THE VICTORIAN WATER INDUSTRY SEISMIC NETWORK.

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ABSTRACT.

The Victorian Water Industry Seismic Network was substantially upgraded in 1999. This paper will look at the design and outcomes of the seismic network from a risk management and emergency management perspective. Funding issues for a diversified network providing benefits to a range of clients within the one industry group will also be discussed.

Prior to 1999 the Victorian seismic network had been developed on an ad hoc basis resulting in an incomplete level of seismic coverage throughout the state. The upgraded network now provides sufficient coverage to provide an intensity based alarm service for all contributing Victorian Water Authorities.

KEYWORDS.

Risk management, earthquake alarm, earthquake response, emergency simulation.

SEISMIC NETWORKS

The major outcomes from seismograph networks may be categorised as:

- Long term estimation of seismic activity parameters *ie* rate of activity, the relative number of small to large earthquakes (b value), identification of active seismogenic structures.
- Determination of attenuation of earthquake motion with distance and measurement of structural response.
- Earthquake alarm or warning functions.

The mix of outcomes required from a particular seismograph network will determine the characteristics of the network.

The first two categories of outcomes require long term monitoring but do not require real-time telemetry of data.

The third category requires real-time telemetry of seismic data, 24 hours per day response and rapid response. The requirement for rapid response often implies a need for some degree of automation. This paper will primarily concentrate on the third category of outcomes.

A seismograph uses precise timing to determine the distance to an earthquake. A network of at least three seismographs is normally required to precisely locate an earthquake epicentre and focal depth for events within the network. The more recordings used, the more precise the location.

Earthquake depths can only be precisely determined if the distance to the *nearest* seismograph is not greater than about twice the earthquake depth or about 10 kilometres, whichever is the larger. East Australian earthquakes usually occur at depths from just beneath the surface to 20 kilometres.

The scale of operation for a seismograph network can vary from tens or hundreds of metres for mining related seismology to thousands of kilometres for global seismological studies. Smaller scale seismograph networks usually record higher frequency motion with higher timing precision and accuracy that results in higher precision for earthquake locations.

The scale of network required for a real time earthquake information system therefore depends primarily on the earthquake location precision required and the minimum magnitude earthquake about which you are likely to require information.

For example to determine the epicentre of an earthquake to a location precision of plus or minus a few kilometres, the earthquake must be inside a network of three or more seismographs all within 100 kilometres of the epicentre. To determine the depth of the event requires that one seismograph is near the epicentre.

VICTORIAN WATER INDUSTRY SEISMIC NETWORK PRE 1999

Since 1976 the water industry has been the primary sponsor of earthquake monitoring in Victoria.

For many years the SRC operated instruments for the Rural Water Corporation at the Grampians, Cairn Curran reservoir. and Dartmouth reservoir (later for Wimmera-Mallee and Goulburn-Murray Water).

Networks of instruments were also operated for the MMBW (later Melbourne Water) around Sugarloaf, Thomson and Upper Yarra reservoirs. In 1996 the Melbourne Water seismic network was re-organised to provide an earthquake alarm service for a broader range of Melbourne Water assets.

Aside from the water industry a network of three recorders is operated in the Latrobe Valley for the electricity generation industry. Following the Newcastle earthquake, the state government funded the operation of urban monitoring instruments in Melbourne and Geelong.

The Australian Geological Survey Organisation also has seismographs at Toolangi and Bellfield.

Figure 1 is a map showing the distribution of Victorian water industry funded seismographs in 1998. Continuously telemetered sites are indicated by a black diamond, non-telemetered sites by a grey diamond.

It should be noted that there are other non-water industry funded instruments located in the Latrobe Valley, Melbourne and Geelong as well as a number of unfunded recorders operated by the SRC, however the ongoing operation of the unfunded recorders can not be guaranteed.

The map shows that continuously telemetered data, which is necessary for the provision of an earthquake alarm, was only available from central Victoria, east of Melbourne, and Gippsland.

The map shows large gaps in the seismograph coverage in both northern and southern west Victoria, far east Gippsland, south Gippsland, central Victoria and northern Victoria.

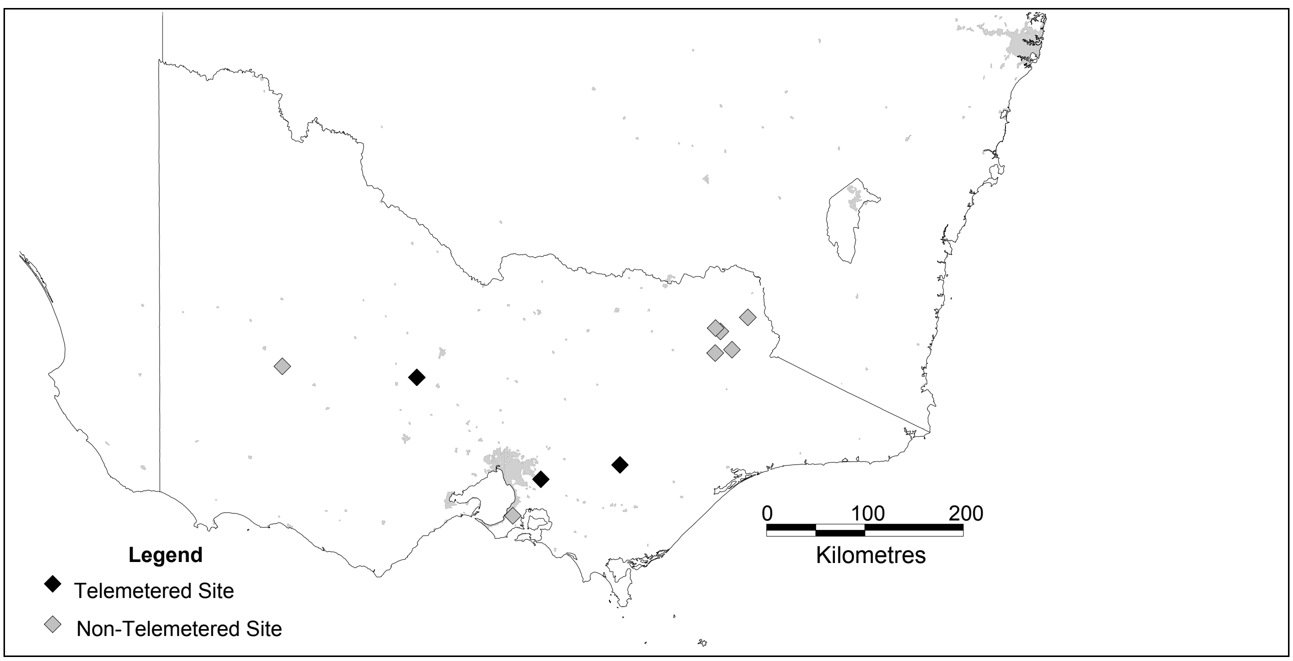

Figure 1: Victorian water industry funded seismographs, 1998

VICTORIAN WATER INDUSTRY SEISMIC NETWORK POST 1999

Following extensive discussions between the Water Bureau at the Victorian Department of Natural Resources and Environment, the Victorian water industry dams working group and the SRC, the Victorian seismic network was extensively upgraded in late 1998 and early 1999.

Figure 2 shows the location of the recorders that make up the upgraded seismic network.

The Victorian Water Industry seismic monitoring network operated by the Seismology Research Centre now comprises five pre-existing seismographs and seven new or upgraded seismographs. One channel of seismic data is continuously telemetered to the SRC laboratory from the recorders at Cardinia, Cairn Curran, Mt Macedon, Molesworth, Rowsley and Thomson. The remaining recorders all have dial up telephone connections to provide additional data following a significant earthquake.

The tighter instrument spacing of the upgraded network allows for higher accuracy locations to be computed, particularly in western and central Victoria.

The additional telemetered sites mean that more accurate rapid locations can be computed to raise alarms. Furthermore two of the new telemetered sites use spread spectrum radios to send data to the SRC so some data will still be received at the laboratory even if the telephone system fails during a significant earthquake.

There are still significant gaps in the seismic network, particularly in south Gippsland, the north-west, far east and north of the state.

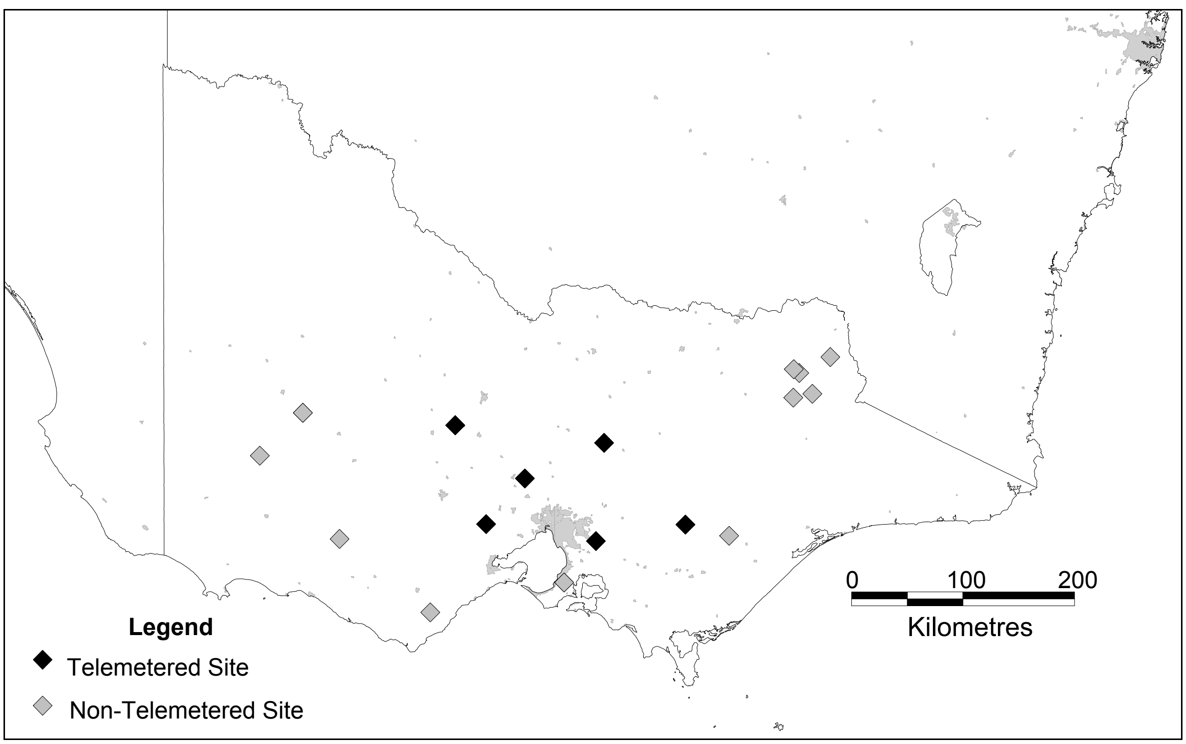

Figure 2: Victorian water industry funded seismographs, 2000

Figure 3 is a map showing the distribution of high hazard classification dams overlaying the seismic recorder network and shows that there is good coverage of the high hazard dams within Victoria.

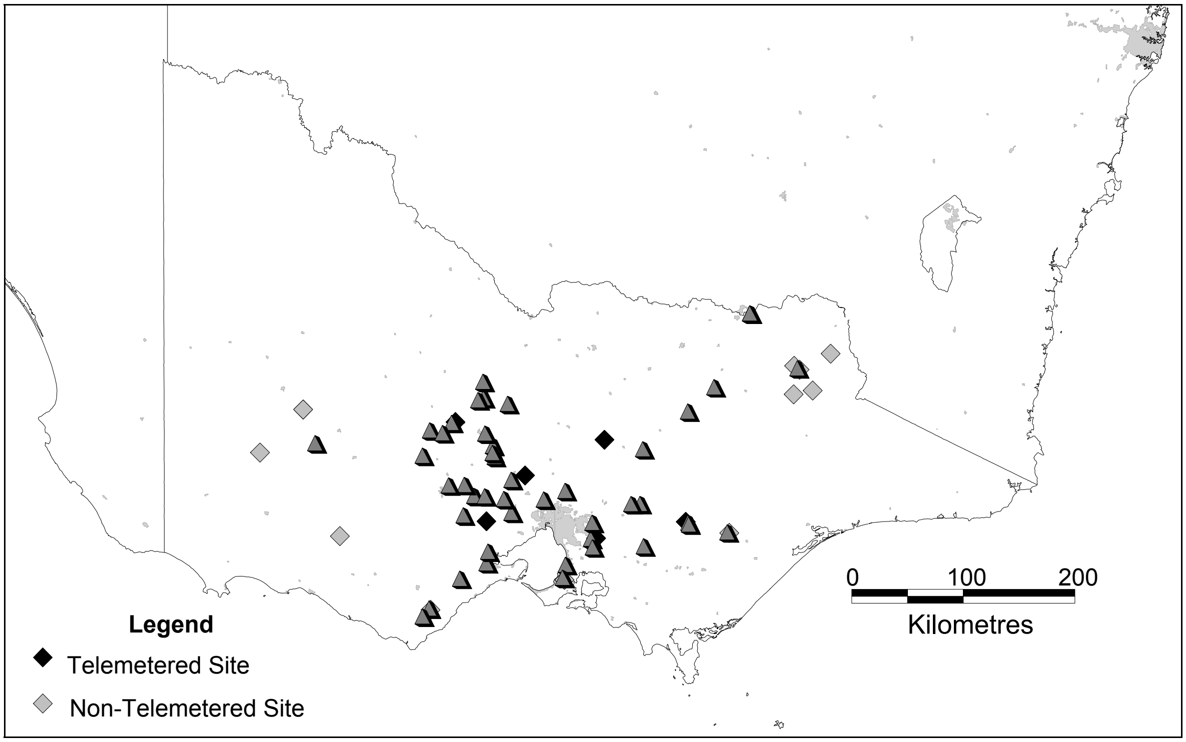

Figure 3: Victorian water industry funded seismographs and High hazard classification dams, 2000

RESULTS FROM THE UPGRADED NETWORK

There are two levels of alarm service provided by the SRC Earthquake, Preparation. Alarm and Response (EPAR) system to water industry stakeholders. The premium level of service provides information about intensities at the authority's assets within 30 minutes of an earthquake occurring during normal working hours, or 60 minutes outside of normal working hours. The standard level of service provides earthquake location and magnitude information as soon as possible, and certainly within 2 hours of the event occurring.

Since January 1999 there have been seven earthquakes of significant magnitude to alert water industry personnel. Even though most of the seven events occurred at night, in every case all relevant water industry personnel were informed of the event within one hour of the earthquake origin time, exceeding the contractual requirements of the network.

The two largest earthquakes that have occurred within Victoria since January 1999 are described below.

2000 March 12, Gaffneys Creek, ML 3.7.

A magnitude ML 3.7 event occurred at a depth of eight kilometres near Gaffneys Creek, about 100 kilometres east of Melbourne on 12 March, 2000 at 12:26 am AEDT. Reports of the earthquake being felt were received from Yarra Junction, Lilydale, Belgrave and as far west as Preston and Greensborough in the northern suburbs of Melbourne. The maximum reported intensity in the epicentral area was MMI 4. A magnitude 3.7 earthquake would normally be felt over a radius of about 70 to 80 kilometres.

No reports of any structural damage were received, and none would be expected from an earthquake of this magnitude and depth. Even minor damage would not be expected unless the earthquake depth was very shallow, within a couple of kilometres of the surface.

There were two moderate aftershocks in the 24 hours following the main shock, one of magnitude 2.3 at 12:39 am (thirteen minutes after the main shock), and another of magnitude 1.9 at 7:26 pm.

The preliminary location for this earthquake was computed by the SRC duty seismologist within 15 minutes of the origin time and personnel from five different water authorities were contacted and informed of the event. The first notification was at 12:51 am AEDT and the last at 1:08 am AEDT

2000 August 29, Boolarra, ML 4.8.

On 29 August, 2000 at 11:05 pm AEDT an earthquake of magnitude ML 4.8 occurred just west of Boolarra in Gippsland, about 22 kilometres south-west of Morwell and 130 kilometres south-east of Melbourne.

This earthquake was the largest to occur in Victoria since the ML 5.0 Mt Baw Baw earthquake of September 1996.

The Boolarra earthquake was strongly felt in Gippsland and was felt throughout the suburbs of Melbourne particularly in the east, but as far west as Sunshine.

Two foreshocks occurred in the hours before the mainshock, the larger being of magnitude ML 2.6 and occurring at 9:20 pm AEDT.

Because the SRC duty seismologist had completed a location of the foreshock, water industry personnel who felt the event and contacted the SRC were able to be given a preliminary estimate of the location and magnitude of the earthquake within minutes of the origin time.

Formal notification of water industry personnel began at 11:34 pm and personnel from six different water authorities were informed of the event details by 11:50 pm.

FUNDING ISSUES

Figure 4 is a map showing the rural, metropolitan and non-metropolitan urban water authority stakeholders contributing towards the Victorian water industry seismic network. Not shown on this map is the contribution of the Victorian Department of Natural Resources and Environment (DNRE).

The DNRE contributed substantially to the capital cost of the upgraded network. The remaining capital costs were apportioned based upon a formula related to the number of high or significant hazard structures owned by the various water authorities.

Ongoing operating costs of the seismic network and the earthquake alarm service are likewise apportioned using the same formula based on the number of high or significant hazard structures.

This funding structure allows water authorities that would otherwise be unable to fund a network on their own to contribute towards an extensive seismic network, the benefits of which are available to all stakeholders.

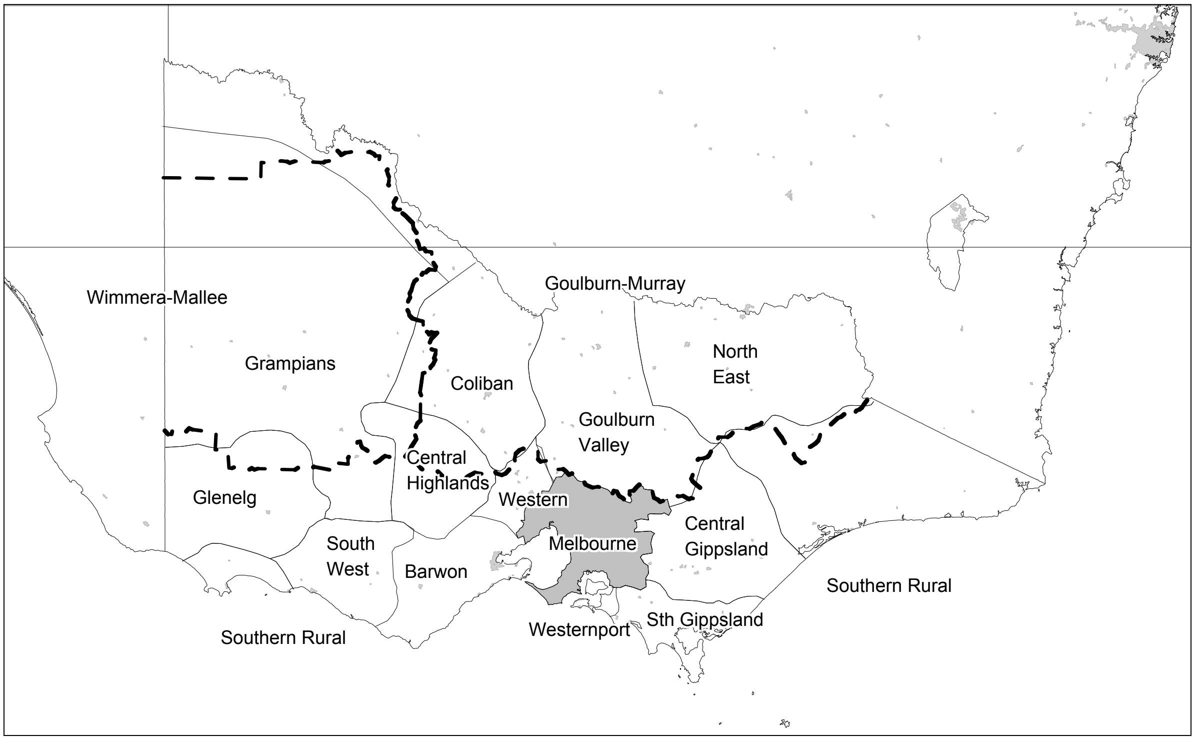

Figure 4: Victorian water industry seismic network stakeholders

ACKNOWLEDGEMENTS

The authors wish to thank David Watson and Siraj Perera of the Victorian Department of Natural Resources and Environment as well as the members of the Victorian water industry dams working group.

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