STREAMLAND 48

FLOOD FORECASTING — THE NEW WAY

In Egypt in the days of the Pharoahs the High Priests retained their power by being able to prophesise whether there would be floods or drought in the coming season. They did this by sending emissaries into Ethiopa to observe the severity of the summer rains. The consequences of an error in their forecasts were extremely severe!

Flood forecasters nowadays are not liable to the same drastic penalties if they are wrong, but their accuracy and reliability are no less important. Communities which rely on a forecast of impending high water levels to determine whether they should lift their shop goods off the floor or move their sheep out of the paddock beside the river, need to have complete faith in those forecasts.

Further, there is a growing trend to replace the construction of expensive stopbanks with flood warning systems which can mobilise civil defence authorities for evacuation and sandbagging. In future these systems will be enhanced by zoning laws which will prohibit the building of flood-prone structures in the flood plain.

The Christchurch Hydrology Centre has developed an accurate and reliable flood forecasting system which has a cost effectiveness which makes its installation in all major rivers in New Zealand a feasible and worthwhile goal.

Telemetry

The key to the success of this flood forecasting system is the ability to monitor at the forecasting centre both the water levels of the upstream tributaries of a river and the rainfall in

Figure 1:
Looking upstream to the Clyde Dam and the flood-prone area surrounding it.

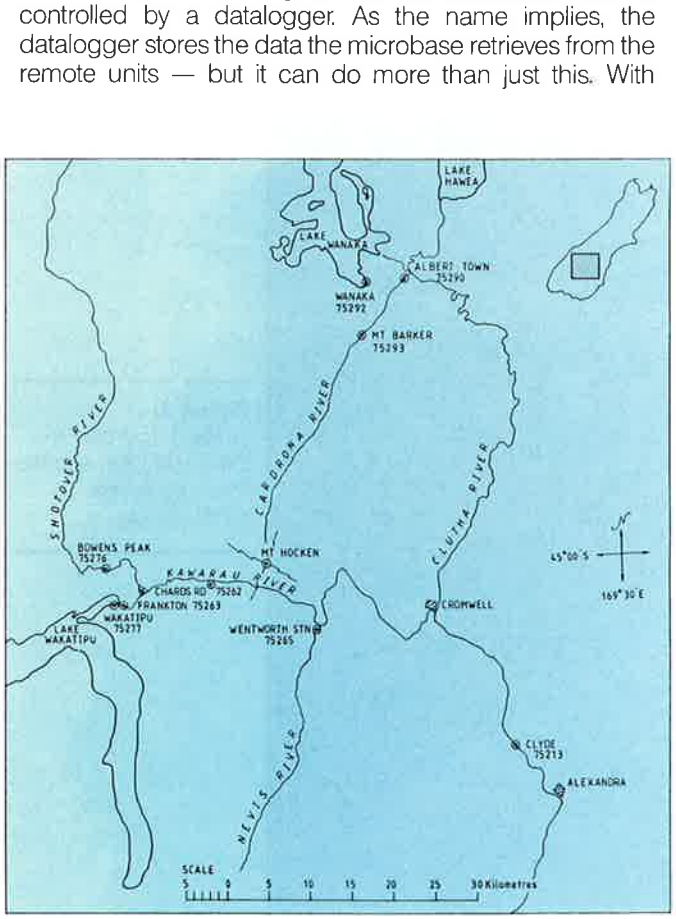
the mountains. This is the important task handled by the Aquitel 2 telemetry system.
The system is controlled by a microbase unit based in the forecasting centre. The microbase controls up to 255 forecasting units at remote locations, monitoring the level in the river and perhaps the rainfall. Up to two weeks of data can be stored in each remote unit and the microbase communicates with them by specially coded messages over the radio.

'Wake-up' call

To obtain data from a particular remote the microbase sends out a message which contains the remote's number. The message is preceded by a tone which partially wakes up all the remotes in the system. If the communication number is not their own they fall back to sleep again. The remote whose number it is responds by becoming fully awake and listening to exactly what the microbase wants. Requesting data stored in the remote's memory is only one of the many things a microbase can ask for. The remote also has in its memory specified limits of the maximum water level and rainfall intensity. If the water level or rainfall exceeds these limits, as occurs during a flood or in very heavy rainfall, the remote wakes up and sends an alarm message back to the microbase. The microbase sounds an alarm in the base office. If the office is unoccupied and the alarm is not acknowledged, the microbase initiates a series of telephone calls to selected staff at their homes. If the staff do not respond with a special acknowledgement code the series of calls is repeated until the alarm is acknowledged correctly.
In this way, under the control of the microbase, a complete river catchment or several catchments can be monitored continuously and automatically.

Datalogger

Back in the forecasting centre the microbase itself is controlled by a datalogger. As the name implies, the datalogger stores the data the microbase retrieves from the remote units — but it can do more than just this. With sophisticated programs developed in the Hydrology Centre the datalogger can print, plot and process the data in a variety of forms. Furthermore, using the information retrieved from the stations in the upper parts of the catchment, it can forecast what the flow will be in lower parts of the catchment some hours ahead.



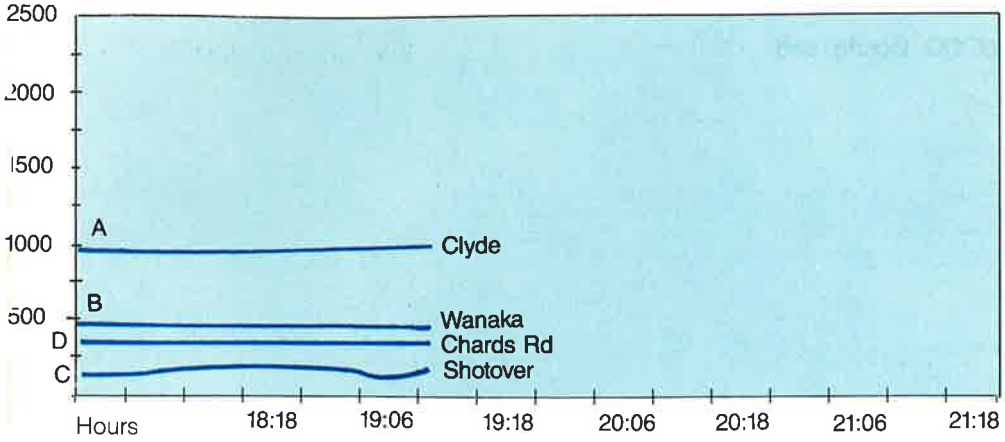
The Upper Clutha Installation

An example of such a system that has been operating successfully for two years is in the Upper Clutha River. It is operated by the MWD Hydrological Field Party in Alexandra who undertake flood forecasting for the Clutha Valley Development staff and contractors working on the Clyde Dam. During floods it may be necessary to evacuate personnel and equipment from the construction site. Forecasting the river levels 12 hours ahead allows the evacuation to be planned more carefully than would be otherwise possible.
Figure 1 shows the layout of the Upper Clutha telemetry system. The Clutha River begins as the outflow from Lake Wanaka, and at Albert Town is joined by the Hawea and Cardrona Rivers. The major tributary of the Clutha is the Kawarau, which emanates from Lake Wakatipu and joins the Clutha at Cromwell. Just downstream of the lake outlet the Kawarau is joined by its major tributary, the Shotover.
During floods in the Shotover, the Kawarau backs up and drowns the outlet gates from Lake Wakatipu. The water level recorder at Frankton is used to detect this. Radio communication with each of the remotes and with the microbase at Alexandra is through a repeater on Mt Hocken.
The normal flood forecasting procedure involves using the flow from the Shotover, Lakes Wakatipu and Wanaka to forecast the flow at Clyde. In the event of failure of any of the three stations which give the flow in the Kawarau the station at Chards Road can be used as a backup, although the forecast lead time is reduced.

Flood forecasting

In times of flood in the Upper Clutha system the first indication of trouble is that the flow in the Shotover exceeds 220 cumecs. When this occurs the microbase issues a beeping alarm. If the MWD Hydrological Field Party Leader does not acknowledge the alarm within a few moments the microbase will try to ring him at home. If he is not there, the microbase will phone up to five other people and will keep ringing until someone acknowledges the alarm. Another piece of telemetry equipment, called a "mobile", is then used to interrogate any of the remote stations to find what the water levels have been over the last few hours. If it is confirmed that a flood is imminent a hydrologist will report into the MWD office in Alexandra.
The first thing to do is to retrieve the previous day's data from all the sites in the catchment and display them on the plotter. In the December 1984 flood in the Clutha the microbase issued an alarm at 1pm on Wednesday the 19th and when the data was retrieved the situation was as shown in Figure 3.
At the time the recorder in Lake Wakatipu was out of service so the backup recorder at Chards Road in the Kawarau

Figure 2:
The layout of the Upper Clutha telemetry system showing nine telemetred sites and the radio repeater at Mount Hocken.



First Alarm

Figure 3:
The situation in the Clutha at 1 p.m. on Wednesday, December 19th 1984 when the microbase issues the first alarm.

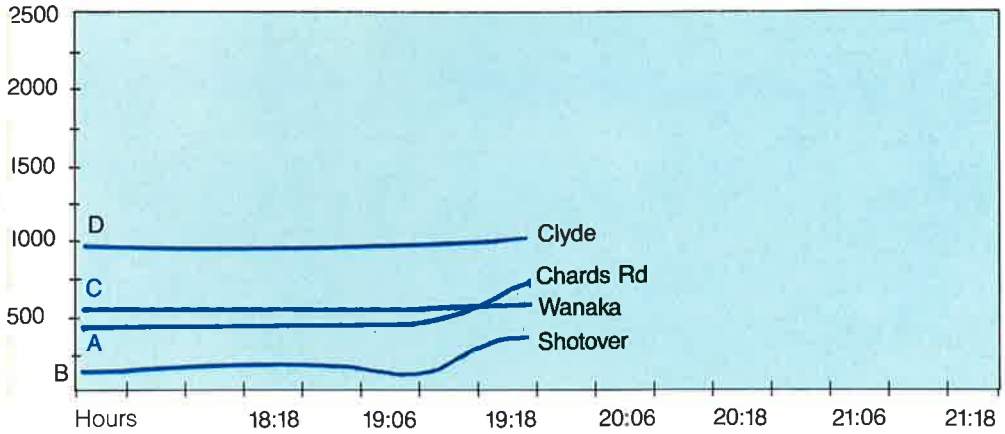
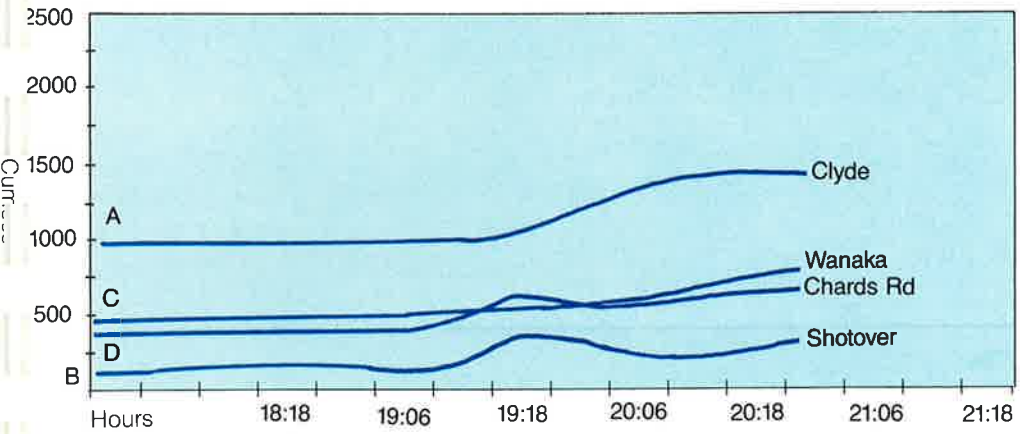


Figure 4:
The situation six hours later at 7 p.m. when the Shotover River has peaked and is starting to fall.



Second Alarm

Figure 5:
Two days later the alarm flow of 220 cumecs in the Shotover is again exceeded, this time at 1 a.m. The situation is now serious and a full-scale flood warning is issued.

Entire Flood

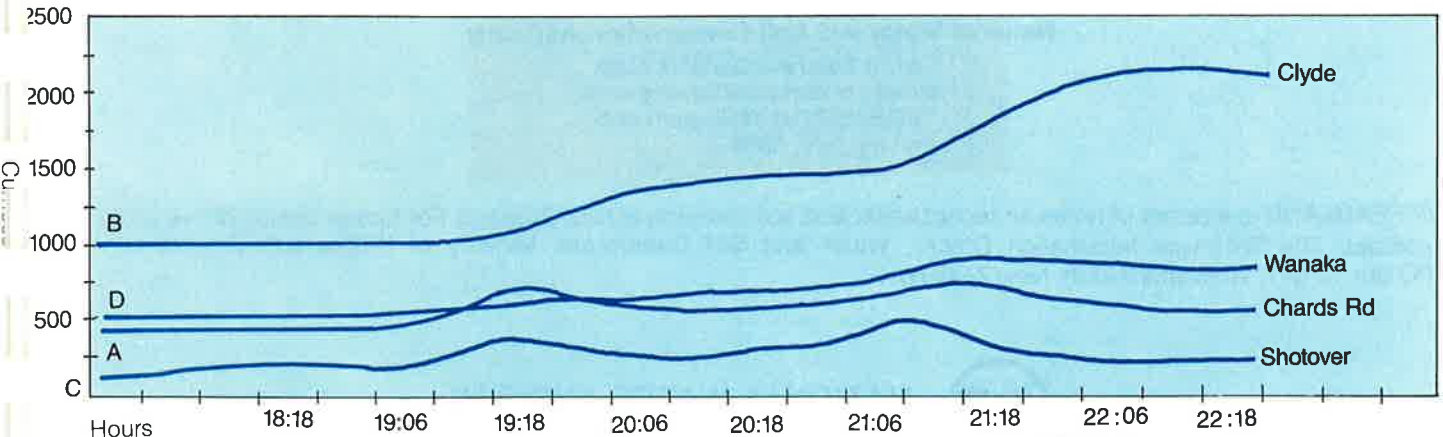


Figure 6:
A plot of the entire flood build-up in the Upper Clutha in December, 1984.

had to be used. Since Chards Road is downstream of the confluence of the Shotover the flow recorded there includes the flow from both the Shotover and Lake Wakatipu. Notice that the flow in the Shotover is rising steadily and there is no indication of when it will peak. Flow out of Lake Wanaka is pretty steady at this time, as it is at Clyde.

Figure 4 shows the situation six hours later when the Shotover has peaked and is starting to fall. It is now possible to estimate the maximum flow at Clyde using a mathematical model. The method which has been used in the past in New Zealand dates back to the times of the Pharoahs when the High Priests forecast the levels of the Nile using past experience of the behaviour of the river to estimate its future behaviour. In New Zealand the equivalent of the Egyptian High Priest is a senior engineer or hydrologist who has worked with the river for perhaps 20 or 30 years and who knows intuitively how the river will behave in flood.

'Black box' method

Researchers at the Hydrology Centre have developed a technique which is similar to this in that it uses historical data to establish the behaviour of the river, but it also uses mathematical techniques and a computer in what is called a "black box" method (instead of the "grey box" method of the past — so named because the forecasters were invariably grey haired, either from age or from worry and frequently from both).

Applying the black box method to the data shown in Figure 4 results in a forecast that the flow at Clyde will be 540 cumecs at midnight. (In fact it peaked at 550 cumecs at 11p.m.). A flow of 540 cumecs at Clyde is not a significant flood and would cause no problems and, although the level of Lake Wanaka is still rising slowly, the Shotover is dropping. Previous experience indicates that the Shotover is an important indicator of flooding at Clyde. Thus, a full-scale flood situation has not eventuated and normal routines are returned to.

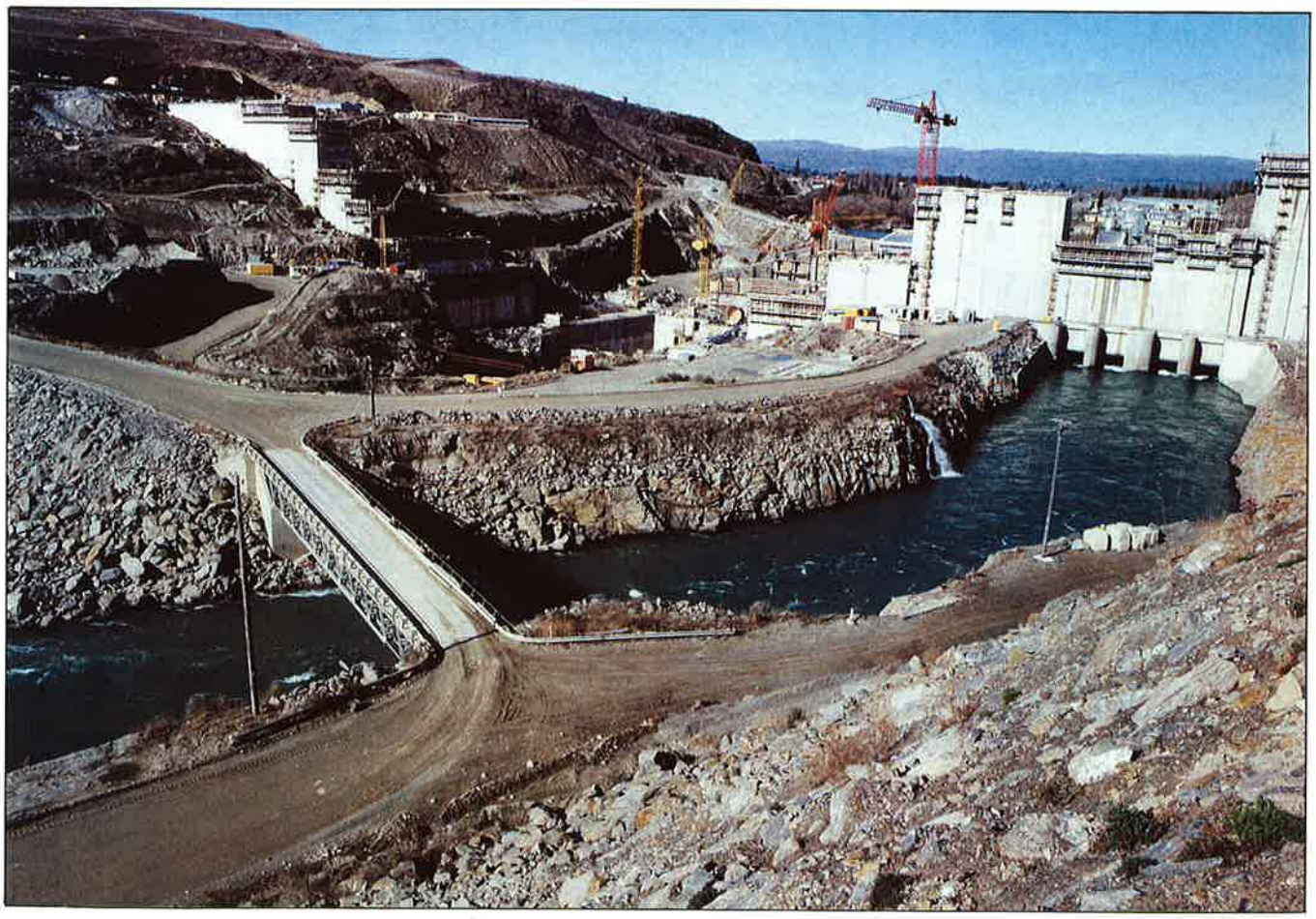
Two days later the alarm flow of 220 cumecs in the Shotover is again exceeded. Figure 5 shows the plot of forecast river levels. The situation is now becoming serious as the Shotover is adding to already swollen rivers.

At midday on the 21st when the Shotover has peaked a second time, a peak flow at Clyde of 2200 cumecs is forecast for 1am the following day. A full-scale warning is issued and equipment and personnel are evacuated from the Clyde Dam construction site. (The actual peak was 2250 cumecs which occurred at midnight).

The loss of no lives in the 1984 flood in the Upper Clutha and the minimal damage to equipment at Clyde Dam can be attributed in no small part to the new technology which has been developed by the Hydrology staff of the MWD. Further refinement of the techniques and equipment is being actively pursued and the Upper Clutha is being used as a test bed for these developments. In the meantime the proven equipment is available for use elsewhere in New Zealand and strong interest has been expressed by other countries in Oceania, particularly Fiji which has negotiated a contract with MWD to install a system involving six remote sites on the Rewa River, near Suva.

Figure 7:

View of Clyde Dam from the upstream side showing the coffer dam and the construction taking place behind it. In the '84 flood the water level came up almost to the top of the bridge.



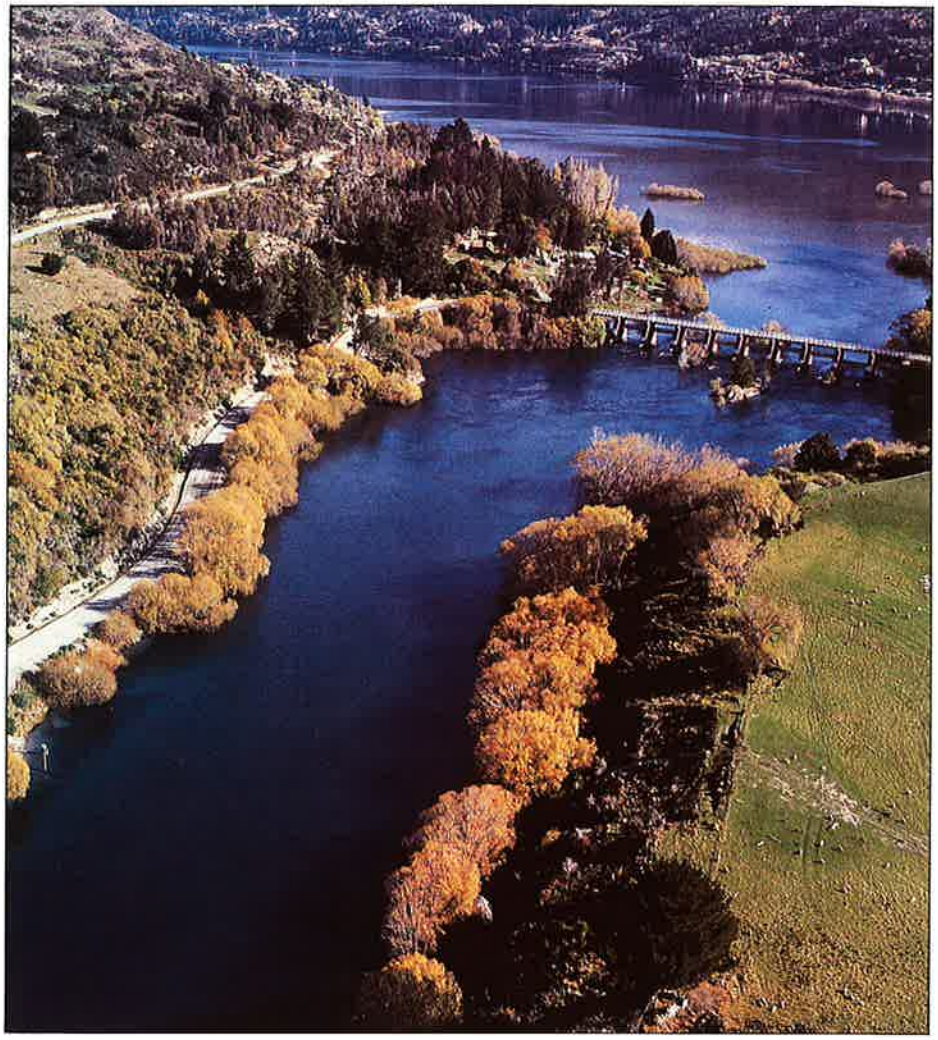


Figure 8:
Looking upstream into the Frankton arm of Lake Wakatipu. The river in the foreground is the Kawarau. A water level gauge can be seen at the side of the river in the left foreground.

Figure 9:
A cableway above the Shotover River at Bowen's Peak. A member of the field party is in the cablecar, below which is hanging a "bomb" used to suspend a current meter into the river. The instruments beside the hut in the right foreground can also be suspended from the cablecar to collect samples of sediment flowing down the river.

Further Information
Further information on flood forecasting can be obtained from the Scientist in Charge, Hydrology Centre, MWD, PO Box 1479, Christchurch.
This leaflet is based on the work of DG Goring and associates.

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STREAMLAND is a series of notes on recent water and soil research in New Zealand. For further copies of this leaflet contact: The Technical Information Officer, Water and Soil Directorate, Ministry of Works and Development, PO Box 12-041, Wellington North, New Zealand.

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