Appendix H - Data and Information Sources

This appendix is mainly aimed at the Geographic Information Systems (GIS) profession. It gives a run-down of what hardware, software and datasets were used to undertake the Earthquake Risk Assessment of Newcastle and Lake Macquarie.

Hardware:

- PC – Silicon Graphics Workstation
- 18 Giga byte Unix storage disk
- Aero2100 Palmtop PC
- Garmond Differential GPS
- 1 Mega Pixil Digital Camera
- HP800 – Colour DesignJet Plotter

Software:

- Windows 95 / NT / 2000 / CE
- Exceed Version 6.2
- Solaris Version 8
- ArcView 3.2a
- Extensions include Spatial Analyst and ECW for ArcView
- ArcInfo Version 8.0.2
- ArcPad Version 5.0.1
- MAPINFO Version 6
- ER Mapper Version 5.5
- ERDAS Imagine Version 8.4
- Microsoft products including Excel, Word

Database:

- Building Inventory - September 2000 (GA)
- Microtremor Survey - 1999 (GA)
- National UBD raster - June 2000 (Telstra)
- Aerial orthophotos – 2000 (Land Property Information)
- DEM – 2000 (Land Property Information)
- Vector Boundaries (Land Property Information)
- Building Damage – 1989-90 (Newcastle City Council)
- Insurance data – 1989-90 (NRMA)

For the risk assessment to be modelled a building inventory database was collected through the Cities Projects' Data Acquisition Units. It was acquired over a period of 3 weeks comprising 5 staff. A total of 6339 building points were collected. For a more detailed explanation of what was collected refer back to Chapter 5.

Figure H - 1 shows the total coverage of this survey. Some suburbs were missed due to time restraints and permission clearance. These areas are shown on some of the previous figures in this report as not classified. Also in some of the same figures, certain suburbs may have been not classified due to their low building count over the total area of the suburb, removing these suburbs tends to create a more precise picture.

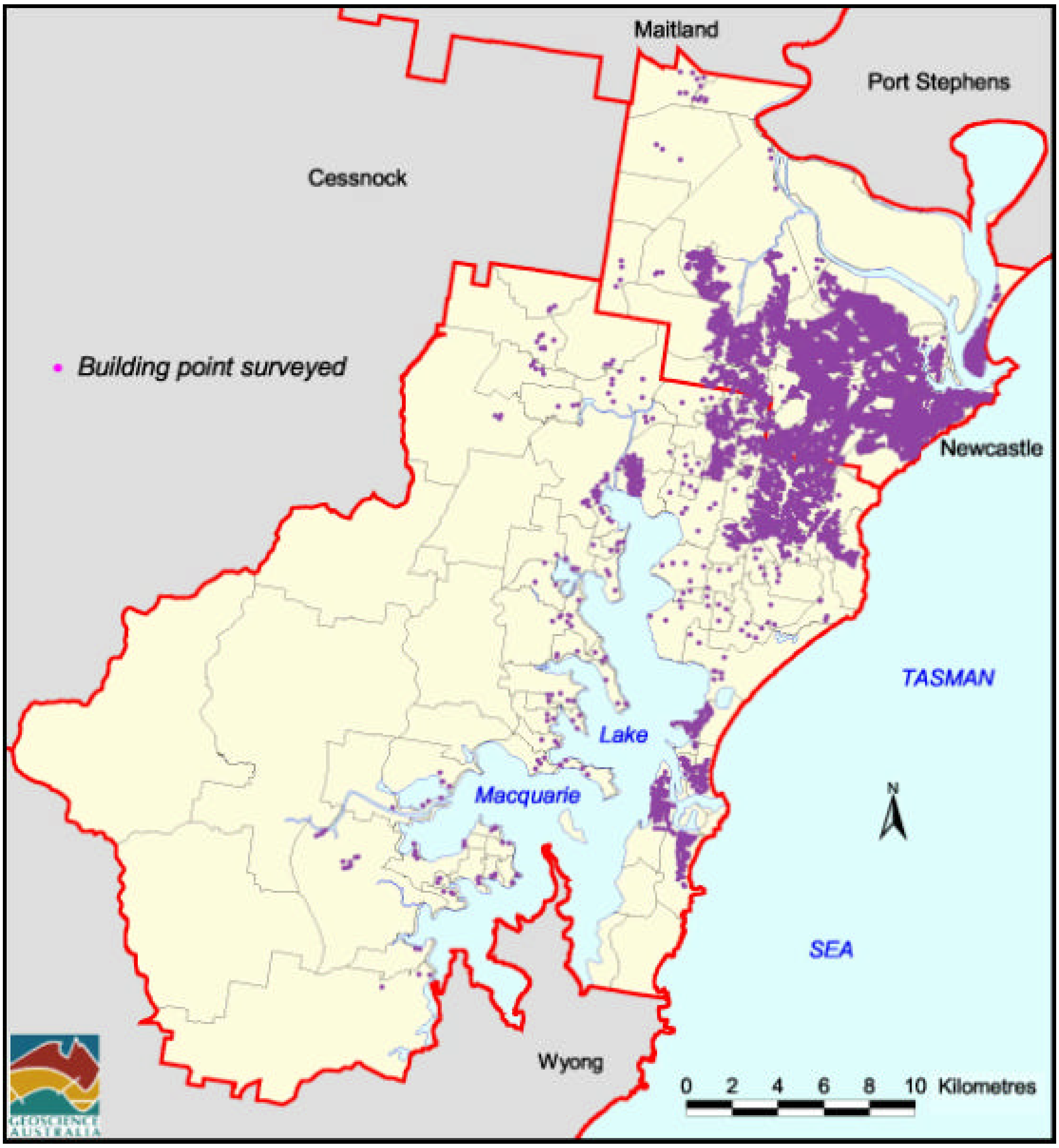

Figure H - 1: Surveyed building point locations total of 6339

The National UBD raster dataset was sourced for this assessment to help with the collection method in the field. It aided the surveyor with the combined effort of the GPS, allowing the precise location to be easily acquired and visually checked, increasing the data precision and quality of the dataset. Figure H - 2 shows the UBD raster image on the Palmtop PC with surveyed sites already completed.

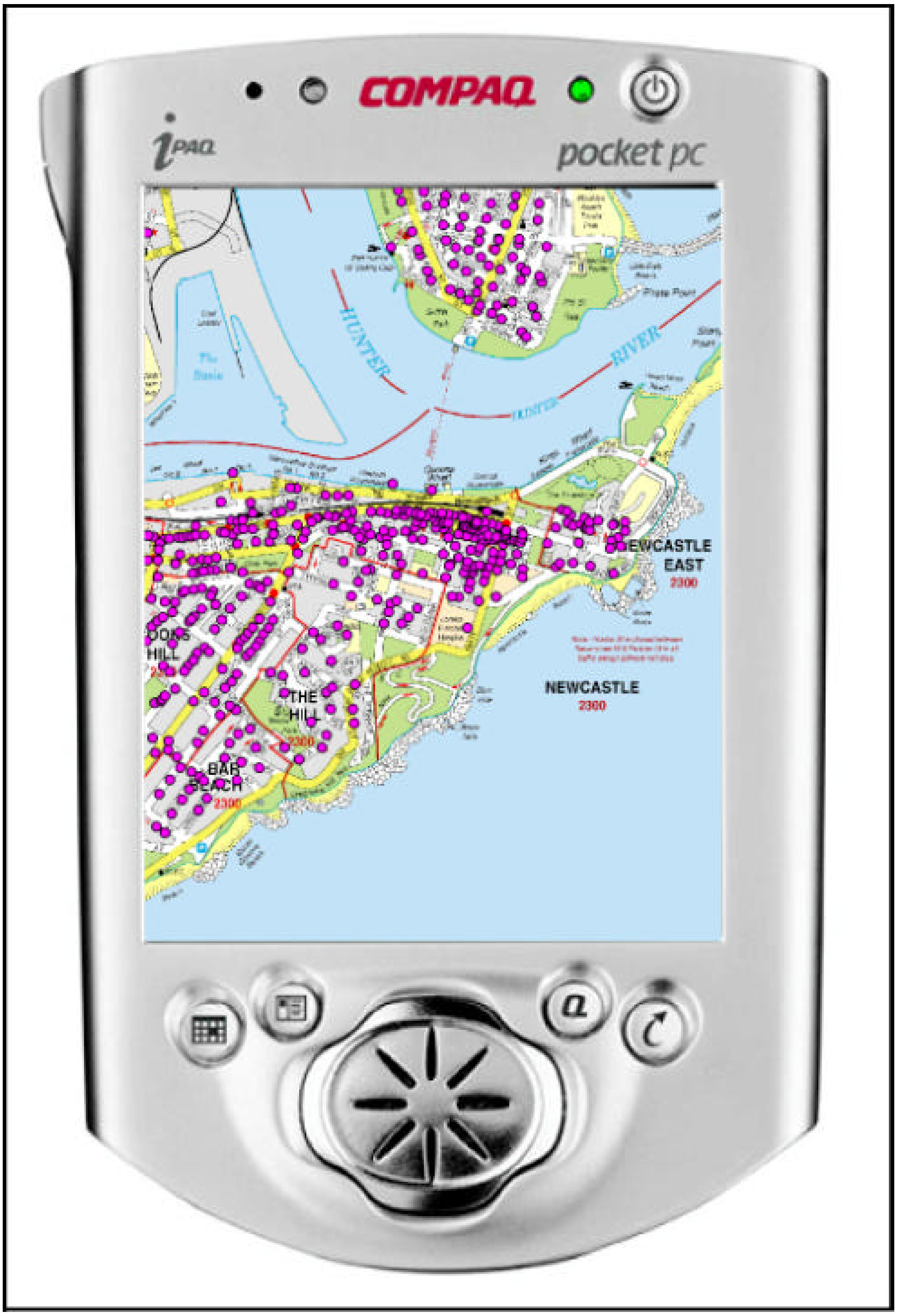

Figure H - 2: PalmTop PC with points collected in the field

Due to the file size of the raster images, we had to clip the images to fit onto the Palmtop PC, this problem can be overcome by using more expensive Pamltop PC's running faster chips, or having the ability to save the images into a different format such as MrSID. As our Data Acquisition Units were built to a strict budget we were driven towards the more labour intensive handling of the raster images.

Price list of One Unit:

- Compaq Aero 2100 - $740.00
- Differential GPS - $450.00
- ESRI ArcPad Software - $940.00
- Kodak Digital Camera - $550.00

The aerial orthophoto's were received from the LPI in MrSid format on CD. They were then re-compressed using ER Mapper and saved as ECW and placed onto our Unix disk. This allowed easier handling between our different software packages. The images were used for a heads up count of building numbers in each suburb, also for display purposes and to visually check data locations. Figure H - 3 shows the aerial photo

Figure H - 3: Aerial orthophoto of an area in Lake Macquarie with surveyed building points

The Vector boundaries acquired from LPI consisted of:

- Local Government Boundaries
- Culture

- Drainage
- Easements
- State Election Boundary
- Mine Subsidence
- National Parks
- Cadastral Boundaries
- Parish Boundaries
- Suburb Boundaries

The main vector coverages used for this assessment from the LPI are the local government boundaries as this defined the study area to work in, also the cadastral boundary cover. This was used to cross check the total building count for each particular suburb with the aerial photos. The building count for each particular suburb needed to be well defined, as it played a major part in determining the 'multiple factor' in the risk model.

The Damage Building database which was supplied by the Newcastle City Council consisted of some 8735 entries. It was in the format of a spreadsheet and hence had no spatial concept. This dataset needed to be spatially located for us to visually compare the damage location sites with our modelled damage. An attribute in the spreadsheet called lot number allowed us to join it with another attribute of similar style in the cadastre database. Some 6214 points matched automatically while the remainders didn't due to their incorrect naming or mismatched attribute. Figure H - 4 shows the building damage database with the attribute of damage shown as a red, amber, blue, green dot.

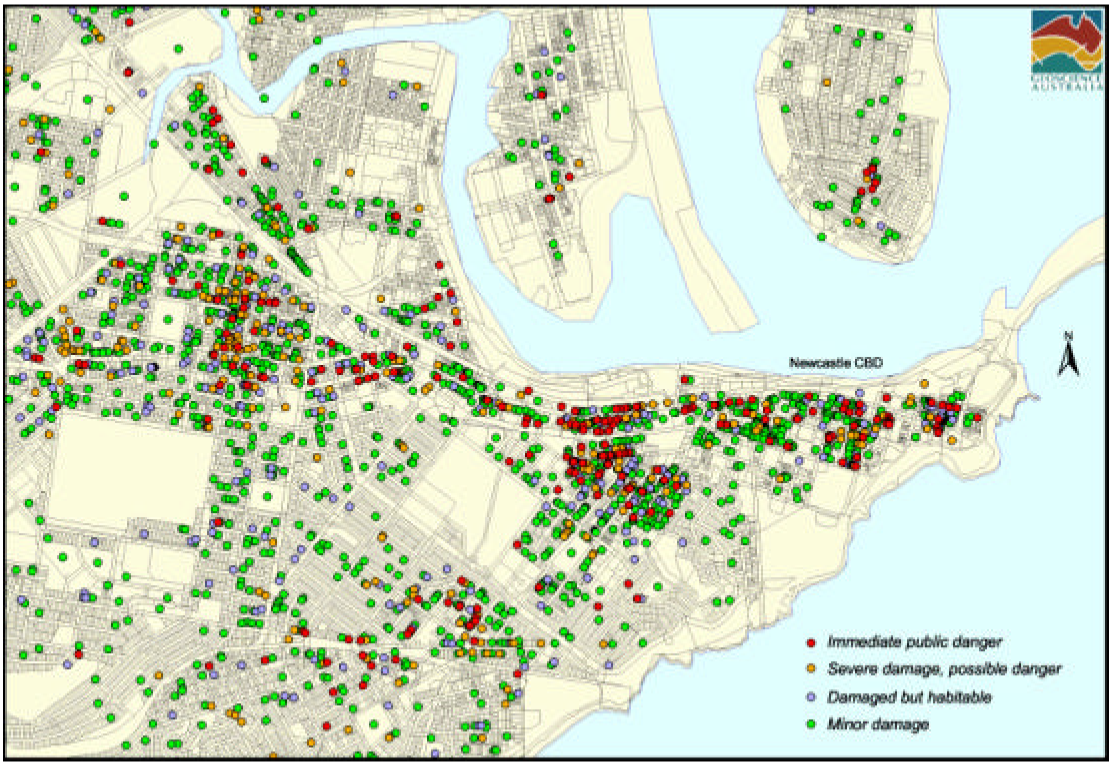

Figure H - 4: Newcastle City Council damage database spatially located

This appendix is by no-means the entire list of data sources but a good outline of what data was acquired and value added.

Appendix I - EXTRACTS OF KEY REPORTS ON THE 1989 NEWCASTLE EARTHQUAKE

I.1 Introduction

Several of the reports and documents relating to the Newcastle 1989 earthquake are so significant and are of such direct relevance to the present work that considerable excerpts from them are quoted below for easy reference. The reports/documents included in this Appendix are:

The Newcastle Earthquake Database (Newcastle Regional Library, 1999).

IEAUST 1990 Report (Melchers, 1990).

NSW PWD Report (NSW PWD, 1992).

The Centre For Earthquake Research In Australia Report (CERA, 1995).

'Earthquake Tremors in The Hunter Valley Since White Settlement' (Hunter, 1991).

Some additional reference to page numbers is given to improve access, referencing and readability.

I.2 Information Resources on the Newcastle Earthquake

Welcome to this interactive CD-ROM containing comprehensive information resources on the Newcastle Earthquake. The 1989 Newcastle earthquake was the first earthquake in Australia to cause death and destruction - 13 people died, more than 160 people sustained injuries and over 10,000 buildings in Newcastle suffered modest to substantial damage with insurance pay outs exceeding the billion dollar mark. The earthquake measuring 5.6 on the Richter scale struck Newcastle, Australia's sixth largest city on 28 December 1989 and shattered the myth that disastrous earthquakes never occur in Australia.

I.2.1 The Newcastle Earthquake Database

The Earthquake Database is a collection of electronic resources on the 1989 Newcastle Earthquake. It comprises of bibliographical information, abstracts and full text documents, images, and excerpts of sound and video clips relating to the first disastrous earthquake in Australia.

The overall goal of the Earthquake Database project is to improve community awareness of risk, preparedness and response to natural disasters by focussing on the experience of the 1989 Newcastle earthquake.

I.2.2 The Following Types of Information are Available:

- Published materials
- Photographs and pictures
- Oral history interviews
- Radio broadcasts
- Video recordings

Topics Include:

- seismology
- earthquake engineering
- emergency management

- social impact
- insurance
- economic aspects
- seismic history
- heritage issues
- health and psychology
- recovery and renewal

Full text and digitised information

This CD-ROM is based on materials available at the Newcastle Region Library. Full text materials, images and other information have been reproduced with the permission of copyright owners specifically for this project.

A number of bibliographical entries in this CD-ROM do not have full text documentation or other associated formats attached. This is because permission is not available at present for their reproduction from copyright owners or it is an unpublished format that is not suitable for reproduction.

Images have been electronically scanned from hardcopy versions that are available in the Library's collection. Whilst every effort has been made to reproduce images in a reasonable quality, this has not always been possible because of the poor original quality of the available source in our collection.

The following materials are not available in their entirety in this CD-ROM:

1. Unpublished and primary material have been indexed and abstracted in the database but have not been reproduced for confidentiality purposes or because they are of an archival nature. Please contact the Newcastle Region Library directly for access to these materials.
2. Video and audio recordings have been indexed and excerpts of these recordings have been digitised for inclusion in this CD-ROM. The entire recordings could not be reproduced as they are too lengthy or cannot be reproduced for legal reasons. Users who wish to listen or view sound and video recordings in their entirety, are asked to contact the Newcastle Region Library for access.

Sponsors

The project was largely made possible through grant funding from the Australian IDNDR Committee.

The project also received support from the following:

The Institution of Engineers, Australia (Newcastle Branch)

The Insurance Council of Australia

Newcastle City Council

I.2.3 Newcastle Earthquake Database CD ROM Project Team

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Newcastle Region Library
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Newcastle NSW 2300
Australia

I.3 IEAust 1990 Report

I.3.1 Preface

The present report is the outcome of the offer made by the President of the Institution of Engineers, Australia to the Premier of New South Wales that a study be commissioned on the significance of the Newcastle earthquake in relation to building regulations and related matters.

On 10 January 1990 the Acting-Premier accepted the Institution's offer. A Steering Committee was appointed by the President. It agreed on 15 January 1990 to the study objective and terms of reference given below.

The Steering Committee appointed a joint Study Team consisting of personnel drawn from the University of Newcastle and the National Building Technology Centre, CSIRO, Sydney. The report was written by members of the Department of Civil Engineering and Surveying, The University of Newcastle, using data and information obtained from a wide variety of sources but principally 'with contributions from NBTC-CSIRO; NSW Public Works Department; Newcastle City Council; Bureau of Mineral Resources, Canberra; Seismology Research Centre. Melbourne; Mine Subsidence Board, Newcastle, and The University of Newcastle as well as some commissioned work.

OBJECTIVE: To determine the significance of the damage in relation to current building regulations and existing building stock.

I.3.2 Terms of Reference:

(1) To record, classify and map the general pattern of damage (R2, R15).

(2) To estimate, if able, the maximum ground accelerations experienced in the areas of serious damage (Rl, R3.3, R3.4).

(3) To study the overall performance of modern structures in the areas of serious damage (R2, R4.1, R4.2, R4.3, R.4-4, R8.1, R8.2, R8.3, R8.4).

(4) To investigate in detail typical damage to modern structures (R8.1, R8.3. R8.4).

(5) To study the overall performance of older structures (R4.1. R4.2. R4.3. R4.5).

(6) To investigate in detail typical damage to older structures (R4.5, R.4.6).

(7) To investigate behaviour of structures with a post-disaster function (R4.2, R4.3. R6.1, R6.2).

(8) To determine to what extent local ground and geological conditions may have contributed to the severity of the ground shaking in the areas of serious damage (Rl. R2, R3.1, R3.3, R3.4).

(9) In consultation with seismologists, to assess the risk of a similar or greater intensity earthquake occurring in major centres of population where the current perceived risk of earthquakes is low (R3.1).

(10) To make recommendations on the adequacy of current building regulations in areas of perceived low earthquake risk (R2, R3.1, R3.2, R4.1, R4.2, R4.3, R5.1, R7.1, R8.3, R9, R12).

(11) To make recommendations regarding the safety of existing buildings in respect of earthquakes throughout Australia (R3.1, R3.2, R4.1, R4.2, R4.3, R4.4, R4.5, R5.1, RIO).

In the above Terms of Reference, cross-reference is made to the relevant Recommendations of the Study.

I.3.3 Conclusions and Recomm endations

I.3.3.1 Seismological Information

Cl.l Seismological information about the Newcastle earthquake has been characterised by the scarcity of recorded data from Australian and in particular regional sources (Ch.3). This has hampered statistical and engineering studies and has provided little information for improvement of the Earthquake Code (Ch.3).

C1.2 No major urban area in Australia has an adequate earthquake monitoring network (Ch.3).

Rl The seismological data collection, processing, interpretation and information dissemination facilities for Australia should be properly established and maintained on a national basis, using international criteria for such facilities as a guide [ToR 2, 9], NSW. AUS.

I.3.3.2 Earthquake Design Requirem ents For Newcastle

C2.1 Given the previous history of lack of significant earthquake damage in the Newcastle and surrounding regions, there was a perception that Newcastle was a region of low seismic risk. This perception has changed since the occurrence of the earthquake on 28 December 1989 (Ch.3, 9).

C2.2 In general, damage to modern buildings in Newcastle was confined to non-structural aspects and is broadly in accordance with structural engineering expectations, given that the buildings were not specifically designed to be earthquake resistant (Ch.5).

C2.3 The Newcastle observations show a high degree of correlation between areas of significant damage and areas in which the foundation material consists of alluvial soil strata and/or fill. This aspect is not properly considered in the current Earthquake Code (Ch.3, 4).

C2.4 There appears to be little correlation in Newcastle between significant damage and areas known to be undermined due to previous mining activities. This suggests that past mining and mine subsidence were not significant factors in contributing to damage (Ch.4).

R2 As an interim measure before the Earthquake Code is revised, the Newcastle region should be considered to be in zone A as defined in AS2121-1979 except for the alluvial soil and filled areas where the interim zoning should be zone 1 (Ch.3. 4, Set. 10.2). [ToR 1. 3, 8, 10], BR.

I.3.3.3 Minimum Earthquake Design Requirements For Australia

C3.1 Because recorded earthquake history in Australia is short, there is a large degree of uncertainty associated with predictions of proneness to earthquake activity for much of Australia. Seismological information indicates that an earthquake similar to that which occurred in Newcastle could occur in other parts of Australia. Hence some base level of earthquake resistant structural design requirement is desirable for all parts of Australia (Ch.3, 10).

C3.2 A large part of the damage observed in Newcastle is related to masonry construction. Much of this is non-structural. It is considered that the damage caused to modern construction would have been less had some low level structural engineering design requirement existed for lateral loading on masonry and other forms of non-ductile construction. This could have been achieved if the Earthquake Code had rated the Newcastle region Zone A (or higher) (Ch.5, 10). It is further considered that modern construction in Newcastle is not substantially different from that in other parts of Australia.

R3.1 It is recommended that minimum structural engineering design requirements for non-ductile construction should be specified for all parts of Australia. It is considered that this should correspond to zone A of AS2121-1979 except for alluvial and/or filled areas where it should be zone 1 (see also R3.2), (Ch.3, 10). [ToR 8. 9. 10, II], BR. SAA.

R3.2 The requirements for zones A and 1 should consider potentially unstable as well as non-ductile materials and should consider the need to design for structural forms known to have undesirable earthquake response (Ch.5, Set. 10.4), [ToR 10. 11]. BR, SAA.

R3.3 In the current revision of the Earthquake Code specific provision should be made for the amplification effects associated with alluvial soils and filled areas. Such provision should consider the experiences of and observations in Newcastle as well as recent overseas experiences (Set. 3.8, 4.2). [ToR 2. 8], SAA.

R3.4 Local Councils and Government departments with building jurisdiction should be required to prepare maps and/or establish data hanks specifically for information about the extent, depth and geo technical characteristics of areas of alluvium and fill obtained from all geo technical investigations under their jurisdiction. The maps and/or data banks should be publicly accessible (Ch.3, 4), [ToR 2. 8], BR.

Note: No specific recommendation is made whether R3.1 and R3.2 are incorporated in the revised Earthquake Code or in future revisions of material codes. This matter should be considered by Standards Australia (Set.10.3).

I.3.3.4 Existing Buildings

C4 Most masonry construction in Newcastle predates the existence of the Earthquake Code. Much of the damage is related to the quality of the original construction and the state of the structure at the time the earthquake occurred. There is widespread evidence of material deterioration and this is considered to be a factor in the scale of the damage. There was evidence of material deterioration already before the occurrence of the earthquake (Ch.5). Taken together, these factors may have implications for the safety of remaining buildings in Newcastle. They also have wider implications since the building stock in Newcastle is not, on average, necessarily very different in type and age to that elsewhere in Australia.

R4.1 Apart from domestic dwellings, all structures in Newcastle and other areas affected by the earthquake should be inspected for structural safety. Damaged parts should be removed and rebuilt or repaired, all to the satisfaction of the Local Council or appropriate authority and in accordance with the Interim Earthquake structural requirements of R2 or to the Earthquake Code when revised (Set.9.3. 10.6. 10.8). [ToR 3, 5. 10, II], BR, HOC. PTO. ACS.

R4.2 It is considered that in general upgrading of existing buildings, structures and facilities in Newcastle for earthquake resistance is not justified- However, upgrading should be evaluated for:

1. buildings which have suspended awnings or parapets or other projections likely to be dangerous to the public under earthquake conditions;

2. buildings, structures and facilities having a possible post-disaster or lifeline function (eg. Hospitals, fire-stations etc.).

3. buildings and places of public assembly and where significant loss of life may be incurred in an earthquake event, and

4. buildings and structures containing or supporting hazardous materials or processes.

(Set.9.3, 10.6). [ToR 3. 5. 7, 10, II], BR. NCC, FWD. ACS.

R4.3 Specific procedures and rules should be established for the upgrading program of R4.2 (Set. 10.6). [ToR 3, 5. 7, 10. II], BR, NOC. PWD. ACS.

R4.4 Consideration should be given to extending the policy in R4.2 and R4.3 to all other parts of Australia (Set.9.3. 10.6), [ToR 3. II], BR, ACS, PWD. SAA-

R4.5 Consideration should be given to the introduction of a program of building inspection for structural safety by suitably qualified engineers for areas in Australia having corrosive environments and/or with known or suspected problems of structural deterioration. It is suggested that the first such inspection should occur not more than 40 years after construction, with subsequent inspections at shorter periods (Set-10.8). (see also K7 below), [ToR 5. 6. 11]. BR.

R4.6 Research should be undertaken on the rates of structural deterioration of existing buildings, the methods for detection of such deterioration and on methods of economic repair (Set.10.8). [ToR 6. 11].

I.3.3.5 Domestic Construction

C5 Serious structural damage to domestic construction was mostly confined to cavity brick construction and to a lesser degree to brick-veneer construction. Weatherboard construction generally behaved well. Conclusion C4 also applies to domestic construction. Improved understanding of earthquake behaviour of conventional Australian domestic construction is required.

R5.1 Earthquake design provisions of the 'deemed-to-comply' type and corresponding to Recommendations R3.1 and R3.2 should be incorporated into requirements for domestic construction. It is considered that this should be done through development of an Australian Standard for structural engineering aspects of domestic construction (Ch.5. 10). This standard should also consider other natural hazards [ToR 10]. SAA.

R5.2 NBTC-CSIRO or a similar organisation should be invited to prepare a report on available information and research requirements for the improvement of the earthquake resistance of Australian forms of domestic construction.

I.3.3.6 Post-Disaster Function And Special Function Buildings

C6.1 Buildings having a post-disaster and other special function suffered relatively little structural damage in the Newcastle earthquake. However, their operational functions were affected and in some cases, such as at the Royal Newcastle Hospital, severely so. Further, the potential for disruption to essential services such as ambulance, fire-brigade, telephone services etc. whether due to structural damage or other causes is considered to have been substantial and is very likely to have been revealed had the earthquake been slightly more severe or of longer duration (Ch.6).

C6.2 It is not clear that the factors for post-disaster and other special function buildings in the Windloading Code (AS1170.2) and in the Earthquake Code (AS2121-1979) are wholly compatible considering that there are different conditions to be met (Set.9.3).

R6.1 Reviews should be undertaken of the structural and functional adequacy of all buildings and systems having a post-disaster function, considering all relevant hazard-scenarios. Where inadequacies are revealed, appropriate measures should be instituted (Ch.6). [ToR 7]. PWD. ACS.

R6.2 A review should be undertaken of the appropriate level of risk associated with the post-disaster function factor for AS2121 and its compatibility with that in AS1170.2 (Ch-6, Set.9.3). [ToR 7], SAA.

I.3.3.7 Safety Assessment

C7.1 Existing powers of Local Councils do not appear to be wholly adequate to deal with buildings considered by Council to be potentially unsafe. This matter is particularly acute in the aftermath of a major disaster (Set.10.8).

C7.2 In relation to approval. Inspection and certification of new and existing buildings for structural safety, it is not clear that engineers with appropriate qualifications and experience can be identified under existing systems of professional recognition. This also applies to certification of structural design and construction for new buildings and building alterations (Ch.5, 10).

R7.1 The powers of Local Councils to enforce compliance with structural safety requirements (including those under R4.5) should be improved. This applies in particular to situations where public safety is considered by Council to be at risk (Set. 10.8), [ToR 10], BR.

R7.2 Structural safety approvals, inspection, supervision, and certification should be carried out by engineers appropriately qualified and experienced as defined by the relevant professional body (i.e. The Institution of Engineers. Australia) (Set. 10.9), [ToR 10]. BR.

R7.3 Consideration should be given to establishment of a. national register of structural engineers complying with requirements under R7.2. The register should be recognized at all levels of government (Set. 10.9).

I.3.3.8 Quality In Design And Construction

C8 There is inadequate understanding at most levels in the building industry of the need to achieve high quality of construction. There is also inadequate appreciation at the unskilled and skilled trade level of the rationale for specific practices prescribed in building specifications. The problem appears to be particularly acute in relation to masonry construction, but is also of importance in concrete construction (Ch.5).

R8.1 The requirements of current Masonry Codes should be observed at all levels in the building industry for all forms of masonry construction [ToR 3. 4].

R8.2 Trade courses in masonry construction should be mandatory for bricklayers. Such courses should consider basic structural engineering aspects associated with masonry construction (e.g. an

overview of the requirements of. and reasons for, the principal requirements of masonry Codes) (Ch.5), [ToR 3. 4].

R8.3 Requirements generally similar to *VS* 2 for operatives in concrete construction [ToR 3, 4].

R8.4 Undergraduate programs in civil and in structural engineering should he encouraged to consider earthquake engineering, masonry construction, and quality management in their syllabi (Ch.5, 9.2). [ToR 3, 4].

I.3.3.9 Risk Management For Buildings

C9 Risk management for buildings may be uneven across building jurisdictions due to different policies, procedures and practices. This applies state-wide and nationally to building approvals, structural design, inspection and supervision and control of risk after construction (Set.9.5),

R9 It is recommended that the Building Regulation Review Task Force take note of this matter [ToR 10].

I.3.3.10 Industrial Facilities And Lifelines

C10.1 Industrial facilities and lifelines generally suffered little structural damage and what there was is consistent with damage elsewhere in Newcastle. However, damage with potentially serious consequences was caused to mechanical and electrical equipment (Ch.7. 8).

C10.2 Underground facilities and mines appeared initially to have suffered little damage. Some damage is becoming evident but it is of a relatively minor nature to date. However, the full extent of damage is unlikely to be revealed for some time.

RIO All architects and engineers should be made aware that the need to design for earthquakes also applies to mechanical, electrical and other equipment [ToR 10. 11].

I.3.3.11 Counter-Disaster Aspects

Cll Counter-disaster agencies were able to handle the situation in Newcastle reasonably well, at least from the perspective of building and structural safety. However, it is considered that this may not necessarily have been the case had the damage and the concomitant loss of life and injuries been significantly greater. Further, sufficient structural engineering and earthquake engineering expertise was not immediately available (Ch.l, Set.9.6).

Rll-1 It is considered appropriate for counter-disaster agencies to study the Newcastle experience and to incorporate the findings in their counter-disaster plans (Set.9.6)

R11.2 Engineers and building inspectors should be attached to the State Emergency System, with the special function to perform initial emergency building appraisals in disaster areas (Set.9.6).

R11.3 The following should be established by the national or state counter-disaster systems: (i) guidelines for professional engineering and scientific input to various natural or other hazard scenarios, (ii) a national register or network of specialist engineering and scientific expertise available to counter-disaster organizations, and (iii) mechanisms to bring such expertise into action when required (Set. 9.6).

I.3.3.12 Demolition And Rebuilding

C12 Demolition and rebuilding commenced in Newcastle immediately after the earthquake. Some of the rebuilding is to unknown standard, although most probably conforms to building and structural standards in force prior to the earthquake.

R12 Uniform national policies and procedures need to be established at all levels of building jurisdiction and in conjunction with counter-disaster organizations for the control of demolition and rebuilding immediately after a disaster event (Set. 10.10), [ToR 10]. BR.

I.3.3.13 Insurance

C13.1 The Newcastle earthquake has exposed the insurance industry to significant claims in respect to property and consequential losses, greater than might have been expected on the basis of previous -experience in Australia. This is considered to be partly the result of past insurance practices (Set.9.5). It has also led to pressure on building owners to settle insurance claims quickly, despite some evidence of continuing damage (Ch.4).

C13.2 The degree of under-insurance in Newcastle was found to be significant but is considered to be not atypical for Australia generally. This has complicated insurance settlement and rebuilding and has, in some cases, led to repair of some buildings to suspect standards (Set.9.5).

R13.1 The insurance industry should be encouraged by government to consider realistic variables in setting premiums and levels of deductibles. This may require legislation. The variables which should be considered include at least: (i) geotechnical conditions at the insured site. (ii) building age, and (iii) structural condition of the property (Set. 10.8). NSW. AUS.

R13-2 The insurance industry should be encouraged to take a realistic attitude to the question of under-insurance and assist building owners in determining appropriate valuations. It should also review its settlement procedures in the light of the Newcastle experience.

I.3.3.14 Heritage Buildings And Issues

C14 The existence of earthquake-damaged old buildings in Newcastle led to time-consuming debate and discussion about heritage issues. This could have been avoided if policies and procedures had been available.

R14 Policies, guidelines and economic systems should be developed to allow prompt decisions with regard to the preservation of buildings with heritage (or potential heritage) classification (Set.10.7).

I.3.3.15 Further Work

C15 The present report has been completed with the information available at the time of writing. Further detailed studies are being undertaken by various organizations and individuals.

R15 It is recommended that the data collection and compilation programs and other studies being carried out by HOC, PWD. ACS and others continue to be supported by government,

The following abbreviations were used:

ACS Australian Construction Services

AUS Australian Government

BR Building Regulations

C Conclusion

Ch. Chapter

NCC Newcastle City Council

NSW Government of NSW

PWD Public Works Department

R Recommendation

SAA Standards Association of Australia

Set. Section of a Chapter

ToRTerms of Reference

I.3.4 Summary and Conclusions (page 43)

The following conclusions can be drawn from a study of the damage:

1) In general, modern buildings, both framed and loadbearing, behaved reasonably well. With a few exceptions, damage was confined to cladding and infill with the structural system carrying the earthquake forces satisfactorily.

The structural damage which did occur illustrated the desirability of symmetry in plan layout and the need to design for torsional effects on, and potential "soft storey" behaviour of the structure.

2) Most of the damage in modern structures occurred in masonry construction. In some cases this was exacerbated by poor standards of workmanship and construction, matters which need to be addressed by the masonry industry, educational institutions and others. The bulk of the damage could have been avoided by greater attention to detail with regard to tying and the transfer of horizontal forces between the frame and its cladding.

It is considered that the damage to the brittle components of modern construction would have been significantly less had some minimum horizontal capacity been provided. For brittle components, zone A of AS2121 has such a requirement.

3) The general evidence of poor standards of construction (particularly in masonry), indicates the need for the more effective implementation of current masonry codes for all forms of masonry construction at all levels of the building industry.

Trade courses in masonry should be mandatory for bricklayers, and such courses should consider the basic structural engineering aspects associated with masonry construction. In addition, undergraduate programs in Civil and Structural Engineering should be encouraged to consider earthquake engineering, masonry construction, and quality management in their syllabi.

4) Older buildings were more extensively damaged, mostly due to problems with both structural and non-structural masonry. Corrosion of wall ties was widespread, resulting in facade failure in many cases. This problem was exacerbated by inadequate placement of wall ties, soft and eroded lime mortar joints, bad workmanship and general deterioration. It is significant to note that irrespective of the earthquake zoning for Newcastle, implementation of AS2121 would not have prevented this damage, as all construction took place well before its publication.

5) The widespread incidence of wall tie corrosion has significant implications for all older masonry construction. There is a need for research into the durability of wall ties together with methods of detection and the economic replacement of corroded ties in existing buildings.

6) Parapets and suspended awnings were a major source of damage. Awnings collapsed because of inadequate anchorage of the steel tiebacks which were often attached only to the masonry facade. Since these types of detail appear to be widespread in Australia, there is an immediate need for a program to check the adequacy of these forms of construction wherever they have been used.

7) Damage to domestic structures was considerable, particularly for the older cavity brick structures. The more modern brick veneer houses performed better, although damage to the brick veneer was sometimes sustained. Timber houses exhibited the best performance, with relative movement between the more flexible timber structure and its footings or any adjoining brickwork being the main symptoms of distress.

It is clear from the extent of damage sustained by houses in Newcastle that there is a need for some minimum standards of earthquake resistant construction for housing. This is particularly the case for the more brittle form of cavity brick construction, which is still widely used in many parts of Australia.

It is considered desirable to develop a set of simple "deemed to comply" rules for domestic construction which could be applied at the planning and design stage. These rules could incorporate details for all forms of extreme loading, including earthquake. The cost per dwelling of incorporating these provisions should be negligible, as mainly attention to detail would be involved.

8) Some damage was the direct result of weakening of the structure due to structural alterations. To ensure that the structural integrity of the building is maintained, all alterations should be designed and supervised by an experienced structural engineer.

Newcastle Hospital as the principal public hospital in the Newcastle region. The hospital suffered only very minor structural damage, but considerable non-structural damage (e.g. racking of masonry infill panels) as described in Section 5.3.3.

There was also very considerable damage to mechanical plant and equipment, largely due to shifting off vibration isolation pads. For example, several of the air-conditioning units moved by as much as 250 mm. This caused damage to the attached ducting. Electrical wiring and piping attached to masonry infill panels were also damaged when the panels themselves were displaced and racked. The loss of such equipment and services could have had serious implications for an operational hospital.

I.3.4.1 6.5.5 Other Hospitals

Other hospitals in the Newcastle region, including; Western Suburbs, Belmont, Christo Road and Lingard Hospitals suffered no significant damage, and were all in a position to accept a limited number of patients if the need had arisen.

I.3.4.2 6.6 HALLS AND PLACES OF PUBLIC ASSEMBLY

School halls and auditoriums are often used as local emergency shelters in times of natural disasters. In general, all school halls survived the earthquake with no significant damage. The reason for this appears to be that most halls are of recent construction, and typically of an engineered steel or reinforced concrete framed design. The relatively favourable structural behaviour of the school halls was highlighted in some cases by the extensive damage caused to adjacent school classrooms, particularly those of older construction (see Set.5.4.5).

I.3.4.3 6.7 CONCLUSIONS AND RECOMMENDATIONS

Major structural and non-structural damage was sustained to several important buildings with a post-disaster function. Damage to hospitals, possibly the most important class of building with a post-disaster function, resulted in the closure of several wards, some temporary evacuations, and considerable (and possible life threatening) hindrance to their operations.

It is considered that the damage to fire, ambulance and hospital buildings would have been much greater if the earthquake had been of a moderately higher intensity or longer duration. The precise effect that this might have had on the operation of such facilities can only be speculated; it is considered that greater attention needs to be given to the risk level appropriate to this class of structure. Current SAA structural standards recognize post-disaster functions and make some allowance for this in setting design load levels for structural design. These standards should be reviewed in the light of the Newcastle earthquake. Consideration should also be given to a program of inspection and possibly upgrading of existing facilities (including mechanical and other equipment) to new earthquake and other hazard design standards.

I.3.4.4 7.6 CONCLUSION AND RECOMMENDATIONS (Page 63)

The greatest damage to industries, if the significant effects of power failure are ignored, resulted from cracking and, in some cases, collapse of masonry infill. Lack of adequate restraint to masonry from the supporting structure appears to account for most of this damage. It is clear that for building construction aspects the conclusions and recommendations of Chapter 5 apply here also.

There is a further aspect, however, and that is the design for hazards associated with an industrial facility (e.g. a chemical plant) as influenced by its structural system. The present SAA Earthquake Code (or other loading codes) does not address this situation.

Regarding plant and equipment, it would appear that the potential for loss of life, injuries and damage was far greater than the actual damage due to a number of fortuitous circumstances, not the least being the fact that the earthquake occurred during the Christmas-New Year holiday period when many plants are closed and not operational. It is considered that much of the (potential) damage could have been avoided if the requirements of AS2121 had been invoked using the lowest non-zero zoning (i.e. zone A) and if mechanical and other plant had been perceived as non-ductile elements. This aspect needs review in the current revision of the Earthquake Code. Further, mechanical and electrical engineers need to be alerted to the need to design for potential earthquake effects.

I.3.4.5 8.7 CONCLUSIONS AND RECOMMENDATIONS (Page 68)

In a sense Newcastle was fortunate that there was not greater damage to its lifelines. Such damage might have been expected when comparison is made to other earthquake events in other parts of the world. In making such comparisons it is important to recognize that the earthquake magnitude was relatively small by world standards. Nevertheless, it is considered that damage would have been significantly greater had the earthquake been of slightly greater intensity or longer duration or both. It is also likely that more damage will be revealed with time, particularly for lifelines on or buried in the ground.

It is considered likely that some of the damage, particularly that to mechanical and electrical equipment could have been prevented if a minimum earthquake design requirement had existed for such equipment. It is also important to note that mechanical and electrical engineers should be aware of the relevance of the Earthquake Code to plant and electrical equipment when considering building services. Further, it is recommended that where appropriate, lifeline systems be reviewed as to their capacity to with-stand low to moderate earthquake activity. In the case of buried services, it is unlikely that changes in design standards are required.

I.3.4.6 9.4 RISK MANAGEMENT IN STRUCTURAL ENGINEERING (Page 72)

The risk of failure of buildings and structures and hence the risk of death and injury for their users is controlled through a number of factors which together may be viewed as a risk management system for structures. The factors of importance are:

(i) the actual loads acting on the structure (including their magnitude, duration, frequency);

(ii) the strengths of the various materials of which buildings are constructed, including deterioration effects and any prior damage;

(iii) structural engineering design rules as laid down in building regulations and design codes;

(iv) the risk levels implicit in structural engineering design rules;

(v) interpretation of codes, conservatism in design and costs perceptions by design engineers;

(vi) inspection and checking processes during design and construction or subsequently;

(vii) quality management systems, including quality control, etc. during construction;

(viii) building maintenance procedures and practices;

(ix) insurance policies and practices;

(x) post-disaster safety measures.

The factors relating to earthquake levels, structural resistance and design codes will be addressed in detail in Chapter 10, as will related matters such as maintenance of building quality. Of the remaining matters, the principles, policies and the practices used for the implementation of building regulations and Australian Standards are of interest, as are insurance policies and practices (Set.9.5) and post-disaster measures (Set.9.6).

It is understood that an examination of building regulatory matters is within the scope of the Building Regulations Review Task Force established during 1989. Nevertheless, some brief observations will indicate areas of concern which it is considered are relevant to the structural safety of buildings and which are related to the present study.

1. It appears that each local authority and each state and federal authority with legislative responsibility for building approval can institute its own policies and procedures. Apart from any economic and administrative implications, this means that at the design stage structural risk management can be uneven across the various building jurisdictions.

2. Similarly, inspection and supervision during construction of buildings is the norm in all building jurisdictions, although local councils, at least, are not obliged to inspect, nor is there a minimum laid down. Further, the qualifications and expertise of persons carrying-out such inspections and supervision need not necessarily relate to assessment of structural safety. It follows that this aspect of building structural risk management can be very uneven across building jurisdictions.

3. Further, control of risk at later times, through management and inspection of the building or structure for continued safety, is not yet widely adopted, even in structural engineering generally. Exceptions are special structures such as bridges and floating structures (ships, offshore oilrigs etc.). However, inspection of buildings for continued safety is a feature in New Zealand and California in relation to safety of buildings under earthquake conditions. Some research into appropriate policies, practices and procedures for Australia would be useful in this area.

4. The standard of quality management during construction is a matter of considerable concern to many in the building industry. Its importance has become even clearer as a result of the Newcastle earthquake. Much of the widespread but mainly minor damage has been attributed to poor quality of construction (see Chapter 5). It is

considered that urgent attention should be given to means and procedures to enhance quality in building construction.

I.3.4.7 9.5 BUILDING INSURANCE

Risk management for buildings includes the aspect of insurance. If buildings of high risk are equally treated for insurance purposes as buildings of low risk, there is little incentive for owners or society to be concerned about building quality maintenance. The Newcastle earthquake could, and should, have an impact on insurance practices.

The cost of damage sustained in Newcastle is more than an order of magnitude larger than that of the 1954 Adelaide earthquake (of the order of 40-50 million dollars in today's values). The Newcastle losses are likely to be comparable to those of Cyclone Tracy and the 1983 Ash Wednesday bushfires. Based on this estimate, it is likely that most underwriting companies with a significant exposure in Newcastle will have exceeded their own exposure limits and will be depending on the international reinsurance industry to meet a proportion of the loss.

Previous estimates by the insurance companies of the probable maximum losses due to earthquake have been based on the Adelaide earthquake. However, since then the value of construction has increased in real terms at a greater rate than the population, the value of contents has increased relative to the building value and the insurance practice has changed from indemnity insurance being the most common to replacement insurance being the most common. As a result, exposure has increased dramatically and this, together with the possibility of an upward revision of earthquake occurrence risk estimates, is likely to have a significant effect on premiums and insurance practices. The Newcastle earthquake provides the insurance industry with a opportunity to improve the basis for estimating probable maximum losses. This should be done by rigorous analysis and should take account of variables such as geotechnical conditions, building age and quality of construction and condition at the time of the earthquake. If policy conditions, premium levels and deductible levels were to also take such variables into account, the insurance industry could play a significant long-term role in maintaining building standards.

One further issue the insurance industry needs to address is the question of under-insurance; the Newcastle experience has shown this to be a significant proportion (20-30% uninsured, about 40% under insured). Under the present system there is little guidance to building owners as to when they face the risk of under-insurance.

I.3.4.8 9.6 Counter-Disaster Meas ures

Counter-disaster measures and their management form a component of the overall management of building risk. The demolition of buildings very early after the earthquake event in Newcastle raised important questions about the effectiveness of the present counter-disaster systems in their capacity to assess buildings and their safety after a natural disaster. This issue is addressed in this Section.

The counter-disaster system consists of the Natural Disaster Organization and the Australian Counter Disaster College, State counter disaster organizations and locally-based groups of State Emergency Service volunteers. Planning for future major disasters takes place largely against a background of previous disasters such as bushfires, tropical cyclones and floods. The Newcastle earthquake was the first major earthquake disaster experienced within the lifetime of Australia's current counter disaster system. It was an event for which experience with the other major disasters was not necessarily a reasonable guide, particularly for three important aspects; (i) the fact that there is no warning of impending earthquake occurrence, (ii) that building safety needed to be considered, and (iii) the possibility of after-shocks.

As in other disaster situations, there was the need to rescue those trapped by collapsed structures, to clear away debris from the streets, to restore essential services, to provide relief to the injured and homeless and to make provision for the dead. There was the added problem that every building had to be considered potentially structurally unsafe until inspected and determined otherwise. Unsafe buildings or parts thereof need to be shored or otherwise rendered safe or the surrounding area barricaded to prevent entry. All of these operations should be considered hazardous in themselves due to the possibility of after-shocks.

There is no doubt that the situation in Newcastle was handled successfully by the available resources. However, the situation could have been considerably different had the earthquake occurred at a different time of day (see Ch.l) or had been of greater intensity or duration or had significant after-shocks occurred (Ch.3). As it was, the situation caused considerable stress to those involved on counter-disaster management. Structural engineering expertise was not immediately at hand, at least in the quantity required. The fact that earthquake engineering expertise exists in Australia was also not identified until much later. In view of these observations, it would be appropriate for counter-disaster organizations to study the Newcastle response and to incorporate the findings into their counter-disaster plans. It is submitted that such findings should have applications beyond earthquake events.

As a contribution to such a review, the following is recommended for consideration:

1. Involvement of building inspectors and engineers in the State Emergency Service system, with the special function to perform initial emergency building appraisal in disaster areas.
2. Establishment of guidelines for professional engineering input to various natural or other hazard scenarios, establishment of a national register of specialist engineering expertise available to counter-disaster organization and establishment of mechanisms to bring such expertise into play when required.

I.3.4.9 9.7 CONCLUSION

In this Chapter the question of overall risk and risk management in buildings and structural engineering was addressed. Several important issues were identified:

1. Risks, including earthquake risks, must be perceived to exist before rational decisions can be made about them. This requires education at various levels and appropriate framing of minimum design requirements.
2. If insufficient data about potential consequences are available, decisions about structural risks may need to be based on comparisons to other risks. However, allowance should still be made for building failures with potentially severe consequences (e.g. post-disaster structures, places of public assembly and buildings with hazardous operations or contents).
3. Risk management for buildings and structures has many components. Of particular concern are the regulations and standards themselves, the policies made to implement them, and the implementation of the policies in practice. All of these matters deserve attention and should be referred to the Building Regulations Review Task Force.
4. Building insurance practices have the potential to play a significant long-term role in quality and safety maintenance of buildings. Specific recommendations are made in Section 9.5.
5. Counter-disaster policies and practices should be reviewed in the light of the Newcastle earthquake. Some specific recommendations are made in Section 9.6.

I.3.4.10 10.10 DEMOLITION AND REBUILDING (Page 85)

Within days of the earthquake and even while the city was still barricaded, rebuilding work had commenced in Newcastle. Demolition was also in progress on various sites, even before any demolition the Newcastle City Council had issued permits. Almost without exception, building owners were keen to repair their buildings and continue with their lives. Such action has also been noted in the aftermath of the recent San Francisco earthquake. However, it raises the question whether it is sensible to repair to old standards and whether such construction in times of considerable stress on council officials can be properly controlled and inspected. There have been a number of reports of very poorly executed repairs and others of debatable standard.

There is no doubt that NOC can respond to this situation in due course and demand (perhaps partial) demolition or further repairs in the interest of public safety. However, this is an unsatisfactory way of proceeding and one likely to be unpopular (if only through lack of understanding of the issues involved). The real question is simply what should be the rules and requirements for rebuilding after a disastrous event and before interim rules for rebuilding (such as discussed in Set.10.2 above) can be properly formulated.

It is considered that this matter ought to be investigated by the existing counter-disaster organizations in conjunction with relevant state and federal departments responsible for building construction both at local government level and higher. Uniform national policies and procedures need to be developed so that these can be implemented by emergency services and building regulators in the immediate aftermath of a disaster.

I.3.4.11 10.11 CONCLUSION

This Chapter has been concerned with particular aspects and deficiencies of building regulations and standards which it is considered require attention.

The following are the principal points which were addressed:

1. Newcastle should be given an interim earthquake structural design requirement corresponding to zone A of AS2121-1979 except in alluvial and/or filled areas where it should be zone 1.

2. A minimum structural engineering design requirement for non-ductile construction should be specified for all parts of Australia. It is considered that this requirement should correspond to zone A of AS2121-1979, except for alluvium and/or filled areas where it should be zone 1.

3. The requirements for zones A and 1 should consider potentially unstable as well as brittle materials and should consider the need to design for structural forms potentially having undesirable earthquake response.

4. 'Deemed-to-comply' requirements corresponding in intent to the minimum earthquake structural design standards specified above should be developed for domestic construction. Research may be needed to make this feasible.

5. Existing building stock in Newcastle and elsewhere should be upgraded to the new earthquake zoning requirements only to the extent corresponding to building repairs, alterations, additions or usage changes. However, buildings, structures and facilities with special functions or dangerous features should be upgraded completely as soon as feasible (see Set.10.6).

6. Guidelines and economic systems should be developed for the preservation of heritage buildings.

7. Progress needs to be made on the issue of proper identification of engineers with appropriate qualifications and experience to carry out structural engineering work.

8. Uniform national policies and procedures need to be developed at all levels of building jurisdiction and in conjunction with counter disaster organizations for the control of demolition and rebuilding immediately after a disaster event and before considered interim guidelines can be given.

I.4 PWD Report Jan 199 2

Report prepared by:-

The Earthquake Reconstruction Project,

Newcastle Regional Office.

Authors:- S. Murphy, C. Abbs, A. Slinn.

Comments were received from other Public

Works staff notably:- J. Loke and J. Mak.

Particular acknowledgment is due to the many PWD staff and contractors who have contributed to this report by way of completing questionnaire forms.

Some of the preparation of this report was carried out concurrently with a project for the University of Newcastle.

I.4.1 Foreward

The Newcastle earthquake is unique in Australian history. It is the first to result in loss of life and significant damage to a major urban centre.

There are many lessons which have been learnt from the experience, including those relating to building design, construction and maintenance.

The earth's crust is divided into large, slowly moving plates. Earthquakes are common at the boundaries of these plates. Cities in these regions typically have stringent building codes with allowance made for earthquake loads.

Attracting international attention, the Newcastle earthquake is seen as a reminder that earthquakes away from plate boundaries do occur. While less common than earthquakes at plate boundaries, they too can be very large in magnitude. Communities can be totally unprepared for such an event, as was seen in Newcastle.

While, in international terms, the Newcastle earthquake (at Richter Scale 5.6) was relatively small in magnitude, it is nevertheless significant. Analysis of this event is of wide-reaching interest.

"The Newcastle Earthquake had important implications to many areas of low seismicity such as the UK." (EEFIT). "We have to admit the possibility of a large quake coming out of nowhere". (Finkbeiner, USA). These papers and other studies discuss the need for retrofitting old buildings to improve earthquake resistance and for incorporating minimum detailing requirements into building codes.

Public Works has been involved with the inspection of over 1000 public buildings, which include structures of many different designs, materials, ages and methods of construction. A survey of 650 damaged State Government buildings was carried out during 1991 in the course of managing repair works.

It is the purpose of this report to present statistical data relating to these buildings, particularly in connection with key features which have been linked to earthquake vulnerability. The report briefly considers the implication of the Newcastle experience on the management of other State Government building stock.

The report consists of two parts:-

Volume I contains analysis and discussion of the data.

Volume II contains the original data collected in the survey.

Further information has been collected on other State Government properties (including undamaged buildings). It is expected that this will be incorporated into the database at a later date.

I.4.2 Executive Summary

In January 1990, Public Works established an earthquake project team in Newcastle. The team's dual role was to co-ordinate funding for the repair of State Government properties and to manage reconstruction programmes for various government departments. Funding was provided on a dollar-for-dollar basis by State and Federal Governments through the New South Wales Treasury Managed Fund.

Public Works has been involved with the inspection of over 1000 public buildings and the repair of over 600 State Government buildings.

The present report provides a brief overview of Public Works' role in the Newcastle recovery process. Funding conditions and the reconstruction process are described. The nature and scope of repair, strengthening and maintenance works are detailed.

This report presents statistical data relating to 650 damaged public buildings. The emphasis of the analysis is on key building features which have been linked to earthquake vulnerability.

The statistical analysis showed the following building properties were associated with higher than average levels of major, moderate and hazardous damage:

i) location within the Newcastle City Council area;

ii) ground foundations alluvium;

iii) building containing unreinforced masonry;

iv) storey height greater than one storey;

v) building age greater than 50 years;

vi) presence of parapets and gables on the building;

vii) in close proximity to ocean;

viii) building heritage listed.

It was quickly recognized that it would be unwise to simply replace - without upgrading - building elements damaged during the earthquake. As such, it was agreed that structural strengthening and maintenance to improve earthquake resistance, could be carried out under certain conditions.

As a result, much worthwhile improvement work has been undertaken. Some 120 buildings have benefited by the execution of strengthening works (such as tying gables to roof structures) and around 40 buildings have had structural maintenance work carried out (such as the replacement of brick ties).

'However, there have been many instances where the need for improvements has been identified but works have not been carried out because of non-compliance with the conditions of funding. In many cases buildings, although repaired, have not been examined for earthquake resistance because they were not significantly damaged in this particular event to be eligible for funding to carry out upgrading works.

The report recommends the establishment of an upgrading programme for public buildings to improve earthquake resistance. Studies to date indicate that buildings in the following categories are most in need of attention: high occupancy buildings; buildings with post-disaster functions; heritage listed buildings and buildings with elements inherently weak in earthquakes, such as parapets and chimneys.

The report identifies building elements particularly susceptible to deterioration and recommends that a systematic and ongoing structural maintenance programme be established.

The viewpoints of the Institution of Engineers, Australia and the Newcastle City Council regarding such a programme are provided for comparison.

I.5 The Centre for Earthq uake Research in Australia

FINAL REPORT ON EARTHQUAKE ZONATION MAPPING

OF THE CITY OF NEWCASTLE

NEW SOUTH WALES

FOR

NEWCASTLE CITY COUNCIL

COMPLIED BY

THE CENTRE FOR EARTHQUAKE RESEARCH IN AUSTRALIA

BRISBANE

MAY 1995

NEWZON NCC/CERA-IDNDR MAR95 JR

I.5.1 Acknowledgments

The Newcastle Earthquake Zonation Study has been realised through teamwork.

The Study team would like firstly to acknowledge the contribution made immediately after the 1989 earthquake by the Mayor, Alderman John McNaughton, the then head of Newcastle SES, the late Mr Don Geddes, the then Director of Health and Building Services, Mr Harold Stuart, and the Council and other officers of the City of Newcastle in their concern for the community with their later consideration to commission this Study.

The encouragement and advice given by the Australian IDNDR Coordination Committee of Emergency Management, Australia committee personnel, former Chairman Commodore Clem Littleton A.O. (Retired), Executive Officer Mr Trevor Hatchard and member Mr Robert Hogg has been greatly appreciated. Special thanks must be extended to Dr Konrad Moelle (Institute of Coal Research, University of Newcastle) for the geological information provided and his advice. Also acknowledgment of our international experts is recommended. Professor Haresh Shah (Stanford University, USA), Professor Tsuneo Katayama (INCEDE, University of Tokyo, Japan), at the US Geological Survey, Dr Walter Hays (Reston Va) and Dr Roger Borcherdt

(Menlo Park Ca) and to Dr Klaus Jacob (Columbia University, New York) who all provided expert comment and advice on this earthquake zonation project.

THIS STUDY IS TOTALLY FUNDED BY THE COUNCIL OF THE CITY OF NEWCASTLE AND IS A CONTRIBUTION TO THE

UNITED NATIONS INTERNATIONAL DECADE FOR NATURAL DISASTER REDUCTION (IDNDR) AS FACILITATED BY

EMERGENCY MANAGEMENT AUSTRALIA AUSTRALIAN IDNDR COORDINATION COMMITTEE DESIGNATED AS

PROJECT 3/91: EARTHQUAKE ZONATION OF URBANISED AREAS IN AUSTRALIA PHASE 3 (1993-1994)

NEWZON NCC/CERA-IDNDR MAR95 JR

I.5.2 Executive Summary

I.5.2.1 1. The Project

The vulnerability of the City of Newcastle to severe earthquake damage was clearly evidenced in the 28 December 1989 Newcastle earthquake. It is most important that this project of earthquake zonation mapping of The City of Newcastle be undertaken in view of the knowledge gained from this 1989 earthquake, the now known history of major earthquakes and their consequent damage to the communities in the Newcastle-Hunter region and the information base that the 1989 Newcastle earthquake has given to both Australia and the international community at-large.

The 1989 Newcastle earthquake was the catalyst for a program of earthquake zonation mapping in Australia facilitated by Emergency Management Australia (EMA) under the United Nations International Decade for Natural Disaster Reduction (IDNDR) (1990-2000). The contribution of this earthquake zonation mapping to this international program has been sponsored and funded by the Newcastle City Council, and forms part of the 3rd Phase of the Project "Earthquake Zonation Mapping of Urban Areas in Australia".

I.5.2.2 2. Hazard Mitigation for Newcastle

The Report increases the awareness of the potential earthquake hazard in the region and so provides information for emergency management planning, local and state government, engineering, land-use planning and socio-economic programming. This information can be applied in a practical manner to assist in developing and implementing preparedness and mitigation plans and actions so as to reduce the potential losses from future earthquake occurrences. Earthquake zonation mapping is indeed a required necessity.

Earthquakes are the most devastating natural disaster known to human civilisation. Recent earthquakes on continents in urbanised areas; such as the 1989 Newcastle earthquake in Australia and those 1993 earthquakes in Okishura (Japan) and the 1995 Kobe earthquake in Japan, are further reminders of the potential havoc that can be caused. Australia is not immune from this natural phenomenon and must be prepared for future effects to the national community.

The potential earthquake effects assessed in this study are derived through a multi-disciplinary method. The approach is one of integrating the necessary research, technical information and experiences from the 1989 Newcastle and other devastating earthquakes worldwide, with the practical requirements of the user community - the emergency management authorities. The aspect of involving such authorities as active participants in the project, and not just as readers of a final report, is a necessity in such earthquake mitigation procedures. This has led to modifications to the methodology stages, in this case, specifically related to a single local government authority.

The City of Newcastle, Australia's sixth largest city, serves a vital socio-economic purpose for both its local region, the Hunter Valley, and the nation of Australia. The City contains all aspects of commerce and industry, including major steel manufacture plants, one of Australia's major export coal and primary produce ports, aluminium smelters, and associated industry and manufacturing, and thereby supports a significant domestic population and local infrastructure. Of vital importance is the awareness of emergency management to monitor sustainable development. The scope of any natural disaster, most particularly an earthquake, is clearly increasing as time goes on. The problems of both awareness to and preparedness for a potential earthquake disaster has now been addressed by the community through relevant, national, state and local programmes.

I.5.2.3 3. Community Vulnerability

The important issues relating to the vulnerability of community and it's facilities to earthquakes included:

(i) geological situation - e.g. surface soil types, active surface fault, or "blind" source; alluvial deposits; stone stability and landslides; terrain and topography.

(ii) built environment - e.g. age, type, style, construction and maintenance of engineered and non-engineered structures and surface underground infrastructure.

(iii) past earthquake history - not only for the local area or region but also for similar continental areas worldwide.

This Newcastle project illustrates the vital role played by geology, particularly the alluvial deposits in the coastal environment. The major damage caused in Newcastle was due to amplification, of the wave motion, in addition to poor building construction and maintenance and the lack of knowledge of any earthquake history relevant to the Hunter region prior to the 1989 occurrence.

Past earthquake experiences in the region and their relationship to geological structures, both on land and offshore, provide the basis for evaluating potential earthquake sources. This, together with both the existing and planned built environment for the region, dictates the expected vulnerability levels which can be prepared as generalised earthquake zonation especially also where located on alluvial sediments or in steep terrain. For this study, the mapping assessment is based on a Richter Magnitude ML 6.0 earthquake within a radius of 50 km of the Newcastle Central Business District (CBD). Ground motions leading to vulnerability levels for an expected earthquake of a particular magnitude can be scaled up or down, accordingly, using a known relationship for attenuation of earthquake energy with distance for Newcastle.

Areas of high vulnerability can expect damage levels to some buildings and infrastructure. particularly in the CBD, and areas of high urbanisation located on alluvial sediments. Some damage to underground infrastructure could also be expected.

Both of these were indeed the effects experienced in the 1989 Newcastle and previous historical earthquakes. With the extensive local knowledge gained in the response to and recovery phases of the 1989 earthquake, this Report provides the City of Newcastle with quantitative information source to further augment local emergency management and city planning procedures for the betterment of the community.

I.5.2.4 4. Recommendations

The implementation of such a Study and the Report thereof must be considered at the highest level possible to enable the community to receive the maximum benefit available. The following recommendations as ascertained from undertaking the Study should be implemented.

1. That the Newcastle City Council adopt the Report and the findings contained therein.

2. That the contents of the Report be used to develop future land use and strategic planning for the development of the City of Newcastle.

3 That the Newcastle and Hunter regional emergency service organisations, regional services and infrastructure provision agencies, and relevant state and federal government departments and agencies operating in Newcastle and Hunter regions use the findings of the Study to develop their future plans and management strategies, and

4. That a full Hunter regional earthquake zonation study should be recommended and undertaken to assess the earthquake vulnerability of the entire region, and to prepare regional planning strategies and management for all aspects of development in the Hunter region.

I.6 The Earth was Raised up in Waves Like the Sea … Earthquake Tremors Felt in the Hunter Valley Since White Settlement

Cynthia Hunter, 1991

I.6.1 Foreword

Earthquakes are not popularly associated with Australia. Students of geology are still taught that Australia is the quiet country, slowly drifting north astride the Australian plate at the speed of a growing fingernail. The occurrence of the Newcastle earthquake on 28 December 1989 has not dispelled this myth entirely. It was a relatively small earthquake, and the death toll low compared with the 655 000 reported deaths at Tangshan, China in 1976. And earthquakes were unheard of in the district... or were they? This book answers that question, and gives a fascinating insight into the people and their lifestyles over the past 150 years.

Cynthia Hunter's research has unearthed several reports of an earthquake that was felt only five months after the landing of the first fleet in Sydney Cove in 1788. I have had the pleasure of reading Governor Phillip's account of the earthquake in his original letter to Lord Sydney, now held at the UK Public Records Office in London. Some 50 years later in 1837, the first European settlers in Adelaide felt the ground shake for 20 seconds during a local earthquake. Adelaide has the dubious distinction of being the first Australian city to suffer significant earthquake damage, as a result of a magnitude 5.5 earthquake close to the city on 1 March 1954. In the Adelaide city area, chimneys and parapets in older buildings collapsed and cracks appeared in walls of old domestic brick and stone dwellings. The 1989 Newcastle earthquake affected similar types of buildings but far more severely.

One of the world's first seismographic stations was established at California's Lick Observatory in 1883; five years later the first Australian seismograph was installed at Sydney Observatory. These early instruments were very insensitive, recording only large or very close moderate sized earthquakes. Sometimes, the only clue that an earthquake had occurred was when it was reported in the press by someone who had felt it. Newspaper accounts are often the only record of Australia's pre 1960 earthquakes, and finding them requires dedicated and diligent research. Adequate monitoring was lacking until the early 1960s, when the Commonwealth Government's Bureau of Mineral Resources undertook to install a network of seismographs in Australia to monitor both local and worldwide earth-quakes.

Cynthia Hunter's book is a scholarly historical study of the early earthquakes felt in the Hunter region. It will interest seismologists as well as the general reader. Isoseismal maps show the distribution and intensity of shaking. They can be compiled where there are enough reports, as there have been for the 1989 Newcastle earthquake, and the resultant map is reprinted in the book. From such maps the earthquake's magnitude, epicentre and approximate focal depth can be inferred. Cynthia Hunter's research is already enabling seismologists to make a more educated analysis of the seismic risk in Newcastle than was previously possible. The benefits of this research will flow on to engineering standards and the Australian Building Code and therefore the wider community.

The book is stimulating reading for anyone interested in Australian history, in the evolution of building styles and material, colourful settlers, visiting explorers and notorious bushrangers. The Newcastle earthquake showed that similar studies of early earthquake history should be undertaken in each Australian city, so that better risk assessment improves the safety and well being of our population. It should be compulsory reading for all town planners.

Kevin McCue

Australian Seismological Centre

Bureau of Mineral Resources, Canberra

I.6.2 Preface

In December 1989 the Hunter Valley community was paid an unwelcome visit by a fatal and destructive earthquake. At the time, popular knowledge about previous quakes in the Valley was almost non-existent. As a student of regional history, I was prompted to recall descriptions of early nineteenth century quakes amongst my research material. These interesting old records assumed a new relevance after the December 1989 earthquake. Copies of them were forwarded to the media and a few of the seismological research centres which had responded so unreservedly to the predicament in which Newcastle was unexpectedly placed. Dr Jack Rynn, Research Fellow (Seismology) at the University of Queensland, encouraged me to undertake what proved to be a fruitful paper-chase through old scientific journals, books and newspapers to locate as complete a record as possible of past tremors. The results of this search form the basis of a retrospective study of earthquake activity in the Valley (Rynn, J. M. W. and Hunter, C., The Historical Records of Earthquake Activity in the Newcastle and Lower Hunter Valley Regions, New South Wales, 1990 (in preparation)). Additionally, this research has enabled me to compile the following narrative of past Hunter Valley earth tremors. Earthquakes are not merely geological events of time and place, but are episodes of human experience; written accounts of them reflect the nature of the society which they disturb so alarmingly.

Cynthia Hunter

June 1991

I.6.3 1989

A bad earthquake at once destroys the oldest associations: the world the very emblem of all that is solid, has moved beneath our feet... one second of time has conveyed to the mind a strange idea of insecurity, which hours of reflection would never have created.

Charles Darwin. Journal of Researches into the Geology and Natural History of the Various Countries visited by HMS Beagle from 1832 to 1836. *1839, p369.*

On 28 December 1989 at 10.27 a.m. an earthquake was felt over much of eastern New South Wales stretching south to Batemans Bay, north to Armidale and west to Dubbo. This earthquake was unlike any other in Australia's history because the convulsion released its tremendous energy beneath a principal city and its nearby suburbs. Falling shop awnings and the collapse of part of a major public venue killed twelve and injured about a hundred and sixty citizens. The cost for insurance companies to satisfy earthquake-related property damage claims will eventually be computed. The complexity of managing the crisis precipitated by the quake, and the inventory - will it ever be completed? - of the devastation attributable to it, reveal the vulnerability of a populous and technology-dependent urban area. Every facet of damage has opened a window on some aspect of almost 190 years of settlement, reminding us that the Hunter Valley was occupied for the exploitation of resources, and that the subjugation by Europeans of the wide, silty estuary was always conditional; in the past, great floods have told us that.

Telex services and telephones cast forth news of the earthquake, and full-colour, moving images of the havoc were almost instantaneously transmitted by satellite to media databases around the world. Over the following months the procedures and terminology of insurance services became commonplace in the Hunter Valley community. The quake was Australia's largest insurance loss.

Following the Newcastle and district earthquake most people wondered why the convulsion was as great a shock to the store of knowledge in our heads as it was to the earth and buildings thereon. What was immediately apparent was that some pages were missing from our history books! Not even trivial anecdotes remained in folklore. It was as if a selective process had been at work, excluding all references to earth tremors from oral and written histories, culling out observations that earthquake risk, although slight, was possible, and overlooking the fact that minor tremors had played a small role in our recorded past. Did Australian geology lose part of its memory when Reverend Clarke's research papers were consumed by fire? If Professor Cotton had published his analysis of the 1925 quake, would we have been more aware? Did the repeated assurances that 'there was no cause for alarm', so kindly given in the past by those whose expertise was sought by journalists and frightened citizens, unwittingly divert our attention from the earth's explicit messages?

Only one Hunter Valley historian, Henry William Hemsworth Huntington, included the occurrence of earthquakes in his writing. In 1897, when the people of the Newcastle region were preparing to celebrate the centenary of John Shortland's discovery of the entrance to Hunters River, Huntington wrote a History of Newcastle and the Northern Districts in one hundred parts. The episodes were printed regularly in the Newcastle Morning Herald from August 1897 to August 1898, the final one dealt with events of the 1840s.

Part 27 continued a lengthy review of the first survey of the mouth of the Hunter River undertaken in 1801. Under a sub-heading entitled 'Earthquakes in Newcastle District in 1801' Huntington wrote:

Among the most remarkable events in the early history of the northern district were two smart shocks of earthquakes in 1801. The writer has before him a long list of earthquakes throughout the colony, many of which were felt by the colonists of the northern district.

After a brief discourse on earthquakes, volcanoes and geological phenomena of the Hunter district, Huntington quoted from the journal of Mr David D Mann and other records in his possession which indicated that two tremors were felt at Newcastle in 1801. He also noted that 'after a careful examination of this subject of earthquakes, the writer has found that most earthquake shocks taking place simultaneously at the Hawkesbury and Parramatta extend their phenomena to the Hunter.'

Part 45 of the History described district events in 1804, including the visitation of an earthquake shock. Part 48 recorded the earthquake at the Upper Hunter in 1806.

Part 93 is entitled 'Newcastle Earthquakes in 1829,1837, and 1841'. The sources to which Huntington referred for his account of these quakes appear to be the 1859 Sydney Magazine of Science and Arts, contemporary newspapers, and the journals of Reverend Alfred Glennie.

A copy of Huntington's work has been in my possession for some years. I also held a copy of Dr McKinlay’s letter describing the 1841 earthquake, not because of a concern about earthquakes, but because of an interest in the life of Dr McKinlay, a significant pioneer of the Williams River district. After the quake of December 1989 these documents provided the stimulus to assemble this record of tremors and quakes as they shook the Hunter Valley and its inhabitants from the earliest days of settlement. It is not claimed to be complete. Additional quakes, perceptible by human sensitivity, may be retrieved from written records by other researchers. The sum total should be a more complete understanding of our natural and social history,

In the last few decades, equipment for detecting and measuring seismic disturbance has become increasingly sophisticated and centres for research are compiling ever-expanding catalogues and up-to-date articles for publication at home and abroad. A special Seismological Society was founded in New South Wales in 1973. No one can yet predict when a quake may occur and the practical safeguards of today are the same as ever before: to build structures which can keep standing and allow the waves to pass, doing physical harm to as few people as possible, then to build again, drawing on the indomitable spirit which enables life to exist on the surface of an unquiet earth.

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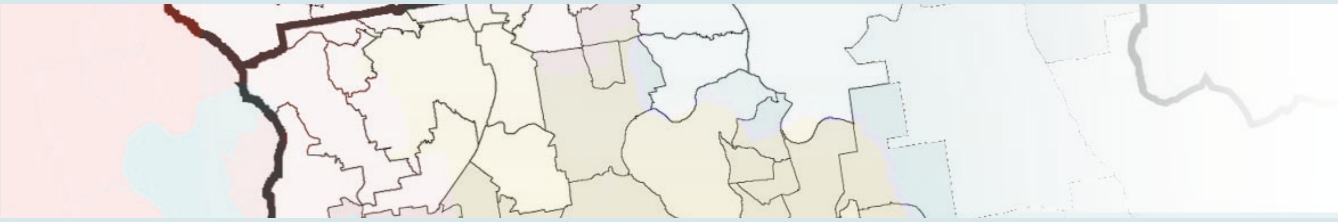

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