroft	Geoff Wood
2003	Martin Doyle David Leong	Phoebe Loris	Charles Pearson Gillian Crowcroft	Andrew Jones
2004	Graeme Horrell David Leong	Lucy McKergow	Charles Pearson Gillian Crowcroft	Andrew Thomas
2005	Graeme Horrell David Leong	Lucy McKergow	Charles Pearson Gillian Crowcroft	Joseph Thomas
2006	Paul White Mike Ede	Lucy Kergow	Charles Pearson Gillian Crowcroft	Joseph Thomas
2007	Paul White Mike Ede	Lucy Kergow	Charles Pearson Ed Brown	Jon Williamson
2008	Asaad Shamseldin Mike Ede	Raelene Hurndell	Charles Pearson Ed Brown	Jon Williamson
2009	Asaad Shamseldin Mike Ede	Raelene Hurndell	Gil Zemansky Ed Brown	Jon Williamson
2010	Ross Woods Sam Trowsdale	Raelene Hurndell	Carl Steffens Ed Brown	Jon Williamson

the quality of the Journal. Eileen McSaveney was appointed as the Assistant Editor in 1979, a position she still holds today. Cliff Press, Deslandes and The Caxton Press have been our printers.

Symposia

The second major aim of the Society's founders was to hold an annual symposium. In its formative years, the Society symposia were held as part of Meteorological Service or Soil Conservation and Rivers Control Council meetings. The first meeting was convened less than three months after the Society was formed. Each symposium represents considerable effort on the part of strong local organising committees. Recent events have had 200-250 participants, which shows how significant they are in the Society calendar. At all of these events papers were presented and discussed, and abstracts were included in conference proceedings. Trade exhibitions have been held, guest speakers organised and field trips undertaken. Workshops have featured in the last 20 or so years. Above all, people of a common interest have met together each year and got to know each other better. They have in this way promoted a better understanding of hydrology in all its many facets. Cities where symposia have been held are shown in Figure 4.

Joint symposia with other organisations have featured in the last 20 years, and these meetings often have over 300 participants. We met with MetSoc in 1983, 1995, 1998, 2000, 2006, and 2008, the LimSoc/NZFSS in 2000, 2001 and 2009, and the New Zealand Association of Resource Management in 2006. The 2000 conference included a Southeast Asian meeting of the Regional Steering Committee for the International Hydrological Programme (IHP).

International meetings have also featured. A symposium held in 1970 on *Results of Research on Representative and Experimental Basins* is undoubtedly one of the highlights of all our symposia, especially for a Society that had not yet had its 10th birthday. It was a full international symposium and, although organised by the New Zealand Hydrological Society, it was a joint effort with the Royal Society of New Zealand and the International Association of Scientific Hydrology (IASH) and UNESCO (participants shown in Fig. 5). Of the 85 papers presented, 70 originated overseas. The majority of the papers were published as IAHS Publication No. 96, with the remaining 20 papers appearing in JoHNZ Volume 9(2).

A second IAHS Symposium was the *International Symposium on Erosion and Sediment Transport in Pacific Rim Steeplands* held in Christchurch in January 1981. The symposium was organised by many Society members, with John Hayward as the convenor. The Society underwrote the publication of the proceedings, published as International Association of Hydrological Sciences Publication No. 132. This 644 page volume was edited by Tim Davies and Andrew Pearce. The balance of the papers appeared in JoHNZ 20(1). About 100 delegates from 16 countries attended and 37 papers were presented.

Two conferences have been held with the National Committee on Water Engineering of the Institution of Engineers, Australia. Alistair McKerchar convened the first, which was held in Christchurch in 1989 on *Comparisons in Austral Hydrology*. Over 150 delegates attended, with 100 coming from Australia. The second conference, convened by Bryan Bates, was in 1997 at Auckland with the theme '*Water/Land: Wai Whenua*'.

Twenty-one members of the Australian Hydrographers Association joined us in Wellington in 1996, and in 2005 we held a joint conference with the Australian Chapter of the International Association of Hydrogeologists in Auckland with the theme '*Where waters meet*'. David Leong and Noel Merrick led the respective New Zealand and

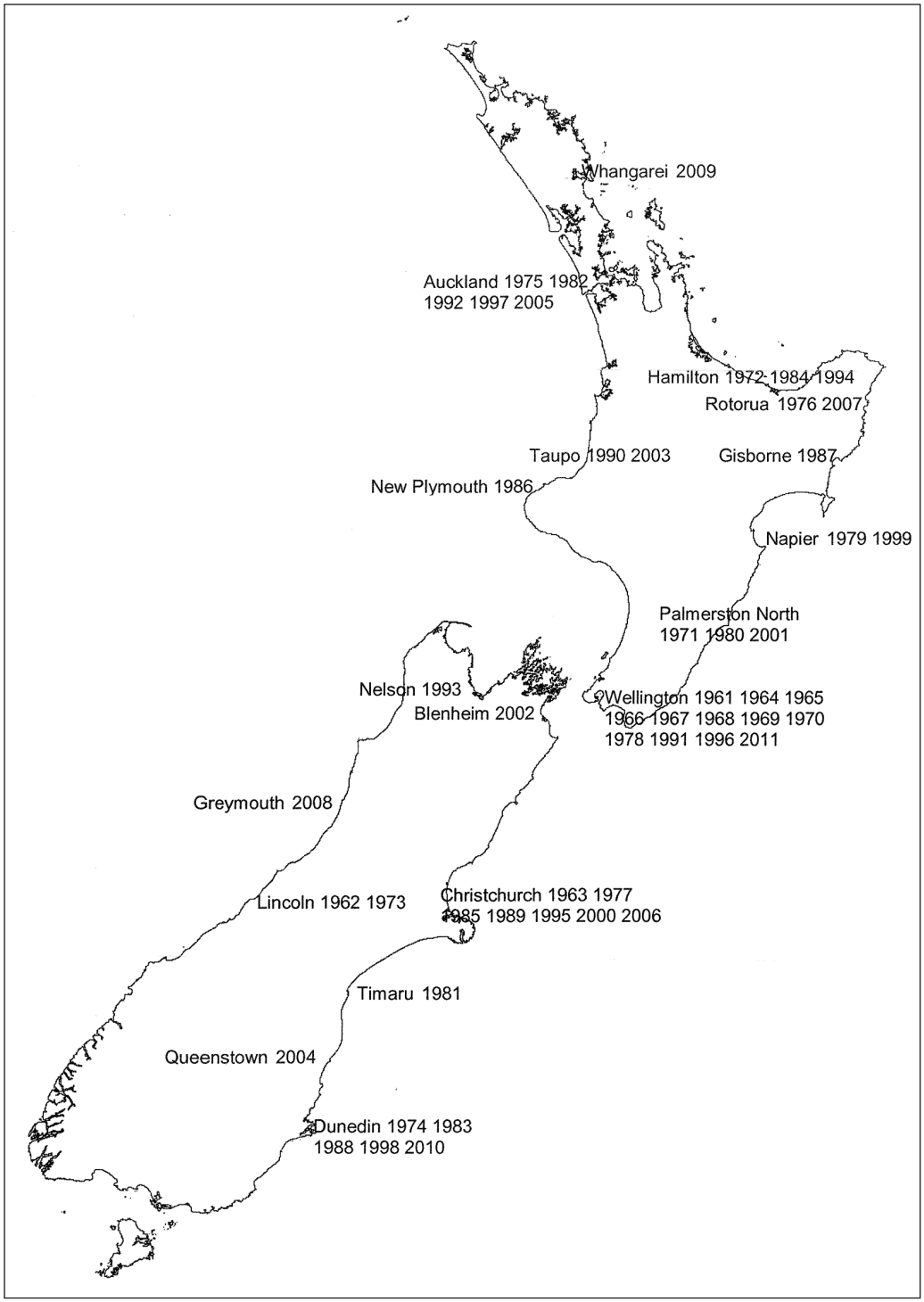


Figure 4 – Symposia venues

Figure 5 – The participants at the 1970 Symposium on *Results from the Representative and Experimental Basins* held in Wellington. Kees Toebes front left; John Hayward, Ian Simmers and Pat Grant seven rows back on left; spot the other New Zealanders!

Australian teams for the latter conference with the New Zealand Society of Soil Science also taking part.

Workshops

Workshops and seminars have been another avenue where the Society assists in spreading the word. While a number are held each year in conjunction with the annual symposium, many are stand-alone over one or two days, or held in conjunction with the Local Authority Environmental Monitoring Group. These workshops have covered a diverse range of topics: the Auckland 'water crisis', Pukekohe floods (with Meteorological Society of New Zealand), the Nelson land-use seminar, saltwater intrusion, environmental monitoring, current-meter calibration, mathematics in hydrology, water metering, water economics, climate variability and impacts on water resources, and water allocation, to name but some.

Newsletters

In the 1960s the Society produced a newsletter, but no copies were archived and no record of its timeline exits. The newsletter was resurrected in 1979 by Burn Hockey and Frank Scarf, but lapsed shortly thereafter through lack of support – again no copies were archived. It was not until 1992 that the Committee made another attempt to have a regular newsletter and the first edition of Current appeared in May 1993. This time we had a coordinator in Eileen McSaveney and through her efforts in soliciting copy from contributors within local authorities, universities, CRI's and consultants, Current has continued to arrive on our desks every 6 months, all 100 odd pages of it.

Other publications

In addition to the Journal and conference proceedings mentioned above, NZHS has published several notable books or been the

prime mover in ensuring these were published. The first of these was *Physical Hydrology: The New Zealand Experience*. Produced in 1979 and edited by Dave Murray and P. Ackroyd, this volume of 12 invited papers from 19 authors was subtitled 'the Toebes Memorial Volume' in recognition of Kees' role in establishing and promoting the Society, and furthering hydrological science in New Zealand and internationally. The volume was part funded by the New Zealand National Water and Soil Conservation Authority.

Faces of the River: New Zealand's Living Water was produced for the Society by David Young and Bruce Foster in 1986. This book developed from a 1982 proposal by Brian Kouvelis (Knowles) and was published by TVNZ Publishing with the assistance of grants from the Society. The book tells the stories of ten rivers, the Wanganui, Hakataramea-Ahuriri, Waipaoa-Motu, Buller, Waikato, Taramakau, Manawatu, Rakaia, Rangitikei and Clutha rivers, from the points of view of the people whose lives they flow through – scientists and engineers, fishermen and farmers, canoeists and rafters, hunters and trampers, and the Maori to whom the rivers were sources of food and highways.

To spread the science of hydrology further, five textbooks (see page 42) have been produced, pitched at water scientists, engineers and managers and at senior undergraduate and postgraduate students. These books have the aim of providing for New Zealanders local information and examples instead of having to rely on material found in overseas texts.

The first book, *Waters of New Zealand,* appeared in 1992. Edited by Paul Mosley, about 30 hydrologists, mostly members, contributed 20 chapters on New Zealand hydrology. The need for this book citing New Zealand information was demonstrated by a sell-out print run of 1000 copies.

Floods and Droughts: the New Zealand Experience (1997) Paul Mosley and Charles Pearson edited this book for the Society. Chapters were contributed by 19 hydrological scientists and water resource professionals who had worked on different aspects of floods and droughts. Chapters covered a broad range of topics, from observations of historically significant floods and droughts and their analysis, cause-and-effect relationships with land-use changes, instream uses, erosion and sedimentation processes, to the management of floods and droughts with case studies.

Gravel Bed Rivers V (2001) Another volume edited by Paul Mosley, this one emanated from the 5th Gravel Bed Rivers Workshop held in Christchurch and Franz Josef in 2000 and attended by over 100 specialists. This book contains 23 papers and a description of a field workshop at the Waiho River; a CD-Rom of the 43 poster papers was compiled by T. Nolan and C. Thorne. The Society underwrote this symposium and received spare copies of the proceedings for sale.

Groundwaters of New Zealand (2001) Edited by Michael Rosen and Paul White, this book is divided into two sections, the first of which was made up of 11 chapters by 18 authors describing the science behind all aspects of groundwater – water resources, recharge, irrigation, quality, health, etc. The second section of the book addresses the groundwater resources and issues within each of the 15 regions of New Zealand.

Freshwaters of New Zealand (2004) This was a joint production with the NZFSS and was produced to fill the gap created by the out-of-print *Waters of New Zealand*. This mammoth production, over 700 A4 pages, 46 chapters by 95 authors, was ably pulled together by Jon Harding, Paul Mosley, Charles Pearson and Brian Sorrell. This book had a vastly expanded coverage compared to *Waters of New Zealand* and topics included atmospheric circulation, snow, soil water, flow regimes, water quality, stream inhabitants, birds, lakes, wetlands, groundwater, land use, dams, restoration, instream values, and health

amongst others. Like *Waters of New Zealand*, *Freshwaters* will also be a sellout.

For all our books, using 'volunteers' to write the chapters, review and edit them, meant that we are able to produce very affordable books for members, students, and hydrological professionals.

Life Members

The Society has provision for Life membership. Three awards have been made as follows:

1981 Pat Grant – a founder member of the Society, long-term editor of, and contributor to JoHNZ, and overall a significant supporter of Society events and publications over many years.

1998 Horace Freestone – a long serving Committee member (18 years) who helped organise several symposia, he was a supporter of enhanced data management and quality control.

2004 Paul Mosley – a former President, editor and Committee member, Paul coordinated the Society's submissions to Government on local authority and science restructuring and has edited/co-edited four of the Society's books.

Awards

Award for Outstanding Achievement This was proposed in 1979 and rules drawn up after vigorous debate in 1980. The purpose was to recognise outstanding achievement demonstrated by scientific publications or an assessment of a person's impact on the management of New Zealand's water resources.

Recipients of the medals so far are:

1980 Dr Andy Pearce
1982 Dr George Griffiths
1983 Dr Paul Mosley
1985 Ian Jowett
1990 Dr Alistair McKerchar
1993 Charles Pearson
1996 Lindsay Rowe
2000 Dr Barry Fahey
2000 Dr Dave Murray
2001 Dr Mike Stewart
2003 Dr Steve Thompson
2006 Andrew Fenemor
2008 Dr Hugh Thorpe
2009 Dr Vince Bidwell
2010 Dr Ross Woods

Achievement in Operational Hydrology In 2002, the Executive instigated an award to recognize outstanding contributions to operational hydrology. Recipients have been:

2002 Jeff Watson
2003 Dave Johnstone
2003 Graeme Elley
2007 Jim Price
2007 Bob Curry
2008 Doug McMillan

Other activities

The Society's Executive has always been on the lookout to improve services for members. Apart from symposia and books, a number of initiatives have been undertaken which help promote the Society and the science of hydrology and associated water management in New Zealand.

New Zealand Hydrological Sciences Fellowship

This was a 3-year Postgraduate Fellowship funded jointly by Electricity Corporation of New Zealand and the NZHS in 1993. Adrian Croucher was the recipient working in the Department of Engineering Science at the University of Auckland. His topic began as modelling waste heat dispersal from the Huntly power station on the Waikato River, but evolved into contaminant transport modelling through to the Manukau Harbour; his PhD thesis is *Modelling contaminant transport in rivers and estuaries.*

Web page: www.hydrologynz.org.nz

The first webpage was developed in 1999. Hosted initially by Landcare Research, a major upgrade was undertaken by Avatar in 2002 after transfer to a RSNZ server in 2000. A total upgrade was undertaken by WorldNZ in 2006 and they currently host it. This site is a major conduit for membership applications, book purchases, conference information and project fund applications, as well as hosting a thesis database, and listing job vacancies, useful web links, and Society awards.

Listserver

In 2001 we set up a listserver so that the Committee could communicate more effectively with members, and for members to post announcements or hydrology-related queries. Initially hosted on a NIWA server, it was transferred to the RSNZ server in 2002, and latterly we have it with Actrix in an attempt to have a stable, long-term environment.

Travel grants

In excess of 50 travel grants have been awarded by the Committee to subsidise overseas travel undertaken by members. While presentations at conferences have been the main request, study tours and invited attendance to WMO and UNESCO planning meetings have also been funded.

Water information directory

Funded by the Ministry for the Environment Sustainable Management Fund and local authorities, in 2001 the Society was contracted to establish a web-accessible water information directory. This meta-database collating the hydrological information held by territorial authorities, research institutes, and universities was completed in 2004. While useful at its inception, this has largely been overtaken by the now publically accessible databases held by these agencies.

H2Know: www.h2know.org.nz

Since 2001, the Society has been operating a second website with a focus on educational material and links to appropriate sites.

Posters

Three A1 size posters were produced in 2003 and copies were sent to every secondary school in the country. With funding from the Sustainable Farming Fund and collaboration from crown research institutes, the posters were: The Water Cycle (GNS), Where is water? (NIWA), and Who needs water? (Landcare Research). With help from the Christchurch College of Education we were able to target this information at schools. The territorial authorities undertook the posting of these posters and Phoebe Loris produced a complementary teacher's resource kit on CD-Rom.

NZHS Project fund

Established in 2003, the NZHS Project fund was set up to encourage projects that further the science of hydrology and its application in New Zealand by making available a source of funding for members to pursue projects that raise the profile of hydrology. So far, the project fund has assisted 14 small projects, ranging from flood studies, wetlands, snow studies, the Forever Fair Fresh Water Trading System, to education resources.

Thesis database

A database of hydrology-related theses accessible through the Society's website was established in 2004; abstracts and summaries were included up until 2008, mainly through the efforts of Mike Broadbent. Material was added through to 2011 but, as with the Water Information Directory, access now, often to full theses from university libraries via the internet, is becoming easier and rendering further upgrades unnecessary.

Summer school

An initiative to run one-week summer schools for secondary-school leavers was trialled in December 2006. This was designed to demonstrate some activities of hydrologists for those interested in hydrology as a profession. While the first course was successful, numbers were not encouraging and the idea was abandoned.

Groundwater school/courses

More successful has been the collaboration with the Centre for Groundwater Studies at Flinders University, Adelaide. Using professionals from both sides of the Tasman, courses were held from 2006 to 2009.

Korean Water Resources Association

In 2007 a memorandum of understanding between NZHS and KWRA was signed. This MOU set out steps to advance links between the two associations for exchanging information. This has generally taken the form whereby several members of each association attend and present papers at each other's conferences, and field visits and visits to other institutions are commonly arranged.

The future

This brief history of the Society shows that we have come a long way since the beginnings in 1961. The vision of Kees Toebes in setting

Figure 6 – Tim Davie, Julian Weir and Graeme Horrell with Drs Boosik Kang and Connie Chung of KWRA's international committee, and a staff member touring the Han River restoration project control centre prior to the conference in May 2011. There is a replica of an old Korean rain gauge in the photo. (Photo: Julian Weir)

up an association whose '*members be capable of furthering the science of hydrology*' has been amply justified. The Constitution we now have states:

The objective of the Society is to further the science of hydrology and its application to the understanding and management of New Zealand's water resources by:

a) promoting hydrological research,

b) promoting education in all aspects of hydrology,

c) disseminating information through the publication of a scientific journal, newsletters, books, and other appropriate means,

d) hosting meetings and conferences for the interchange of research findings, information and experience,

e) other activities considered appropriate by the Executive from time to time.

The preceding sections show the Society is successfully fulfilling all these objectives. Having nearly 600 members from a wide range of disciplines with hydrology as the connective tissue shows the strength of the Society and this is borne out at the stimulating annual conferences. The Society certainly has the foundation for another productive 50 years and more. We hope the Society in 2061 can look back to now and give us the pat on the back which our eight founding members deserve.

The development of hydrology in New Zealand

J. R. Waugh[1] and A. I. McKerchar[2]

[1] *formerly: Opus International Consultants Ltd, Wellington.*
[2] *formerly: NIWA, Christchurch*

Introduction

Maori and Pakeha settlers arriving in New Zealand faced hydrological conditions that were beyond their experience in their Pacific island and European home countries. For settlers from the British Isles, the rugged terrain and variable weather were a complete contrast. Pakeha settlers in the Wellington region in the 1840s soon learned that the superficially attractive lowland areas adjacent to the Hutt River were in fact flood plains subject to periodic inundation. Similarly, early Canterbury residents had little understanding that the Waimakariri River naturally changed course in its lower reaches and would periodically flow through what is now much of urban Christchurch. As these rivers had few British parallels, efforts to control them tended to rely on European experience with rivers flowing from the Swiss Alps (Nelson, 1928).

In the Otago area, hydraulic gold mining methods were introduced from the Californian goldfields. Very extensive water races that diverted headwater streams to prospective sluicing sites remain around central Otago hillsides. The country's first hydroelectric installation, in 1886, was in fact a plant at the Bullendale mine in the upper Shotover River to power a quartz stamping battery (Martin, 1991).

As settlements expanded, the needs for power and security from flooding grew. Not surprisingly, hydrological studies in New Zealand for the first half of the 20th century were directed toward single purposes such as hydroelectric power investigations, flood protection and irrigation development. Estimates of flow rates in rivers and streams are core components of these studies.

The early years

Earliest hydrological investigations

The first major hydrological study in New Zealand was a systematic investigation of the potential of rivers for hydroelectric power generation. A lake level record for Lake Coleridge for the years 1890 to 1902 was gathered. Water level recorders were imported by the Public Works Department (one in 1899, and six more by 1906) and flow measurements of the Wairua River and the Waikato Rivers began in 1903. P.S. Hay, the Superintending Engineer of the Public Works Department (PWD), undertook an epic investigation and prepared a major report on the country's hydroelectric potential that was presented to the Houses of Parliament in 1904 (Hay, 1904).

Hay provided estimates of mean flows and the hydroelectric potential of many rivers. For Lake Wakatipu, he used outflow gaugings and 800 daily staff gauge observations of lake levels to estimate the mean outflow as 'just over 11 000 cubic feet per second' (311 m^3/s). He noted that this indicated a mean annual runoff for the Lake Wakatipu catchment of about 131 inches (3327 mm) per year, which was much more than the

rainfall rate observed at Queenstown. This implied that

> *… the rain- and snow-fall on the mountain-tops and higher slopes must be very great … This result, so far as it goes, is very valuable, as showing the flow that may be expected from any of the large lakes in the Alpine districts of South Canterbury and Otago.*

Indeed it was – this result has been the basis of many subsequent studies of the extreme and highly variable precipitation regime of the Southern Alps.

Hydroelectric power investigations

In the late 1920s, interest in hydropower potential saw lake level recorders established on most of the large southern lakes and on some North Island lakes (Table 1). The earliest archived water level records are from Lake Taupo (1905) and Lake Rotoiti (1906). In 1921 water level records commenced for Lake Arapuni and at Lake Waikaremoana (Benham, 1951).

In North Auckland a monthly chart recorder was installed above Wairua Falls on the Wairua River in December 1912, and regular current meter flow gaugings were carried out between 12 May 1911 (when the flow was 2556 cusecs, 72.4 m^3/s) and about 1916. This led to the building of the Wairua Falls power station, which supplied the Portland Cement Works.

Thus by 1930, the 23 water-level recorder stations established up to that date were all for power investigations.[1]

The earliest water-levels recorders were Littlejohn chart recorders with an annual chart. Later came monthly Kent charts and weekly/monthly Lea recorders. Staff of the Public Works Department and State Hydro Department operated these early power investigation stations. Other local officials assisted – for example the Postmaster at Queenstown recorded the daily lake levels of Lake Wakatipu used by Hay for 800 days, from September 1901 to October 1903.

Table 1 –Water level recorders for hydropower investigations

Lake/River	Date archived records begin
Arapuni	1921
Taupo	1905
Rotoiti	1906
Waikaremoana	1921
Rotoroa	1934
Tekapo	1925
Pukaki	1925
Ohau	1926
L Waitaki	1927
Hawea	1929
Wanaka	1929
Wakatipu	1926
Clutha River at Alexandra Bridge	1930
Te Anau	1926
Manapouri	1926
Monowai	1930

Irrigation investigations

The 1930s saw a major push into irrigation investigation, especially in Canterbury, and as a consequence a series of square concrete towers were built in the gorges at the inner edge of the Canterbury Plains (Table 2).

T.G. Beck was in charge of setting up irrigation in Canterbury, following on from

1 Anderson (1938) lists other flow records for Mangahao (1933-1936) and Mangahao No 2 Dam (1921-1927), Waimakariri at Sheffield (1923-1936), Harper Diversion (1927-1936), Taieri at Styx (1908-1930), Waipori at Intake (1911-1923) and Mataura at Mataura (1927-1936).

Table 2 – Irrigation investigation stations in Canterbury

River	Site	Date records begin
Hurunui	SH Bridge	1938
Ashley	Gorge	1938
Waimakariri	Lower Gorge	1929
Waimakariri	Otarama (power investigation)	1922 to 1939
Rakaia	Gorge	1935
North Ashburton	Gorge	1938
South Ashburton	Mt Somers	1936
Rangitata	above Rangitata Diversion Race	1936
Opuha	Skipton	1936
Opihi	Rockwood	1935

earlier work in Otago. Beck had visited the United States to inspect irrigation and on his return to New Zealand established a hydrological data collection network in Canterbury. This included collecting rainfall data and infiltration testing of soils on the Canterbury Plains. These early investigations included a network of recording raingauges in the catchment of the North Ashburton River.

Staff of the Public Works Department (which became the Ministry of Works (MoW) in the 1950s, and the Ministry of Works and Development (MWD) in the early 1970s) operated these water level recorders and carried out current-meter flow gaugings. Eric Lawrence was involved in these early pre-war investigations; later he worked on the construction of the Cobb Power Scheme and became the District Commissioner of Works, Christchurch.

World War II severely disrupted the early power and irrigation investigations: water level records were collected but with loss of manpower the flow gaugings virtually ceased. For the same reason a number of long-term rainfall records have gaps during this period.

1941 saw the Soil Conservation and Rivers Control Act passed and the establishment of Catchment Boards and the Soil Conservation and Rivers Control Council (SCRCC), serviced by the Public Works Department.

Post-war period (1946-1959)

In the immediate post-war period and following up on the new legislation, with its emphasis on both river control and soil conservation, there was a burst of activity which employed engineers and men returning from the war, together with new migrants and school-leavers. In 1949 three 'Hydraulic Survey' parties were established at Hamilton, Palmerston North and Blenheim. E. J. Speight and party operated out of Blenheim and went on grand tours of the South Island. A. C. Hopkins and others operated from a base at Palmerston North. Most of New Zealand's larger rivers had flows measured in this period. W. H. (Bill) Macey was working in Northland in this period and carried out very valuable low flow gaugings of Northland streams during a major drought in 1945. He subsequently worked in the Waikato (1950-1958). The 'Hydraulic Survey' parties employed such noted personalities as E. J. (John 'Daddy') Speight, A. C. 'Hoppy' Hopkins, C. (Kees) Toebes and W. B. (Barry) Morrissey.

The hydrological network began its rapid post-war expansion at this time. Standard

circular concrete towers were constructed at this time as 'permanent' recorder stations. Some were built in the most unlikely locations, e.g., on Waimate Creek near Waimate (June 1954-1963). With the new emphasis on flood control and the occurrence of major floods in the 1950s and 1960s, recorder stations were soon established on many of New Zealand's larger rivers. Examples are the Waikato at Ngaruawahia (1957) and the Clutha at Balclutha (1954). Schnackenberg (1951) reported that in May 1946 there were 11 automatic lake level gauges, 15 automatic water level recorders on rivers and 97 staff gauges.

Catchment Boards and the Waikato Valley Authority began to establish water level recorder stations on rivers with flooding and erosion problems. The February 1958 flood on the Waikato River led to comprehensive investigations of the Waikato. Similar activities followed in most parts of New Zealand. Early photographs of major floods show that many towns were virtually unprotected by stopbanks up to 1960.

Post-war hydroelectric power investigations

Hydroelectric power investigations also expanded rapidly in the post-war period and saw many new stations added to the network. Examples are the Rangitikei River at Mangaweka (1953) (power and flood control), Buller at Lake Rotoiti (1951), Acheron at Clarence (1958), and Rangitaiki at Murupara (1952)

Investigations began for the Tongariro Power Scheme and this saw numerous stations established, including Tongariro at Upper Dam (1958) and Waihohonu at Desert Road (1961). The British consultants Sir Alexander Gibb & Ptnrs undertook some of this work with very limited data. (One of the Gibb hydrologists, John Sutcliffe, was subsequently a distinguished scientist at what was the British Institute of Hydrology (now the Centre for Ecology and Hydrology) at Wallingford, and his Tongariro investigations are summarised in Sutcliffe (2004).

In 1963 further power investigations led to a comprehensive network of recorder stations being established on the Buller River and its tributaries, e.g., Matakitaki at Mudlake (1963), Maruia at Falls (1963), and Buller at Te Kuha (1963).

Development of technical standards

In 1951 E.C. Schnackenberg published a paper on 'Difficulties in Obtaining and Presenting Hydrologic Data' in New Zealand. He discussed problems arising in hydrological work in New Zealand rivers, mentioned the use of US Geological Survey (USGS) Depth Integrating Sediment sampling equipment and outlined ideas for flood gauging and current meter rating. Schnackenberg was a strong advocate for high national standards for hydrological work in the Departmental (Draft) Instruction 'Gauging of Rivers in New Zealand'. Schnackenberg was appointed as 'Senior Engineer', employed directly by the Soil Conservation and Rivers Control Council, as were other early hydrological staff, with pay, rations and logistics provided via the Public Works Department.

In an unpublished paper, Schnackenberg set out the Soil Conservation and Rivers Control Council's requirements for the collection of rainfall data and the selection of suitable river reaches for long-term recording of water level and discharge. Kent float-operated chart recorders (weekly or 28 days) were selected as the standard recorder, as was the Evershed electrical plumbob. Another paper addressed 'Gauging structures' such as recorder towers, gauging cableways, gauging footbridges and static tubes (intake pipes). Equipment and field practices adopted in New Zealand closely followed those used by the Water Resources Division of the United States Geological Survey (USGS) and this has greatly benefited hydrology in New Zealand.

From 1953, 'Hydrology Annual' publications were compiled to make hydrological

data widely available. Early volumes also contained technical articles by the officers in charge of the Hydraulic Survey Parties. Standard procedures were written by staff members in Wellington, but also by the field hydrologists, e.g., A. C. Hopkins' 'Suspended Sediment Sampling: Approximate Methods'. A whole series of 'standard procedures' were soon produced. Numbers 1 to 10 were issued in 1961 and by 1964 the 'Handbook of Hydrological Procedures' with Numbers 1-32 was available.

In 1957 the Soil Conservation and Rivers Control Council published 'Floods in New Zealand 1920-1953' which was compiled by Colin Cowie and A.K. Atwood while seconded to the Council's Staff.

Developments from 1959

Expansion of the hydraulic survey parties

In 1954 a Hydraulic Survey party was established in Whangarei, in the Ministry of Works Residency Office. Cornelis (Kees) Toebes became officer in charge, assisted by Herman Drost, Horace Freestone (1961) and others. Herman Drost moved to Hamilton to head a party in the Waikato. Later in 1963, Horace Freestone moved to Whakatane to staff a survey party there, moving to Rotorua in 1968. Pat Grant joined the Ministry of Works in 1966 in Hawkes Bay following a period with the Hawke's Bay Catchment Board. He built up a strong survey and research group, at one time employing 25 staff, with a field team at Gisborne. Pat and his staff engaged in a wide range of research and survey activities including groundwater investigations in the Heretaunga Plains, interception studies in beech forest at Ngahere basin, regime changes in the Tukituki River, coarse sediment yield from the upper Waipawa River, rainfall measurement and rainfall distribution in the Kaweka Ranges, and rainfall in relation to drought.

Similar wide-ranging hydrological investigations were carried out by the 'Hydrological Survey' scientists and field teams during the 1960s and early 1970s, prior to the establishment of the three Science Centres in 1975-1976.

The MWD 'Districts' each established field parties carrying out hydrological survey activities. Survey parties were operating out of Nelson, Christchurch and Dunedin in the South Island. In 1960 the North Island 'Hydraulic Survey' party was still based at Palmerston North, but 'Hydro Investigation' parties were operating from Whanganui and Taumarunui.

In the 1960s the South Island groups established smaller field parties based at various times at Invercargill, Timaru, Lake Tekapo, Alexandra, Greymouth and Westport. In the North Island field parties were based in Wellington, Gisborne and Turangi; while the 'North Island' party moved from Palmerston North to Whanganui and established a field party in Taranaki. These developed into NIWA field teams, currently located at Whangarei, Auckland, Hamilton, Rotorua, Napier, Turangi, Whanganui, Wellington, Nelson, Greymouth, Christchurch, Lake Tekapo, Alexandra and Dunedin. The scope of their work has expanded considerably into a wide range of environmental monitoring.

Role of the Kainga Instrument Depot and the 'rating tank'

Central to the success of hydrology in New Zealand was the decision to establish a central instrument depot at Kainga, beside the Waimakariri River on the northern outskirts of Christchurch in 1959. A specially designed 50 m tank for calibrating current velocity meters (the 'rating tank') commissioned in 1963 enabled current meters to be regularly rated and serviced in New Zealand, rather than being sent abroad – over 8000 calibrations have been undertaken with this facility (D. Gibb, pers. comm.). E. J. Speight moved to Christchurch and the instrument depot steadily developed (Campbell, 1959). Speight

played a critical role in the development of the Instrument Depot. He was responsible for designing the standard bridge gauging crane, which is still used in New Zealand.

By adopting standard recorders (Kent and Lea Charts), Watts and Gurley current meters, standard bridge gauging cranes and winches, etc., it was possible for the Kainga Depot to both stock equipment and hold an inventory of spare parts. This centralised servicing and calibration of equipment enabled a high standard to be maintained over many years.

This was in contrast to the situation in the USA and Australia, where equipment tended to be serviced locally or by the manufacturer. During the 1970s and early 1980s Rick Moore was officer in charge of the New Zealand Instrument Services Depot and made a substantial contribution to the efficient operation of the Depot. New equipment continued to be developed, or imported and evaluated. The use of systematic checking systems for recorder equipment greatly improved their field reliability and reduced the periods of missing record. The requirement for data in near-real-time for a wide range of purposes stimulated the adoption of modern instrumentation coupled with telemetry. Innovative development of new equipment has continued to be a feature of the group now known as 'NIWA Instrument Systems'.

In 1999, the NIWA Instrument Systems Group relocated to new premises at the main NIWA Campus at Kyle Street in Riccarton, Christchurch, but the current meter rating tank at Kainga was retained. The activities of the Group now encompass instrumentation support for the broad range of environmental monitoring and research activities undertaken by NIWA and its many client organizations.

Technical conferences

Two important technical conferences were held in New Zealand, one in December 1959, and another in May 1962 and proceedings of these meetings were published (SCRCC, 1959, 1962). These proceedings reflect the development of hydrology in New Zealand in the post-war period. The growth was fostered by the Soil Conservation and Rivers Control Council and concurrent interest in river engineering and land management within the Catchment Boards, Ministry of Works and the State Hydro Department. Interested engineers and scientists from universities, Soil Bureau, the Meteorological Service and New Zealand Railways (Bridge Engineer) attended the December 1959 meeting. A major report was compiled and published for the Soil Conservation and Rivers Control Council entitled 'Hydrology – Proceedings of a Meeting of Design Engineers employed on Hydrological Works'. The 1962 technical symposium was held at Lincoln College and focussed on 'Hydrology and Land Management'. The papers presented at Lincoln included some on small catchment research and soil conservation issues.

Role of C. Toebes (Grant, 1979)

Cornelis Toebes (called 'Case' and spelled 'Kees') arrived in New Zealand from the Netherlands in 1951 and joined the Hydraulic Survey in Palmerston North in 1952. He subsequently instituted the Northland Hydraulic Survey at Whangarei in 1954 and transferred to the Ministry of Works head office in Wellington in 1960, where he remained until 1974.

In his head office position, where he became 'Chief Scientific Hydrologist', he stimulated national interest in regional and experimental hydrology and initiated and led major programmes of works on regional and experimental basins. In later years he had under his control a staff of about 33 engineers and scientists and 110 field and data processing technicians. He had a major role in the adoption of the UNESCO International Hydrological Decade within New Zealand and chaired the organisation of an International Association for Hydrological

Sciences (IAHS) Symposium on results of representative and experimental basins that was held in Wellington in 1970. Toebes wrote two volumes for the Education Department, entitled 'Applied Hydrology'. They were produced for qualification training and were used for in-house training courses.

In 1961 he was instrumental with several others in establishing the New Zealand Hydrological Society and served as foundation president until 1973. The first issue of the society's Journal of Hydrology, with Pat Grant as Editor, was published in 1962, and pre-dates the Elsevier publication of the same name. Toebes's contributions were recognised by the society's publication of the Toebes Memorial Volume in 1979.

Regional hydrology

Both conferences (above) featured sections on 'Regional Hydrology'. In 1959 Toebes presented a paper on 'The Hydrology of the Tongariro Area', while A. P. Campbell outlined some general ideas on the establishment of a network of 'regional' catchments or hydrological base stations.

Toebes and Neef (1962) presented a paper on 'Regional Hydrology' which clearly sets out the basic concepts that were later used and developed in New Zealand as part of New Zealand's contribution to the International Hydrological Decade.

International Hydrological Decade (1964-1975)

New Zealand participated in UNESCO's International Hydrological Decade (IHD) from 1964 to 1975, establishing 74 representative basins. These were located in the more important of the 90 hydrological regions defined by Toebes and Palmer (1969) on the basis of rainfall, slope and geology. A resulting publication 'Representative Basins of New Zealand 1970', (Ministry of Works, 1970) documents the catchments established or planned up to 1969. Its introduction sets out the three main research objectives of the programme – the prediction of low and mean flows within a region, the study of hydrological processes, and the development of mathematical and/or physical prediction models.

This programme provided a major boost to hydrology in New Zealand in a number of ways. A sample of New Zealand catchments were now being monitored in a systematic and organised manner, including remote catchments within distinctive regions, e.g., Cleddau at Milford Sound in Fiordland and Cobb at Trilobite in Northwest Nelson. The representative basins programme greatly widened New Zealand's hydrological network to sample a range of catchment sizes and to monitor catchments other than the larger rivers already monitored for power, flood-control and irrigation.

High-quality instrumentation was introduced, e.g., 1964 saw the first Fischer & Porter punched-tape recorder deployed for field-testing. Automatic raingauges were installed, together with networks of storage and daily manual gauges (read by local residents). This complemented New Zealand Meteorological Service's rainfall network by placing rain gauges in remote areas.

Automated data processing began to replace manual methods. A punch-tape-reader in Wellington allowed for immediate input into a computer-based databank (by 1967), bypassing tedious hand reading on chart records.

Regular visits to overseas conferences, particularly by C. Toebes, assisted in the introduction of new equipment and ideas. The highly successful 1970 IAHS 'Symposium on the results of research on representative and experimental basins' in Wellington enabled New Zealand's hydrologists to make contact with many overseas scientists and engineers.

The developments received international recognition: for example Rodda (1976) noted that

> *Because of the relatively small size of the country (New Zealand) and because of the rational approach, it is probable that the New Zealand network of representative basins provides the world's best example of a comprehensive national system of this sort.*

Toebes was first author of an international guide on representative and experimental basins (Toebes and Ouryvaev, 1970).

Present status of representative basins

In total some 74 hydrological regions in New Zealand have data available from 76 regional stations. Sixteen regions have had no data collected, mostly from small lowland regions such as Karamea, or confined areas such as the Waitakere Ranges (Mokora basin selected). In 2000, 53 representative basins were still operational, and 21 had been closed. Currently, 13 of the operational stations are now run by Regional Councils, having been transferred from NIWA during the cutbacks of the 1990s.

Experimental basins

As part of New Zealand's contribution to the International Hydrological Decade (1964-1975) a series of small experimental catchments were set up to examine the effect of land-use changes. Others, such as the Moutere catchments, were established in 1962 to examine soil conservation and erosion problems, but were subsequently adapted to compare the hydrological effects of plantation forest planting with pasture (Duncan, 1995). Similarly, the Soil Bureau's Taita Catchments had been established prior to the International Hydrological Decade, between 1955 (Taita at Native 1) and 1961 to 1963. The Makara catchments near Wellington also date from 1956.

Other experimental basins were established at Puketurua (1964) in Northland, where three nested catchments ranged in size from 0.0142 km^2 (Pukeiti) to 0.389 km^2 (Pukewaenga) up to 2.48 km^2 (Puketurua). These catchments were monitored under manuka scrub and heath, then burned and converted into pasture in 1971-1972 and are still being farmed.

Otutira, on the north shore of Lake Taupo, had a set of catchments established in 1965-1966, while at Purukohukohu a joint Forest Research Institute (FRI) and Ministry of Works programme saw a set of native and pine forest catchments established in 1967-1971and operated by MWD, Rotorua.

The Forest Research Institute also developed suites of small experimental basins to investigate the influence of forest cover and forestry operations on runoff and sediment movement at Maimai near Reefton and at Big Bush in southwest Nelson. Other catchment and process studies were carried out at Glendhu Forest in eastern Otago, and at Mangatu Forest inland from Gisborne, at Ashley Forest in north Canterbury, and at Larry River north of Reefton.

Largely due to the high cost of operating experimental catchments over long periods of time, most have since been closed. However, data from these catchments has been used in many research studies and reports.

Water resource mapping

Water resource mapping of hydrological regions was initiated during the 1970s by staff of the Ministry of Works. Scarf (1972) mapped the water resources of the hydrological region of Nelson, while Waugh (1970) examined the relationship between geology and low flows across the hydrological regions of Northland.

In Hawkes Bay, Grant (1971) examined the low flow characteristics on three rock types of the East Coast. This involved the translation of some representative basin data.

In Canterbury, Ogle prepared a map (not published) of water resources for a large part of the Canterbury region. In more recent years Canterbury Regional Council/Environment Canterbury has produced detailed water resources surveys of individual catchments. Similar studies have been carried out by other Regional Councils.

Data processing and Tideda

In the late 1960s, with the rapid growth of the hydrological network, manual data processing became an impossible task. New Zealand adopted punched-tape water-level recorders and computer-based data processing. Stephen Thompson played a pivotal role in the development of Tideda, a time-dependent data processing, storage, analysis and modelling system. It was originally set up to operate efficiently on early computers, which had very limited electronic storage. It is now a sophisticated computer package that is used extensively throughout New Zealand and in several other countries. Its great virtue is that it stores original time-stage data and stage-discharge ratings to allow for the computation of discharge and a wide range of hydrometric statistics, with time resolutions ranging from seconds to decades. A team of staff led by Richard Ibbitt ensured that the Tideda data processing package was implemented throughout the country. Between 1970 and 1978 all the data recorded on charts and paper tapes were loaded onto magnetic tape to form the first national archive of hydrological data. Prominent members of the Head Office data processing team were Vanessa Black, Linden Johnson, Vas Parag, Bill Christie and Hans Hartog.

Catchment Boards to Regional Councils

During the 1980s there was rapid growth of data collection by Catchment Boards, which merged into Regional Councils in 1989. Radio-telemetry of hydrological data became widely used during the 1980s for flood warning, water-resource management and basic data collection. At the same time, the advent of cheap computers enabled data processing and archiving to be decentralised. The creation of local or regional databases, however, created problems in maintaining a national hydrological archive. Quality assurance concepts were accepted to ensure the data entering archives met specified standards. The existence of a single national hydrological archive of high quality data is a major asset, which is particularly valuable for nationwide studies such as flood frequency (McKerchar and Pearson, 1989). Another important hydrological database is the 'power' database now operated by Opus International Consultants, formerly the Ministry of Works and Development Power Division, on behalf of ECNZ and then the power companies. This database contains inflow records for most of New Zealand's lakes, plus flow data relating to electric power stations in New Zealand. Power Division of MWD held data collected by field parties from the late 1950s; these were added to power division records going back to 1905-06 (two sites) and to the numerous lake records established in the 1920s and 1930s.

Many Regional Councils (formerly Catchment and Regional Water Boards) also monitor groundwater, both by monthly manual readings and with automatic recorders. In some catchments the links between surface and groundwater have been investigated – for example Horrell (2001) examines this issue in a report on the low flow regime of the Ashburton River. The NZ Hydrological Society's publication 'Groundwaters of New Zealand' (Rosen and White, 2001) covers the history of groundwater development in New Zealand, regional resources and groundwater research.

The growth of New Zealand's hydrological network is reflected by the data available for flood studies. In 1982 Beable and McKerchar, using data up to 1978, had

160 stations available for analysis. By 1989 there were 343 suitable stations available. Of these, 275 stations had records of 10 or more years, with an average record length of 21 years (McKerchar and Pearson, 1989). In 1959 New Zealand had 109 permanent flow stations operating, but by 1989 the network had increased to 915 permanent water level recording stations (M Duncan, pers.comm. and Acheson, 1968).

Establishment of research centres

In the 1970s Water and Soil research activity was consolidated, and three research centres were established at Hamilton (Water Quality), Aokautere near Palmerston North (Land Resources) and Christchurch (Hydrology). The Water Resources Survey emerged as a separate entity, and all of these groups were moved to the Department of Scientific and Industrial Research in 1988 and then to the National Institute of Water and Atmospheric Research (NIWA) in 1992.

Establishment of Crown Research Institutes

With the transition into the DSIR, and subsequently into the Crown Research Institutes (CRIs) in 1992, the linkage between land and water that was the cornerstone of the MWD Water and Soil Division ceased. Former Water and Soil scientists and technicians moved into various CRIs. Geologists, glaciologists and groundwater scientists moved to the Institute of Geological and Nuclear Sciences (GNS); soil scientists, botanists and forest hydrology went to Landcare Research; hydrologists, aquatic ecologists, limnologists, hydraulic engineers and hydrological field teams went to the National Institute for Water and Atmospheric Research (NIWA), and water quality scientists moved to Environmental Science and Research (ESR) and NIWA.

Since formation of the CRIs, the structure of research groups working in hydrology in NIWA has been stable. The old hierarchical structure of the MWD was replaced by flat management structures, with dispersed groups able to communicate freely by both telephone and e-mail. For example, NIWA established a virtual 'National Climate Centre' in 1999, in which climatologists and hydrologists located in Auckland, Wellington and Christchurch meet infrequently, but interact at monthly intervals using telephone and internet services to discuss oceanic, meteorological and hydrological observations from around the country and to make hydro-climate projections.

Soon after the formation of CRIs, the management of GNS determined to shift a team of groundwater science staff located in Christchurch to Wairakei in the central North Island. In retrospect, given the importance of groundwater for the city of Christchurch and the Canterbury Plains, this was unfortunate. In the event, only one of the staff shifted and the experienced team dispersed, with the result that groundwater research was set back for a number of years. The staff who remained in Christchurch continued to produce excellent work. Hugh Thorpe played a pivotal role in establishing groundwater research in MWD during the late 1970s, beginning with the Heretaunga Plains groundwater investigations in 1976. In 1978 Hugh Thorpe moved to Christchurch, where he built up the groundwater research group within MWD's Research Centre.

With the establishment of the CRIs, the government missed an opportunity to integrate the forest hydrology research programme from the New Zealand Forest Service into NIWA. Instead, it was placed in Landcare Research and the ongoing programme struggled to secure adequate funding and has largely lapsed as senior staff retired.

Importance of computers

It is difficult to overstate the importance of the widespread adoption of computers. The

revolution in communications and computing in the 1980s and 1990s has been an essential component in advances in hydrology over this time. What are simple tasks now were once major issues. When the Science Centre in Christchurch formed in the late 1970s, the MWD had one mainframe computer in Wellington. Most staff were allowed to use only standard civil engineering programs, and the only useful science package was multiple linear regression, with data submitted on punched card at a terminal several city blocks away! Even electronic calculators were in limited supply.

The introduction of personal computers in the 1980s enabled centralised, specialised hydrological data processing to be dispersed to the field teams. Stephen Thompson and the then research director (Michael Taylor) were instrumental in this achievement. This overcame long delays in processing punched tapes caused by the inadequacy of the MWD's tape translation facilities. Being able to check and archive their own data in a timely manner enhanced the status and interest of the field teams, and enabled them to address local issues. Coupled with the introduction of decentralised computing was the development of 'Aquitel' telemetry. This system initially used existing MWD VHF radio links to transmit data from remote sites on request. It was justified on two grounds: through the efficiencies that it introduced by enabling the operation of stream gauges to be checked without having to visit the site and by providing near-real-time data for flood warning and flood forecasting. With robust construction to military standards, it continued in use by NIWA and regional councils for many years, but it has become obsolete as replacement parts became difficult to procure. More recently, dedicated radio channels and cell phones have been used.

Archives of data underpin virtually all the progress in hydrology. The archives include not only the 'Tideda' archive for rainfall, water level and river flow, but also other data archives such as the Climate Database (CLIDB), the New Zealand Land Resource Inventory, maintained by Landcare Research, and the Land Cover Database, held by the Ministry of Agriculture and Forestry. As an illustration of the power of computing, it is now possible to make an analysis of New Zealand's entire river flow archive in less than an hour, and then graphically or numerically interpret the results by linking them to other nationwide databases using Geographical Information Systems. This linking of geographic and time series data is a significant milestone in advancing catchment hydrology. To the writers of this article, who did all their undergraduate university studies using slide rules, this is remarkable.

Hydrological data collection

A theme apparent from reviewing the development of hydrology in New Zealand has been the need to gather data using defined procedures and known standards and instrumentation, and to archive the data in a form such that the original observations can be scrutinised decades later.

For example, the record of Lake Taupo levels, which starts in 1905, was originally gathered specifically for hydroelectric power investigations. It is now an invaluable resource for assessing drought severity, and the impacts of the El Niño Southern Oscillation phenomenon and other decadal-scale oceanic-atmospheric oscillations of river flows.

NIWA's field teams continue to collect hydrological and environmental data through national monitoring networks, which complement regional and district council networks. This continues the tradition set in the 1970s of MWD and catchment board collaboration in this area. NIWA's hydrological data collection has been funded in the 1990s by public research funds, hydropower generators and other partners. One of the main features

of New Zealand's hydrological data collection and instrumentation has been the emphasis placed upon quality assurance of data. This was led by Paul Mosley, with assistance from Doug McMillan, John Fenwick and Alistair McKerchar.

Hydrological research programmes

The following are examples of programmes that have involved NIWA staff. A notable feature is that the structure of NIWA has been an important stimulus for hydrological research by encouraging and facilitating the incorporation of hydrological components into broader research programmes.

Land-use change

A number of catchment studies have been carried out to assess the effects on streamflow hydrology of alternative land-use practices. The major driving question has been the influence of forestry on runoff as compared with pasture or native tussock. The Moutere catchment study, led by Frank Scarf and Maurice Duncan, is an excellent example of this type of work. This study, and others undertaken elsewhere by the Forest Research Institute (and subsequently Landcare Research), demonstrated the importance of the interception of rainfall in the forest canopy. Water loss through evaporation from the canopy reduces the quantity of rainfall reaching the ground. Soil moisture levels were lower under forest canopies, and runoff was reduced. The results have been fundamental for a number of resource consent hearings that have seen water resource users seeking to restrict forestry development because of its potential to reduce runoff.

The distribution of rainfall

Studies that attempted to estimate design flood percentiles as functions of estimates of basin rainfall intensities have had limited success, and a contributing reason is that in many regions in New Zealand, rainfall is known only approximately, and in hilly and mountainous regions, the approximations are poor. This was first recognized in Hay's 1904 report and was developed in a study of the 'Clutha River flows and design floods' (Jowett and Thompson, 1977). The authors used records of outflows from each of the three Clutha catchment lakes to show that the mean annual rainfall in each catchment was greater than that measured at any of the long-term raingauges. Annual rainfall near the main divide of the Southern Alps had to exceed 8000 mm/yr to balance rainfalls of less than 1000 mm/yr measured at locations such as Hawea, Wanaka, and Queenstown on the southeastern sides of the catchments, and still produce the measured flows. The result focussed attention on the dominating influence of the mountain ranges in intercepting precipitation from moist maritime wind flows. The need to derive reliable estimates of extreme floods for hydroelectric dams on rivers draining the Southern Alps has been an imperative behind this work. Three areas of work have developed from this.

Alpine transect study:

The alpine transect study delineated the profile of rainfall across the Southern Alps. Trevor Chinn initiated this work with a Rakaia/Hokitika transect, it was continued in the MWD Hydrology Centre by Maurice McSaveney, Graeme Horrell and others. Subsequently in NIWA, Roddy Henderson installed tipping-bucket rain gauges along three transects near Milford Sound, Haast and Franz Josef. Data from these showed that storm rainfalls occurred nearly simultaneously over wide areas along the Alps, and that annual rainfall partway down Milford Sound toward the sea is probably double the annual mean of 6715 mm (1981-2010) for the Milford Sound climate station.

Southern Alps Experiment:

The Southern Alps Experiment (SALPEX) conducted in NIWA was an integrated hydrometeorological study of precipitation and runoff processes in the alps that followed from the rainfall transect studies. Data collected are being used to better calibrate detailed models of the atmosphere that will eventually enable improved warning of potential flooding.

Regional flood estimation:

In work initiated by Alistair McKerchar and Charles Pearson, a regional method for estimating floods was developed. Flood percentiles at a site of interest are estimated from mapped flood values inferred from sites with records. The resulting design flood estimates have been shown to be more reliable than estimates based on design rainfall estimates. The approach contrasts with methods used in other countries that produce estimates based on statistics of extreme rainfalls. Recently, the method has been used to examine the influence of the El Niño Southern Oscillation (ENSO) phenomenon on river flows, and to determine whether decadal-scale changes in frequency of occurrence of El Niño and La Niña episodes are evident in the magnitudes of floods (McKerchar and Henderson, 2003).

Hydrological models

Computer models of the fluxes of water moving through catchments were first developed on large computers in the 1960s, notably at Stanford University. Richard Ibbitt, who had completed a PhD under Terence O'Donnell at Imperial College in London and joined the MWD in 1970, is probably New Zealand's best known exponent of catchment rainfall-runoff modelling. With Ross Woods, the Topmodel concept of Keith Beven in the U.K. has been developed and applied to represent the spatially distributed features encountered in natural catchments. A field study of spatial variation in the hydrology of the Mahurangi catchment 50 km north of Auckland led by Ross Woods attracted collaboration from a number of international participants, as well as research groups from Landcare Research, Geological and Nuclear Sciences, Hort Research, University of Auckland, University of Waikato and Forest Research Institute (Woods *et al.*, 2001).

Enhanced computer power in recent years and the availability of detailed digital elevation models has facilitated progress in hydrological modelling. Recent models, combined with precipitation forecasts that are downscaled from global weather models, hold the promise of considerable enhancements to flood forecasting capabilities. The same model, when linked to databases of soil type and land cover, is also being used to predict the impacts on low river flows of potential changes in land use and climate.

Glacier and snow studies

Because of the rugged topography and difficulty in access, measurement of the volume of snow accumulated in the Southern Alps through winter has proven extremely difficult. Measurements of snow on skifields, on the eastern fringes of the alps, do not measure this accumulation. A snow accumulation model that uses a series of snow wedges for each altitude band, and temperature and precipitation data from long-term climate stations around the alps has been developed by Blair Fitzharris of Otago University. This model provides a reconstructed history of annual snow accumulation for each winter back to 1930.

The role of snow and ice in the country's hydrology is reviewed in two chapters in Harding *et al.* (2004). The importance of perennial snow and ice in different catchments was quantified in Anderton (1973). He showed that the total volume of glaciers was about 63 km^3. About 57% was

contained in basins draining to the east coast, and the Waitaki basin alone accounted for 45% of the total. It is especially important in this basin because the Waitaki River is one of the country's major hydro-electric power resources. However the volume has decreased with glacial wasting in recent decades. Initially from within the MWD, and latterly in the DSIR and in CRIs, Trevor Chinn has led continuing studies of glaciers in both New Zealand and in the Dry Valleys of Antarctica. Recent support for the work has come from the recognition that glacier size is an extremely sensitive indicator of climate change. A particular contribution of Chinn has been annual surveys by aerial photography of the end-of-summer snow lines of glaciers. Yearly shifts in snowline are an integration of cumulative precipitation and temperature shifts.

Land management and estimation of sediment load

The extent to which clearance of native forest and its replacement with pasture, and the burning of native tussock to promote pasture growth had exacerbated soil erosion and worsened flood risk by aggrading alluvial river channels was a hotly debated issue for at least four decades from about 1940. In some areas, soil conservators perceived that changed land use and over-grazing of sparse vegetation had accelerated erosion and this was undoubtedly so for some catchments, such as the Waipaoa River near Gisborne. This finding was supported and popularized by some geographers (e.g., Cumberland, 1944). It led to a national soil conservation policy whereby subsidies were provided for large areas of steep high country land on pastoral leasehold land to be fenced off and 'retired' from grazing.

However others (e.g., Hayward, 1979) saw erosion in the South Island high country as a natural consequence of extreme rainfall events, which occurred infrequently in low rainfall areas and very frequently in some alpine areas. The lack of clear guidance was one of the imperatives that led to the establishment of the three 'Science Centres' by the MWD in the 1970s. There was significant progress, for example, by dating the weathering rinds of rock from screen slopes, to demonstrate that many erosion scars were very old features, and also by comparing late 19th century and present-day photos of the same landscape features. Continuing questions have been the rate of sediment accumulation in the Clutha River hydro lakes, and more recently, the rates of supply of sediment from rivers and urban streams to estuaries and harbours, and sediment loads to margins of the sea. George Griffiths and Murray Hicks have led innovative measurement programmes that have provided improved estimates of these quantities. Hicks *et al.* (2001) reported a major catchment-wide study of the Waikato River and its sediment budget and processes.

Hydrology and ecology

The effects of water resource developments on instream flora and fauna have been studied in aquatic biology programmes. The growth of periphyton, the removal of the periphyton by invertebrate grazing and sloughing during freshes have all been investigated by Barry Biggs, while Alastair Suren has focussed on aquatic mosses. This work demonstrated the key role of flow variability in determining biomass production. More recent work has centred on the spread and possible control of the exotic algae, didymo. Conditions favourable to growth of invertebrates and the habitats preferred by freshwater fish species have been identified by Ian Jowett. This work has been important for the determining the residual flows to be maintained in streams when abstractions are planned.

In other work, hydraulics experts (Vladimir Nikora and Derek Goring) have used acoustic doppler velocity meters to measure the details of turbulent flow near stream boundaries.

This enables a better understanding of the habitat conditions favorable for periphyton growth.

Water resources and low flows

Interest in water resources assessment has continued as problems relating to the effects of abstraction and the requirements of a multitude of instream users have intensified. In particular, several attempts have been made to use the growing archive of hydrological data and new mapping tools to advance understanding of the low-flow resources of New Zealand. Paul Hutchinson (1990) and Charles Pearson (1995) mapped low flows as a function of catchment characteristics using a regression approach. Roddy Henderson has led an extension of this to smaller catchments, with considerable effort being put into assembling a database of the myriad low-flow and water resource gauging runs that have been made over many years at many small streams. Regional Council staff have contributed to this work with enthusiasm and produced many excellent water resource summaries for individual catchments.

Overview

As we compiled this brief history, several aspects have stood out in the material we reviewed.

From the earliest days in New Zealand, standards of field work and instrumentation were high, with the establishment of the Kainga Instrument Depot as one of the keys to the success of hydrology in New Zealand. Training of technical staff to promulgate consistent national standards for field hydrology and data processing, especially in the 1960s-1980s, was important.

The early adoption of computers for handling data and for developing national archives was crucial to progress. On-going efforts to maintain high standards in the collection of hydrological field data, and the application of quality assurance to data collection and processing, have helped to ensure that good quality hydrological data are available to underpin a wide range of research activities, engineering and resource consent investigations. The efforts have been assisted by the devolution of data archiving to the field teams and the adoption of telemetry for data retrieval.

Most importantly, hydrology in New Zealand has benefitted from the commitment of many skilled people who have seen the opportunity for satisfying careers in the field of hydrology.

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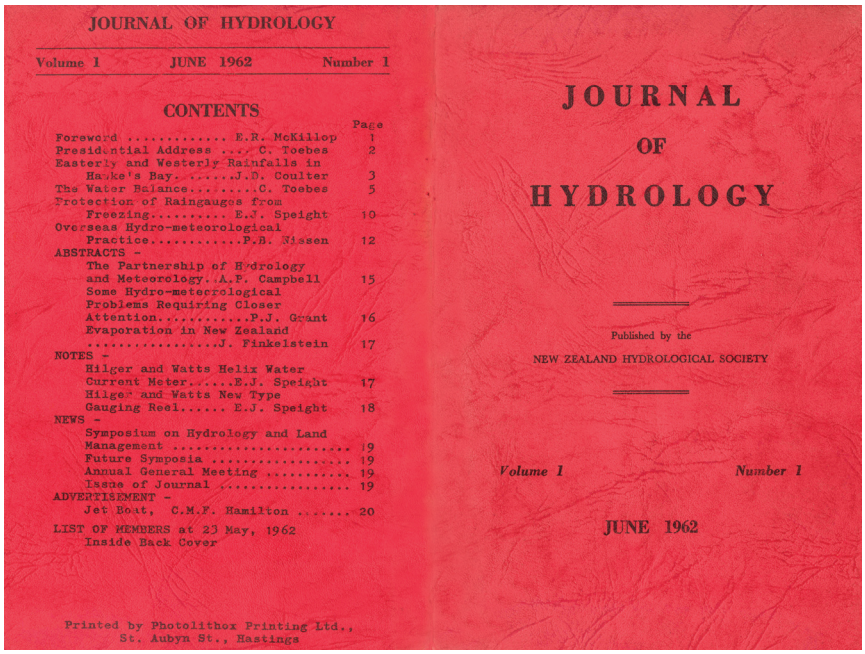

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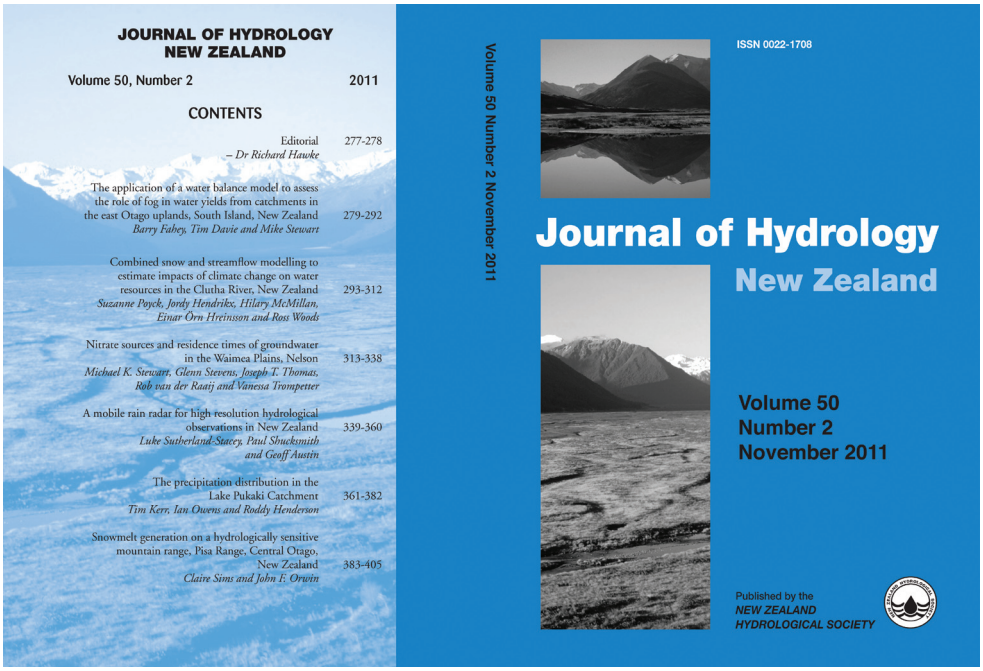

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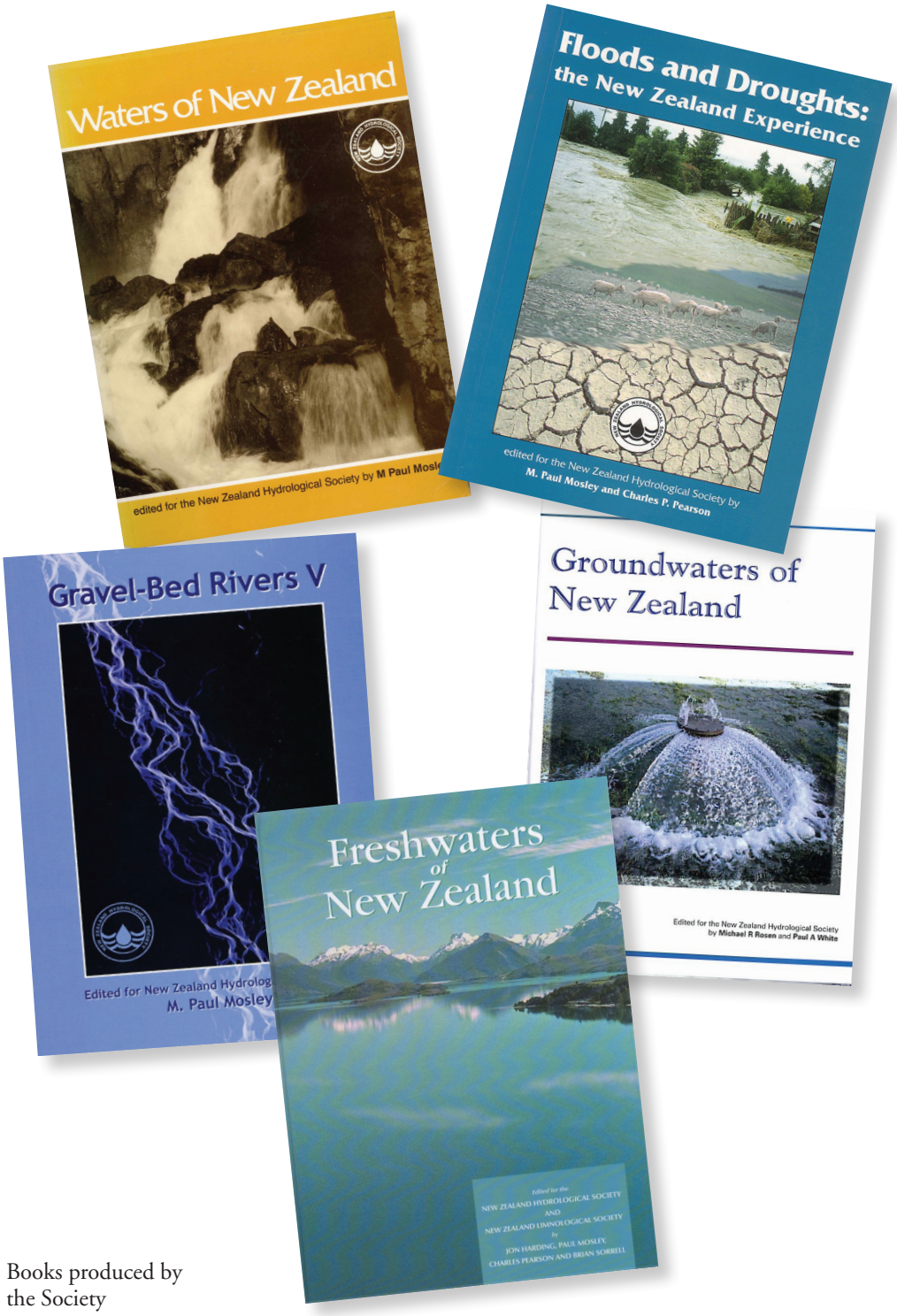

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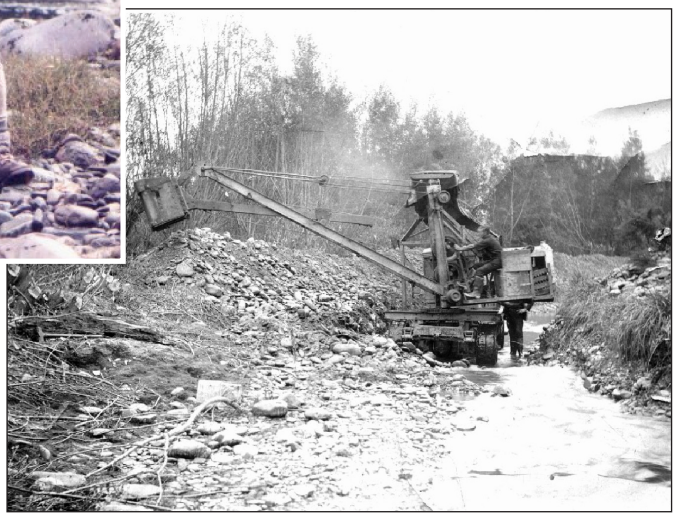
Jet boat gauging on the Manawatu river 1994.

The perks of the job – Pete Mayall in the Aorere River.
(Photo supplied by M. Doyle)



Early river works in Nelson region – great machine.
(Photo supplied by M. Doyle)

Flood gauging on the Wairoa at Brightwater. One extreme …
(Photo taken by Martin Doyle)

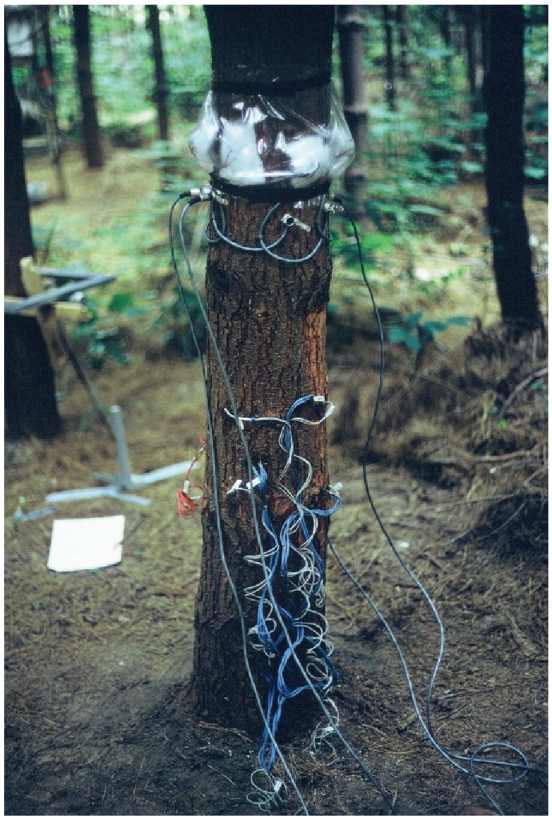
… and the other extreme – Bob Curry and John Fenwick gauging the Whakapapa River at Footbridge, 1989 (Photo supplied by Bob Curry)

Puketurua Weir 1967 (Photo supplied by Gary Blake)

ABOVE: Digital punched tape weighing bucket rain-gauge in Otago – 1960s.
(Photo MoW, Dunedin)

LEFT: Wading gauging at Papakaio Weir, Lower Irrigation Main race.
(Photo supplied by David Hamilton)

BELOW: Ooops. Ngaruroro River 1998 – submerged crane constructing new motorway.



Sapflow measurements at Forest Research Institute.
(Photo supplied by Gary Blake)

Waimana River recorder
July 1998 flood.

Water level and rainfall recording sites in New Zealand: 1850–2010

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Introduction

Rainfall in New Zealand has been systematically recorded from at least the mid-1800s and water levels from the late 1800s.

Estimates of the number of rainfall and water level recording sites that cover much of this period have been published previously. These estimates include NZIE (1964), Acheson (1968), NWASCO (1985), and Mosley *et al.* (1992). In 1977 Waugh (pers. comm.) estimated the number of active water level recorders in New Zealand from 1900-1977 and the proportion with data available electronically. The present author undertook similar studies to estimate the number of rainfall sites in 2001 and water level sites in 2004, based on site index information from various recording agencies (Keane, 2001, 2004). Both these studies are updated here with information about recording sites up to 2010.

An index of hydrological recording sites has been published at regular intervals since the 1970s. The most recent version (Walter, 2000) provides a list of recording sites and includes details of their location, the recording authority and the start and end dates for records. This site information, along with additional information supplied by NIWA, regional councils and other recording authorities, has been used as a basis for estimating the number of sites, between 1850 and 2010, where water level and rainfall have been systematically recorded.

The observed trend in the number of recording sites can be viewed in terms of the development of hydrology and meteorology in New Zealand. Waugh and McKerchar describe the development of New Zealand hydrology in the previous chapter. The early development of the rainfall recording network, included within a history of meteorology, is recounted in Acheson (1968).

Compilation of information

Most water level and rainfall site data are archived in the National Hydrometric and Climate Databases administered by NIWA and in regional databases administered by regional councils. Other significant databases include the Power Archive administered by Opus Consultants and similar databases operated by individual power generation companies. Each of these organisations maintains lists of sites and related details (metadata) both for the sites that they themselves operate and site data from other agencies with which they share data. Information about sites in 2010 was requested from recording authorities so that the information compiled for the previous studies could be updated.

Site information in the Climate Database and the Power Archive (Opus, 1998) were compiled into subsets along current regional council boundaries so that regional statistics could be aggregated as needed. Recording sites on outlying islands are included in totals for the relevant regional authority.

For example recorders on Chatham Island are included in the Canterbury region, and Stewart Island and the Sub-Antarctic islands in the Southland region.

Because data is shared between agencies, details for a particular site may be contained in site lists from two or more agencies. In some instances information on the start and end dates for particular sites were not consistent from different sources. This situation arises because many sites have, at one time or another, been operated by different agencies, and sometimes site details provided relate to archived data only, rather than data for the complete period a site has been in operation. In these cases the longest record was assumed. A list of sites was compiled from all sources and duplicate site information, identified by site number and name, was excluded from the analysis.

Having start and end date information for sites allows the number of sites and the length of their records to be calculated. Our longest running records of rainfall, water levels and flow are sometimes compiled from recording sites in close proximity. Where identified these have been included as single composite sites. Examples of this include sites recording water level on the hydro storage lakes such as Lake Pukaki and Lake Taupo, and long-term rainfall sites such as Albert Park in Auckland. However the number of 'sites' with long records in this analysis will be under-represented, because when sites are relocated a short distance away they are assigned a new site number and listed separately. Similarly, the record length for some sites will be over-estimated because they have been reopened, with the same site number, some years after being closed. Generally insufficient detail is included in the site lists to account for the period when sites were temporarily closed. In all but a few cases where information was supplied, these sites have been assumed to be open until their final closure.

Water level recording sites have been divided into groundwater sites and surface water level sites (which includes river, lake and tidal gauge sites). No distinction has been made between manual and automatic recording sites because the dates when sites were automated are not apparent in the site list information. The early hydro storage lake level records, for example, began with daily staff gauge readings and generally, at some stage between about 1926 and 1950, these sites were automated with chart and later digital recorders. Similarly, there are instances of manually read ground water and rainfall sites that have been automated for a time and then revert to manual readings.

While there are some limits to the information, a good estimate of the number of recording sites open and the length of records for those sites can be obtained and estimated for each decade.

Water level recording sites

Regional totals for surface water level and groundwater level recording sites open at the beginning of each decade are aggregated for New Zealand in Table 1 and Table 2 respectively. These totals are plotted in Figure 1, with the addition of intermediate values at 5-yearly intervals after 1960 to improve the definition of the trend.

The plot of water level sites shows the number of surface water recording sites increasing slowly from 1905 until 1950, after which the number of sites increases rapidly until a hiatus beginning in 1985. After 1995 the number of sites increases again and by 2010 the number of sites is increasing at a rate similar to that during the 1960s. In contrast, the number of open groundwater level sites increased slowly from 1940 until 1970, after which the number increased more rapidly.

The estimated number of surface water level recording sites in Table 1 is generally consistent with previously reported sources

Table 1 – Regionalised summary of the number of surface water level recording sites in each decade.

Region	1900	1910	1920	1930	1940	1950	1960	1970	1980	1990	2000	2010
Northland	0	0	0	0	0	0	3	20	40	48	35	44
Auckland	0	0	0	0	0	4	5	14	34	42	102	93
Waikato	0	1	1	6	5	8	28	85	138	150	124	176
Bay of Plenty	0	1	1	5	6	7	17	35	56	63	72	85
Gisborne	0	0	0	0	0	0	1	3	19	28	31	30
Hawkes Bay	0	0	0	2	2	2	4	19	57	55	74	92
Wellington	0	0	0	1	1	1	17	35	52	46	55	111
Manawatu-Wanganui	0	0	0	1	4	8	18	53	79	65	75	115
Taranaki	0	0	0	0	0	0	0	3	19	26	25	26
Nelson	0	0	0	0	0	1	3	24	47	30	32	45
Marlborough	0	0	0	0	0	0	2	10	13	15	29	38
Canterbury	0	0	0	7	14	15	24	62	106	138	174	212
Otago	0	0	0	1	3	3	8	31	71	86	97	116
Southland	0	0	0	1	3	4	6	27	48	51	59	67
Westcoast	0	0	0	0	1	1	4	25	50	46	35	45
Antartica	0	0	0	0	0	0	0	3	3	5	5	5
North Island	0	2	2	15	18	30	93	267	494	523	593	772
South Island	0	0	0	9	21	24	47	182	338	371	431	528
New Zealand	0	2	2	24	39	54	140	449	832	894	1024	1300

Table 2 – Regionalised summary of the number of groundwater level recording sites in each decade.

Region	1910	1920	1930	1940	1950	1960	1970	1980	1990	2000	2010
Northland	0	0	0	0	0	0	0	5	14	13	13
Auckland	0	0	0	0	0	0	0	55	35	42	42
Waikato	0	0	0	0	0	0	0	1	2	7	6
Bay of Plenty	0	0	0	0	0	0	0	4	7	8	9
Taranaki	0	0	0	0	0	0	0	0	2	2	1
Hawkes Bay	0	0	0	0	0	0	7	8	15	76	91
Manawatu Wanganui	0	0	0	0	0	0	0	1	4	16	16
Wellington	0	0	0	0	0	0	7	13	28	39	39
Nelson	0	0	0	0	0	0	0	15	23	28	45
Marlborough	0	0	1	1	1	1	1	4	10	24	35
Canterbury	0	1	1	1	4	18	17	49	89	131	146
Otago	0	0	0	0	0	0	0	0	9	20	23
North Island	0	0	0	0	0	0	14	87	107	203	217
South Island	0	1	2	2	5	19	18	68	131	203	249
New Zealand	0	1	2	2	5	19	32	155	238	406	466

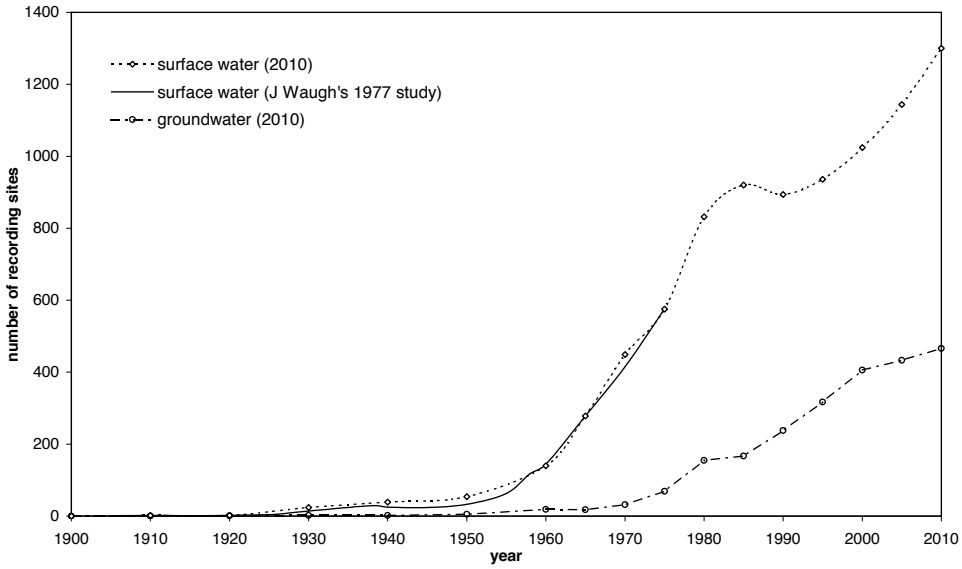

Figure 1 – The number of surface and groundwater level recording sites since 1900.

(Schnackenberg, 1951; Acheson, 1968; NZIE, 1964; NWASCO, 1985; Mosley *et al.*, 1992). There are some differences between the current estimates and the historical reports of numbers prior to 1940. These differences seem to relate to the inclusion or otherwise of recording sites related to power stations and staff gauges installed solely for the purpose of flood warning. Similarly, some inconsistency exists with respect to the earliest site information when compared with Waugh and McKerchar's account of the earliest systematically recorded water levels (Lake Coleridge 1890–1902) in the previous chapter. This could be a case where water levels have been recorded but have not been digitised and archived, so those records don't appear in site lists. Archived records for Lake Coleridge level begin in 1928 (Opus, 1998).

The earliest archived water level recording sites are Lake Taupo in 1905 and Lake Rotoiti (North Island) in 1906. Both begin with the installation of staff gauges near the lake outlets. Records are still being collected at these lakes in the same general locality as the original and therefore are the longest continuously running recording sites, with more than 100 years of continuous record. Initially the staff gauges were read daily until the sites were upgraded with automatic chart recorders at Taupo in 1932 and at Rotoiti in 1942 (Opus, 1998).

These first surface water recording sites were installed following the passing of the Water Power Act in 1903, and a comprehensive survey of water resources in lakes and on major rivers was undertaken in 1904 by P.S. Hay to assess potential for hydro-electric generation. In 1920 the Rivers Commission identified a need for basic hydrological information on major rivers (Acheson, 1968). Similar sites were established on major rivers and lakes in both the North and South Island during the 1920s and early 1930s to investigate sites for government hydro power and irrigation schemes. By 1940 there were about 40 recording sites.

The Soil Conservation and Rivers Control Act was passed in 1941 to tackle the problems of flooding and the loss of soil by erosion. The Soil Conservation Council established an advisory committee on hydrological

data which reported in 1947 the number of rainfall and runoff gauges. River gauging equipment then included 97 staff gauges and 17 automatic gauging stations on rivers and another 11 on lakes (Acheson, 1968). Some of the 97 staff gauges would have been for river control and flood warning. This involved the measurement of flood levels, which when combined with flow gaugings, allowed bridges and river control works to be designed. Many of these staff gauge sites would not have been read over the full range of flows, and consequently recorded levels were not digitised and archived. From about this time the number of recording sites increased steadily, fuelled by a need to investigate catchment control schemes to alleviate flooding around settlements and productive farm land alongside the major rivers.

The establishment of three Ministry of Works hydraulic survey teams in 1951 (increasing to at least one in each 'district' by the late 1960s) facilitated expansion of the network in support of a wide range of hydrology research and applied engineering. Catchment boards established similar field teams in the 1960s and developed networks of sites focussed on local needs such as flood warning and land drainage. What followed was a remarkable sustained expansion of the network for the next 30 years that coincided with the development of water projects, including construction of hydro-power schemes throughout the country, the development of irrigation schemes mainly in the South Island, and flood control schemes in many catchments large and small. The establishment of 74 representative basins during the International Hydrological Decade (1964-75) and the need for field data for catchment hydrology research contributed to the number of water level recording sites rising to over 800 in the 1980s.

In the late 1980s central government departments involved in the collection of hydrological data, and water-related research and development were reorganised and commercialised. Initially deregulation and 'user pays' were introduced to data collection, which led to joint funding of sites by different agencies and commercial organisations. Data could be shared more easily between the Ministry of Works and catchment boards with the development of common computer systems and real-time data collection. The Water Resources Survey teams of the Ministry of Works and Development, which had a major role in data collection for scientific and commercial purposes, were moved to the Department of Scientific and Industrial Research (soon to become NIWA in1992). Local government structure was also reorganised, with the aggregation of catchment boards in 1989 to form regional councils, which operated networks for water resource planning, water allocation and flood warning. Regional councils took a more active role in monitoring for non-scientific purposes. Changes to the National Hydrometric Network in response to a 20% reduction in central government funding for hydrometric monitoring in 1994 are described by Pearson (1998). Between 1994 and 1996, objective and pragmatic approaches were used to downsize and focus the network structure to accommodate new funding arrangements, which were a mix of central government funding for a core of medium and long-term sites, sites operated for commercial clients, and comparatively short-term funding for a range of research projects. As a consequence of reorganisation of the National Hydrometric Network, sites that retained value for local purposes were transferred to the regional council networks.

The organisational changes contributed to the hiatus in the expansion of the network (at around 900 sites) observed from the mid-1980s to the mid-1990s. In subsequent years the network has continued to grow in size, albeit at a much more moderate rate,

principally due to expansion of some regional council networks.

The hydrometric network has been operated principally by central and regional government organisations, and the balance of responsibility has shifted from central government in the first half of last century, to regional government in the closing decades. In 1985, Frank Scarf reported to an Operational Hydrology Seminar (NWASCO, 1985) that until 1973 operational hydrology at regional and national scales was largely controlled by the Ministry of Works Water and Soil Division. As a consequence of administering the Water and Soil Act in 1967, catchment authorities built up field staff numbers, data collection and data processing capability over a period of 10 years to a level where most could satisfactorily service sites traditionally operated by the Ministry of Works. At the same seminar, Horace Freestone reported that in 1979 catchment authorities were operating 42% of water level recording sites, rising to 55% in 1985. In 2000, regional councils were responsible for operating 59% of water level sites, crown research institutes 28% and other (mainly commercial) agencies 13%. In 2010 regional councils operate 63% of surface water level recording sites and NIWA 24%. This increased share by regional councils reflects both the down-sizing of the National Hydrometric Network in the 1990s and the regional councils' primary responsibility for resource planning, water allocation and management of compliance under the Resource Management Act (RMA). The increased proportion of sites attributed to other agencies could reflect joint funding of sites since 1985.

The length of hydrological records available for analysis, together with the quality of the data, influences the value of the dataset. It is thus interesting to observe how the length of hydrological records has changed with the passing decades. Many applications in hydrology rely upon long records to minimise the uncertainty in research conclusions or design parameters. For example, a reliable mean annual flood estimate can be obtained from a good quality record of 10 years or more, and as a general rule the uncertainty in flood estimates decreases proportionately with the length of flow record available. In longer records of several decades, inter-decadal patterns may start to emerge that could influence engineering decisions. Very long records of perhaps 70 to more than 100 years are valuable for observing long-term trends that may corroborate observed or predicted changes in climate.

The occurrence of record length for surface water recording sites open at the start of each decade are tabulated for the whole of New Zealand in Table 3. The number of sites in each decade in each category of record length is plotted in Figure 2. Until the mid-1980s, the number of sites in all categories of record length increased. This reflects the rapid growth of the network of sites and the number of sites closed being offset by a greater number opened. From 1985 until 2000, the number of sites with

Table 3 – Incidence of record length for open surface water recording sites in each decade.

Record length	1900	1910	1920	1930	1940	1950	1960	1970	1980	1990	2000	2010
1-9 years	0	2	0	15	15	13	83	269	354	316	287	330
10-29 years	0	0	2	2	20	32	29	96	321	448	454	498
30-49 years	0	0	0	0	2	2	18	25	23	67	203	331
50-69 years	0	0	0	0	0	0	2	2	11	19	28	84
70->100 years	0	0	0	0	0	0	0	0	2	2	10	18

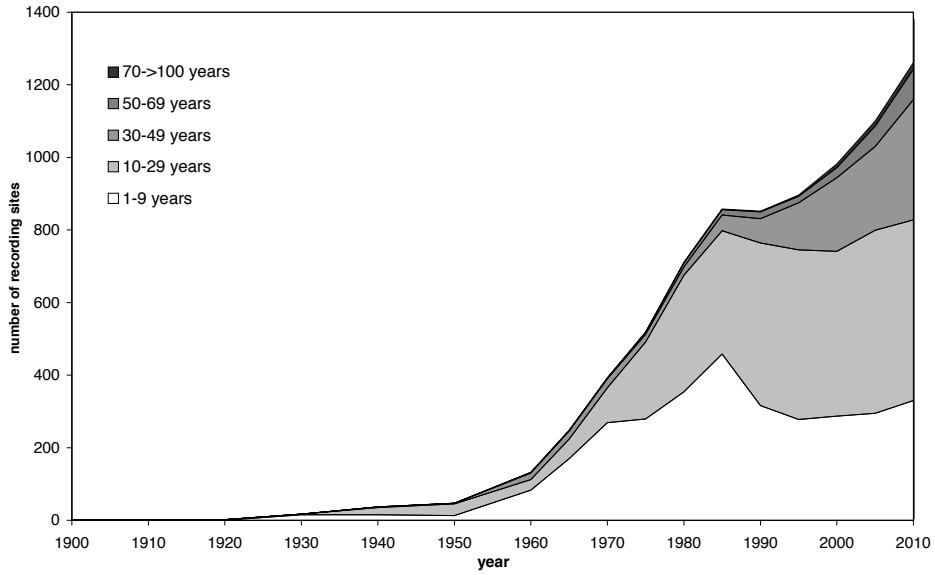

Figure 2 – Incidence of record length for open surface water level recording sites in each decade.

records longer than 50 years remained static. Since 2000 the number of sites has increased again. Sites with less than 30 years record length decrease in number after 1985 and increase after 2000. A marked reduction in sites with less than 10 years record length occurred prior to 1990, with slight increases in recent years. The reduction in sites with less than 30 years record coincides with the period of reorganisation of central and local government. The retention of a large proportion of sites with significant or long-term records seems to have been successfully negotiated during this period. The proportion of sites with records greater than 50 years length has however continued to increase. This can be interpreted as a maturing of the network, with a core of medium- to long-term sites which continue to operate both in the central and regional government networks.

The number of groundwater recording sites open in each region, by decade, are shown in Table 2. This includes both manually read and automatic recorder sites. The total does not include records for the West Coast and Gisborne regions, for which site lists were not available.

The earliest groundwater recording site and the site with the longest record (73 years) is the Springs Road site on the campus of Lincoln University. Archived records begin in 1912 and end in 1985. Groundwater site information provided by Environment Canterbury indicates records for an unnamed well at Papanui from 1914–1916 and eight other unnamed wells in Lincoln and Christchurch with records between 1921 and 1924.

The number of groundwater sites in New Zealand (Figure 1) rose slowly until the 1950s, when the number of sites in the Canterbury region increased. In the 1970s the number of sites increased significantly in the Auckland, Wellington, Manawatu and Canterbury regions (Table 2). The number of sites increases again after 1985.

In 2010 nearly half of the groundwater recording sites are located in Canterbury and Hawkes Bay regions, where significant groundwater resources have been allocated for irrigation.

Table 4 – Incidence of record length for open groundwater sites in each decade.

Record length	1900	1910	1920	1930	1940	1950	1960	1970	1980	1990	2000	2010
1-9 years	0	0	1	1	0	3	14	12	107	138	184	128
10-29 years	0	0	0	1	2	1	3	16	23	61	188	243
30-49 years	0	0	0	0	0	1	2	1	2	11	18	52
50-69 years	0	0	0	0	0	0	0	1	2	1	1	10
70->100 years	0	0	0	0	0	0	0	0	0	0	0	0

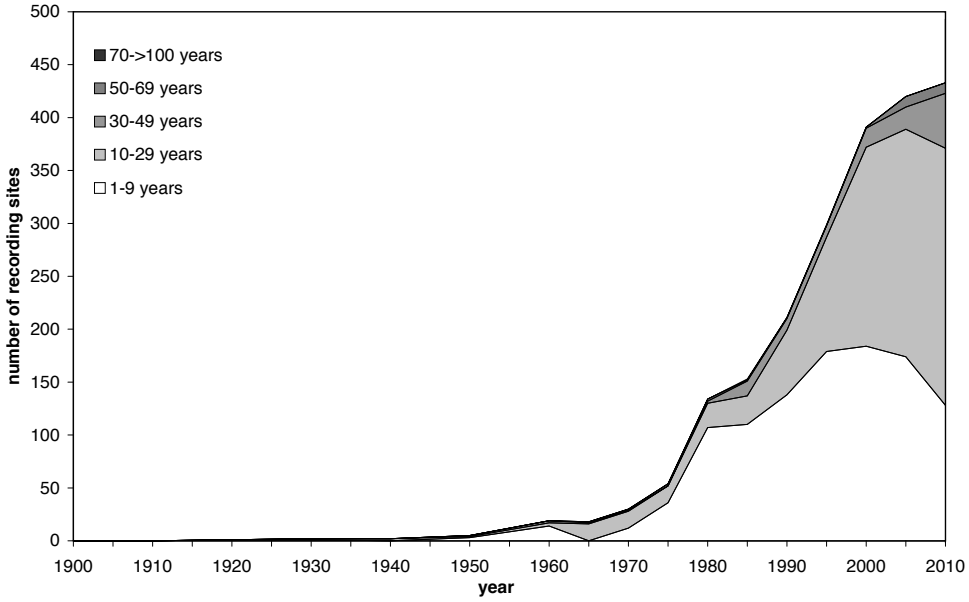

Figure 3 – Incidence of record length for open groundwater level recording sites.

The length of records in each decade are summarised in Table 4 and the trends plotted in Figure 3. In 2010 there were 466 active groundwater recording sites, about 60 of which have a record length longer than 30 years (Table 4). The number of sites with records of intermediate length is declining, suggesting that fewer new sites have been established in the past 10 years – 30% of sites have a record length of less than 10 years and none are longer than 70 years (Figure 3). A sizable database of groundwater level information has been established, but only a small number of sites have attained what might be regarded as long-term record status. It seems highly desirable that some groundwater recording sites be retained in a core network of regionally representative long-term sites, as has been advocated over many years for surface water sites.

In 1985 87% of groundwater level recording sites were operated by catchment authorities and the remainder by the Ministry of Works. In 2000 regional councils operated 92% of sites and crown research institutes the remainder. In 2010 nearly 98% of groundwater recording sites are operated by regional councils.

Rainfall recording sites

A regionalised summary of the number of rainfall recording sites between 1850 and the present time is shown in Table 6. This includes sites in the rainfall, climate and weather station networks operated by the Meteorological Service, NIWA and regional councils. It shows that the number of sites peaked at nearly 2000 in 1980 (Figure 4) and since that time the number has slowly declined to 1648 in 2010.

Previous estimates of the number of rainfall recording sites are summarised in Table 5. Several of these estimates suggest a larger number of sites during the 1990s, however the general trend is similar to the present study.

The earliest archived rainfall records are in the climate database at Albert Park in Auckland City, beginning in 1853, and in Wellington at Kelburn from 1862. The number of rainfall recording sites appears to have grown steadily from about 1880, possibly following the development of a system for recruiting volunteer rainfall observers around this time and a move to develop weather forecasting services by the Marine Department (NZIE, 1964).

The early development of meteorology and hydrology in New Zealand is described by Acheson (1968) from notes by N. G. Robertson, a former Director of the New Zealand Meteorological Service. Observations of rainfall and weather were made at Auckland and Wellington as early as 1840 and 1841. The first information to be published indicating a sparse network of rainfall observation sites in the colony was included in an appendix to the Statistics of New Zealand 1853-56. Plans for the establishment of a network of government observatories were drafted in 1859 and partially implemented over the next 20 years. Observatories were established in Auckland, New Plymouth, Nelson, Wellington and Dunedin (1862), in Hokitika and Bealey (1867), in Queenstown and Wanganui (1872), at Cape Campbell (1874) and on Chatham Island (1879).

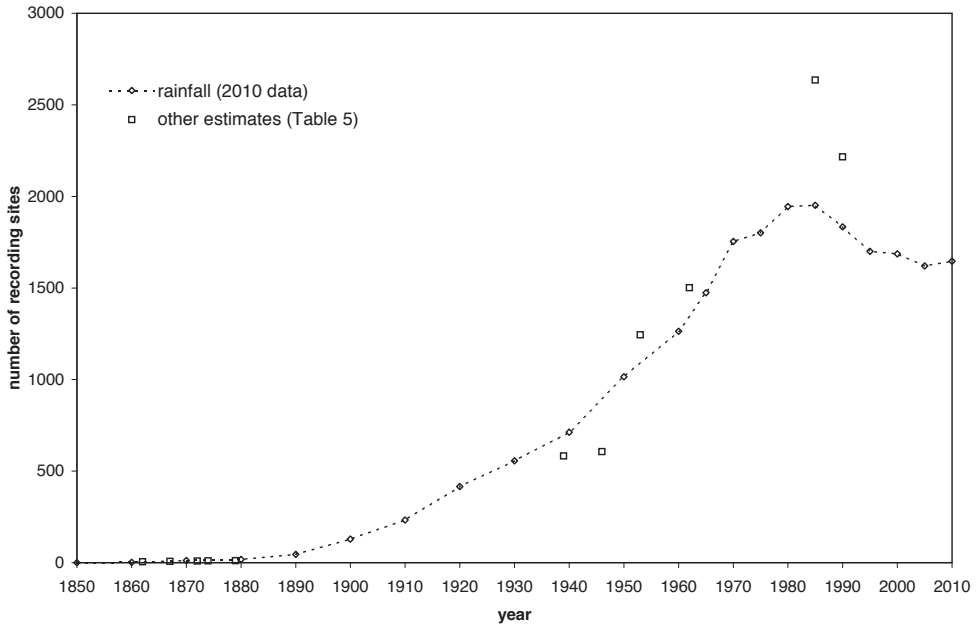

Figure 4 – The number of rainfall recording sites in New Zealand since 1850.

Table 5 – Previous estimates of the number of rainfall recording sites in New Zealand.

Year	Weather	Climate	Rainfall		Total	References
			Auto	Manual		
1840	2				2	Acheson (1968)
1862	5				5	Acheson (1968)
1867	7				7	Acheson (1968)
1872	9				9	Acheson (1968)
1874	10				10	Acheson (1968)
1879	11				11	Acheson (1968)
1939	63		520		583	Acheson (1968)
1947			28	578	606	Acheson (1968)
1953			94	1150	1244	Schnackenberg (1951)
1962	124	178	114	1085	1501	Acheson (1968)
1985			464	2171	2635	NWASCO (1985)
1988		380				Mosley *et al.* (1992)
1990	149	231	503	1333	2216	Mosley *et al.* (1992)
1992		200		670		Mosley *et al.* (1992)

Table 6 – Regionalised summary of the number of rainfall recording sites in each decade.

Region	1850	1860	1870	1880	1890	1900	1910	1920	1930	1940	1950	1960	1970	1980	1990	2000	2010
Northland	0	0	1	1	1	3	11	26	31	38	56	69	108	130	135	116	127
Auckland	0	1	1	1	1	2	6	14	21	24	38	46	64	85	92	122	114
Waikato	0	0	0	0	1	5	16	33	57	65	69	110	150	179	206	151	152
Bay of Plenty	0	0	0	0	1	4	9	18	26	38	52	59	109	114	98	91	90
Gisborne	0	0	0	1	1	5	10	25	28	30	47	51	53	48	57	60	56
Hawkes Bay	0	0	1	2	6	15	21	34	48	57	74	98	129	177	183	176	180
Wellington	0	0	1	2	10	14	23	26	41	47	72	93	126	128	116	119	111
Manawatu-Wanganui	0	0	1	1	5	23	39	49	55	65	103	132	198	210	143	125	145
Taranaki	0	0	1	1	5	7	14	20	26	26	27	35	55	59	53	56	59
Nelson	0	0	1	2	3	6	10	18	21	34	57	60	86	89	89	79	89
Marlborough	0	0	0	1	1	3	7	13	14	22	32	35	41	41	43	46	45
Canterbury	0	0	2	2	3	20	24	64	89	125	189	217	246	244	249	237	217
Otago	0	1	2	3	5	13	25	50	58	76	98	142	167	168	162	142	138
Southland	0	0	0	0	1	3	9	15	20	30	50	62	86	109	84	80	85
Westcoast	0	0	1	1	1	6	9	11	21	35	51	55	136	164	124	86	38
North Island	0	1	6	9	31	78	149	245	333	390	538	693	992	1130	1083	1016	1034
South Island	0	1	6	9	14	51	84	171	223	322	477	571	762	815	751	670	612
New Zealand	0	2	12	18	45	129	233	416	556	712	1015	1264	1754	1945	1834	1686	1646

In 1874 the Marine Department began to develop a weather forecasting system to assist shipping services. The first purely rainfall observatories were established in 1879 and a system for recruiting private rainfall observers a few years later. Conflict between scientific interest and the more practical applications of meteorology resulted in several changes in administration. By 1906 the Marine Department was responsible for climate observations and weather forecasting. In 1926, as government departments, including Agriculture, Forestry, Air and Public Works, showed interest in rainfall and runoff observations (and forecasting services), the network was placed under the control of the Department of Scientific and Industrial Research. The Soil Conservation and Rivers Control Act in 1941, with its interest in rainfall and runoff problems, necessitated an expansion of the rainfall and meteorological network.

By 1946 eleven catchment boards had been set up and a further six were established by 1961 (NZIE, 1964). A number of rain gauges that were the responsibility of the local authorities were established for purely local investigations.

In 1947 the Soil Conservation and Rivers Control Council undertook to assist financially in the installation of rainfall stations; additions to the national network were operated by the Meteorological Service (Acheson, 1968). By 1962 the Meteorological Service's national network included 1200 rainfall stations, 1085 of which were manual, and 220 of these were private observers using their own equipment. In addition, there were 124 synoptic reporting stations and 178 climatological stations, most of which it is presumed would record rainfall.

During the 1960s the rainfall sites operated by local authorities and Ministry of Works survey teams grew in number, principally to support the scientific and local body requirements outlined earlier. The reorganisation of local and central government during the late 1980s has resulted in regional councils adopting catchment board sites and other sites omitted from the National Hydrometric Network. Records from the Meteorological Service network of synoptic, weather and rainfall observation stations are archived in the Climate Database (CLIDB) administered by NIWA. At this time some significant reductions occurred in the network. For example between 1988 and 1992, a substantial decline occurred in the number of climate stations operated by the Meteorological Service, reducing from 380 stations to just 200 stations (Mosley *et al.*, 1992). A large proportion of the closures resulted from the privatisation of the New Zealand Forest Service, which had operated many of the climatological stations throughout the country.

The number of manual rainfall observation sites in the Meteorological Service network increased steadily to 1065 in 1970 but declined to 585 in 2000, probably because private observers were not replaced when they retired. The availability and favourable cost of telemetered automatic recording stations, combined with the convenience of receiving on-demand electronic data means that this decline can be expected to continue.

The record length for rainfall recording sites that were open at the start of each decade is shown in Table 7 and the trend is plotted in Figure 5. The categories for dividing the length of records for presentation here is arbitrary. A record length of 30 years is typically used for normalising rainfall statistics.

The number of rainfall recording sites in each category of record length increased quite steadily until about 1980. While some sites would have closed during this period, they were more than replaced by the addition of new sites. The number of open sites with more than 30 years records has increased by 4% since 1980. The number of sites with long-term records has remained steady, and

Table 7 – Incidence of record length for open rainfall sites in each decade.

Record length	1850	1860	1870	1880	1890	1900	1910	1920	1930	1940	1950	1960	1970	1980	1990	2000	2010
1-9 years	0	2	10	5	16	71	123	202	172	190	328	391	628	559	521	418	350
10-29 years	0	0	1	12	15	35	101	179	280	349	336	459	570	734	669	627	703
30-49 years	0	0	0	0	1	10	14	30	77	141	221	261	228	284	286	319	302
50-100 years	0	0	0	0	0	0	1	9	13	32	76	132	229	284	240	237	218
>100 years	0	0	0	0	0	0	0	0	0	0	0	1	4	8	14	28	34

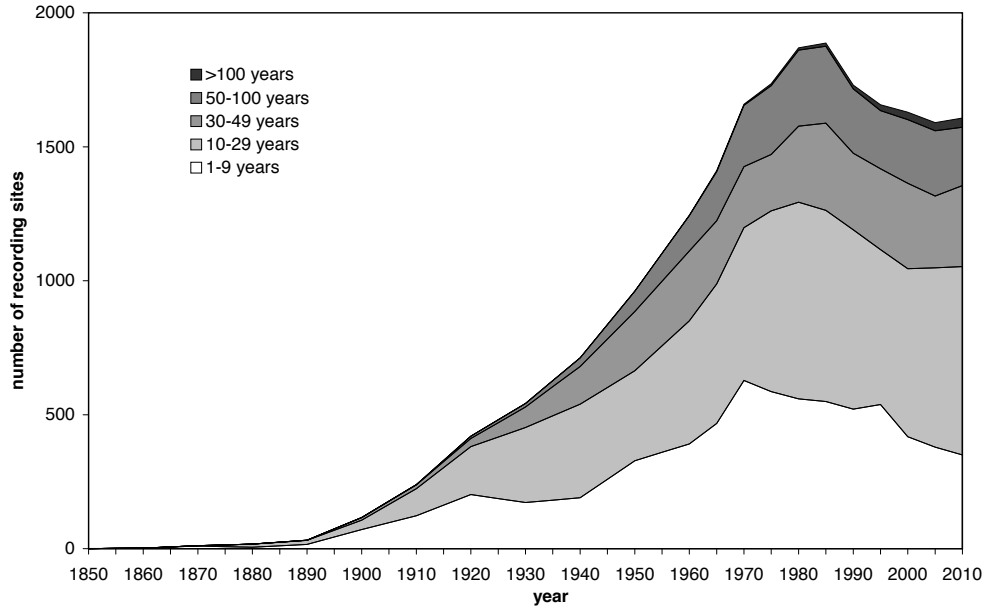

Figure 5 – Incidence of record length for open rainfall recording sites.

those sites with longer than 100 years record has steadily increased over the past 30 years. This suggests that rainfall recording sites established in the towns and population centres at the end of the 19th century, principally for weather forecasting, have been retained in the network.

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Hydrological reflections from the Sixties

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Horace Freestone's undying loyalty and Dave Murray's untimely departure has finally got my butt off the chair to record something of hydrological life in the Sixties past or thereabouts. Not that the butt gets much wear with a large resource educational committment and the extreme flood events that currently dictate life on the wild, rugged and beautiful Coromandel peninsula.

I joined the Hydrological Survey in 1964, having completed a Physical Geography Masters at Canterbury. Dr Jane Soons was my tutor. John Waugh decided to work off his Teaching Studentship, while I opted to pay mine back. The Ministry of Works was seeking to employ hydrologists but none came trained, and the outcome was that many interesting people eventually trained themselves to be hydrologists.

I travelled by ferry from Christchurch to Wellington to meet with Kees Toebes, the impressive, tall, bald, enthusiastic Indonesian Dutchman. He and the rest of the Soil Conservation and Rivers Control Council (which housed the embryonic Hydrological Survey) were housed in the old wooden Government Building on Lambton Quay. It was a huge place with undulating floors and lots of rooms. Some of the characters were Doug Campbell, Chief Soil Conservator, and his powerful secretary, Miss Clark. Many said she ran Soil Conservation, but Doug was one of the pioneers of aerial topdressing. He was also an uncle to Alan Chandler. Arch Campbell was there as Engineer Hydrologist, Tom Nevins as Rivers Engineer and Noel Collins as Soil Conservation engineer. There were no doubt others, but my stay was brief.

The Hydrological Survey was never an official title. It was called by other names like Hydraulic Survey, and when the MOW became the MWD it was part of the Water and Soil Division. However everybody knew of the Survey, and at one stage we tried to have it transfered to the DSIR.

Kees knew where his version of Hydrology was going. I was told that to become a competent Hydrologist I would need three years of on-the-job training: one year learning field techniques, second year researching basin hydrology and a third on data analyses. I believe I was the only one to have actually done this programme, and that was when I did my first OE – from Christchurch to Whangarei. Before leaving the home town I attended the first of a number of training courses at the Hydrological Instrument Depot, Kainga, on the banks of the Waimakariri River and headed by the inimitable John 'Daddy' Speight. It was here I first met Barry Morrissey and John Forth of the Christchurch Survey. Ian Simmers was looking after the Dunedin Survey. Alf 'Hoppy' Hopkins was looking after Palmerston North, Pat Grant Napier, and Herman Drost Whangarei and Hamilton. It was all very new.

1964 marked the begining of the International Hydrological Decade, which opened in Budapest, and Kees Toebes attended with his four languages. The next ten years was a stimulating experience for a virgin hydrologist. The local data collecting and research activities expanded rapidly, in keeping with like activities all round the planet. The neat thing was that all those interested in water joined in, irrespective of their origins,

and it was the same internationally. There were a few disagreements, but probably the most ridiculously tedious was whether water was more important than soil. Apparently global hydrological networks peaked during this Decade and are now declining, despite the ever-increasing need for data.

Whangarei was the base for the Auckland Survey, and each District had an office plus field parties. We had one in Auckland. Whangarei was like a foreign country for a mainlander. Here I met two very good friends, Rob Aspden and Nick Rodgers, who later became part of our KARGAN forest venture. The resident engineer was the very accommodating Alec Aitken, Herman Drost was about to depart for Hamilton, Keith Russell was running the field programme, ably supported by Maureen in the office, and Colin Hovey, Vic Freestone, Alastair Fairburn and John Howe. We also had a hermit-like character called Ivan looking after the equipment and he smoked the most peculiar tobacco.

In 1964 data was extracted from water level and rainfall charts by hand. There was always something to do. Manually operated adding machines were still around, but the new electrical Frieden calculators were coming of age. These greatly helped flow gauging and other calculations. Another difference is that all memos had to be hand written and sent to the typing pool for processing. One of the blessings of the computer is that it has caused the extinction of typing pools and the dragons that invariably guarded them. The Residency staff were always helpful, particularly the team of overseers, they knew everything and it was here that the image of MOW staff leaning on their shovels was despatched for ever.

As a graduate wally I will be forever grateful to the Whangarei team for teaching me some hydrology, because I knew nought. We did not have the wildest rivers on the Northland peninsula, but we had some interesting experiences. During 1964/66 we established much of the regional hydrology progamme (Representative Basins) and the Puketurua experimental basin to study the hydrological processes in changing the land use from scrub to pasture. About 10 weirs and flumes were built, some quite big, and without the need for resource consents. At Selwyn Swamp, north of Kaitaia, we built a small V-notch weir in the flat sand dune Northern Sands basin. Unfortunately the weir was 30 cm too high, causing backwater problems for the local dairy farmer. So a little further down stream we built a copy. There was enough money left in the initial quote and the first weir was to be demolished, without record, on the day the RE decided to visit. Also of note was the flume in Pukewaenga catchment 2 at Puketurua. The foundation was slush and so, supported by our Hydraulic engineer, a large mound of clay was placed on site, holes drilled into it, and 300lbs of gelignite placed and ignited. A superb bang displacing the slush and placing the clay allowed the flume to be constructed. Rob Aspden was designing the SH1 realignment across the mudflats south of Whangarei but was not allowed to use the technique by Auckland. We used Paraquat herbicide to clear weeds from the main Puketurua channel, given that it would not damage other biota!! One of the problems with toxins is that their full effect may not be known for decades.

Interesting experiences at Puketurua included soil surveying with the intrepid Ted Cox, DSIR, wading through gorse and the protea *Hakea acicularis* (introduced from horse feed along the original Kaikohe road), sulphur and a pH less than 2, moa crop stones and tektites; serving the tea tree interception plot at midnight in a storm; Northfork infiltrometer runs with Peter Lykles, and later witnessing the transformation from scrub to pasture of this gumland basin. Crit Schouten comprehensively reported this study.

Amos Glass and John Bartleet looked after soil conservation matters from the Waikato

River north. They built miles of graded banks to improve the moisture regime of the incredibly hard and difficult gumland soils. The rush was a problem weed, but we now know from our donkeys at Thames that they eat this plant with relish and should be used as very systematic controllers of weeds, but that is another story. Amos spent much time studying the erosion problems of Pukekohe market gardening soils and introduced trucks to cart the soil from the bottom of the slope back up to the top. And they are still doing it!! How about contour cultivation? The late Harry Gibbs, Soil Survey boss, 'talks' to me frequently. He was always reprimanding us for not getting soil survey terminology correct (oops, we now don't have a Soil Survey) and he constantly bemoaned the disrespect for highly productive soils shown by local government in favour of urban sprawl. Auckland region is planning two new cities around Papakura and Pukekohe. 'When will they ever learn.'

Alan Moores, Northland Catchment Commission, was also a very supportive local. There are many interesting memories. I remember, while on a rain gauge hunt in the Mangakahia basin with Vic Freestone, walking round in circles in the fog, flood gauging the deep, turbid and sluggish Wakapapa river from the SH1 bridge, and the use of rope and timber to slow speeding traffic. Tidal gaugings on one-way SH bridges required stamina and stupidity, and if you were to collect toheoroas from Ninety Mile Beach in a Works vehicle, make sure a raingauge was nearby. We used to stay at the Awakino pub (an old WW2 hospital located on one of several old airfields) and on one ocassion Axey Young, boss of the Soil Mechanics lab, was reported by a member of the public for using a Works vehicle to go to the pictures in Kaitaia. Current Government agencies take note.

Then there was the morning that one of the staff arrived at work to say that the Survey's A40 van was now upside down in several punga trees off the Whananaki road. This same vehicle was also slept in when in the field by some to save on accommodation expenses. Looking back, salary and expenses were ok. We always got paid, whatever we were doing, which is much appreciated by those of us in private employ. However it's interesting to note that my salary in 1964 was $954 (then pounds) and that of the Resident Engineer was about $2000, and that was big money.

At the end of 1967 it was part of the plan for me to transfer to Head Office, Wellington, with John Waugh moving to Whangarei. Our first office was the magnificent Bishop's Court, next to the old St Paul's Cathedral. With lots of people in action it is difficult to recall some details. Our room had about 5 staff. Our statistician Colin Smythe died in a climbing accident on Mt Elie de Beaumont, and there was Dick Pittams, whose pride and joy was a Wolseley auto. Carol Warner was a dominant voice on many matters and a capable editor of publications. Most of the staff had transfered from the wooden building down the road. Several excellent dressup parties were had in this building before we transfered, in 1967, to the new earthquake-proof Vogel Building over the road.

Frank Scarf arrived from Wairakei Geothermal and there was the bubbly Beth Stringer and Jane Hodgson. A Winston Churchill Fellowship saw me overseas for the duration of 1968 and in Czechoslavakia during the overthrow of President Dubcek by the Russians. I took this year of study very seriously and returned monthly reports to NZ. On my return the only info retained by colleagues was the gradient of the subterranean wine bar stairs in Budapest, which provided a check on the inebriated. Also, once the Churchill office got my final report they did not want to know more. More than I can say for the SIS, who were interested in my experiences behind the Iron Curtain. I replied by saying I saw very little difference between Moscow and Washington.

Most of the Water and Soil Division were located on the 3rd floor where the SCandRCC, WAC, and NWandSCA were serviced. It was a fantastic opportunity for us youngins to meet the players in the Water and Soil industry. Staff numbers increased and we moved to the 4th floor with the Roading Research team, another neat relationship. These engineers, led by Norm Major, laid the basis of today's roads.

Room 401 was a large open-planned room. I believe it housed 18 of us artists, scientists and engineers, but am not sure. The groups task mostly was to study hydrological processes as dictated by water, soil and plants. Apart from myself with little knowledge and control of this interesting group, there was Warren Burke - botany, Mike Hendy - ground water, Gordon Mallinson - infiltration, Richard Ibbit - mathematical models, Alan Cook - engineering applications, Judy Taylor - phytomorphology, Sandra Franks - transpiration techniques, Robyn Gaelic - data analyses, Max Wigbout - statistics, Barry Morrissey - field hydrology, Tony Pritchard - publications, Brian St Clair Corcoran - water quality, Bruce Palmer - regional hydrology, and Dave Greenall - statistical models.

Back on the 3rd floor the Hydrological Survey still had a little territory. There was Kees and Milton Yates, who provided excellent liaison between Soil Conservation and Hydrology. Then Alan Chandler, Hoppy Hopkins, Ted Kellett and Hans Hartog looking after instrumentation, training and data processing, with several helpers

HQ was also the centre of many embryonic computer arguments and some were obscene. Over the 10-year period our data processing capabilities had gone from Frieden calculators to onsite computers. The only problem was we could not always keep up. Also on the 3rd floor were our Soil Con colleagues – Ray Dixie, Graeme Howard, Tony Warrington, and engineers Noel Collins, Tom Nevins, Ross Howard, George Caddie, Russell Howie, Don Bagnall, Gary Williams, Mike Beable, Phil Thompson, Ian Jowett and Kit O'Halloran, and Graeme McBride (sorry to any I have forgotten).

Such a young and inexperienced group in HQ was unusual but it had its worth. We revamped the code for open planning, such that staff could retain a degree of privacy. We examined noise levels and carpet became the recognised best floor covering, although we never got any. There was always something happening. I have mentioned the debate over which was more important, soil or water. Well this was followed by the Research debate, which I will come to.

Vogel Building was the first building designed to earthquake specifications. The core and floors would stay intact but every thing else would fall off. I was in Kees Toebes office when one hit and it was fascinating to watch pillars and walls moving independently, only to come back to centre. Each Wednesday we would practice light rescue by being lowered from high-rise buildings around Wellington. This was our contribution to CD.

'Who should be Research Director' was a very unpleasant experience. John Wendelkin from Forest Service was the first appointee, but this was appealed by Kees and others. Alan Greenall of the Otago Catchment Board was next, and Jerry Dunford, USDA, was appointed as an advisor. There was further dissatisfaction and eventually Dr Ken Mitchell of DSIR, Climate Laboratory fame, was appointed. He sadly died in office. Kees Toebes and a number of us resigned as the new Research Centres came into being at Hamilton, Palmerston North and Christchurch about 1972. Room 401 ceased to exist.

We who resigned set up Tonkin and Taylor's first Wellington office in Kees' apartment. This was the first water resource consulting group in New Zealand and we were able to survive because of NZ Aid to Malaysia and Indonesia and the 3-year Kelantan river basin study in

NE Malaysia. Staff include Max Wigbout, Leigh Houston, biologist, and myself. We did the Otaki river hydro investigations from here, the Taupo Spa Hotel Court case, Aswan dam investigations and others.

Messrs Colin Mcleod and Warren Gibson were the two Division Directors while I was in HQ. There were many notable folk coming and going, including Tom Fancourt (Manawatu Catchment Board) and Lindsay Poole (former NZFS DG and Chairman of the SCandRCC). Another benefit of HQ was the opportunity to see the country. I had interception plots at Trounson kauri forest, FRI Rotorua, Otutira, Moutere and Twin Stream, Mt Cook. The latter was Tony Archer's high-altitude grassland research station on Glentanner station. This was also an opportunity to rub shoulders with Trevor Chinn's Snow and Ice group based at Tekapo and Timaru.

As for the good admin folk, my memory fails me. I know they kept us in order and there were few hiccups so they must have worked pretty efficiently. There were some pretty interesting stories about how admin operated, but this did not stop some of them reaching the top of the Public Service or marrying other members of staff. During the Decade I can recall around 10 marriages.

Enough has been said of the Auckland District, so south to Hamilton where Alan Singleton oversaw the field programme and Joyce Havebier data processing, while Dick Pittams looked after data analyses. A large monitoring network and the Otutira and Purukohukohu experimental basins featured prominently. The water quality of Lake Taupo was of concern then, and we did tritium sampling with DSIR's Mike Taylor to assess the lake's turnover time. DSIR also set up a large Freshwater Ecology lab in Taupo and Mike Timperley spent much time there. The Waikato Valley Authority's Geoff Ridall, Hunter Young and Bob Priest were involved, as was Pat Noble (Agriculture Rukuhia), Bob Jackson (FRI, Rotorua) and Geoff Fish (Internal Affairs, Rotorua), who was involved with the water quality of Lake Rotorua. Mike Selby (University of Waikato) did mass movement studies and later became its Vice Chancellor.

We spent a lot of time in Rotorua at FRI, assisted by Horace Freestone and his field party. Bob Swanson of Canada liked what we were doing to measure sapflow rates in trees and he was impressed with the massive growth rates in our trees compared with those back home. He stayed for 18 months from 1971, developing the heat pulse technique on different age groups of *Pinus contorta*, *Pinus radiata*, Douglas fir and *Nothofagus* species. Bob was so impressed with the quality of flounder fish that we had it every day for lunch, and also our real ice cream.

Two hydrological quotes sum up the Hamilton District. Heggie Holtan of infiltration fame said he reckoned that the infiltration rate for the pumice was infinite, while Horace Freestone, attempting to measure the Motu river in flood with an Amsler current meter, recorded a surface velocity of 6.5 m/sec. We get these velocities nowadays in our local Coromandel streams.

Wanganui District was less on my itinerary, but ably led by Chas Page and a very competent jet boat driver who served on HMNZS Achilles. The Plant Materials Centre at Palmerston North was frequently visited. Under Chris van Kraayenoord's management this was a centre of diverse conservation plant research which was fully tested when poplar rust arrived and hybrids had to be rethought. Chris has since been recognised for his contribution to plant science and I still see him at Farm Forestry meetings.

Napier District, with Pat Grant and Jim Price, had the Mangatu experimental basin and some of the highest sediment discharges anywhere. Studies in the Kaweka range were a relief from the hectic pace of hydrological life. Most notable was Brian St Clair Corcoran's

study of Heretaunga underground water, which showed it to be polluted by the upper plains rubbish dump, which took 8 years to close.

Wellington District, on both sides of the Strait, had Dick Bellamy, Richard Wilcox and eventually Frank Scarf. Alec Aitken, my Resident Engineer in Whangarei, became the District Civil Engineer in Wellington, which had its interests. The Soil Bureau at Taita had its catchments and a vast amount of soil information which now ceases to exist. The Makara Soil Con reserve on the spectacular south-west coast was looked after by Milton Yates, and was where we did neutron soil moisture research and tried alternative land uses on some flumed catchments, gales permitting. Hugh Thorpe and Nick Rogers operated the Gracefield Hydraulic Models laboratory for many years, and models included the Lower Clutha river and Wellington airport.

Ray Dixie's old camping ground, Moutere Soil Con reserve, was now run by Allan Gillingham, Frank Crimp and Maurice Duncan. Some of the large number of flumed catchments were being converted from grass to forestry studies and it was on the Moutere Gravels that the wisdom of logging up hill was realised. I can still see logging trucks negotiating stream channels, while Eric Graynoth of Internal Affairs was demonstrating the benefits of riparian plantings on native trout habitat.

Working from Wellington was a fantastic experience, but it was not where the work was done. The Ministry of Works and Development, contrary to the 'leaning on the shovel' theory, was a hugely diverse and competent technical organisation. Schemes like the Upper Waitaki, Tongariro, Manapouri, Kaimai tunnel, Porirua housing et al. would now be difficult to execute. Government should have retained the planning, research, design and archives, and shed the consultation and construction instead of sending the baby out with the bath water. Our later work offshore benefitted from MWD backup.

Christchurch will always have the home-town feeling. The Southern Alps smell so different from the northern volcanoes. At Rangiora, the Forest and Range Experiment Station was led by Jack Holloway, John Morris, Colin O'Loughlin, Lindsay Rowe, Andrew Pearce, Ian McCracken and Alan Nordmeyer. Paul Mosley also worked here for a short time before becoming a prodigous editor for the New Zealand Hydrological Society.

At Lincoln there was the Tussock Grasslands and Mountain Lands Institute headed by the intrepid and religious Keven O'Connor, and ably supported by John Hayward, Tony Archer and others. I used Tony's high-altitude research base at Glentanner station for alpine interception studies. Also at Lincoln was the Agricultural Engineering Institute, led by Australian John Burton, who favoured farm dams for water control over vegetation. Terry Heiler and Vince Bidwill also worked here.

Time spent in the McKenzie country will never be forgotten. The Tekapo field party was under the control of Trevor Chinn, who also looked after Antarctic activities, from Timaru, but it had its characters. Graeme Tailby later operated from Malacca, Malaysia on the NZ Aid Hydrology programme, and Ian Halstead still operates the field party and has seen huge changes to the waterways of the Upper Waitaki.

Archer's dunny at Glentanner had the most magnificent view of Lake Pukaki and the frosty Basin. While playing with artificial rain gear I watched helicopter shooting of thar in 1970 and I wonder why DoC are still trying to do the same. We need to get pest control right. Glentanner was developing as a tourist venture, with an airstrip for Newmans Air. North across the Tasman River is Mt Cook station and the base for St Barb Baker, Man of the Trees. At the entrance to the McKenzie

basin, Mathew Burke erected a cairn at the summit of Burkes Pass reminding us to plant trees, for our life would depend on them. How true.

Mt Cook Airlines gave me many magnificent views of glaciers and alpine catchments and a trip via Queenstown to Alexandra to visit the Manorburn experimental basin. I spent many occasions walking and deer stalking the catchments of this southern region as a student. Even then one had to be impressed by the grandeur of Nature and the need to not forget the importance of Natural Capital.

Written a year or two ago …

Reminiscences from 40 years in hydrology (1967-2007)

John Waugh

I joined the Hydrological Survey of Ministry of Works (MOW) in 1967 and was posted to Christchurch for training. We were based at Kainga, near the Waimakariri River, on the same site as the Instrument Depot, with some of the data-processing staff in Bates Building in Central Christchurch. I set about finding out what field hydrology was all about – this involved one to two-week tours to the West Coast, or to Marlborough and Nelson, on jet-boat gauging surveys.

Similar trips took us to the Buller River and all its tributaries, which had a network of power investigation stations. In Murchison we met up with the legendary Dave Tamm, who lived in a single man's hut in the Works Depot. Dave always lit up his thermette and made a hot brew of tea about 10 am, most welcome on a frosty winter morning. We always seemed to be at some river station around 10 am.

We spent a week at Haast doing a site survey at Roaring Billy (86802) where a recorder station was established in 1969. John Fenwick may have been on that job, I remember someone standing on the north bank of the Haast surrounded by a dense black halo of sandflies – good insect repellent was essential. We got a rap on the knuckles for daring to drive home through 'Otago District' without advising Dunedin. You almost needed to get your passport stamped.

The first data processing job I did was to manually process years of monthly Kent chart records from site 68504, Lake Heron at South Lake, which had chart records beginning in 1938. You didn't need to process too many years of data by hand to realise the virtues of electronic data processing. A few years later it was possible to digitise chart records. Hydrology in New Zealand largely got around that problem by investing in a new generation of digital punched-tape recorders. These punched binary-digital code (numbers) into foil-backed tape which could be read into a computer. The first Fischer and Porter recorder (NZ1) went into the field in Northland in 1964 and was still operating when I arrived in January 1968.

In late 1967 I spent three months in Head Office, on the 4th floor of the Vogel Building, Aitken Street, in transit to Whangarei. I mainly worked for Milton Yates, analysing some data from the Makara catchments. I also got to know Barry Morrissey, Kees Toebes and other Water and Soil Division staff. I attended the annual Hydrological Society conference in Wellington late in 1967.

Hydrology in Northland

As District Hydrologist for Auckland District, I was responsible for all hydrological investigations north of the Waikato River. We were based in Whangarei and reported to the Resident Engineer, Atholl Buckland. I later established a field party in Otahuhu, working on urban hydrology and thermal power station investigations on the Manakau Harbour.

Northland is a fascinating place to work in hydrology, as it has very varied geology and very extreme climate. In the first four months of 1968 we experienced a reasonably severe drought and did hundreds of low-flow gaugings between Auckland and Kaitaia. I tried to ensure that the field staff gauged close to the lowest flow at each of our recorder stations, to pin down the lower rating curve. This drought ended in late March – early April with two tropical cyclones (including Cyclone Giselle, the Wahine storm), which dumped 900 mm of rain in 10 days around Puhipuhi, in the headwaters of the Wairua River. Only the tops of houses and cowsheds poked up through the floodwaters of Hikurangi Swamp. I was not surprised when we heard that the Wahine had been sunk.

We got to do a wide range of interesting investigations. In 1968 we assisted with nuclear power investigations on the Kaipara Harbour. Our team from Whangarei sailed from a wharf near Matakohe on a launch that Keith Russell had hired, and motored out to the South Head of Kaipara Harbour near Te Kawau Point. The Kaipara is an enormous harbour with deep water in the main channels. We anchored and did velocity readings with current meters over a large range of depths. Because we were in salt water, the meter cabling contacts had to be kept dry (to stop electrolysis messing up the signal), so Keith Russell ordered a gross of condoms from the Auckland stores office. After a considerable 'hissy-fit' from the Auckland stores office, the requested items were delivered and did an excellent job, all in the interests of science. We rapidly learned to tie all our tools onto lanyards, otherwise when the boat rolled all the loose spanners and screwdrivers went over the side. We also filled in time when there was no current running, at high and low tide, by fishing. We caught enough snapper to feed the whole crew, all cooked by the skipper's wife. We were there for two to three days. Horace Freestone and a party from Hamilton were similarly engaged off Shelly Beach, further up the South Kaipara Harbour.

Part of the job involved radio-tracking drifting semi-submerged floats, to find out how long a body of water took to exit the Kaipara. Keith Russell tracked some surplus (out-dated) RNZ Airforce sonar buoys, which were ideal as they floated submerged and transmitted a radio signal via a whip aerial. We got a truck-load, because if we wanted some, we had to take the whole lot. They did an excellent job and had a MOW address painted on them. Months later one found on North Head was handed in to the Dargaville Works depot.

In the 1968 floods, the Mangakahia River at Titoki rose over 40 feet and we flood gauged it from the road bridge. In parts of the gauging section the Amsler meter had to be lowered through submerged willow trees. Fortunately, it was deep, but very slow flowing. At that time the Survey owned a 'punt' (as used by duck-shooters) and staff were using it to work on the Titoki staff gauge or maybe to free a trapped current meter. The punt capsized and sank – one of the field staff complained about the difficulty of swimming through submerged blackberry bushes in his body-waders. The lost punt had to be written off, along with sundry tools (actually all the tools were missing). Our local Stores Officer duly completed the action and commented that it was no wonder the punt sank!

The same Stores Officer hauled me into his office to complain about the fact that two of my staff driving a J1 Bedford van had

passed him on the Ruakaka straight and he could not catch up to them to reprimand them. Such was life in the MOW in the 1960s. The Whangarei Residency was a great outfit to work in, and I was lucky to be there when we celebrated the Centenary of the Ministry of Works.

Low-flow gauging from the droughts in 1968 and 1970, together with data from the recorder stations, gave us plenty of data to examine the low-flow water yield in relation to the geology of catchments north of Auckland city. There was a very clear relationship between the water yield under baseflow conditions during the droughts and the geology of the catchment. This was most clearly defined on the greywacke and also in the areas with volcanic rocks. Areas with claystone (flysch deposits) simply had no flow during droughts and this often covered quite large catchments. Driving around near the end of a drought and checking for flow at culverts and bridges could provide a lot of useful information for one to two day's work. On one occasion, in the Manganui catchment, we were checking for flow and noting an old staff gauge on the bridge pier, when a local farmer raced up in his truck and accused us of being stock-rustlers. We talked our way out of that confrontation. The water yield information I mapped was very useful in preliminary investigations for small rural water-supplies, or for small towns. For example, greywacke catchments yield 5 L/s per square kilometre, or 0.46 cusecs/square mile in 1968. Furthermore, this water yield is reasonably uniform over quite large areas. I find it encouraging that this basic information was still being used in Northland 20-30 years later.

Puketurua experimental basin, 613 acres, was actually three nested catchments that were covered in manuka scrub and some hakea when I arrived in 1968. The flow measuring stations and climate station had already been set up by Gary Blake and Nick Rodgers. Puketurua was part of the Titoki land development block run by the Department of Lands and Survey. During World War 2 it had been used by the Americans as an artillery range and for troop training. It was littered with bits of ordnance, mostly exploded, and sundry slit trenches, hidden in the scrub. On one inspection visit in winter an engineer disappeared with a shriek. He scrambled out soaking wet – he had fallen into a slit trench full of water.

In 1970 we spent several days keeping fire out of Puketurua as Lands Department staff burned off the areas adjacent to our eastern catchment boundary. In the summer of 1971-1972 Puketurua was to be cleared of scrub and heath by burning, followed by giant discing, cultivation and sowing down to pasture. The fire was lit by Lands Department staff down in the centre of the basin, on a calm hot autumn day. The fire rapidly spread up the slopes through 20- to 30-foot high manuka and developed into a roaring wall of flame. All our vehicles were moved out of the basin to safety, as petrol tanks can explode from the extreme heat. Burning off 613 acres, almost a square mile, took all day and is described as a 'controlled burn-off'. In reality it was anything but controlled, and when the wall of flame, around 30 to 50 feet high, reached the top of the western ridge, the fence posts on the opposite side of the road spontaneously burst into flames. The adjacent land owner got a new fence out of that accident. As the fire developed, a really strong wind blew across the ridge tops, carrying oxygen in to the centre of the fire. This later developed into a regular gale and birds had a difficult time escaping from the burning area. The field staff saw a large Brown Kiwi run across the road and chased it on foot. The kiwi escaped at speed through old standing burnt scrub on the adjacent block – so much for them being 'nocturnal birds', they seem to see perfectly well in daylight. Wildlife Service had attempted to trap and remove kiwi prior to the burn-off.

During the land development we had an excellent opportunity to examine the loss of nutrients and sediment in storm rainfall events. Puketurua may have been farmed in the 1920s and 1930s, and it had clearly been dug over for kauri gum, which left very broken land surfaces. No fertiliser had been applied to it for at least 30 years and the Northland gumland soils were very infertile. Land development involved applying two tons of lime and seven hundred-weight of superphosphate per acre. I managed to interest Bob McColl and Ed White from Taupo in this project. We collected water and sediment samples during storms and they analysed the samples and wrote up the results. It was a worthwhile investigation and produced some good results.

During the land development we found all sorts of interesting objects, like artillery rounds (luckily a dud) and nose cones, complete with the setting ring (I still have one as a paperweight). It would have made rather a nasty mess if it hit a person when it exploded. There were also quite a number of mortar rounds sticking up out of the soil, and large siliceous concretions (hard and very heavy), not to mention numerous small patches of polished and coloured stones, which we realised were Moa crop-stones.

In 1972 I attended the Engineering Hydrology and Groundwater courses at the University of New South Wales at Sydney. This excellent course was run by Dave Pilgrim and Ian Corderoy. I had completed five years of field hydrology by 1972 and had a thorough knowledge of how rivers worked during both floods and droughts. Other students on the course were similarly experienced, and it made for a very lively and interesting three months.

Hydrology Centre, Christchurch

In 1975 Dr Ken Mitchell, the new Research Director, visited Northland and inspected our activities. He later invited me to move to the Hydrology Centre in Christchurch, as 'Officer in charge of National Hydrology', with oversight and training roles for the Hydrological Survey teams. After a period of political turmoil there was a need to get the Hydrological Survey teams settled down with clear work programmes, good technical standards and in-house training.

One of the first things we did was to re-establish an 'Index to Gauging Stations', as no one knew where all the flow stations and raingauges were. This resulted in a series of 'Index to Gauging Stations' reports, compiled and published by Kathy Walters. Successive issues became more complete and included equipment owned by Catchment Boards and other local bodies, e.g. Waitakere City Council, and WaterCare Services in the Auckland area. It is rather difficult to 'manage' a network if you don't even know where the equipment is located, or how many instruments of each type are in the field. Later, in 1978, Horace Freestone moved from Rotorua to Christchurch to join the National Hydrology group. Later still, Doug McMillan joined us at the Hydrology Centre.

We organised annual 'Missing Record' surveys, which soon highlighted problems with some types of recorders, e.g. jammed and bent punches on Fischer and Porter recorders. Another major source of missing record were clock failures. Rick Moore and his team at the Kainga Depot soon rectified these problems and missing records decreased dramatically. One of the lessons learned was to keep equipment simple. The more complex it is, the more likely it is to fail.

In July 1976 the Department (Ministry of Works and Development) sent me to North America to attend WMO's Commission for Hydrology CHy-V session, at Ottawa, Canada. I met staff of the Water Survey of Canada, whose field work and training were similar to ours. After the conference I travelled via Niagara Falls, to Lincoln, Nebraska, then across to Grand Teton and

Yellowstone National Parks, then west again to Seattle. I had an organised itinerary to visit several government agencies in the western USA. At that time the US Geological Survey and the Canadians were trying out satellite-based telemetry for hydrological monitoring. New Zealand joined the programme with two stations, in the Rakaia Gorge and on the Hurunui at Mandamus. This put two satellite platforms south of 40 degrees south latitude and they worked well once we had beefed-up the aerial array to withstand our Nor'westers. Data came back on telex via a base station in Maryland, a bit cumbersome, but alright for a trial. The field operations of the Water Resources Division of the US Geological Survey were essentially identical to field practice in New Zealand, not surprising as we had borrowed lots of ideas from the USGS back in the 1940s and 1950s.

South Canterbury Catchment Board (1982 to 1990)

In January 1982 I moved to Timaru and joined the South Canterbury Catchment Board, working as a Field Hydrologist, under Frank Scarf in the Water Resources section. It was a great job and I really enjoyed my time in South Canterbury. In 1982 we installed new permanent recorder stations on the North Ashburton at Old Weir, South Ashburton at Mt. Somers, and on the Tengawai, Pareora and Waihao. Within a year or two we added telemetry to all our main river stations for flood warnings, and found it was hugely useful for water management in summer droughts.

When I arrived in Timaru in 1982 the flow records showed that there had not been much flood activity for some years; this continued through till December 1985. It seemed we might be overdue for a flood! In March 1986 it arrived, a massive flood event which wiped out several recorder stations. On the Tengawai, Pareora and Waihao the flood was probably in excess of a 200-year event. It was massively larger than the February 1945 flood. Luckily it peaked during the day on 13 March, allowing numerous helicopter rescues of stranded people. Only one person lost their life, and around 2,000 people had to be evacuated. The flood caused about $60 million of damage to bridges, stopbanks, roads, railways, farmland and fences, and to flooded houses, especially around Pleasant Point and Temuka. I later wrote parts of a comprehensive 'Report on Flood, 13th March 1986'. This was the first of several major flood reports I compiled during my career in hydrology. Following the March 1986 flood, SCCB installed an extensive network of telemetered automatic raingauges, as these would give around 6 hours of extra flood-warning time, vital for farmers trying to move stock in inclement conditions. Most of this network is still working today.

In 1984 I worked with Frank Scarf and Kevin Swete to produce the 'Opihi River Water Management Plan, 1984-1990'. Then in 1986 we produced the 'Rangitata River Water Management Plan, 1986-1996'. These were quite slim document of 30 to 40 pages, but contained all the essential information and policies. They were quite well received by people in Water and Soil Division in Wellington. I find it encouraging that many of the features of the 1986 Rangitata plan were later embedded in the Rangitata River Water Conservation Order. The only thing we missed in 1986 was a cap on allocation.

In 1990 I moved to the Head Office of the Department of Conservation, still in a water-related job. Almost the first thing I did was to deliver the proposed Kawarau Water Conservation Order (WCO) to the out-going Minister of Conservation. Philip Woollaston signed it off and that allowed it to be lodged with the Minister for the Environment. Over the next decade I prepared and presented hydrological evidence at WCO Hearings, on behalf of the Minister of Conservation and for Fish and Game. I attended the Mohaka

hearing, where I met Geoff Hulbert, a DoC lawyer who specialised in WCO matters. Later I went to Westport to present evidence at the Buller WCO hearing; preparing for this had involved a memorable field inspection with Neil Deans of Fish and Game (Nelson) and David Young (author, and previously editor of the Water and Soil magazine). We were also involved in the Motueka River WCO hearing, where the local body hydrologist was Andrew Fenemor. Eventually all these WCO applications came to a satisfactory conclusion. By 1995 I had moved to Works Consultancy Services in Wellington, because of a chance meeting with Horace Freestone on a bus stop in lower Willis Street. I joined Horace's team in what was then Power Division of Works Consultancy Services, soon to be Opus International Consultants. DoC engaged me to present the hydrological evidence for the Kawarau WCO hearing at Queenstown, and this too also ground its way to a successful outcome.

Opus International Consultants (1995 to 2003)

In the years 1995 to 2003 I was based in Wellington, living in an historic farmhouse at 116 Wilton Road. Looking back, one of the main tasks I took part in was writing up a series of reports on major floods. This started with the December 1995 flood in the Clutha and Waitaki catchments, which saw 3,000 cumecs discharged over Waitaki dam. Ian Halstead and his team from Tekapo did some very high-flow gauging in the Waitaki, below Waitaki Dam. An ECNZ engineer asked us why high-flow gauging had not been done in earlier years, but you needed to go back to 1948 to find a large flood and that was only a fraction of the December 1995 event. Hydrology staff from Dunedin and Alexandra did high-flow gauging on the Clutha, and also pegged flood levels from Alexandra down towards Roxburgh Dam. This seemingly simple job yielded some extremely useful information on the behaviour of the Clutha River flow through the Roxburgh gorges. In effect, the gorge below Alexandra was behaving like an enormous Parshall flume.

In November 1999 another very large flood occurred in the Clutha catchment, and to a lesser extent in the Waitaki. We also got involved in the resource consent renewal process for the hydro-power dams on the Clutha and Waikato Rivers, together with similar work at Lake Coleridge, Cobb and Waikaremoana. I wrote up 'Flood History' reports for both the Clutha and the Waikato. I had finished a first draft of the Waikato report when the large July 1998 flood occurred. It then had to be incorporated into the Flood History report. One thing that became obvious from reporting on large floods is that any storm that dumps more than 200 mm of rain in 24 to 48 hours is going to produce a major flood.

Towards the end of my career in hydrology I spent quite a lot of time preparing evidence and presenting it at Regional Council hearings, e.g. the Lake Coleridge hearing at Environment Canterbury, or before the Environment Court. As mentioned earlier I presented hydrological evidence at all the WCO hearings and in cases that ended up in the Environment Court. Even after I had retired from full-time work in 2003, and moved back to Timaru, I made two trips to Nelson to present evidence for Fish and Game relating to the Gowan River. All the cases that I presented evidence for in the Environment Court ended with a successful outcome for our clients; I always tried to keep my evidence simple and used basic hydrological information that was clear and easy to understand. An elderly lawyer told us to 'always visit the scene of the crime', it was something I always tried to do, and I regard it as very good advice. On one such visit to the Gowan I observed it at a relatively low lake level and low flow. I documented this by reading the staff gauge on the wharf in Lake

Rotoroa, and by photographing several key reaches down the Gowan River.

I continued to work part-time for Opus from 2003 to 2006, and then did a few small jobs for Opus via my son's firm, Waugh Infrastructure Management Ltd. of Timaru. This mostly involved evidence for the renewal of stockwater consents for Selwyn and Ashburton District Councils, a job that had begun in 2001 and ended in 2010.

I have greatly enjoyed working in hydrology in New Zealand. In my view hydrology has made a significant contribution to the development of this country, and continues to do so today.

86,400
Fond remembrances of Micro-Tideda by 'DOS' Doyle

Martin Doyle
Tasman District Council

Earlier this year, with one hand held aloft, a former cornerstone of New Zealand Hydrology slipped quietly under the polluted waters of the sea of change. This flotsam had been swirling in the current while time ticked down from the 1st Jan 1940. Exactly 2,147,783,647 seconds after this date, the DOS version of Micro-Tideda ceased accepting any more data.

This programme came into being in 1985, and for the first time in New Zealand enabled all aspects of data entry, processing and analysis to be carried out quickly and easily on a small stand-alone computer. That computer was the venerable IBM 286, the forerunner to modern home PC's.

Micro-Tideda was a significant step forward. Prior to this time work had to be carried out on mainframe computers, either on a terminal connected to the MWD Vogel computer centre in Wellington (if you were lucky enough to have a terminal), or on the PDP-11 computers used by the Catchment Boards. Information was collected on paper charts and foil-backed tapes, and these were processed in Wellington, while editing and analysis could be done remotely. It was however, a complicated business requiring you to remember a string of commands to do the simplest thing.

The initial version of Micro-Tideda was used on the Altos computers. These were noisy little boxes which operated with two 8-inch floppy disks, one holding the programme and the other the data. The Altos was a giant leap forward for remote field teams, but it was only when the IBM-architecture PC arrived and Bill and his mates wrote MS-DOS that the wheels really started spinning.

Micro-Tideda was the result of work carried out by many people back into the 1960's. Credit is given in the Tideda manual to H Kennedy, R Howard and P Thompson for their early efforts. Following on, S Thompson and G Wrigley took the baton along with P Mansfield, R Ibbitt and B Grant.

Richard Ibbitt and Ian Jowett in particular drove further development by overseeing the

creation of large archives of data, and Stephen Thompson and Mark Rodgers worked with S Close, P Pallister and A Wood to write successive versions of Tideda. Tony Hill and Guy Halliburton then added their expertise to take Micro-Tideda to the level it reached in the early 1990's. Part of the success of Micro-Tideda can also be attributed to the work Doug McMillan did introducing staff in remote field offices to modern computing, providing training and establishing procedures until most of the country's hydrology staff were competent Tideda users.

A Windows-based product was introduced in 1995 and this 'Kiddy' Tideda soon became the standard. The word is that several outposts of serious DOS men and women still existed, with single fingers tapping out P this and PL that and the odd T of the other. Soon however, everyone was using a mouse and drop-down menus, easier or course, but not as quick. Some really useful general knowledge ceased to be relevant at this time – like, how many seconds are there in a day?

Now of course Windows Tideda has gone through several more evolutions and Hilltop software is also widely used in New Zealand. Both have their pedigree in the algorithms written for DOS Tideda, and I guess that's a pretty good legacy for those that worked on it over the years.

Doug McMillan's cartoon explains floppy disks back in the mid-80's

Field party makes own entertainment on Saturday night

Bob Curry

As recalled, it was a Saturday back in the late 1960s, following a week of very heavy rain in the Tararuas and Eastern Wairarapa ranges, and the Ruamahanga River was in full flood, testing the performance of the newly formed Diversion Channel on the partially completed Lower Wairarapa Barrage Flood Control Scheme. The Diversion Channel cut had shortened the overall channel considerably and the river bed was progressively adjusting upstream, causing some concern about the integrity of the Tuhitarata Road Bridge (then the only river crossing downstream of Waihenga, near Martinborough), as the resulting degradation and lower water levels had caused the pile caps and significant lengths of the piles to be exposed.

Thus there was a need to recalibrate the stage-discharge relationship at Tuhitarata in order to know the flows which were finally going down through the Scheme, and so the Ministry of Works Trentham Residency Hydrological Field Party, comprising Murray McGregor (later to become Technical Correspondence Institute Hydrology Tutor), Dave Comber (a Reg. 130 – the designation given to a non-staff wage-worker) and Bob Curry (ex MOW/DSIR/NIWA), was mobilised to continuously gauge the flood flows throughout the entire upper portion of the hydrograph.

Several weeks before there had been a large earthquake in the Murchison area which was felt strongly in the Wairarapa and the local paper had expressed concerns that this may exacerbate the integrity of the Tuhitarata Bridge with its exposed piles, degraded bed, and resulting higher velocity causing increased bed scour around the piles.

After a long day undertaking numerous gauging runs back and forth across the bridge, the Party worked on into the night,

taking breaks in between runs in order to allow the stage to change significantly, and of course to have the necessary cups of tea, before commencing the next run. Come ~10 pm on the Saturday night, the pub traffic from Featherston (~20-minutes up the road), began to increase, as did the enquiries and smart remarks about the gear being dangled from bridge – how's the fishing? caught anything? being some of the more quotable remarks.

To help get through the night, it was time-to-have-some-fun – so in exchange for the alcohol-fuelled, remarks from the occupants of the next vehicle, which approached the appropriately lit, signed and traffic-coned bridge, they were told that the bridge was under siege from the flood, and that they would need to cross it very carefully in order to minimise any shaking and possible failure. This they duly did, and the driver of the next vehicle to offer a smart remark was told of the predicament of the "dodgy" bridge and instructed to back up the road and take a run at it, in order to get over the bridge as quickly as possible, thereby minimising the

time and associated risk on the bridge. Thus, to the Party's amusement, alternate slow–fast –slow instructions were issued on into, and through the night. The tight horizontal bends both ends of the bridge, coupled with the steep vertical approaches up onto both ends of the bridge deck, made for an interesting spectacle, particularly for those advised to back up and take a run at the bridge – the vertical configuration launching some of the faster vehicles into the air in true Dukes of Hazard – General Lee style!

Well, you can imagine the confusion the next day, when the South Wairarapa country party lines ran hot the following morning, when tales of "we only just made it home last night over the Tuhitarata Bridge" and "that we had to go real slow over the bridge to get home safely"; were exchanged with tales of "that's funny so did we … but we were told to go real fast to minimise our time on the bridge?" It even made headlines in the local South Wairarapa newspaper – "*Locals Receive Mixed Messages on Crossing Tuhitarata Bridge in Flood*".

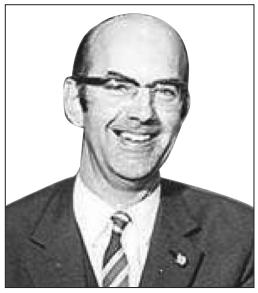
Fortunately there were no repercussions or "explain whys", but it certainly helped to alleviate the boredom of the many hours of flood gauging through the night, and no-doubt added a bit of interest, humour and bewilderment for the local community. Not sure that ~50 years later, with more vigilant journalism, and a PC society, that we would have gotten away with this one?

A hydrological gallery: people, events and places

Lindsay Rowe

This chapter is a compilation of some of the people who have been nominated as having made significant contributions to the Society and hydrology in New Zealand. Giving priority to some founder members, Life members and Award winners, combined with space constraints, have meant that some deserving candidates have missed out. These notes have been extracted from Society records or provided by colleagues. The photographs scattered throughout this section have been supplied by members. I am grateful to all those who have helped.

Cornelis (Kees) Toebes (1925-1975)



Kees Toebes was a larger-than-life Dutchman who arrived in New Zealand in 1951 and had a profound influence on New Zealand hydrology. From his early days in the North Island Hydraulic Survey, he rose to become the Chief Scientific Hydrologist of the Water & Soil Division (WSD) of the Ministry of Works (MoW) and was responsible for all the hydrological works of the Division. He was instrumental in setting up programmes to demarcate the hydrological regions of New Zealand and to establish the representative and experiment basins networks. Training was another strong point and he instituted the *Handbook of Hydrological Procedures* and wrote a two-volume text, *Applied Hydrology.* The International Hydrological Decade (IHD) commenced in 1965 and Kees was involved both in New Zealand and overseas; his mana was such that he co-authored an international guidebook, *Representative and Experimental Basins.* A high point was the IAHS Symposium on the *Results of research from representative and experimental basins* held in Wellington in 1970. Kees was also heavily involved in many UNESCO working groups.

Kees left the WSD in 1974 to join Tonkin & Taylor, consulting engineers, and his tasks included the development of the Malaysian national hydrological organisation and the Kelantan River basin project. He died at Aswan in Egypt in December 1975 while undertaking an assessment for future work in the Nile Basin, especially in relation to sedimentation issues.

In 1961, Kees guided the formation of the NZ Hydrological Society and was President for 13 years; excellence in hydrological science was to be the guiding philosophy of NZHS.

(Extracted from a more comprehensive article by Pat Grant. 1973. Cornelis Toebes, 1925-1975. *In:* Murray, D.L.; Ackroyd, P (Eds.) Physical Hydrology: New Zealand Experience. Pp 1-9.)

Pat Grant

As well as being a founding member of the Society, Pat was our first Life member, in recognition of his 12 years as editor of the Society's Journal, time spent on the Committee, and the many papers in the Journal of Hydrology (New Zealand) (JoHNZ) and conference presentations. Pat had various jobs (an Air Force draughtsman

during WWII and in NZ Forest Service National Forest Survey teams) before joining the Hawke's Bay Catchment Board as an engineering assistant and thence to the MoW. There he developed an interest in the Kaweka and Ruahine Ranges, investigating rainfall measurement and distribution, droughts and low flows, river sediment yields, etc., and became involved with the IHD programme. These varied research interests earned him a Doctor of Science from the University of Waikato in 1988. Once retired, Pat published "Hawke's Bay Forests of Yesterday" summarising his views of how mankind, in conjunction with the stresses of the physical environment, contributed to the loss of forests in the region.

A scholar and a gentleman always willing to debate and share information with others, as editor of JoHNZ Pat was a mentor to authors but with high standards, and this was reflected in his own meticulous work.

Pat Grant stands under a boulder lodged in a tree. The boulder was moved in a flood generated by Cyclone Alison in the Waipawa River in early 1975. (Photo: Hugh Thorpe)

Horace Freestone

Horace started his career in the Hydrological Survey of the MoW at Whangarei in 1961 and became leader of field parties in Whakatane and then Rotorua. As a reflection of his meticulous approach to data collection and processing, Horace moved to the Hydrology Centre in Christchurch, where he drafted standard procedures, worked on field standards and ran national training courses. When he returned to Wellington he was in charge of the 16 field parties, and ran more training schemes and aided the introduction of telemetry for data retrieval from field sites. A move to the Power Directorate, MoW, led to projects on sedimentation, floods, and low flows. Horace moved to Works Consultancy Services (later to become Opus) in 1988 and worked on projects from catchment modelling to probable maximum floods, as well as having stints in Cambodia and India.

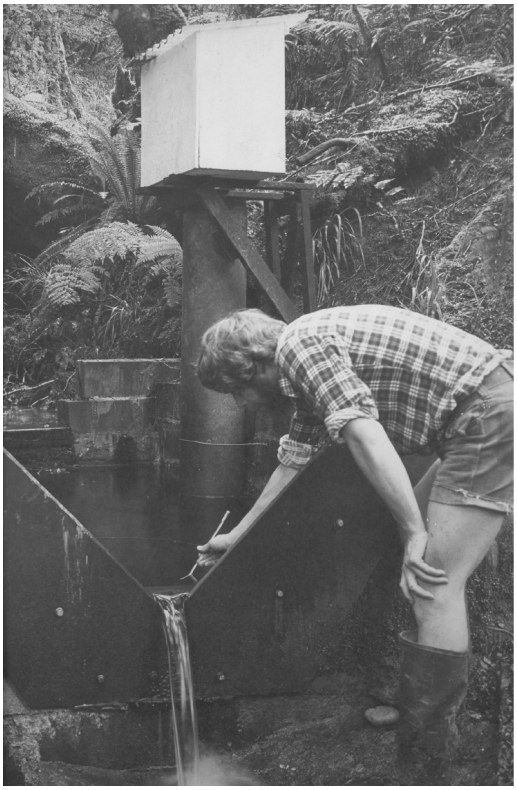
Horace has always been a tremendous supporter of NZHS, serving on the Committee for 18 years, and helping organise and giving presentations at conferences. In recognition of these contributions, Horace was became the second Life member of NZHS in 1998.

Paul Mosley

Paul has been one of the stalwarts of the Society since joining in 1976. Roles as president, editor, committee member and editor/co-editor of four of the Society's books show Paul's commitment to the Society and to providing texts of value to Society members, students and others, all with New Zealand examples. In addition, Paul has given many presentations to conferences. As President, Paul made submissions to Government on the changes to science and water management organisations as restructuring occurred in the 1980s-1990s.

In his professional life in New Zealand, Paul undertook research on small South

Island catchments run by the Forest Research Institute (FRI) before moving to WSD. There his work included the management of the hydrological network, data quality assurance programmes, research on the management of rivers for instream uses, and National Water Conservation Orders for the Motu, Ahuriri and Rakaia Rivers. After a period as Professor of Geography at the Victoria University of Wellington, he undertook contract work in Asia and New Zealand on environmental issues. The Society recognised Paul's contribution to New Zealand hydrology with its Outstanding Achievement Award in 1983 and in 2001 the Royal Society of NZ (RSNZ) caught up and awarded Paul their Science and Technology Silver Medal. After *Freshwaters of New Zealand* was published in 2004, Paul became the third Life member of the Society.



Paul Mosley at one of the Maimai weirs.

Vince Bidwell

Vince graduated from the University of Auckland with a PhD in Engineering and then headed overseas, spending two years in Colorado developing a new method for assessing agricultural response to drought, and a further two years in Malaysia working on flood forecasting and designing hydrometric network and data analysis techniques for the Malaysian Government. Back in New Zealand he spent the majority of his career associated with Lincoln University at the NZ Agricultural Engineering Institute (NZAEI) and Lincoln Ventures Ltd. There he worked on a wide range of topics, including drainage and irrigation technology, sugar beet production for conversion to ethanol, and adaptive flood forecasting techniques (with Canterbury Regional Council), but he has been especially productive in the areas of water and contaminant transport through soils into groundwater, and the modelling of groundwater dynamics. Vince has been particularly adept at developing models of environmental processes, often taking them from a conceptual understanding through to fully developed mathematical models available for use as a tool. Latterly he has helped develop a groundwater transport model for integrating the effects on groundwater quality of nitrate from land-use activities.

A prolific author of journal articles, Vince has also been a great supporter of the New Zealand Hydrological Society through presentations at our annual conferences at which he has been a frequent winner of the award for best paper at the conference. Vince was awarded the NZHS Outstanding Achievement Award in 2009.

John Burton

John Burton taught, practised and encouraged hydrology during his time in New Zealand from 1965 to 1970. An Australian civil engineer and university academic specialising

in flood hydraulics and water resources, he was the first Professor of Agricultural Engineering at Lincoln College and the University of Canterbury and simultaneously the first Director of the NZAEI. He designed and implemented a new professional engineering degree, in agricultural engineering, jointly taught between Lincoln College and the University of Canterbury. He also realised that very little engineering hydrology was being taught in New Zealand, so set about teaching it himself as masters courses, which quickly became very popular with students of both universities. Together with Terry Heiler, he introduced Australian practice in water conservation and farm dams and tailored it to New Zealand conditions. John was a tireless traveller to, and lobbyist in, Wellington. Notwithstanding, or perhaps because of, his colourful language and Australian drawl, his advice was sought and listened to in the engineering profession, in university management and by local and central government politicians. He was also a very entertaining after-dinner speaker, including at Society symposia. He introduced to New Zealand a unit for very large volumes of water, the 'Sydarb' - the approximate volume of water in Sydney Harbour! Professor John Ralph Burton was widely respected in Australia, where he returned in 1971 to set up the School of Natural Resources at the University of New England, a new degree programme in Resource Engineering and then a new School of Engineering. He was widely known for his work chairing the Lake Pedder Enquiry in Tasmania. John was awarded the Order of Australia in 1990 and an Honorary Doctorate from the University of New England in 1995. He continued working as a consultant after a stroke in 1995 and died in 2000, aged 71.

Bob Curry

Bob Curry worked as a hydrologist for MoW, DSIR and NIWA from 1967, following two years working in land surveying and draughting. Bob's early hydrological duties with the MoW in Wellington covered the gamut of field hydrology, including design, construction and servicing of flow measuring weirs and bed control structures; development of guidelines for district offices and catchment and regional water boards on hydrological field techniques and data analysis methods; site and river channel surveys, etc. His start in hydrology overlapped with the IHD, which saw the MoW establish monitoring of "representative basins" across New Zealand. In 1971 Bob was promoted to the District Hydrologist position for the Wellington Works District, involving the overall management and operation of hydrological research and survey activities in the Lower Manawatu, Horowhenua, Wairarapa, Wellington, Nelson, Marlborough and Upper Buller regions. From 1989 Bob continued to play an important role in ensuring hydrological data were collected to the required quality, and archived safely for present and future uses, and took on national leadership and oversight of NIWA's hydrometric projects. Bob was New Zealand's Secretary of UNESCO's International Hydrological Programme.

A particular hallmark of Bob's career has been his ability to adapt his New Zealand knowledge to overseas situations. He has worked extensively in Australia, Bangladesh, Fiji, Kiribati, New Caledonia, Papua New Guinea, Solomon Islands and Vanuatu. In the late 1980s Bob spent four years working in the Solomon Islands as the Senior Water Resources Adviser attached to the Solomon Islands' Ministry of Natural Resources.

Through his leadership and direction in the field of operational hydrology Bob made significant contributions, both in New Zealand and internationally. For example, a comprehensive "Hydrologists Safety Manual"

written by Bob was later adopted by the World Meteorological Organisation. He was presented with the Hydrological Society's Award for Achievement in Operational Hydrology in 2007.

Barry Fahey

Barry Fahey's initial foray into hydrology was summer work with the Hydrological Survey at Green Island, and this led to degree work in the Department of Geography, Otago University—a study of interception by pine, manuka, and tussock grassland. Postgraduate studies at Colorado and teaching at the University of Guelph kept Barry overseas until 1985, when he joined the FRI at Christchurch, just before the Forest Service was disbanded and the science organisation restructured. Initially he worked on road erosion studies, but then became involved with the FRI small catchment land-use studies at Maimai, Big Bush and Glendhu. With a strong leaning towards Otago, the Glendhu catchments rekindled his interest in tussock grassland hydrology. Here, with Dave Murray, he worked on the water balance of the tussock grasslands and the controversial topic of the role of fog interception in streamflow generation. Barry supervised a number of Otago students' research projects and collaborated with visiting scientists and Mike Stewart (GNS) on subsurface flow studies. Other highlights of his career have been leader of the IUFRO Working Group on Forest Hydrology based in Vienna, and lecturing in hydrology at Forestry and Geography at Canterbury University.

Barry was an early member of the Society, joining in 1964, and has spent 12 years on the Society Executive, including four years as Secretary. Apart from papers published in JoHNZ, Barry contributed papers to conferences and chapters in Society books. In 2000, he was awarded the Society's Outstanding Achievement Award.

Maurice Duncan

After gaining a first degree in agricultural science, Maurice joined the MWD in 1968 and undertook postgraduate study at Lincoln College on a rainfall simulator to investigate phosphorus erosion rates. When this was completed, he moved to Nelson where he was responsible for the hydrological survey team in the Nelson/Marlborough area. He was also in charge of running the Moutere Field Research Centre, which had been established to study rates of runoff from small catchments in the Moutere Hills area, in particular identifying the changes in runoff due to planted pine forest in pasture catchments. In 1977 he moved back to Christchurch to take charge of the MWD hydrological survey teams in the Canterbury region. He has developed wide-ranging research interests in: water resources and flow regimes; braided rivers sediment movement; instream habitats and values; irrigation assessments; hydrologic modelling.

Maurice has been a great supporter of the Society having served on the committee for 14 years, presented many papers at our conferences and published papers in the journal and four of our books.

Graham Elley

Graham has worked with the MoW, DSIR and NIWA since 1974, specialising in environmental monitoring. He has originated, and contributed to, many hydrological projects while based with the Instruments Systems group. He has been a key contributor to the successful operation of numerous data collection networks, encompassing a range of environmental parameters including hydrological, meteorological, and water quality. Graham's responsibilities have included network design, monitoring system design, installation and commissioning, operational maintenance and the development of data collection systems.

His skills encompass instrumentation, electronics, data communications, hydrology and meteorology. Graham has 20 years of experience in the design and implementation of environmental monitoring systems. Notable projects include reviews of hydrometric instrumentation equipment for hydro electricity generators, the design and integration of remote hydrological monitoring systems with hydropower operational systems, and helping to design a floating meteorological monitoring platform for the America's Cup. His expertise in electronics and radio telemetry were instrumental in the development and implementation of the Aquitel water-level telemetry system of the 1980s, which enabled near real-time knowledge of river flows for a wide range of water resource management and warning purposes, efficiencies in field operations, and contributed greatly in the quality assurance of hydrological data. In 1992-95 Graham led the Instrument Systems group, when it was based at Kainga, just north of Christchurch. He has since developed a broader role covering the full design, implementation and operations of environmental monitoring systems in New Zealand and the Pacific region. Graham's achievements were recognised with the NZHS Award for Achievement in Operational Hydrology in 2003.

Andrew Fenemor

Andrew Fenemor studied agricultural engineering before taking on a job as a water resources officer with the Nelson Catchment Board in 1976 and then the US Department of Agriculture Soil Drainage Research Unit until the early 1980s. Back in New Zealand he worked as a groundwater scientist with the Hydrology Centre in Christchurch, developing the first groundwater flow model of the Waimea Plains before returning to Nelson as an analyst and resource manager. Andrew's forte has been his ability to integrate science with resource management as in, for example, the Waimea, Moutere and Motueka-Riwaka Plains water management plans, setting up and reporting to stakeholder meetings, liaison with consultants, contractors and water users, and presenting options and results to public meetings. Issues around tradeable water permits have been another interest. Andrew left Tasman District Council for Landcare Research in 2002 to lead the Integrated Catchment Management research programme focussed on the Motueka catchment. More recently he has been involved with the organisation of UNESCO/ WMO "Hydrology for the Environment, Life and Policy" programme and as a Commissioner hearing submissions on the Central Plains Irrigation Scheme proposal, Canterbury.

On the Society Executive for 13 years, four as president, Andrew has contributed to the JoHNZ and Society books. He was awarded the Outstanding Achievement Award in 2006.

George Griffiths

George Griffiths completed a PhD in Civil Engineering at the University of Canterbury in 1976 and then joined the Ministry of Works and Development, where he led a team researching suspended sediment and bedload transport, stable channel design and flow resistance in gravel bed rivers, river sedimentation, rainfalls and quantitative geomorphology. Results included an analysis of suspended sediment yields of New Zealand rivers, rainfall distribution across New Zealand mountain ranges, and assessment of the risk of occurrence of geomorphic events such as rock avalanches.

In 1985 George took up the position of Hydrologist at the North Canterbury Catchment Board and Regional Water Board. There he developed floodplain management plans, notably for the Waimakariri River,

undertook water resource investigations and did research work on flood and drought frequency, flood modelling, bedload transport, and sediment translation waves.

Following the establishment of Regional Councils in 1989, George became the Regional Engineer for the Canterbury Regional Council (CRC) and worked on regional policy and plans, as well as rainfalls, low flows and hydraulic geometry. He was instrumental in developing the Canterbury Water Management Strategy, which delivered a water balance for the Region, and noted sites for potential water storages, together with pre-feasibility assessments of the effect of constructing the storages.

In 2007 George retired from the position of Director of Investigations and Monitoring at CRC and joined NIWA, where he is now working part time on rainfalls, flood frequency, flood estimation and low flows.

John Hayward

John Hayward was a Committee member and President in the 1970s. A soil conservator originally, who loved Otago tussock and mountain country, John obtained Lincoln College BAgSc and MAgSc degrees, with a thesis on alpine erosion plot studies. His PhD (1978) involved multi-disciplinary research on land-use effects in Canterbury's Kowai River catchment. John was a genuinely charming man who attracted international scientists to work alongside him. An exchange in 1974-75 with Stan Schumm and his team at Colorado State University fuelled John's interest in creative, interdisciplinary watershed management. He was robustly critical of 'silo' thinking. John joined the Tussock Grassland and Mountain Lands Institute at Lincoln College in 1964 and survived its reforms to become Director of the Centre of Resource Management. There, John was able to extend resource management to include economics, sociology, policy analysis and planning in an interdisciplinary approach. John often spoke of "standing on the shoulders of others" in research and his own debt to Lance McCaskill. The high regard in which he was held led to positions on the Planning Council and the Environmental Council (Chairman). John received a Commemoration Medal in 1990 for services to the environment. He died aged 55 in 1993 following cancer. A collection of John's later essays and unpublished papers entitled "Monday's Agenda: rethinking environmental management and values" will be published in 2013. In John's words, our challenge is "not to prescribe solutions", rather it is to present planners, political leaders and students alike with "ways of thinking about, or approaching, environmental problem solving and decision making".

Richard Ibbitt

Richard Ibbitt arrived in New Zealand in 1970 after studying at Imperial College London. From 1970 to 1978 Richard worked with the MWD at its Head Office in Wellington, where he led a team that implemented TIDEDA on a mainframe computer and developed computerised office facilities for overseeing the routine data processing that led to production of the New Zealand Hydrological Archive. Richard laid the data foundation on which much of New Zealand's subsequent hydrological analysis and modelling is based. In 1978 Richard moved to Christchurch to lead a group at the MoW Hydrology Centre, and from 1986 he led all the Centre's research. In 1989, the Hydrology Centre was absorbed within the DSIR, and Richard became the Manager of the Centre, providing leadership for 25-30 staff, until the Centre was moved into NIWA in 1992.

In his early Hydrology Centre days, Richard led work on catchment modelling, hydrological software development (including Tideda), data quality assurance techniques,

low flow estimation and hydrological instrument development. Richard's later research focused on better understanding and modelling of surface water processes, using catchment models such as SHE, HYCEMOS and TOPNET. Richard also worked on irrigation scheduling, urban water-demand scheduling and operations, and hydrological impacts of land-use change and climate change.

A highlight throughout Richard's career has been his international work, particularly for UNESCO with his leadership of the International Hydrological Programme for the South East Asian region. Many national hydrological services within the region received direct leadership from Richard in establishing their hydrological infrastructure. Richard retired from NIWA in 2010 after 40 years of outstanding service to hydrology.

Dave Johnstone

Dave worked in field hydrology and environmental monitoring instrumentation with the MoW, DSIR and NIWA since 1973. Dave combined a formal science background in chemistry with a passion to investigate methods to improve the reliability and accessibility of hydrological measurement systems. Dave's areas of expertise have included flow measurement (including salt dilution gauging), water level and velocity measurement, water quality sensors, data loggers and programming of loggers. For several years Dave was a key member of the Instrument Systems group providing support to both NIWA (and its predecessors) and regional council field teams to enable the successful operation of their hydrometric monitoring networks. Dave was heavily involved in training others, and has developed and run numerous training courses to update the instrumentation skills of several hundred hydrological New Zealand field technicians. Similarly, Dave has been a key person investigating the suitability of new monitoring technologies in a New Zealand context, and in investigation of the performance of current technologies. In particular, Dave contributed to the comprehensive analysis of the performance of mechanical current meters and their calibrations, developing better understanding of the complex relationship between meter revolutions and water velocity. The New Zealand Hydrological Society recognised Dave's significant contributions to, and leadership in, the collection of high-quality, quality-assured hydrological data, with the Award for Achievement in Operational Hydrology in 2003.

Ian Jowett

Ian Jowett's early career was with the Power Division of the MWD, where he did a lot of computer modelling of catchment hydrological responses for central Otago hydropower developments. His most outstanding contributions have been in the field of eco-hydraulics and his work in understanding the relationships between the distribution, abundance and response of fish populations to flow regime, hydrology, and physical habitat. His key studies have included the "100 rivers study", which led to a model of brown trout abundance, and long-term studies of fish populations in a number of rivers to determine factors that control populations of brown trout and native fish. With others in NIWA, Ian has contributed greatly to our knowledge of habitat use by fish and benthic invertebrates, and has developed methods that allow this information to be used to assess the potential effects of flow changes. With over 30 years of experience in engineering hydrology and environmental flow requirements, and a very practical focus, Ian has provided advice to a wide variety of clients on the biological implications of flow regime alteration and environmental flow

requirements, including in-stream habitat, water temperature, flushing flows, seasonal flow variations, and flow fluctuations below hydro-peaking stations. This experience has been used to formulate methods for assessing flow regime requirements in rivers by many regional councils in New Zealand.

Alistair McKerchar

Alistair received his tertiary education at the University of Canterbury, with a BE (Civil) and a PhD on the hydrology of the South Island's main hydroelectric catchments. In 1971-72 Alistair spent time at Purdue University working with hydrologists there, and then went on to work at the Institute of Hydrology (1973-75) around the time of the publication of the major UK Flood Studies Report. In 1976 Alistair joined the MoW Hydrology Centre in Christchurch, which was later moved to the DSIR and then NIWA. With Mike Beable, Alistair worked on the first major New Zealand flood study, published in 1982 and based on similar methods to the UK study. In 1989 Alistair revised the flood study with Charles Pearson, using new methods. Besides flood studies, Alistair has been involved in a wide range of hydrological studies, such as time series analysis, extreme rainfalls, low flows, network design and hydrometry, and has worked on projects in South East Asia and Sri Lanka. He has published many papers on these topics. Over the last decade he has been an integral part of NIWA's seasonal climate forecasting team. At the same time he has contributed new knowledge on non-stationarity of hydrological processes and their links to climate phenomena such as the Interdecadal Pacific Oscillation.

Alistair was the Editor of the JoHNZ from 1977-80. In 1990 Alistair was awarded the Society's Award for Outstanding Achievement. He also received a New Zealand Water and Wastes Association's Arch Campbell Award in 2000 for his contributions on regional flood estimation.

Doug McMillan

Doug McMillan started his hydrological career in 1966 with the MoW Hydrological Survey in Palmerston North. His first role was in data processing, working under the guidance of Mr A.C. Hopkins (Hoppy) and Chas Page. With obvious skills in data processing, Doug moved to the MWD Head Office (Vogel building) in Wellington in 1972 to help maintain the national hydrological archive.

After a short spell in Malaysia, Doug sought re-employment with MWD and ended up in the Hamilton district office before moving to the Hydrology Centre in Christchurch. This move saw Doug training all 14 MWD field offices on how to use the Tideda program on an Altos computer. He did not have Powerpoint or a data projector in those days, just his cartoons and personable style. His success was truly remarkable, and soon all the MWD hydrology data was captured using the new facilities. This new technology enabled field technicians to control all aspects of their role and enabled the new kind of quality assurance that followed.

With the transfer of the Hydrology Centre to DSIR, Doug joined the newly created Water Resources Survey, where with Paul Mosley he initiated the DSIR quality assurance programme for hydrology. This work was truly world class and saw him doing similar work in Australia. Paul relied heavily on Doug to explain and implement the changes in work practice that were part of developing the Water Resources Survey into a world class hydrological service. A visit from Doug always provided an opportunity to clear up uncertainties in techniques or to learn a new process.

Since retiring from NIWA, Doug continued to work in the field of Quality

Assurance, expanding his client base into diverse fields such as meat processing. The New Zealand Hydrological Society awarded Doug its Achievement in Operational Hydrology Award in 2008.

Barry Morrissey

Barry Morrissey was an Irishman recruited in the early 1950s into the Blenheim-based Hydraulic Survey Party where he absorbed a vast knowledge of hydrology on the job. Much of his insight into hydrological processes was gained by observations when hunting and fishing. After transfers to Christchurch and then Wellington, Barry was to spend 10 years training technical staff and improving the standards of field hydrology in the water and soil organisation. Over the years he gathered a tremendous knowledge of instrumentation, gauging sites, measurement structures, and developed techniques for water resources mapping. Barry was a strong believer in the representative basin programme, which would provide data for extrapolation to ungauged catchments.

Barry was one of the eight founder members of this Society.

Dave Murray

For 33 years Dave taught hydrology in the Department of Geography at the University of Otago and many of his students are still members of the Society; some have served on the Executive. Teaching without lectures was a radical step for Dave and his students. Weekly readings, discussions of theory, problems and self-administered tests left most students enthused about hydrology. He was regarded as a tough but fair supervisor of students.

His main research interests were in the hydrology of tussock grasslands and groundwater modelling. Given his strong mathematical background, he was particularly interested in the accuracy with which components of the water balance could be measured, and was critical of those who did not include an error analysis in their calculations. In mid-career, a developing interest in groundwater modelling, with sabbaticals spent at GNS, led to the incorporation of this material in new courses and projects for students.

Dave was highly respected by his students and by those with an interest in hydrology, was incisive and forthright with his views on research matters, and was a man of principle with a sense of humour and enthusiasm for life.

Dave served the Society as president, editor, committee member and co-authored the first Society book (Murray, D.L.; Ackroyd, P (Eds.) 1973. Physical Hydrology: New Zealand Experience). He was a great supporter of NZHS conferences, helped to organise some, and encouraged students to attend and present papers. In 2000, the Society honoured him with the Outstanding Achievement Award for his contribution to hydrology.

Colin O'Loughlin

Colin was a West Coaster who joined the NZ Forest Service as a trainee in 1955. During university vacations, the NZFS had him working in high country surveys, which led him into a career studying the influence of forests on slope stability and mountain climate and hydrology. After gaining a PhD from the Unviersity of British Columbia on the stability of steepland forest soils, he took over the Geohydrology section of FRI in Christchurch. Under Colin's guidance, the section soon embarked on setting up suites of small research catchments at Maimai (West Coast), Big Bush (Nelson), Glendhu (Otago) and elsewhere, to determine the effects of land-use change on water resources. Colin's research interests in these catchments were mainly in sediment and water yields,

but he managed to continue researching the influence of tree roots on slope stability at Maimai and Mangatu Forest north of Gisborne. His skills saw him overseeing the setting up of catchment studies in Malaysia and led to his international involvement in slope stability programmes.

Colin was promoted out of the team to direct the Protection Forestry Division and rose to Director of Research for FRI and then to senior positions in other organisations. His impish nature and love of the outdoors was typified by his regular comment said with a wide grin "every day is a picnic in the bush", even when working out in torrential rain.

Chas Page

Chas Page commenced his hydrology career with the MoW in Taumarunui, after many years spent in hydrographic surveying with the British and New Zealand navies. After a short stint in Taumarunui, he resigned to undertake hydrographic survey work with Shell Oil in Nigeria. Shortly afterwards civil war broke out and he returned to New Zealand to be re-employed by MoW in the Palmerston North office under the leadership of Mr A.C. (Hoppy) Hopkins. When the District Office was established in Wanganui, Chas became the District Hydrologist. Among his responsibilities were the hydrological investigations for the Tongariro Power Project and the Taranaki ring plain survey. With the demise of the MoW in the late 1980s, Chas decided to retire rather than move to the DSIR Water Resources Survey. However, retirement came slowly, as he then spent the next decade working part time with the Manawatu Catchment Board and Manawatu-Wanganui Regional Council helping beat their data into shape, at the same time sharing his wisdom and tales of his exploits to many young hydrological staff within those organisations, often well into the following morning.

Chas's focus was always on the production of high quality data for current and future generations rather than on the pure science of hydrology. He delighted in having a thorough understanding of everything that confronted him, and every problem along the way was always seen as an interesting challenge to be solved rather than a hindrance. Chas left a fine legacy of quality data and, more importantly, a large number of individuals who were privileged to have learnt from him and who are still in the industry and trying to carry forward the high standards that he taught and expected.

Andrew Pearce

Andy Pearce joined the hydrology team at FRI located at Christchurch in the mid-1970s and became heavily involved in the research programmes, mainly at the FRI catchments at Maimai on the West Coast, Big Bush at Nelson and Glendhu in North Otago. This work focussed on the effects of land-use change on water and sediment yields and on hydrological processes, notably streamflow generation and the significance of evapotranspiration in the water balance.

Andy progressed from research to management of natural ecosystem research at FRI in the 1980s, and when the CRIs were established in 1992 became the founding Chief Executive Officer of Landcare Research, holding that position until 2005. He still has his interest in water matters, being the Chair of the Regional Committee to give effect to the Canterbury Water Management Strategy.

Andy was on the Society's Executive from 1979-1986, with two years as president. He published many papers in JoHNZ and elsewhere, made many presentations at Society symposia, and helped organise the IAHS International Symposium on Erosion and Sediment Transport in Pacific Rim Steeplands held in Christchurch in 1981. In 1980 Andy was the first recipient of the Society's Award for Outstanding Achievement.

Charles Pearson

Charles joined the Hydrology Centre of the MWD in 1982. He subsequently complemented his BSc degree in statistics from the University of Canterbury with an MSc degree in engineering hydrology from the University College Galway, Ireland. His primary research interest has been in hydrological statistics and he has published widely on regional frequency methods, floods and droughts, flood forecasting, hydrological network design, and rainfall-runoff modelling; the Society's Journal contains many of these papers. He was a co-editor with Paul Mosley of "Floods and droughts: the New Zealand experience" and contributed papers for three of the Society's books. The Hydrology Centre became part of the Freshwater Division of the DSIR in the late 1980s and it then morphed with other groups to form NIWA in 1992. Charles is currently the Regional Manager for NIWA's centres at Christchurch and Lauder.

In addition to publications, Charles was on the Society Executive for over 10 years and was presented with the Society's Outstanding Achievement Award in 1993. He is a hydrological advisor for the New Zealand permanent representative to the WMO.

Jim Price

Jim Price, has been described as the perennial field hydrologist, and was vastly experienced and ever patient with the newly employed and eager to pass on hard-won experience.

Jim joined the Hawkes Bay Catchment Board as a hydrological assistant in 1961. He worked on various investigations for drainage and flood control works. His duties involved field collection of data, installing and maintaining field structures and processing the data collected. In 1966, he joined the MWD as a Senior Hydrological Technician with the Napier Hydrological Survey. In this role, he was responsible for daily supervision of up to 15 field staff involved in hydrological station installation and maintenance, and ground water and coastal investigations. The job required extensive liaison with data processing staff. This was to be the theme running through Jim's career, including time with the Christchurch Water and Soil Science Centre groundwater group and then the Waikato Valley Authority, where he advanced from 'hands-on field hydrology' to overall management of Environment Waikato's data collection processes.

Jim has strongly supported national initiatives on the collection and management of environmental data. Principal among these has been the Local Authority Environmental Monitoring Group (LAEMG), which Jim was instrumental in forming in 1992 (and Chairman of for many years). This group has been a very successful forum for airing issues and unifying Council hydrology staff and practices throughout New Zealand. The meetings have also been a valued forum for younger technical staff to see the national picture, learn from case studies and other presentations, and perhaps make a presentation themselves in the only relevant setting available to them.

The Society recognised Jim's contribution to hydrology with the Award for Achievement in Operational Hydrology in 2007.

Lindsay Rowe

Lindsay Rowe served the Society tirelessly for 22 years, 21 as secretary and treasurer. Together with his wife Jan, he carried out most of the Society's administration over that period before stepping down in 2011. During his time as secretary/treasurer/administrator, the society grew substantially in membership numbers and in the extent of services offered. Much of this growth was only made possible by Lindsay and Jan's efforts.

Lindsay served as a scientist with the Forest Protection Division of FRI in first Rangiora and then Christchurch, and later,

Lindsay Rowe at an interception study at the Maimai catchments, West Coast

Landcare Research at Lincoln, for a total of 33 years. He worked mainly on the effects of land-use changes on the hydrology of small forested research catchments. He has many publications on this subject in the Society's and other overseas journals. His last work before retirement in 2001 was to pull together a series of bibliographies on New Zealand land-use hydrology, and the hydrology of radiata pine and Douglas fir forests. He received the Society's Outstanding Achievement Award in 1996.

Dave Scott

David Scott has been an important figure in the field of groundwater hydrology in New Zealand. David started with the Christchurch Drainage Board before moving to the WSD of MoW. During this time he completed his Masters degree in Agricultural Engineering from Lincoln University. In the early 1980s David spent three years working abroad in first Malaysia, and then the Solomon Islands. Returning to the DSIR in 1985, David started working almost exclusively in groundwater, forming a fruitful collaboration with Hugh Thorpe and others in the Geology and Geophysics Division. He moved to the Canterbury Regional Council in 1993, where he has remained, apart from two years leave of absence when he was attached to the South Pacific Applied Geoscience Commission in Fiji.

While with Environment Canterbury, David has been a leader in developing groundwater models for the region and providing expert scientific advice in an often contentious resource management environment. David has always been strong in producing high quality scientific publications while still working at his 'day job' in Environment Canterbury. Of particular note is the work that he did with Bruce Hunt in verifying the analytical solution to leaky aquifers through numerical modelling. David's colleagues at Environment Canterbury greatly appreciate the depth of knowledge and thoughtful consideration he brings to any project and few are able to match his considerable prowess on the squash court!

John 'Daddy' Speight launching the Hamilton jet boat with river gauging boom for one of the very first jet boat gaugings – on the Waimakariri River near SH1. (Photo supplied by Bob Curry)

John Speight

John Speight was another of the eight founder members, being on the Committee for three years and continuing as a long-standing member of the Society. He was appointed to a position as one of the two leaders of Hydraulic Survey Parties in 1949 and was to oversee the collection of hydrological data for the South Island. Active in instrumentation, he was responsible for the design of the standard gauging crane and was able to persuade the manufacturers of the Watts-Price current meters to make significant improvements to their design. John established the National Water and Soil Instrument depot in Kainga in 1958 and conducted the first National Hydrology Course in New Zealand in 1961. He continued to work in instrumentation after he retired from MWD.

Mike Stewart

Mike Stewart has been at the forefront of isotope hydrology in New Zealand since joining DSIR's Institute of Nuclear Sciences in 1965. Mike pioneered techniques for vapourising water samples for mass spectrometry analysis and has been innovative in his approach to groundwater dating. A prolific author, he has worked with many overseas and New Zealand scientists using stable isotopes to determine subsurface flow pathways in hillsides, the generation of catchment runoff, and the processes that make up the hydrological cycle. In addition he has used isotopes to characterise the sources, age, and flow pathways of water in groundwater aquifers and geothermal systems. Mike has also been part of a working group on water age measurements for New Zealand Water Standards.

Mike served on the Society executive for nine years, six as Editor of the JoHNZ, and was awarded the Society's Outstanding Achievement Award in 2001 followed by the RSNZ Science & Technology Bronze Medal in 2002.

Stephen Thompson

Stephen had an aptitude with numbers and, as a MoW bursar, he gained a B.E. (Hons) (and a concurrent B.Sc. in maths) and an M.E. in Civil Engineering from the University of Canterbury. His master's thesis on gravel-bed rivers was supervised by Professor

F.M. Henderson. He gained experience in construction and then took up a scholarship to Cambridge University, where he gained a D.Phil. degree studying turbulence under J.S. Turner in the Department of Applied Mathematics and Theoretical Physics.

On returning to New Zealand in 1969, he resumed employment with what had become the MWD, first in the Computer Services Division and then in the Power Design Office. Here he drove the development of a computer package that he named Tideda, an acronym for Time Dependent Data. His brother Phillip organised the digitising of what are now termed "break point" rainfall data. The first implementation of this package was on the MWD mainframe IBM 360 computer and its adoption throughout the MWD District Offices was overseen by Richard Ibbitt. Installation of Tideda on personal computers in the 1980s, ably assisted by Mark Rodgers and others, was a major achievement.

In 1979 he moved to Christchurch as Scientist-in-Charge of the WSD Science Centre. With the advent of commercial activity in 1986, this became the Hydrology Centre and was absorbed into NIWA when the CRIs were established in 1992. Stephen led or encouraged work *inter alia* in sediment transport, alpine precipitation and electricity market information supply. His major legacy to New Zealand hydrology is the existence of computerised archives of nearly all the stage and flow data collected by various agencies, which enables the best available data to be used for any water-related problem. He retired from NIWA in 2003 and was awarded the Society's medal in that year.

Hugh Thorpe

Hugh graduated from University of Canterbury in 1961 with degrees in mechanical engineering and science. His working career began with the MoW as an engineer. In 1963 he completed a PhD in fluid mechanics at the University of Aberdeen and returned to New Zealand to work in the hydraulics laboratory of the MoW before spending time lecturing at Khon Kaen University, Thailand, which stimulated a life-long interest in the hydrology of developing countries.

On returning to New Zealand, Hugh joined the WSD in Wellington leading one of New Zealand's first comprehensive regional groundwater investigations—in the Heretaunga Plains, Hawkes Bay. Success with this project took Hugh back to Christchurch to head the groundwater group at the Hydrology Centre. There he led a multi-disciplinary team of hydrogeologists, modellers, chemists and geophysicists who worked all over New Zealand providing technical assistance with the catchment boards and regional councils. When Hugh joined the Hydrology Centre there were very few people across the country who were active in groundwater research and assessments. Recognising the skills gap, Hugh instigated groundwater training courses, initially for catchment boards and regional councils, which proved very popular. Since 1993, Hugh has been a researcher at the University of Canterbury, where his interests have included the measurement and modelling of groundwater recharge from rainfall, which led to the current recognition by Environment Canterbury of 'red zones' where the level of groundwater allocation may be a problem for groundwater resource sustainability.

Within the NZ Hydrological Society Hugh has actively promoted Oxfam 'Water for Survival'—a project that aims to provide clean water supplies for developing country villages. He has contributed to the JoHNZ and several books. In 2008, NZHS awarded Hugh its Outstanding Achievement Award.

Jeff Watson

Jeff Watson came from the "old school", beginning his hydrology career in 1970 with the MoW in Wanganui under the tutelage of Chas Page. Chas's influence on Jeff was notable, and he has been a great advocate for the fundamental technical skills in hydrology—proper gauging technique, rating curve construction, site selection skills, and carrying out correct and conscientious field inspections. Jeff made his move away from the MWD in 1975 for a short period with the Hawkes Bay Catchment Board, before settling back in Palmerston North as a hydrologist with the Manawatu Catchment Board. He has stayed with the Board in its various guises, managing the Hydrology and Surveying sections for the Horizons Regional Council.

In later years Jeff became an influential figure in the field of environmental monitoring among the Regional Councils and at the national level, and in particular has encouraged sharing of ideas and development, and acting as always with what he knows to be best for our science. He has often taken initiatives in developing new equipment, a prime example being the software version of the Aquitel Microbase. Jeff encouraged the development of many other new technologies that have been quickly tried and tested in the Manawatu.

Jeff Watson was given the Society's first Award for Achievement in Operational Hydrology in 2002.

Ross Woods

Ross Woods has achieved an outstanding record since joining the MWD in the mid-1980s and then through the transitions to DSIR and NIWA. He has built a worldwide reputation for excellence in his research on spatial and temporal variability of hydrological fluxes at scales from hillslopes through catchments to New Zealand. An important aspect of Ross's work has been collaboration with New Zealand and overseas researchers at sites such as Maimai on the West Coast and Mahurangi in North Auckland. Numerical modelling has been a key component of Ross' research, and he is probably best known in New Zealand hydrological circles through the development of the TOPNET model; his modelling work has always been well backed up by field studies.

On the international scene, Ross is a theme leader within the IAHS large work programme "Prediction in Ungauged Basins" (PUB). He has always been a strong supporter of the NZHS annual conference and contributed chapters in our books, has recently been elected to the Society's executive, and was the recipient of the Outstanding Achievement Award in 2010.