University of Queensland
SEISMOLOGY GROUP
DEPT. OF GEOLOGY AND MINERALOGY

QUEENSLAND SEISMIC RISK STUDY

PROGRESS REPORT
TO
THE STATE GOVERNMENT
OF QUEENSLAND

THROUGH
THE DIRECTOR-GENERAL OF MINES
MINES DEPARTMENT
ON BEHALF OF THE
INTERGOVERNMENTAL COMMITTEE

REPORT QSRS-2

1 NOVEMBER 1985-
15 FEBRUARY 1986

Prepared by:

DR. JOHN M.W. RYNN

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15 February, 1986

Submitted with the approval of

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Dr. G. R. Orme, Head of Department

INTRODUCTION

This is the second progress report for the Commission entitled "Queensland Seismic Risk Study" and covers the fifteen (15) week period 1st November, 1985 through 15th February, 1986.

The emphasis in this second stage has been directed towards completing the basic data set of earthquake occurrences in Queensland. This has been for both instrumental and macroseismic data and covered Tasks (i), (ii)(a) and (iv) of the Commission Brief.

In addition research into the interpretative aspects of the project, including a literature survey, compilation of formulae suitable for seismic risk analyses in Queensland, determination of empirical formulae for the Queensland data and formulation of concepts of possible causal relationships between the seismicity, geology and tectonics, has begun. These aspects cover Tasks (ii)(b),(iii),(iv) and (v).

This report details the research currently in progress, the status to date and projections for the remainder of the one year Commission. The results, in the formats of maps, tables and graphical representation are not included in this Report as they are still in preliminary forms. These will be shown and discussed at the Steering Committee meeting on Wednesday, 26th February, 1986.

PROJECT STATUS IN TERMS OF COMMISSION BRIEF

Task	Description	Status	Completion
(i)	Basic Data Set		
	(a) Catalogue of Queensland earthquakes (spatial distribution-listing and map)	completed	
	(b) Earthquake zones in Queensland (delineation of zones and map)	completed	
	(c) Macroseismic data (listing and maps)	completed	
	(d) Descriptive catalogue of Queensland earthquakes	completed	
	(e) Details of other seismic phenomena	completed	
	(f) Seismograph stations in Queensland	completed	
	(g) Statistics for earthquake parameters	in progress	May 1986
(ii)	Magnitudes of Queensland earthquakes		
	(a) Determination of magnitudes	completed	
	(b) Magnitude-frequency relations	in progress	May 1986
(iii)	Recurrence relations for earthquakes	in progress	May 1986
(iv)	Assessment of ground motion attenuation	in progress	Aug. 1986
(v)	Estimates of maximum ground motion acceleration, velocity and intensity for specified time periods	in progress	May 1986
(vi)	Upgrading Earthquake Risk Map of Australia, Queensland Sector - available seismic data	completed	
Final report and publications for project			Aug. 1986

PROJECT DETAILS TO DATE

As the research has proceeded, the modes for presentation of the data and interpretation has become more clear. These can be categorized as follows:

(a) Basic Data Set for Queensland Seismicity

This information, which includes both instrumental and macroseismic data has been compiled in its entirety. Such are presented in three formats - tables (or listings), maps and catalogues - which were discussed in detail in QSRS REPORT No. 1 (Rynn, 1985b). These now constitute the "QUEENSLAND EARTHQUAKE DATA FILE".

(b) Queensland Seismograph Stations and Their Instrumentation:

Complete details of these stations have been compiled in terms of their historical development, tables, maps and recommendations for the future. Preliminary details were given in QSRS Report No. 1 (Rynn, 1985b).

(c) Earthquake Magnitudes and Derived Parameters for Seismic Risk Assessment:

This aspect is the central and most critical part of the project. Once the complete and reliable determinations of magnitude values was available, statistical procedures on this data and comparison of such results with those from other seismic regions of the world (including, in part, a comprehensive literature survey) was initiated.

(d) Quantitative Assessment of Seismic Risk in Queensland:

One of the basic aims of this research has been to ensure standardised methods in data interpretation. This has a dual purpose: (a) to conform to past and present interpretations for Australian data in other states (b) to allow reliable direct comparisons with other seismic regions of the world. Consequently, the seismic risk analyses employ methods of the Bureau of Mineral Resources, Canberra and those particularly related to the central, northeastern and southeastern U.S.A. In addition, this allows our results to be utilised without change or re-computation in upgrading the Queeensland sector of the Bureau's earthquake data files. Other Australian agencies which require such data and results will also be afforded standardised information.

(e) Causal Relationships: Seismicity - Geology - Tectonics:

This aspect will be one of the most exciting outcomes of this project for continual seismological research for Queensland. In essence it pertains to the vital aspect of geological considerations for future seismic risk assessment (e.g. Booth, 1984). Discussions on this aspect are currently in progress with the Geological Survey of Queensland concerning the Wide Bay-Burnett region (Queensland's most active seismic zone, designated Zone 1; Rynn, 1985b). To further discuss this aspect, a seminar-forum is planned, details of which will be considered at the Project Meeting of this Report No. 2.

(f) Presentation of Data:

The data and results for this project have been and/or will be presented in the following manner:

(i) Research Publications;

Several publications are either in review or about to be submitted for publication. These primarily are related to reports of historical earthquakes of great significance to the seismic risk in Queensland and to studies of the Wivenhoe Dam seismic surveillance programme.

(ii) Final Report for this Commission:

It is suggested that this be a comprehensive document of a nature that all interested parties (Government Departments, civil engineering community, academics and the citizens of Queensland) will benefit from this initial research project. Already, there are several aspects which are clearly necessary for continual study.

(iii) Conferences:

A paper was presented to the "Intraplate and Interplate Earthquakes" Symposium held in Canberra in September 1985. Details of this were given in Rynn (1985a)

A paper was presented at the 8th Australian Geological Convention in Adelaide in February 1986. A copy of the Abstract is included in Appendix 1 of this Report.

An invitation has been extended and accepted to present a paper at a two-day seminar in December 1986 on Earthquake Hazard.

The research during this second stage of the project has concentrated on completing the Queensland Earthquake Data File of epicentres, macroseismic data file and determining magnitudes for all Queensland earthquakes. This has been accomplished through the following aspects:

(i) Complete analysis of all available seismograms consisting of:

Brisbane (BRS)	1937-1984
(includes	
BRS I - City	1937-1951
BRS II - St Lucia	1951-1963
BRS - Mt Nebo	1963-1984)
Charters Towers (CTA)	1957-1984
(includes	
old station (IGY)	1957-1963
WWSSN	1963-1984
Hi-Gain	1970-1974
ASRO	1974-1984
Townsville (TVL)	1956-1965
Kuranda (KDA)	1959-1964
Wivenhoe Dam Network (WDN)	1977-1984
Mt. Isa (ISQ)	1979-1984
Rathdowney (RYQ)	1980-1981

Boondooma Dam (BDDM)	1980-1984
Awoonga Dam (AWMG)	1981-1984
Burdekin Falls Dam Network (BFN)	1981-1984
Roma (RMQ)	1983-1984
Interstate Stations:	
Riverview, NSW (RIV)	1909-1984
Adelaide, SA (ADE)	1909-1984
Canberra, ACT (CAN)	1958-1984
Toolangi, Vic. (TOO)	1962-1984
SA Network (Univ. Adelaide)	1962-1984
Alice Springs (ASP)	1970-1984
SE Australia Network, NSW and ACT (Aust. Nat. Univ.)	1971-1984
Warramanga Array, N.T. (WRA)	1974-1984
Cooney, NSW (COO)	1974-1984
Stephens Creek, NSW (STK)	1974-1984
Cobar, NSW (CMS)	1982-1984

(ii) Determination of Magnitudes

Magnitudes have been determined following the methods detailed in Table 4 of QSRS Report No. 1 (Rynn, 1985b). Values could only be determined from seismograph stations whose instruments were fully calibrated (i.e. for which frequency response curves (magnification of ground motion versus frequency or period)) were available. These were as follows:

Richter Local ML - BRS, CTA, WDN, ISQ, COO, RMQ, STK
Body Wave MB - BRS, CTA and interstate stations
Surface Wave MS - CTA and interstate stations

The determination of ML and MB with respect to specific epicentral distances has been more uniquely defined. Table 4 of Rynn (1985b) can be slightly modified according to (where Δ = epicentral distance):

For ML: $0 < \Delta < 600$ km — $ML = \log A_1 - \log A_0 + \log R$ (as defined in Table 4 of Rynn, 1985b)

$600 < \Delta < 1100$ km — $ML = \left[\begin{array}{l}\text{ML from Eiby-Muir} \\ \text{nomogram, 1961}\end{array}\right] + \log R$

For MB: $\Delta > 1100$ km — $MB = \log A_2/T + Q$ (as defined in Table 4 of Rynn, 1985b)

For these determinations, several other points are worthy of note:

(a) The methods of determinations follow those employed by the Bureau of Mineral Resources for the Australian data base.

(b) For all earthquakes of about ML $\geq$ 5.0 which occurred prior to the 1940-1950 era, seismograms from the Riverview (RIV) station are the only available records for such calculations.

(c) The listed magnitudes do not include those for the Queensland stations of the Burdekin Falls Dam Network, Boondooma Dam or Awoonga Dam. These stations have not been calculated in-situ to

date, their frequency response curves being those quoted in the respective instrument manuals.

(d) Frequency response curves have been compiled for the instruments at the three Brisbane stations (BRS I, BRS II and BRS-Mt. Nebo). Information was found in the log books and files of these station operations to enable calibration to be theoretically calculated. These included

Milne-Shaw horizontal seismographs:		Dr. D. Denham, pers. comm., 1985
Benioff vertical seismograph	:	Seismology files and Willmore (1959)
Gilman vertical seismograph	:	Seismology files and Willmore (1959)

Note: The final report and publication will contain full details of relevant seismograph stations, their instrumentation and calibration details (i.e. frequency response curves).

Station Corrections:

To facilitate consistency between magnitude values for individual stations, a simple statistical analysis of all stations, based on the method described by Gumper and Scholz 91971) was undertaken. This provides an "internal" correction for each station whereby the scatter in individual magnitudes is minimised.

Differences in magnitudes between individual stations (once the respective instrumentation and subsequent correction term log R in the Richter ML formula is taken into account) are a function of the local geology of the station location, radiation pattern of the seismic energy and the path (epicentre to station) differences.

The station corrections for the various seismograph stations are listed in Table 1.

Derived Magnitudes:

For many of the earthquake occurrences prior to the advent of seismograph stations in Queensland only macroseismic data is available. This pertains to events with magnitudes in the range $3.0 < ML < 5.0$ during the pre-1950 years. Magnitudes ML have been computed from such data based on the study of McCue (1980). In the first report of the seismicity of Queensland, (Rynn 1984), such derived magnitudes ML(I) (defined in Table 4 of Rynn, 1985b), were obtained using McCue's (1980) formula which had been based on southeastern Australian data.

It is pleasing to report that the Queensland data set is sufficient to enable a specific study, similar to that of McCue (1980), to be undertaken. This is currently in progress.

For many earthquakes, although some macroseismic data is available, there is not sufficient to allow isoseismal maps to be produced. In such cases, derived magnitudes of the type ML(Io) (Table 4; Rynn, 1985b) have been calculated based on an empirical determination of the Io vs ML relationship (e.g. Chinnery and Rogers, 1973). Note that in the seismic risk assessment this relationship has important connotations for the estimation of possible maximum intensities (Io) for specific ML values.

TABLE 1

STATION CORRECTIONS FOR ML DETERMINATIONS

The station corrections, STAC, for the vertical component instruments, are included in the formula for the Richter local magnitude ML as:

$$ML = \log A - \log Ao + \log R + STAC$$

where all other symbols were defined in Table 4 of Report QSRS No. 1 (Rynn, 1985b).

SEISMOGRAPH STATION NAME	CODE	STATION CORRECTION STAC EPICENTRAL REGIONS		
(A) SOUTHERN QUEENSLAND:		WIVENHOE (Δ<100 km)	CENTRAL AND SOUTH EASTERN QUEENSLAND (100 <Δ< 400 km)	NORTH EASTERN NEW SOUTH WALES (200 <Δ< 500 km)
Wivenhoe Network:				
Deep Creek	DC	0	0	
Kipper Creek	KC	0	-0.1	
Logan Creek	LC	+0.4	+0.4	
Lowood Range	LR	+0.6	-0.6	
Middle Creek	MC	+0.1	+0.2	
Mt. Esk	ME	-0.1	-0.1	
Scrub Creek	SC	-0.1	-0.1	
Byron Gully	BG	+0.1	+0.1	
Summerholm	SH	(-0.20	+0.8	
Grandchester	GR	(-0.2)	n.d.	
Perry's Knob	PK	n.d.	0	
Somerset Dam	SD	(-0.2)	-0.5	
Lowood	LL	n.d.	-0.5	
Wivenhoe Dam	WX	n.d.	n.d.	
Wivenhoe Dam	WD	n.d.	(-0.1)	
Pine Mt.	PM	-0.1	+0.1	
Toogoolawah	TG	-0.1	+0.1	
Plainlands	PL	0	-0.1	
Mt. Brisbane	MB	-0.2	-0.5	
Thallon Road	TR	+0.1	+0.1	
Reedy Creek	RC	+0.2	+0.2	
Buaraba	BA	-0.1	-0.1	
Wivenhoe Hill	WH	0	0	
Rathdowney	RYQ	i.d.	i.d.	
Brisbane				
Mt Nebo	BRS			
1963 Feb - 1977 Apr		+0.1	+0.1	
1977 May-1979 May		+0.5	+0.5	
1979 Jun-1984 Dec.		+0.1	+0.1	
St. Lucia	BRSII			
Benioff 1951-1955		n.d.	+0.1	
Gilman 1955-1963		n.d.	-0.2	
City	BRSI			
Benioff 1947-1951		n.d.	n.d.	
Cooney	COO	n.d.	*	STD
(B) NORTHERN QUEENSLAND:		M.L. REGIONS		
Charters Towers	CTA	STD		

STD - This defines the seismograph station as the STANDARD for magnitude calculations in the particular region as follows:
Wivenhoe - ML(WDN) which is defined as the arithmetic mean of ML values for all stations of the Wivenhoe network recording the earthquake.
Central - and South-Eastern Queensland - ML(WDN)
Northern Queensland - ML(CTA)
Northeastern New South Wales - ML(COO)
n.d. - no data available

Statistical Considerations:

In determining empirical relationships using magnitude values (ML), it is necessary to involve some basic regression statistics (e.g. York, 1966; Bäth, 1977; Vere-Jones and Smith, 1981). Most seismological cases involve linear regression wherein the data usually conform to a straight line of the form

$$y = ax + b$$

in relation to either linear-linear or log-linear plots, which are, in effect, linear approximations to the data sets.

At this stage of the analyses of Queensland earthquake data, the earthquake parameters concerned include

(a) Maximum Intensity (Io) = f (Richter Local Magnitude (ML)

(b) Richter Local Magnitude (ML) = f (Radius of perceptibility of the Isoseismal line for MM = III (R_{pIII}))

(c) Number of earthquakes (N) (i.e. Recurrence Relations) = f (Richter Local Magnitude (ML))

In straight-line fitting to such data, caution must be exercised in recognizing the type of data set and in employing the correct regression technique (e.g. Bolt, 1978). When most of those data sets are presented in graphical plots, the data show a large scatter and conform to oval-shaped point clouds rather than being collinear or nearly so (Bäth, 1977). The most acceptable statistical method to determine the "best" straight-line fit is that of orthogonal regression or major axis solution (York, 1966; Bäth, 1981). Such a method has been applied to the Queensland earthquake data.

(iii) Macroseismic Data

In collating the macroseismic data for Queensland earthquakes, additional felt information was found for two earthquakes including the 1935 Gayndah and 1960 Mt. Glorious. New isoseismal maps have been drawn and the relevant earthquake parameters recalculated. Macroseismic data analyses have also been completed for the 1984 Cooyar (4 March) and Murgon (30 October) earthquakes.

The importance of this data is again emphasised in reference to determining magnitudes of those earthquakes which occurred in pre-instrumentation years (namely the derived magnitudes).

(iv) Studies of Specific Earthquakes

In determining magnitudes for Queensland earthquakes, it became apparent that many of the larger events (say ML > 5.0) were recorded on seismograph stations throughout the whole of Eastern Australia. Such events are being given special consideration as it seems possible more definitive and quantitative magnitude scales may be possible. This study may also provide additional information for consideration of the

attenuation of seismic energy in this part of Australia. A possible consequence, particularly of interest to the engineering community, will be that of more reliable error assessments for magnitude values. (As previously mentioned this aspect will be the subject of the invited at the December 1986 earthquake symposium).

PROJECT EXPENDITURE

The following expenditure through February 1986 has been incurred:

(a) University of Queensland Account O-GEOL-DEPT. MINES-SEISMIC RISK -822040

1985	August	Salary Dr. J.M.W. Rynn	$2024.00
	September	Salary Dr. J.M.W. Rynn	$2698.66
		Canberra Conferences	
		Airfare	$363.20
		Per Diem (5 days)($68 pd)	$340.00
	October	Salary Dr. J.M.W. Rynn	$2698.66
	November	Salary Dr. J.M.W. Rynn	$3049.73
		Canberra Conference Costs Reimbursement	$400.75
	December	Salary Dr. J.M.W. Rynn	$4090.37
1986	January	Salary Dr. J.M.W. Rynn	$4574.58
		Total:	$20591.02

(b) Department of Geology and Mineralogy, University of Queensland

To support this project, departmental costs in terms of clerical assistance (approximately 5% .of total departmental time), photocopying and stores (stationery) supplies have been incurred. No absolute monetary costing was available.

GENERAL COMMENTS

(1) Since the last meeting in November 1986, several questions have been raised by members of the Steering Committee. These are as follows and are considered important aspects to this research project:

(a) Research papers in progress:
These have been mentioned earlier in this Report. Several others are in progress or planned and a detailed statement will be given in the next Report (Report QSRS No. 3).

(b) Consideration of northern New South Wales seismicity:
The question was asked re the effects of earthquakes in this region on the southern parts of Queensland. It is noted that the area is indeed being taken into account and had been designated Earthquake Zone 6 (Rynn, 1985b) with the status of seismicity through 1982 reported by Rynn & Lynam (1984).

(c) Status of earthquake activity for 1985:
This matter has been considered, in preliminary form, for the paper to be presented at the 8th Australian Geological Convention (see Appendix 1)

(d) Effects of the Somerset Dam Earthquake of 8 January 1986:
Brief details of this earthquake are given in Appendix 2 of this Report.

(2) It is considered that the time is now opportune to have some discussions between Dr. Rynn and several interested parties re specific aspects of the seismicity of Queensland. The following discussions are requested for consideration.

(a) Dr. J. Fenwick (M.R.D.) re upgrading the Earthquake Risk Map of Australia, Queensland Sector (Project Task iv);

(b) State Emergency Services re their needs for assimilation and possible publication of certain aspects of the data and interpretation;

(c) Mr. W.H. Boyce (Cameron-McNamara) re the specific requirements of the civil engineering community in relation to those earthquake parameters of prime importance in earthquake engineering studies;

(d) Other State government Departments which are deemed necessary.

(3) Requests of the Steering Committee

(a) The preparation of a seismological computer program package:
This item was raised in QSRS Report No. 1 but unfortunately no comment has been forthcoming. It is now considered appropriate to initiate this item and suggested that a small group of interested persons be convened by Dr. Rynn.

(b) Per Diem funds for visit to BMR, Canberra by Dr. Rynn:
Dr. Rynn visited the BMR from 12th to 16th February 1986 for

the purpose of analysing Riverview Observatory (RIV; Sydney) seismograms for Queensland earthquakes prior to the 1950's. These are the only records available in Australia and because of their delicate nature they could not be transported to Brisbane. In addition to these analyses further discussions were held with Dr. D. Denham and his staff re the seismic risk project. The reimbursement requested is for 4 days per diem at the University capital city allowance rate of $78 per day totalling $312. Note that the cost of travel (airfare) was funded from other sources as part of Dr. Rynn's return trip to the 8th Australian Geological Convention in Adelaide.

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Contributions from the Dominion Observatory, Ottawa, Canada Vol. 3, No. 12.
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Canadian Journal of Physics, 44, 1079-1086.

APPENDIX 1

Abstract of paper entitled "The Seismicity of Queensland and Northeastern New South Wales - 1866 Through 1985" presented at the 8th Australian Geological Convention, Adelaide, 16-21 February, 1986.

THE SEISMICITY OF QUEENSLAND AND NORTHEASTERN NEW SOUTH WALES 1866 THROUGH 1985

John M.W. Rynn

Department of Geology & Mineralogy, University of Queensland, Brisbane

When considering the seismological nature of the Australian continent with the current available published information of either earthquake occurrences, epicentral distribution or ground motion parameters for seismic risk assessments, it appears that the seismic activity in the northeastern Australian region is extremely low. Recent studies have shown that this is not the case. Indeed, the level of activity is one of the highest within the Australian continent.

The known seismic history spans 120 years with the earliest reported earthquakes being in 1866 on Cape York and 1975 near Warwick. A large proportion of the data is based on macroseismic observations principally because of the lack of seismograph stations in the region. The major stations were installed in Brisbane in 1937, Charters Towers in 1957 and Cooney Observatory (near Armidale) in 1974. In recent years, seven single component stations have been added and multi-station networks for reservoir induced seismicity studies about Wivenhoe (southern Queensland) and the Burdikin Falls (northern Queensland) dams implemented. Despite this increased instrumental coverage, an improved station distribution is still needed to provide more precise determinations of earthquake parameters for this region.

A distinctive spatial distribution of earthquakes has now emerged. Earthquakes occur in both the terrestrial and marine terranes. They appear to be concentrated within the eastern parts of the Tasman Fold Belt system, with more intense pockets of activity in the northern, central and southern sectors in Queensland, the New England Tableland and along the Queensland-New South Wales border. Off the coast, epicentres have been located in the Coral Sea Basin, along the Great Barrier Reef, in the Capricorn-Bunker groups of islands and associated with the Tasmantid seamounts (old Tasman Ridge). Many are confined to the continental shelf areas. The most active region is that defined as the Wide Bay-Burnett zone in central-eastern Queensland.

An attempt has been made to define the epicentral distribution in terms of broad causal relationships with geological structures. The criteria involved include faults, major lineaments and volcanic provinces. Such relationships are considered on a broad regional sense rather than small-scale localised interpretations. This multi-disciplinary approach has allowed an earthquake zoning map to be produced wherein the region has been divided into nine zones.

Little definitive information can be afforded on the temporal distribution of earthquakes over the 120 years. This is due to the bias in population distribution in the early years (macroseismic data) and the poor distribution of seismograph stations (instrumental data) in the region.

Magnitude values are now available for all earthquakes. These have been calculated using the classical formulae for instrumental data (m_b, MS and ML) and for macroseismic data from both isoseismal maps (ML(I)) and the ML-Io relationship (ML(Io)). For those earthquakes where only isolated felt reports are available, maximum possible magnitudes (ML(E/M)) have been estimated for the ML-Io relationship and comparisons with other known earthquakes in the same area.

A considerable amount of macroseismic information is available for the region. More than 50 isoseismal maps have been produced and many more instances of felt reports are on file.

Several aspects of the seismicity are worthy of note. Seventeen earthquakes with magnitudes greater than ML 5.0 are known to have occurred in the 120 year period. The largest event was the 1918 "Queensland" earthquake (ML 6.2). The effects of this earthquake were experienced over 300000 sq. km. of southern Queensland and northeastern New South Wales. Several other earthquakes have effected areas of about 100000 sq. km.

Current research involves the compilation of all known seismic data for the region which is being integrated towards the quantitative assessment of seismic risk for northeastern Australia. Analyses are directed towards the definition of parameters for all earthquakes, satistical studies of the data and the multidisciplinary approach to determine causal relationships between the seismicity and the geology/tectonics. The study is being undertaken in cooperation with geologists and civil engineers in the academic, governmental and counsulting communities. Funding is provided by a consortium of departments of the State Government of Queensland.

APPENDIX 2

The "Somerset Dam" Earthquake of 8 January 1986 - Brief Details

SOMERSET DAM EARTHQUAKE OF 8 JANUARY 1986

Preliminary Details

Origin time: 8 January 1986 09h 55 m 55.69s U.T.
Epicentre: 27.08°S, 152.52°E
(approximately 5 km NW of Somerset Dam)
Focal Depth: 8 km
Magnitude: ML 4.0 (COO), 3.9 (RMQ), 3.9 (CTA)
MB 4.0 (CTA)
ML(I) 3.5

Macroseismic Details:

Maximum Intensity Io MM-5 Mt. Archer - structural damage to walls, ceiling and brick work of private home and cracks in concrete paths

Somerset Dam - crack in concrete; small items fell from shelves

Felt Area of approximately 2000 km^2 encompassing towns and districts of Somerset Dam, Cooeeimbardi, Kilcoy, Mt. Archer, Woodford, Villeneuve, Mt. Beppo, Toogoolawah, Harlin, Esk. Isolated felt reports from Benarkin and Crow's Nest. The effects were definitely not felt in Brisbane, Wivenhoe Dam, Tarong Power Station and Caboolture.

General Comments:

(i) The effects were felt most strongly (violent shaking of houses, windows and doors rattling) in the Somerset Dam - Kilcoy area. Many residents at Somerset Dam were quite alarmed.

(ii) Unfortunately the accelerometers purchased for the Wivenhoe Dam - Split-Yard Creek Power Station complex early in 1985 were not operational for this earthquake. Thus only a theoretical estimate of the acceleration can be made. Using Hays (1980) curves for Acceleration vs Epicentral Distance (Fig. 17, page 22).

$$A = 0.279e^{0.08M} R^{-1.64}$$

where A = Peak ground acceleration (g)
M = Richter local magnitude (ML)
R = Epicentral distance (km)

with ML = 4.0, R (Wivenhoe Complex) = 35 km for this earthquake

gives A (Wivenhoe Complex) $\simeq$ 0.013 g.

Reference: HAYS, W.W., 1980: Procedures for Estimating Earthquake Ground Motions
U.S. Geological Survey Professional paper 1114, 77pp.