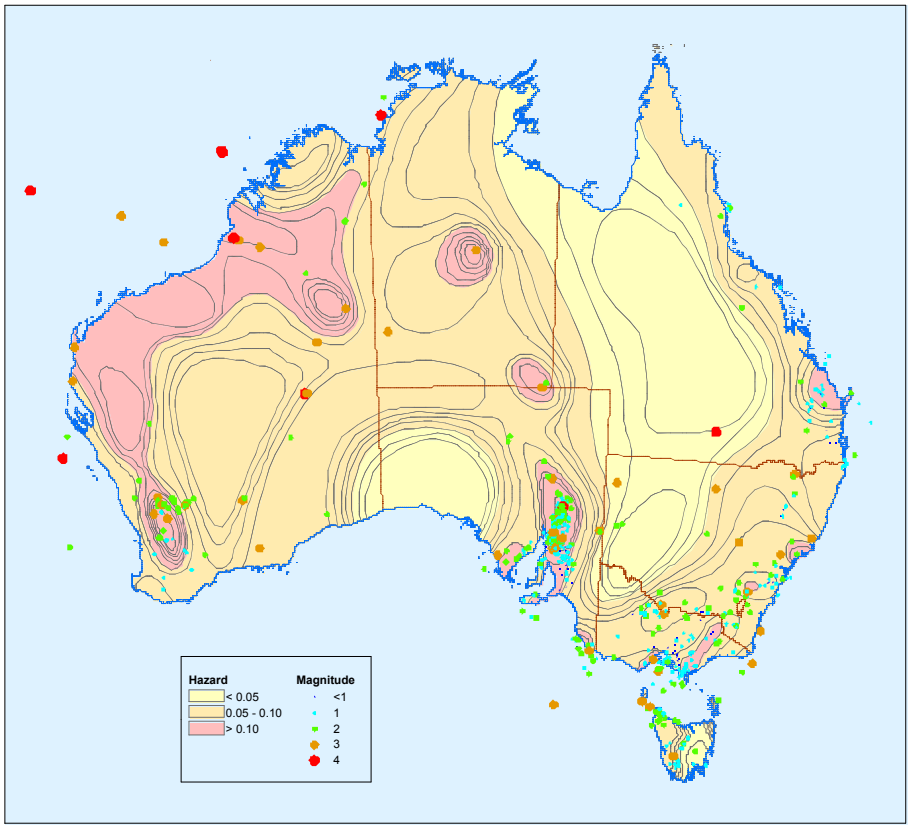
Australian Seismological Report 2008 - addendum



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Kevin McCue[3] (Compiler), Claire Payne[1] and Wayne Peck[1]

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Geoscience Australia (GA) operates the Australian Seismological Network as described in the report by Glanville (2009) available on the GA website www.ga.gov.au. There are several other network and single station operators in Australia, state or territory governments, private companies such as ES&S and individuals, some operating under the public seismic network umbrella who also contribute data and information about Australian earthquakes.

This supplement to the GA report was compiled to showcase this other contribution where it could be made public.

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CONTENTS

Cover picture: Produced by David Love. Hazard map of Australia superposed with 2008 epicentres, data from network operators ES&S, SADME, GA and IRIS and from private station operators Gary Gibson, Mike Turnbull and Kevin McCue

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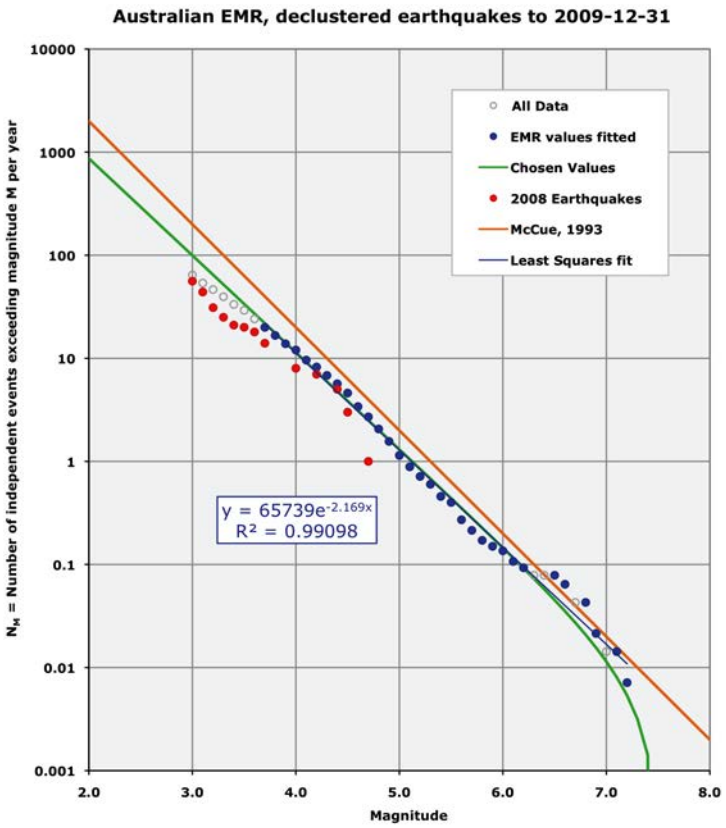
Australian Seismicity

The largest earthquake in Australian territory in 2008 was near Macquarie Island on 12th April, its magnitude 7.1. Here is an edited extract from the daily log by Barry Copley, Australian Antarctic Division Station Leader Macquarie Island 2008[1]: *A major earthquake at 10:30 this morning, with the centre 110kms to our SSW, the quake smashed some glassware at the Brothers Point "Googie"* (Ed.- a fibreglass field hut*) and caused a lot of items to fall from shelving (Ian radioed in from Brothers). At the Station there were some plates dislodged from shelving and some items fell from shelving in the Multi Purpose Building. No structural damage, Tim checked the water tanks and advised that there were large waves in the tanks, this 30 minutes after the quake!)*[1].



Continental Australia fared much better, the 2008 level of Australian seismicity was well below average as seen from the recurrence relation in figure 1. The largest earthquake, near Broome WA, had a magnitude of just 4.7, well below the expected once-per-year magnitude of 5.3 (according to McCue (1993) or 5.0 (Gibson this report). There were no nasty surprises in the epicentre distribution when compared with the expected pattern as can be seen on the cover plot of epicentres superimposed on the earthquake hazard background. Earthquakes happened where they had been known to happen in the last 100 years.

FIGURE 1 Cumulative number of earthquakes above any magnitude M in Australia in 2008 (red dots) compared with the expected number (orange line McCue, 1993; blue dots and green line historical data Gibson this report).

The orange dashed line in figure 1 is given by the equation: LogN = 5.3 – M the implied 'b' value is 1.0. There is no Mmax. The linear part of the green line is given by the equation: Log N = 6.95 – 0.94M with an Mmax of 7.5, the generally accepted value of Mmax in Australia. There is no physical reason for an upper bound of 7.5 and fault-capable structures exist in Australia (e.g. the Darling Fault, WA).

The largest recorded earthquake in Australia since 1901 when the first worldwide seismograph network was in place was that offshore WA in 1906, its magnitude Mw 7.2 as revised by Abe and Noguchi (1983a,b) from the value of $7^3/_4$ by Gutenberg and Richter (1954).

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Australia's largest and most destructive earthquakes are listed in Appendix 1.

Interesting Earthquakes in 2008

The maps and tables presented by Glanville (2009) give a general view of seismic activity in Australia but forensic details can be gleaned from the state and local area networks to further our knowledge of intraplate seismicity. The ES&S earthquake catalogue contains over 300 local earthquakes during 2008 excluding blasts and quarry events. For 2007 there were over 200 local events however this is probably reflective of improvements in our procedures relating to trigger processing, event detection and network coverage rather than any true change in the seismic activity rate.

South Australia

During 2008, 247 earthquakes were located using the PIRSA network (see epicentre map below). This is the most since 1995, but part of the increase is due to the new network installed around Adelaide. More information on the network is at http://www.pir.sa.gov.au/minerals/earthquakes/earthquake_-_new_network). Seventeen events were over magnitude 3.0, the largest being magnitude 4.2 which is slightly above the yearly average. Events reported felt numbered 27. More events than usual occurred in the South East and close offshore. There was also one well offshore with a magnitude of 3.5.

Reviewing the area within 100km of Adelaide, seventeen earthquakes were located, of which the largest was only magnitude 1.4 and none were felt. The closest was about 35km NE of the city. This is more than recorded in previous years due to the installation of the new real-time network around the city.

The state's largest earthquake occurred 55km NE of Hawker, and was not associated with the magnitude 4.7 earthquake that occurred 22km south of Hawker on 2007-12-26. An aftershock survey was undertaken for this latter event, with a number of aftershocks recorded early in 2008.

In November 2008 a PSN station opened at Mount Torrens primary school, run by Garry McPherson. A new private station was opened in Hindmarsh Valley near Victor Harbor, and the owner is kindly sending the data in real-time, to improve our network. The new network around Adelaide, funded by the Natural Disaster Mitigation Program, is now operational, although a few stations require minor improvements.

Table 1 Epicentre details, South Australian earthquakes recorded by PIRSA

Date	*Time*	*Long*	*Lat*	*Place*	*ML*	*MMI*
2008-01-18	0042	138.349	-32.057	HAWKER 20KM S	3.2	4
2008-03-17	0656	137.521	-25.698	SIMPSON DESERT	3.1	
2008-03-23	2000	138.248	-33.468	PORT PIRIE 38KM SE	3.3	4
2008-04-30	2111	141.585	-30.255	TIBOOBURRA 101KM SW	3.2	
2008-05-12	1944	138.362	-32.866	PETERBROUGH 46KM W	3.1	3
2008-05-17	1357	138.633	-40.567	MT GAMBIER 354KM SW	3.5	
2008-06-24	0703	140.615	-38.169	MT GAMBIER 40KM S	3.5	
2008-07-01	0650	138.691	-33.079	PETERBOROUGH 17KM SW	3.1	4
2008-07-25	1126	138.110	-30.199	LEIGH CREEK 43KM NW	3.1	
2008-07-27	0734	138.290	-32.701	PORT AUGUSTA 54KM SE	3.0	
2008-10-02	0514	135.231	-33.792	PORT LINCOLN 120KM NW	3.1	
2008-10-07	1238	138.634	-32.078	HAWKER 28KM SE	3.0	3
2008-10-18	0202	138.781	-32.933	PETERBOROUGH 7KM NW	3.1	3
2008-10-23	1152	140.790	-32.520	BROKEN HILL 89KM SW	3.6	
2008-11-16	0202	138.751	-31.478	HAWKER 55KM NE	4.2	4
2008-12-04	1635	138.414	-33.401	PORT PIRIE 45KM SE	3.1	4
2008-12-28	1402	138.231	-32.696	PORT AUGUSTA 49KM SE	3.0	

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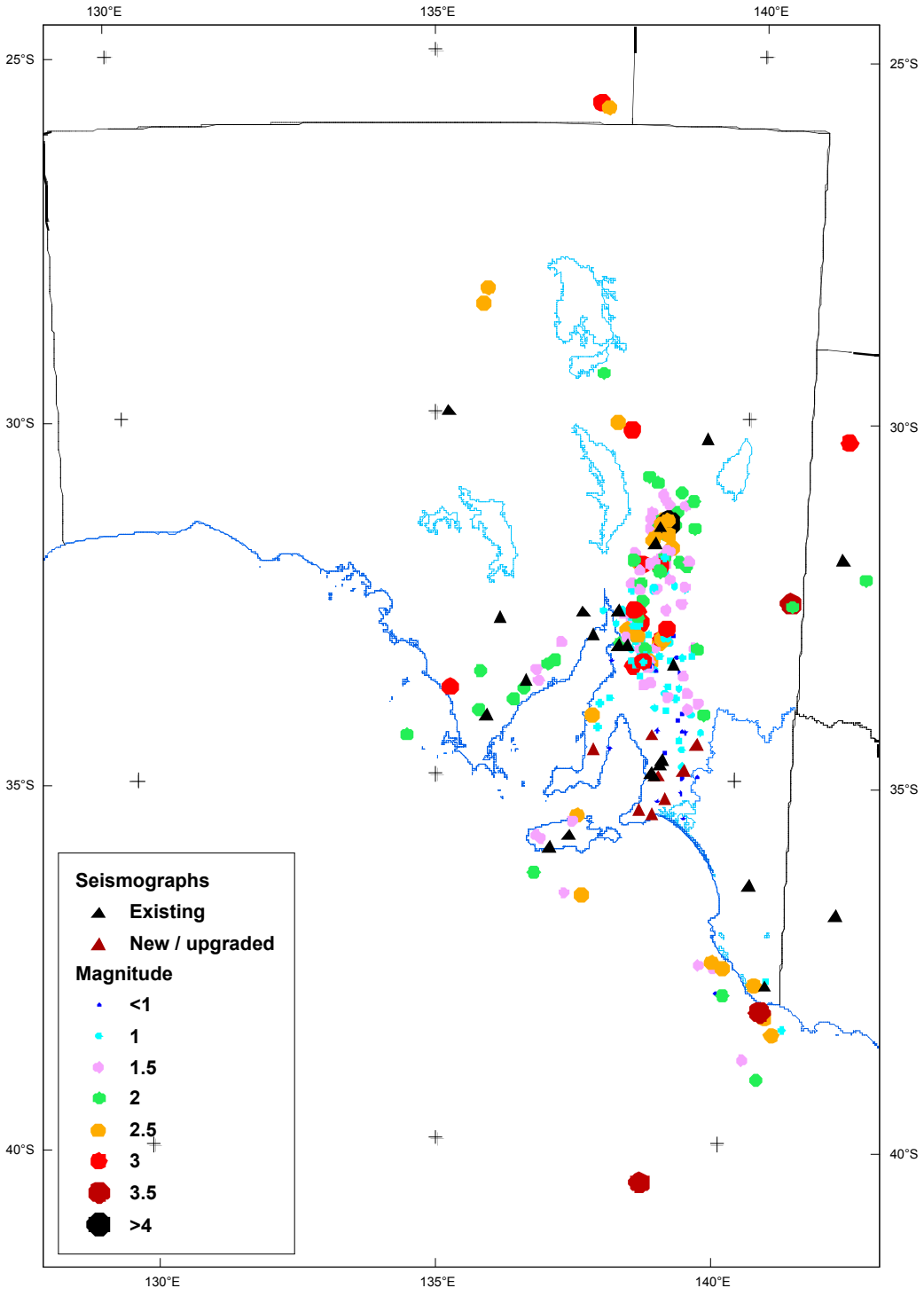

FIGURE 2 Epicentres of earthquakes in South Australia during 2008 (coloured dots) and seismograph locations (black triangles) by PIRSA.

Australian Capital Territory

Earthquakes The ACT is surrounded by active regions, Dalton-Gunning to the north (see New South Wales below), the Sydney Basin to the northeast and

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Snowy Mountains to the south and moderate earthquakes from these regions have periodically shaken Canberra over the nearly 100 years since its founding. Small earthquakes up to magnitude ML3.5 have been recorded in the ACT including an extensive swarm of earthquakes only 10 km north of the GPO. Major faults bound the horst and graben structures that shape the landscape in the ACT and decisions made about their level of activity influence the design of important infrastructure in and around Canberra.

The epicentre of a small magnitude ML 2.4 earthquake 10 km north of Googong Dam on 17 June at 09:34 UTC plots on the Queanbeyan Fault (within the ± 2 km location uncertainty). This does not necessarily mean that the fault is active as there are many more small earthquakes off the fault than on it. The question of what constitutes an 'active' fault in intraplate Australia has not been universally accepted, not in the way that it has in interplate California and New Zealand. One might think the definition ought to be the same in both environments despite the large difference in the frequency of damaging earthquakes.

Two larger-than-normal quarry blasts south and west of Canberra went awry and were widely felt in Canberra suburbs, a good opportunity to investigate crustal structure in the ACT using both P and S waves.

Seismographs

FIGURE 3 ACT seismographs and accelerographs in 2008 (Google Earth).

Geoscience Australia operates a downhole broadband seismograph at Kowen Forrest (CNB), about 10 km east of Queanbeyan. A Geoscope broadband seismograph (CAN) is operated in a tunnel under Mt Stromlo and maintained by ANU although the data are made available through GA. Private operators Marion Leiba (KBHa, station KBH is in Japan) and Kevin McCue (RNDA) operate short period vertical seismographs.

ActewAGL (50% ownership by the ACT Government agency ACTEW) maintain a network of accelerographs on or near ACTEW's high consequence dams (Corin – CORA/CORT) and near (Googong GGD/GGT) in the ACT. The COTA station was put out of action by the 2004 bushfire when the wooden power poles burnt.

New South Wales

There were no significant changes to the ES&S network in NSW during 2008 (Figure 5). A number of sites were changed from CDMA to GSM or NextG telemetry due to the closure of the CDMA network but fortunately none had to be relocated. Several PSN stations were operating in NSW during 2008; at Marks Point 20 km S of Newcastle, operator Dale Hardy, at Coonabarraban operator Andre Phillips; .at Gundaroo primary school, operator Sue Kominek; Mt Victoria primary school 20 km W of Katoomba, operator Toni Imrie; Michelago, operator Jennie Goldie.

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A small shallow magnitude ML3.2 earthquake occurred near Dalton NSW on 26th August 2008. It was felt locally and recorded as far as Broken Hill on digital seismographs of GA's national network. Most importantly it was recorded with impulsive first P-wave motions on seven closer digital seismographs and another two with emergent but readable first motions.

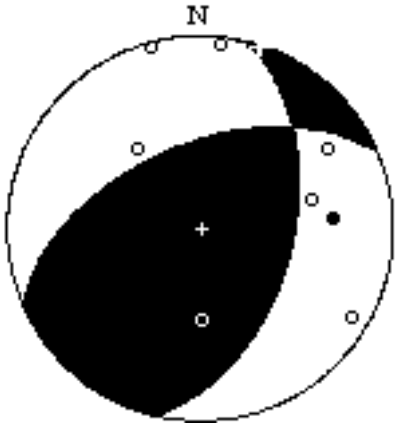

FIGURE 4 Dalton NSW earthquake 2008-08-26 at 05:34UTC. Focal mechanism, lower hemisphere projection open circles sp dilatations, closed circle sp compression.

These digital stations are operated by four independent owners. All the first arrivals, bar one of the emergent first arrivals, were dilatations.

Despite this sparcity of data a focal mechanism was obtained, figure 4 which satisfies all but two of the first motions, a dilatation at MILA (GA) and the emergent and only compression (first motion up) at Fitzroy Falls (ES&S). There is a spread of take-off angles due to some of the first arrivals being the direct P whilst others were refracted Pn. This and the key first motion at CAN Mt Stromlo (ANU) being an emergent arrival despite it being only 65 km away, the same distance as RNDA (ASC) and CNB (GA) both clear dilatations, was critical. Forcing one of the nodal planes to intersect the CAN station location was the key to deriving the solution.

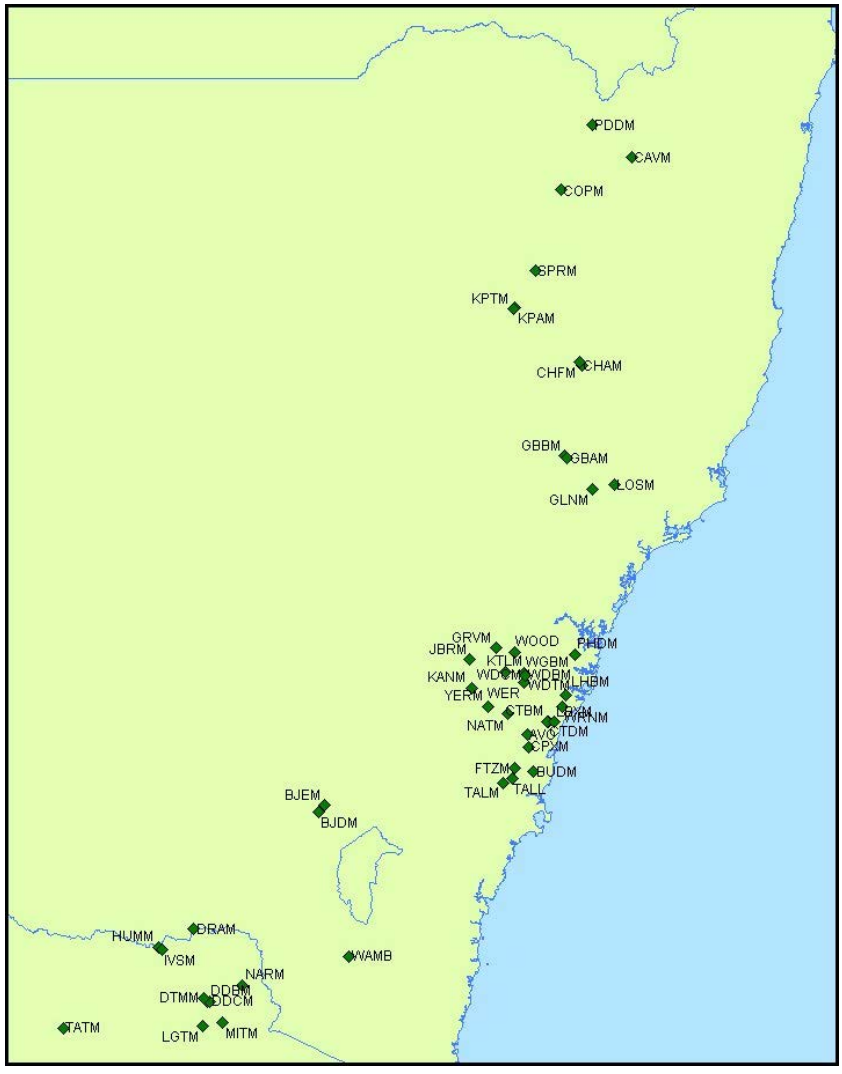

FIGURE 5 ES&S network stations in NSW in 2008.

The mechanism shown above is that of a predominantly thrust-type event with the principal stress direction oriented NW/SE and near horizontal. This is consistent with mechanisms of earlier earthquakes there. The more mechanisms that are available, the better we are

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able to define the stress field and the extent of domains within which the stress field is apparently consistent.

This example shows the benefit of all operators sharing earthquake data, this mechanism would not have been distilled without the shared data mechanism

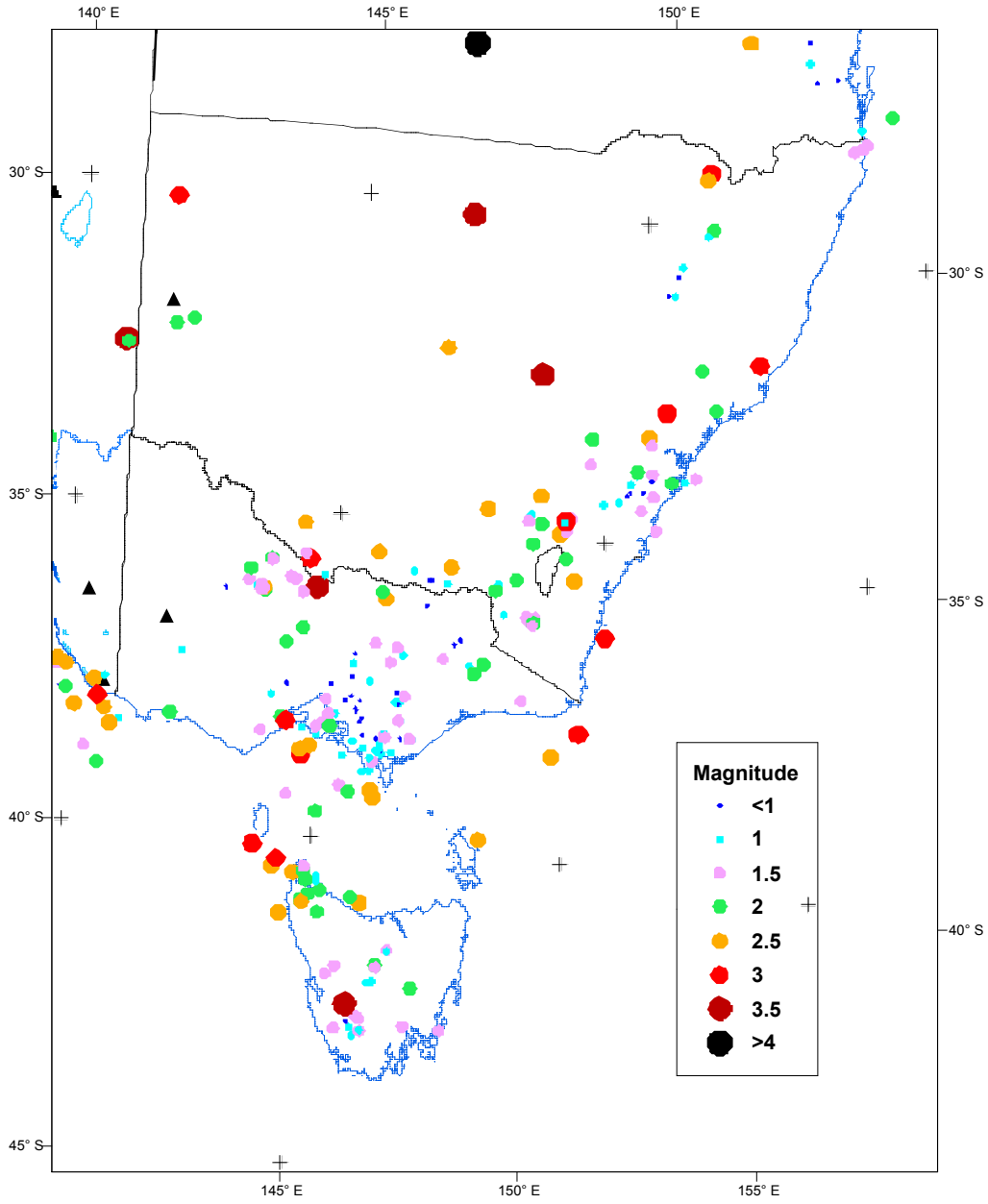

FIGURE 6 All earthquakes recorded in SE Australia on the ES&S network. The map area is comprehensively monitored down to about magnitude ML2.5.

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Tasmania

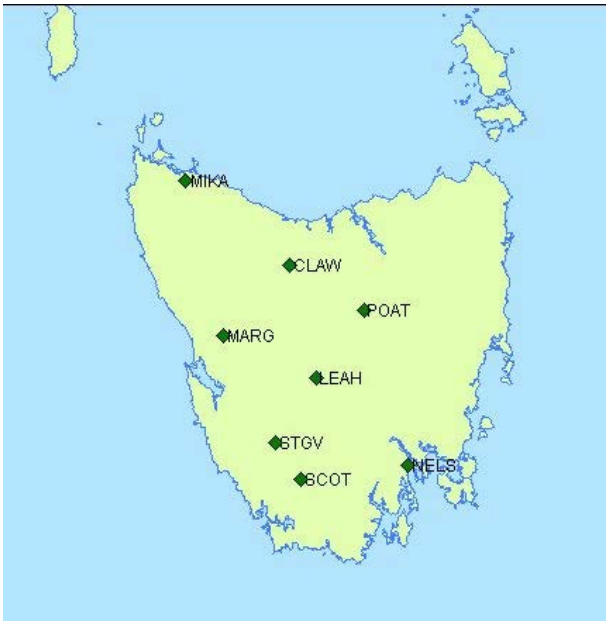

FIGURE 7 Seismographs operated by ES&S in Tasmania

These stations are in addition to the Tasmania University site (TAU) in Hobart, and a station north of Hobart (MOO) from which data are telemetered to Geoscience Australia in near real time.

The Joint Urban Monitoring Program accelerographs at Launceston are not shown.

The Hydro Tasmania funded seismographs at POAT, LEAH, MARG, CLAW and STGV were upgraded from Kelunji D series to Kelunji Echo recorders during the year. In addition the LEAH seismic site was re-located back to the old University of Tasmania vault at Tarraleah resulting in an improvement in the noise level at this site. These upgrades together with the existing Kelunji Echo recorders at Lake Mikany (MIKA) south of Smithton and Mt Nelson (NELS) south of Hobart now provide improved statewide coverage. The MIKA site in particular has made it possible to identify many events off the northeast coast that were previously unlocatable.

Victoria

Victoria has the densest network of seismographs of any state or territory in Australia and a location capability similar to South Australia. In addition to the stations shown operated by ES&S, Geoscience Australia has stations at Toolangi NE of Melbourne and ARPS in the southwest of the state (Glanville, 2009).

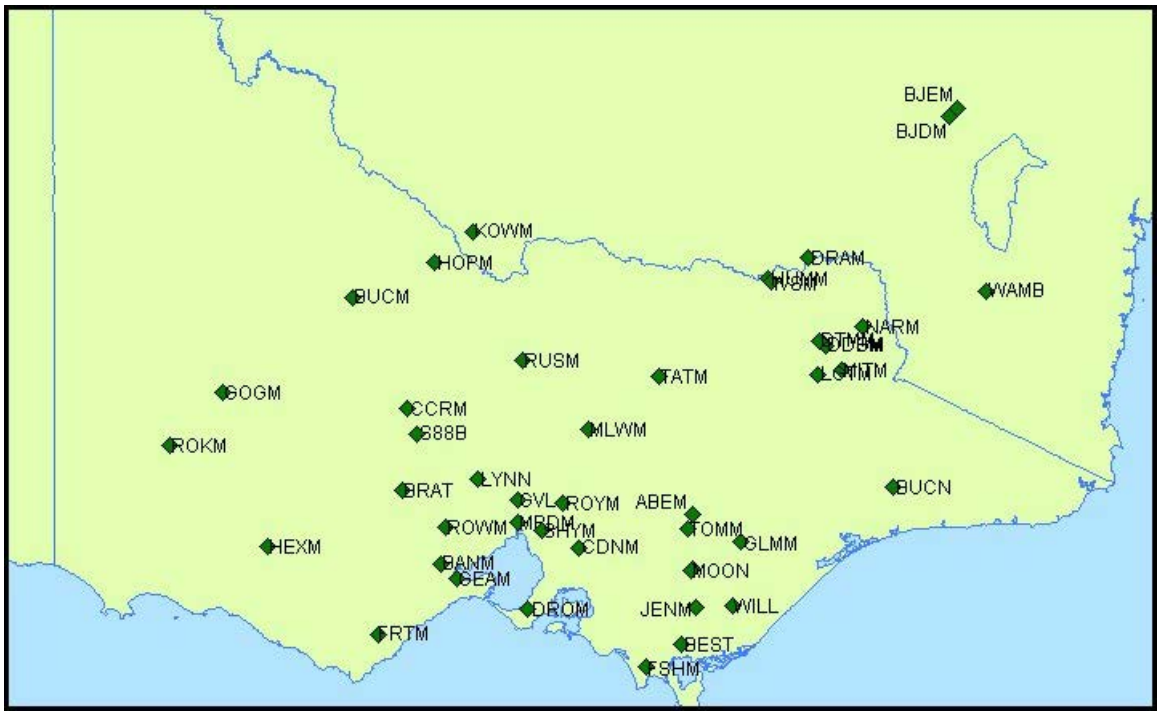

FIGURE 8 Seismographs operated by ES&S in Victoria

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The Victorian water industry funded sites at GOGM and NARM were upgraded from 3 channel Kelunji Classic recorders to 6 channel Kelunji Echo recorders extending the distribution of free field strong motion recorders in the state. The Rocklands site (ROKM) was relocated (ROKL) a short distance due to the closure of the CDMA network and now has an alternate telemetry method. The Dartmouth Dam strong motion accelerographs at DDC and DDB were also upgraded to Kelunji Echo recorders and a new site was installed near Buchan (BUCN). This site has extended the network coverage considerably in the far east of the state, picking up a number of events off the coast near Marlo.

Western Australia

Geoscience Australia operates 13 seismographs in WA, most near the coast except for Meekatharra. Several mining companies operate extensive in-mine monitoring networks in WA, some operate through the Australian Centre for Geomechanics in Perth, and there are networks in other states but none of this data are available to the public or government agencies.

There were three PSN stations operational in WA in 2008, at the University of Western Australia Perth, Broome and Gnowangerup and their data are available on request.

The WA government has no interest in monitoring earthquakes in the state and devolved all responsibility to the Australian Government when the Bisley Observatory seismograph (PER) was closed on the establishment of Mundaring by BMR in 1959.

Western Australia is the most seismically active state of the Commonwealth with the three largest known earthquakes (1906, 1941 and 1968) and the largest mapped fault, the Darling Fault.

A map and table of the largest earthquakes in the State during 2008 are in GA's 2008 Annual Seismological Report (Glanville, 2009).

Northern Territory

The Territory is well served by monitoring equipment. The UK owned seismic array near Tennant Ck operated by the ANU and the US owned and operated array near Alice Springs, were both established in the 1960s to monitor distant nuclear explosions, not local earthquakes. The data from elements of both arrays are telemetered to GA and a single element of the Alice Springs array AS31 is publicly available from the GA website using autodrm. The only other seismograph in the Territory is a broadband station at Kakadu, east of Darwin, run by Geoscience Australia.

The Northern Territory Government is not involved in monitoring earthquakes yet the Territory is experiencing to this day the tail of an extensive series of earthquakes which began in 1987 and peaked in 1988 and included three large ground fracturing earthquakes which caused damage in Tennant Ck and led to the abandonment of plans to build a hazardous waste facility near the town. Darwin is shaken every year by major earthquakes in the Banda Arc to the north, two of them causing structural damage in the city. Local earthquakes have also been felt there.

A map and table of the largest earthquakes in the Territory in 2008 are in GA's 2008 Annual Seismological Report (Glanville, 2009).

Queensland

Earthquakes Only 23 events with magnitude greater than ML1.5 were located in Queensland in 2008 which is below average. The two largest of these (2008-02-

13 at Cunnamulla, ML4.4, and 2008-06-09 at Brewarrina, ML4.0) were both near the Queensland – New South Wales border.

Network operations The network operated by ES&S for the State Government underwent significant upgrades with the Kelunji D-series recorders at some sites being replaced with Kelunji Echo recorders. These replacements (at UKAQ, FAIR and MORG) significantly improved data telemetry uptimes.

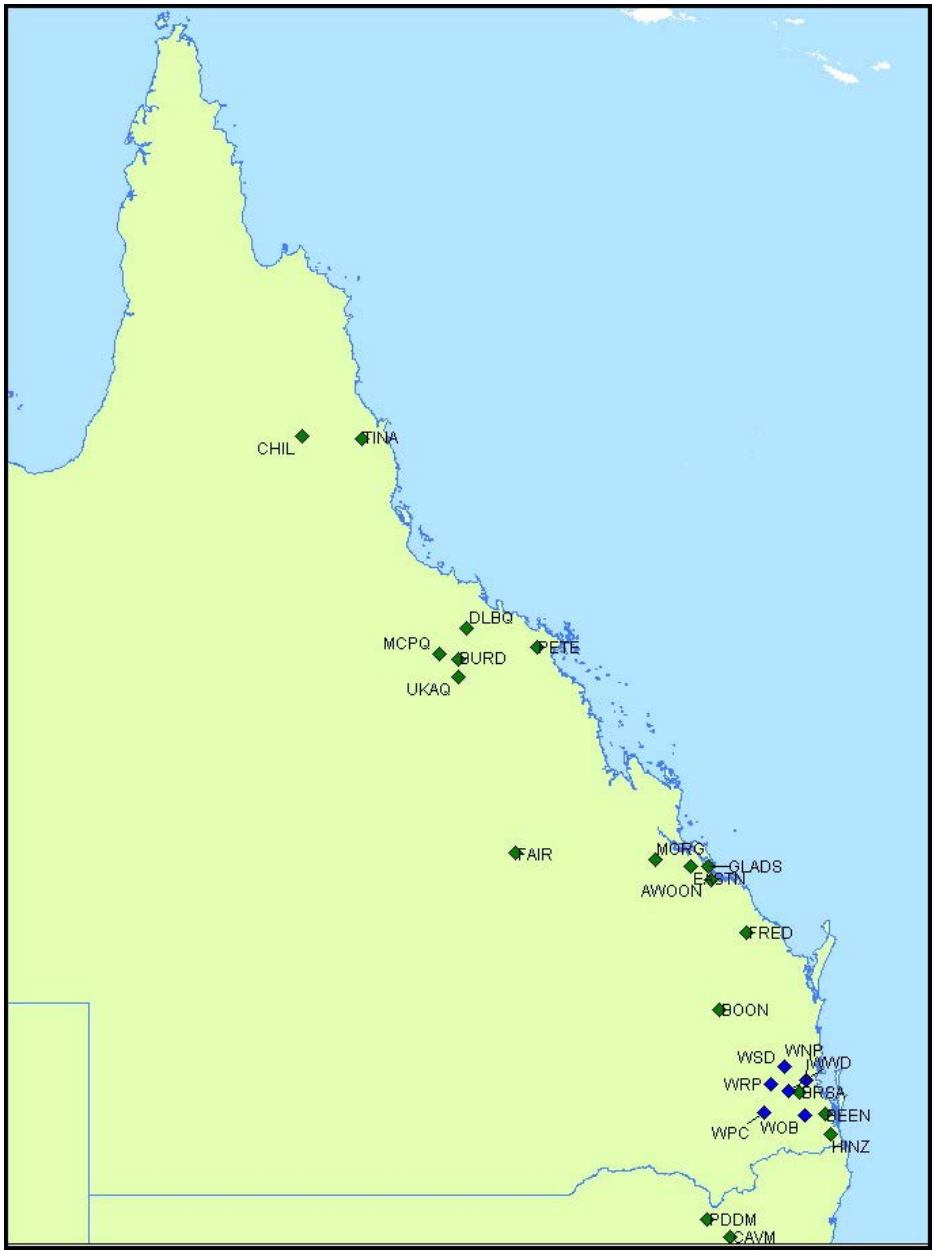

FIGURE 9 Station operated by ES&S in Queensland

Three Kelunji Echo recorders were installed at sites around Gladstone for the Gladstone Area Water Board. Data from these sites is being fed via NextG modems into the ES&S alarm system.

The eleven Queensland JUMP sites were decommissioned late in 2008 to coincide with the installation of Reftek recorders as part of an upgrade to the national JUMP network by Geoscience Australia.

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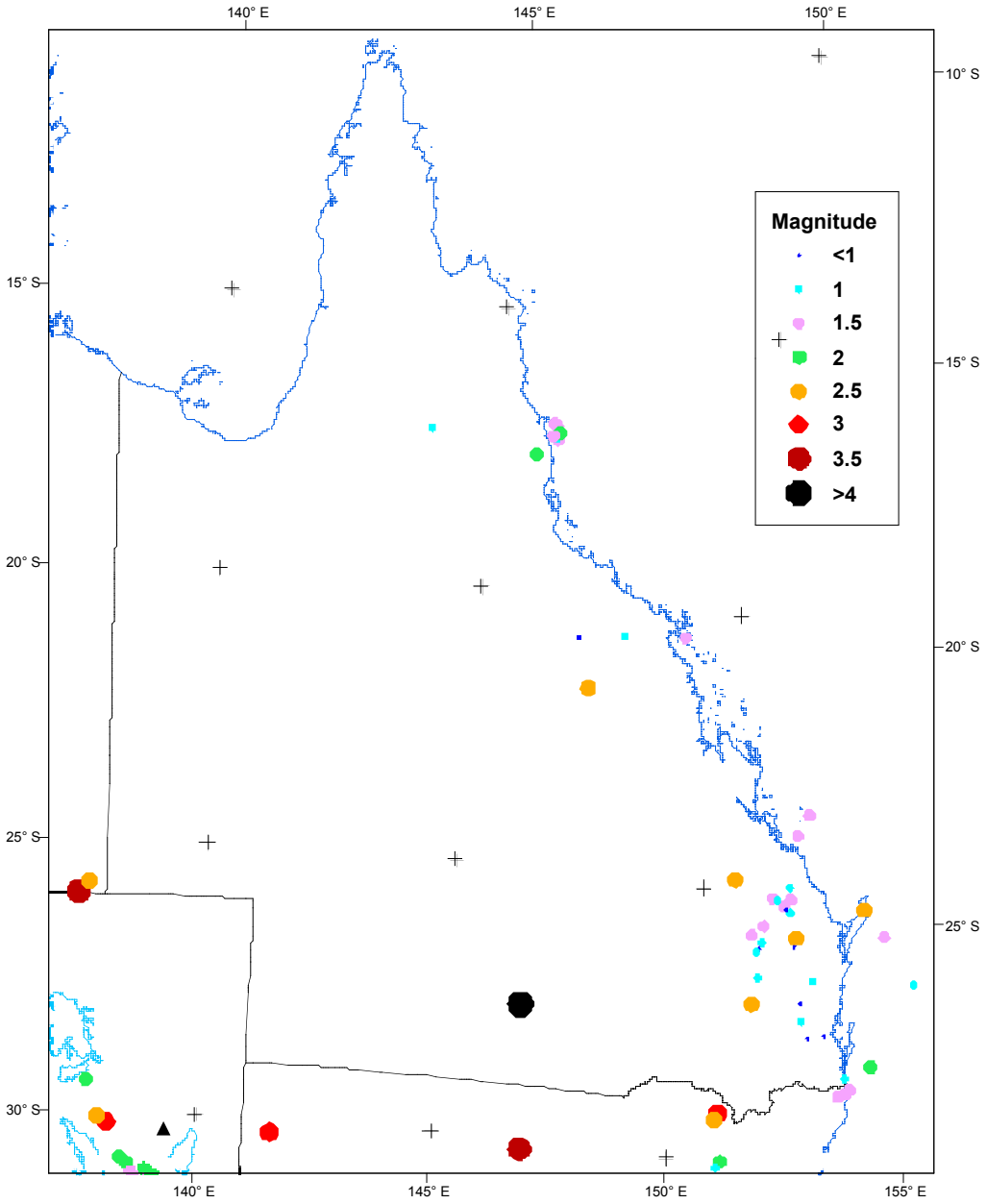

FIGURE 10 Earthquakes recorded on the ES&S network in Queensland. Coverage in the area shown is comprehensive down to about magnitude ML 3.0.

The Kelunji Classic recorder at the Elanora Gold Coast JUMP site was replaced with a Kelunji Echo recorder with telemetry of both continuous and triggered data via ADSL. The University of Queensland continued to operate seismographs at Mt. Nebo (BRSA) - which was upgraded to continuous telemetry in March 2008 - and Monto (MNT). Data from both these sites are provided to ES&S for incorporation into the State network database. The site at Hinze Dam (operated by the University of Queensland and Environmental Systems and Services for the Gold Coast City Council) was relocated from the dam site to a nearby property after construction for the raising of the dam wall commenced.

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Intensity The small ML 2.6 earthquake at Rawbelle (2008-12-18) was felt by a local farmer but insufficient data were available to draw an isoseismal map.

Isoseismal Maps

A number of earthquakes were felt in Australia in 2008, and a single isoseismal map was drawn up during the year, by Claire Payne and Wayne Peck at ES&S as shown. A web based intensity assessment is used at ES&S with some telephone interviews if required.

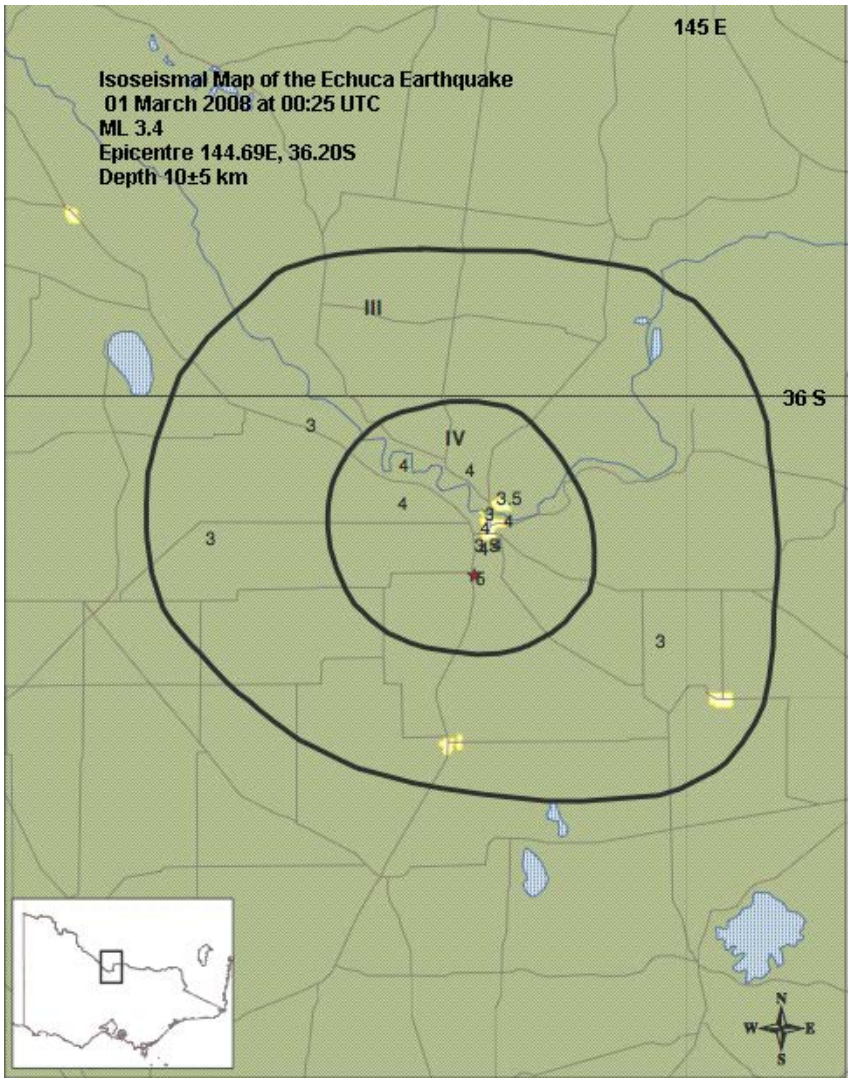

FIGURE 11
ISOSEISMAL MAP OF THE ML 3.4 ECHUCA VIC EARTHQUAKE, 01 MARCH 2008.

The earthquake location was quite well constrained by seismic data with uncertainties in any horizontal direction less than 2km.

The computed location also fits very nicely with the intensity data though observation points were limited by the population distribution as can be seen on the isoseismal map. This event triggered the notification of three of the water authorities who fund the Victorian network and all three were notified within the time specified under their contracts. The earthquake was just south of the Murray River marking the NSW/Vic border and almost due north of Melbourne.

The maximum intensity was rated at MM5 on the basis of reports from residents throughout Echuca-Moama who described a loud crack/banging, followed by rumbling, vibrations and shaking of buildings. Several reporters estimated the direction and commented that sleepers were awakened. In some cases there was slight damage; such as cornices being slightly displaced from cabinets.

Major earthquakes Worldwide

The level of seismicity throughout the world was about average with no *great* earthquakes (strictly speaking Mw≥8.0), the largest and most destructive earthquake magnitude Mw7.9 was in Eastern Sichuan Province China where nearly 70,000 people were killed. There were 12 major earthquakes (Mw≥7)

Table 2, 10 of them shallow, compared with an average of 10 to 12 major shallow earthquakes per year. The two deep major earthquakes were both under the Sea of Okhotsk, off the Russian east coast.

As mentioned below there were no destructive tsunamis in the year. The Macquarie Ridge earthquake on 12th April was a thrust event with near horizontal principal stress at an azimuth of 96°. Interestingly no tsunami seems to have been generated by this major, shallow, thrust-type event, normal parameters for a tsunamigenic earthquake. Note the difference in magnitude between the GA (7.4) and NEIC (7.1) reports of this event.

Table 3 Worldwide major shallow earthquakes in 2008 (latest first from NEIC)

Mw	*Date*	*Depth km*	*Place*	*Description*
7.3	November 24 2008	490	Sea of Okhotsk	Too deep to cause damage.
7.4	November 16 2008	30	Minahasa, Sulawesi, Indonesia	At least six people killed, 77 injured, 10,000 people displaced, 1,000 buildings damaged and communications disrupted in the Buol area and in Gorontalo. Felt Darwin (MMII).
7.0	September 29, 2008	36	Kermadec Islands New Zealand	The epicentre is only 50km SSE of Raoul
7.0	July19 2008	22	Off the East Coast Of Honshu, Japan	No damage but small tsunami observed.
7.7	July 05 2008	635	Sea Of Okhotsk	Too deep to cause damage.
7.0	June 30 2008	10	South Sandwich Islands Region	Too far from civilisation to have caused damage.
7.9	May 12, 2008	19	Eastern Sichuan, China	At least 69,195 people killed, 374,177 injured and 18,392 missing and presumed dead in the Chengdu-Lixian-Guangyuan area. More than 45.5 million people in 10 provinces and regions were affected. At least 15 million people were evacuated from their homes and more than 5 million were left homeless. An estimated 5.36 million buildings collapsed and more than 21 million buildings were damaged in Sichuan and in parts of Chongqing, Gansu, Hubei, Shaanxi and Yunnan. The total economic loss was estimated at 86 billion US dollars. Beichuan, Dujiangyan, Wuolong and Yingxiu were almost completely destroyed. Landslides and rockfalls damaged or destroyed several mountain roads and railways and buried buildings in the Beichuan-Wenchuan area, cutting off access to the region for several days. At least 700 people were buried by a landslide at Qingchuan. Landslides also dammed several rivers,

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				creating 34 barrier lakes which threatened about 700,000 people downstream. A train was buried by a landslide near Longnan, Gansu. At least 2,473 dams sustained some damage and more than 53,000 km of roads and 48,000 km of tap water pipelines were damaged.
7.1	April 12 2008	10	Macquarie Island Region	The 04/12/2008 event is the largest known historic earthquake on the section of the plate boundary south of the 1989 event since a nearby magnitude 8.3 earthquake in 1924
7.3	April 09 2008	33	Loyalty Islands	The New Hebrides arc region of the Australia/New Hebrides plate-boundary experiences numerous strong earthquakes. In the past quarter century, the thousand kilometer section of the arc centered on the epicenter of the April 9 earthquake has produced over 20 earthquakes of magnitude 7 or greater, the largest having magnitude 7.7.
7.2	March 20 2008	23	Xinjiang-Xizang Border Region	Four houses collapsed at Pulu and about 2,200 houses destroyed or damaged in Lop, Qira and Yutian. 46,594 people were displaced in Xinjiang. Felt at Aqqan and Bostan.
7.2	February 25 2008	35	Sumatra, Indonesia	No damage locally but earthquake felt in Singapore.
7.4	February 20 2008	35	Simeulue, Indonesia	Three people killed and 25 seriously injured in Western Aceh Province.

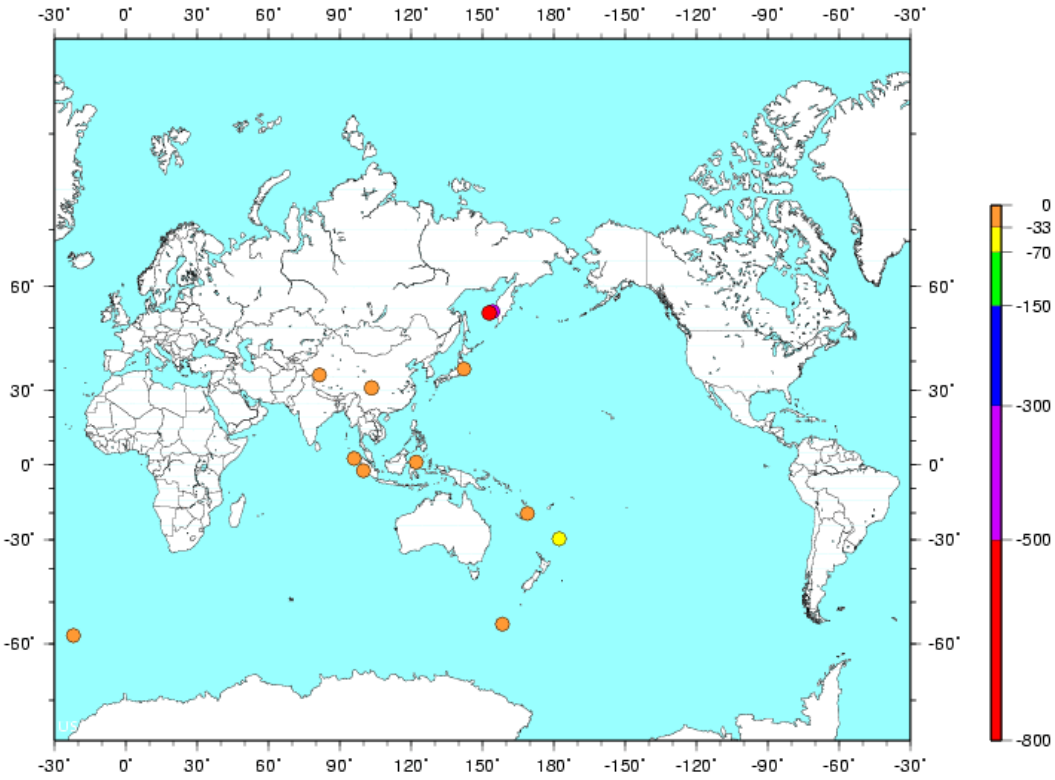

FIGURE 12 Major Earthquakes recorded Worldwide in 2008 Mw ≥7.0 (USGS).

Tsunamis Worldwide

There were six tsunamis recorded during the year according to NOAA, three of them in our region though none of them impacted Australia, and none caused casualties near the epicentre that we know of. The tide gauge record below is from the last listed earthquake in Indonesia (#11 in the table below) which was reported felt in Darwin.

Table 4 Tsunamis worldwide in 2008

Month	day	Time	M	Country	Max Height m
2	25	08:36	6.5	Indonesia	0.12
4	9	12:46	7.3	New Caledonia	0.15
4	28	18:33	6.4	Vanuatu	0.03
7	19	02:39	6.9	Japan	0.20
9	11	00:20	6.8	Japan	0.09
11	17	17:02	7.3	Indonesia	-

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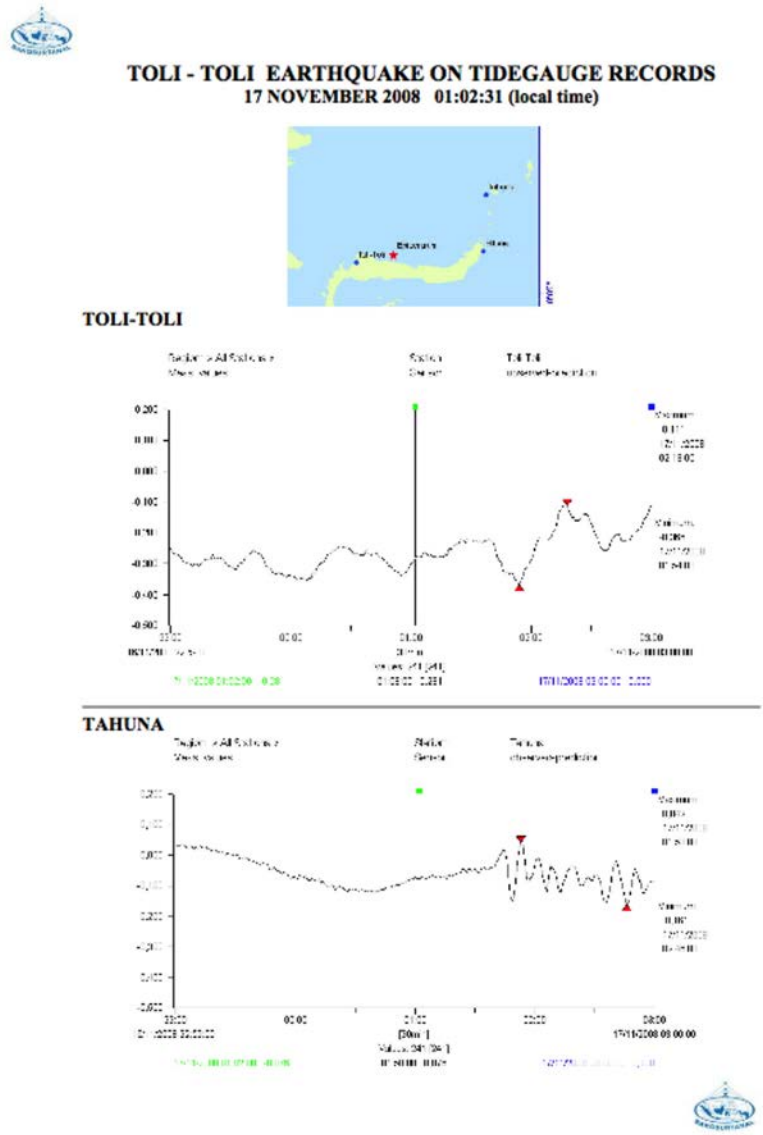
Figure 13 (below) A maregram from Indonesia 16 November, stations Toli Toli and Tahuna.



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Appendix

Large Australian earthquakes, 1788-2008, M≥6.0

Date UTC	Time	Lat °S	Long°E	ML	Ms	$AUS loss	Location
1873 12 15	0400	26.25	127.5		6.0		SE WA
1884 07 13	0355	40.5	148.5		6.2		NE Tasmania
1885 01 05	1220	29.0	114.0		6.5		Geraldton WA
1885 05 12	2337	39.8	148.8		6.5		NE Tasmania
1892 01 26	1648	40.3	149.5		6.6		NE Tasmania
1897 05 10	0526	37.33	139.75		6.5		Kingston SA
1902 09 19	1035	35.0	137.4		6.0		Warooka SA
1906 11 19	0718	21.5	104.5		7.2		Offshore WA
1918 06 06	1814 24	23.5	152.5	6.0	5.7		Gladstone Qld
1920 02 08	0524 30	35.0	111.0		6.0		Offshore WA
1929 08 16	2128 23	16.99	120.66		6.6		Broome WA
1941 04 29	0135 39	26.92	115.80		6.9		Meeberrie WA
1941 06 27	0755 49	25.95	137.34		6.5		Simpson Desert
1946 09 14	1948 49	40.07	149.30	6.0	5.4		West Tasman Sea
1968 10 14	0258 50	31.62	116.98		6.8	31	Meckering WA
1970 03 24	1035 17	22.05	126.61	6.7	5.9		L Mckay WA
1972 08 28	0218 56	24.95	136.26		6.2		Simpson Desert
1975 10 03	1151 01	22.21	126.58		6.2		L Mckay WA
1978 05 06	1952 19	19.55	126.56		6.2		L Mckay WA
1979 04 23	0545 10	16.66	120.27	6.6	5.7		Broome WA
1979 04 25	2213 57	16.94	120.48		6.1		Broome WA
1979 06 02	0947 59	30.83	117.17	6.2	6.1	10	Cadoux WA
1983 11 25	1956 07	40.45	155.51	6.0	5.8		Tasman Sea
1986 03 30	0853 48	26.33	132.52		5.8		Marryat Ck SA
1988 01 22	0035 57	19.79	133.93		6.3	1.3	Tennant Ck NT
1988 01 22	0357 24	19.88	133.84		6.4		Tennant Ck NT
1988 01 22	1204 55	19.94	133.74		6.7		Tennant Ck NT
1997 08 10	092035.2	16.10	124.38		6.3		Collier Bay WA

Damaging ($M) Australian earthquakes, 1788-2008

1989 12 27	2326 58	32.95	151.61	5.6	4.6	1270	Newcastle NSW
1954 02 28	l809 52	34.93	138.69	5.4	4.9	107	Adelaide SA
1994 08 06	1103 52	32.92	151.29	5.3		34	Ellalong NSW
1968 10 14	0258 50	31.62	116.98		6.8	31	Meckering WA
1979 06 02	0947 59	30.83	117.17	6.2	6.1	10	Cadoux WA
1961 05 21	2140 03	34.55	150.50	5.6		3	Bowral NSW
1973 03 09	1909 15	34.17	150.32	5.6	5.3	2	Picton NSW
1988 01 22	0035 57	19.79	133.93		6.3	1.3	Tennant Ck NT
1985 02 13	0801 23	33.49	150.18	4.3		.09	Lithgow NSW
1903 04 06	2352	38.43	142.53	4.6			Warrnambool Vic
1903 07 14	1029	38.43	142.53	5.3			Warrnambool Vic
1935 04 12	0132 24	26.0	151.1	5.2	5.4		Gayndah Qld
1970 03 10	1715 11	31.11	116.47	5.1	5.1		Calingiri WA

Note The damage is quoted in 1990 dollar values.

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Largest earthquakes in the World, 1901-2008

http://neic.usgs.gov/neis/eqlists/10maps_world.html

	Location	Date UTC	Mw	Lat.	Long.	Reference
1	Chile	1960 05 22	9.5	-38.29	-73.05	Kanamori, 1977
2	Alaska	1964 03 28	9.2	61.02	-147.65	Kanamori, 1977
3	Northern Sumatra	2004 12 26	9.1	3.30	95.78	Park et al., 2005
4	Kamchatka	1952 11 04	9.0	52.76	160.06	Kanamori, 1977
5	Off the Coast of Ecuador	1906 01 31	8.8	1.0	-81.5	Kanamori, 1977
6	Rat Islands, Alaska	1965 02 04	8.7	51.21	178.50	Kanamori, 1977
7	N Sumatra, Indonesia	2005 03 28	8.6	2.08	97.01	USGS
8	Assam - Tibet	1950 08 15	8.6	28.5	96.5	Kanamori, 1977
9	Andreanof Islands Alaska	1957 03 09	8.6	51.56	-175.39	Johnson et al., 1994
10	Southern Sumatra Indonesia	2007 09 12	8.5	-4.438	101.37	USGS
11	Banda Sea, Indonesia	1938 02 01	8.5	-5.05	131.62	Okal and Reymond, 2003
12	Kamchatka	1923 02 03	8.5	54.0	161.0	Kanamori, 1988
13	Chile-Argentina Border	1922 11 11	8.5	-28.55	-70.50	Kanamori, 1977
14	Kuril Islands	1963 10 13	8.5	44.9	149.6	Kanamori, 1977

Note these Mw are USGS magnitudes and may differ considerably when compared with other sources