Seismic Monitoring at Geoscience Australia

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Abstract

Geoscience Australia builds, maintains and operates the Australian National Seismic Network and Urban Monitoring Network across the Australian continent, its territories and overseas. To locate earthquakes and other seismic activity across the country and overseas, Geoscience Australia streams real time data from 206 stations across Australia. Additionally, 100's of stations are streamed into Geoscience Australia from international data centres and monitoring agencies and institutions. From station design through to dissemination of data, the geophysical networks section at Geoscience Australia provides the seismic data that underpins critical seismic monitoring activities undertaken in Australia and internationally. All the Australian data collected by Geoscience Australia is publicly available from GA servers and is delivered to the Incorporated Research Institutions for Seismology (IRIS). This data is freely available as a near real time feed and archived for use by other earthquake and nuclear monitoring centres, tsunami warning centres and well as research groups and institutions.

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The Geophysical Networks (GN) Section in the Community Safety and Earth Monitoring Division of Geoscience Australia (GA) is responsible for the operation of the Australian National Seismograph Network (ANSN, Figure 1, 2). The Australian National Seismograph Network is a state-of-the-art network of stations and sophisticated instrumentation that monitors natural and anthropogenic (human-made) hazards in Australia and around the globe. The Geophysical Networks Section also operates an Urban Monitoring (UM, Figure 1, 2) network, affiliated international seismic stations, and provides support to International Monitoring system of the Comprehensive Nuclear Test Ban Treaty which includes seismic, infrasound and hydroacoustic facilities. This support extends across continental Australia, Australian Antarctic Territory (AAT), throughout the Pacific, Indian and Southern Oceans, and PNG. For The Australian National Seismograph Network, the Urban Monitoring network and Comprehensive Test Ban Treaty monitoring Geophysical Networks constructs, operates and maintains infrastructure for; seismometers, accelerometers, microbarometers and hydrophones.

In addition, the section is responsible for the ingestion of real time data streams for over 200 additional seismic stations worldwide to support the operations of the Joint Australian Tsunami Warning Centre (JATWC) at GA.

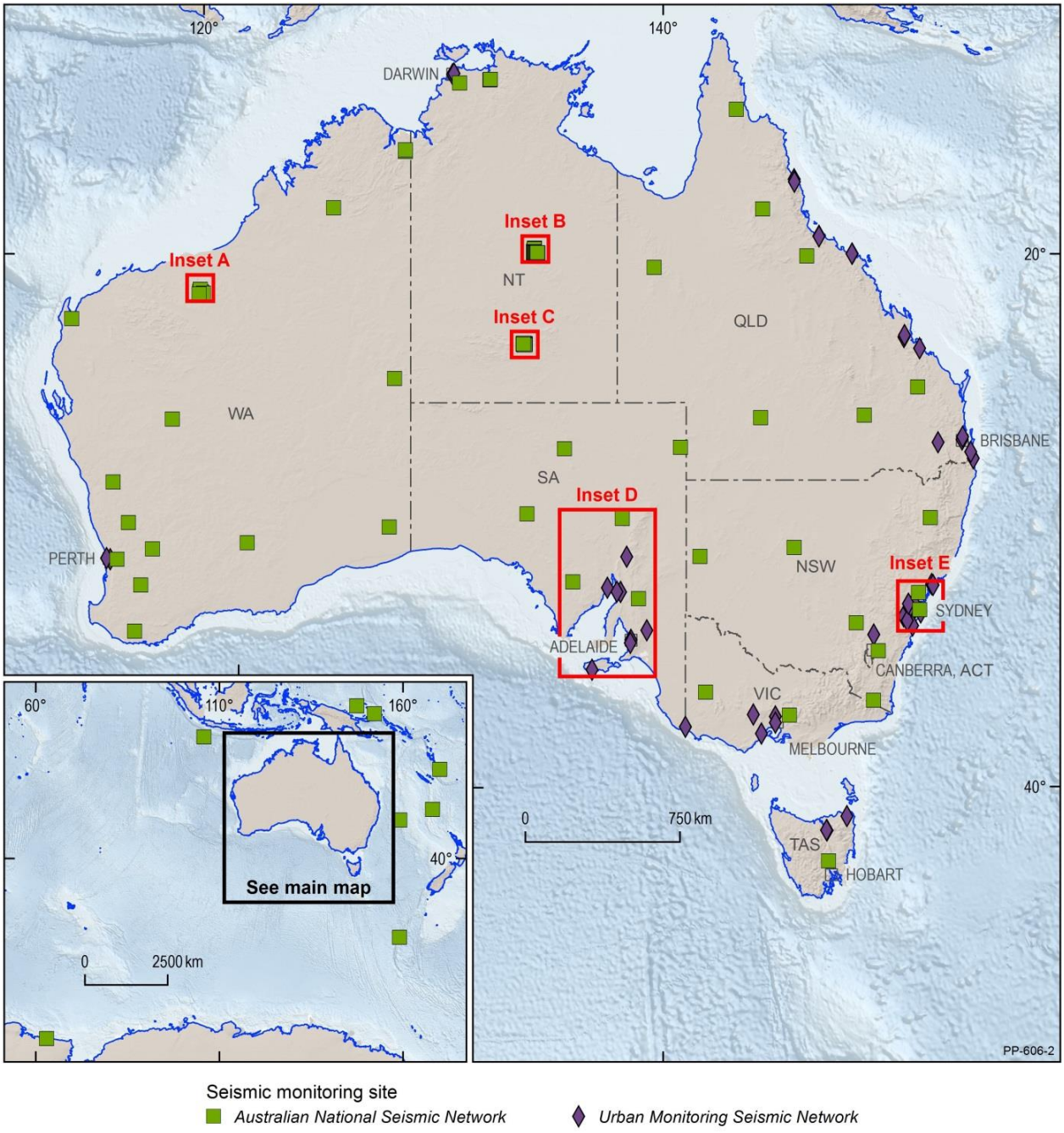

Figure 1. Seismic monitoring stations operated for near real time monitoring in Australia and the region by Geoscience Australia.

For all data streams GN is required to ensure that data is fit for purpose to meet client needs. To do this the section invests significant effort into State of Health (SoH) monitoring, Quality Assurance (QA) and Quality Control (QC) of seismic and ancillary data using commercial and in-house developed tools as well as ongoing review of metadata.

The GN section is also responsible for the delivery of data to stakeholders both internal and external to GA. The focus for external stakeholders is on international warning centres and consequently resources are primarily devoted to the serving of real time data streams. In 2017 we continued to deliver all ANSN real time data locally and to the IRIS DMC who provide a suite of tools designed to meet most external client needs.

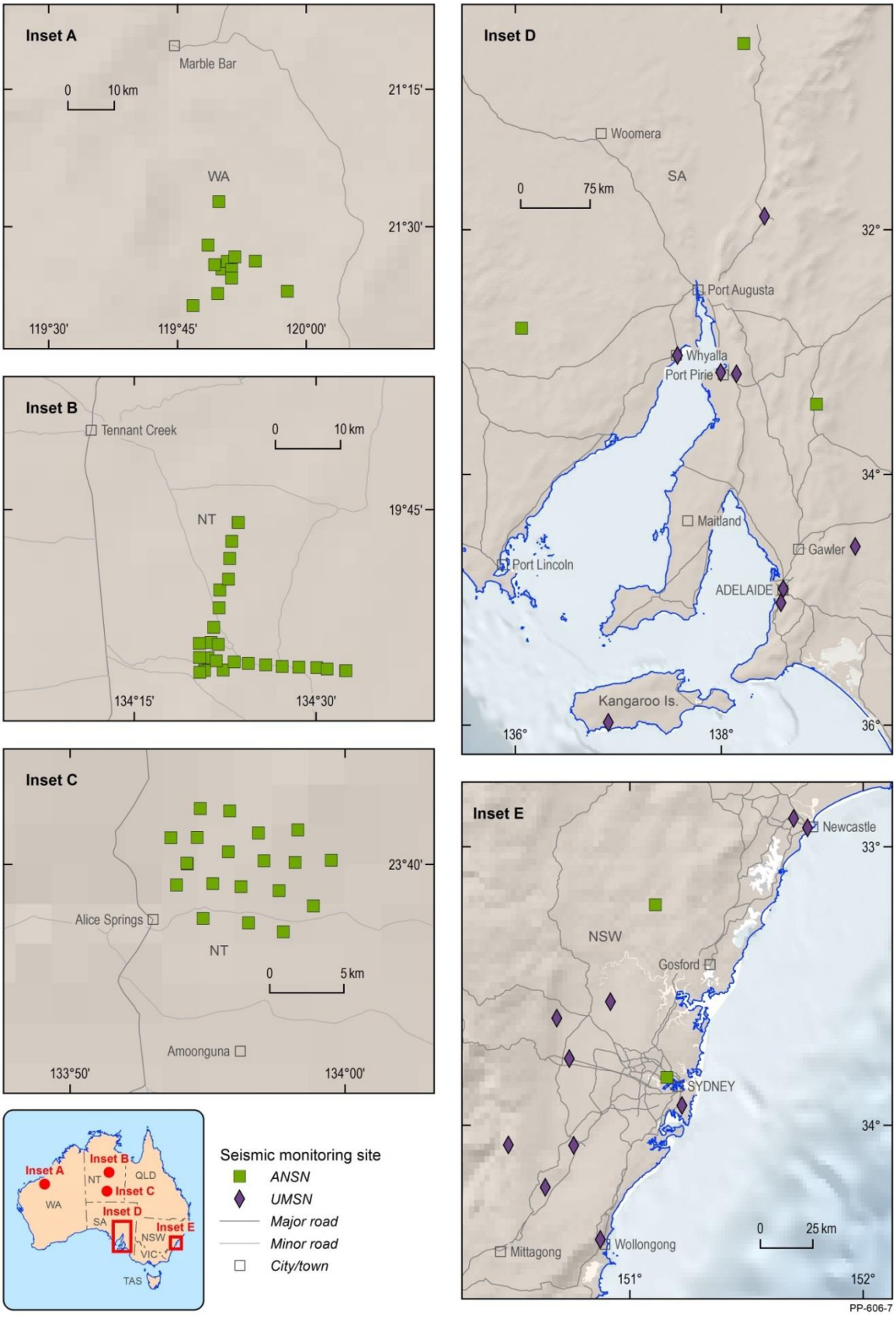

Figure 2. Insets showing greater detail of seismic monitoring stations operated for near real time monitoring in Australia and the region by Geoscience Australia.

The network design and operation is based around a series of defined requirements. These have evolved over the last 30 or so years and were first articulated in a review of BMR activities in the fields of earthquake seismology and geomagnetism undertaken during 1981 (BMR Record 1981/15). The main recommendations of this report were:

'That a national seismograph network should be developed to provide the capability for:

- Locating all Australian earthquakes with magnitudes greater than 4.0 on the Richter Scale (Ml);
- Locating all earthquakes with magnitude greater than 3.0 on the Richter Scale (Ml) in the continent's most seismically active and populous areas.
- Detecting all Australian earthquakes with magnitudes greater than 3.0 on the Richter Scale (Ml)

The current operational metrics for the ANSN are:

- Enable the detection, location (position, depth) and magnitude estimation of all earthquakes of magnitude 3.5 (Ml) or greater anywhere in Australia within 20 minutes of an earthquake event;
- Enable the detection, location and magnitude estimation of 99.9% of earthquakes of moment magnitude 6.0 (Mw) or greater anywhere in the region of the Indian Ocean, Southwest Pacific, and the Indonesian archipelago within 10 minutes of the earthquake having occurred

The Australian National Seismograph Network (ANSN) is a primary component of the Geophysical Networks. The first permanently established seismograph was installed at Riverview College in Sydney, New South Wales, with continuous seismic measurements recorded since 17 March 1909. The number of permanent installations increased significantly over the next 100 years with landmark events generating a better awareness of seismicity within Australia. These events include: The International Geophysical Year 1957–58; Newcastle Earthquake 1989; and, the Indonesian Earthquake and Tsunami 2004. The creation of the Urban Monitoring network in the aftermath of the Newcastle Earthquake led to an increase in number of Seismic recording station in the 1990's. In 2011, GA commissioned the 13 element Pilbara Seismic Array (PSAR), which is the only un-staffed seismic array in the world. The Array was designed and built to allow GA to monitor the seismic activity of the Indonesian trenches to provide rapid evaluation of the location and tsunami threat from this area.

Urban Monitoring (UM) stations are located close to population centres with 50,000 people or more; this secondary network is located around urban Australia and is used to improve the response and assessment of Australian earthquakes and for hazard modelling. Temporary installations associated with increased natural and anthropogenic seismic activity are linked into the network from time to time. Following a significant seismic event short-term rapid aftershock deployments are typically installed in the following days and are located in a radius less than 100 km of the earthquake epicentre.

Current best practice design principles call for sensors to be buried in a vault, designed to reduce the effects of localised noise interference from wind as well as maintaining a thermally stable environment for the sensor. The received signal is sent to a digitiser or field processor, then transmitted via satellite, internet or mobile communications in real-time to GA where it is analysed both automatically and manually for seismic events (Figure 3). Data are captured and made available within one minute of acquisition, via a public server at GA from which a number of organisations access the data for operational and research purposes. These organisations include both the Pacific and Indian Ocean Tsunami Warning Centre (PTWC, IOTWC), Incorporated Research Institutions for Seismology (IRIS), and GNS Science in New Zealand.

Figure 3. The seismic monitoring station at Lord Howe Island. In the foreground are the top of the seismic vault and vault cover with the hut containing the electronic processing equipment and battery bank in the background.

The data are quality controlled using software that calculates the distribution of power spectral density using probability density functions to determine the noise performance of an installation (McNamara and Boaz, 2005). The state of health of an installation is also monitored in an effort to minimise downtime and maximise data availability. Parameters such as power levels and equipment temperatures are monitored because they can provide an indication of an emerging issue at the remote site. Seismic data are freely available either directly from GA or from IRIS in standard formats that are compatible with all modern seismic processing software and are used continuously for operational monitoring activities such as earthquake monitoring for community safety response activities (tsunami warnings and potentially damaging earthquakes) and infrastructure safety response (power stations, dams, train lines).

Data is fed into the Joint Australian Tsunami Warning Centre (JATWC) from the Australian National Seismic Network, Urban Monitoring Network, Seismometers in Schools Network (Figure 4.) and 130 international seismic stations in near real-time. The seismic information is automatically analysed by GAs seismic monitoring and analysis systems that form part of the 24 hours a day, seven days a week JATWC operations centre. When a significant earthquake occurs, this system automatically computes preliminary information on the earthquake's origin time, location, depth and magnitude. The potential for the earthquake to cause a tsunami or generate damaging shaking to an Australian population Centre is then assessed. The seismic data are also used by GA and organisations world-wide: to assess which areas have the greatest earthquake and tsunami hazard potential; assess the likelihood of earthquake or tsunami hazards occurring; model the impact of the hazards; estimate the potential loss to communities; and, collect data when a hazard occurs to help prepare for future events.

GA helps Australia fulfil its obligations under the Comprehensive Nuclear-Test-Ban Treaty (CTBT) by monitoring for nuclear explosions worldwide and by contributing to the development of the CTBT verification regime. GA is responsible for the operation and maintenance of Australia's seismo-acoustic International Monitoring System facilities (seismic stations, infrasound stations and one hydroacoustic station, Figure 4). Additionally, GA is in the process of building a station in Antarctica to complete Australia's seismo-acoustic International Monitoring System network for the Comprehensive Nuclear-Test-Ban Treaty (CTBT).

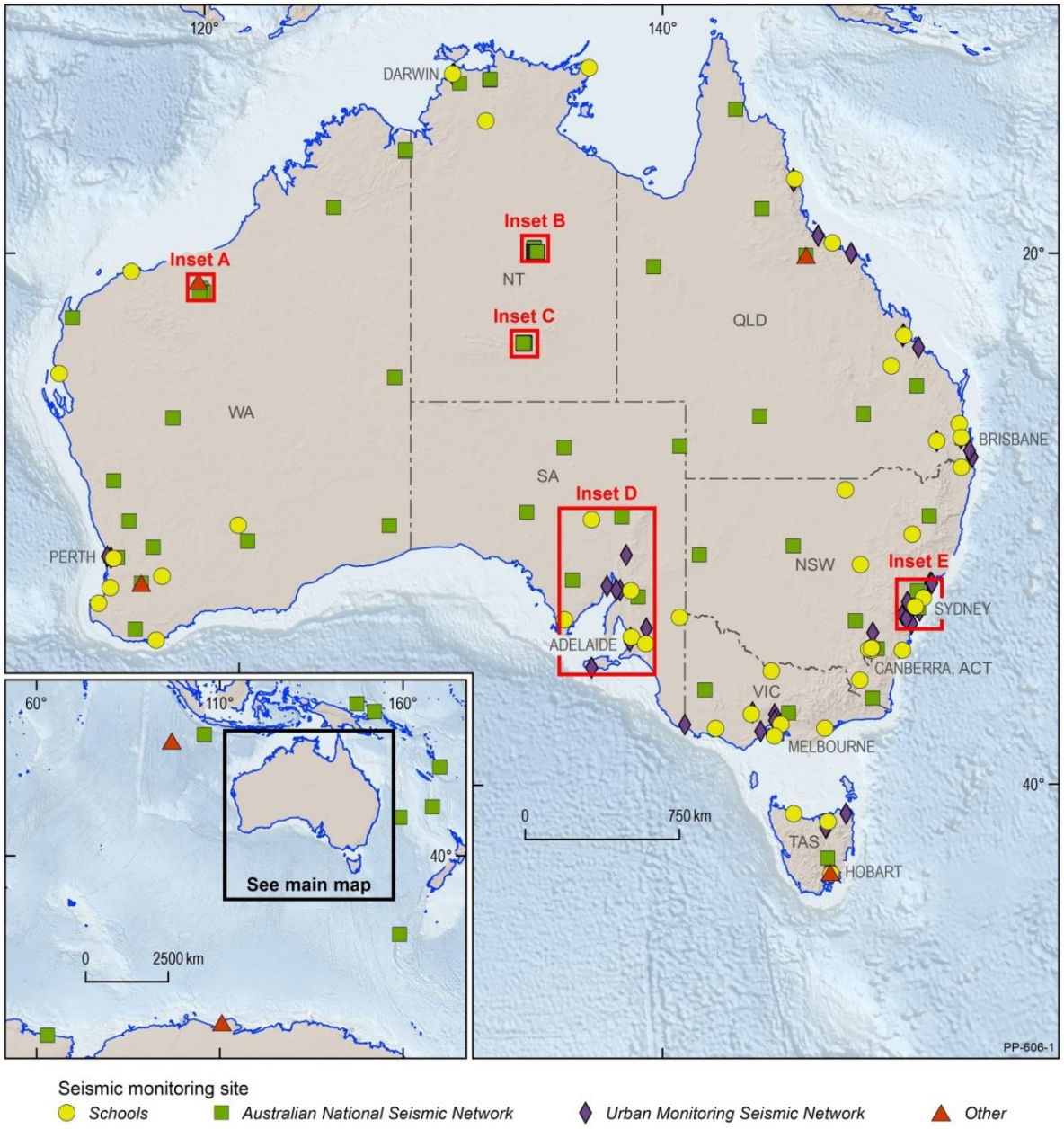

Figure 4. Seismometers in schools are used to supplement coverage seismic monitoring stations operated for near real time monitoring in Australia and the region by Geoscience Australia.

Table.1 Geoscience Australia operated real time telemetry seismic stations in 2017

Network	Station Code	Station Name
AU	ARMA	Armidale, NSW
AU	ARPS	Mount Arapiles, Vic
AU	ASAR	AS01 to AS19 Alice Springs Array Elements
AU	BBOO	Buckleboo Station, SA
AU	BLDU	Ballidu, WA
AU	BN1H	Brisbane Hard Rock, Qld
AU	BN2S*	Brisbane Soft Rock, Qld
AU	BRAT*	Ballarat Reservoir, Vic
AU	BW1H*	Bowen Hard Rock, Qld
AU	BW2S*	Bowen Soft Rock, Qld
G	CAN	Mt Stromlo, Australian Capital Territory (Geoscope)
AU	CARL*	Carlisle, Perth, WA
IU	CASY	Casey, AAT (IRIS IU)
AU	CATI	Cattai, NSW
AU	CMSA	Cobar, NSW
AU	CN1H*	Cairns Hard Rock, Qld
AU	CN2S*	Cairns Soft Rock, Qld
AU	CNB	Kowen Forest, Australian Capital Territory
II	COCO	Cocos Island, Indian Ocean (IRIS/IDA II)
AU	COEN	Coen, Qld
AU	CORO*	Coronation Park, Launceston, Tasmania
AU	CTA	Charters Towers, Qld (CTBTO IM)
IU	CTAO	Charters Towers, Qld (IRIS IU)
AU	DLN	Dalton, NSW
AU	DPH*	Darwin Parliament House, NT
AU	DRS*	Darwin Rock Store, NT
AU	EIDS	Eidsvold Station, Qld
AU	FITZ	Fitzroy Crossing, WA (CTBTO IM)
AU	FORT	Forrest, WA
AU	GC1S*	Gold Coast Soft Rock, Qld
AU	GC2F*	Gold Coast Fill, Qld
AU	GEES*	Gees Lookout, Launceston, Tasmania
AU	GEXS	Deakin University, Geelong, Victoria
AU	GHSS*	Government House, Adelaide, South Aust.
AU	GIRL	Giralia, WA

Network	Station Code	Station Name
AU	GLAD*	Gladstone, Tasmania
AU	GD1S*	Gladstone Soft Rock site, Qld
AU	GVL*	Greenvale Reservoir, Victoria
AU	HTT	Hallett, SA
AU	INKA	Innamincka, SA
AU	KDU	Kakadu, NT
AU	KLBR	Kellerberrin, WA
AU	KMBL	Kambalda, WA
AU	KNRA	Kununurra, WA
AU	LCRK	Leigh Creek, SA
AU	LHI	Lord Howe Island
AU	MABG	Mount Annan Botanical Gardens, NSW
AU	MANU	Manus Island, Papua New Guinea
AU	MAW	Mawson, Antarctica (CTBTO IM)
IU	MBWA	Marble Bar, WA (IRIS IU)
AU	MCQ	Macquarie Island
AU	MEEK	Meekatharra, WA
AU	MGCD	Mangrove Creek Dam, NSW
AU	MILA	Mila, NSW
AU	MLBS*	Scienceworks, Melbourne, Vic
AU	MOO	Moorlands, Tasmania
AU	MORW	Morawa, WA
AU	MTKN*	Mount Kenneth, Perth, WA
AU	MTN	Manton Dan, NT
AU	MTSU	Mount Surprise, Qld
AU	MULG	Mulgathing, SA
AU	MUN	Mundaring Weir, WA
AU	NAPP*	Napperby, SA
AU	NFK	Norfolk Island
AU	NIUE	Niue, Pacific Ocean
AU	NTLS*	Newcastle Soft Rock, NSW
AU	NTLH*	Newcastle Hard Rock, NSW
AU	OKDL	Oakdale, NSW
AU	OOD	Oodnadatta, SA
AU	PSAR	Pilbara Seismic Array, WA
AU	PTPS*	Port Pirie, SA

Network	Station Code	Station Name
AU	QIS	Mt Isa, Qld
AU	QLP	Quilpie, Qld
AU	RABL	Rabaul, Papua New Guinea
AU	RIV	Riverview, NSW
AU	RK1H *	Rockhampton Hard Rock, Qld
AU	RK2S*	Rockhampton Soft Rock, Qld
AU	RKGY	Rocky Gully, WA
AU	RMQ	Roma, Qld
AU	SYM	GA Symonston, ACT (Test site)
AU	STKA	Stephens Creek Reservoir, NSW (CTBTO IM)
AU	SYDH*	Kingswood College, Sydney, NSW
AU	SYDS*	David Phillips Sportsfield, NSW
AU	TOO	Toolangi, Vic
AU	TV1H*	Townsville Hard Rock, Qld
AU	TV2S*	Townsville Soft Rock, Qld
AU	TW1H*	Toowoomba Hard Rock, Qld
AU	TWOA*	Flinders University, Adelaide, South Aust.
AU	WHYH*	Whyalla, SA
AU	WOLH*	Wollongong Hard Rock, NSW
AU	WRKA	Warakurna, WA
AU	WTPK	Wilton Park, NSW
AU	XMI	Christmas Island Airport
AU	XMIS	Christmas Island Grants Well
AU	YARR	Yarramundi, NSW
AU	YNG	Young, NSW

** indicates a former Urban Monitoring station*

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