UNITED STATES

DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

PROCEEDINGS OF CONFERENCE XXI

A WORKSHOP ON "CONTINUING ACTIONS TO REDUCE POTENTIAL LOSSES FROM FUTURE EARTHQUAKES IN THE NORTHEASTERN UNITED STATES"

JUNE 13-15, 1983

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

CAMBRIDGE, MASSACHUSETTS

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CONVENED UNDER AUSPICES OF
NATIONAL EARTHQUAKE HAZARDS REDUCTION PROGRAM

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U.S. GEOLOGICAL SURVEY
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COMPILED BY
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Reston, Virginia
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BACKGROUND AND SUMMARY OF THE WORKSHOP ON "CONTINUING ACTIONS TO REDUCE POTENTIAL LOSSES FROM FUTURE EARTHQUAKES IN THE NORTHEASTERN UNITED STATES"

by

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INTRODUCTION

The workshop on, "Continuing Actions to Reduce Potential Losses from Future Earthquakes in the Northeastern United States," was held at the Massachusetts Institute of Technology, Cambridge, Massachusetts, June 13-15, 1983. The workshop was cosponsored by the U.S. Geological Survey (USGS) and the Federal Emergency Management Agency (FEMA). This workshop was the twenty-first in a series of workshops and conferences that USGS has sponsored since 1977, usually in cooperation with one or more other agencies or institutions. Each workshop and conference has the general goal of improving knowledge utilization by bringing together knowledge producers and users. For each workshop or conference, a steering committee is created to tailor the objectives to the geographic region and to foster a process that will enhance utilization of research results. This process emphasises the creation of a network to link knowledge producers and users, if no network exists, and the improvement of existing networks.

Sixty people having varied backgrounds in earth science, social science, architecture, engineering, and emergency management participated in the workshop on "Continuing Actions to Reduce Potential Losses from Future Earthquakes in the Northeastern United States." They represented local, State, and Federal Government, industry, architectural and engineering firms, academia, and voluntary agencies. Most came from the Northeastern United States.

DIFFICULTIES IN EVALUATING EARTHQUAKE HAZARDS IN THE NORTHEAST

Although the Northeastern United States has not experienced a New Madrid or a Charleston type earthquake, it has experienced a number of moderate earthquakes in the past several hundred years (see Figure 1 and Appendix A). Canada had experienced moderate to severe earthquakes in this time period. New England, a region of moderate earthquake hazard, has experienced during

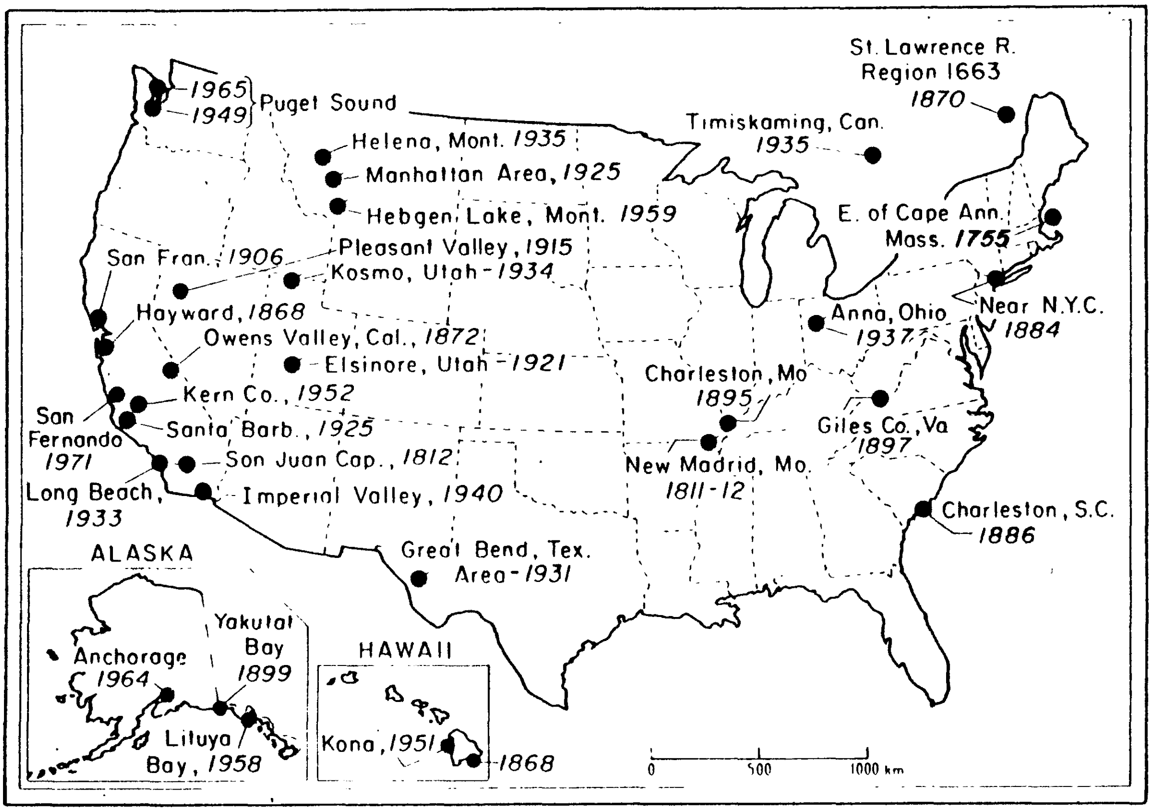

Figure 1.--Map showing location of notable earthquakes in the United States.

its 350 year recorded history many small and several moderate earthquakes. This historical record of seismicity shows that the Northeast can not ignore the earthquake threat.

Since the first account of strong earthquakes by 17th century European explorers and immigrants, the region has continued to experience damaging earthquakes from time to time. One of the most notable earthquakes in the Northeast was the November 18, 1755, Cape Ann, Massachusetts, earthquake. Boston was shaken by the Cape Ann earthquake which was felt as far away as Halifax, Nova Scotia, the Eastern Shore of Maryland, Lake George in eastern New York, and offshore on the Georges Banks about 250 miles east of Boston. In the Cape Ann earthquake, walls and chimneys were thrown down and stone fences were knocked down (intensity VIII on the Modified Mercalli intensity scale). Some descriptions mention violent movement of the ground, like waves of the sea making it necessary to cling to something to prevent being thrown to the ground. Whitman (1983) estimates that Boston experienced a peak accelerations of about 0.12 g. The St. Lawrence valley of Northeastern Canada has generated a number of earthquakes, one of which is thought to have a magnitude (M_S) greater than 8 in 1663. Recent events in the Northeast include the 1982 New Brunswick, Canada-Gaza, New Hampshire, earthquakes and the 1983 Blue Mountain Lake, New York, earthquake.

On the basis of the record of historical seismicity, the Northeastern United States and neighboring Canada must expect to continue to experience moderate and, possibly, large earthquakes from time to time. This fact raises the question of how buildings constructed in Boston since 1755--particularly during the great expansion that took place in the 19th century, when the Back Bay and other tidal areas were filled--would fare in an earthquake comparable to the one of 1755 or in a larger earthquake.

Evaluation of the earthquake hazards of ground shaking, surface fault rupture, tectonic deformation, and earthquake-induced ground failures in the Northeastern United States is difficult for the following reasons:

1) The largest historical earthquakes occurred before instruments were available to record their effects. Thus, the epicentral locations,

magnitudes, and focal depths derived from intensity data have more uncertainity associated with them than if they had been derived from instrumental data. The mechanisms and source properties of these large historical events are debated in scientific circles today.

2) Until 1975, the number of seismometers in the Northeast was small. Today, the Northeastern United States Seismic Network having about 50 instruments has been established (see Figure 2) to monitor the seismicity.

3) The level of seismic activity is quite low when compared to the West; therefore, the data collection process is slow, even with reasonably good instrumentation.

4) Limited strong ground motion data from moderate to large earthquakes exist in the Eastern United States to guide earthquake-resistant design.

5) Surface faulting from earthquakes has not been observed in the Northeast. The area is covered with a layer of glacial till, making it difficult to correlate the seismic activity with the geologic structures producing the events.

Although evaluation of the earthquake hazards is a difficult problem, it must be addressed. The region faces potential losses because of the sizeable population living and working in high-density urban centers of the Northeast, the large number of buildings that are not earthquake resistant, and the number of critical facilities located throughout the area. To a greater extent than for other parts of the United States, the chance for loss (earthquake risk) in the Northeast is compounded by high population density, many old buildings, and a high degree of modern industrialization. A damaging earthquake today in the Boston area, for example, could have serious social and economic impacts on the region and perhaps on the Nation. Although the severity of the potential impacts are not completely identified at this time, the societal impacts of future events could be reduced if an effective seismic safety policy is devised and implemented at all levels of government in the Northeast.

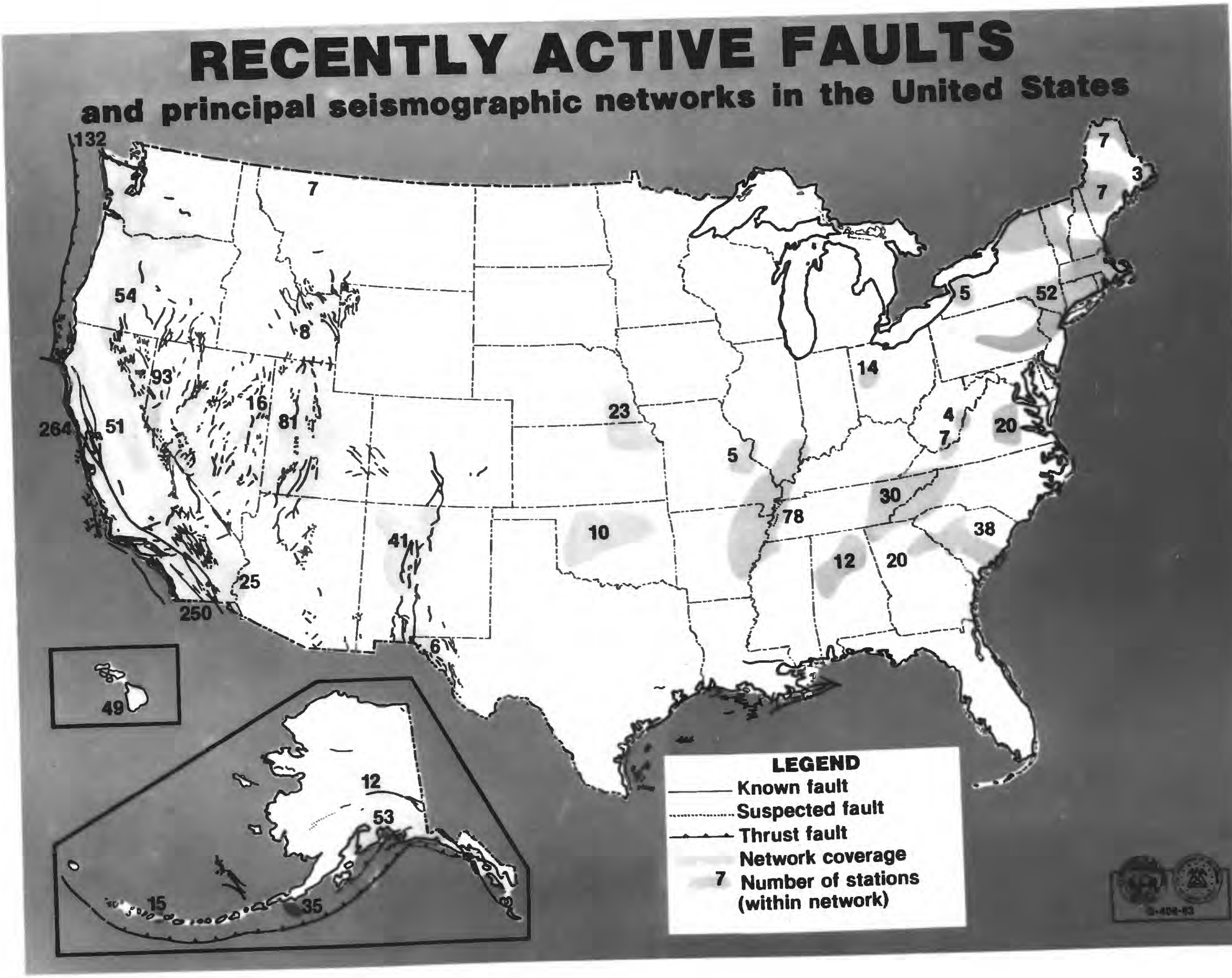

Figure 2.--Recently active faults and the principal seismographic networks in the United States.

.07/1.70

RECENT SEISMIC STUDIES IN THE NORTHEAST

The United States Nuclear Regulatory Commission (NRC) has sponsored technical studies pertaining to earthquakes in the Northeast in the past several years. The New England Seismotectonic Study and the Northeastern United States Seismic Network are two programs sponsored by NRC. Recently, the Seismic Risk Analysis Subcommittee of the Boston Advisory Committee completed a vulnerability analysis of the Boston area. This study was sponsored by the Massachusetts Civil Defense Agency. A report entitled "The Seismicity of New England and the Earthquake Hazard in Massachusetts," was completed in December 1981.

A voluntary group of members of the Boston Chapter of the American Society of Consulting Engineers has for several years taken the lead role in drafting and urging the enactment of State-wide building standards that incorporate appropriate seismic safety standards for Massachusettts.

The USGS increased its research activities in the Northeast following the Earthquake Hazards Reduction Act in 1977. One of the studies involved the preparation of national ground-shaking hazard maps (Algermissen and others, 1982). These maps (and the predecessor map (Figure 3) produced by Algermissen and Perkins, 1976) are being used by the Applied Technology Council (ATC) to evolve a model buidling code that may, in time, replace the Uniform Building Code. The ATC, organized by the Structural Engineers Association of California in 1971, completed a draft report entitled "Tentative Provisions for the Development of Seismic Regulations for Buildings," in 1978. This report contains ground motion maps of effective peak acceleration and effective peak velocity for bedrock sites. These maps show the estimated ground motion in a 50 year period with a 90 percent probability of not being exceeded, and provide a realistic basis for comparing the relative severity of ground shaking throughout the United States (see Figure 4). In the Northeast, the value of effective peak acceleration for sites underlain by bedrock is less than 0.2 g. The recommendations contained in the ATC report are currently being tested in trial designs at a number of locations throughout the United States by the Building Seismic Safety Council, a program funded by FEMA.

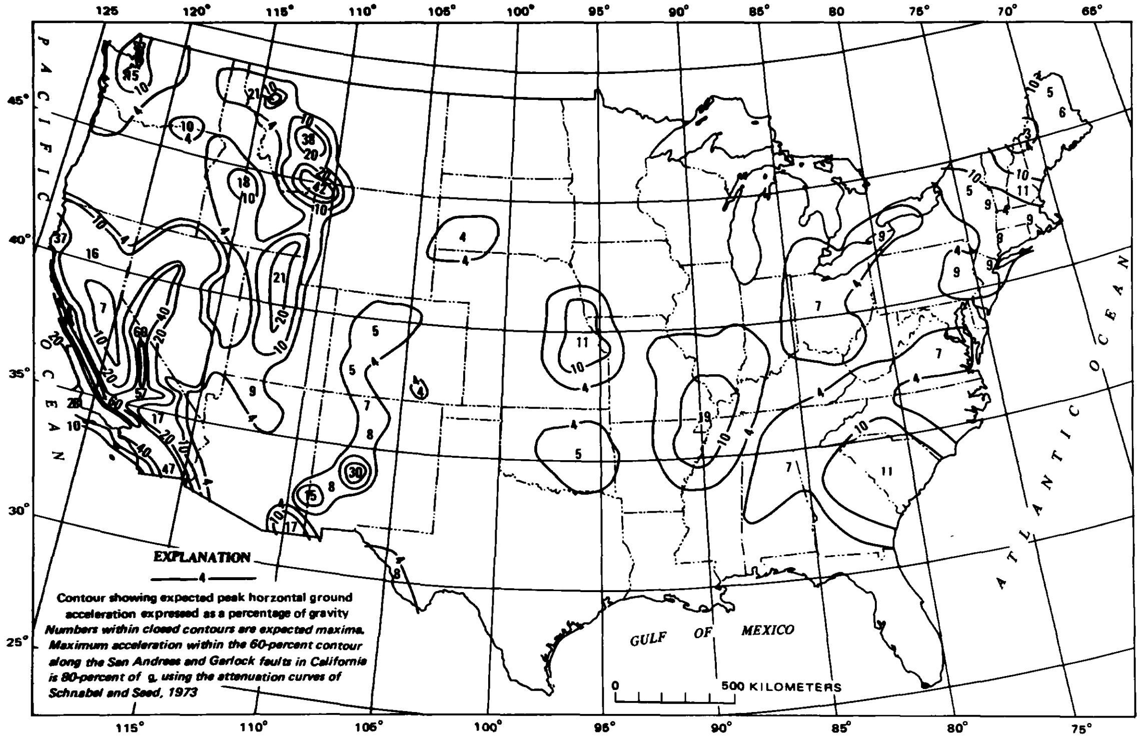

Figure 3.--Map showing maximum levels of peak horizontal ground acceleration at rock sites in the United States in a 50 year period, (Algermissen and Perkins, 1976). The contoured values of acceleration represent the 90 percent probability level; that is, there is a 90 percent chance that these values will not be exceeded within a 50 year period.

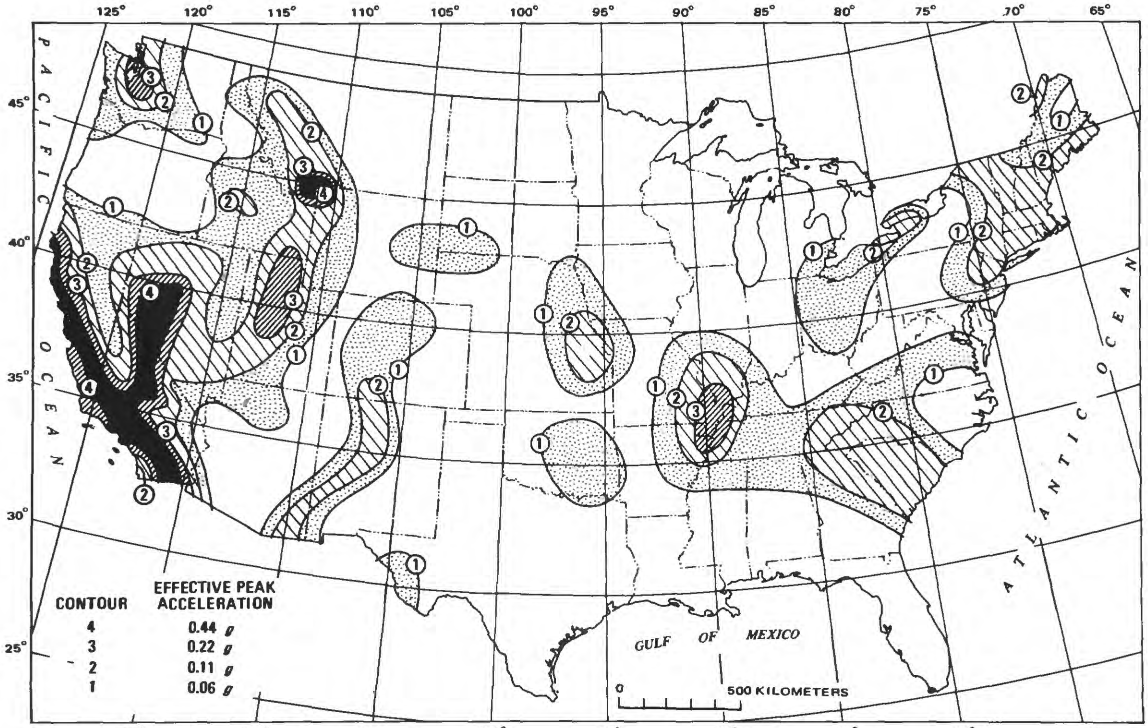

Figure 4.--Map showing preliminary seismic zones proposed by the Applied Technology Council (1978). Contours connect area having equal values of peak acceleration. The Northeast falls mainly in zones 1 and 2.

OBJECTIVES OF THE WORKSHOP

This workshop is the fourth in a subseries specifically designed to define the earthquake threat in the Eastern United States and to improve earthquake preparedness. The three prior workshops on earthquake preparedness were also sponsored by USGS and FEMA and brought together producers and users of hazards information with the goal of fostering partnerships. The first workshop, "Preparing for and Responding to a Damaging Earthquake in the Eastern United States," was held in Knoxville, Tennessee, in September 1981. The Knoxville workshop (described in USGS Open-File Report 82-220) demonstrated that policymakers and members of the scientific-engineering community can assimilate a great deal of technical information about earthquake hazards and work together to devise practical work plans. The workshop resulted in the creation of a draft 5-year work plan to improve the state-of-earthquake-preparedness in the Eastern United States and marked the birth of the South Carolina Seismic Safety Consortium. The second workshop, "Continuing Actions to Reduce Losses from Earthquakes in the Mississippi Valley Area," was held in St. Louis, Missouri, in May 1982. It resulted in the identification of specific actions with a high potential for reducing losses that could be implemented immediately and the formation of the Governor of Kentucky's Task Force on Earthquake Hazards and Safety. The results of the workshop (described in USGS Open-File Report 83-157) reaffirmed that pratical work plans can be created efficiently by a diverse group. The third workshop, "The 1886 Charleston, South Carolina, Earthquake and its Implications for Today," was held in Charleston, South Carolina, in May 1983. The Charleston workshop (described in USGS Open-File Report 83-843) had multiple objectives involving the discussion of scientific information and its use in the siting of critical facilities and preparedness.

THE WORKSHOP PROCESS

This workshop was the first major forum in a Northeastern city brining together policymakers, scientist, and engineers in the region to discuss seismic hazards, risk, and preparedness in the Northeast. During the 2-1/2 day workshop, four major themes were addressed:

1) The nature of the earthquake threat in the Northeast and what can be done to improve the state-of-preparedness.

2) Increasing public awareness and concern for the earthquake hazard in the Northeast.

3) Improving the state-of-preparedness through scientific, engineering, and social science research.

4) Possible functions of one or more seismic safety organizations.

The procedures used in the workshop were designed to enhance the interaction between all participants and to facilitate achievement of the objectives. The following procedures were used:

PROCEDURE 1: Research reports and preliminary papers were distributed to each participant at the workshop and used as basic references.

The technical papers were finalzed after the workshop and are contained in this publication.

PROCEDURE 2: Scientists, social scientists, engineers, and emergency management specialists gave oral presentation in six plenary sessions.

The objectives were to integrate research--hazard awareness--preparedness knowledge and to define the problem indicated by the session theme. These presentations served as a summary of the state-of-knowledge and gave a multidisclipinary perspective.

PROCEDURE 3: The participants responded to the presentations of the speakers and panelists, using questions posed to focus the discussion.

PROCEDURE 4: Discussion groups were convened following the plenary sessions to generate recommendations for future research and mitigation actions.

PROCEDURE 5: Ad hoc discussions on topics not addressed during the plenary and small group discussions added a spontaneous dimension to the workshop.

PLENARY SESSIONS

The theme of the workshop was discussed in six plenary sessions and in several small discussion groups. The themes, objectives, and speakers, for each plenary session are described below:

SESSION I: THE EARTHOUAKE THREAT

OBJECTIVE: Presentations giving an overview of the relative risk, scale, and nature of the potential losses from earthquakes and other natural hazards in the Northeastern United States.

SPEAKERS: Joseph Fischer
Nafi Toksoz
Goetz Buchbinder

SESSION II: RESPONDING TO THE EARTHQUAKE THREAT

OBJECTIVE: Discussion of the state-of-preparedness in the Northeast and strategies for improving it.

SPEAKERS: Philip McIntire
Walter Anderson
Stan McIntosh
Patrick Breheny

SESSION III: INCREASING AWARENESS AND CONCERN

OBJECTIVE: Presentations describing ways to involve segments of the public in hazard awareness and response activities.

SPEAKERS: Risa Palm
Anthony Prud'homme
Bob Cooke
Doug Nilson
Norton Remmer
Joyce Bagwell
Dan Prewitt
Howard Simpson

SESSION IV: INCREASING EARTHQUAKE RESISTANCE OF BUILDINGS AND LIFELINES

OJBECTIVE: Presentations describing what can be realistically achieved with regard to earthquake-resistant design of new buildings and lifelines and the renovation of existing facilties.

SPEAKERS: Daniel Schodeck
Christopher Arnold
Kenneth Wiesner

SESSION V: RESEARCH NEEDS

OBJECTIVE: Presentations identifying scientific, engineering, and social-science research needed in the Northeast.

SPEAKERS: Patrick Barosh
Robert Whitman
Andrew Murphy

SESSION VI: SEISMIC SAFETY ORGANIZATIONS

OJBECTIVE: Presentation giving the advantages and disadvantages of a regional seismic safety organization in the Northeast to deal with earthquakes and other natural hazards.

SPEAKER: Paul Pomeroy

DISCUSSION GROUPS

The following subjects were discussed in a small group setting, seeking to achieve personal identification with both the problem and the its solution:

1) The earthquake threat in each State (and/or region) of the Northeast and the perception of the present capability to respond to it.

2) Progress made since the September 1981, Knoxville, Tennessee, workshop to increase the state-of-preparedness and concern.

3) Steps or activities which individuals can take to increase earthquake awareness and concern in their workplace.

4) Actions which individuals can take to improve the seismic safety of their homes.

5) The advantages and disadvantages of a seismic safety organization.

SUMMARY OF CONCLUSIONS

The papers describing the sessions listed above are contained later in this report. The reader can refer to these papers for details.

The participants concluded the following:

1) Although the earthquake threat is not the greatest hazard that the Northeast faces, a realistic effort should be made to prepare for it.

2) Progress has been made since the September 1981, Knoxville workshop. Research studies have provided information needed to achieve some of the goals described in proceedings of the Knoxville workshop (USGS Open-File Report 82-220). Other actions are in the beginning stages.

3) Many realistic steps and activities for improving earthquake awareness and increasing concern can be identified, but most have not yet been implemented in the Northeast.

4) Although the actions which will make a home safer in an earthquake are becoming well known (e.g. "How to Survive an Earthquake," by Lafferty, (1982)), most of the actions have not been implemented in homes in the Northeast, even by members of the earthquake preparedness community.

5) A New England Regional Council should be formed, as a minimum, to act as a resource, coordinator, and initiator of seismic safety policy in the Northeast.

ACKNOWLEDGMENTS

A special note of appreciation is extended to each of the following individuals for the contributions:

1) The Steering Committee of Walter Anderson, Joseph Fischer, Ugo Morelli, Paul Pomeroy, Philip McIntire, Andrew Murphy, Claire Rubin, and Susan Tubbesing, Paula Gori and Walter Hays. They planned and organized the workshop.

2) The participants who joined in the plenary sessions and the discussion groups were the key to the success of the workshop. Their vigorous and healthy exchange of ideas made the workshop pratical and interesting.

3) Robert Whitman provided valuable assistance in arranging for conference facilities at MIT.

4) Nafi Toksoz and Robert Whitman provided logistical support throughout the workshop.

5) Carla Kitzmiller, Joyce Costell, Cheryl Miles, Susan Kibler, Diana Darnell, Beth Bufa, Lynne Downer, Wanda Fuller, and Peggy Randalow provided strong and capable administrative support.

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EVALUATION OF THE BOSTON WORKSHOP ON CONTINUING ACTION TO REDUCE LOSSES FROM EARTHQUAKES IN THE NORTHEASTERN UNITED STATES: ANALYSIS AND RESPONSE OF PARTICIPANTS

by

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At the conclusion of the two-and-a-half day gathering, participants were asked to evaluate the success of the workshop in reaching its goals, to rate various activities, and to estimate possible changes in awareness and concern as a result of having taken part. The workshop was designed to define the earthquake threat in the Northeast, describe current capabilities for responding to an earthquake in the Northeast, develop strategies to increase awareness and concern, recommend future research, and encourage the formation of seismic safety organizations.

Responses were elicited on a five-point scale, 1 and 2 representing the lowest level of agreement, 3 moderate agreement, and 4 and 5 highest agreement, or a "yes" response (see Figure 1). Since not all respondents answered all the questions, percentages are based only on those who submitted evaluations (see Figure 2).

Evaluations returned by 31 participants indicate that the workshop was successful in meeting its goals Seventy-five percent of the evaluators thought the workshop did a moderate to good job of defining the earthquake threat in the Northeast. However, over 70% felt that the workshop did a less than adequate job when it came to providing information dealing with current response capabilities. Respondents were somewhat more impressed with the workshop's role in developing strategies to increase awareness and concern. Response was similarly mixed in evaluating the success of the workshop in recommending future research. One-quarter of the respondents viewed the workshop as only slightly helpful in this regard, while nearly half thought it

FIGURE 1

Evaluations of the Workshop by Individual Participants

	Low 1	2	3	4	High 5
1. Did you find the conference to be useful for:					
a. defining the earthquake threat in the Northeast?	2	7	9	7	7
b. describing the current capabilities of responding to an earthquake in the Northeast?	4	13	8	4	3
c. developing strategies to increase earthquake awareness and concern?	0	7	13	6	5
d. recommending future research?	0	8	14	8	2
e. formulating future seismic safety organizations?	0	3	6	12	8
2. Did the conference benefit you or your organization by:					
a. providing new sources of information and expertise you might want to utilize in the future	0	3	8	13	7
b. establishing better understanding of the problems faced by researchers and decisionmakers	0	2	7	12	11
3. Did you find the following activities useful:					
a. formal presentations?	0	1	3	22	3
b. discussions following the formal presentations?	0	3	9	12	5
c. small discussion groups?	0	1	9	12	5
d. discussion groups based on regional representation	0	3	6	17	4
e. informal discussions during coffee breaks, lunches, and after hours?	0	5	7	10	9
f. notebook and abstracts	0	3	7	12	7
4. If the clock were turned back and the decision to attend the workshop were given you again, would you want to attend	0	1	1	12	17
5. Should future workshops be planned to continue the work initiated at this meeting?	1	1	1	12	15
6. Prior to attending this workshop, I would rate my <u>awareness</u> of the earthquake threat in the Northeast as	0	6	5	6	14
7. Prior to attending this workshop, I would rate my <u>concern</u> about the state-of-earthquake preparedness in the Northeast as	3	7	9	3	11
8. I now rate my awareness as	0	0	1	9	18
9. I now rate my concern as	0	1	8	8	14

FIGURE 2

Evaluations of the Workshop by Percentages of Participants

	Low 1 & 2	3	High 4 & 5
1. Did you find the conference to be useful for:			
a. defining the earthquake threat in the Northeast?...	27%	27%	45%*
b. describing the current capabilities of responding to an earthquake in the Northeast?.................	55%	26%	22%
c. developing strategies to increase earthquake awareness and concern?............................	22%	42%	35%
d. recommending future research?......................	26%	45%	32%
e. formulating future seismic safety organizations?...	10%	19%	65%
2. Did the conference benefit you or your organization by:			
a. providing new sources of information and expertise you might want to utilize in the future............	10%	26%	65%
b. establishing better understanding of the problems faced by researchers and decisionmakers............	6%	22%	74%
3. Did you find the following activities useful:			
a. formal presentations?.............................	3%	10%	80%
b. discussions following the formal presentations?....	10%	29%	55%
c. small discussion groups?..........................	3%	29%	55%
d. discussion groups based on regional representation.	10%	19%	68%
e. informal discussions during coffee breaks, lunches, and after hours?.................................	16%	22%	61%
f. notebook and abstracts............................	10%	22%	61%
4. If the clock were turned back and the decision to attend the workshop were given you again, would you want to attend?..	3%	3%	93%
5. Should future workshops be planned to continue the work initiated at this meeting?.......................	6%	3%	87%
6. Prior to attending this workshop, I would rate my awareness of the earthquake threat in the Northeast as.	19%	16%	65%
7. Prior to attending this workshop I would rate my concern about the state-of-earthquake preparedness in the Northeast as..................................	32%	29%	45%
8. I now rate my awareness as............................	-	3%	87%
9. I now rate my concern as..............................	3%	26%	71%

*Percentages may not equal 100% as not all respondents answered all questions.

was moderately helpful, and roughly one-third said it was quite successful. In terms of the workshop's contribution to starting up seismic safety organizations, the meeting was given moderate to high marks by nearly 85% of the participants who submitted evaluations (see Figure 2).

In order to determine in what specific ways the meeting was useful to participants, questions addressed sources of information and how they provided a better understanding of the seismic problem in the East. Nearly 65% of the respondents gave the workshop high marks for providing new sources of information or expertise, and another 26% were at least moderately happy with new sources suggested by the workshop.

Certainly a major achievement of the workshop was the extent to which it gave participants an appreciation of the problems faced by decisionmakers. Seventy-four percent said that the workshop was very successful in providing a better understanding of problems faced by decisionmakers, and 22% said that it was at least partially successful in this area.

To indicate which activities were viewed as the most useful, participants were asked to rate formal presentations, follow-up discussions, small group discussions, regionally defined groups, informal discussions, and materials such as notebooks and abstracts. Formal presentations received the most enthusiastic evaluation; 80% of the respondents judged them to be highly useful. Follow-up discussions and small group discussions were a bit less valuable, but still were judged by more than half of the group to be very useful and by one-third to be moderately useful. Small groups which had been regionally defined received high marks from nearly 70% of the respondents. Informal discussions and materials were seen to be valuable parts of the meeting (see Figure 2).

The importance attached to this workshop is shown in the response of 95% of those submitting evaluations that they would, knowing what to expect, attend similar workshops. Nearly as many respondents strongly agreed that future workshops should be planned to continue work initiated at this gathering.

The most interesting and significant impact of the workshop has been its influence on heightening levels of awareness and concern. Significant numbers of participants (19%) reported their levels of awareness prior to the workshop would have best been described as low. Sixteen percent rated their levels of awareness as moderate, and 65% rated them as high before the workshop. Following the workshop, no participant felt his or her awareness was low; only 13% considered their awareness moderate, while 87% judged their awareness to be high. Similarly, levels of concern were heightened significantly by participation. Before the workshop, concern was judged to have been low by nearly one-third of the respondents, with 29% registering moderate concern and only 45% high concern. After the workshop, participants revised their perceptions of concern significantly; only 3% defined their levels of concern as low, 26% said they were moderate, and 71% said they were highly concerned about the seismic hazard potential in the Northeastern United States.

Looking at individual responses, it can be seen that only one person registered a decline in level of concern after participating in the workshop, and 12 of the 31 respondents registered no post-workshop changes in levels of awareness or concern. However, of these 12, eight identified themselves prior to the workshop as already possessed of great awareness and concern, and they remained in those categories. The remaining 58% (18) showed increases in level of awareness or concern or both after taking part in the workshop.

Another important judgment of the success or failure of a workshop can be made by looking beyond the impacts it had on attitudes, to ways in which it may have affected behavior. In order to determine whether the workshop had any long-term effect on the behavior of participants, the final question on the evaluation sheet asked respondents to consider actions they might take to improve the awareness and concern of others or to implement mitigation activities in the Northeast. Response to this question was varied, and reflected the range of levels of experience and knowledge present in the group.

Some of the participants had been actively carrying out research in the field and came, in some cases from other parts of the country, to share this knowledge. Others had been charged with responsibilities at the Federal or State level to improve hazard mitigation programs. These participants also had a range of experience; some had lengthy involvement and others were rather new to the issue of northeastern seismicity. It is evident from their responses that the workshop both reinforced ongoing activities and generated new and innovative ideas. Among the future activities were plans to continue support and participation in a northeastern regional seismic safety council and to begin lobbying and educational efforts directed toward States and professional associations, including those active in building code development. Among proposed new initiatives was one urging the incorporation of hazard information in public school curriculum to improve understanding of natural hazard issues.

As part of this workshop evaluation, a number of the participants were contacted subsequently to learn whether on not they had taken any action to carry out proposed activities. Since the workshop, efforts have in fact been moving forward to organize not one, but two regional seismic safety councils, one designed to serve the New England region and the other for New York State. Activities related to more stringent building codes and design standards are by nature long-term and show incremental progress, but in this area as well there has been some progress.

The need to improve public understanding of geologic process and other natural hazards is well recognized and has been cited in many of the preceding U.S. Geological Survey workshop open file reports devoted to seismic hazard reduction. Activities devoted to improving the understanding of hazards for the general public have been documented in Saarinen's Cultivating and Using Hazard Awareness, Environment, and Behavior, Univesity of Colorado, 1983, by Regulska and Nigg, and by McCabe in the Earthquake Information Bulletin. Activity in this area has been started with the support of FEMA and the USGS in California through the SCEPP project, in the Midwest at the University of Tennessee through the Earthquake Information Center, and in the Southeast at Baptist College of Charleston.

From the evaluations it can be seen that a logical and desirable outcome of the workshop would be that the regional seismic safety councils in the Northeast be funded to provide necessary ongoing support to the kinds of long-range mitigation programs now going on in other parts of the country, and especially to heighten the public understanding of seismicity in the Northeastern United States.

REPORT OF NEW YORK, NEW JERSEY, PENNSYLVANIA STUDY GROUP ON THE QUESTION OF A REGIONAL SEISMIC SAFETY ORGANIZATION

by

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FORWARD

This report was developed at the workshop on "Continuing Actions to Reduce Potential Losses from Future Earthquakes in the Northeastern United States" by members representing the New York-New Jersey-Pennsylvania Study Group. The members discussed the two questions proposed in the plenary session:

1) Does a regional seismic safety organization offer additional capabilities to the States to: a) increase hazard awareness, b) list support of business and industry, political officials, public service organizations, professional societies, and volunteer agencies, c) implement earthquake-resistant design, and d) support scientific, engineering, and social science research?

2) What are the first steps which a regional seismic safety organization should take to confront the issues associated with the topics listed above?

The membership of the discussion group included:

Christopher Arnold	Building Systems Development, Inc.
Mike Augustyniak	New Jersey Office of Emergency Management
Joyce Bagwell	Baptist College at Charleston

Goetz Buchbinder	Earth Physics Branch (Ottowa)
Joseph Fischer (Recorder)	Geoscience Associates
Walter Hays	U.S. Geological Survey
David Herper	New Jersey Geological Survey
Philip McIntire	Federal Emergency Management Agency-Region II
Stanley McIntosh	Federal Emergency Management Agency-Region II
Walter Mitronovas	New York State Geological Survey
Ugo Morelli	Federal Emergency Management Agency
Douglas Nilson	Arizona State University
Paul Pomeroy (Chairperson)	Rondout Associates, Inc.
Charles Ridgeway	American Red Cross in Greater New York
Claire Rubin	George Washington University
Leonardo Seeber	Lamont Doherty
Clement Shearer	U.S. Geological Survey
Etta Sims	Federal Emergency Management Agency-Region III
Susan Tubbesing	University of Colorado

INTRODUCTION

The discussion was structured to allow the group to establish a positive response to the questions listed above. Members of the group who had attended both the Knoxville and Boston workshops felt that the groundwork had been laid for planning the mitigation of the possible effects of a damaging earthquake in the Northeast. On the basis of these two meetings a series of assumptions were made about the existing political, social, and technical environment. These assumptions provided a basis for addressing whether or not a seismic safety organization is needed, and if such a need exists, what initial tasks should the seismic safety organization attempt. Finally, the discussion centered on the group's ideas as to the implementation process that would lead the formation of a functioning committee.

The assumptions, listed below, used to define the goals and processes of the hypotetical regional seismic safety organization, are not deemed ideal. Therefore, the tasks and implementation process suggested below should be considered as preliminary. The suggestions do, however, represent a consensus of the group about the most expedient process available at the time of the workshop, with the goal of saving lives in potential future earthquakes.

The assumptions made by the group are:

1. A council (or councils) is (are) needed to achieve hazard mitigation in the Northeast.

2. "Top down" planning is necessary at this time, (but not to the exclusion of all other input at a later date).

3. Our current "best estimate" is that the level of the earthquake hazard varies in the Northeast (which includes Eastern Canada), and hence must be considered as such in future technical and political deliberations.

4. The level of the earthquake hazard in the Northeast is not high enough to rate significant economic interest from the public, local governments, developers, bankers, and others.

5. The level of the earthquake hazard in the Northeast is high enough, however, to create concern for potential loss of life.

6. The operation of the Agency of the Federal Government (FEMA) most concerned with the implementation of disaster mitigation measures in the Northeast (as discussed at the Knoxville Workshop - see USGS Open-File Report 82-220) is divided into three separate regions. Although the generic hazard (and its possible variations) is generally similar in FEMA's Regions I, II, and III in the Northeast, the political constraints cause by the separation require consideration in any creation and functioning of a regional seismic safey Organization.

RECOMMENDATIONS

The discussion group recommended that two seismic safety organizations be created, one for the New England States and one for New York-New Jersey-

Pennsylvania. One regional seismic safety organization would actually be preferred, but the political and regional constraints suggest that one organization may not be practical. Furthermore, the discussion group felt that the implementation process should begin immediately, otherwise the impetus provided by the Knoxville and Boston workshops (and perhaps even the concern evidenced by the Federal Government and the attendees) would fade.

The discussion group suggested the following list of major tasks for the regional seismic safety organization(s):

1. Define a "consensus" earthquake hazard for the Northeast.

2. Work toward implementing building code modifications appropriate for the Northeast.

3. Interface with FEMA to assure that emergency response plans for earthquakes (and earthquake-induced situations) also incorporate consideration of the possible secondary effects of strong ground-shaking (e.g. fire, dam failure with resulting flood hazard, lost communication, chemical spills from damaged tanks, etc.). Such considerations could be achieved by altering existing conventional emergency response plans.

4. Identify significant hazards, whether manmade or natural, that could increase the potential for loss of life in an earthquake.

5. Establish an <u>appropriate</u> awareness program (both public and professional groups).

6. Identify research goals that will enhance progress in preparedness.

7. Interface with appropriate Canadian agency counterparts (for example, the Earth Physics Branch of the Department of Energy, Mines, and Resources).

8. Interface with other counterparts, both within FEMA and the public domain, who are concerned about earthquake hazards.

9. Establish relationships with the media to: a) aid in the dissemination of useful information, b) increase political and public awareness to a realistic level of concern, and c) aid in completing the task of the regional seismic safety organization(s), when appropriate.

The discussion group suggested an implementation process to create the seismic safety organization(s), having the following steps:

1. FEMA must be the leading force in the initial creation of the seismic safety organization(s) (i.e. give birth, organize, fund, etc.). USGS must provide initial, technical, managerial, and financial support, as required.

2. The seismic safety organization(s) should be staffed, with consideration given to the following disciplines and characteristics:

    a) Chairman (strong leader)
    b) Administrative assistance (provided initially by FEMA)
    c) Planner
    d) Seismologist
    e) Translator (one who translates scientific results into a useable format for non-scientists)
    f) Social scientist
    g) Structural engineer
    h) Geotechnical engineer
    i) Architect
    j) Banker/Insurer
    k) Community leaders
    l) Educator

(Note: These disciplines are not necessarily mutually exclusive)

3. Establish liaison with Governors' and legislators' staffs. Also establish liaison with State geologists and State offices of emergency services in the Northeast. Interact with Northeast Governors Council.

4. Establish liaison with South Carolina Seismic Safety Consortium and other State seismic safety organizations to take advantage of their experience.

5. Prepare a Science/Environmental Educational package and dissiminate it to the appropriate institutions, agencies, and the public sector.

6. Develop a work plan having specific goals.

CONCLUSION

The discussion group representing New York-New Jersey-Pennslyvania believe that two regional seismic safety organizations, serving the interests of the New England Region and New York-New Jersey-Pennslyvania, would be the practical and effective way to achieve a realistic seismic safety policy in the Northeast. Before two seismic safety organizations are created, consideration should be given to the feasiability of accomplishing the goals of both the New England Region and New York-New Jersey-Pennsylvania by one seismic safety organization.

REPORT OF NEW ENGLAND STUDY GROUP ON THE QUESTION OF A REGIONAL SEISMIC SAFETY ORGANIZATION

by

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FORWARD

This report was developed at the workshop on "Continuing Actions to Reduce Potential Losses from Future Earthquakes in the Northeastern United States" by members representing the New England Region Group. The members discussed the two questions proposed in the plenary session:

1) Does a regional seismic safety organization offer additional capabilities to the States to: a) increase hazard awareness, b) list support of business and industry, political officials, public service organizations, professional societies, and volunteer agencies, c) implement earthquake-resistant design, and d) support scientific, engineering, and social science research?

2) What are the first steps which a regional seismic safety organization should take to confront the issues associated with the topics listed above?

The membership of the discussion group included:

Bud Andress	Federal Emergency Management Agency
Andrew Ball	Federal Emergency Management Agency-Region I
John Ebel	Weston Observatory
Edward Fratto	Massachusetts Civil Defense Agency
Paula Gori	U.S. Geological Survey
Kenneth Horak	Federal Emergency Management Agency-Region II
Pamela Johnston	Office of Civil Defense-Virgin Islands

Ralph Lewis	Connecticut Geological Survey
Kevin Merli	Federal Emergency Management Agency-Region II
Andrew Murphy	Nuclear Regulatory Commission
Russell Needham	U.S. Geological Survey
Risa Palm	University of Colorado
Dan Prewitt	American Red Cross
Anthony Prud'homme	Atlantic Richfield Company
Jay Pulli	Massachusetts Institute of Technology
Sidney Quarrier	Connecticut Geological Survey
Norton Remmer (Chairperson)	City of Worchester
Howard Simpson	Simpson, Gumpertz, and Heger, Inc.
David Sparks	Federal Emergency Management Agency-Region I
Edward Thomas	Federal Emergency Management Agency-Region I
Nafi Toksoz	Massachusetts Institute of Technology
Ann Trehu	U.S. Geological Survey
Stacy Webber	Federal Emergency Managment Agency
Ken Weisner	LeMessurier Associates/SCI
Robert Whitman	Massachusetts Institute of Technology

INTRODUCTION

The two questions listed above were discussed thoroughly at the workshop. In addition, one issue was reviewed--whether there should be two regional councils which would represent New England as one separate entity and New York, Pennsylvania and New Jersey as another.

SUMMARY OF DISCUSSIONS

The consensus of the New England Regional Group was to retain New England as a separate regional entity. This conclusion was based primarily on physical proximity, long standing existing cooperation, regional involvement, and close political ties. The conclusions of the group included:

1. A New England Regional Council should be formed to act as a resource, coordinator, and initiator of seismic hazard reduction programs for the New England Region. The Council would act as an advisor to the State governments and work with FEMA in coordinating government programs.

2. The following steps could establish the Regional Council:

   - FEMA will act as the agent to form a Steering Committee for the creation of the Regional Council. The Steering Committee would include members from the existing advisory panel for the Massachusetts Civil Defense Agency's Earthquake Preparedness Project, members of the Massachusetts Seismic Design Advisory Committee and others from the New England Region, including representation by social scientists.

   - FEMA would provide technical advice and possibly some administrative assistance.

   - FEMA would consider the possibility of appropriating about $10,000 to provide funding for the establishment and operation of the Council.

3. After creation, the Steering Committee will recommend and appoint the membership of the full council.

4. The council would proceed to develop its work plan.

5. The Regional Council would seek endorsement from the New England Governor's Council as a basis for providing it with formal recognition in its role of fostering regional seismic hazard mitigation programs.

The New England Group suggested three areas of emphasis for the work of the Regional Council:

1. Evaluation of the seismic hazard

2. Building code and building design practices

3. Pre-and-post-disaster preparation

The objectives associated with each area of emphasis in the Regional Council's work include:

1. Definition

2. Understanding

3. Implementation

CONCLUSION

The New England Group felt that a regional council was the most effective method for developing the resources and coordination necessary to produce programs that were meaningful. The group recognized that Massachusetts, which has a detailed seismic code, mandatory enforcement since January 1, 1975, and a Seismic Advisory Committee, has the most experience in the region. Many of the individuals involved in these efforts could provide the nucleus for the development of the Steering Committee and regional council.

EVALUATION OF EARTHQUAKE HAZARDS IN THE NORTHEASTERN UNITED STATES

by

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INTRODUCTION

Earthquake hazards (natural phenonmena accompanying an earthquake, such as ground shaking, surface fault rupture, tectonic deformation, and earthquake-induced ground failure) are not the dominant hazard in the Northeastern United States. Hurricanes, winter storms, and flooding occur more frequently than damaging earthquakes and receive more attention.

This paper reviews the basic principles of earthquake hazards, explaining in simple terms what an earthquake is and how the scientific community describes and categorizes an earthquake and its physical effects. In the Northeastern United States, it is easy to misunderstand the level, the significance, and the nature of the earthquake hazard and the risk (chance of loss). Knowledge of the frequency of occurrence, the physical effects, and the earthquake potential of the Northeastern United States lags behind that of the Western United States, making the evaluation of earthquake hazards a difficult task. The awareness about earthquakes of an individual living in the Northeastern United States is generally based on accounts in the media of California earthquakes, which occur much more frequently than in the Northeasten United States (a great earthquake in California occurs about once every 150 years; whereas, a great earthquake in the Eastern United States occurs about once every 1000 years, or so). This fact causes the level of concern to be lower and the rate of implementation of earthquake-resistant design and other mitigation measures in the Northeast to be a more difficult process than in California.

THE PROBLEM

A typical community in the Northeast (shown schematically in Figure 1) must evaluate the threat from earthquake hazards, taking into consideration the structure or facility exposed to the threat and its functional lifetime and uses. (Consideration must also be given to other natural and technological hazards.) Scientists and engineers analyze basic data when evaluating

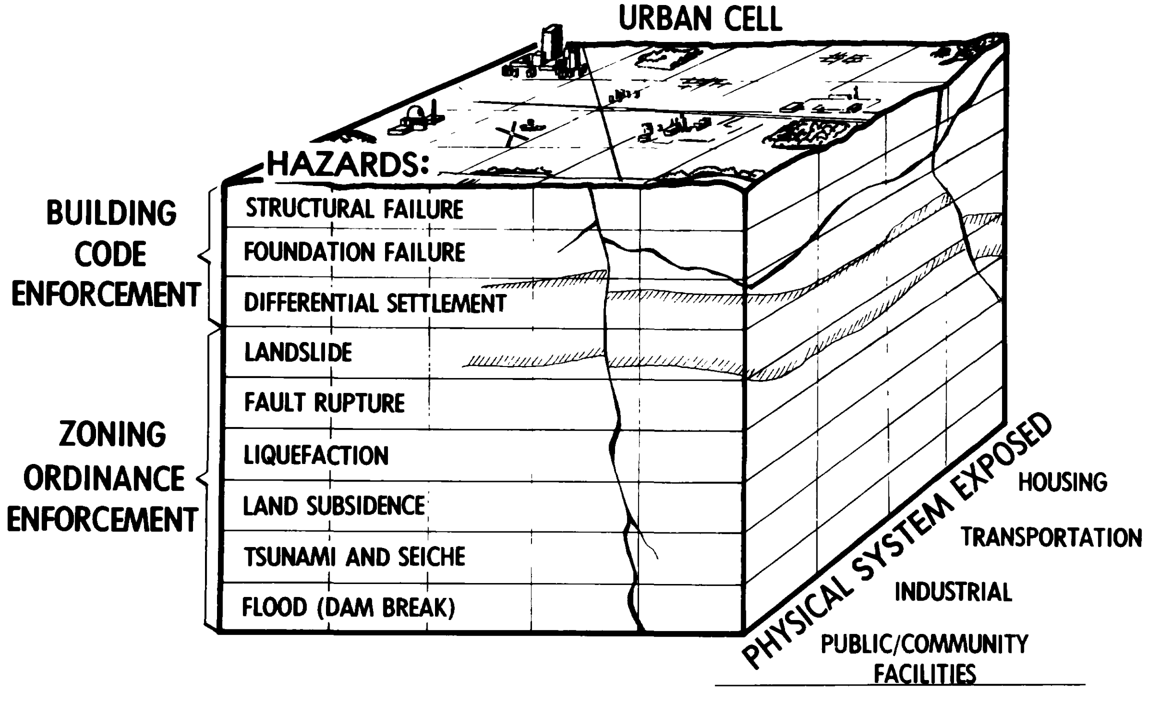

Figure 1.--Schematic illustration of a typical community in the Northeastern United States having housing, industrial, transportation, and public/community facilities exposed to the earthquake hazards of ground shaking, surface fault rupture, tectonic deformation, and earthquake-induced ground failures.

earthquake hazards of ground shaking, surface fault rupture, tectonic deformation, and earthquake-induced ground failure to obtain answers to the questions: **"WHERE?, HOW OFTEN?, HOW BIG?, HOW SEVERE?, and WHAT ARE THE OPTIONS?"** The decisionmaking process integrates all of the scientific and engineering information to determine the appropriate mitigation measures.

DESCRIPTION OF AN EARTHQUAKE

An earthquake can be described by a magnitude scale (see Figure 2) (of which there are several; for example, body wave magnitude (M_b), Richter magnitude (M_L), surface-wave magitude (M_S), and moment magnitude)) and an intensity scale (for example, the Modified Mercalli intensity scale). Magnitude is a numerical quantity (expressed in Arabic numbers on the logarithmic scale) determined from instrummental records that is characteristic of the total energy released by the

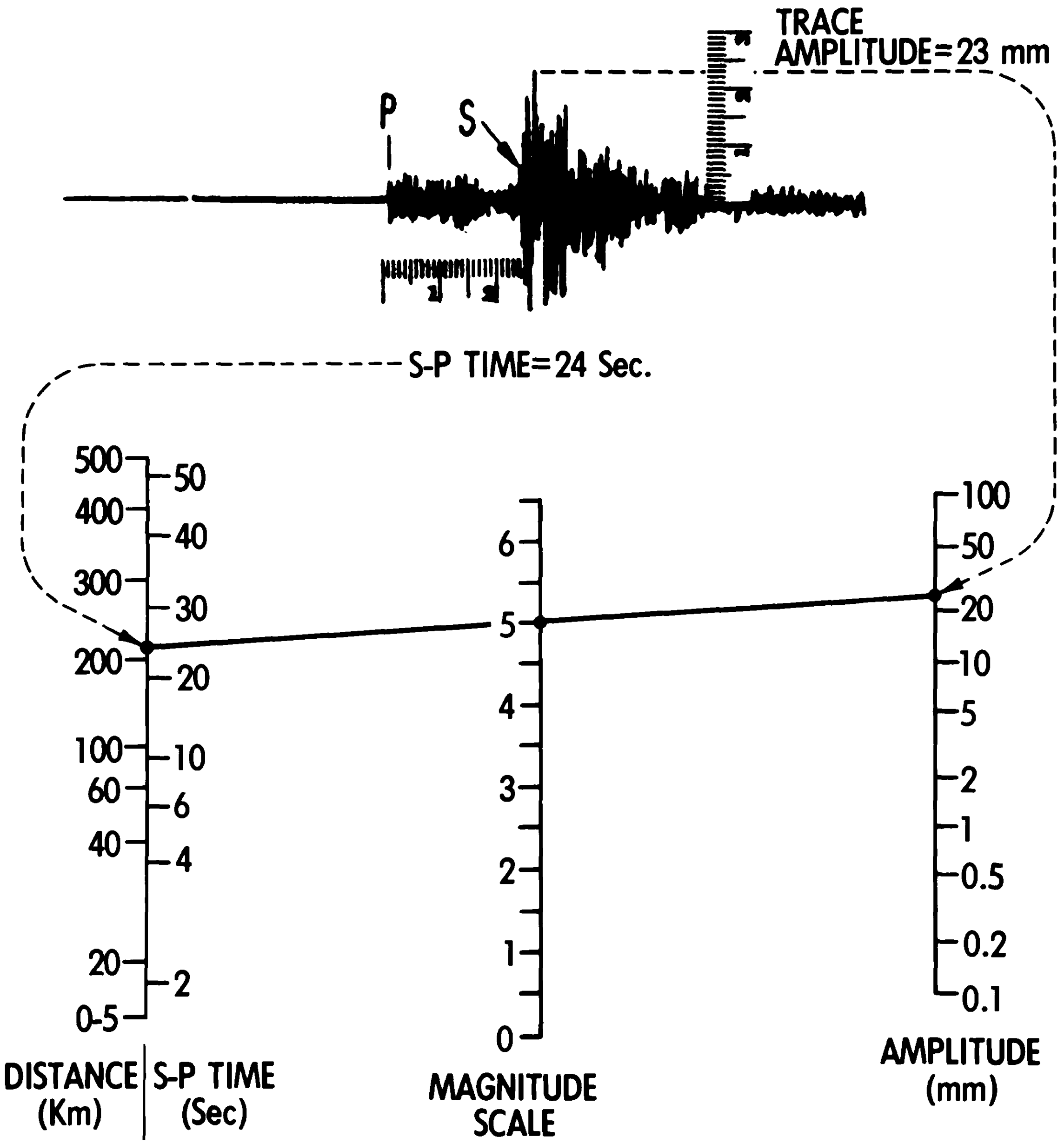

Figure 2.--Illustration showing how a magnitude is assigned to an earthquake.

earthquake; whereas, intensity is a numerical index indicated by Roman numerals from I to XII describing the effects of an earthquake on the Earth's surface, on man and on structures build by him. An earthquake is assigned one value of magnitude and many values of intensity.

The causative mechanism for Northeastern United States earthquakes are thought to be different than those for California. Consequently, the effects of a damaging earthquake upon an unprepared populace and structures, not designed to withstand ground shaking, are likely to be markedly different. The transferability of a Western United States data base defining earthquake ground-motion parameters, (such as peak acceleration, time histories, response spectrum, and attenuation of ground motion with distance) is not a straight forward process and may be misused in the Northeastern United States unless considerable care is taken.

DISCUSSION OF THE PROCESS

Figure 3 illustrates schematically the steps that are involved in evaluating the seismic hazards of ground shaking, surface fault rupture, and earthquake-induced ground failure for structures and facilities of various kinds.

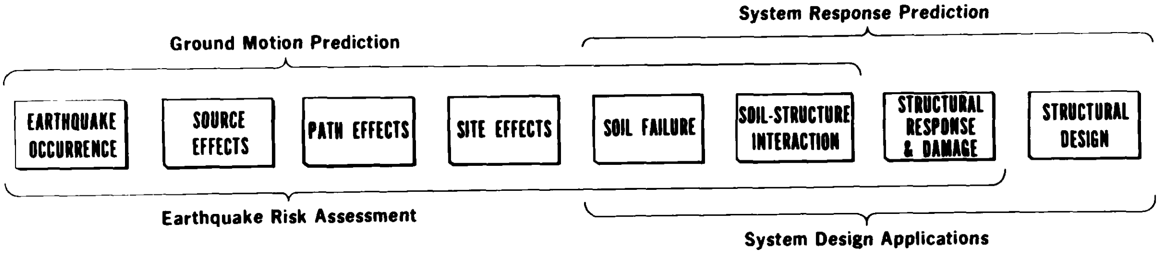

Figure 3.--Schematic illustration showing the steps involved in evaluating earthquake hazards.

To quantify the earthquake hazards satisfactorily, it is necessary to establish a state-of-the-art understanding of:

1. theory of plate tectonic,
2. temporal and spatial distribution of historical earthquake activity,
3. regional geologic structure, identifying potential candidates for future seismic activity,
4. contemporary stress regime of the region,
5. seismic-wave attenuation of the region (Figure 4),
6. regional damage distribution and physical effects of historical earthquakes, and
7. the effect of local (near-surface) soil and rock on ground motion.

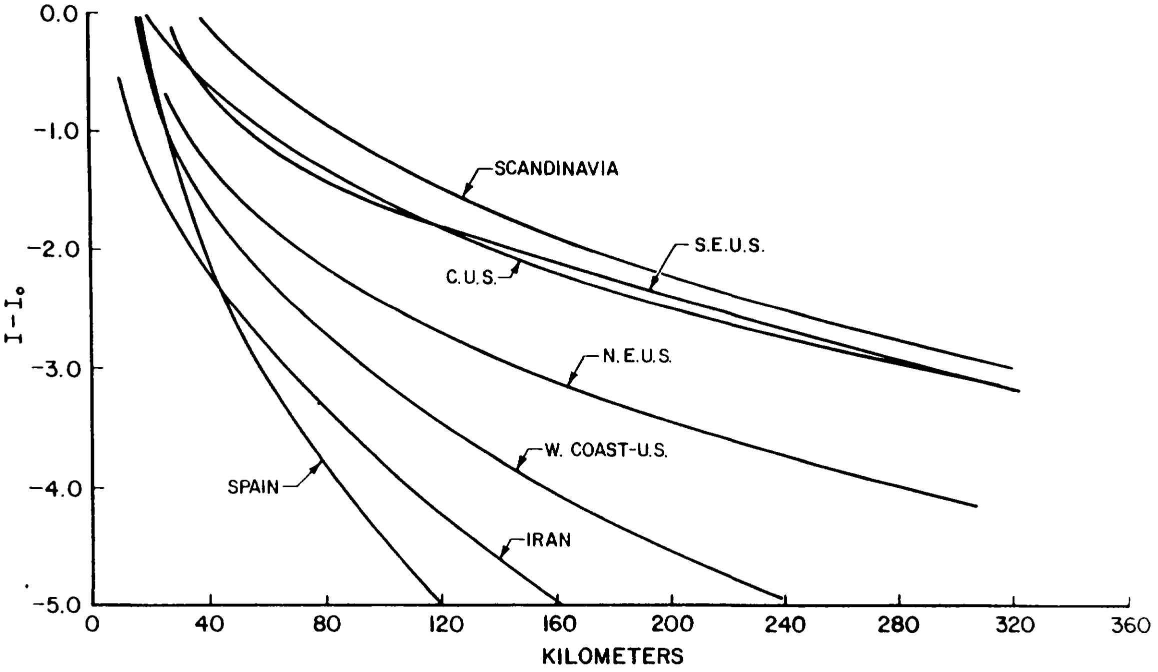

Figure 4.--Comparison of seismic-wave attenuation relations.

Two sites in the upstate New York area located in different tectonic regimes were selected for a range of results for discussion. The results of the evaluation are presented in Table 1. Two cut off points were selected on the graphs of intensity versus frequency of occurrence. The first cut off was simply the maximum earthquake experienced in the source region. The second cut off was a linear extrapolation to an intensity level one unit greater than that indicated by the record of historical seismicity.

The hazard estimates differ widely, even though from two relatively nearby areas, typifying the difficulty the scientist can have in providing a realistic estimate of the level of earthquake hazard and risk in the Northeastern United States. In addition, the results demonstrate the difficulty the planner, engineer, businessman, public official, social scientist, and others have in their effort to mitigate, effectively and economically, the potential effects of a damaging earthquake in a region having low seismicity.

In the example, the probability of occurrence of a relatively major earthquake during the economic life of two different structures varied from a high of less than 1% to a very low probability. Whether these values are precise or not is unimportant. What is significant is that we are dealing with a seismic hazard level which is quite low for a particular location; however, if we extrapolate the hazard calculations to the possibility of a damaging earthquake occurring somewhere in the Northeast during our lifetime, the likelihood of such an earthquake becomes significant. A number of difficult questions must be addressed: **WHERE?, WHEN?, WHO DO YOU WARN?, WHO ISSUES THE WARNING?, HOW DO YOU COMMUNICATE THE LEVEL OF HAZARD AND RISK THAT EXISTS?, and IS IT SIGNIFICANT (AND ACCEPTABLE) IN THE CONTEXT OF OUR NORMAL LIFESTYLE?**

A difficult task is to specify the amount of damage and loss of life that will result from a potentially damaging earthquake in the Northeast. If it occurs in a desolate region, such as the locale of the recent New Brunswick earthquakes, the damage and loss of life probably will be minimal. But what if it is centered near Boston? Will the building code in effect in the Boston area mitigate the damage (at least, partially), or will the lack of seismic design experience of the local professionals negate the intent of the code provisions? What if the shock is centered near New London? Will the ancient gas pipe lines and the artificial fill along the shore line result in a conflagration rivalling the fire following the great 1906 San Francisco earthquake?

TABLE 1

Earthquake Probability -- Auburn Site

Assumption	Recurrence Interval	Probability of Occurrence During 25-Yr. Economic Life
Truncation at Intensity VI	VI - 17,000	.15%
Linear Extrapolation To Intensity VII	VI - 6,000	.42%
Linear Extrapolation To Intensity VII	VII - 39,000	.07%

Earthquake Probability -- Rouses Point Site

Assumption	Recurrence Interval	Probability of Occurrence During 50-Yr. Economic Life
Truncation at Intensity VIII	VIII - 19,000 yrs	.25%
Linear Extrapolation to Intensity IX	VIII - 7,000 yrs	.07%
Linear Extrapolation to Intensity IX	IX - 47,000 yrs	.01%

To place the earthquake hazard in the Northeastern United States in context, it is necessary to compare the earthquake hazard with other natural hazards such as; fire, flood, hurricane, tornado, etc. For example, the annual probability of experiencing a major earthquake is roughly 0.1%; whereas, the chance of New York City being hit by a major windstorm (hurricane or Beaufort force 12 storm) is on the order of 0.5% per year. The expected storm tide in a 100 year storm (annual probability of 1%) for portions of Long Island is about 16 feet above mean low water level.

This paper has presented some of the considerations that enter into the evaluation of earthquake hazards relative to other natural hazards? No final answers are given; the question is posed for others in this workshop to comment upon.

EARTHQUAKE HAZARDS IN THE NORTHEASTERN UNITED STATES -- SOME CONTRASTS TO CALIFORNIA

by

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INTRODUCTION

The Northeastern United States is a region subject to unequivocal earthquake hazard. There is a 350 year record of seismic activity in the area. Both the historic record of "felt earthquakes" and high quality instrumental data that have been gathered in the past ten years show that no part of the Northeastern United States is immune from earthquake hazard. This is illustrated by Figures 1 and 2 where both historical and recent instrumental epicenters are shown.

CHARACTERISTICS OF NORTHEASTERN SEISMICITY

Many characteristics of earthquakes in the Northeastern United States are different from those in California and other parts of the country. Some key properties of New England earthquakes are:

Fewer Earthquakes

The Northeastern United States has fewer earthquakes in general, and may never have an earthquake greater than magnitude 7. With fewer felt events, it is difficult to maintain public awareness and institutional responsiveness.

Earthquake Epicenters are Scattered

The majority of earthquakes in the Northeastern United States and especially those in New England can not be associated with well defined faults. There are many geologic faults, but it is not possible to identify a single fault

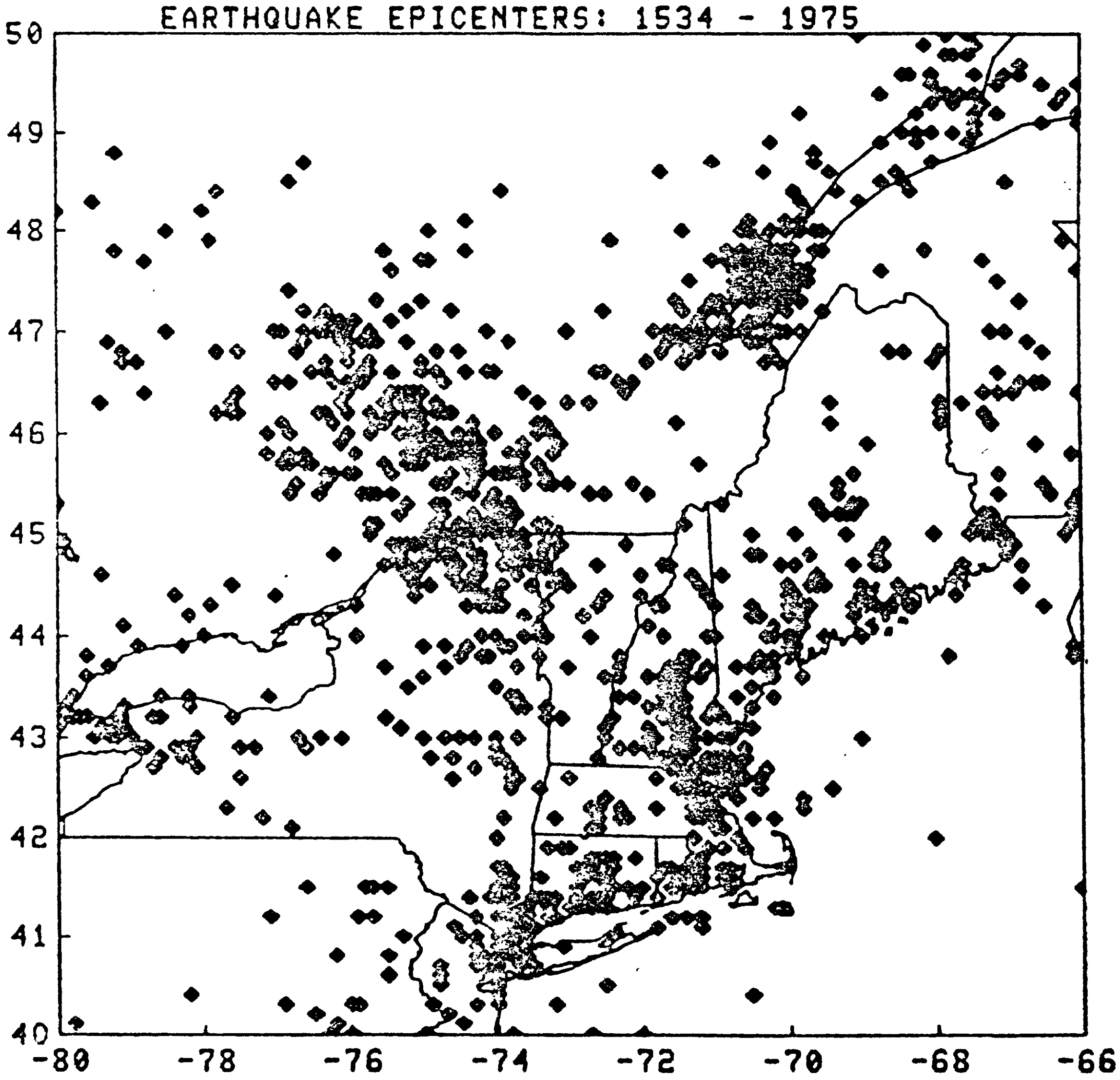

Figure 1.--The seismicity of the Northeastern United States and Southeastern Canada for the period 1534-1975.

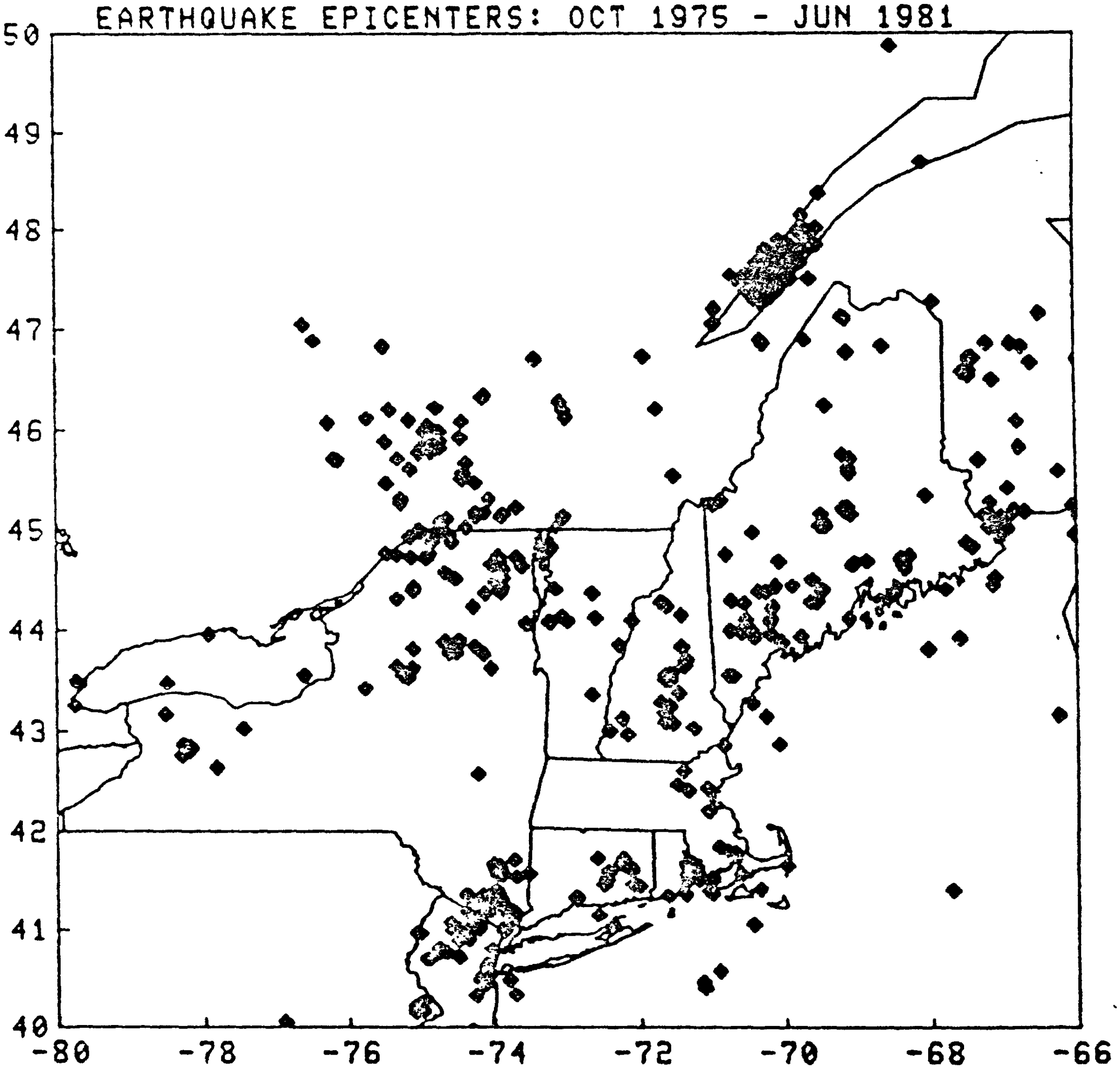

Figure 2.--Instrumentally located earthquakes in the Northeastern United States and Southeastern Canada covering the period 1975 through June 1981.

system such as the "San Andreas" to account for the majority of earthquakes. As a result, seismic zoning is more difficult and needs to be done primarily on the basis of seismicity rather than geology.

Attenuation is Low, Areas of Shaking is Greater

The attenuation of ground motion as a function of distance from the epicenter is much lower in the Northeastern United States than in California (Figures 3 and 4). As a result, an earthquake of a given magnitude can shake with the same intensity an area 100 times greater in New England than in California.

Higher Frequency Ground Motion

As it was learned from the January 1982 New Brunswick, Canada and Gaza, N.H. earthquakes, that the Northeast produces ground shaking at higher frequencies than those in California. This may be attributed to higher stresses at earthquake sources. As a result the response spectrum to be used in engineering design should be different in the Northeast than in California.

Contrasts Between Grenville (New York) and Appalachia (New England) Provinces

In addition to the differences betweem tectonic history, geology and crustal structure, the seismic characteristics of the two provinces are different. Earthquakes in the Grenville province seem to be produced by uniform regional stress, while those in the New England States are results of stresses which change rapidly (Figures 5 and 6). As a result it is more difficult to do seismic zonation in New England than in upper New York State, for example.

Impact of Climate

A damaging earthquake that might occur in a cold winter month in the Northeast would create a much greater hazard than if it was to occur in the summer. In winter more people would be indoors, making requirements for heat and shelter immediate and the relief effort slower. The Northeast must take these factors into account for emergency preparedness planning.

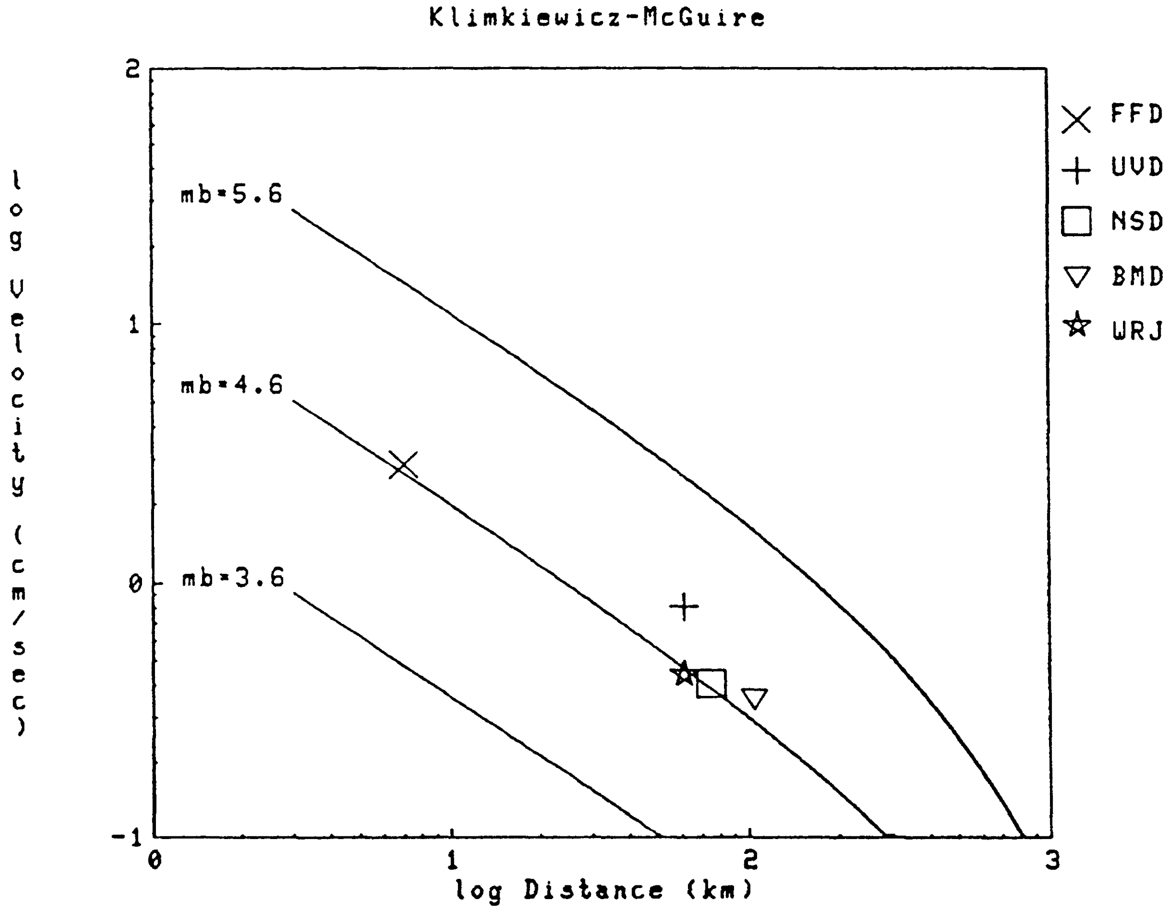

Figure 3.--Comparison of the strong motion data for the January 19, 1982, Gaza, New Hampshire, earthquake with the theoretical curves for New England.

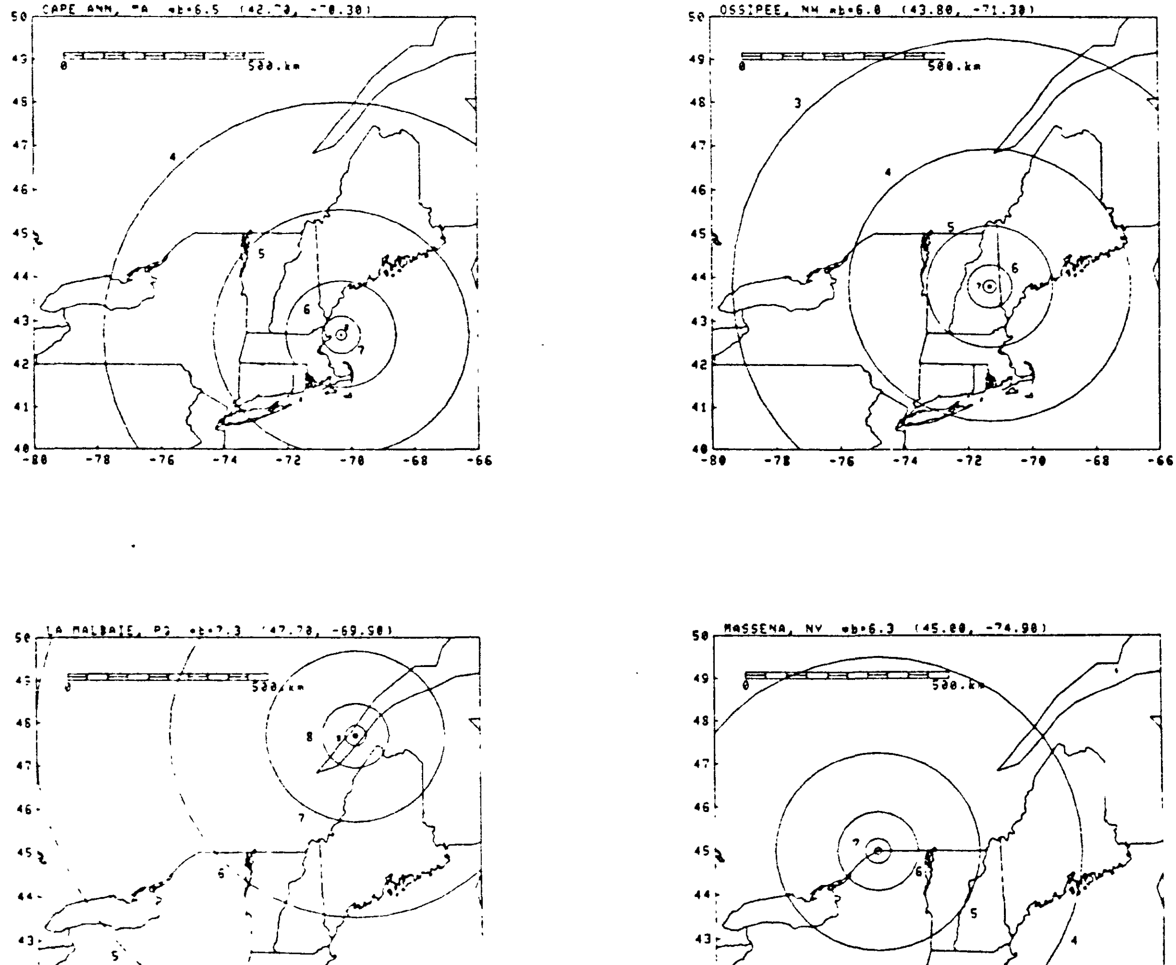

Figure 4.--Distribution of the Modified Mercalli intensities for four hypothetical earthquakes.

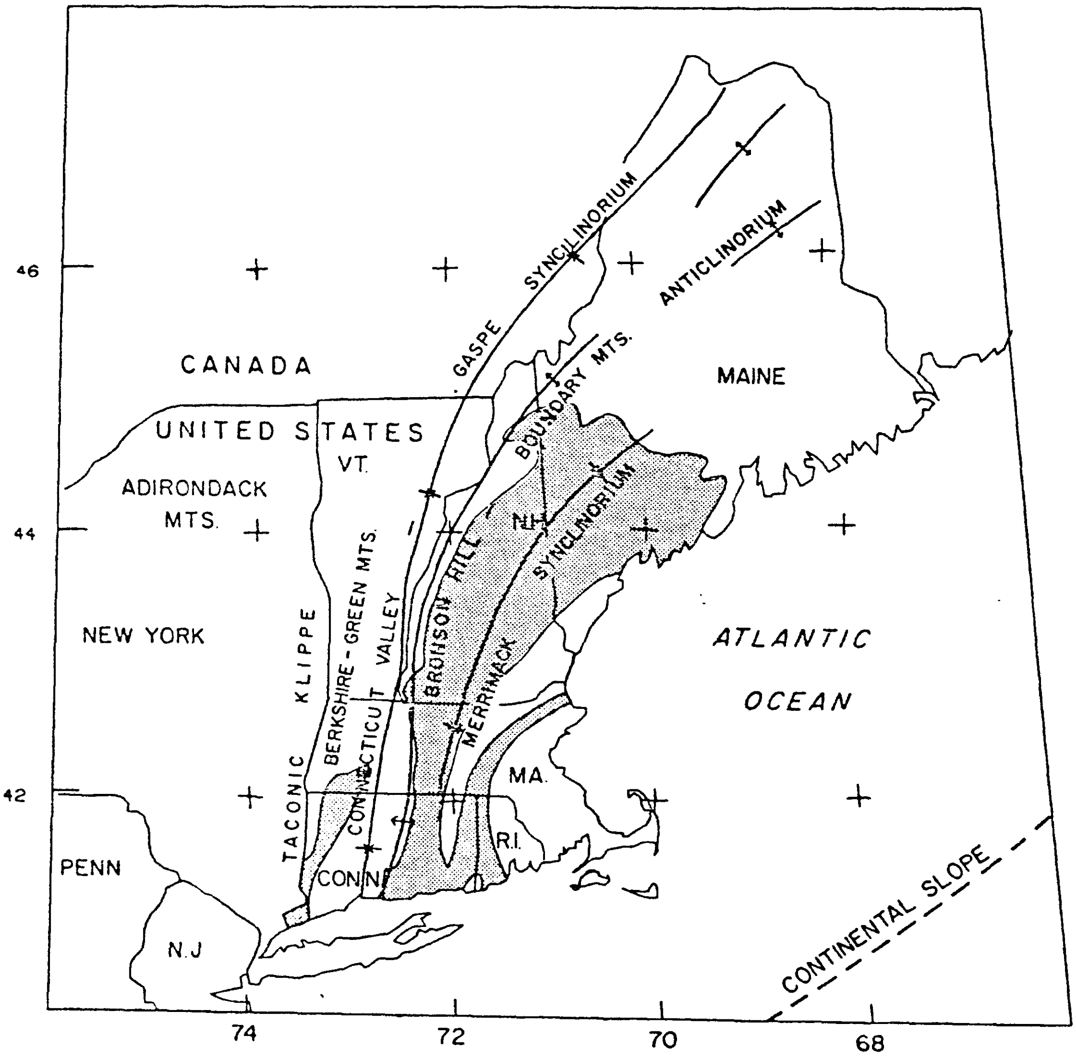

Figure 5.--Major structural and tectonic features of the Northeastern United States.

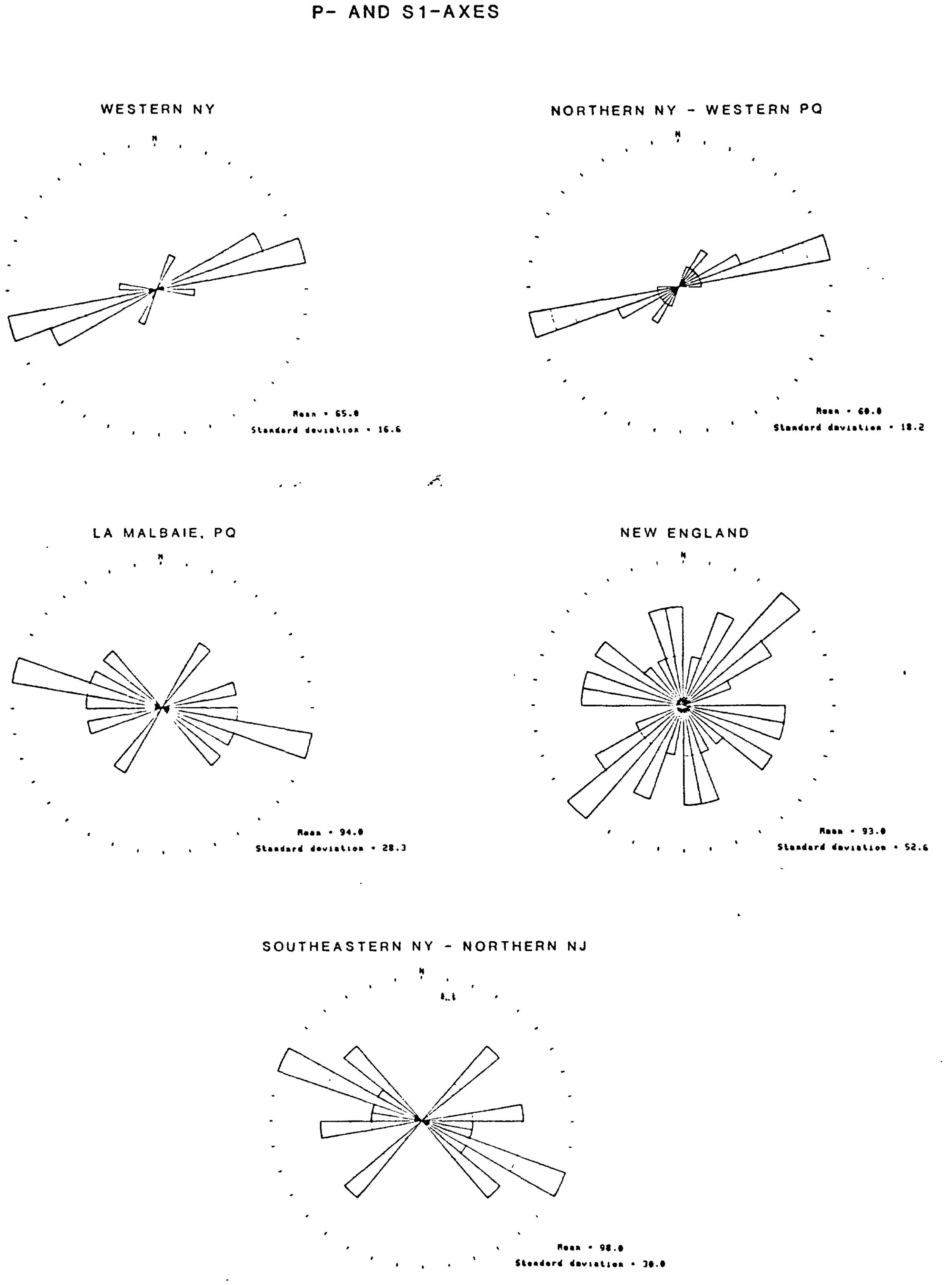

Figure 6.--Rose diagrams showing the distribution of fault plane strikes for the area west of the Appalachians (top) and east of and including the Appalachians (bottom).

SUMMARY

Although the Northeastern United States can learn much from the California earthquake experience, it should not adopt the California plans without appropriate adjustments in engineering design, education and emergency preparedness.

SOME RESULTS OF AND CONSEQUENCES FROM THE MIRAMICHI, NEW BRUNSWICK EARTHQUAKES OF 1982

by

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INTRODUCTION

The earthquake of magnitude (M) 5.7 that occurred on January 9, 1982, in the Miramichi region of New Brunswick was the largest event since 1944 in Eastern Canada and the largest in human memory in New Brunswick. The principal shock was felt generally to a distance of 400 km from the epicentre; and by a few occupants of high-rise buildings to distances of 800 km.

In spite of this, only minor isolated damage was caused, essentailly because it occurred in an uninhabited region. This event and those following in January and March produced a mass of data, information and papers. In the following, only a limited number of items will be discussed: a) historical seismicity, b) interpretation of the Miramichi mechanisms, c) strong motion recordings, d) seismic risk, e) Earthquake Response preparedness?

HISTORICAL SEISMICITY

The knowledge of moderate historical earthquakes in New Brunswick is quite limited. Two events with magnitudes greater than 5 occurred in southern New Brunswick or southeastern Maine in 1869 and 1904. Two events with magnitudes greater than 4 occurred in 1855 in southeastern New Brunswick and in 1922 in the Miramichi region. Beyond the immediate region of New Brunswick, large (M 7) earthquakes have occurred most recently on the continental slope south of Newfoundland in 1929 and in the Charlevoix zone, Quebec, in 1925.

The instrumental seismicity in recent years shows a relatively uniform distribution of M 3-4 earthquakes throughout New Brunswick, and concentrations of similar events in the Lower St. Lawrence and Charlevoix zones to the north and west.

INTERPRETATIONS OF MIRAMICHI MECHANISMS

The main shock of January 9 was followed for several months by an impressive aftershock sequence including an M 5.1 on January 9, M 5.4 on January 11, and M 5.0 on March 31. Each of the principal aftershocks was followed by its own aftershock sequence, and the one following the January 11 event was the most intense. Aftershocks have continued at low levels into 1983.

The distribution of the aftershock sequence was studied during field trips by the Earth Physics Branch and other organizations following the earthquakes of January 9 and 11 and the event of March 31. A study of some 158 January aftershocks showed that the sequence was located near 47^{o} N and 66.6^{o} W in a zone 4 km N-S and 6 km E-W with depths varying from 0 to 7 km. In an E-W section, the activity describes a "V" of which the eastern branch is poorly defined. The study of 77 aftershocks of the March 31 event has shown that the sequence was centered in a zone 3 km N-S by 2 km E-W with the depths varying from 0 to 4 km in the northeastern portion of the January sequence. The aftershock distribution and focal mechanism results are in agreement with conjugate thrust faulting with north-south strike; the January 9 and March 31 events are on the eastern limb and the January 11 event on the western limb.

Composite first motion studies of the aftershocks suggest that the dip of the thrust planes changes progressively with depth, steepening towards the surface. No primary rupture has been found at the surface following the main shocks, although a secondary crack has been found in the southern part of the aftershock zone of the January events. This north-oriented crack, about 2 m long shows thrusting of about 25 mm (west up) and is believed to have been a direct result of the earthquakes. It has not been possible to associate the seismic activity with any previously mapped geological features in the epicentral region.

STRONG MOTION RECORDINGS

Strong Motion records from the M 5.0, March 31 aftershock were the first significant set of records obtained in Eastern Canada. Peak accelerations ranged up to 3 m/s^2 with frequencies as high as 45 Hz at a hypocentral distance of about 6 km. Although some of the high values may be explained by instrument foundation and subsoil amplification, the general high level of acceleration is believed to be real. High frequency accelerations are significant for special engineering systems, but for the design of ordinary buildings, the frequency range of concern is below 10 Hz. Fourier amplitudes (and also response spectra) in this frequency range are factors of 3 to 10 below the peak values.

SEISMIC RISK

The earthquake source zone model developed for probabilistic seismic risk estimates for National Building Code applications assumes a random distribution of seismicity throughout New Brunswick and northern New England with an upper-bound magnitude of 6.0. The occurrence of the 1982 Miramichi earthquakes has not necessitated a change to this model. However, neither has the well-defined focal mechanism for this sequence provided any guidance on where similar events may occur in the future.

New Brunswick and New England residents can be considered fortunate that a significant improvement in understanding of a moderate earthquake sequence has been gained without loss of life or significant structural damage. Had these earthquakes occurred near an urban area, the effects would have been similar to those caused by the similar magnitude Cornwall-Massena earthquake of 1944.

EARTHQUAKE RESPONSE PREPAREDNESS

The Earth Physics Branch has scientific and public information responsibilities in relation to all significant earthquake occurrences in Canada. The Miramichi earthquakes provided an opportunity to test preparedness under very difficult mid-winter conditions.

The field team from Ottawa with aftershock monitoring equipment were en route to New Brunswick by the afternoon of the day of the first shock. Instruments were installed along an accessable highway by the following afternoon, but access to the epicentral region was not gained until a few days later after deep snow was plowed from summer roads. The eventual success of the aftershock monitoring was ensured when within a few days eight other agencies from Canada and the United States offered assistance with personnel and equipment and participated in the field program.

The public relations demands during the earthquake sequence were very great on both the Ottawa office and the field coordinator. In many cases the public, the media, and emergency measures organizations were seeking assurances that the worst was over. The inability of the seismologists to be certain of their facts was not aided by the occurrence of a second shock of similar magnitude three days after the main shock.

THE STATE OF PREPAREDNESS IN THE NORTHEAST AND FEDERAL EMERGENCY MANAGEMENT AGENCY'S NEW DIRECTION: INTEGRATED EMERGENCY MANAGEMENT SYSTEM

by

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THE STATE OF PREPAREDNESS IN THE NORTHEAST

The subject of this paper is the State of Preparedness in the Northeast. The basic question we are concerned with is how well prepared is the Northeast to respond to a major earthquake? We submit that this region of the country is well prepared to deal with the effects of a major earthquake.

At Knoxville, the participants agreed that it would be very difficult, if not impossible, for earthquake preparedness activities to be funded or given priority solely on their own merits. Therefore, the group concurred that earthquake preparedness can best be achieved by "piggy backing" other preparedness efforts.

Probably the most comprehensive preparedness effort ongoing in the Northeast is the Radiological Emergency Preparedness Program or REP. This program requires in-depth planning for States and local governments within 10 miles of commercial nuclear power plants to respond to an accident at the plant. This program has been ongoing for almost three years and is now approaching completion of the developmental stage.

Among the requirements of the program are a full scale exercise yearly for each facility. These exercises are the most comprehensive of any that the members of the panel have ever observed. As a result, States in the Northeast that have commerical nuclear power plants, which include both New York and New Jersey in FEMA Region II and a majority of States in New England, have in place a comprehensive disaster response capability.

The challenge, as we see it, is to strengthen and broaden this capability so that more of this capability is directly transferable to earthquake preparedness. In the past year FEMA has moved in this direction.

EARTHQUAKE PLANNING IN NEW YORK STATE

In fiscal year 1984, FEMA will commence funding the State of New York to develop an Earthquake Hazard Preparedness Plan. The planning process will address the specific hazard, earthquake. However, planning will include the analysis of all hazards and the level of preparedness to address them.

New York State has in the past developed various plans to respond to a host of man-made and natural hazards. It is expected that the information developed through their planning effort will be utilized in developing a response modality to earthquake hazards.

INTEGRATED EMERGENCY MANAGEMENT SYSTEM AND FEMA'S CURRENT DIRECTION

After evaluating its experience in the last year and a half, FEMA has embarked upon the development of a change in strategy for implementing its programs. FEMA was created to provide an integrated approach to emergency management for both domestic and national security emergencies. The integrated approach to such emergencies has not been employed in the United States to this point. Natural disasters, technological disasters, resource shortages, conventional war, and nuclear attack preparedness programs have been managed as separate activities under diverse legislative authorities and separate organizations. Natural hazards and emergencies are addressed in the Disaster Relief Act; war in the Defense Production Act; the National Security Act and the Civil Defense Act; and technological hazards and emergencies related to commercial power plants, earthquakes, hazardous materials and the hazards in still other pieces of legislation.

In order to rectify this situation, FEMA will institute an Integrated Emergency Management System (IEMS). The purpose of IEMS is to:

Develop generic plans and emergency capabilities which reflect common functions across multihazards for mitigation preparedness, response and recovery from natural, technological and attack related hazards.

The objectives of this system are:

- save lives and protect property threathened by hazards;

- reduce duplication of effort and resources;

- increase jurisdiction's flexibility in upgrading its capability to handle potential hazards;

- provide a greater degree of credibility and practical application to States and local governments in their emergency systems and

- Integrate Federal emergency management objective support with State and local emergency operational requirements to enhance overall preparedness for all hazards.

In order to deploy resources adequately, an appropriate level of capability must be developed. IEMS will assist State and local government in attaining this goal through a capability development process. This process includes:

- prepare hazard vulnerability analysis;

- assess existing capability versus standards;
  develop multi-year plans for addressing capability deficiencies;

- prepare generic plan for all hazards;
  prepare contingency plan for unique features of specific hazards;

- acquire and maintain capability and evaluate, train, exercise and update plans, facilities and personnel.

In meeting its mandate, FEMA will fund State and locals utilizing the following programs:

State and Local Emergency Management

This program provides the foundation for the Federal, State and local partnership that is essential in achieving the integration of emergency management activities. Funding is provided to support State and local organizational requirements and operational operating cost. The program augments FEMA and State and local emergency management organizations with military reservists and also provides guidance and technical assistance to enhance emergency management organization's capabilities.

Population Protection

Population protection consists of State and local government plans and systems and capabilities required to improve the survivability of the population from the effects of natural disasters, technological hazards and nuclear attack. This activity embraces the identification of shelters, protection of industrial capability and development of evacuation plans.

State and Local Direction, Control and Warning

These functions provide the basic capability of States and local leaders to maintain control of government resources, communicate decisions to the public and deploy assets to meet critical needs. This critical function is the foundation on which continuity of government is built and authority exercised in the aftermath of large scale, catastrophic emergencies.

Radiological Defense

The mission of radiological defense (RADEF) is to provide individuals, citizens, and decisionmakers with the skills and knowledge, situation information and guidance needed to minimize the effects of radiological hazards, including fall-out radiation hazards from nuclear attack.

Radiological Emergency Preparedness

The mission of the radiological emergency preparedness is to provide assistance to State and local governments for enhancing their capabilities to plan for and respond to radiological emergencies off-site at fixed nuclear facilities. Fixed nuclear facilities include commercial nuclear power plants, nuclear material licensees, weapons production storage facilities, nuclear fuel cycle facilities, test reactor and operational bases.

Flood-Plain Management

Flood plain management is an overall nonstructural program of corrective and preventive measures for reducing and mitigating flood damage through land use controls. The National Flood Insurance Program, (NFIP) which provides flood insurance in participating communities, provides the stimulus for communities to exercise sound planning principles with respect to land-use decisions in riverine and coastal flood plains. Additionally, FEMA identifies and maps floodplains, provides funding for States to build flood plain management capabilities and provides technical guidance to States and locals.

Earthquake Preparedness

The earthquake preparedness program's efforts include: (1) providing grants to States for vulnerability analyses and contingency plans, (2) providing technical assistance, (3) developing improved seismic building practices and standards, and (4) developing preparedness and mitigation guidelines on earthquakes for incorporation into an integrated emergency management process.

Hurricane Preparedness

The focus of the natural hazards planning effort, to date, has been directed to 22 highly vulnerable hurricane area in the United States to foster development of preparedness plans for hurricane disasters through the provisions of technical and financial assistance to States.

Dam Safety

FEMA's dam safety program consist of two major elements: coordination and monitoring of Federal programs policies and activities, including research to ensure Federal Dam Safety.

Disaster Assistance

The Disaster Assistance Program is the vehicle under which the president is authorized to provide Federal assistance to supplement the efforts and resources of State and local government in response to major disaster and emergencies.

The Disaster Assistance Program can be divided into two broad categories: (1) Public Assistance (aid to State and local governments) and (2) Individual Assistance, grants for emergency protective measures, debris clearance, and the repair and/or restoration of damaged public and certain private nonprofit facilities. A wide range of assistance programs for individuals also is available. Temporary housing is provided to displaced disaster victims through one of the following methods: privately-owned housing units available on the open market; Government-owned or assisted housing units; FEMA-owned mobile homes; minimal repairs on owner-occupied residences; and temporary assistance with mortgage or rental payments, if required. Other forms of individual assistance under the Disaster Relief Act include disaster unemployment and job placement assistance, legal services to low-income families, and crisis counseling and referrals to appropriate mental health agencies to relieve disaster-related health problems.

Emergency Management Training

The National Emergency Training Center (NETC), located in Emmitsburg, Maryland, provides a nationwide coordinated curriculum planning effort. This cost effective means of delivering training is to assist State and local governments in building their own capabilities for offering training programs through field deployment.

Fire Safety and Research

The newly structured United States Fire Administration (USFA) is divided into four program focuses: Fire Policy and Coordination, Firefighter Health and Safety, Fire Prevention and Arson Control, and Fire Data and Analysis. With members of the Joint Council of Fire Service Organizations, priorities are established for each of these program areas to guide the effective allocation of resources of the Fire Administration to meet its primary goal: improving fire safety in the United States. The National Emergency Training Center (NETC) and the USFA are making every effort to include fire services in the comprehensive emergency management spectrum.

HOW TO GAIN THE ATTENTION AND COMMITMENT OF BUSINESS AND INDUSTRY TO TAKE ACTION TO LESSEN THE EFFECTS OF A DESTRUCTIVE EARTHQUAKE: THE ROLE OF THE HOME MORTGAGE LENDER

by

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INTRODUCTION

Unlike the Northeast, the State of California has had a long and continuing history of at least moderate earthquakes and has had at least a modicum of public attention to earthquake hazard mitigation. The interest of private industry in earthquake hazard mitigation both stimulated and assisted the functioning of the State-assisted Southern California Earthquake Preparedness Program (SCEPP) which involved meetings, discussions and planning sessions among some of the most influential leaders of business and industry in southern California.

Our interest in the home mortgage lender stems from the potential impact of this institution in informing homeowners of hazardous geologic conditions and, in some ways, conditioning the repsonse of home buyers. If private and public institutions do not discourage homebuyers from exposing themselves to earthquake related economic risks, and indeed if homebuyers are rewarded for buying and selling uninsured property susceptible to earthquake losses (through profiting in the subsequent sale of a house whose value has vastly increased because of inflationary forces), the economically rational individual will not be disuaded from investing in such property by public information campaigns. But, in such a case, it is not only the homebuyer, but also the financial institution providing mortgage financing, which is subject to major losses in the event of a catastrophic earthquake. It is foolhardy to imagine that the equity in property counted on to encourage the continuation of mortgage payments in ordinary times would continue to exist after a major damaging earthquake (for example, what would a $250,000 California bungalow be "worth" after major structural damage - would the $150,000 mortgage actually now exceed its current sales price?). Indeed, even in a State such as California with continuing reminders of hazards of earthquakes (such as the Sylmar-San Fernando event of 1971 or the Coalinga event of 1983), there remain thousands of single family dwelling units located very close to known and active earthquake faults susceptible to major damage from fault rupture, even larger numbers of dwellings in areas susceptible to known ground failure hazards, and only a miniscule percentage of homeowners willing to purchase the widely available earthquake insurance addendum to the homeowners policy.

Financial institutions can effectively legislate a form of earthquake hazard mitigation by requiring, as a condition for loan approval, the purchase of earthquake insurance, just as they now require the purchase of fire insurance. However, the decision of a lender to set such a stipulation follows from an estimate of (1) the probable profit accruing from the transation - the fees and interest payments obtained from the borrower, (2) the possible losses associated with the many reasons why borrowers might default, the security property might decline in value, or the profitability of a longterm loan decline in future years and, (3) the competitive advantage or disadvantage in setting terms if other lenders set different terms.

CURRENT PRACTICE OF CALIFORNIA LENDERS

It might be of interest to report some of the current perceptions and practices of California home mortgage lenders, to present a case where earthquake hazard should be part of the lending decision-making. In the fall of 1982 a survey of home mortgage lenders in the States of Washington and California was conducted by two of my research assistants. I will report some of the findings of the California portion of this study. The California survey included 28 of the 30 largest home mortgage loan originators, 31 of the next 70 ranked lenders, and 21 lenders with smaller home loan portfolios (less than $2 million in home loans assets in 1981). Forty-seven of these lenders were headquartered in the Los Angeles region, 27 in the San Francisco Bay area, 4 in San Diego, and 2 in other metropolitan areas. Of the lenders, 55 were savings and loans, 23 were commercial banks, and 2 were mutual savings.

(We omitted industrial banks since we were interested in originators of first loans.)

In an early, open-ended question, respondents (vice presidents in the home loan departments, usually) were asked to list the characteristics of a property they considered to be important in the decision to grant a home mortgage loan. Sixty-six percent did not mention any type of geophysical condition (such as landslide susceptibility or seismic hazard). When asked specifically whether, when analyzing their portfolios of assets, the lenders consider seismic risks to their own real assets (e.g. buildings), 82 percent said no (Table 1).

Similarly 81% do not have earthquake insurance on their own real assets, 68% do not consider seismic risk when making loans on commercial properties, 77% do not consider seismic risk in setting loan conditions for residential real estate, and 88% do not insure their overall property portfolio for damage associated with earthquakes. In short, although a few lenders do take seismic risk into consideration when assessing whether loans should be granted, and do insure their own real assets and investments (loan portfolios), the vast majority do not. It is perhaps of interest to note that when asked <u>why</u> lenders do not insure their overall portfolios (Table 2), several mentioned that their portfolios are geographically diversified and that therefore only a small percentage would be damaged in a given event (11 percent gave this response), but most indicated that they do not insure their portfolios because they perceive earthquake insurance to be too expensive (17.5 percent) or that there is only a low risk of default asscciated with earthquakes (36 percent gave this response). Very few indicated that they felt insurance was unnecessary because homeowners equity covers the lender (exposure (2.5%) or that government assistance would be sufficient to aid borrowers and lenders (6.3 percent). A full 70.5 percent said that they had never refused to grant a loan or modified loan conditions when the property was known to be underlain by a surface fault trace, and only 3.7 percent said they "frequently" refused to loan or modified lending conditions in such an instance (Table 3). When asked to rank five possible causes of mortgage default, unemployment of head of household emerged as a primary cause, with a major earthquake clearly last (Table 4). Finally, lenders have certain expectations concerning the aftermath of a major earthquake - and despite these expectations, including the insufficiency of aid from federal and State government and an increase in mortgage defaulting, still seem to choose to ignore seismic risk in everyday business practices (Table 5).

CONCLUSIONS

What conclusions are transferable to the perceptions and behavior of lenders in Northeastern States? I fear the implications do not seem promising. Even in a State with widespread public awareness of seismic risk and an active campaign to involve the private sector in discussion and actions towards the initiation of mitigation behavior, one still finds the majority of large home mortgage lenders reluctant to change longstanding policies and to take seismic risk into account in their lending policies. It is even less probable that one can expect this kind of change of behavior in States where fault traces have not been mapped, there have been no recent catastrophes, and other economic problems must seem more pressing. It is likely that economic or legal incentives to undertake earthquake mitigation measures will have to come from outside the banking community - in the form of package insurance requirements from the secondary mortgage market or outright legislation by the federal government - perhaps in the form of the flood insurance program. Such suggestions, while perhaps politically unpalatable to those who believe in the sanctity of "the invisible hand," may simply be necessary to both gain the attention and achieve commitment to earthquake hazard mitigation among home mortgage lenders.

Table 1

DO YOU CONSIDER SEISMIC RISK WHEN YOU ARE ANALYZING YOUR PORTFOLIO OF ASSETS?

1. Such as seismic risk to your real assets (buildings)?

   no 58 (81.7%)
   yes 13 (18.3%)
   (no response 9)

2. Do you have earthquake insurance on any of your real assets?

   no 43 (81.1%)
   yes 10 (18.9%)
   (no response 27)

3. Seismic risks to commercial property?.

   no 50 (67.6%)
   yes 24 (32.4%)
   (no response 6)

4. On loans for residential real estate?

   no 57 (7.12%)
   yes 23 (28.8%)

5. Do you insure your overall portfolio for losses associated with earthquakes?

   no 60 (88.2%)
   yes 8 (11.8%)
   (no response 12)

Table 2

FOR THOSE RESPONDENTS WHO DO NOT INSURE OVERALL PORTFOLIOS FOR LOSSES ASSOCIATED WITH EARTHQUAKES, WHAT ARE THE REASONS FOR THIS DECISION?

low risk	25	(31.3%)
high cost of insurance	15	(17.5%)
portfolio is geographically diversified	9	(11.2%)
mortgages only a small part of portfolio	5	(6.3%)
government would aid borrowers and lenders	5	(6.3%)
it would be uncompetitive	2	(2.5%)
damage from an earthquake would be too great for insurance to be effective	2	(2.5%)
they sell most of their mortgages on the secondary market and are therefore not "holding" the paper	2	(2.5%)
homeowners equity covers the lender's exposure	2	(2.5%)
it is not required by law	1	(1.2%)

Table 3

HAVE YOU EVER REFUSED TO LEND OR HAVE YOU EVER MODIFIED LOAN CONDITIONS (HIGHER POINTS, HIGHER INTEREST CHARGES) BASED ON THE FACT THAT THE PROPERTY IS UNDERLAIN BY A KNOWN SURFACE FAULT TRACE?

never	55	(70.5%)
rarely	13	(16.7%)
sometimes	7	(9.0%)
frequently	3	(3.8%)

(no answer - 2)

Table 4

RANK THE FOLLOWING FIVE POSSIBLE CAUSES OF MORTGAGE DEFAULT:

	Number who ranked it as					Mean Rank
Cause	1	2	3	4	5	
unemployment of household head	65	12	1	1	1	1.2
divorce	12	55	5	2	5	2.2
house fire	4	34	21	20		3.7
major flooding		2	23	37	17	3.9
major earthquake	2	4	13	15	45	4.2

Table 5

(Southern California version)

Consider the folloiwng estimates of property and personal losses projected by the Federal Emergency Management Agency for an 8.3 Richter scale magnitude earthquake:

An earthquake along the Southern San Andreas fault has a high likelihood of occurrence. An 8.3 event would claim $17 billion in property damage, between 3,000 - 14,000 dead, and between 12,000 and 55,000 hospitalized, depending upon the time of day the event occurs (1980 dollars). Which of the following would like occur?

1. Increased mortgage defaults?	(94% yes)
2. The combination of State and Federal aid would be fully adequate to reimburse homeowners for their disaster losses	(59.2% no)
3. Changes in building code regulations would be made	(68% yes)
4. A local recession would occur	(65% yes)
5. Fire insurance would become more expensive for resisents	(68% yes)

HOW TO GAIN THE ATTENTION AND COMMITMENT OF BUSINESS AND INDUSTRY

by

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HOW TO GAIN THE ATTENTION OF BUSINESS AND INDUSTRY

There are a number of actions or events which will help to concentrate the minds of business and industry on preparing for earthquakes. Among the most effective ones are the following:

1. The Actual Occurrence of an Earthquake

   This is not meant facetiously. Businesses located in earthquake-prone areas of the country are far more sensitive to earthquakes and, undoubtedly, much better prepared for them than are businesses located in areas which rarely experience such phenomena.

   In the Northeastern United States, the incidence of earthquakes is probably too infrequent to galvanize the business community at large into action. Perhaps the most that can be done is to chronicle past earthquakes and describe the extent of damage. If the historical record is sufficiently impressive, some businessmen may be motivated to take at least basic precautions.

2. Focus on All Major Hazards, Not Just Earthquakes

   If earthquakes are not a normal occurrence, it may be possible to gain the attention of business and industry with regard to preparing for other kinds of emergencies, such as hurricanes, tornados and the like. Such preparations are almost always a benefit in the event of earthquakes, although they are often inadequate.

3. Publicity

If most people believe they live in an area where earthquakes are expected to occur, businesses will respond to their perceived needs for planning and preparedness activities. By the same token, if the public is not aware that severe earthquakes may occur, it is unlikely that many businesses will spend the time, effort, and other resources necessary to develop appropriate preparedness plans.

Government officials, particularly at the State level and in particular State Governors, can exert considerable influence in convincing companies to make adequate preparations. If a State Governor is convinced that an earthquake in his State is likely, he can publicize this generally and speak to the business community at large or on an individual basis -- and can exert considerable influence on companies to undertake planning and preparedness activities.

4. Seminars and Conferences

Seminars and conferences are another form of publicity. They bring together knowledgeable people to discuss the likelihood of earthquakes and damages. They then publicize the results of their deliberations. Special conferences or programs aimed at business and industry can be put together. However, without supporting government publicity and pressure, and without general awareness among the population, such conferences, even if specifically designed for business and industry, are not likely to be well attended.

5. Credible Earthquake Predictions

If earthquake predictions are developed for an area and are endorsed by the National Earthquake Prediction Evaluation Council (NEPEC), a flurry of earthquake planning and preparedness activity can be expected. However, the art of earthquake prediction is not sufficiently far advanced to make this a likely prospect.

6. Private Business and Industry Leadership

If some companies, particularly leading ones, are developing their own plans, it is hard for other companies to dismiss these efforts out of hand. By the same token, those companies which are undertaking preparedness activities may be willing to publicize these actions and host seminars and conferences explaining what they are doing and why.

HOW TO GAIN THE COMMITMENT OF BUSINESS AND INDUSTRY

1. Convince Management

Convince business leaders that earthquakes are probable within a reasonable period of time. Unless a company's management is convinced that a damaging earthquake is likely, it makes no sense for it to expend resources preparing for such an event.

2. Educate Companies to Earthquake Hazards

Demonstrate to companies what kind of buildings are serious earthquake hazards and what kinds are considered resistant to earthquakes. Show how building structures and interiors can be strengthened to reduce earthquake hazards.

3. Demonstrate the Benefits of Being Prepared

Prepare cost/benefit analyses to demonstrate the economic value of being prepared for earthquakes or other major emergencies. Show that relatively modest investments of time and money can protect against potentially enormous losses.

Convince companies that measures taken in anticipation of earthquakes are often very effective in the event of other kinds of emergencies, such as: hurricanes, fires, explosions, etc. Demonstrate that such preparedness measures do have an economic value to the company.

4. Demonstrate the Costs of Being Unprepared

Show how liabilities for injuries and damage can be reduced or contained by adequate preparation for earthquakes. The conventional wisdom in companies is that unless negligence is proved, a company is not likely to be held liable for injuries and damage caused by earthquakes, and that if negligence should be proved, normal liability insurance will provide protection. This proposition has not been adequately tested in the courts and so its validity is not certain. At the same time, many companies will find that their liability insurance is woefully inadequate in the event of an earthquake where injuries and damage are extensive and can lead to enormous claims.

5. Establish an Emergency Planning Position in the Company

Most companies attach the emergency planning function to some other position. This means it represents one more thing to do for someone who is often already fully occupied, if not overburdened. As a result, emergency planning tends to get overshadowed by the person's other duties.

If emergency planning is set up as a separate function, it will be the primary responsibility of one or more individuals and will not be submerged by other activities. This will ensure that plans are developed and reported and that appropriate issues are raised, even if most company managers would be reluctant to commit their own limited resources to such projects.

CAVEAT

The senior management of a company must be convinced of the value of emergency planning and support this activity. Without such support, no efforts by subordinates can bear fruit.

HOW TO GAIN THE ATTENTION AND COMMITMENT OF POLITICAL OFFICIALS: AN EARTHQUAKE POLITICS PRIMER

by

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INTRODUCTION

Since socio-political climates and decisionmaker psychologies still interact to permit local officials to ignore earthquake responsibilities, nothing less than cleverly formulated strategies can induce approval of rudimentary measures in earthquake prone communities. Recent and prospective advances in geoscience and seismic safety will continue to enhance the credibility of earthquake specialists, while researchers and practitioners in the politics of disasters now can suggest ways to minimize conflict on mitigation and preparedness issues. Although the outcomes of impending deliberations will appear unimpressive as means to decrease vulnerability, any steps taken can at least increase receptivity to future information and--in so doing--facilitate later adoption of "second generation" seismic safety initiatives.

STRATEGIES

An approach consistent with these assumptions falls short of the optimal, yet remains practical and certainly an improvement over the status quo. The ensuing practical strategy consists of eight viable statements and explanatory commentaries. Substantial progress in winning local leader acceptance of these premises will assure endorsement of at least some aseismic activity.

1. Earthquakes can strike during your term in office.

   Dispel any beliefs that serious earthquakes cannot happen here and now. New and contemplated research will more precisely measure recurrence intervals. These can readily be converted into annual and cumulative probabilities (for "politically meaningful" time intervals). Where applicable, put public officials and "attentive publics" on notice that there is a "non-zero" probability of a damaging earthquake this year. Political matters must have some immediacy. Declaring a present threat--even with a low probability--grants some contemporary status to the problem. This advantage of currency exceeds the preparedness costs of reporting a low annual probability. Likewise, the confidence demonstrated by specifying a quantitative estimate exceeds the credibility costs of reporting the invariably large error term associated with each estimate. These errors suggest using high, middle, and low recurrence estimates to generate probabilities/time interval. Recommend the conservative course of using the most imminent "prediction" for planning purposes. Typically this provides a long time horizon, but still suggests "capping" programs well before the next damaging earthquake is due.

No mention of earthquakes should be devoid of reference to their devastating consequences. Abstractions characteristic of standard briefings must be accompanied by vivid portrayals. Cultivate skillful ways to "bring the emergency home." Either a historical earthquake in the same region or a contemporary earthquake in another community may be "borrowed." This earthquake can be "rerun" with a plausible local epicenter. In both cases interest in the "real" event would add salience to the projected consequences of the simulated quake.

2. Earthquake problems can be managed.

Earthquakes--however imminent and destructive--become meaninfgul public problems only when officials believe in the efficacy of countermeasures. To oversell the threat risks denial unless viable steps can be taken in response. Awareness that earthquake vulnerabilities stem from the location, design, and construction of the built environment sensitizes elites to recognize that seismic hazards are essentially manmade--and amenable to human solution. At a problem specific basis, earthquake specialists must carefully establish the modifiable causes of earthquake losses and clearly explain the ameliorating effects of seismic safety programs. An ability to describe the threat in quantitative terms reassures authorities about the problem's manageability. Plausible summaries of consequences in lost lives, dollars, and person-hours provide crucial baselines for comparisons. Expected gains--attributable to particular mitigation/preparedness investments--can then be expressed as reductions in deaths, damages, and down times. Finally, realistic, if inexact, costs must then be attached to selected mitigation/preparedness strategies. Such a formatting of information not only gives policy makers a simple calculus for making seismic safety decisions, but also strengthens their perceptions that emergency planners and managers really "understand" earthquake phenomena.

3. Earthquake consequences can unleash political reverberations.

Aside from numerous legal liability issues which remain to be resolved, elected and top appointed officials dread "political liability." Political liability varies with public perceptions of blame. Uncontrollable acts of God yield little attribution of fault. Preventable tragedies, on the other hand, produce harsh judgments--to the chagrin of officials deemed responsible. As elites, specialists, and key publics increase their threat and adjustment-to-threat awareness, then accountability perceptions will move in the "preventable tragedy" direction for earthquakes. Of course authorities who have shown courage in trying to overcome inertia on seismic safety are apt to gain politically in the aftermath of an earthquake.

4. Hazard mitigation/preparedness measures can be feasible.

When presentations of benefit/price ratios facilitate comparisons, the cost effectiveness of seismic safety investments impresses policymakers--even if officials must recognize the likelihood of serious inaccuracies in the estimates. Cost ambiguities pose greater problems in gaining approval for earthquake management expenditures vis-a-vis competing priorities. Understandably, these problems diminish when seismic safety advocates request modest allocations. Nevertheless, other characteristics of demands for public resources affect political feasibility. Program success varies inversely with the extent to which restrictions on uses of existing property are retroactive. Program success also varies directly with the degree to which incentives--as opposed to penalties--are used to attain program goals.

While the seismic safety community cannot abandon crucial retrofit or design regulation programs, any agenda of policy recommendations must also include more humble fare. If a jurisdiction can only afford measures which make few demands on community resources and relationships, depict this choice as a modest but useful contribution to earthquake safety. Since such precedents often incrementally expand into more substantial programs, comprehensive emergency management proponents would be well advised to avoid forcing "either/or" choices between the "rational" and "nothing."

5. Burdens can be spread across society and over time.

Numerous means exist for distributing pain more broadly and gradually. Direct or indirect subsidies can remove punitive characteristics from retrofit programs. Lengthy, incremental enforcement schedules can displace retroactive elements from many of the same programs. Granting building officials discretion to alter rules slightly with each ownership, occupancy, or use change avoids severe penalties for any one actor. Obviously these illustrations are not exhaustive, but they do suggest ways to diminish politically deleterious equity problems.

An effective approach to the problem of allocation of justice also uses the long time horizon to advantage. Estimate the human, property, and productivity costs of the model earthquake. Specify acceptable risk levels by declaring the reductions in these amounts a acceptable risk levels by declaring the reductions in these amounts a decisionmaking body intends to achieve through policy. Estimate the monies required to reach these objectives. Finally, divide these mitigation/preparedness costs by the number of years in the interval constituting a cumulative earthquake probability of 50%. The quotient will probably indicate that small amounts of money need be invested each year. Such a figure will seem outrageously small to those committed to improving seismic safety, yet might appear very reasonable to an official with general responsibilities. Such reasonableness can determine whether earthquakes receive some attention or no attention.

6. <u>Seismic safety solutions can serve multiple social purposes.</u>

Cross fertilization between earthquake and other disaster preparedness planning can benefit both--substantively and politically. At the mitigation level, emergency managers will assuredly acknowledge the compatability between the goals of more stringent lateral force requirements and wind load standards sufficient to protect structures from hurricane force winds. Firemen, too, whose lives often depend on the structural integrity of burning buildings are likely to support programs to retrofit hazardous structures. And administrators of infrastructures which include rusty, leaky lifelines appreciate having additional arguments for accelerating repair and replacement schedules.

More general support can result from identifying seismic safety goals with overall redevelopment purposes. When broad coalitions of interests seek improved safety, efficiency, and beauty in an area, increased earthquake safety should be both an advertised and an actual benefit of the project. In the same vein, neighborhood associations working to decrease crimes, fires, and household emergencies will often express an interest in earthquakes. Not only is seismicity increasingly recognized as a serious (but largely soluable) problem, but because it is also such a fascinating topic, it serves organizational maintenence and enhancement needs.

In these and other cases the consistency between seismic safety goals and others facilitate approval chances. They also make activist friends for seismic safety proponents. Perhaps a parting caution is in order: be sure to distance yourself from single issue advocates who use seismic safety cynically and largely for other purposes. While seismic factors deserve detailed consideration before locating and building critical facilities, the reflexive identification of seismic safety with the underlying issue in the minds of many can discredit seismic safety.

7. Seismic safety solutions can create recognizable beneficiaries.

Rather than wanting to approve general--even symbolic--policies in the "public good," many politicos prefer to indulge specific industries, professions, firms, or individuals. This implies nothing about any party's honesty or ability. Certainly such beneficiaries' commitment and competence usually remain above reproach. This argument depends more on the desire of politicians and bureaucratic entrepreneurs to construct a series of exchange relationships. Relatively tangible media of exchange-contracts, grants, access, publicity, etc.--facilitate clarity--if not necessarily explicitness--in bargaining. The official needs personal or program support in holding or expanding his resources, responsibilities, and constituencies. Those with specific stakes in the transaction are apt to understand and deliver on their end of the agreement. Furthermore, a pro manifests more persistence than a broadly focused amateur, assuring a more stable relationship. The message of this generalization can be stated unambiguously: Do not be reluctant to express your professional judgment and conscience because there is a chance that you might make some money.

8. <u>Seismic safety solutions can generate sufficient coalitions.</u>

Conditions can continue to become more favorable for earthquake safety proponents. A nucleus of long term supporters consists of an expanding array of public and private sector professionals with occupational interests. Middle range supporters include those prominent in organizations whose goals dovetail with seismic safety. People responding to recent media accounts of earthquake phenomena comprise shortrun supporters of such a coalition. While never large except after a community experiences a serious earthquake, the collection can be diverse enough to raise many facets of the problem. In the absence of a concerted opposition, the net effect will be to put the issue on the public agenda. While this represents a moral victory by itself, strong cases and appropriate tactics can yield program victories that begin to institutionalize seismic safety. Of course success in pulling these resources together depends on the quality of leadership and the suitability of its strategy.

SUMMARY

Two themes suffuse the above eight points. First, that aseismic strategies must be based on a consensual politics model under current northeastern circumstances. Given the many constraints inherent in that kind of politics, program successes must be small ones. Second, that small seismic safety steps now can establish precedents for larger steps later. This theme is premised on the belief that formal jurisdictional acceptance of "earthquake threat" <u>as a principle</u> is nearly irreversible. Finally, these themes are accompanied by an attitude. While forging a new basis for policy remains a complex and difficult task, the task nevertheless <u>can be accomplished</u> by patiently and persistently communicating with elites and informed publics. Imagination and flexibility remain our most crucial, overlooked resource.

HOW TO GAIN THE ATTENTION AND COMMITMENT OF POLITICAL OFFICIALS

by

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INTRODUCTION

The ability to gain the attention and commitment from political officials depends on many factors which may have little to do with the merits of the issue. Arthur A. Atkisson and William J. Petak summarized many of the problems of gaining attention and commitment in their paper "The Politics of Community Safety."

SUMMARY OF IMPEDIMENTS TO ACCOMPLISHING GOALS

The list of impediments to gaining recognition of seismic problems as a critical issue and eliciting action has been discussed and reviewed in many papers and forms. In summary, some of the most important problems are as follows:

1. There are other more dramatic and immediate public safety needs. Events like fires, airplane crashes and multiple death highway accidents occur frequently and have the image of potentially affecting the entire population.

2. The number of individuals who can knowledgeably advocate the issue and those who are able to perceive the need and act politically are limited. In fact, the general atmosphere is to perceive that any action relative to seismic safety is an unnecessary economic burden.

MEANS OF GAINING ATTENTION AND COMMITMENT

There are two models which could be considered as a means of achieving the objectives of establishing a program of seismic safety. In both cases, it is the Federal Government that provides the incentive and the system and those will be reviewed below.

The question naturally arises of whether there is any other model on a state or local basis which might show that it is possible to achieve the goals without Federal programs. I believe that this can best be answered by looking at the experience of California. A review of the history of programs to achieve seismic safety in that State, shown in Table I, shows that significant progress was made usually in response to actual disasters. And even then the programs are limited, and as recent experience shows, the State is still very vulnerable to a significant level of damage and injury. Based on this history, the answer from any experienced political observer is that it would be extremely difficult even in areas considered highly vulnerable to gain local or State attention and commitment without some outside forces influencing the adoption of mitigation programs. Two good examples of programs which have produced results are the following:

1. Federal control of construction of buildings subsidized by Federal programs or funds. This method, especially in medical care facilities, nursing homes and housing for the elderly dictates the standard and ensures programs to accomplish the objectives.

2. Flood Plain Regulations: Again, a program tied to financial benefit which imposes the need for a close liaison with state and local authorities.

HISTORY IN MASSACHUSETTS

Until 1970, the risk of earthquakes was generally ignored in Massachusetts. In January of 1969, Dr. S. T. Algermissen proposed a new seismic risk map for the United States. This map placed the cities of Boston, Massachusetts and Charleston, South Carolina in the same category as California - Zone 3.

However, this zone was based on a lower Modified Mercalli value than normally associated with Zone 3. This map was adopted by the Uniform Building Code and resulted in considerable discussion of the validity of imposing the same seismic design requirements for Boston as for San Francisco. At the same time, the City of Boston was creating a new City Building Code. The Boston Building Code, recognizing that there was in fact a difference between the seismic hazard of Boston and San Francisco, placed Boston in a Zone 2 and referenced the current Uniform Building Code seismic requirements. At that time (1972), because of the notice given the professional and scientific community by Algermissen's map, there was considerable concern over seismic codes and the appropriate level of risk for the Boston area. At about the same time, however, legislation was passed leading to a uniform, mandatory State building code, and the concerns about seismic risk and building code requirements became the province of the newly created State Building Code Commission.

In 1971, research work started in the Department of Civil Engineering at Massachusetts Institute of Technology (MIT) under the direction of Professor Robert V. Whitman on a National Science Foundation funded project entitled "Optimum Seismic Protection for East Coast Metropolitan Areas." This work was succeeded by another research project in 1973 entitled, "Seismic Design Decision Analysis for Eastern Metropolitan Areas." The research done at MIT provided an opportune basis for interacting with the State Building Code Commission and its newly created Seismic Design Advisory Committee in developing and evaluating seismic provisions for the State of Massachusetts. With the help of MIT, the Seismic Design Advisory Committee and the professional and academic community especially in the Boston area, the seismic provisions were incorporated into the newly published State Building Code on January 1, 1975.

There were, then, a series of events which proved coincidental and fortuitous, and, when taken altogether, provided a building code for seismic design in Massachusetts without political interference. The question arises whether the code would be instituted again if the circumstances were not the same. I would guess that if there was an attempt to promulgate the same seismic code today, it would not be successful.

SUMMARY

California shows that it is very difficult to initiate action even when seismic events are a virtual certainty. There are possibilities of using Federal programs to achieve some goals in ways similar to other Federal programs. In Massachusetts, a somewhat unique State in terms of seismic safety, it appears that there is a program, not because of political attention or commitment, but because of unique circumstances.

REFERENCES

Atkisson, Arthur A.; Petak, William J. - "The Politics of Community Seismic Safety," United States Department of the Interior, Geological Survey, Proceedings of Conference XVIII, "A Workshop on Continuing Actions to Reduce Losses from Earthquakes in the Mississippi Valley Area," 24-26 May 1982, St. Louis, Missouri.

Table I

Earthquake Codes in California to 1974

1906	San Francisco Earthquake - After the earthquake: Rebuilt under a code requiring 30 pounds per square foot loading for both wind and earthquake resistance.
1927	Uniform Building Code included provisions for lateral earthquake forces proportional to masses.
1928	California State Chamber of Commerce recognized need for a building code "dedicated to the safeguarding of buildings against earthquake disaster." Initiated studies by leading structural engineers of the State which formed the basis for the codes which followed.
March 1983	Long Beach earthquake destroyed many public school buildings, State Legislature adopted "Field Act" controlling design and construction of public school buildings.
1933	Riley Act adopted requiring all buildings except dwellings and farm buildings to be designed to resist a specified lateral force.
1933	Los Angeles building ordinance required a lateral force of 8% of dead load plus half live load.
1935	Uniform Building Code adopts provisions similar to Los Angeles.
1943	Los Angeles incorporated a coefficient recognizing the influence of flexibility.

1947 San Francisco adopted a table of varying coefficients applied to vertical design loads for buildings of different heights with variations for soil conditions.

1960 First publication of the Seismic Code by the Structural Engineers Association of California (SEAOC).

1963 SEAOC Seismic Code republished with one revision.

1966 SEAOC Seismic Code republished with several changes.

1967 SEAOC Seismic Code republished with updated commentary.

1971 San Fernando Earthquake.

1971 California Legislature passed requirements for "Seismic Safety Element" as part of legislation requiring all cities and counties to adopt a general plan as included in the following: "A seismic safety element consisting of an identification and approval of seismic hazards such as susceptibility to surface ruptures from faulting, to ground shaking, to ground failure, or to the effects of seismically induced waves such as tsunamis and seiches."

1973 SEAOC Seismic Code republished with additional commentaries.

1973 Hospital Safety Legislation passed requiring that hospitals remain "completely functional" during and after an earthquake. This concept may also be applied to other "critical" buildings.

1974 SEAOC Seismic Code republished with significant changes.

HOW TO GAIN THE ATTENTION AND COMMITMENT OF PUBLIC SERVICE ORGANIZATIONS

by

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INTRODUCTION

There is no choice involved as to when or where a damaging earthquake will occur. There is a choice as to whether or not we are prepared. To become prepared requires gaining the attention and commitment of public service organizations. Why do you want the attention and commitment of the public service organizations? What message do you want to convey to others through their attention?

Earthquake hazard awareness and preparedness has been with us for some time, but only recently has concern become heightened that we in the East are simply not prepared for a damaging earthquake. The return rate of the Charleston 1886 earthquake (MM=X) has been extrapolated to 700-1000 years by seismologists. We are not necessarily talking about a MM=X earthquake, but that the possibility of a MM=VII-VIII earthquake occurring in the Eastern United States within the next few decades is strongly probable. In our densely populated areas, an earthquake of this intensity could be very damaging. Therefore, this is why we want the attention and commitment of these organizations to aide in taking positive steps to inform, educate, and implement an earthquake preparedness program. This is not easily done in Boston or anywhere in the East. I agree, however, there must be bridges of knowledge built concerning earthquake awareness and preparedness.

The public service organizations represent one group to implement earthquake awareness and preparedness.

FACT FINDING

Everybody's job is nobody's job. The responsibility for finding out which public service organizations would take leading roles to motivate and educate the community on earthquake awareness and preparedness should be with one "body" that has been designated. Identify the public service organizations. Find out what motivates each organization and provide that motivation. There are some service groups that are "turned on" to working with a particular audience or age group. The "body" should correlate this information.

The more information you gather, the more questions you have. Every public service organization meets regularly. Each is interested in having a program that will hold the attention of their members. Provide the public service organizations with an earthquake awareness program that piques their interest. It should be clear that first you should find out what their interests are, the target audience they want to reach with service, and what earthquake hazard awareness and preparedness has already been done. Like a house guest comes with gift-in-hand that is never refused, approach the group with one appealing plan that they feel is relevant to them. It will not be refused.

The Chamber of Commerce of each city or town will provide you with a list of public service organizations. In that list, the presidents of the organization with their address and phone number are given. A telephone call is the initial step after you have found out what the facts are and know how your earthquake awareness and preparedness program can be implemented by a particular organization.

Cooperative Planning

Arouse the curiosity of the service organization by relating the earthquake hazard awareness and preparedness to their personal families. The relativeness of any program to a person's family will gain their interest.

For example, the Kiwanis Club of Summerville had asked me to speak to them about earthquakes in lower South Carolina. I monitor the United States Geological Survey (USGS) thirty-one channel network at Baptist College at Charleston. Whenever earthquakes large enough to be felt occur, my students and I canvass the community conducting intensity surveys. From the responses, isoseismal maps are drawn. Since 1977, I have isoseismals on seven felt events. There have been many unfelt events and some events barely felt. In relating the isoseismal work performed on the September 1, 1980 earthquake, M=2.9, every member there immediately perked up when the epicenter was shown and began trying to relate that position with his home not his business.

Incorporate their reaction to the proposals you are making. A cooperative effort in thorough planning results in shorter implementation time. The Japanese seem to have discovered the importance of thorough planning in increasing productivity. The following diagram illustrates this.

U.S.A Start / Planning / Implementation / Finish /
Japan Start / Planning / Implementation/ Finish / /

Time saved by extra planning.

By getting Public Service Organizations and Volunteer Agencies to "buy into" your plan at the outset, there will be fewer implementation problems, thus more productivity. Establish as many written procedures as possible so the wheel doesn't have to keep being "reinvented".

Involvement Gains Commitment

Once the special roles played by the service organizations have been incorporated in the planning, implementing the plans begin. Involvement gains commitment. Unless the group has to perform a task, the interest and commitment will dwindle. Utilizing a planning ladder as a check list of steps in executing any plans is probably an integral part of your personal work now. Carry this organization over to implementing a strategy for gaining the attention of service groups to earthquake awareness and preparedness.

Begin implementing the program where you are. In the case of Boston, you have a well-developed system of volunteer organizations. In fact your resources of well-defined organizations and volunteer programs should put you ahead of the game plan to incorporate earthquake education. There is a wealth of hazard-awareness material already available, but consideration of tailoring the material to the Northeast United States would need to be done. In the Southeastern United States and Central United States these products are being modified for their regions.

There are 5,000 languages in the world. To communicate we must be speaking a language that a specific group can understand. One-on-one conversation is the most effective form of communication. The one-on-one basis will grow, particularly when a speaker at a civic group program strikes a chord to a member of that particular audience. Say that this member holds a key position in the community to which he can incorporate information to his job. He leaves the meeting and takes a positive step in implementing the information gained from the speaker--unknown to speaker.

An incident such as just described actually happened when I was speaking to a civic group in Charleston at a luncheon program. The upgrading of the building code resulted. It was for only one main segment-City of Charleston-but it was a positive step.

Expressing appreciation through certificates of merit and publicizing an organization's work is a way to say "thank you" and solidifies a feeling of commitment.

CONCLUSION

In summary to gain the attention and commitment of public service organizations:

1. Clearly identify groups.

2. Reach the groups on a one-on-one basis at outset.

3. Incorporate the goals of earthquake awareness and preparedness education with goals of the organizations.

4. Write explicit plans.

5. Involve the organizations.

6. Reward the work done by each organization.

GAINING COMMITMENT OF VOLUNTARY AGENCIES

by

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INTRODUCTION

Volunteerism and the agencies formed to provide avenues for voluntary action in the United States have often been cited as unique to American culture. A phenomenon of sharing and concern for others is not seen in other societies of the world, at least not to the degree known here in the United States. Consequently, one would think that how volunteers and their organizations operate and what is entailed in obtaining their interest in community action is well understood by most of us. Unfortunately, this tends not to be the case. We tend to forget that these agencies are composed of people just like us. In fact, the majority of Americans are volunteers in their communities in one way or another. Therefore, the methods necessary to gain voluntary agency commitment to a particular cause is verv similar to the methods of gaining our individual commitment to a cause. Gaining voluntary agency commitment has three basic components.

STRATEGIES

Do Your Research

There are two primary types of voluntary agencies, they can be characterized as traditional and non-traditional. Organizations such as the various religous/ church groups, the Red Cross, the Sierra Club, and the Y's fall into the first group. They share the qualities of being well-known, have clear mandates as legitimate volunteer action groups, are usually multi-faceted in their programs and motivation, and are often able to tap into the financial and people resources of a national organization.

Non-traditional volunteer agencies are harder to "get a handle on." Often single community based and usually known as single cause groups, the non-traditional agency often does not have the advantage of a broad-based national constituency, or relatively secure financial base. They have the advantage of being highly innovative in approaches to problem solving and enjoy extraordinarily high commitment from their adherents.

Resources available from each agency must be identified. Is the group primarily a service agency? An advocacy group? Do they have a highly visible public information component? Do they have an on-going natural disaster program element? By seeking the answers to these and similar questions it becomes possible to come to know the character and philosophy of each agency.

Additionally, it is essential to understand the motivation of their leadership and the members at large. Volunteers are like all of us. The motives for voluntary action do not differ greatly from the motives for success in the workplace. The only major difference is that the altruistic payoff is not in monetary terms; but, the other and perhaps more important benefits of recognition, prestige and a sense of contribution are just as germaine to the volunteer as it is to the vice-president of General Motors. We cannot expect to gain the commitment of the voluntary sector without addressing and providing these essential benefits.

Know What You Wish The Voluntary Agency To Contribute

Voluntary agencies or groups are again similar to individuals in that ambigous concepts tend to diminish our understanding which concomitantly diminishs the ability to effectively deal with tasks. Agencies are willing, in most instances, to help formulate the task; however, the need must be clear cut and supported by solid factual data presented in understandable terms.

Nearly as important as presenting a clear concept of what the voluntary agency is asked to do is the requirement to bring them into the project as early as possible. The earlier - the better. Few agencies will appreciate being asked to participate only after other approachs have failed or when they have not had adequate opportunities to contribute to the assessment and planning components of a project.

Sell The Agency On The Need

Voluntary agencies have many activities they wish to accomplish and too few resources to accomplish all of their priorities. In order to sell these groups on earthquake planning, a telling argument must be made in order for them to reorder their priorities and resource allocations. Contact must be made with the senior volunteer and paid leadership of these groups and a convincing presentation provided that clearly demonstrates the need.

Once again, appeals to their altruistic motivations is appropriate. The leadership are also members of their communities, they are legally responsible for planning for safety and security of their volunteer workforce and the physical plants owned by their agencies. The constituency of the dozen or so largest traditional agencies is in excess of 100,000,000 persons - approximately 1/2 the nations population. In addition, the buildings and other physical plant of these agencies are capitalized in the many billions of dollars. Pointing out that a earthquake will threaten their personal and agency's security can go a long way in "selling" the need to participate in a hazards reduction plan. This approach can have a secondary effect. For instance, if a church's parochial school system retrofits it's buildings due to earthquake hazards, can the public school deny the need for retrofitting their building?

When agreement has been reached with agencies for their commitment, it is important that a "contract" be negotiated. This may be either formal or informal; yet, must be precise as to what the group or agency is willing to accomplish. It tends to be another myth that volunteers cannot be held accountable. Nothing can be further from the truth. Effective organizations always welcome accountability, regardless of their basis for being (i.e. private, non-private, governmental, etc.), since accountability is the "mirror" which reflects their success as an organization.

Yet, like all organizations, leadership turnover is a constant, and a contract in the form of a written agreement of cooperation can often be the difference between a fragmented, stressful involement or a well coordinated and productive collaboration

SUMMARY

When the three tasks cited above are adequately addressed, the voluntary agencies of this country constitute a formidable and available resource to accomplish many of the objectives of this workshop. Key to activating that resource will always be a good understanding of why these agencies exist, their motivations and the resources each may bring to bear.

ASSESSING THE RELATIVE VULNERABILITY OF URBAN HOUSING TO EARTHQUAKES

by

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A primary difficulty in the development and implementation of policies for mitigating the effects of natural hazards (earthquakes, hurricanes, etc.) on housing in urban areas is simply that of assessing the probable magnitude of the problem confronted. How many units might experience what damage levels and where are they located? This paper describes on-going research directed towards developing an analyticai model--based on specific housing inventory procedures--for making detailed assessments of the overall vulnerability of a community with respect to different disaster agents.

The first part of the project described in tne paper dealt with developing methods based on photogrammetric techniques for identifying, classifying, and inventorying existing housing structures in hazard-prone urban areas. As part data system (ODYSSEY) was used which allowed information derived from aerial photographs to be recorded, graphically displayed, and manipulated. Output capabilities included that of automatically generating display maps showing the geographic distribution of different housing types present within the selected study areas. Seismic assessments of the relative vulnerability of different housing types identified as being prevalent were next made. Finally, maps showing distributions of the relative vulnerabilities of existing housing in different portions of the study areas were generated by using the cartographic data system to relate specific housing type vulnerabiiity measures with stored housing inventory data. The locations within an urban area potentially most vulnerable to disaster effects could therefore be targeted. Policy response measures could be similarly targeted instead of having to be broadly applicable to large areas.

PRIMACY, DECLINE, AND DECREPITUDE: THE BUILDING LIFE CYCLE, AND ITS RELATIONSHIP TO EARTHQUAKE HAZARD REDUCTION STRATEGIES

by

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The problem of building performance is central to the earthquake issue because by far the greatest death, injury and property loss are caused by the relationship between building performance, ground motion, and people. It has often been observed that the greatest of earthquakes occurring in open country is of interest only to the seismologist.

This paper develops a scenario for dealing with buildings in the Northeastern United States as they relate to the earthquake threat. The term "scenario" is used to indicate something less, or more schematic, than a plan. In doing this, it is proposed to pull together information from a number of sources, including knowledge of building performance, experience in California in dealing with the regulation of building design and construction, and knowledge of the nature of the threat in the Northeastern United States, which is derived predominantly from papers presented at this workshop. This paper may present a view somewhat different from that normal to this kind of discussion and as such the extent to which it stimulates controversy and interest may serve to throw some of the issues into sharper relief. While specifically responding to the problems of the Northeastern United States, the analysis presented here may also be applicable, in principle, to other areas of the United States

As a beginning, it is suggested that the experience in the small town of Coalinga, California, in May 1983, was a blessing in disguise. A succinct description of what happened is that the extensive damage and destruction of unreinforced masonry buildings accelerated, into the space of about 10 seconds, a natural process of building decay that normally would have taken some 20 years or so.

Figure 1 shows three stages of normal building life related to time: these are, the new building in its prime, the building going into decline (though still socially, economically, and environmentally valuable) and the building entering a decrepit state. "Decrepit" we would define as below an acceptable level of thermal environment, health, structure, fire safety, weather proofing and appearance. For the building with a 100 year life shown in Figure 1, it is decrepit for the last 20 years. If the building is removed during its decrepit state, this is economically and environmentally advantageous, and

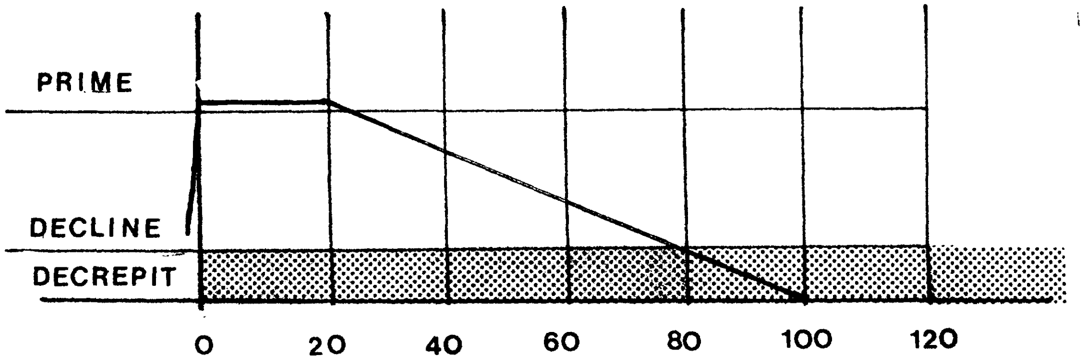

Figure 1.--Normal building life (100 year example).

ideally the building would be removed when it enters this State, so that the building stock would not be encumbered with decrepit buildings[1] (Figure 2). It can be argued that the Coalinga earthquake removed buildings that were in a decrepit state: it "pulled the plug," and provided the city with an unexpected opportunity for re-planning and reconstruction with State and Federal economic aid that would otherwise never have been presented, and saved the city from a slow and depressing decay. Replanning does not necessarily

1 The argument is often made that old buildings ("decrepit" in our terms) serve a useful social and economic purpose by providing housing for the poor or facilities for marginal commercial enterprises. It is a fine point as to whether social ends are really served by enabling people to live and work in decrepit buildings that are unhealthy and dangerous.

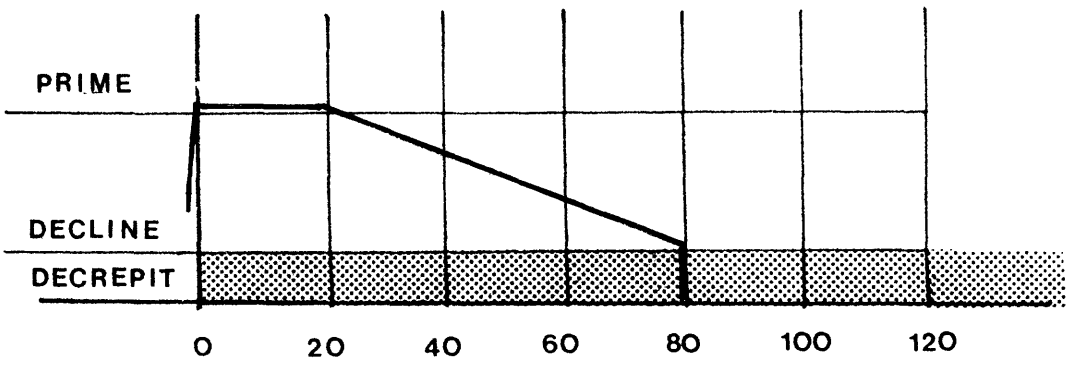

Figure 2.--Building demolish at optimum time, entry into decrepitude

imply the replacement of the old downtown, but rather the investigation of new construction strategies that make sense in relation to Coalinga's economic future. Downtown Coalinga at the time of the earthquake, for all its charm, was not exactly a hot investment prospect. This enforced pause provides an opportunity for a thorough investigation of the city's future.

To the argument that perhaps many of the Coalinga buildings had not, in fact, entered the decrepit state and were still in useful decline, it can be countered that the earthquake tested the building structures and they were proved inadequate in no uncertain terms, and hence were ripe for removal. Also, the upper floors of most buildings were unoccupied because of non-adherence to fire codes.

The effect of renovation or remodeling is to prolong the building life. Figure 3 shows normal decline arrested by minor remodeling at the 30th year, and the prime life span renewed by a major renovation after 50 years. Many variations of this pattern are, of course possible. Figure 4 shows the life of a major historical movement, such as a cathedral, which, by continual renovation is kept close to prime condition. This activity is not cost-beneficial and only justified if the building is of great aesthetic or cultural value.

The period of time which a building occupies in these stages may vary considerably. A small store will have a much shorter life than a major institutional building. The observations in this paper are directed to the

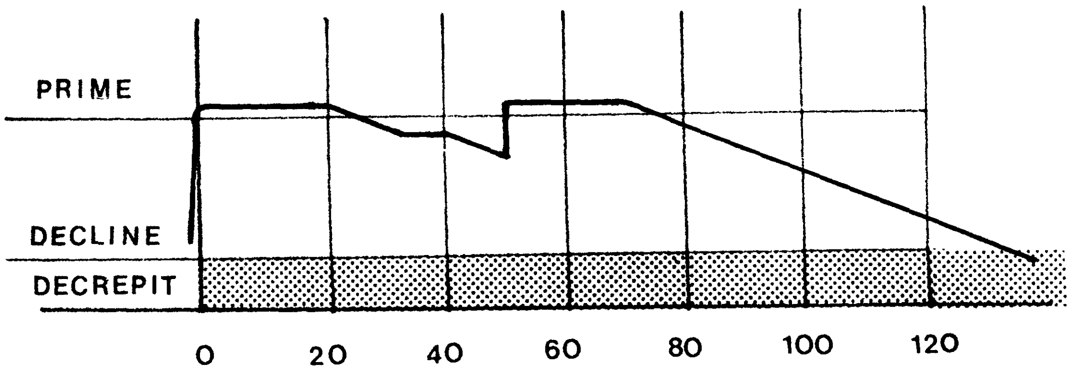

Figure 3. Building life span extended by renovation

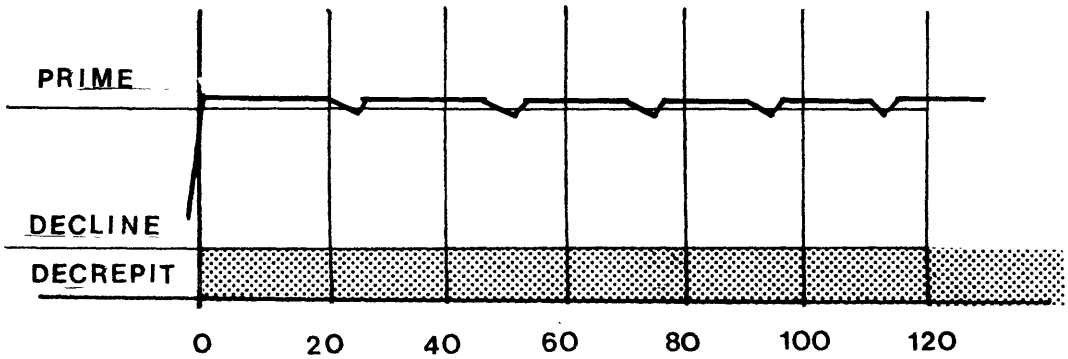

Figure 4.--Life span of historic monument

typical commercial - retail and office buildings, and small industrial facilities that make up much of our downtown building stock.

But even if it was beneficial economically to Coalinga to have its decrepit buildings removed by "radical surgery," were the casualties too high a price to pay for this convenience? It is reasonable to argue that, not withstanding the injuries and one near-death in Coalinga,[2] the casualties through the earthquake are <u>less</u> than if the buildings had lived out their full life, in the course of which time people would have been injured and even killed by fires, gas explosions, falling down rotten staircases, and the like.

The argument that this earthquake was a good thing for Coalinga can, of course, only be maintained if individuals who lost property are taken care of and made economically secure whether by insurance, State or Federal government means, and that the psychological trauma of the earthquake has not left permanent detrimental effects on Coalinga's citizens.

The important point that this argument introduces is that there is in fact a natural life for buildings and to the extent that one improves the building one is increasing its life; and when earthquake or fire removes the building, they are terminating it. This termination may be premature, but in the case of an old, decrepit building, is often an economic and even social benefit.

The predominant earthquake threat is to existing buildings because every year our construction adds some 2 to 3% to the building stock, so that in a 50-100 year period, depending on the nature and quality of each existing building, our building stock is essentially replaced. At the same time people are living and working in existing buildings and only quite slowly does the effect of new building begin to change the inventory of buildings.

In relation to the issue of whether to retrofit the existing buildings in the Northeast to make them seismically safe, one can see that there is a good

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2 At the time of writing, 10 weeks after the earthquake, one casualty is still in hospital, in a coma.

match between the natural replacement cycle of 50-100 years by which old and dangerous buildings will be replaced or renovated through the normal market process, and the figures presented by Professor Toksoz which discussed the probabilities of a Modified Mercalli VII earthquake in this region. Prof. Toksoz gave a minimum figure of 35.7 years, a maximum figure of 219 years and a mean figure of 88 years for the return period of an MM VII earthquake, with a 95% confidence factor. Thus, it can be seen that the mean figure is also approximately the mean figure for our normal replacement time. It should also be noted that an MM VII earthquake is one that would damage and destroy only buildings poorly constructed of unreinforced masonry, such as those of Coalinga or many in the Northeastern United States. The probabilities of a great earthquake in the MM IX range, as presented by Prof. Toksoz, seem so remote that using the figures in any way to encourage public action would not make sense. He shows a minimum of 276 years and maximum of 2,770 years with a mean of 876 years, as the return period for this intensity earthquake.

Based on this it is suggested that the correct procedure for dealing with existing unsafe buildings in the Northeastern area is to do <u>nothing about them at all</u>. At the same time, the public should be continually reminded how dangerous these buildings are. An exception would be that any buildings which, through normal market reasons or because of their historic merit, are rehabilitated so that their life is extended, should be subject to seismic requirements. In addition, new buildings should be subject to seismic requirements. With this strategy, then, the existing buildings would be allowed to decay in relation to their natural lifetime, but any new or rehabilitated building will be brought up to a seismic condition that responds to the expected requirements of a Northeastern earthquake. Thus in the period of 50-100 years with no special attention paid to ordinary existing buildings, the building stock of the Northeastern United States would then be seismically resistant. This strategy has the happy effect of making political, economic, and social sense.

This strategy, then, says that no active planning should be done for the retrofit of average existing buildings. At the same time energy and resources should be developed for initiating a realistic seismic code for new and rehabilitated buildings and for improving the design and construction practices in the region. So our strategy has two parts, passive and active, that are precisely related to one another and to the expectations of seismic activity.

In looking at the code issue - what kind of seismic code is appropriate for the Northeastern United States - it is suggested that the traditional code approach as used, for example, in California, is not appropriate. By this is meant a code which is essentially based on developing design force levels to which the entire building must then be designed. There is considerable evidence to show that historically the force to which a building has been designed i.e. the traditional code level, has had much less effect on the performance of the building in earthquakes than issues of general import such as the configuration of the building, the number and type of interior walls and partitions, the quality of its construction, and in particular, the extent to which the walls and floors have been structurally tied together (see Note 1). It is suggested then, that a code approach for the Northeast, which essentially is dealing with earthquakes of lesser magnitude than are faced in California, might concentrate on improving general standards of construction, and mandate a few simple construction practices - even of a prescriptive nature - that ensure that the building is well constructed, tied together, and reinforced to a reasonable level. The code should also reflect the different nature of the Northeastern earthquake relative to California, which might be summarized as being of lower magnitude and longer period, which is beneficial in respect to the unreinforced masonry building which is the greatest threat, because these are generally short period buildings, and hence amplification of ground motion is less likely.

If this strategy were to be pursued there are two alternative futures. The first future is that no significant earthquake occurs within the next 50-100 years. If this is so, the building stock is replaced through the normal cyclical process with safe buildings and from that point on the whole aim of any hazard reduction program that relates to buildings has been accomplished on an extremely cost effective basis.

Suppose, however, that a damaging earthquake does occur before a significant amount of the buildings stock has been replaced. Based on our analysis the buildings that will be seriously damaged or destroyed will, for the most part, be those that have entered the decrepit state, so their removal is economically and environmentally beneficial. The major issue then becomes the extent to which there will be deaths and injuries, because these have much more emotional impact than property loss.

It can be argued, that even under these circumstances, casualties in the Northeast would not be very severe.[3] There are three reasons for this. The first is that experience has shown that death and serious injury are caused by the total collapse of buildings, not simply by severe damage. The Coalinga experience has reinforced this view (see Note 2). Analysis of Coalinga damage shows that very few buildings suffered total collapse, and hence there were few casualties. The second part of the argument is that old buildings by their (decrepit) nature tend to be marginal economically and are often of low occupancy. In Coalinga 30-40% of the downtown buildings were empty, partly because the community could not support the rentals and partly because in some instances upper parts of the buildings had been declared unsafe for fire purposes. Moreover, old buildings are often for industrial and storage purposes in which the occupancies at risk are very low relative to the size of the building. The third argument relates to the exception to the above: masonry residential buildings which may in fact have fairly high occupancy. However, research has shown that residential buildings are intrinsically safer than commercial or industrial buildings, and hence the probability of total life threatening collapse is even more remote (See Note 3). The reason for this is that residential buildings have short structural spans, a large number of small rooms and relatively small windows. This results in a large number of walls which provide for much more support compared to a wide span commercial or industrial building.

So although there will be some casualties in a Northeastern earthquake, under these circumstances, it is a reasonable speculation that they would not be very great, and the argument presented earlier would hold good: that for these

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3 This argument holds true in other seismic areas also. In areas of more severe shaking than the Northeast, we can expect the major casualties in large concrete frame buildings, of poor architectural configuration, constructed prior to about 1973, when the impact of new codes following the 1971 San Fernando earthquake began to be felt.

decrepit buildings, casualties occurring through their normal life might equal or exceed those caused by an earthquake that cuts it short. And, of course, to the extent that marginal and decrepit buildings are destroyed without injury the result, as noted earlier, would be a benefit to the environment and economy of the city.

A related response to pursue if the earthquake occurs is then for the authorities to say in effect, "I told you so," and relate the damage to the fact that the public had been told that unstreqthened buildings would be subject to damage. At that point, if a real seismic threat is established, there is then ammunition to go into a fully publically supported retrofit program, recognizing the common statement of all who have studied these problems that without a disaster a retrofit program will never fly.

Even in California, where threat of danger is far more intense than in the Northeastern United States, retrofit programs have proven most difficult to get underway and at this time there are only three in existence. The most sophisticated of these is the ordinance adopted by Los Angeles in 1981, after 8 years of study, which is related to the possibility, estimated at something like a 10% probability in the next 30 years, of a great earthquake in the Los Angeles area.

This ordinance provides for a two-stage construction program under which if wall anchoring systems are installed, the time limit to complete the remaining structural strengthening (3 years) is automatically extended from 1 to 7 years, depending on the level of risk in the building. To date the building department has issued 1250 orders to building owners, has checked 750 renovation plans, and issued 500 building permits. One hundred and thirty retrofit projects are under construction, and 140 are finished some of which are first stage construction (see Note 4). One of the useful aspects of this program has been to force building owners of marginal buildings to consider the nature of their building and to take action of some sort, thus arresting the natural process of decay, or accelerating it in a beneficial way by demolition. By this process, if a building is renovated, its natural life is extended; and the ordinance requires a seismic retrofit. If it is demolished, then the authorities are initiating a "controlled earthquake," ensuring collapse when the building is uninhabited.

In summary then, the proposed strategy for the Northeastern United States would have the following features:

1) continue a low level public information program on the earthquake nature to buildings,

2) put the major effort into code reform and professional education and development,

3) develop innovative code approaches appropriate to the nature of the Northeastern United States threat, and

4) stress in doing this that it is directed to a general improvement of building construction quality rather than being explicitly oriented towards earthquakes.

The effects of the arguments presented here in relation to other areas of the country would be two. First to relate the probability of earthquakes to the natural life of buildings and if the pattern is similar to that of the Northeast, then to pursue a similar strategy to that proposed. Second, if the earthquake threat is seen as greater, then, instead of efforts to mandate wholesale retrofit of all masonry buildings at great cost and possible little gain, to conduct an analysis aimed at identifying those buildings that have entered the state of decrepitude. These buildings should then not be flagged for renovation but their removal should be encouraged, through tax incentives or other mechanisms, with due respect for individual, social or economic hardship that relates to the building.[4]

But policies that attempt to insist on prolonging the life of buildings that are better off dead will never make political, social or economic sense.

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4 Present tax structures provide for lower taxes on old buildings. A more logical one would be to increase taxes on decrepit buildings to make it economically beneficial to owners either to renovate or demolish their undesirable structures.

NOTES

1) For example: Henry J. Degenkolb, "Earthquake Performance of Old Buildings," EERI Seminar 'Fix'em,' 1982. to quote, "... a fact that in the design and construction of buildings, the reliance upon and conformance to codes has relatively little to do with the performance of buildings in earthquakes." This paper develops this argument in some detail.

2) Another example is that of the Imperial County Earthquake of 1979. Structural engineers performed emergency inspections of 19 unreinforced masonry buildings, of which 5 were not posted unsafe, 5 had portions roped off or posted unsafe, and 6 were posted unsafe. None suffered total collapse, no one was killed or injured in these buildings.

3) Martel studied masonry buildings in Compton, California after the 1933 Long Beach Earthquake. Out of 122 commercial buildings, 53% were demolished. Out of 21 residential buildings, 0 were demolished. Martel, R.R., "Earthquake Damage to Type III Buildings in Long Beach, 1933," in Earthquake Investigations in the Western United States, 1931-1964: U.S. Coast and Geodetic Survey Publication 41-2 (1966).

4) Information from Earl Schwartz, Chief, Conservation Bureau, Department of Building and Safety, Los Angeles, June 23, 1983.

SOME ASPECTS OF EARTHQUAKE LOSS REDUCTION IN NEW AND EXISTING BUILDINGS

by

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INTRODUCTION

Earthquake losses in the Northeastern States can be reduced by requiring earthquake resistance for new buildings, by requiring some earthquake resistance for buildings undergoing substantial rehabilitation, and by seismic retrofit of at least certain classes of existing buildings. In dealing with existing buildings, important questions concern which buildings ought to have increased seismic resistance, how much, and what are cost-effective methods for accomplishing this. A seismic survey of certain classes of existing buildings is proposed.

DESIGN OF NEW BUILDINGS

Massachusetts has since 1975 required new buildings to comply with the earthquake resistance previsions of the State Building Code. Buildings built by the Federal Government or with Federal aid in the Northeastern States are required to have seismic resistance. Except for Rhode Island, the other States in the Northeast do not require new buildings to be designed for seismic resistance, yet the earthquake risk in these States is not significantly different from the risk in Massachusetts. Since 1980 Rhode Island has required seismic design for buildings over six stories high, plus fire stations, hospitals, police stations and high hazard structures. The first step toward reducing earthquake hazards in the Northeast would be for all these States to issue mandatory seismic design and construction requirements for new buildings.

The basic purpose of the seismic design provisions of building codes is to reduce injuries and loss of life. Quoting the Massachusetts Code: "...to protect life safety by limiting structural failure." If a code were to try to also minimize building damage or property loss, the seismic design forces would have to be much larger or seismic drift limits would have to be imposed, or both, at substantially higher cost.

The Massachusetts State Building Code serves as an example of a cost-effective Code, in that seismic design forces are fairly low, with a Zone factor of only one third (1/3), but much emphasis is placed on ductility. Drafters of the Code recognize that a major earthquake will subject buildings to forces much larger than the specified Code forces. In a major earthquake this will result in significant damage to many buildings. By specifying that new buildings be provided with significant ductility, Code drafters expect properly designed new buildings to withstand a major earthquake without collapse and with minimal loss of life.

EXISTING BUILDINGS

The great majority of existing buildings in the Northeast are buildings which were not specifically designed to resist earthquakes. In the event of a major earthquake, the greatest loss of life would result from partial or total structural collapse of such existing buildings. Some of these buildings were designed to withstand strong wind forces, so would have fair to good seismic resistance. However, wind forces are external while seismic forces are generated by the inertia of the building responding to ground shaking. Thus two buildings of the same size, shape and height could have identical loading and strength for wind, but if their masses were different would have quite different earthquake resistance. Also many existing buildings have very little ductility or have poor geometrical arrangement, non-uniform distribution of lateral stiffness, and other attributes which would lead to partial or total collapse in earthquakes.

It has become much more common in recent years to extend the life of reasonably sound older buildings by altering and structurally rehabilitating them, as compared with the usual earlier practice of demolishing these older buildings. Even the present Massachusetts State Building Code does not require any existing building to meet the seismic provisions of the code unless there is a change in use to a new use carrying a higher fire hazard. This is treated in Chapter 22 of the Code adopted in 1979. Chapter 22, entitled "Repair, Alteration, Addition, and Change of Use of Existing Buildings" has these key provisions:

- For any building, the alterations must not reduce the present degree of compliance with the Building Code.

- A building must be made to comply with the Code for New Construction if its occupancy is changed to Institutional or is changed by an increase of 2 or more hazard index numbers.

There is an escape clause allowing "compliance alternatives" in the event the building official rules that full compliance "is impractical because of construction difficulties." Such alternatives for seismic resistance are not defined, and can be "as determined by the building official." Based upon discussion with other professionals, I believe that very rarely has a rehabbed older building been structurally upgraded to comply with the seismic design provisions of the Code. The few known cases are buildings owned by the United States Government and some hospital alterations.

The engineering community in Massachusetts was deeply involved in writing the seismic provisions of the State Building Code, through a Seismic Advisory Committee to the State Building Code Commission, which was active from 1973 to 1981. The Advisory Committee had official status only from 1978 - 1981. That Committee was succeeded in the last few years by a Seismic Design Advisory Committee appointed by the Boston Society of Civil Engineers Section/ASCE. We on the Committee have wrestled for many hours with issues concerning existing buildings. This presentation was not cleared with the Committee nor does it necessarily reflect its views, however.

The BSCES/ASCE Seismic Design Advisory Committee has worked on Guidelines for Evaluating Seismic Resistance of Brick Masonry Shear Wall Buildings. The Committee has also discussed preparing a list of recommendations for simple methods to upgrade seismic resistance of old buildings at reasonable cost. We have also discussed publishing some case study reports on seismic evaluation and

upgrading of specific existing buildings. For the past four years, the Committee has devoted over half its meeting time to existing buildings issues.
For existing buildings, some important questions are:

1. Which buildings ought to be made more seismic resistant?

2. How much seismic resistance should be required?

3. What design criteria should be imposed, in strengthening a building?

4. What are the most cost-effective methods for increasing seismic resistance?

Concerning question (1), the answer lies in the public or political domain, with advice concerning risk and estimated costs to be provided by the scientific/engineering community. If one studies the proposed guidelines in ATC 3-06,[1] Chapter 13,"Systematic Abatement of Seismic Hazards in Existing Buildings",it is found that the answer is no existing buildings in the Northeast United States. I find that difficult to accept. For example, some seismically weak older buildings house large numbers of people, contain facilities such as fire apparatus, ambulances, police, and civil defense headquarters, essential to dealing with post-disaster conditions, and some house persons who are ill or restrained or handicapped. Should such existing buildings be required to be seismically strengthened (i.e. retrofitted), even if not being rehabbed or altered? This is a sensitive issue and deserving of careful thought and study. It will be addressed further in a later section of this paper.

Concerning questions (2) and (3), how much seismic resistance and what design criteria, the answers cannot be arrived at simply. For some buildings, the cost of fully complying with new construction seismic requirements would be so high that an owner or developer required to retrofit would either demolish the

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1 "Tentative Provisions for the Development of Seismic Regulations for Buildings", Applied Technology Council, ATC Publications ATC 3-06, June 1978.

building or, if rehab were being proposed, would choose not to rehab the building. Therefore partial compliance ought to be an option. There are some proposed guidelines for partial compliance in ATC 3-06, to serve as a starting point. (Pgh. 13.2 and 13.3). The crucial question is: how much ground shaking should a given building be able to withstand without major collapse? Micro-zoning within a State or region should be considered. Then what design criteria concerning lateral forces, ductility, and so on, should be imposed?

Concerning question (4), cost-effective methods for increasing seismic resistance, the engineering and construction community should work together to provide technical and some cost guidance to aid architects and engineers faced with the problem of increasing seismic resistance of an existing building. Chapter 14 of ATC 3-06, and its 9 page bibliography, is a useful reference for repair and strengthening of structural and non-structural components of buildings, as a starting point.

This limited paper can only briefly touch on the subject of seismic strengthening of existing buildings. It should be noted that deficiencies requiring corrective work are often found in floor and roof diaphragms, unreinforced masonry walls, parapets, lack of structural ties or proper collector elements, connections of precast concrete or stone veneers, and structural connections.

Seismic strengthening methods may add mass and/or stiffness, leading to increased earthquake forces. The engineer must design for such larger forces.

SEISMIC RESISTANCE SURVEY OF EXISTING BUILDINGS

Governmental bodies are usually reluctant to commit to a course of action to solve a problem unless they have a grasp of the scope of the problem and some idea of the cost of solving it. In order to quantify the risk of doing nothing, as well as the reduced risk produced by doing something, to increase seismic resistance of existing buildings, I suggest as a necessary first step the preparation of a seismic resistance survey, in a limited geographic area.

A meaningful seismic resistance survey of all existing buildings in an area would be a hopelessly large task, so the survey ought to be limited to certain classes of building occupancy and to buildings which have seismically hazardous features such as heavy parapets. One objective of such a survey would be to identify existing buildings having high risk to life safety, for a large number of persons, caused by damage or collapse in the event of specified earthquake ground shaking. Those who perform the survey should qualitatively assess the probable degree of earthquake damage, estimate the number of building occupants, and of course itemize a number of facts concerning each building. Some photographs would be helpful. In some cases, it may not be possible to even approximately assess seismic resistance. Where the building size or number of occupants warrant, a more detailed analytical engineering study should be made. See Appendix A for more details of the proposed seismic resistance survey.

From the data base provided by such a survey, qualified engineers would then conduct a risk analysis. Others would then make rough estimates of the cost to upgrade the seismic resistance of the more hazardous buildings to a specified level. A desired result of the process would be an approximate cost-benefit analysis in which, for the specific group of surveyed buildings, an evaluation is made of cost in dollars per "unit" of reduced risk in which risk is quantified in terms of injury and loss of life.

SOME ASPECTS OF EARTHQUAKE LOSS REDUCTION IN NEW AND EXISTING BUILDINGS

Appendix A - Seismic Resistance Survey

A. Outline of Process

1. Screen and select buildings for qualitative evaluation.

    - Detailed list of building occupancy types.
    - Select types to receive "Qualitative Evaluation".
    - For geographical area, prepare list of all buildings to be so evaluated.

2. Evaluate the selected buildings qualitatively.

    - Team of professional engineers plus assistants.
    - Methodology - see ATC 3-06, Chapter 13.

3. Screen and select buildings for analytical evaluation.

    - On basis of qualitative evaluations, select buildings with highest risk to most people, in general.
    - Also, buildings in which seismic strength of structural system cannot be qualitatively assessed.

4. Analytical Evaluation

    - Objective: To determine estimated value of seismic capacity factor "r_c".

$$r_c = \frac{R_{avail} - R_{other}}{R_{seismic}}$$

r_c = fraction of design base shear at which building, or specific member or component, reaches its allowable stress.

R_{avail} = allowable total capacity (building, member, component).

R_{other} = that part of the allowable total capacity used for resistance to other load effects (D, D + L, etc.).

$R_{seismic}$ = that part of the allowable total capacity used for resistance to seismic effects.

    - Note: If $r_c \geq 1.0$, building would conform to code for new construction.

- If r_c < 1.0, one method of determining acceptance criterion is given by Chapter 13 of ATC 3-06 (Refer to Figures C 13-5 and C 13-6).

5. Select for Seismic Strengthening.

   - Buildings with high risk and r_c < say 0.4?

6. Design and estimate cost of seismic strengthening.

   - Increase r_c to what minimum value?

7. Perform risk analyses.

8. Prepare report.

B. Analytical Evaluation - Process and Problems

1. Investigation of building.

   - Review existing drawings, reports, etc.

   - Field observations and measurements of structural systems and foundations.

   - Obtain material samples, structural specimens for testing. (Number? Type? Locations?)

   - Chemical and physical tests.

   - Evaluate test results, estimate strengths of existing materials, components. (Problems)

2. Seismic computations.

   - Earthquake forces acting on primary structural systems resisting lateral forces, also non-structural components. (Base shear magnitude?) (Distribution? Per code, for distribution with height, but how distribute in plan?).

   - Lateral force analysis to determine internal seismic forces or stresses in members and connections, forces on foundation.

3. Non-seismic computations.

   - Determine gravity dead and live loads, plus any loads due to other effects (such as soil pressure, hydrostatic pressure, etc.)

   - Analysis to determine internal forces or stresses in members and connections, forces on foundation.

4. Determine seismic capacity factor " r_c ".

$$r_c = \frac{R_{avail} - R_{other}}{R_{seismic}}$$

$R_{seismic}$ calculation in step 2b.

R_{other} calc. in step 3b.

R_{avail} = allowable total capacity.

EXAMPLE: STEEL BENDING MEMBER

Allowable F_b = 22 ksi x 4/3 = 29.3 ksi

f_{other} = 19 ksi

$f_{seismic}$ = 15 ksi

$$r_c = \frac{29.3 - 19}{15} = \frac{10.3}{15} = \underline{.687}$$

PLANNING FOR EARTHQUAKE STUDIES IN THE NORTHEASTERN UNITED STATES

by

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INTRODUCTION

Most of the studies over the past seven years, pertaining to earthquakes in the Northeastern United States have been performed by the New England Seismotectonic Study in conjunction with the Northeastern United States Seismic Network. Both programs are sponsored by the Nuclear Regulatory Commission. The seismic network was expanded to over 100 stations and now provides a good record of the present day seismicity. The seismotectonic study, a cooperative effort of university personnel and state geological surveys, consists of a large varied program of investigations to identify seismic source zones and delineate seismotectonic provinces in the region (Barosh and Smith, 1983). These highly successful programs have accomplished much, but more needs to be done. Plans for future work in the Northeastern United States should provide for maintainence of the seismic network and continuance of the types of research done by the seismotectonic study until the region has been uniformly investigated. A brief description of the research program of the seismotectonic study and that remaining to be done follows, with emphasis on obtaining basic data needed to determine source zones and seismotectonic provinces, steps that are necessary before the earthquake risk can be meaningfully assessed.

RESEARCH PLANS

The distribution of seismic activity is highly variable in the Northeastern United States. Most of the earthquakes are concentrated in certain areas as shown by both historic and present day record (Fig. 1). This fact means that, although more areas need to be investigated in the region, there is a much

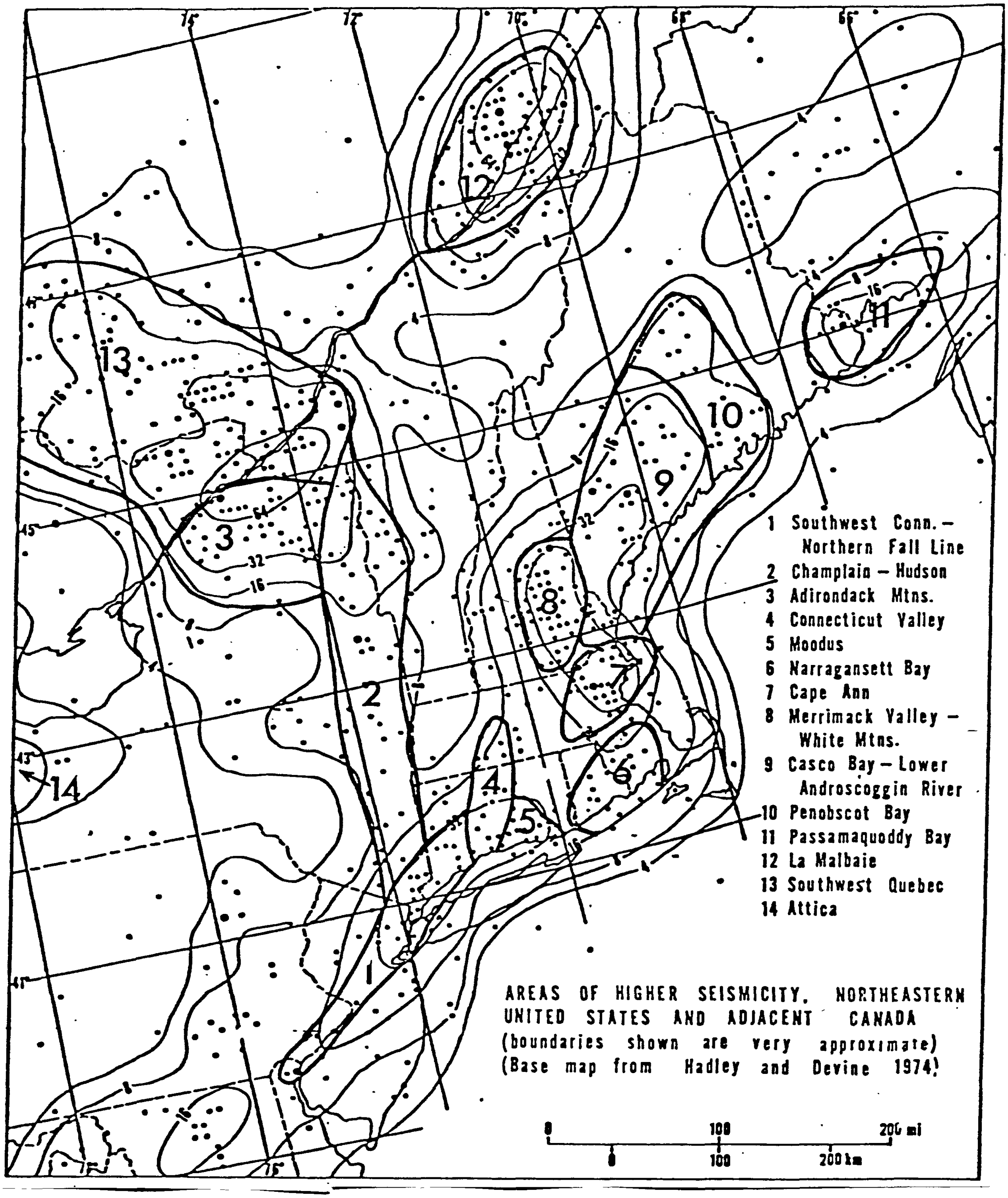

Figure 1.--Areas of higher seismicity, Northeastern United States and adjacent Canada.

greater opportunity to determine the cause of seismicity by comparing the geologic features found in the areas of relatively higher seismicity. The geologic structure at the surface in the region is generally representative of that occuring at the shallow depths of the earthquakes. This method of investigating all the active areas and comparing them has already resulted in recognizing a set of features associated with the earthquakes (Barosh, 1982) and assigning a probable cause (Barosh, 1981).

Understanding the cause of seismicity is a geologic study that is aided by geophysical and other methods to find the controls for events located by seismology. In light of this, a systematic multi-disciplinary program was inagurated that has attempted to:

1) Provide regional information needed for a general understanding of seismicity in New England and the relationship of geologic and geophysical features to seismicity.

2) Employ all pertinent types of scientific research to provide more detailed data in the areas of higher seismicity and recent tectonic movements and strive towards an equivalent level of detail for all areas.

3) Combine the data from 1) and 2) to determine source zones and delineate seismotectonic provinces.

The regional data included compilation of an earthquake catalog and new epicentral (Nottis, 1983), gravity, fault and maximum experienced intensity maps for the entire region. Landsat lineament studies and geologic compilation and mapping at 1:250,000 and 1:125,000 scales provided the regional structural setting. This was necessary as much of New England is only covered by reconnaissance geology and there is scant reliable data or structure. Studies to find previously unlisted historic earthquakes and relocate others have been done. Investigations of present day vertical movements in the region by geodetic, surficial geologic, historic construction, salt marsh, archaeologic and tidal gage studies have been very successful. Also a number of specific fault zones were investigated to understand the nature and history of faulting and search for Holocene fault movement. Several of these investigations should be continued especially those on vertical movements.

For each of the areas of relatively high seismic activity, adequate geologic, geophysical, and seismological data is needed. Most of the areas lacked any information on faults and were very poorly known geologically at the beginning of the Study. To date only the Moodus area in Connecticut has nearly sufficient data. Work has progressed well on the other areas, but more information is needed to describe the structure and accurately locate earthquake in relation to it. Local seismic arrays, such as that in the Moodus area, should be installed for a year or more in the more active areas. Good geologic maps are still lacking for most areas, although the geologic knowledge has been greatly improved and the places needing additional data are better defined. Gravity surveys of a 1 milligal contour interval or better and aeromagnetic surveys of at least half-mile flight-line spacing that at contoured by hand, are extremely useful in delineating structure in New England. Most areas are now covered by gravity surveys, but only a few have adequate aeromagnetic surveys. Seismic surveys generally provide poor results in the crystalline rocks of the Northeast, but shipboard surveys have been very useful in lakes and coastal waters. Additional data would be helpful at a few other coastal locations. Landsat analysis, that has been demonstrated to reflect structure well, is needed for several areas.

A great deal has been learned about the location of earthquakes and their relation with geologic structure, tectonic features and present-day vertical movements. Establishment of first-order level lines at carefully chosen sites in several areas would help delineate further vertical movement. This should be done after the rest of the presently available data is adequately analyzed.

SUMMARY AND RECOMMENDATIONS

The desired goal of placing seismic risk assessment on a solid scientific basis in the Northeastern United States can be achieved. It is not necessary to have to rely on probalistic methods based on assumptions. The results of the New England Seismotectonic Study over the past seven years have demonstrated that earthquake source zones and seismotectonic provinces can be determined from an integrated program of systematic basic research using proven methods and experienced personnel.

The source zones appear to be indicated by a set of geologic characteristics that can be determined. Vertical movement appears to be one of the most important features. New evolving methods, such as deep vibroseis and deep hole strain measurements, should be avoided, until they are shown to be reliable in the crystalline rocks of the region, especially if they are very expensive.

The recommendations of highest priority are:

1) Maintain the seismic network at the present or expanded level.

2) Operate local seismic arrays in the areas of relatively higher seismicity.

3) Perform detailed geologic mapping in the active areas where not done.

4) Continue a variety of studies of present day vertical movements until the entire region has been assessed.

5) Perform detailed gravity surveys on active areas where not yet done.

6) Produce aeromagnetic maps of the active areas in northern New England at 1/4 mile flight-line spacing.

Such a program with moderate funding over several years using experienced personnel will provide a much more complete and reliable set of data to in Risk assessment.

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SCIENTIFIC, ENGINEERING AND SOCIAL SCIENCE STUDIES NEEDED IN THE NORTHEAST

by

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INTRODUCTION

Based upon over a decade of thinking about and working upon the "earthquake problem" in New England, I have reached certain conclusions:

1. On a strictly dollars and cents basis, there is no economic justification to having required seismic provisions in New England. Very simply, damage causing earthquakes are very infrequent.

2. Nonetheless, there is a definite risk of life loss when a major earthquake does occur. I have estimated that a repetition of the 1755 Cape Ann Earthquake today might cause on the order of 75 fatalities in the Metropolitan Boston area.

3. There cannot possibly be political support for a crash program aimed at prevented those 75 fatalities. The risk is associated primarily with older buildings, and the economic and political cost of reducing that risk is enormous.

4. At the same time, I do not think we should just ignore the problem. There are steps which can and should be taken to reduce the risk in the future.

A GENERAL PROGRAM OF ACTION

First let me say that I like to "nibble" at problems rather than attempting to deal with the totality of the problem all at once. I do not think we should engage in a massive, splashy program, such as may be suitable in California. Any effort that overemphasizes the immediacy and enormity of a major earthquake in New England will simply create a credibilitv gap.

It is appropriate that the public and governmental officials be reminded frequently that a problem does exist. Our local press does a reasonably good job of this, seizing opportunities when small earthquakes here, or major earthquakes elsewhere, make the public curious about the matter. Such efforts, and less frequent ones by local TV, should be aided and encouraged.

Disaster preparation efforts are certainly worthwhile, although I would caution against "gaming" our next big earthquake in precise terms. We can say in general the types of problems that might be faced in disaster response, but we do not have much idea where the next big earthquake may occur and we know very little about the possible performance of specific buildings and elements of infrastructure.

It is certainly worthwhile to have appropriate seismic building code provisions, applicable to new construction, in effect throughout the area. Leadership from the professional engineering community may not be sufficient to achieve this goal, but it certainly is necessary. Contacts among the several local chapters of the American Society of Civil Engineers could be very useful in this regard.

I do not believe that an effort to require seismic upgrading of all existing buildings is politically feasible nor desirable. On the other hand, there often are opportunities to increase seismic resistance - by relatively simple steps, but not necessarily to the level of resistence required of new buildings - when a building undergoes massive rehabilitation. The need is for guidelines and standard details applicable to such situations.

Lifelines should not be ignored. I would expect a repetition of the 1755 earthquake to cause fires in Boston, the fighting of which would be hampered severely by breaks where water mains pass through unstable ground. The need is to translate experience in California into simple guidelines appropriate for New England.

SOME RESEARCH TASKS

Seismologic and geologic studies: Lack of understanding as to the causes, and most likely locations and possible magnitudes of earthquakes is a major impediment to a rational attack on the earthquake hazard. Obviously, any studies that will help understand these matters better are important. This primarily means monitoring small earthquakes as they occur and analyzing the resulting records.

It is also important to maintain a network of strong motion instruments to record such motions in the rare instances that they occur.

Zonation of the Northeast is a troublesome question. Here in Massachusetts, for example, the western part of the State tends to oppose existing State-wide building requirements because they think earthquakes are strictly an eastern Massachusetts problem. Yet the seismologists cannot agree upon any plan for zoning the State. A workshop with the goal of developing an agreed upon zonation plan for the Northeast might possibly be of value.

Engineering and social science studies: It is almost impossible in the Northeast to separate the problems of developing codes and standards and implementing such instruments. Here follow some studies, mostly requiring understanding of both engineering and political/economical/social issues, that would be of value.

There is a need to put in place and maintain strong State and/or city building departments.

It would help greatly to develop standard, acceptable design details for low rise buildings (especially those using masonry) that receive little or no engineering.

We should learn, from a serious, honest survey, what if any additional construction and engineering costs have resulted - for various types of buildings - from the Massachusetts Building Code seismic provisions that went into effect nearly a decade ago.

There need to be regulations governing the rehabilitation of existing buildings: when upgrading of seismic resistance is required and what level of shaking should be used to check/design the rehabilitated structure. Standard details for various types of construction should be developed.

One study of a purely engineering nature would be to conduct dynamic shaking tests on typical existing construction that is about to be demolished.

GETTING STARTED

The efforts mentioned above require, primarily, the devoted effort of engineers and seismologists within New England. There is not a great need for the Seismic Safety Commission, although the existence of such a commission would no doubt stimulate action. However, there is nothing now stopping engineers or seismologists in the several States from meeting, talking to each other, and initiating actions aimed at agreeing upon such matters as zonation, code requirements, etc. Some funding is probably necesary, to reimburse costs of meetings and, more importantly, to provide staff support in the form of technical studies to assist otherwise volunteer committees.

THE NRC SUPPORT FOR EARTHQUAKE HAZARD RESEARCH IN THE NORTHEASTERN UNITED STATES

by

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One of the basic objectives of the U.S. Nuclear Regulatory Commission (NRC) seismological/geological research effort in the Northeastern United States is to improve our understanding of the earthquake hazards there and to establish the level of uncertainty associated with those hazards.

The mainstay of that research effort is the Northeastern United States Seismic Network (NEUSSN) coordinated for the NRC by Paul W. Pomeroy. The NEUSSN is composed of five U.S. subnetworks operated by Boston College, Massachusetts Institute of Technology, Columbia University, the State University of New York at Stony Brook, and Pennsylvania State University with the Eastern Canada Telemetered Network operated by the Earth Physics Branch, a cooperative partner. Approximately 75% of the $1.1 to $1.2 million in the NRC research budget for the N.E. U.S. is spent on the seismic networks. This supports about 120-130 stations, most with high-magnifications, high-frequency, and narrowband sensors.

This major funding commitment reflects the role of the seismic networks as the key source of data about earthquake hazards in the NEUS. The networks provide the basic seismicity data, location, depth and magnitude which are the fundamental data for establishing the seismic source zones and the recurrence relations in them. This information is used to select the areas which are currently seismically active and thus most likely to be productive for geological and geophysical investigations. One of the primary objectives of the NRC research program is to establish, if possible, the relationship between seismicity and tectonic features.

In its Long-Range Research Plan (NUREG-0961) the NRC recognizes a need for earthquake hazards research. But it must be recognized by the non-NRC users of this information that the NRC is a mission oriented agency and that under the current economic conditions of limited resources, other aspects of nuclear safety research may legitimately be more critical to public health and safety than seismic data. Thus, NRC support of the seismic networks might have to be partially or fully withdrawn to provide research funds for more critical work. If full withdrawal occurs without a significant advance warning, the NEUSSN with the notable exception of ECTN would collapse because of its overwhelming dependence of NRC support. This is not a tolerable situation for either the NEUSSN or the NRC.

The Earth Sciences Branch has been attempting to broaden the support of earthquake hazard research in the Eastern United States. This effort will be considerably more vigorous in Fiscal Year 1984. Approximately 18 months ago considerable support was voiced for the seismic networks and the need for their continued operation. This support was accepted. In responding to these supporters, the NRC suggested that they consider financial support for the networks. The level of support was not as critical as the willingness to financially support the agencies did not have primary concern for earthquake hazard or large financial resources. In the NEUS, there was no further diversification of funding sources and actually there was some significant withdrawal of funding.

On the other hand there are a number of organizations that are sponsoring cooperatively funded research efforts. These include both State and Federal agencies. There are also a number of organizations doing hazard related research and data collection without being directly involved in the National Earthquake Hazard Reduction Program. These include State and Federal agencies as well as private industry such as the seismic monitoring associated with operating nuclear power plants.

THE NEED FOR, ADVANTAGES AND PROBLEMS OF A NORTHEAST REGIONAL SEISMIC SAFETY COUNCIL

by

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The question is whether or not there is a need for a Northeast Regional Seismic Safety Council. The probability of a major earthquake occurring in the Northeastern United States is quite low, but moderate to severe earthquakes have occurred in the region in the past and, certainly, they will occur in the future. More than in most other parts of the United States, the earthquake hazard problem is compounded by a high population density, many old, large buildings, and a high degree of modern industrialization. At present, in the Northeast, no specific plans exist for response to a major earthquake other than the general disaster response plans of the Federal Emergency Management Agency (FEMA).

The Northeastern United States is perhaps unique in that many of the governmental units already involved in emergency preparedness and response are interknit in regional councils, inter-State cooperative agreements, etc. Thus, the precendent for cooperation on an earthquake preparedness plan is well established.

Because of the uniqueness of the Northeast, the appointment of a properly constituted Northeast Regional Seismic Safety Advisory Council (NERSSAC) is critical to the accomplishment of the following tasks:

- Task I: Hazard Awareness and Public Information
- Task II: Intergovernmental Relations and Cooperation
- Task III: Local Earthquake Resistant Design
- Task IV: Land Use
- Task V: Response to a Damaging Earthquake

The Council, which should be appointed by the National Research Council, should have the preliminary responsibility for the development of a seismic safety policy and the coordination and enactment of the first five-year effort. The Council should have the political authority to ensure that its recommendations will be carried out and must have the personnel and financial resources to move forward. Once the Council is in place, specifics in each of the five task areas can be addressed.

The Northeast is fortunate in that many regional cooperative programs, both political and scientific, are already in place and the precendent for regional cooperation is well established. Moreover, a number of responsible, concerned individuals are already working to enhance awareness of the earthquake risk in this area of low probability of occurrence. The success of any programs such as this requires the active, long-term participation of these and other individuals (as well as corporate entities).

Because of the high degree of industrialization, the large number of older buildings, and the high population density in the region, the occurrence of a major earthquake in the Northeast would result in a major loss of life and property. The earthquake preparedness program outlined here would result in a major reduction of these losses.

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OCTOBER 01, 1981 - DECEMBEER 31, 1981

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ABSTRACT

This report is the twenty-fifth quarterly bulletin of seismicity in the northeastern United States for the period October - December 1981. Included are geographic maps of the network stations and seismicity during the quarter, and of the cumulative seismicity for the twenty five quarters. Also included are tables of station locations, epicenters, and all event data for the quarter. An appendix describes the velocity models appropriate for the northeastern United States.

ACKNOWLEDGEMENTS

Partial or full support from various agencies for the operation of the Northeastern seismic Network (NEUSSN) is gratefully acknowledged. Agencies providing support to members of NEUSSN include the U.S. Nuclear Regulatory Commission, Office of Reactor Safety Research; the U.S. Geological Survey Office of Earthquake Studies; the National Science Foundation, Geophysics Program; the New York State Energy and Resources Development Authority; and the New York State Science Service.

Data from stations operated by Weston Geophysical Research, Inc., and Woodward-Clyde Consultants are routinely provided to NEUSSN when available. Epicentral and station data for some of the events in Canada near the U.S. border are provided by the Earth Physics Branch, Dept. of Energy, Mines, and Resources, Ottawa, Canada.

In addition to the above operational support, equipment has been provided by the Advanced Reaearch Projects Agency of the Dept. of Defense and by the Office of Environmental Geology of the U.S. Geological Survey.

INTRODUCTION

Station operations and seismicity results for the quarter are summarized in three figures and five tables (the formats of the tables are described in the section EXPLANATION OF TABLES).

Figure 1 is a geographic map of NEUSSN stations which were operational during the reporting period; Figures 2 and 3 are maps of seismicity for the reporting period and for the cumulative period from October 1975, repectively, in which those earthquakes that were felt are shown by red symbols.

Table 1 is a location list of operating stations; Table 2 is a chronological list of epicenters during the reporting period; Table 3 lists station arrival times, distances, azimuths, amplitudes, and periods for the events of Table 2; Table 4 lists foreshocks, aftershocks, and microearthquakes occurring during the reporting period.

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Seismicity

During the period October - December 1981, a total of 10 earthquakes were detected and located in the northeastern United States. In addition, 30 earthquakes are included which had epicenters in Canada, 22 of these events were within 100 kilometers of the U.S. border. Table 4 includes 46 aftershocks and microearthquakes.

The magnitudes of the 40 earthquakes in Table 2 range from -1.8 to 3.7. The magnitudes of the events in Table 4 range from -0.5 to -1.9.

EXPLANATION OF TABLES

Table 1: List of operating Seismic Stations

1. Station code
2. Station latitude, degrees north
3. Station longitude, degrees west
4. Station elevation, meters
5. Geographic location
6. Network operator

Table 2: Epicenter List

1. ORIGIN: Origin time in hours, minutes and seconds
2. LAT N: North latitude in degrees and minutes
3. LONG W: West longitude in degrees and minutes
4. DEPTH: Event depth in kilometers
5. MN: Nuttli Lg magnitude with amplitude divided by period
6. MC: Coda duration magnitude
   WES: 2.23 Log(FMP)+0.12 Log(Dist)-2.36
   LDO: 2.21 Log(FMP)-1.7
7. ML: Local magnitude
   WES: Calculated from Wood-Anderson seismograms (Ebel 1982)
   EPB: Richter Lg magnitude
8. GAP: Largest azimuthal separation, in degrees, between stations
9. RMS: Root mean square error of time residual in seconds
10. ERH: Standard error of epicenter in kilometers

11. ERZ: Standard error of event depth in kilometers

12. Q: Solution quality of hypocenter
    A: Excellent
    B: Good
    C: Fair
    D: Poor

13. NS: Number of stations recording event

14. NP: Number of phase arrivals used in epicenter location

Table 3: Event data list

1. STN: Station code

2. DIST: Epicentral distance in kilometers

3. AZM: Azimuthal angle between epicentre to station measured from north in degrees

4. Description of onset of of phase arrival
    I: Impulsive
    E: Emergent

5. R: Phase
    WES and LDO
    P: First P arrival
    S: First S arrival
    EPB
    P: Pg
    p: Pn
    S: Sg
    s: Sn

6. M: First motion direction of phase arrival
    U: Up or compression
    D: Down or dilitation

7. K: Weight of arrival
    0: Full weight
    1: 3/4 weight
    2: 1/2 weight
    3: 1/4 weight
    4: No weight

8. HRMN: Hour and minute of phase arrival

9. SEC: Second of phase arrival

10. TCAL: Calculated travel time in seconds

11. RES: Residual of station arrival

12. WT: Weight of phase used in hypocentral solution

13. AMX: Peak-to-peak ground motion, in millimicrons, of the maximum envelope amplitude of vertical-component signal, corrected for system response.

14. PRX: Period in seconds of the signal from which amplitude was measured.

15. XMAG: Nuttli magnitude recorded at station

16. FMP: Coda duration in seconds at station

17. FMAG: Coda magnitude recorded at station

Table 4: Foreshocks, After shocks, and Microearthquakes

1. Event date, arrival time (UTC), magnitude, nearest recording station and geographic region

REFERENCE

Ebel J.E. (1982). M_L measurements for northeastern United States Earthquakes, Bull. Seism. Soc. Am. 72, 1367-1378.

APPENDIX
VELOCITY MODELS USED FOR EPICENTER LOCATIONS IN THE NORTHEASTERN UNITED STATES

REGION	VEL km/sec	To sec	DEPTH km
Northern New York and Adirondacks (LDO)	6.1	0.0	0.0
	6.6	0.5	4.0
	8.1	6.3	35.0
Attica, New York (LDO)	4.5	0.0	0.0
	5.0	0.2	1.0
	6.0	1.4	6.0
Blue Mtn. Lake, New York (LDO)	5.9	0.0	0.0
Southeastern NY and northern New Jersey (LDO)	5.98	0.0	0.0
	6.62	1.0	7.0
	8.1	6.5	35.0
New England (WES)	5.31	0.0	0.0
	6.06	0.16	0.88
	6.59	1.78	13.09
	8.10	6.72	34.60

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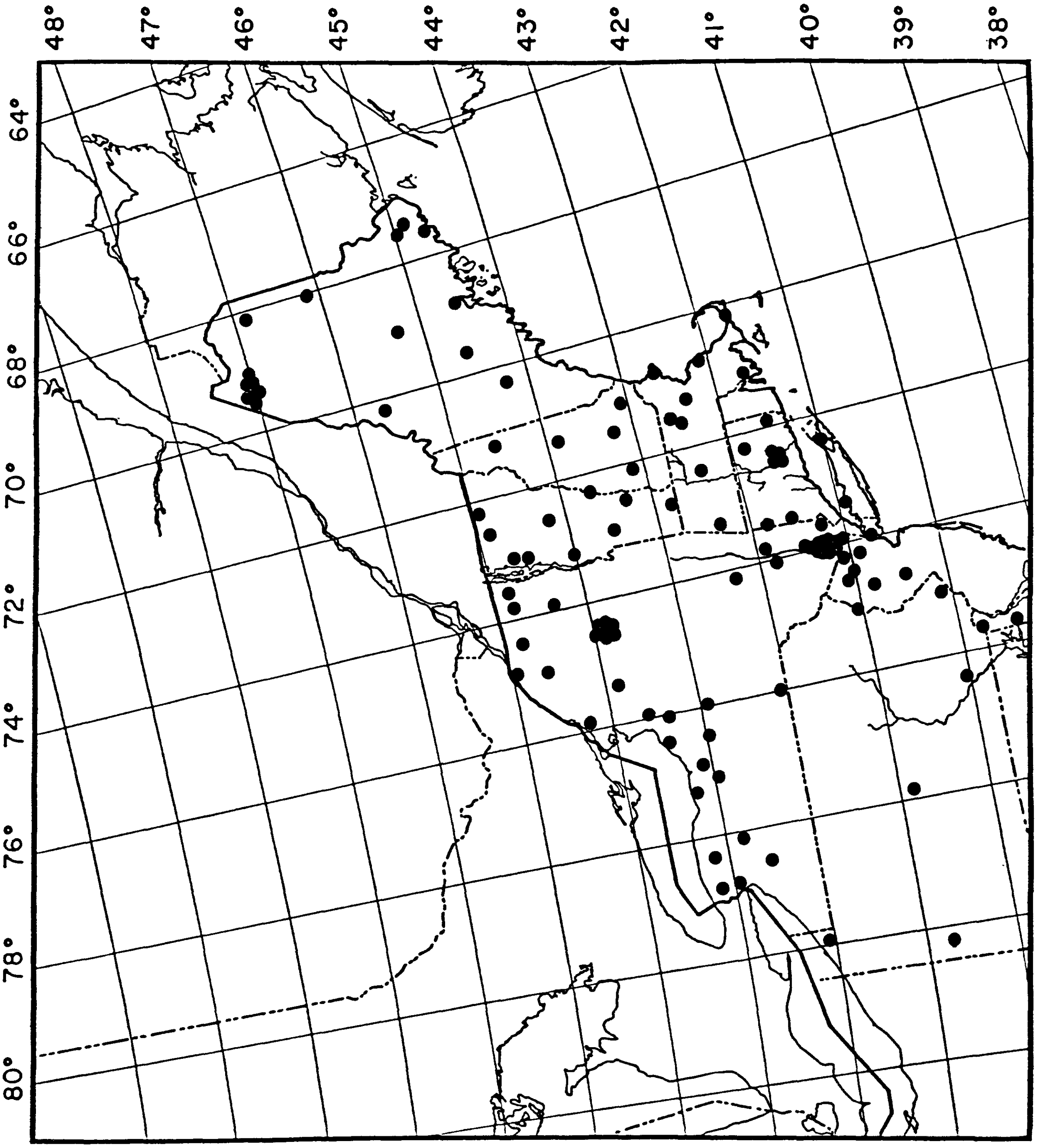

FIGURE 1. Seismic Stations operating during the period

OCTOBER - DECEMBER

1981

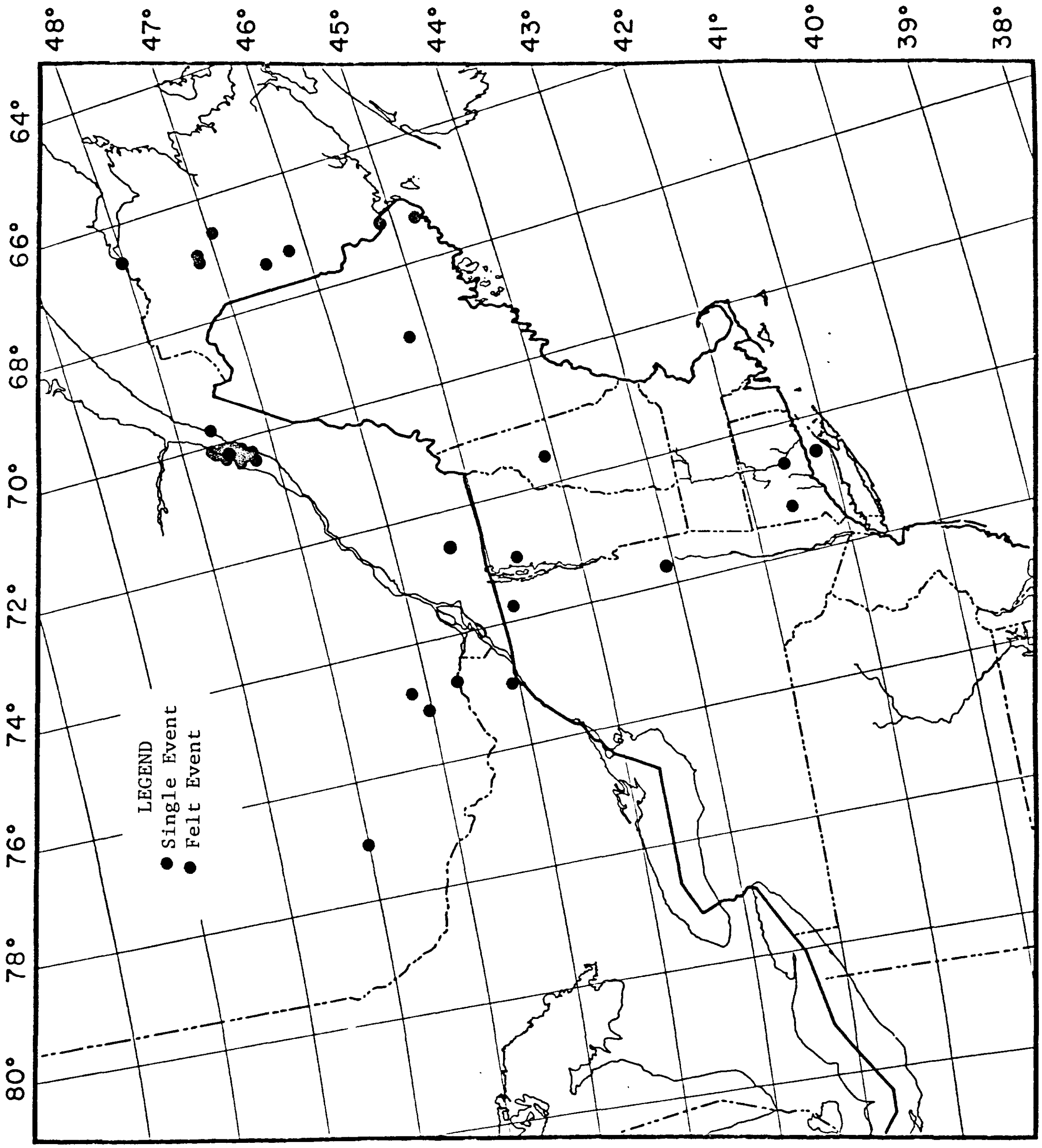

FIGURE 2. Earthquake Epicenters during the period

OCTOBER - DECEMBER

1981

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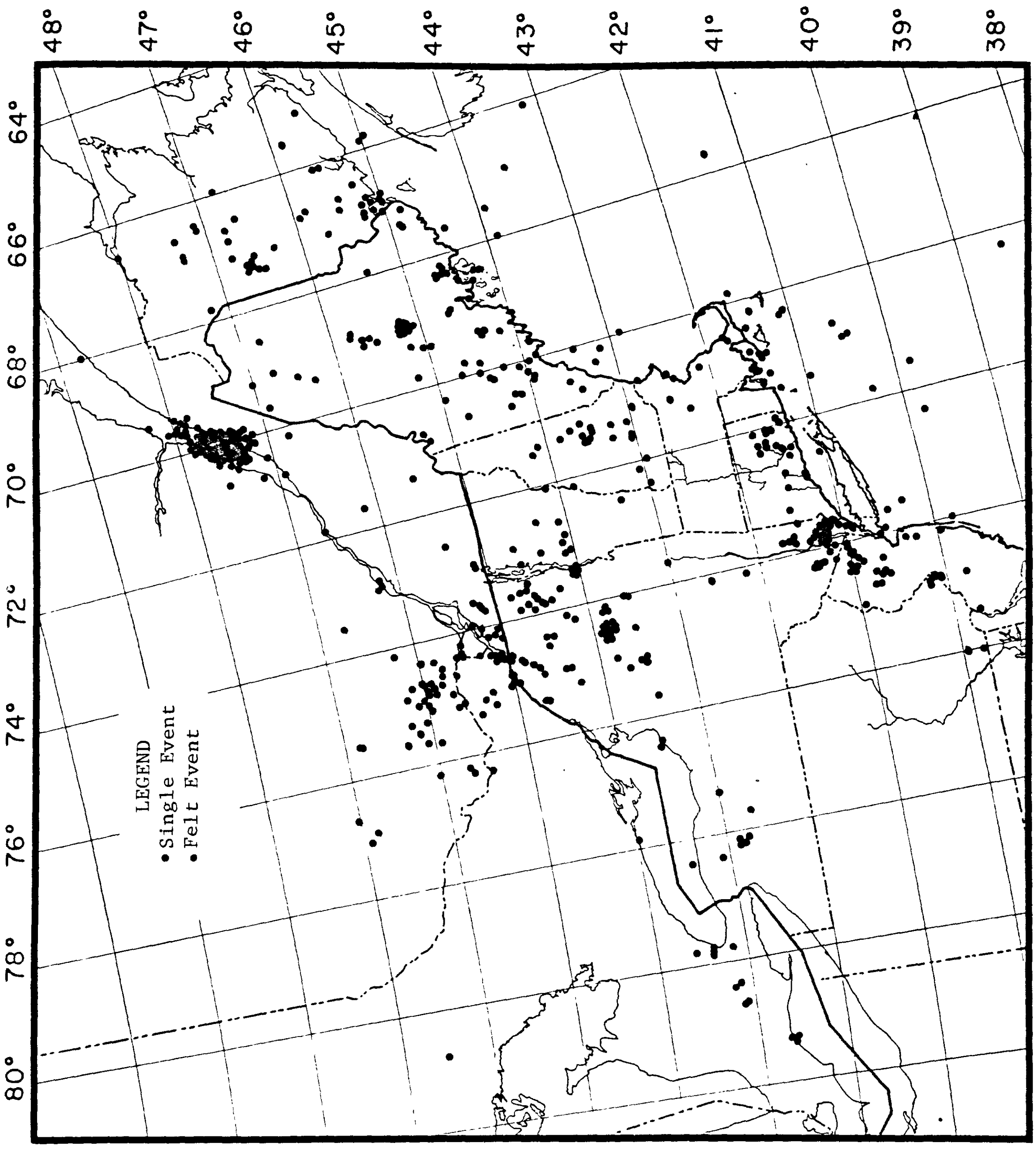

FIGURE 3. Earthquake Epicenters during the period

OCTOBER 1975 - DECEMBER 1981

TABLE 1

LIST OF OPERATING SEISMIC STATIONS BY STATE
OCTOBER - DECEMBER
1981

STATIONS USED FOR LOCATIONS IN THIS BULLETIN

STA ID	LATITUDE degrees	LONGITUDE degrees	ELEVATION meters	LOCATION	OPERATOR
CANADA					
A10	47.2460N	70.1930W	45		EPB
A16	47.4680N	70.0100W	22		EPB
A20	47.7060N	69.6900W	45		EPB
A54	47.4570N	70.4130W	384		EPB
A56	47.5500N	70.3270W	414		EPB
A60	47.6920N	70.0930W	358		EPB
A61	47.6937N	70.0912W	358		EPB
A64	47.8270N	69.8910W	137		EPB
BUO	43.3617N	79.7450W	88	BURLINGTON, ON	EPB
CKO	45.9944N	77.4500W	191		EPB
CW1	45.0733N	74.7050W	55	GLEN DONALD, ON	EPB
CW2	45.1717N	74.4872W	55	GLEN DONALD, ON	EPB
CW3	45.1925N	74.6122W	67	GLEN DONALD, ON	EPB
DLA	42.8583N	81.5733W	227	DELEWARE, ON	EPB
EBN	47.5400N	68.2410W	189	EDMUNDSTON, NB	EPB
EFO	43.0917N	79.3117W	168	EFFINGHAM, ON	EPB
ELF	43.1933N	81.3150W	320	ELGINFIELD, ON	EPB
FHO	45.4550N	76.2170W	72	FITZROY HARBOUR, ON	EPB
GAC	45.7033N	75.4783W	62	GLEN ALMOND, PQ	EPB
GNT	46.3630N	72.3720W	10	GENTILLY, PQ	EPB
GRQ	46.6067N	75.8600W	290		EPB
JAQ	53.8022N	75.7211W	366		EPB
LDN	43.0400N	81.1830W	246	SANSHAWE, ON	EPB
LDQ	53.8060N	77.4280W	198		EPB
LMQ	47.5484N	70.3267W	419	LA MALBAIE, PQ	EPB
LPQ	47.3408N	70.0094W	126	LA POCATIERE, PQ	EPB
LTQ	53.7020N	76.0850W	152	LA GRANDE 3, PQ	EPB
MNQ	50.5300N	68.7700W	564	MANICOUGAN, PQ	EPB
MNT	45.5025N	73.6231W	112	MONTREAL, PQ	EPB
OTT	45.3939N	75.7158W	77	OTTOWA, PQ	EPB
POC	47.3600N	70.0400W	61	LA POCATIERE, PQ	EPB
QCQ	46.7800N	71.2800W			EPB
SBQ	45.3783N	71.9264W	256	SHERBROOK, PQ	EPB
SCH	54.8167n	66.7833W	540	SCHEFFERVILLE, PQ	EPB
SIC	50.1900N	66.7400W	283	SEPT-ISLES, PQ	EPB
SUD	46.4660N	80.9660W	267	SUDBURY. ON	EPB
TRQ	46.2222N	74.5555W	853		EPB
UNB	45.9500N	66.6333W	56	FREDERICTON, NB	EPB
VDQ	48.2300N	77.9717W	305		EPB
WBO	45.0003N	75.2750W	85		EPB

CONNECTICUT

BCT	41.4933N	73.3839W	69	BROOKFIELD, CT	WES
ECT	41.8346N	73.4113W	342	ELLSWORTH, CT	WES
HDM	41.4857N	72.5232W	24	HADDAM, CT	WES
MD1	41.5529N	72.4667W	113	MOODUS (COMSTOCK BRIDGE), CT	WES
MD2	41.5314N	72.4337W	61	MOODUS (PICKEREL LAKE), CT	WES
MD3	41.5066N	72.4715W	152	MOODUS (CAVE HILL), CT	WES
MD4	41.5023N	72.5121W	106	MOODUS (HADDAM NECK), CT	WES
MD5	41.4551N	72.4950W	101	MOODUS (SHAILERVILLE), CT	WES
NSC	41.4807N	71.8516W	110	N STONINGTON, CT	WES
UCT	41.8317N	72.2505W	149	STORRS, CT	WES

DELAWARE

BBD	39.3416N	75.6767W	18	BLACKBIRD, DE	DGS
GTD	38.7414N	75.4144W	15	GEORGETOWN, DE	DGS
NED	39.7042N	75.7082W	46	NEWARK, DE	DGS

MAINE

AGM	47.0817N	69.0233W	240	ALLAGASH, ME	WES
BPM	44.6317N	68.7893N	80	BUCKSPORT, ME	WES
CBM	46.9325N	68.1208E	250	CARIBOU, ME	WES
D1A	47.0586N	69.0989W	304	DICKEY, ME	WES
D2A	47.1304N	69.1524W	402	DICKEY (KELLY MTN), ME	WES
D3A	47.0876N	69.1687W	259	DICKEY (CARTER BROOK), ME	WES
D4A	47.1881N	69.2767W	490	DICKEY (ROCKY MTN), ME	WES
D5A	47.0113N	69.2650W	365	DICKEY (BROWN'S BROOK), ME	WES
D6A	47.0890N	69.4957W	430	DICKEY (TWO MILE STREAM), ME	WES
EMM	44.7392N	67.4894W	20	EAST MACHIAS, ME	WES
HKM	44.6564N	69.6408W	79	HINCKLEY, ME	WES
HNME	46.1599N	67.9867W	209	HOULTON, ME	WES
JKM	45.6555N	70.2426W	378	JACKMAN, ME	WES
MIM	45.2436N	69.0403W	140	MILO, ME	WES
PQ0	44.9863N	67.4674W	219	COOPER HILL, ME	WES
PQ1	44.9035N	67.3271W	93	EAST RIDGE, ME	WES
TRM	44.2597N	70.2551W	113	TURNER, ME	WES

MASSACHUSETTS

COD	41.6856N	70.1350W	-85	CAPE COD, MA	MIT
DUX	42.0686N	70.7678W	27	DUXBURY, MA	MIT
FLR	41.7167N	71.1215W	52	FALL RIVER, MA	WES
GLO	42.6403N	70.7272W	15	GLOUCESTER, MA	MIT
HRV	42.5064N	71.5583W	180	HARVARD, MA	MIT
LNX	42.3389N	73.2724W	345	LENOX, MA	WES
NMA	41.2950N	70.0260W	-100	NANTUCKET, MA	MIT
QUA	42.4566N	72.3738W	201	QUABBIN, MA	WES
WES	42.3847N	71.3221W	60	WESTON, MA	WES
WFM	42.6106N	71.4906W	87	WESTFORD, MA	MIT

NEW HAMPSHIRE

BNH	44.5906N	71.2564W	472	BERLIN, NH	WES
DNH	43.1225N	70.8948W	24	DURHAM, NH	MIT
HNH	43.7053N	72.2856W	180	HANOVER, NH	WES
ONH	43.2792N	71.5055W	280	OAKHILL, NH	MIT
PNH	43.0942N	72.1358W	659	PITCHER MTN, NH	MIT

NEW JERSEY

GMIN	40.8825N	74.1845W	165	GARRETT MOUNTAIN, NJ	LDO
GPD	41.0177N	74.4608W	360	GREEN POND, NJ	LDO
LVNJ	40.8095N	74.7515W	201	LONG VALLEY, NJ	LDO
OGD	41.0667N	74.6166W	-363	OGDENSBURG, NJ	LDO
PQN	41.0073N	74.0858W	229	PAHAQUARRY, NJ	LDO
PRIN	40.3668N	74.7178W	110	PRINCETON, NJ	LDO
RAMA	41.0952	74.2140W	247	RAMAPO, NJ	LDO

NEW YORK

ABRN	42.9963N	76.4853W			
ALX	44.3225N	75.9280W	122	ALEXANDER BAY, NY	LDO
AMNH	40.7808N	73.9738W		MANHATTAN, NY	LDO
APH	43.8413N	74.4970W	564	AIRPORT HANGAR, NY	LDO
BGR	44.8288N	74.3742W	329	BANGOR, NY	LDO
BING	42.0757N	75.9767W	408	BINGHAMPTON, NY	LDO
BLM	41.3297N	73.9550W	134	BLUM, NY	CON*
BML	43.8680N	74.4020W	305	BLUE MOUNTAIN LAKE, NY	LDO
CANY	42.9255N	78.8528W	192	CANISUS, NY	LDO
CAZE	42.9313N	75.9200W			
CHR	41.2080N	74.2211W	183	CALL HOLLOW RD, NY	CON*
CLIN	41.8750N	73.8490W	168	CLINTON, NY	LDO
CLY	43.8513N	74.4490W	579	CRYSTAL LAKE, NY	LDO
CROG	43.9050N	75.4125W	244	CROGHAN, NY	LDO
CTR	43.8741N	74.4600W	585	CASTLE ROCK, NY	LDO
DANY	44.7583N	73.8357W	507	DANNEMORA, NY	LDO
DBM	41.2944N	73.9750W	27	DUNDERBURG MTN, NY	CON*
DHN	42.8255N	78.1930W	491	DOYLE HILL, NY	LDO
DNY	42.8363N	78.1688W	381	DERSAM, NY	LDO
DPL	41.2528N	73.9108W	67	DELLI PAOLI, NY	CON*
DWN	42.8255N	78.7672W		DOWNHOLE, NY	LDO
EGN	43.8596N	74.4818W	549	EAGLES NEST, NY	LDO
GOB	41.3294W	73.9219W	150	GOBBELET, NY	CON*
GSC	41.2661N	74.0039W	110	GIRL SCOUT CAMP, NY	CON*
IPS	41.2672N	73.9483W	0	INDIAN POINT STATION, NY	CON*
LCNA	43.6442N	75.9260W			
LDNY	40.9319N	73.4681W	30	LLOYDS NECK, NY	SBU
AMNH	40.7808N	73.9738W	0	MANHATTAN, NY	LDO
MASH	41.0411N	72.2933W	3	MASHOMACK, NY	LDO
MEDY	43.1818N	78.3903W	186	MEDINA, NY	LDO
MSNY	44.9983N	74.8620W	55	MASSENA, NY	LDO
OCN	43.8848N	74.5293W	701	OVER CASTLE ROCK, NY	LDO

TABLE 2

EPICENTER LIST
NORTHEASTERN UNITED STATES AND ADJACENT REGIONS
OCTOBER - DECEMBER
1981

	ORIGIN HrMn	SEC	LAT N Deg-Min	LONG W Deg-Min	DEPTH km	MN	MC	ML	GAP Deg	RMS sec	ERH km	ERZ km	Q	NS	NP
81OCT02 NB, SW OF MOUNT CARLETON															
*WES	0017	56.26	47-18.14	66-54.60	5.00	2.4	2.5		334	0.46			D	3	5
81OCT02 NB, SW OF MOUNT CARLETON															
*WES	0049	44.54	47-17.19	66-59.62	5.00	2.6	2.7		331	0.27	58.3	45.6	D	4	6
81OCT02 VT, NE OF HYDE PARK															
*WES	1819	5.30	44-45.00	72-31.32	5.00	2.8	2.3		133	0.22	3.0	6.2	C	9	12
81OCT07 ME, E OF DOVER-FOXCROFT															
*WES	0231	9.07	45-12.44	69- 4.27	5.00	2.2	1.9		138	0.29	2.0	1.9	B	5	7
81OCT10 40 KM E FROM LA MALBAIE, QUE.															
*EPB	0955	13.	47-41.40	69-48.60	17			1.1		0.0	0.0			8	10
81OCT12 CT, W OF WATERBURY															
*WES	1458	58.75	41-32.18	73- 6.05	9.30	2.0	1.6		294	0.18	1.7	1.4	B	7	11
81OCT15 30 KM S FROM LA MALBAIE, QUE.															
*EPB	0734	32.	47-17.40	70-22.80	5			1.0		0.0	0.0	1		7	10
81OCT15 NY, BLUE MOUNTAIN LAKE															
*LDO	2339	.48	43-53.66	74-20.9	3.35	1.4	1.3		277	.04	1.1	1.0	C	4	3
81OCT21 NY, LONG ISLAND SOUND FELT AND HEARD															
*LDO	1649	6.98	41- 8.09	72-33.8	6.43		3.5		140	.11	.5	6.6	C	36	8
81OCT22 25 KM SE FROM LA MALBAIE, QUE.															
*EPB	2203	20.	47-27.60	70- 3.00	10			0.5		0.1	0.0	1		6	10

TABLE 2 (Continued) Page 2-4

	ORIGIN HrMn	SEC	LAT N Deg-Min	LONG W Deg-Min	DEPTH km	MN	MC	ML	GAP Deg	RMS sec	ERH km	ERZ km	Q	NS	NP
81OCT28 NH, WHITE MOUNTAINS															
*WES	0027	29.63	44-10.41	71-26.76	5.00	2.3	2.0		137	0.28	1.5	2.2	B	7	9
81OCT29 20 KM E FROM LA MALBAIE, QUE.															
*EPB	0025	26.	47-33.00	70- 4.80	21			1.7		0.1	0.0	1		8	9
81OCT30 15 KM E FROM LA MALBAIE, QUE.															
*EPB	0436	38.	47-31.80	70- 7.20	19			0.1		0.0	0.0	1		6	7
81NOV03 40 KM W FROM ST. GEORGE, N.B.															
*EPB	0856	52.	45- 7.80	67-19.80	1			2.0		0.7	0.0	1		9	14
81NOV04 CT, NEAR MOODUS															
*WES	0842	38.44	41-32.86	72-25.74	0.07	0.0	-1.8		275	0.06	0.0	0.0	A	3	4
81NOV08 ME, SE OF COOPER															
*WES	0227	2.36	44-53.78	67-20.38	9.56	0.0	0.2		163	0.05	0.6	0.6	A	3	6
81NOV12 100 KM NW FROM GRAND-REMOUS, QUE.															
*EPB	1840	14.	46-58.80	77- 2.40	18	3.4				0.8	0.0	1		12	18
81NOV15 40 KM SW FROM MONT-TREMBLANT, QUE.															
*EPB	1948	18.	46- 3.00	75- 3.00	5			1.5		0.1	0.0	1		9	11
81NOV17 25 KM E FROM WILLIAMSBURG, ONT.															
*EPB	1724	37.	45- 1.80	74-58.80	12			1.2		0.4	0.0	3		9	13
81NOV18 20 KM NE FROM LA MALBAIE, QUE.															
*EPB	0942	60.	47-40.20	70- 5.40	11			0.7		0.0	0.0			5	7
81NOV24 30 KM NE FROM LA MALBAIE, QUE.															
*EPB	0937	17.	47-46.80	70- 3.60	0			1.0		0.0	0.0	44		6	7
81NOV26 20 KM E FROM LA MALBAIE, QUE.															
*EPB	2054	53.	47-32.40	70- 3.60	21			0.0		0.1	0.0	1		5	7

	ORIGIN HrMn	SEC	LAT N Deg-Min	LONG W Deg-Min	DEPTH km	MN	MC	ML	GAP Deg	RMS sec	ERH km	ERZ km	Q	NS	NP
81NOV28 120 KM N FROM FREDERICTON, N.B.															
*EPB	0512	03.	47- 1.80	66-36.60	5	3.7				0.7	0.0	1		23	31
81DEC02 NB, SE OF PERTH-ANDOVER															
*WES	0743	42.77	46-34.33	67-28.68	1.11	2.3	2.4		316	0.50	9.7	5.1	D	5	6
81DEC04 10 KM NE FROM LA MALBAIE, QUE.															
*EPB	1335	13.	47-37.20	70-12.60	13			-.4		0.0	0.0	1		4	5
81DEC06 60 KM W FROM SHERBROOKE, QUE. FELT MILDLY															
*EPB	1611	27.	45-22.80	72-38.40	3	3.3				0.3	0.0	2		14	19
81DEC07 20 KM E FROM LA MALBAIE, QUE.															
*EPB	0915	16.	47-32.40	70- 3.60	9			-.1		0.0	0.0			7	8
81DEC07 10 KM S FROM LA MALBAIE, QUE.															
*EPB	2145	17.	47-27.60	70-22.80	5			-.2		0.0	0.0			6	10
81DEC11 25 KM E FROM LA MALBAIE, QUE.															
*EPB	0114	29.	47-31.20	70- 0.60	14			1.2		0.0	0.0			7	8
81DEC14 NY, SARATOGA SPRINGS FELT															
*LDO	1831	38.29	43- 4.79	73-49.9	1.52	1.7	2.3		62	.11	.2	.6	B	16	18
81DEC16 10 KM SW FROM MONT-TREMBLANT, QUE.															
*EPB	1421	30.	46-10.80	74-41.40	3			1.0		0.0	0.0	6		3	6
81DEC20 50 KM E FROM GLEN ALMOND, QUE.															
*EPB	0205	10.	45-40.20	74-46.20	6			1.8		0.2	0.0	2		8	15
81DEC20 20 KM W FROM LA POCATIERE, QUE.															
*EPB	1535	39.	47-21.60	70-15.60	9			0.5		0.3	0.0	5		5	9
81DEC20 110 KM S FROM GROSSES-ROCHES, QUE. FELT AND HEARD															
*EPB	2009	15.	47-58.20	66-46.80	18			2.5		1.0	0.0	5		7	11

TABLE 4 (Continued)

Source	ORIGIN HrMn	ORIGIN SEC	LAT N Deg-Min	LONG W Deg-Min	DEPTH km	MN	MC	ML	GAP Deg	RMS sec	ERH km	ERZ km	Q	NS	NP
81DEC22 NB, N OF BECAGUIMEC LAKE															
*WES	0805	2.47	46-19.00	67-12.00	9.62	1.9	1.7		290	0.21	3.4	2.7	C	4	6
81DEC22 25 KM W FROM LA POCATIERE, QUE.															
*EPB	1710	38.	47-18.00	70-21.60	3			1.0		0.1	0.0	7		6	8
81DEC23 15 KM SE FROM LA MALBAIE, QUE. FELT MILDLY															
*EPB	0128	20.	47-27.60	70-10.20	12			2.3		0.0	0.0			11	10
81DEC24 25 KM NE FROM LA MALBAIE, QUE.															
*EPB	2334	01.	47-42.60	70- 5.40	11			1.8		0.0	0.0			10	10
81DEC26 NY, NEAR ALTONA															
*LDO	2237	45.19	44-51.06	73-45.0	10.16	1.9	2.6		93	.08	.3	.5	B	12	13
81DEC29 30 KM NE FROM LA MALBAIE, QUE.															
*EPB	1443	24.	47-45.00	70- 4.80	10			0.2		0.5	0.0			4	8

* SOURCE
EPB - Earth Physics Branch, Dept. of Energy, Mines, and Resources Canada
LDO - Lamont-Doherty Geological Observatory of Columbia University
WES - Weston Observatory - Boston College

TABLE 1 Continued

ONTR	43.2738N	77.3071W			
OSB	41.3603N	73.9239W	212	OSBORN, NY	CON*
OSWG	43.5170N	76.4162W			
PAL	41.0042N	73.9091W	91	PALISADES, NY	LDO
PHEL	42.9542N	77.0950W			
PNY	44.8341N	73.5550W	177	PLATTSBURG, NY	LDO
PTN	44.5725N	74.9828W	238	POTSDAM, NY	LDO
SANY	43.1738N	78.8703W	172	SANBORN, NY	LDO
SONY	43.1922N	76.9647W			
SNP	41.2408N	73.9711W	30	STONEY PT, NY	CON*
SPS	41.3019N	73.8905W	168	ST PETERS SCHOOL, NY	CON*
SRM	41.2283N	74.0139W	165	SCHERMAN, NY	CON*
STL	41.1886N	74.0036W	125	STILES, NY	CON*
TBR	41.1417N	74.2222W	261	TABLE ROCK, NY	LDO
UWL	43.8378N	74.5433W	561	UTOWANA LAKE, NY	LDO
WGL	41.3589N	73.8994W	152	WEGEL, NY	LDO
WMNY	43.3560N	76.0313W			
WND	42.3375N	74.1525W	602	WINDHAM, NY	LDO
WNY	44.3910N	73.8595W	598	WILMINGTON, NY	LDO
WPNY	41.8030N	73.9707W	76	WEST PARK, NY	LDO
WPR	41.2546N	73.5857W	152	WARD POUND RIDGE, NY	LDO
WVLY	42.4708N	78.5683W	600	WEST VALLEY, NY	LDO

PENNSYLVANIA

BVR	40.7000N	80.3333W	0	BEAVER, PA	PSU
ERI	42.1333N	79.9833W	0	ERIE, PA	PSU
MVL	39.9992N	76.3506W	0	MILLERSVILLE, PA	MSC
PHI	40.1166N	75.1333W	0	ABINGTON, PA	PSU
SCP	40.7950N	77.8650W	352	STATE COLLEGE, PA	PSU

VERMONT

BVT	43.3488N	72.5853W	300	BALTIMORE, VT	WES
COV	44.5777N	73.1458W	85	COLCHESTER, VT	LDO
DVT	44.9620N	72.1709W	370	DERBY, VT	WES
FLET	44.7228N	72.9517W	366	FLETCHER, VT	LDO
HBVT	44.3623N	73.0650W	344	HINESBURG, VT	LDO
IVT	43.5221N	73.0533W	295	IRA, VT	WES
MARL	42.8383N	72.8008W	580	MARLBORO, VT	LDO
MDV	43.9991N	73.1811W	134	MIDDLEBURY, VY	LDO
MGVT	44.9136N	72.6278W	262	MONTGOMERY, VT	LDO
MPVT	44.2783N	72.6067W	240	MONTPELIER, VT	LDO

* STATION CODES NOT ALL CLEARED THROUGH NEIC

OPERATOR CODE

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TABLE 1 Continued

EPB - EARTH PHYSICS BRANCH,DEPT.OF ENERGY,MINES,AND RESOURCES, CANADA	
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TABLE 3

EARTHQUAKE DATA LIST
NORTHEASTERN UNITED STATES AND ADJACENT REGIONS
OCTOBER - DECEMBER
1981

STN	DIST km	AZM deg	RMK	HRMN	SEC	TCAL sec	RES sec	WT	AMX	PRX sec	XMAG	FMP sec	FMAG
81OCT02 NB, SW OF MOUNT CARLETON													
HNME	151.4	213	EP 0	018	20.20	24.38	-0.47	1.60	13	.20	2.4	90	2.5
			ES 0	018	40.00	43.40	0.29	1.65					
PQ0	261.0	190	EP 1	018	35.90	38.37	1.25	0.34	7	.20	2.4	80	2.6
			ES 0	018	64.60	68.29	0.00	0.74					
PQ1	268.6	187	ES 0	018	66.00	0.00	0.68						
81OCT02 NB, SW OF MOUNT CARLETON													
HNME	146.5	211	IP 0	050	8.00	23.64	-0.21	1.91	34	.20	2.8	115	2.7
			IS 0	050	26.80	42.08	0.12	1.94					
PQ0	258.3	188	IP 1	050	23.30	38.03	0.70	0.48	14	.20	2.6	110	2.8
			IS 0	050	52.00	67.69	-0.29	0.86					
PQ1	266.1	186	ES 0	050	54.10	0.00	0.80						
MIM	276.4	215	EP 3	050	23.70	40.27	-1.13	0.01	9	.20	2.5	110	2.8
81OCT02 VT, NE OF HYDE PARK													
DVT	36.4	50	IPU0	1819	11.45	6.13	-0.04	1.53				90	2.2
PNY	82.3	277	IPU0	1819	19.00	13.68	-0.02	1.31					
BNH	101.9	100	IP 0	1819	22.40	16.87	0.15	1.21					
			ES 0	1819	35.40	30.03	-0.06	1.21					
HNH	117.6	171	IP 0	1819	24.70	19.26	0.11	1.14					
			ES 3	1819	38.60	34.28	-1.04	0.18					
IVT	142.9	197	IP 0	1819	28.40	23.10	-0.05	1.01	120	.10	3.6	70	2.3
BVT	155.8	182	IP 2	1819	31.00	25.05	0.59	0.46				70	2.3
			ES 0	1819	49.80	44.59	-0.19	0.95					
JKM	205.4	61	IP 3	1819	38.80	31.51	1.93	0.00	9	.22	2.3	50	2.2
HKM	228.6	93	IP 3	1819	41.80	34.37	2.12	0.00				60	2.3
MIM	280.0	79	EP 3	1819	48.20	40.71	2.17	0.00	10	.30	2.3	55	2.4
81OCT07 ME, E OF DOVER-FOXCROFT													
MIM	4.7	31	IPD0	231	10.10	1.16	-0.15	1.88				70	1.8
BPM	67.7	161	EP 0	231	20.50	11.28	0.14	1.41					
JKM	104.4	298	EP 0	231	26.20	17.25	-0.18	1.12	7	.18	2.0		
			ES 4	231	37.00	30.71	-2.89	0.00					
PQ0	128.6	101	EP 2	231	30.90	20.93	0.87	0.23	5	.15	2.1	55	2.1
			ES 0	231	46.10	37.25	-0.28	0.91					
HNME	135.4	39	EP 1	231	31.70	21.97	0.63	0.56	8	.12	2.4	40	1.9
			ES 0	231	48.20	39.10	-0.02	0.89					

100

TABLE 3 (Continued)

STN	DIST km	AZM deg	RMK	HRMN	SEC	TCAL sec	RES sec	WT	AMX	PRX sec	XMAG	FMP sec	FMAG
81OCT10 40 KM E FROM LA MALBAIE, QUE.													
A20	9	81	P	0955	15.95	2.93	0.02	1.0					
			S	0955	18.20	5.21	-0.01	1.0					
A64	16	337	P	0955	16.65	3.63	0.02	1.0					
			S	0955	19.38	6.42	-0.04	1.0					
A61	21	270	P	0955	17.32	4.27	0.05	1.0					
			S	0955	20.59	7.54	0.05	1.0					
A16	29	211	P	0955	18.36	5.30	0.06	1.0					
			S	0955	22.31	9.32	-0.01	1.0					
LMQ	42	248	P 4	0955	20.20					0.1	1.3*		
			S 4	0955	25.70	12.64	0.06						
LPQ	42	201	P 4	0955	20.30	7.15	0.15			0.1	.9*		
			S 4	0955	25.50	12.54	-0.04						
A54	53	240	P	0955	21.67	8.76	-0.09	1.0					
			S	0955	28.35			1.0					
CHQ	144	232	S 4	0955	52.00	40.46	-1.46			0.2	1.2*		
81OCT12 CT, W OF WATERBURY													
BCT	32.3	262	IPD4	1458	59.30	5.60	-5.06	0.00				40	1.4
HDM	48.6	97	IP 1	1459	7.00	8.22	0.03	0.92					
			IS 0	1459	13.80	14.63	0.43	0.89					
MD4	49.3	94	IP 0	1459	6.90	8.34	-0.19	1.19					
MD1	53.0	88	IP 0	1459	7.75	8.94	0.06	1.20				38	1.6
			IS 0	1459	14.65	15.91	-0.02	1.20					
MD2	55.5	91	IP 0	1459	8.15	9.35	0.03	1.19	6	.10	2.0		
			IS 0	1459	15.10	16.64	-0.33	1.04					
NSC	104.5	93	IP 0	1459	15.85	16.99	0.10	0.89	5	.20	1.9	38	1.8
			IS 0	1459	28.90	30.24	-0.11	0.88					
QUA	118.7	31	IP 0	1459	18.10	19.14	0.18	0.79	8	.20	2.1	40	1.8
			IS 0	1459	32.80	34.07	-0.07	0.80					
81OCT15 30 KM S FROM LA MALBAIE, QUE.													
A10	15	111	P	0734	34.28	2.29	-0.01	1.0					
			S	0734	36.14	4.16	-0.02	1.0					
A54	18	352	P	0734	34.83			1.0					
			S	0734	37.11	5.09	0.02	1.0					
LPQ	28	79	P 4	0734	36.50	4.40	0.10			0.2	.8*		
			S 4	0734	40.00	7.82	0.18						
LMQ	29	8	P 4	0734	36.20	4.43	-0.23			0.1	1.2*		
			S 4	0734	39.70	7.88	-0.18						
A16	34	55	P	0734	37.28	5.27	0.01	1.0					
			S	0734	41.44	9.34	0.10	1.0					
A20	69	48	P	0734	43.00	10.95	0.05	1.0					
			S	0734	51.17	19.18	-0.01	1.0					
A64	70	32	P	0734	43.03			1.0					
			S	0734	51.21	19.32	-0.11	1.0					

TABLE 3 (Continued)

STN	DIST km	AZM deg	RMK	HRMN	SEC	TCAL sec	RES sec	WT	AMX	PRX sec	XMAG	FMP sec	FMAG
81OCT15 NY, BLUE MOUNTAIN LAKE													
CTR	9.1	256	P	2339	2.10	1.59	.03	1.82					
			S 3	2339	3.18	2.78	-.08	.45					
APH	13.3	244	P	2339	2.70	2.24	-.02	1.82					
CROG	85.2	271	P 3	2339	13.80	13.20	.12	.45					
PTN	90.7	327	P 3	2339	14.40	14.04	-.12	.45					
81OCT21 NY, LONG ISLAND SOUND FELT AND HEARD													
MASH	25.3	114	P 1	1649	11.44	4.36	.10	1.00					
MD5	36.1	9	P 4	1649	13.20	6.11	.11	.00					
HDM	39.2	4	P 1	1649	13.60	6.61	.01	1.00					
MD3	42.0	10	P 1	1649	14.00	7.08	-.06	1.00					
NSC	70.8	57	P 1	1649	18.70	11.80	-.08	1.00					
LDNY	79.1	254	P 1	1649	19.97	13.17	-.18	1.00					
			S 4	1649	29.00	22.78	-.77	.00					
BCT	79.2	301	P 1	1649	20.30	13.19	.13	1.00					
UCT	81.7	18	P 1	1649	20.60	13.60	.02	1.00					
WPR	86.5	279	P 1	1649	21.54	14.39	.17	1.00					
OSNY	106.1	275	P 4	1650	.00	16.57	23.55	.00					
PUTN	109.2	285	P 4	1650	.00	17.03	24.01	.00					
PAL	113.7	263	P 4	1649	25.81	18.57	.26	.00					
			S 4	1649	38.71	32.13	-.40	.00					
ANNS	114.4	280	P 4	1650	.00	17.83	24.81	.00					
GARN	116.4	283	P 4	1650	.00	18.13	25.11	.00					
CLAR	120.6	273	P 4	1650	.00	18.76	25.74	.00					
GSC	121.3	277	P 4	1650	.00	18.87	25.85	.00					
AMNH	124.7	252	P 4	1649	27.15	20.25	-.08	.00					
HAVE	129.9	275	P 4	1650	.00	20.16	27.14	.00					
RLSP	130.3	301	P 4	1650	.00	20.22	27.20	.00					
CLIN	135.0	308	P 4	1649	28.61	20.93	.70	.00					
RAMA	138.2	269	P 4	1649	28.90	22.30	-.38	.00					
			S 4	1649	42.48	38.58	-3.08	.00					
WPNY	138.8	303	P 4	1649	29.36	22.38	.00	.00					
			S 4	1649	44.36	38.72	-1.34	.00					
LNX	146.2	337	P 4	1649	30.00	23.50	-.48	.00					
QUA	147.2	3	P 4	1649	30.80	22.78	1.04	.00					
GPD	159.5	266	P 4	1649	32.45	25.52	-.05	.00					
			S 4	1649	50.00	44.15	-1.13	.00					
DUX	181.9	55	P 4	1649	36.15	28.44	.73	.00					
WFM	186.6	28	P 4	1649	36.20	28.73	.49	.00					
LVNJ	187.1	259	P 4	1649	36.00	28.81	.21	.00					
MARL	190.4	355	P 4	1649	35.45	29.23	-.76	.00					
			S 4	1649	58.10	50.57	.55	.00					
COD	211.6	73	P 4	1649	40.60	32.11	1.51	.00					
PQN	211.8	267	P 4	1649	39.30	31.88	.44	.00					
			S 4	1650	2.65	55.15	.52	.00					
PNH	220.7	9	P 4	1649	39.20	32.97	-.75	.00					
GLO	226.1	42	P 4	1649	39.55	33.64	-1.07	.00					
ONH	253.8	20	P 4	1650	.00	37.06	44.04	.00					
DNH	260.3	31	P 4	1650	.00	37.87	44.85	.00					

TABLE 3 (Continued)

STN	DIST km	AZM deg	RMK	HRMN	SEC	TCAL sec	RES sec	WT	AMX	PRX sec	XMAG	FMP sec	FMAG
BING	302.4	291	P 4	1649	50.25	43.06	.21	.00					
			S 4	1650	22.80	74.49	1.32	.00					
81OCT22 25 KM SE FROM LA MALBAIE, QUE.													
A16	3	72	P	22 3	21.76	1.91	-0.15	1.0					
			S	22 3	23.15	3.13	0.02	1.0					
LPQ	14	167	P 4	22 3	23.00	2.98	0.02			0.1	.5*		
A10	26	205	P	22 3	24.78			1.0					
			S	22 3	28.25	8.10	0.15	1.0					
A61	26	353	P	22 3	24.94	4.82	0.12	1.0					
			S	22 3	28.33	8.15	0.18	1.0					
A54	28	270	P	22 3	24.92	5.00	-0.08	1.0					
			S	22 3	28.40	8.48	-0.08	1.0					
A64	43	16	P	22 3	27.28	7.32	-0.04	1.0					
			S	22 3	32.44	12.51	-0.07	1.0					
81OCT28 NH, WHITE MOUNTAINS													
WNH	34.1	174	EP 0	027	35.30	5.75	-0.11	1.72					
BNH	48.8	18	IPCO	027	38.10	8.15	0.25	1.59	6	.12	1.9	60	1.9
			ES 0	027	43.90	14.52	-0.37	1.52					
BVT	129.6	225	IP 2	027	51.50	21.08	0.74	0.27	16	.15	2.5	47	2.0
			ES 0	027	67.10	37.53	-0.15	0.95					
PNH	132.2	205	EP 1	027	51.75	21.48	0.53	0.62					
IVT	148.2	241	ES 0	027	72.10	42.55	-0.17	0.80	6	.15	2.2		
HKM	153.5	70	EP 0	027	54.40	24.71	0.06	0.77	13	.17	2.5	60	2.2
			ES 0	027	73.70	43.98	0.08	0.77					
MIM	224.7	58							5	.18	2.2		
81OCT29 20 KM E FROM LA MALBAIE, QUE.													
A16	10	151	P	0025	30.29	4.19	0.10	1.0					
A61	16	356	P	0025	30.82	4.78	0.04	1.0					
			S	0025	34.03	7.99	0.04	1.0					
LMQ	19	271	P 4	0025	31.20	5.05	0.15						
LPQ	23	168	P 4	0025	31.80	5.52	0.28			0.1	1.1*		
A54	27	249	P	0025	32.07	6.03	0.04	1.0					
			S	0025	36.13	10.15	-0.02	1.0					
A64	34	24	P	0025	32.82	6.90	-0.08	1.0					
			S	0025	37.64	11.68	-0.04	1.0					
A10	35	195	P	0025	33.04	6.96	0.08	1.0					
			S	0025	37.66	11.77	-0.11	1.0					
CHQ	118	232	P 4	0025	48.00	19.78	2.22			0.2	1.6*		
			S 4	0026	1.00	34.04	0.96						
81OCT30 15 KM E FROM LA MALBAIE, QUE.													
A16	11	130	P	0436	41.70	3.60	0.10	1.0					
			S	0436	44.14	6.19	-0.05	1.0					
LMQ	16	278	P 4	0436	42.10	4.14	-0.04			0.1	.4*		
			S 4	0436	45.50	7.16	0.34						
LPQ	22	159	P 4	0436	43.00	4.84	0.16			0.1			
			S 4	0436	46.00	8.35	-0.35						
A54	24	250	P	0436	43.00	5.02	-0.02	1.0					

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TABLE 3 (Continued)

STN	DIST km	AZM deg	RMK	HRMN	SEC	TCAL sec	RES sec	WT	AMX	PRX sec	XMAG	FMP sec	FMAG
			S	0436	46.71	8.69	0.02	1.0					
A10	32	190	S	0436	48.54	10.53	0.01	1.0					
A64	37	27	P	0436	44.75	6.82	-0.07	1.0					
			S	0436	49.87	11.82	0.05	1.0					
81NOV03 40 KM W FROM ST. GEORGE, N.B.													
PQ0	19	214	P	0856	56.75	3.27	1.48	1.0					
PQ1	25	179	P	0856	55.85	4.21	-0.36	1.0					
EMM	46	195	P	0856	59.10	7.57	-0.47	1.0					
			S	0857	5.25	13.02	0.23	1.0					
UNB	106	31	P	0857	9.00	17.36	-0.36	1.0		0.3	2.0*		
			S	0857	22.80	30.02	0.78	1.0					
HNME	126	336	P	0857	14.50	22.92	-0.42	1.0					
			S	0857	31.70	39.89	-0.19	1.0					
BPM	128	245	P	0857	14.30	23.17	-0.87	1.0					
			S	0857	31.50	40.32	-0.82	1.0					
MIM	134	276	P	0857	15.85	23.96	-0.11	1.0					
HKM	190	255	P	0857	22.60	30.74	-0.14	1.0					
BNH	316	260	P	0857	38.20	46.15	0.05	1.0					
			S	0858	13.70	80.41	1.29	1.0					
81NOV04 CT, NEAR MOODUS													
MD2	2.2	196	IP 0	842	38.85	0.41	-0.02	1.04				1	-2.0
			IS 0	842	39.10	0.72	-0.10	0.95					
MD1	3.2	280	IP 0	842	39.10	0.60	0.05	1.02					
MD3	5.8	215	IP 0	842	39.60	1.08	0.07	0.99				1	-1.5
81NOV08 ME, SE OF COOPER													
PQ1	1.3	51	IPD0	227	3.95	1.61	-0.03	1.05				11	0.1
			IS 0	227	5.25	2.87	0.00	1.05					
PQ0	14.2	315	IPU0	227	5.35	2.86	0.10	0.99				10	0.3
			IS 0	227	7.45	5.09	-0.05	0.99					
EMM	21.1	214	IP 0	227	6.20	3.86	-0.03	0.96					
			ES 0	227	9.25	6.88	0.01	0.96					
81NOV12 100 KM NW FROM GRAND-REMOUS, QUE.													
GRQ	99	114	P 0	1840	30.52			1.6		0.1	2.6*		
			S 0	1840	42.85	28.50	0.35	1.6					
CKO	114	196	P 0	1840	32.61	18.83	-0.22	1.6		0.1	2.7*		
			S 0	1840	46.50			1.6					
VDQ	156	334	P 0	1840	39.68	24.97	0.71	1.6		0.1	2.8*		
			S 0	1840	57.40	44.33	-0.93	1.6					
FHO	181	159	P 0	1840	42.52	27.93	0.59	1.6		0.1	2.9*		
			S 0	1841	4.65	51.13	-0.48	1.6					
GAC	186	139	P 0	1840	43.90	28.54	1.36	1.6					
			S 0	1841	5.50	52.54	-1.04	1.6					
OTT	203	149	P 3	1840	44.60	30.70	-0.10	.1		0.1	3.2*		
			S 1	1841	10.50	57.50	-1.00	.4					
TRQ	208	113	P 1	1840	45.90	31.35	0.55	.4		0.1	2.6*		
			S 3	1841	12.00	58.80	-0.80	.1					
WBO	259	147	S 3	1841	25.20	72.94	-1.74	.1		0.1	3.1*		

TABLE 3 (Continued)

STN	DIST km	AZM deg	RMK	HRMN	SEC	TCAL sec	RES sec	WT	AMX	PRX sec	XMAG	FMP sec	FMAG
MNT	311	121	S 4	1841	39.00	87.42	-2.42			0.1	2.9*		
GNT	364	99	S 4	1841	52.00	102.3	-4.31			0.1	2.9*		
LPQ	535	83	S 1	1842	40.70	150.2	-3.49	.4		0.3	3.4		
JAQ	766	7	P 1	1841	53.70	99.31	0.39	.4		0.3	3.4		
			s 1	1843	6.40	173.1	-0.71	.4					
			S 4	1843	53.00	214.9	4.15						

81NOV15 40 KM SW FROM MONT-TREMBLANT, QUE.

STN	DIST km	AZM deg	RMK	HRMN	SEC	TCAL sec	RES sec	WT	AMX	PRX sec	XMAG	FMP sec	FMAG
TRQ	43	64	P 0	1948	24.60	6.55	0.05	2.0		0.1	1.4*		
			S 1	1948	29.60	11.65	-0.05	.5					
GAC	51	221	P 0	1948	26.02	7.93	0.09	2.0					
			S 0	1948	32.05			2.0					
GRQ	88	315	P 0	1948	31.70	13.79	-0.09	2.0		0.0	1.6*		
			S 1	1948	42.70	24.23	0.47	.5					
OTT	90	216	P 4	1948	32.30	14.14	0.16						
			S 4	1948	42.10	24.83	-0.73						
FHO	113	234	P 1	1948	35.90	17.82	0.08	.5					
			S 1	1948	49.30	31.22	0.08	.5					
WBO	118	189	P 1	1948	36.20	18.74	-0.54	.5		0.1	1.5*		
			S 1	1948	50.30	32.82	-0.52	.5					
MNT	127	118	S 4	1948	52.20	35.20	-1.00						
CKO	186	269	P 4	1948	46.70	29.30	-0.60						
			S 4	1949	8.40	51.77	-1.37						
GNT	210	80	S 3	1949	14.50	58.34	-1.84	.1		0.1	1.7*		

81NOV17 25 KM E FROM WILLIAMSBURG, ONT.

STN	DIST km	AZM deg	RMK	HRMN	SEC	TCAL sec	RES sec	WT	AMX	PRX sec	XMAG	FMP sec	FMAG
MSNY	10	112	P	1724	39.20	2.53	-0.33	1.0					
			S	1724	41.30	4.38	-0.08	1.0					
PTN	51	180	P	1724	45.10	8.51	-0.41	1.0					
			S	1724	52.10	14.77	0.33	1.0					
BGR	53	115	P	1724	45.80	8.81	-0.01	1.0					
			S	1724	53.10	15.30	0.80	1.0					
GAC	84	333	P	1724	50.00	13.69	-0.69	1.0					
			S	1725	1.00	23.78	0.22	1.0					
DANY	96	108	P	1724	52.60	15.59	0.01	1.0					
FHO	108	296	P 4	1724	53.00	17.49	-1.49			0.1	1.2*		
			S	1725	8.00	30.37	0.63	1.0					
WNY	114	128	P	1724	55.90	18.54	0.36	1.0					
PNY	115	101	P	1724	55.50	18.65	-0.15	1.0					
CTR	135	162	P	1724	58.35	21.95	-0.60	1.0					

81NOV18 20 KM NE FROM LA MALBAIE, QUE.

STN	DIST km	AZM deg	RMK	HRMN	SEC	TCAL sec	RES sec	WT	AMX	PRX sec	XMAG	FMP sec	FMAG
A61	3	2	P	0943	1.82	1.81	0.01	1.0					
			S	0943	3.22			1.0					
LMQ	22	233	P 4	0943	3.90					0.1	.7*		
			S 4	0943	7.00	6.89	0.11						
A16	23	164	P	0943	4.03			1.0					
			S	0943	7.09			1.0					
A64	23	40	S	0943	7.14	7.13	0.01	1.0					
A54	34	226	P	0943	5.59	5.62	-0.03	1.0					
			S	0943	9.90	9.87	0.03	1.0					

TABLE 3 (Continued)

STN	DIST km	AZM deg	RMK	HRMN	SEC	TCAL sec	RES sec	WT	AMX	PRX sec	XMAG	FMP sec	FMAG
81NOV24 30 KM NE FROM LA MALBAIE, QUE.													
A61	9	192	P	0937	18.75	1.82	-0.07	1.0					
			S 4	0937	19.83	2.94	-0.11						
A64	14	67	P	0937	19.57	2.60	-0.03	1.0					
			S	0937	21.35	4.29	0.06	1.0					
LMQ	32	218	P 4	0937	22.70	5.49	0.21			0.1	1.1*		
			S 4	0937	26.20	9.30	-0.10						
A16	35	173	P	0937	22.81	5.88	-0.07	1.0					
			S	0937	27.02	9.99	0.03	1.0					
A54	44	217	P	0937	24.41	7.42	-0.01	1.0					
			S	0937	29.77	12.68	0.09	1.0					
LPQ	49	175	S 4	0937	31.10	13.94	0.16			0.2	1.0*		
81NOV26 20 KM E FROM LA MALBAIE, QUE.													
A16	9	153	P	2054	56.79	3.73	0.06	1.0					
			S	2054	59.47	6.49	-0.02	1.0					
A61	17	353	P	2054	57.56	4.46	0.10	1.0					
			S	2055	0.81	7.77	0.04	1.0					
LMQ	20	273	P 4	2055	1.30	4.74	3.56			0.1			
A54	28	251	S	2055	2.85	9.89	-0.04	1.0					
A64	34	22	P	2054	59.49	6.54	-0.05	1.0					
			S	2055	4.32	11.37	-0.05	1.0					
81NOV28 120 KM N FROM FREDERICTON, N.B.													
UNB	120	181	P	0512	22.80	18.83	0.97	1.0		0.2	3.4*		
			S	0512	36.00	33.07	-0.07	1.0					
HNME	143	228	P	0512	25.80	22.59	0.21	1.0					
LMN	190	133	p 0	0512	32.80	29.73	0.07	3.8		0.2	3.6*		
			s 3	0512	55.40	52.28	0.12	.2					
GSQ	212	350	p 1	0512	36.30	32.36	0.94	1.0		0.3	3.3*		
			S 4	0513	2.90	58.88	1.02						
GGN	213	184	p 1	0512	34.52	32.40	-0.88	1.0		0.1	3.7*		
			s 1	0513	1.90	56.96	1.94	1.0					
PQ0	236	197	p	0512	37.20	35.33	-1.13	1.0					
PQ1	243	194	p	0512	38.60	36.06	-0.46	1.0					
LPQ	260	279	p 0	0512	41.17	38.22	-0.05	3.8					
			P 4	0512	44.50					0.3	3.7*		
			s 4	0513	2.00	67.10	-8.10						
			S 1	0513	16.20	72.43	0.77	1.0					
EMM	264	195	p	0512	41.90	38.70	0.20	1.0					
MIM	272	224	p	0512	41.70	39.67	-0.97	1.0					
BPM	316	213	p	0512	46.90	44.97	-1.07	1.0					
JKM	319	243	p	0512	47.80	45.38	-0.58	1.0					
HKM	354	223	p	0512	51.80	49.59	-0.79	1.0					
MNQ	422	339	p 1	0513	0.30	57.92	-0.62	1.0		0.2	3.8		
			s 3	0513	45.20	101.5	0.72	.2					
GNT	447	263	p 1	0513	3.40	61.00	-0.60	1.0					
			S 4	0514	8.00	124.8	0.23						
SBQ	450	248	S 1	0514	9.50	125.5	1.04	1.0		0.3	4.0		
MNT	567	255	S 1	0514	14.70	105.1	26.60						

TABLE 3 (Continued)

STN	DIST km	AZM deg	RMK	HRMN	SEC	TCAL sec	RES sec	WT	AMX	PRX sec	XMAG	FMP sec	FMAG
GAC	698	261	p 1	0513	34.00	91.63	-0.63	1.0					
			s 3	0514	43.00	160.3	-0.28	.2					
			S 4	0515	24.00	195.1	5.90						
GRQ	708	270	p 3	0513	34.70	92.80	-1.10	.2		0.4	3.7		
			s 1	0514	45.90	162.3	0.57	1.0					
			S 4	0515	17.00	197.7	-3.72						
WBO	708	255	p 3	0513	36.00	92.82	0.18	.2					
			s 1	0514	46.30	162.4	0.95	1.0					
FHO	761	260	s 1	0514	55.70	173.7	-1.00	1.0		0.3	3.7		
			S 4	0515	42.00	212.8	6.23						
VDQ	864	283	P 3	0513	52.50	111.9	-2.40	.2		0.5	3.6		
JAQ	993	323	p 1	0514	12.00	127.6	1.38	1.0					
			s 4	0515	44.00	223.1	-2.06						
			S 4	0516	36.00	277.7	-4.67						

81DEC02 NB, SE OF PERTH-ANDOVER

STN	DIST km	AZM deg	RMK	HRMN	SEC	TCAL sec	RES sec	WT	AMX	PRX sec	XMAG	FMP sec	FMAG
HNME	60.3	220	IP 0	743	53.10	10.02	0.27	1.66	12	.10	2.3	85	2.3
			IS 0	743	60.20	17.84	-0.47	1.66					
PQ0	176.3	180	EP 2	743	68.30	28.33	-2.84	0.07	5	.13	2.3	75	2.4
			ES 0	743	93.00	50.43	-0.26	1.00					
PQ1	185.8	176	ES 0	743	95.80	0.00	0.93						
MIM	191.1	219	EP 4	743	64.50	30.16	-8.45	0.00	7	.15	2.3	85	2.4
			ES 1	743	97.00	53.68	0.51	0.68					
EMM	203.7	180							9	.15	2.5		

81DEC04 10 KM NE FROM LA MALBAIE, QUE.

STN	DIST km	AZM deg	RMK	HRMN	SEC	TCAL sec	RES sec	WT	AMX	PRX sec	XMAG	FMP sec	FMAG
LMQ	12	228	P	1335	15.50	2.51	-0.01	1.0		0.1	-.3*		
			S 4	1335	17.50	4.63	-0.13						
A61	12	47	P	1335	15.68	2.60	0.08	1.0					
			S	1335	17.78			1.0					
A54	23	220	S	1335	20.21			1.0					
A64	34	46	S	1335	22.70	9.73	-0.03	1.0					

81DEC06 60 KM W FROM SHERBROOKE, QUE. FELT MILDLY

STN	DIST km	AZM deg	RMK	HRMN	SEC	TCAL sec	RES sec	WT	AMX	PRX sec	XMAG	FMP sec	FMAG
SBQ	56	90	P 0	1611	35.65	8.63	0.02	4.5		0.1	2.5*		
			S 1	1611	42.07	15.23	-0.16	1.1					
MNT	78	280	P 0	1611	39.27	12.28	-0.01	4.5		0.1	2.1*		
			S 1	1611	48.76	21.61	0.15	1.1					
GNT	111	11	P 1	1611	44.10	17.51	-0.41	1.1		0.1	2.3*		
			S 1	1611	58.22	30.69	0.53	1.1					
WBO	212	259	p 3	1611	59.30	32.72	-0.42	.3		0.1	2.7*		
			s 4	1612	25.00	57.40	0.60						
			S 4	1612	26.30	58.99	0.31						
GAC	225	280	p 1	1612	1.80	34.32	0.48	1.1					
			s 4	1612	26.90	60.17	-0.27						
			S 4	1612	28.80	62.65	-0.85						
OTT	241	271	p 3	1612	4.40	36.32	1.08	.3		0.1	2.8*		
			S 4	1612	33.50	67.24	-0.74						
FHO	281	273	p 3	1612	8.90	41.10	0.80	.3		0.2	3.1*		
			s 4	1612	41.00	72.01	1.99						
			S 3	1612	45.00	78.23	-0.23	.3					

TABLE 3 (Continued)

STN	DIST km	AZM deg	RMK	HRMN	SEC	TCAL sec	RES sec	WT	AMX	PRX sec	XMAG	FMP sec	FMAG
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LPQ	297	42	P 1	1612	10.05	43.11	-0.06	1.1		0.1	3.1*		
			s 4	1612	42.00	75.53	-0.53						
			S 3	1612	47.40	82.85	-2.45	.3					
CKO	381	282	P 3	1612	19.50	53.39	-0.89	.3		0.1	2.9*		
			s 3	1612	59.30	93.45	-1.15	.3					
			S 3	1613	10.70	106.4	-2.74	.3					
GGN	458	92	S 4	1613	32.50	127.8	-2.33			0.2	3.2		
VDQ	516	310	P 4	1612	38.40	69.82	1.58			0.3	3.4		
			s 4	1613	29.00	122.1	-0.11						
			S 4	1613	46.90	144.1	-4.24						
GSQ	573	45	P 3	1612	44.60	76.84	0.76	.3					
MNQ	641	25	P 3	1612	51.80	85.13	-0.33	.3		0.2	3.3		
			s 3	1613	52.80	148.8	-3.04	.3					
			S 4	1614	21.50	179.3	-4.78						
JAQ	963	348	P 4	1613	29.60	124.3	-1.75						
81DEC07 20 KM E FROM LA MALBAIE, QUE.													
A16	9	155	P	0915	18.25	2.27	-0.02	1.0					
			S	0915	19.79	3.78	0.01	1.0					
A61	18	352	P	0915	19.57	3.47	0.10	1.0					
LMQ	20	273	P 4	0915	20.00	3.86	0.14			0.1			
			S 4	0915	22.50	6.51	-0.01						
LPQ	22	170	P 4	0915	20.30	4.14	0.16			0.1			
			S 4	0915	22.70	6.99	-0.29						
A54	28	252	P	0915	21.03	5.04	-0.01	1.0					
			S	0915	24.56	8.58	-0.02	1.0					
A10	34	197	P	0915	21.98	5.93	0.05	1.0					
A64	35	21	P	0915	21.98	6.02	-0.04	1.0					
			S	0915	26.27	10.28	-0.01	1.0					
81DEC07 10 KM S FROM LA MALBAIE, QUE.													
A54	3	267	P	2145	18.02	1.06	-0.04	1.0					
			S	2145	18.80	1.78	0.02	1.0					
LMQ	11	20	P 4	2145	19.10	2.02	0.08			0.1	-.1*		
			S 4	2145	20.60	3.43	0.17						
A10	27	150	P	2145	21.64	4.58	0.06	1.0					
			S	2145	24.88			1.0					
A16	28	88	P	2145	21.53	4.61	-0.08	1.0					
			S	2145	24.95	7.94	0.01	1.0					
A61	34	39	P	2145	22.62			1.0					
			S	2145	26.72	9.68	0.04	1.0					
A64	55	41	P	2145	26.00	8.98	0.02	1.0					
			S	2145	32.51			1.0					
81DEC11 25 KM E FROM LA MALBAIE, QUE.													
A16	6	181	P	0114	31.98	2.89	0.09	1.0					
			S	0114	33.67	4.71	-0.04	1.0					
LPQ	20	180	P 4	0114	33.82	4.39	0.43			0.1	1.1*		
			S 4	0114	36.50	7.33	0.17						
A61	20	342	P	0114	33.43	4.40	0.03	1.0					
			S	0114	36.41	7.34	0.07	1.0					

TABLE 3 (Continued)

STN	DIST km	AZM deg	RMK	HRMN	SEC	TCAL sec	RES sec	WT	AMX	PRX sec	XMAG	FMP sec	FMAG
LMQ	24	277	P 4	0114	33.70	4.94	-0.24						
			S 4	0114	37.00	8.29	-0.29						
A54	31	257	P	0114	35.01	5.97	0.04	1.0					
			S	0114	39.01	10.07	-0.06	1.0					
A64	35	15	P	0114	35.45	6.50	-0.05	1.0					
			S	0114	39.95	10.99	-0.04	1.0					
MNQ	347	15	s 4	0115	53.00	84.86	-0.86			0.1	1.3*		
			S 4	0116	6.00	97.70	-0.70						
81DEC14 NY, SARATOGA SPRINGS FELT													
MCG	15.3	26	P	1831	40.74	2.52	-.07	1.44					
			S 1	1831	42.54	4.41	-.16	1.08					
STWA	18.2	136	P	1831	41.27	2.99	-.01	1.44					
			S 1	1831	43.73	5.23	.20	1.08					
ACC	33.7	25	P	1831	43.96	5.51	.16	1.44					
			S 1	1831	48.06	9.64	.12	1.08					
COM	35.8	88	P 1	1831	44.15	5.82	.04	1.08					
			S 1	1831	48.25	10.18	-.23	1.08					
GLOV	40.6	272	P	1831	44.77	6.55	-.07	1.44					
			S 3	1831	49.74	11.46	-.02	.36					
RPI	41.0	160	P 2	1831	44.90	6.62	-.01	.72					
			S 2	1831	49.80	11.59	-.08	.72					
ROTD	42.1	210	P	1831	45.05	6.78	-.02	1.44					
			S 3	1831	49.95	11.86	-.21	.36					
BERL	56.2	140	P 4	1831	47.92	8.92	.71	.00					
APH	100.2	328	P 4	1831	53.85	15.58	-.02	.00					
			S 4	1832	5.85	27.26	.29	.00					
CTR	101.8	331	P 1	1831	54.20	15.82	.09	1.08					
			S 4	1832	5.60	27.68	-.38	.00					
CLIN	134.0	181	P 3	1831	59.85	20.70	.86	.00					
WNY	145.7	0	P 1	1832	0.80	22.48	.03	1.08					
PTN	189.9	331	P 3	1832	7.90	29.17	.44	.08					
FLET	195.8	21	P 4	1832	9.40	30.07	1.04	.00					
ALX	223			1832									
CROG	161			1832									
81DEC16 10 KM SW FROM MONT-TREMBLANT, QUE.													
TRQ	11	64	P 0	1421	32.10			1.8		0.1	.8*		
			S 1	1421	33.60	3.55	0.05	.4					
GAC	81	230	P 0	1421	43.20	13.19	0.01	1.8					
			S 0	1421	52.80			1.8					
FHO	143	236	P 3	1421	53.00	23.28	-0.28	.1		0.0	1.3*		
			S 3	1422	10.50	40.33	0.17	.1					
81DEC20 50 KM E FROM GLEN ALMOND, QUE.													
GAC	56	274	P 0	02 5	18.98	8.92	0.06	3.2					
			S 1	02 5	25.40	15.55	-0.15	.8					
TRQ	63	15	P 0	02 5	20.16	10.15	0.01	3.2		0.0	1.5*		
			S 1	02 5	27.62	17.68	-0.06	.8					
OTT	80	248	P 1	02 5	22.85	12.92	-0.07	.8		0.0	1.6*		
			S 1	02 5	32.60	22.51	0.09	.8					

TABLE 3 (Continued)

STN	DIST km	AZM deg	RMK	HRMN	SEC	TCAL sec	RES sec	WT	AMX	PRX sec	XMAG	FMP sec	FMAG
WBO	85	208	P 1	02 5	23.70	13.64	0.06	.8		0.1	2.0*		
			S 1	02 5	33.80	23.75	0.05	.8					
MNT	91	102	P 4	02 5	25.70	14.69	1.01			0.0	1.8*		
			S 3	02 5	36.00	25.57	0.43	.2					
FHO	116	258	P 1	02 5	28.10	18.62	-0.52	.8		0.0	1.6*		
			S 1	02 5	42.10	32.40	-0.30	.8					
GNT	201	67	P 1	02 5	40.90	31.25	-0.35	.8		0.1	2.0*		
			S 3	02 6	5.90	56.16	-0.26	.2					
CKO	212	281	P 1	02 5	43.00	32.60	0.40	.8		0.1	1.7*		
			S 3	02 6	7.30	59.20	-1.90	.2					
81DEC20 20 KM W FROM LA POCATIERE, QUE.													
A10	14	159	P	1535	41.44	2.90	-0.46	1.0					
LPQ	19	97	P	1535	43.00	3.65	0.35	1.0		0.1	.1*		
			S	1535	45.50	6.16	0.34	1.0					
LMQ	21	346	P	1535	43.20	4.00	0.20	1.0		0.1	.8*		
			S	1535	45.90	6.77	0.13	1.0					
A16	22	58	P	1535	43.11			1.0					
			S	1535	45.60	6.95	-0.35	1.0					
A61	39	19	P	1535	45.75	6.71	0.04	1.0					
			S	1535	50.25	11.47	-0.22	1.0					
81DEC20 110 KM S FROM GROSSES-ROCHES, QUE. FELT AND HEARD													
GSQ	107	347	P 1	20 9	31.80	17.84	-1.04	1.2		0.3	2.2*		
			S 1	20 9	46.20	30.71	0.49	1.2					
EBN	120	247	P 1	20 9	34.22	19.91	-0.69	1.2		0.1	2.4*		
			S 3	20 9	49.60	34.31	0.29	.3					
UNB	225	177	P	20 9	51.50	33.41	3.09	1.2		0.5	2.8*		
			S	2010	18.50	63.55	-0.05	1.2					
LPQ	253	255	P 1	20 9	52.25	36.83	0.42	1.2		0.2	2.5*		
			S 4	2010	24.70	71.37	-1.67						
LMN	279	147	P 1	20 9	54.00	40.08	-1.08	1.2		0.2	2.3*		
			S 3	2010	32.60	78.79	-1.19	.3					
GGN	317	181	P 4	2010	6.20	44.63	6.57			0.1	2.6*		
			S 1	2010	43.40	89.28	-0.88	1.2					
MNQ	320	334	P 1	20 9	59.96	45.10	-0.14	1.2					
			S 4	2010	33.00	78.47	-0.47						
			S 4	2010	44.00	90.28	-1.28						
81DEC22 NB, N OF BECAGUIMEC LAKE													
HNME	63.2	254	EP 0	8 5	13.40	10.61	0.30	1.47	4	.10	1.8	35	1.6
			ES 0	8 5	21.20	18.88	-0.20	1.54					
PQO	149.3	188	EP 0	8 5	26.00	23.77	-0.27	0.81	3	.12	2.1	30	1.8
			ES 0	8 5	44.90	42.32	0.06	0.86					
PQ1	157.4	184	ES 0	8 5	47.00	0.00	0.79						
MIM	186.3	230	ES 0	8 5	53.50	50.97	0.03	0.54	2	.20	1.8		

TABLE 3 (Continued)

STN	DIST km	AZM deg	RMK	HRMN	SEC	TCAL sec	RES sec	WT	AMX	PRX sec	XMAG	FMP sec	FMAG
81DEC22 25 KM W FROM LA POCATIERE, QUE.													
A10	14	116	P	1710	40.37	2.21	0.16	1.0					
			S	1710	41.74	3.88	-0.14	1.0					
LPQ	27	80	P 4	1710	42.36	4.25	0.11			0.1	1.0*		
			S 4	1710	45.68	7.44	0.24						
LMQ	28	5	P 4	1710	42.80	4.43	0.37						
			S 4	1710	46.70	7.75	0.95						
A16	32	54	P	1710	43.20	5.13	0.07	1.0					
			S	1710	47.09	8.97	0.12	1.0					
A61	48	24	P	1710	45.76	7.71	0.05	1.0					
			S	1710	51.53	13.44	0.09	1.0					
A64	68	31	P	1710	48.75	10.94	-0.19	1.0					
			S	1710	56.92	19.06	-0.14	1.0					
81DEC23 15 KM SE FROM LA MALBAIE, QUE. FELT MILDLY													
A16	12	88	P	0128	22.64			1.0					
			S	0128	24.65			1.0					
LMQ	15	308	P 4	0128	23.40	3.09	0.31						
LPQ	18	139	P 4	0128	23.61	3.45	0.16						
			S 4	0128	26.36	6.05	0.31						
A54	19	267	P	0128	23.55	3.52	0.03	1.0					
			S	0128	26.15	6.16	-0.01	1.0					
A10	24	185	P	0128	24.36	4.31	0.05	1.0					
			S	0128	27.52	7.54	-0.02	1.0					
A61	26	13	P	0128	24.59	4.58	0.01	1.0					
			S	0128	28.01			1.0					
A64	45	27	P	0128	27.42	7.48	-0.06	1.0					
			S	0128	33.10	13.07	0.03	1.0					
EBN	145	86	p 4	0128	43.60	23.91	-0.31						
			P 4	0128	44.17	23.47	0.70			0.1	2.4*		
			S 4	0129	0.68	40.80	-0.12						
GNT	208	235	p 4	0128	52.00	31.53	0.47			0.2	2.2*		
			s 4	0129	16.20	55.12	1.08						
GSQ	278	54	p 4	0129	3.00	40.11	2.89						
			S 4	0129	36.70	77.86	-1.16						
MNQ	356	16	p 4	0129	10.60	49.68	0.92						
			s 4	0129	46.00	86.77	-0.77						
81DEC24 25 KM NE FROM LA MALBAIE, QUE.													
A61	1	197	P	2334	2.48			1.0					
			S	2334	3.87	2.86	0.01	1.0					
A64	20	47	P	2334	4.31			1.0					
			S	2334	7.05	6.03	0.02	1.0					
LMQ	25	226	P 4	2334	5.00	4.07	-0.07						
			S 4	2334	8.00	7.36	-0.36						
A16	27	168	P	2334	5.26	4.32	-0.06	1.0					
			S	2334	8.78	7.79	-0.01	1.0					
A54	37	222	P	2334	6.88	5.87	0.01	1.0					
			S	2334	11.44	10.46	-0.02	1.0					

TABLE 3 (Continued)

STN	DIST km	AZM deg	RMK	HRMN	SEC	TCAL sec	RES sec	WT	AMX	PRX sec	XMAG	FMP sec	FMAG
LPQ	41	172	P 4	2334	7.61	6.47	0.14			0.1	1.6*		
			S 4	2334	12.70	11.52	0.18						
A10	52	189	P	2334	9.17	8.15	0.02	1.0					
			S	2334	15.52	14.44	0.08	1.0					
EBN	140	97	P 4	2334	24.30	22.27	1.03			0.1	1.8*		
			S 4	2334	40.50	38.96	0.54						
GNT	229	230	P 4	2334	37.40	33.89	2.51			0.1	1.6*		
			S 4	2335	3.50	63.88	-1.38						
MNQ	329	16	P 4	2334	48.60	46.11	1.49			0.1	2.0*		
			s 4	2335	23.70	80.79	1.91						
			S 4	2335	31.60	91.82	-1.22						
81DEC26 NY, NEAR ALTONA													
DANY	12.3	214	P	2237	47.70	2.49	.02	2.18					
			S 2	2237	49.50	4.36	-.05	1.09					
PNY	15.5	97	P	2237	48.10	2.89	.02	2.18					
			S 3	2237	50.30	5.06	.05	.55					
BGR	49.2	268	P 2	2237	53.00	7.78	.03	1.09					
			S 4	2237	58.60	13.61	-.21	.00					
WNY	51.9	190	P	2237	53.30	8.18	-.07	2.18					
			S 3	2237	59.80	14.31	.29	.55					
FLET	64.6	102	P 3	2237	55.80	10.09	.52	.00					
			S 4	2238	4.10	17.66	1.25	.00					
MNT	72.8	7	P 4	2238	.00	11.33	56.52	.00					
			S 3	2238	4.80	19.83	-.22	.55					
MSNY	89.0	281	P 3	2237	59.05	13.77	.09	.55					
			S 4	2238	9.45	24.10	.16	.00					
PTN	102.2	253	P 3	2238	1.20	15.76	.25	.55					
			S 4	2238	13.70	27.58	.93	.00					
MDV	104.9	154	P 3	2238	1.85	16.18	.48	.00					
			S 4	2238	15.05	28.31	1.54	.00					
CTR	122.4	208	P 3	2238	4.35	18.82	.34	.55					
GAC	165.1	306	P 4	2238	.00	25.29	70.48	.00					
			S 4	2238	32.60	44.26	3.15	.00					
OTT	165.6	292	P 4	2238	.00	25.36	70.55	.00					
			S 4	2238	31.50	44.38	1.93	.00					
81DEC29 30 KM NE FROM LA MALBAIE, QUE.													
A61	7	188	P	1443	26.24	2.42	-0.18	1.0					
			S	1443	28.17	3.90	0.27	1.0					
A64	16	60	P	1443	27.23	3.50	-0.27	1.0					
			S	1443	29.85	5.77	0.08	1.0					
LMQ	30	219	P	1443	30.50	5.49	1.01	1.0		0.1	.2*		
			S	1443	32.50	9.20	-0.70	1.0					
A16	32	171	P	1443	29.53	5.87	-0.34	1.0					
			S	1443	34.07	9.90	0.17	1.0					

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TABLE 4

FORESHOCKS, AFTERSHOCKS, AND MICROEARTHQUAKES

DATE	ARRIVAL-TIME	MAG	STA
01 OCT	1539		BML[1]
01 OCT	1948		BML
03 OCT	1544		BML
05 OCT	1815		BML
07 OCT	0224		BML
07 OCT	0800		BML
07 OCT	1405		BML
08 OCT	2045		BML
09 OCT	1819		BML
13 OCT	1354		BML
14 OCT	1740		BML
14 OCT	2010		BML
15 OCT	1700		BML
15 OCT	1904		BML
05 OCT	154600.	-0.7	MD1[2]
05 OCT	162809.	-1.1	MD1
07 OCT	121011.	-1.3	MD1
07 OCT	153253.	-1.3	MD1
08 OCT	185828.	-1.5	MD2
09 OCT	185020.	-1.9	MD1
10 OCT	121835.	-0.7	MD1
10 OCT	135250.	-1.0	MD2
10 OCT	165119.	-1.1	MD1
10 OCT	193523.	-1.1	MD1
10 OCT	203522.	-1.7	MD1
11 OCT	175200.	-0.8	MD2
12 OCT	050541.	-0.7	MD2
12 OCT	132153.	-1.7	MD1
12 OCT	151240.	-2.0	MD1
12 OCT	163843.	-0.9	MD1
12 OCT	185422.	-1.0	MD1
13 OCT	103200.	-1.3	MD2
13 OCT	140432.	-1.3	MD1
13 OCT	141245.	-0.7	MD1
13 OCT	172407.	-0.5	MD1
13 OCT	185350.	-1.5	MD3
13 OCT	193944.	-0.6	MD1
14 OCT	115913.	-1.0	MD3
14 OCT	115920.	-1.0	MD4
16 OCT	161443.	-1.3	MD2
21 OCT	205212.	-0.5	MD3

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DATE	ARRIVAL-TIME	MAG	STA
06 NOV	013704.	-1.7	MD2
06 NOV	181635.	-0.9	MD1
07 NOV	010128.	-1.2	MD2
22 NOV	142718.	-1.1	MD2
19 DEC	091144.	-1.5	MD2

Closest Station	Location of Event
1. BML	Blue Mountain Lake, NY
2. MD's	Moodus, CT

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