Hydrological Histories: Richard Ibbitt and TiDeDa

I arrived in New Zealand by ship in 1970 to do computer modelling of hydrology. I'd no sooner got here than I found that the country was in the swing of preparing for a big International Association of Hydrological Sciences meeting, and my boss was somewhat distracted.

I started as best I could. I was going to build the model to end all models. I started with the interception component – quite a challenge in its own right, because the data that had been collected was in a fairly unprocessed state. Nobody was sure how good, bad or indifferent it was.

Prior to the advent of the computer, computational analyses were difficult and tedious, and this led to very simple mathematical descriptions – models, in today's parlance – that attempted to explain catchment behaviour between and during rainfall events. Early instruments generally recorded rainfall depth or water level using ink traces on paper charts, and although the charts were often carefully designed to allow the maximum information to be gained from them, manual transcription and tabulation was not always practical.

It was in 1965, with the advent of UNESCO's International Hydrological Decade, together with New Zealand's development of hydroelectricity and irrigation, that there was finally an explosion of new instrumentation and hydrological data.

Although chart recorders continued in use for many years, they were replaced with digital recorders for important applications. These produced 16-track paper tape, which meant that, in theory, hydrological data could be easily converted into a form that could be input to digital computers, see Figure 1.

What happened in New Zealand is another story.

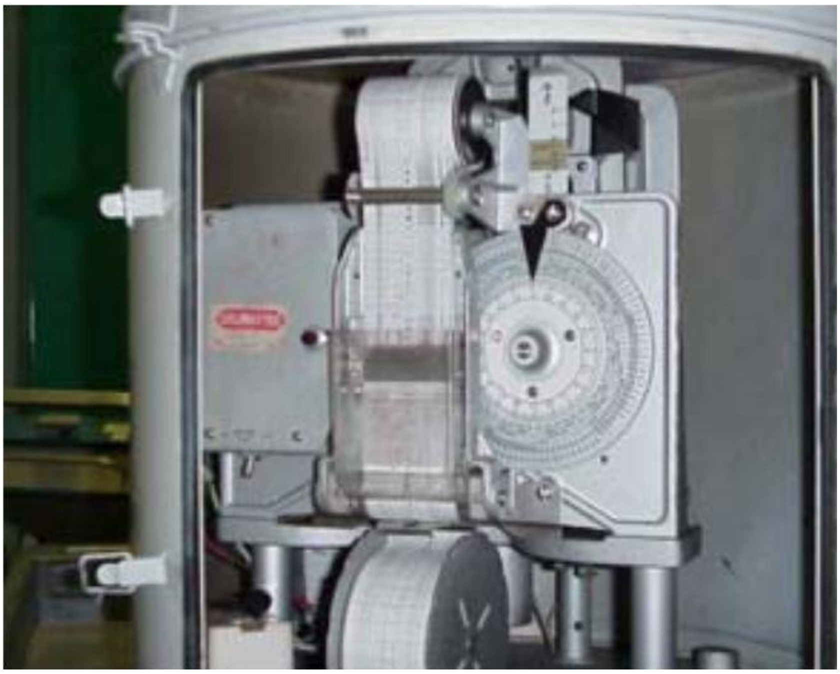

Figure 1: The inside of a Fischer and Porter 16-track punched paper tape recorder showing the paper tape as it was fed into the punching head.

Incompatible systems and an insurmountable problem

New Zealand responded to this rapid growth of data with a sort of ‘automated manual’ system developed on the Elliott computer run by Victoria University. This was used to extract basic hydrological information for publication by the Ministry of Works and Development in the Hydrology Annual.

When the Ministry acquired an IBM computer in the late 1960s, it was hoped that much of the data processing done on the Elliott could be transferred to the IBM machine. However, there was a physical incompatibility between the two systems and at the time this was insurmountable. The Elliott computer used five-track paper tape for input and output, see Figure 2, had no transferable magnetic tape medium, Figure 3, and used the Algol programming language. The IBM computer used 80-column cards, Figure 4, magnetic tapes, and the Fortran programming language.

Figure 2. Five-hole wide punched paper tape

Figure 3 – A 2400 foot long magnetic tape

Figure 4 – An 80 column computer card

Initially, an attempt was made to replicate the Elliott's Algol system for data processing and output using Fortran, but the results proved cumbersome and failed to meet the growing needs of the Ministry of Works and Development’s division for hydropower design, and the water and soil division's for flood protection and irrigation design work.

By the end of the 1960s, there was tension between the Ministry’s user divisions and the computer services division that had been given responsibility to meet their programming and data processing needs. Out of this tension arose an emphasis on producing a new system that would hopefully overcome the cumbersome-ness of the proposed Elliott system conversion.

This led to the establishment of a program called TiDeDa, which stands for Time-Dependent Data.

Birth of the TiDeDa system

The pioneering work on TiDeDa was due to the effort of Dr Stephen Thompson, who had just returned from doing his PhD in Cambridge in 1969. Stephen concluded that continuing with the approach applied up till then was not going to work. He proposed a completely new system that capitalised on newer technology – the IBM computer.

The proposed new system was centred on storing measured hydrological data in the form recorded in the field, and providing fast analysis systems for extracting different types of information from that data.

At the time, there was not much known about data processing systems around the world. The US Geological Survey had a system that relied on being able to translate digital 16-track paper tapes into digital form fairly quickly. Most of their sites were stable, so rating changes didn't occur often, and most outputs seemed available only in the form of daily flows – which is probably alright if you want the flow of the Mississippi at New Orleans, but not much good if you wanted to know how much flow was in the Rakaia Gorge on a particular day.

Some initial principles were established that set a standard for everything that was subsequently developed in New Zealand, and at the time we were the world leaders. These principles were that the system had to be capable of coping with multiple rating changes, retrospectively if necessary, and it had to be able to recreate the original recording document. This meant a wide selection of information could be extracted. You could get hourly, daily and monthly means, you could get plots, you could pick out peaks, correlations, and many other things.

One of the techniques used for fast processing was to remove redundant field measurements before storing the data. The most popular digital field recorders then typically recorded 96 quarter-hourly values of water level each day, Figure 1, even if the water level did not change. A unique-to-New Zealand instrument called the event recorder was developed, which recorded only data when there had been a “significant” rise or fall in water level. These recorders produced much shorter tapes than the standard recorder and greatly reduced the data to be stored, to about 5% of the values recorded in the field.

A direct consequence of this data compression was that times to convert data into a form suitable for storage on magnetic tapes were slashed. This had an even greater flow-on effect, since the time needed to mechanically read magnetic tapes, fast though they were, were orders of magnitude greater than the computing speed of the computer. The overall efficiency of compression was many thousands of percent.

Once the basics were established, attention turned to providing front ends for reading field data, in the form of charts or paper tapes, and providing basic printed outputs such as listing the values retained after data compression, tables of daily means, and statistics such as the annual maxima and minima at a site.

Various editions of the Tideda Manual, Figure 5, describe how to use the system for both data input and the output of tables, plots and statistics.

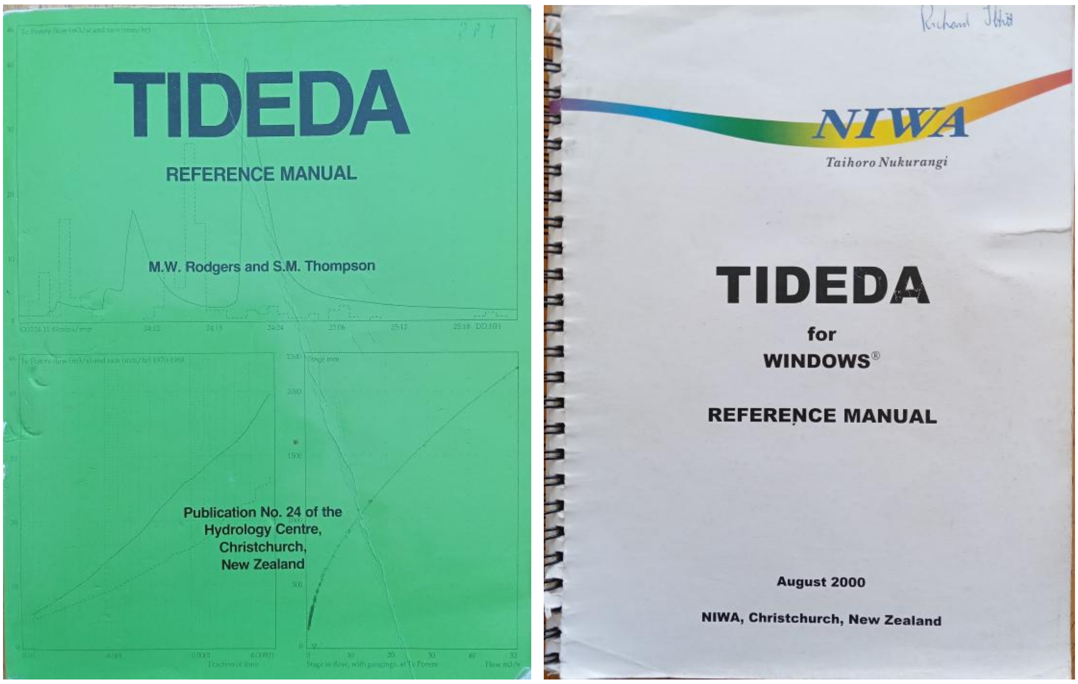

Figure 5 – Two editions of the TiDeDa Manual

It then became necessary to consider how we feed this beast with data.

Data processing hold-ups and hiccups

Once TiDeDa was in its initial user phase, we started looking at how to enter some of the data collected in the three-year hiatus between the suspension of processing on the earlier Elliott computer and the arrival of the Ministry of Works and Development system.

The first tentative steps at full data processing began in 1971, with the introduction of TiDeDa version 1. At the time, I'd been asked by the Water and Soil Division if I would take over data processing. I basically abandoned my efforts at modelling, since I was one of few staff in the division who was computer literate, at least by the standards of those days. Because of my experience with computers, I soon found myself fulfilling a liaison role between the Water and Soil Division, and Computer Science Division.

During this time, relations between the user divisions and the provider division were not good. There was obvious user frustration at not being able to use all the data-gathering efforts in a reasonable time frame, and provider frustration at not having computer-literate liaison people in the user divisions.

Meanwhile, a small and dedicated group of technical staff went on with converting field recordings into computer compatible media, with the eventual expectation that these would be processed by the new TiDeDa system. This was an incredibly frustrating time for field staff, since there was no feedback as to how well they were doing their work. It is testament to the field staff's training and dedication that when data processing finally got into full swing, there were comparatively few human error problems.

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We were processing enough cards to fill the average three-bedroom house. We had a vast backlog of computer cards from previous years, during which only conversion from 16-track paper tape to 80-column card images had been possible. We were limited by computer time allocation as to how quickly these could be read and processed into digital form and stored on magnetic tape. Every week we had to go around the other divisions to scrounge computer time they weren't using. Eventually, upgrades to the mainframe computer removed this obstacle. Figure 6 shows what a 1970's mainframe computer looked like – amazing when you consider it did not have the processing power of a modern day laptop!

Figure 6. IBM computer display {copyright: Barry McKay. 1973. IBM computer display, 1973, 03-1073. Walsh Memorial Library, The Museum of Transport and Technology (MOTAT)]

What started as a half-time deployment from the research work for which I was initially employed, quickly became a full-time pursuit. My motivation was two-fold: I was curious about anything to do with computer operations (I should have known better); and I realised that unless the data were converted into a computer-compatible form, hydrological activities in New Zealand were going to be handicapped, and in particular my own work on modelling river basins.

Human error in processing rainfall data

While the main emphasis on data processing was on water level data, there were also rainfall data to be processed into computer-compatible form. These data came in two basic types: long rolls of chart from siphoning rain gauges, and 16-track paper tape from the tipping bucket rain gauges.

The processing of 16-track paper tapes required new software, and their conversion into card image form exacerbated further the tape conversion problems we were having with the computer services division.

The long rolls of chart required further development of the chart processing software to deal with sudden trace reversals when the gauge siphoned, as well as the need to break a chart up to 10 metres long into sections that could fit onto the digitising table, typically less than a metre in length.

The only instrument capable of digitising chart traces was ancient and required an operator to carefully move the digitising cursor along the trace. Before the instrument irreparably broke down, there were issues with the staff who were tasked to do the digitising. They were almost exclusively trained to operate card punch equipment. Consequently, many traces were poorly digitised. One operator even worked out that as long as the beginning and end of the trace were correctly digitised, the rest of the trace could be ignored. That week we got what the computer manager regarded as excellent service, until he was shown that all the traces plotted manually were just straight lines.

After that, all processing was suspended. Eventually charts were sent to outside contractors for digitising, and processing improved dramatically in quality and timeliness.

The administrative data processing issues were primarily out of a naïve expectation that anybody could do anything. It led to frustration among the troops, and seemingly endless inter-divisional confrontation that sometimes required divisional directors to take matters up with the Commissioner of Works.

While those battles were being fought, a number of constructive things were happening that would have a formative influence on the quality assurance, versatility and security of the available data.

Data storage, quality assurance and security

The system that stored all the data gradually evolved. Initially, the only check we had was to compare values from computer printouts with manually read data from the paper tapes. We soon realised this would not be a viable long-term approach.

Fortunately, at about this time the Ministry of Works acquired a digital plotting device. Once the necessary software had been written, every tape that was processed was plotted. After that, it was easy to check, not only the on and off values as recorded by field staff, but also that the variation between manual observations behaved in ways considered consistent with how a river rises and falls. A similar approach was adopted for chart records, adding an additional exact plot of the digitised values, as these could be checked by overlaying on the original chart.

Soon after the plotting of processed data became standard, the question arose as to who should be responsible for the security of the processed data, and who should be responsible for its quality. While security of the data was clearly the responsibility of the centralised data processing operation, it was perceived that responsibility for data quality should reside with those responsible for its collection – since they were the people familiar with how local conditions could affect the data quality.

It was considered that making field staff responsible for data quality would motivate good field work, especially if they had to do editing that resulted from their mistakes in the field. Some senior field staff were very supportive, although initially editing was somewhat cumbersome.

Meanwhile, at the data processing centre, attention switched towards data security. Initial tape storage used a system called a ‘generation index approach’, with four magnetic tapes used in a cyclic system. This system had several drawbacks. It was difficult for users to access the data, as they had to know where in the cycle the data processing had got to, so they could specify the correct tape number to be mounted. Magnetic tapes were prone to wear, so that while they might appear to be written successfully, the next read operation could fail. Tape failure was exacerbated by reading by users, and it was not unknown for users to sometimes write incorrectly formatted material to the tapes.

On one occasion, months of processing was jeopardised when through a combination of circumstances, only a single member of a 4-tape sequence was readable. This reality check led to the introduction of a user tape that had a standard and unchanging name set up each week. As well, two backup tapes were made at intervals of several months. Finally, the seismic risk posed by operating in Wellington led to offsite backup tapes being sent to Hamilton twice a year.

In addition to the water level tapes, there were a corresponding set of eight magnetic tapes holding processed rainfall data and a set holding groundwater data. The tape system was replicated across each Ministry of Works district, so that at any one time there were 72 magnetic tapes to be kept track of. All told, it took about 25 person-years of effort to get all the data processing up to date by 1978.

My final act was to write a comprehensive data processing manual, see Figure 7.

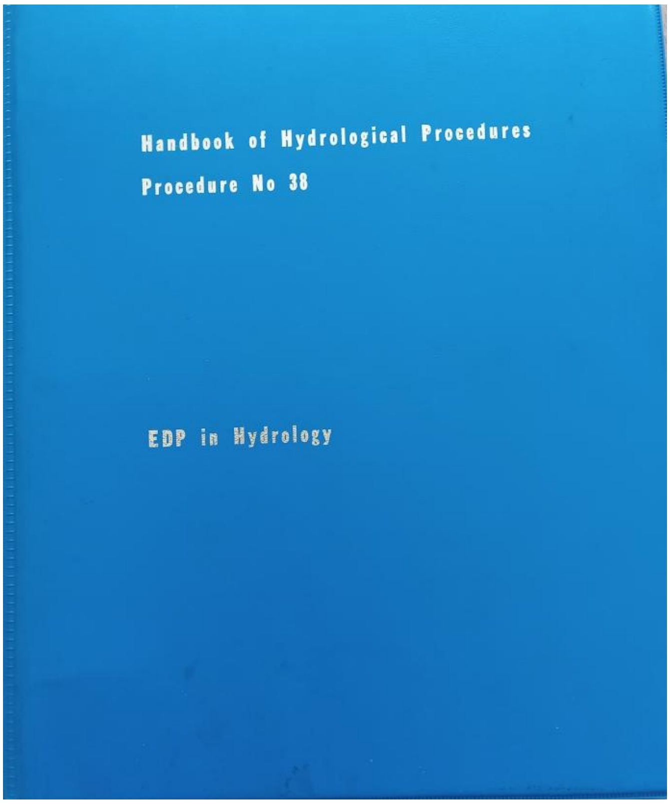

Figure 7 – Handbook of Hydrological Procedures

Key figures

Stephen Thompson and his assistant **Gary Wrigley** came up with the inspiration and design concepts for TiDeDa, upon which the New Zealand Hydrological Archive is dependent. Processing of the bulk of the 16-track paper tape data was down to **Vanessa Frampton** (née Black), whose ability with numbers was mind-boggling. Chart processing was accomplished in the main by **Lyndon Johnson**, while **Doug McMillan** broke in much of the magnetic tape management work and liaised with district staff. Later, **Vas Parag** took over the management work. **Hans Hartog** and **Malcolm O'Connell** assisted with non-routine tasks and cover when other staff were away. Others made valuable contributions, not least the field staff who initially collected the data and made the whole thing possible. It has been my privilege to work with these diverse and inspirational people.

Richard Ibbitt's recollections, from an interview with MS Srinivasan in 2020, are part of a New Zealand Hydrological Society series that documents the times and memories of New Zealand's senior hydrologists.