EARTHQUAKE HAZARDS REDUCTION

HEARING

BEFORE THE

SUBCOMMITTEE ON SCIENCE, RESEARCH AND TECHNOLOGY

OF THE

COMMITTEE ON SCIENCE AND TECHNOLOGY

U.S. HOUSE OF REPRESENTATIVES

NINETY-FIFTH CONGRESS

FIRST SESSION

APRIL 20, 1977

[No. 4]

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EARTHQUAKE HAZARDS REDUCTION

WEDNESDAY, APRIL 20, 1977

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND TECHNOLOGY,
SUBCOMMITTEE ON SCIENCE, RESEARCH AND TECHNOLOGY,
Washington, D.C.

The subcommittee met, pursuant to notice, at 11:53 a.m., in room 2318, Rayburn House Office Building, Hon. Ray Thornton (chairman of the subcommittee), presiding.

Present: Representatives Thornton (presiding), Brown, Hollenbeck, and Dornan.

Also present: Thomas R. Kramer, science consultant.

Mr. THORNTON. Today the Subcommittee on Science Research and Technology is gathering information concerning legislation of earthquake hazards reduction. We believe that such legislation is desirable and we want to develop laws as effective as possible.

Following this hearing, on Tuesday, April 26, the subcommittee will mark up legislation and I expect a full committee markup will be held shortly thereafter.

We are able to build today on past efforts. During the last session of Congress this subcommittee held 3 days of hearings on earthquakes and reported an earthquake hazards reduction bill. The bill reached the floor of the House very late in the session and was not voted the necessary two-thirds majority when it was considered under suspension of the House rules.

In the Senate an earthquake hazards reduction bill was passed last year. Further Senate hearings were held in the Committee on Commerce, Science, and Transportation just yesterday. Senator Cranston has been a strong driving force behind this legislation in the Senate.

This year in the House nearly 40 Members have cosponsored earthquake bills. I might mention especially Mr. Brown of this subcommittee and Mr. Anderson who will present testimony today.

The administration has acted energetically in earthquake hazards reduction, both on its own initiative and in cooperation with this subcommittee. An advisory committee chaired by Dr. Nathan Newmark reported a recommended earthquake program for the U.S. Geological Survey and the National Science Foundation last fall.

Dr. Newmark is unable to be with us today, but he has submitted written testimony and without objection I would like to have it incorporated in the record of this hearing along with portions of the Newmark report, "Earthquake Prediction and Hazard Mitigation—Options for USGS and NSF Programs."

Largely as a result of the Newmark committee report, the House, the Senate, and the administration are all considering spending the same amounts of money for earthquake research. The three parties also agree that the purpose of the bill should be to help reduce the hazards of earthquakes. While it is clear that a great deal of research is needed, all parties are looking past research to the implementation of knowledge in actually reducing the harm that results from earthquakes.

The two broad issues in which agreement has not yet been reached are (1) what steps should the Federal Government take or sponsor to implement what is known about how to reduce the hazards of earthquakes, and (2) how should the Federal Government organize itself to administer an earthquake hazards reduction program?

The legislation before members today is H.R. 35. This bill has been reintroduced as H.R. 3551, H.R. 3552, H.R. 4190, and H.R. 6004. H.R. 35 is essentially the same bill that was considered in the House last year, except that the authorization amounts have been increased to reflect the administration request for fiscal year 1978 and the recommendations of the Newmark report.

The President has designated Dr. Frank Press as his science adviser. We are extremely fortunate in that designation because Dr. Press is an expert in earth sciences and appeared as a witness last year before this subcommittee. Dr. Press' office has worked closely with the subcommittee staff on earthquake legislation in recent weeks. Mr. Philip Smith of that office will testify today. We are looking forward to his testimony and to further cooperation with the administration.

[A copy of H.R. 35 follows:]

95TH CONGRESS
1ST SESSION

H. R. 35

IN THE HOUSE OF REPRESENTATIVES

JANUARY 4, 1977

Mr. TEAGUE (for himself and Mr. BROWN of California) introduced the follow bill; which was referred to the Committee on Science and Technology

A BILL

To reduce the hazards of earthquakes, and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,

SECTION 1. SHORT TITLE.

This Act may be cited as the "Earthquake Hazards Reduction Act of 1977".

SEC. 2. FINDINGS.

The Congress finds that:

(a) Earthquakes have caused, and can cause in the future, enormous loss of life, injury, destruction of property, and economic and social disruption. Although some States

are particularly vulnerable, all 50 States may suffer damaging earthquakes.

(b) Loss of life, property destruction, and economic and social disruption from future earthquakes can be substantially reduced through the development and implementation of earthquake hazards reduction measures, including improved construction methods and practices, prediction techniques and early-warning systems, coordinated emergency preparedness plans, and public education and involvement programs.

(c) In order to insure that appropriate measures are developed and implemented, it is necessary to institute through public and private efforts a coordinated and comprehensive national program of earthquake hazards reduction. The expertise required to address the many facets of earthquake hazards reduction is distributed throughout the public and private sectors, Although concentration of this expertise is not desirable, its coordination is required for a successful program of earthquake hazards reduction.

(d) Recent discoveries in the earth sciences promise development of methods of earthquake prediction. Further research in the fields of geology and geophysics is needed to realize this promise. The consensus of experts in earthquake studies is that a well-funded seismological research program in earthquake prediction could provide data adequate for the

design, within 10 years, of an operational capability that would be able to predict the time, place, magnitude, and physical effects of earthquakes in selected areas of the United States. In addition to earthquake prediction research itself, regular, careful, scientific evaluation of earthquake predictions will be needed to insure the effective development of earthquake prediction capabilities.

(e) To realize the benefits of earthquake prediction capabilities and to use present knowledge of earthquakes effectively, more knowledge of engineering and social behavior is required. Research in the fields of economics, sociology, law, and engineering is needed.

(f) The implementation of earthquake hazards reduction measures would, as an added benefit, also reduce the risk of loss, destruction, and disruption from other natural hazards and manmade hazards, including hurricanes, tornadoes, accidents, explosions, landslides, building and structural cave-ins, and fires.

(g) Because severe earthquakes are a worldwide problem but occur infrequently in any one nation, international cooperation is necessary for mutual learning from limited experiences.

SEC. 3. PURPOSE.

It is the purpose of the Congress in this Act to reduce the risks to life and property from future earthquakes in the

United States through the establishment and maintenance of an effective earthquake hazards reduction program.

SEC. 4. DEFINITIONS.

As used in this Act—

(1) the term "Program" means the National Earthquake Hazards Reduction Program established by this Act;

(2) the term "agency" means any department, part of a department, independent agency, or other establishment in the executive branch of the United States Government;

(3) the term "Committee" means the National Advisory Committee on Earthquake Hazards Reduction established by this Act;

(4) the term "Office" means the Office of Earthquake Hazards Reduction established by this Act;

(5) the term "State" means any State of the United States, the District of Columbia, or any other territory or possession of the United States;

(6) the term "earthquake prediction" means a prediction in definite or probabilistic terms, of the time, place, and magnitude of an earthquake; and

(7) the term "earthquake warning" means a recommendation that normal life routines should be changed for a time because an earthquake is believed imminent.

SEC. 5. NATIONAL EARTHQUAKE HAZARDS REDUCTION PROGRAM.

(a) ESTABLISHMENT.—In order to reduce loss of life, property destruction, and economic and social disruption from future earthquakes, the President shall establish and direct to be maintained in accordance with the provisions of this Act—

(1) a coordinated National Earthquake Hazards Reduction Program, which shall be administered as set forth in subsection (b) and shall include each of the elements described in subsection (c);

(2) an Office of Earthquake Hazards Reduction, which shall be part of an existing agency, and shall be administered as set forth in subsection (b) (2);

(3) a National Advisory Committee on Earthquake Hazards Reduction which shall be constituted and administered as set forth in subsection (b) (3); and

(4) an Earthquake Prediction Evaluation Board composed of scientists, representing the most knowledgeable experts in various disciplines involved in earth sciences related to earthquake studies, whose functions, as described in subsection (c) (1), shall be part of the Program.

(b) ADMINISTRATION.—

(1) PROGRAM.—The President shall, by rule,

within 180 days after the date of enactment of this Act—

(A) identify the agency which shall contain the Office of Earthquake Hazards Reduction; and

(B) assign and specify the role and responsibility of the United States Geological Survey, the National Science Foundation, and each other agency in the Program, including the responsibility for unified review of the Program budget.

(2) OFFICE OF EARTHQUAKE HAZARDS REDUCTION.—The Office shall have the following duties and any others that may be assigned to it by the President:

(A) to develop and maintain a Program plan, which shall include a description of: the overall strategy of the Program, the elements of the Program, agency responsibilities in the Program, a detailed Program budget, and other information deemed pertinent; and to present such Program plan to the Congress within 180 days after constitution of the Committee;

(B) to provide staffing and other assistance to the Committee;

(C) to coordinate the earthquake activities of all agencies, with particular attention to those agencies specified in paragraph (4) of this subsection;

(D) to provide for cooperation and coordination with interested governmental entities in all States, particularly those containing areas of high or moderate seismic risk; and

(E) to provide for cooperation and coordination with private interests, including the insurance and construction industries, concerned with earthquake hazards reduction.

Activities undertaken by the Office in performance of the duties specified in subparagraphs (C), (D), and (E) shall include interagency meetings among those agencies with responsibilities in the Program. Activities shall also include meetings among representatives of any or all groups interested in earthquake hazards reduction, including private industry, State and local government, and the Federal Government.

(3) NATIONAL ADVISORY COMMITTEE ON EARTHQUAKE HAZARDS REDUCTION.—

(A) The President shall designate the chairman and other members of the Committee. The Committee shall have not fewer than ten members, including persons concerned with earthquake hazards reduction who are representative of the research community (including the design professions), private industry (including insurance and construction),

and government (Federal, State, and local), and shall include qualified individuals experienced in earthquake hazards reduction planning, implementation, or preparedness.

(B) The Committee shall serve as an advisory body to the Office, to review and advise on the progress, implementation, and coordination of the Program and shall perform such other duties as the President may assign.

(C) At least annually the Program plan shall be submitted to the Committee, and the Committee shall evaluate the plan.

(D) The annual report required by section 6 of this Act shall be submitted to the Committee before the report is in final form and the Committee shall comment on the report.

(E) Membership on the Committee shall be for staggered, rotating terms.

(F) Members of the Committee shall be reimbursed for actual expenses incurred in the performance of their duties.

(4) AGENCY INVOLVEMENT.—Agencies which may be assigned responsibilities in the Program shall include—

(A) the Department of Commerce (National Bureau of Standards, National Oceanic and Atmospheric Administration);

(B) the Department of Defense (Defense Civil Preparedness Agency);

(C) the Department of Housing and Urban Development (Federal Disaster Assistance Administration);

(D) the Department of the Interior (United States Geological Survey);

(E) the Energy Research and Development Administration;

(F) the General Services Administration (Federal Preparedness Agency);

(G) the National Aeronautics and Space Administration;

(H) the National Science Foundation;

(I) the Nuclear Regulatory Commission;

(J) the Office of Science and Technology Policy; and

(K) the Veterans' Administration.

(c) PROGRAM ELEMENTS.—The Program shall include each of the following elements:

(1) PHYSICAL STUDIES.—Studies of the nature

and behavior of the Earth to promote understanding of earthquakes and to form a knowledge base for earthquake hazards reduction, including—

(A) development of methods of earthquake prediction with the objective of making official earthquake warnings feasible;

(B) development of methods of determining the likelihood of earthquakes in all States with the objective of zonation and microzonation of the States into areas of greater or lesser earthquake risk;

(C) development of theories, devices, and practices designed to promote understanding of the modification or control of earthquakes;

(D) basic and applied research in tectonics, seismology, and geology; and

(E) development of instruments, systems, computer programs, and theories for the collection analysis, storage, and distribution of physical data related to earthquakes.

For purposes of subparagraph (A) the Earthquake Prediction Evaluation Board shall evaluate individual earthquake predictions, compile and maintain a public record of the performance of prediction methods and persons who make predictions, and issue authenticated

earthquake predictions if and when earthquake prediction becomes a sufficiently reliable science.

(2) STRUCTURAL STUDIES.—Studies of structural matters related to earthquakes, including—

(A) the development of economical design and construction procedures to make new and existing structures earthquake resistant;

(B) the characterization of the earthquake vulnerability of individual structures, groups of structures, and construction types; and

(C) the development of improved methods of earthquake engineering analysis.

(3) SOCIAL, LEGAL, AND ECONOMIC RESEARCH.—Research into social, legal, and economic aspects of earthquake hazards, including—

(A) the identification of groups of people particularly vulnerable to the hazards of earthquakes;

(B) the relationship between laws (including tax laws) and earthquake hazards;

(C) the relationship between insurance and earthquake hazards;

(D) the societal effects of earthquakes;

(E) the behavioral and psychological effects of earthquakes on individuals;

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(F) the social and economic effects of earthquake warnings and predictions; and

(G) risk management techniques and methods for making decisions under uncertainty.

(4) IMPLEMENTATION.—Putting knowledge concerning earthquakes to use in reducing the hazards of earthquakes by means including—

(A) development of model building codes, recommended building standards, recommended building regulations, and model zoning provisions related to earthquakes for use by the Federal Government, States, localities, trade associations, and others;

(B) development of recommended regulations to govern the practices of corporations or individuals offering services which reduce or are asserted to reduce the damaging effects of earthquakes;

(C) education of the public, including State and local officials, in areas of earthquake risk concerning earthquake hazards reduction including earthquake phenomena, risk assessment, ways to reduce the adverse consequences of an earthquake, pre-event planning, warning dissemination, and emergency services;

(D) assistance to States, localities, businesses, and individuals in identifying locations and structures

which are especially susceptible to earthquake damage;

(E) assistance to States in carrying out their responsibilities under section 201 of the Disaster Relief Act of 1974 (42 U.S.C. 5131), by making available the results of research and other activities undertaken under this Act;

(F) recommendations for legislation to improve the Program;

(G) maintenance of an earthquake information clearinghouse to provide construction design and analysis information, planning aids, representative plans for protecting large hazardous facilities such as natural gas lines or dams, sample earthquake evacuation plans, earthquake zonation maps, and other pertinent information;

(H) efforts to insure that national needs for people trained in specialties related to earthquake hazards reduction are met (and for this purpose the use of persons for whom earthquake hazards reduction is an avocation should be considered); and

(I) an analysis of the disaster preparedness of State and local units of government in areas of high

seismic risk, and the submission of such analysis to Congress.

(5) OTHER ELEMENTS.—

(A) Studies of foreign experience with all aspects of earthquakes; and

(B) Postearthquake investigations of all aspects of actual major earthquakes.

SEC. 6. ANNUAL REPORT.

The President shall, within ninety days after the end of each fiscal year, submit an annual report to the Congress describing and evaluating progress achieved in reducing the risks of earthquake hazards. Each such report shall include—

(1) an account of the earthquake-related activities and expenditures of each agency involved in the Program during the preceding fiscal year;

(2) an assessment of the effect of Federal activities on earthquake hazards;

(3) any recommendations for legislative or other action; and

(4) any comments which individual members of the Committee may wish to add.

SEC. 7. AUTHORIZATION OF APPROPRIATIONS.

(a) GENERAL.—There are authorized to be appropriated to the President to carry out the provisions of sections 5 and 6 of this Act (in addition to any authorizations for

similar purposes included in other Acts and the authorizations set forth in subsections (b) and (c) of this section), not to exceed $1,000,000 for the fiscal year ending September 30, 1978, not to exceed $2,000,000 for the fiscal year ending September 30, 1979, and not to exceed $2,000,000 for the fiscal year ending September 30, 1980.

(b) UNITED STATES GEOLOGICAL SURVEY.—There are authorized to be appropriated to the Secretary of the Interior for the purposes of carrying out section 5(c) of this Act such sums as may be necessary for the period beginning October 1, 1977, and ending September 30, 1980, except that the total amount authorized for such purposes or similar purposes by all Acts shall not exceed—

(1) $30,000,000 for the fiscal year ending September 30, 1978;

(2) $38,000,000 for the fiscal year ending September 30, 1979; or

(3) $47,000,000 for the fiscal year ending September 30, 1980.

(c) NATIONAL SCIENCE FOUNDATION.—There are authorized to be appropriated to the National Science Foundation for the purposes of carrying out section 5(c) of this Act such sums as may be necessary for the period beginning October 1, 1977, and ending September 30, 1980, except that the total amount authorized for such purposes or similar purposes by all Acts shall not exceed—

(1) $26,000,000 for the fiscal year ending September 30, 1978;

(2) $33,000,000 for the fiscal year ending September 30, 1979.

(3) $39,000,000 for the fiscal year ending September 30, 1980.

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95TH CONGRESS
1ST SESSION

H. R. 35

A BILL

To reduce the hazards of earthquakes, and for other purposes.

By Mr. TEAGUE and Mr. BROWN of California

JANUARY 4, 1977
Referred to the Committee on Science and Technology

Mr. THORNTON. Mr. Hollenbeck, would you like permission to include remarks?

Mr. HOLLENBECK. Yes; I would.

Mr. THORNTON. Without objection, your remarks will be included.

Opening Remarks of Hon. Harold Hollenbeck

Subcommittee on Science, Research & Technology

Hearings on Legislation for Earthquake Hazards Reduction
April 20,1977

I would like to join Representative Thornton in stressing the importance of the legislation we are about to consider. As mentioned, earthquake hazard reduction legislation was given considerable attention last year, but failed to receive the needed votes when it was brought up during the final hours of the 94th Congress. This year, however, Congressional support has been widespread and the Administration has shown a positive concern fot the passage of such legislation. I look forward to receiving today's testimony and to providdng our country with a program that would reduce the hazards associated with earthquakes.

I would like to recognize Mr. Brown for such remarks as he may wish to make.

Mr. BROWN. No thank you, Mr. Chairman.

Mr. THORNTON. Mr. Brown, once again I would like to thank you for your strong leadership and support of this very important legislation.

Our first witness for today, Dr. Frank Press, is unavoidably prevented from appearing before our subcommittee for two reasons. First, we started late—or maybe that is second. First there is a Cabinet meeting in which he is presently involved and he is unable to be here.

He might have been able to attend these hearings had we held them at the originally scheduled time. But Mr. Philip Smith, Assistant Director for Natural Resources and Commercial Services is familiar with the statement which Dr. Press had prepared for submission to the subcommittee.

I would like to recognize Mr. Smith at this time.

[Biographical sketches of Dr. Frank Press and Mr. Philip M. Smith follow:]

BIOGRAPHICAL DATA
FRANK PRESS

Frank Press was born in Brooklyn, New York, on December 4, 1924. His undergraduate work at the College of the City of New York was in physics and geology. He received a master of arts degree in 1947 and a doctor of philosophy in geophysics in 1949 from Columbia University. From 1948 to 1955, Dr. Press served on the faculty of Columbia University, first as an Instructor in Geology and then as an Assistant Professor and Associate Professor of Geology. From 1955 to 1965, he was a Professor of Geophysics at California Institute of Technology. During that time, from 1957, he also served as Director of the Institute's Seismological Laboratory. His most recent academic position was as Chairman of the Department of Earth and Planetary Sciences at the Massachusetts Institute of Technology. His publications include 160 scientific papers in the fields of oceanography, planetary physics, natural resource exploration, regional geophysics, structure of the earth's deep interior, and the mechanism and prediction of earthquakes. He is co-author with R. Siever of the textbook "Earth," widely used in American universities.

Dr. Press was elected to membership in the National Academy of Sciences, and is also a member of the American Academy of Arts and Sciences. He was President of the American Geophysical Union, the Seismological Society of America, and is a member of the Geological Society of America, the Society of Exploration Geophysicists and the Royal Astronomical Society.

Dr. Press has been active in the affairs of the National Academy of Sciences, including membership on the Council, the Commission on Natural Resources, the Geophysical Research Board, and the International Geophysical Year Committee.

Dr. Press' government service includes membership on the President's Science Advisory Committee during the Administration of President Kennedy, membership on the Ramo and Baker Committees which were precursory to the Office of Science and Technology Policy during the Administration of President Ford, and membership on the NASA Lunar and Planetary Missions Board. He was appointed to The National Science Board for the term 1970-1976. He was a member of the Governor's Committee for Atomic Energy in the State of California, and served as consultant to the Department of Defense, the Department of the Interior, the National Aeronautics and Space Administration, the Arms Control and Disarmament Agency, and the Agency for International Development. He was one of the organizers of the International Geophysical Year and a prime mover of the research efforts at earthquake prediction in the United States. He served as a member of the U.S. delegation to the nuclear test ban negotiations in Geneva and Moscow.

Dr. Press has been active in international scientific cooperation as a consultant to UNESCO, as a member of the U.S. delegation to the United Nations Conference on Science and Technology for Underdeveloped Countries, as a participant in the bilateral science agreements with the Soviet Union and Japan, and as Chairman of the Committee on Scholarly Communication with the Peoples Republic of China.

Dr. Press' honors include the Columbia University Medal for Excellence (1959), the California Scientist of the Year Award (1960), Life Magazine - One of the Hundred Most Important Young People in the United States (1962), Distinguished Service Award, Department of the Interior (1971), Gold Medal of the Royal Astronomical Society (1971), Arthur L. Day Medal of The Geological Society of America (1972), and Honorary Doctoral degrees from the University of Notre Dame and the College of the City of New York.

On March 18, 1977, President Carter nominated Dr. Press to be Director of the Office of Science and Technology Policy in the Executive Office of the President and to serve as Science and Technology Adviser to the President. The nomination was confirmed by the Senate on April 27, 1977 and Dr. Press was sworn into office on April 29, 1977.

Dr. Press is married to the former Billie Kallick of St. Louis, Missouri. They have two children, William Henry Press, who is a Professor of Astronomy at Harvard University, and Mrs. Paula Press Checkoway, a school teacher in Chapel Hill, North Carolina.

BIOGRAPHICAL DATA
PHILIP M. SMITH

Mr. Smith has been the Assistant Director for Natural Resources and Commercial Services, Office of Science and Technology Policy in the Executive Office of the President since August 1976.

Mr. Smith was born in Springfield, Ohio, May 18, 1932. He received a B.Sc. in 1954 and a M.A. in 1955 from Ohio State University. During 1955-56 he was an officer in the United States Army, serving as a specialist in polar logistics and transportation in Greenland and Antarctica. He was responsible for much of the siting and construction of the first Byrd Antarctic Station for the International Geophysical Year. During the International Geophysical Year he was a member of the staff of the U. S. National Committee for the IGY, of the National Academy of Sciences and the Arctic Institute of North America.

Mr. Smith joined the staff of the National Science Foundation in 1958 when the U. S. Antarctic Research Program activities were assumed by the Foundation. He served subsequently between 1958 and 1973 in a variety of positions as Director of Field Operations, Deputy Head and Acting Head of the Office of Polar Programs. In 1972 he directed the interagency planning that resulted in the transfer of the Antarctic program responsibilities from the Navy to the Foundation. In 1973 Mr. Smith became a member of the staff of the Office of Management and Budget, serving as Acting Branch Chief for the General Science Branch. In 1974 he returned to NSF to serve as Assistant to the Director in both his NSF and Science Adviser capacities. In 1976, with the establishment of the Office of Science and Technology Policy, he transferred to that office.

Mr. Smith is a member of the American Association for the Advancement of Science, the American Management Association, and other organizations. He served as Executive Secretary of the President's Committee on the National Medal of Science in 1974-76. He is the author of a number of articles on polar research and logistics and two books: "Defrosting Antarctic Secrets" and "The Frozen Future."

Mr. Smith resides in Washington, D.C.

STATEMENT OF PHILIP M. SMITH, ASSISTANT DIRECTOR FOR NATURAL RESOURCES AND COMMERCIAL SERVICES, ON BEHALF OF DR. FRANK PRESS, DIRECTOR-DESIGNATE, OFFICE OF SCIENCE AND TECHNOLOGY POLICY

Mr. SMITH. Thank you very much, Mr. Chairman. We appreciate this opportunity to make a last minute substitution, so to speak. Had the Cabinet meeting been on any other subject than the energy message which the President plans to give this evening to the Congress, Dr. Press would have changed his order of priorities, but as you know, he is deeply interested in this subject.

To summarize very briefly Dr. Press' testimony——

Mr. THORNTON. Without objection, I think it might be appropriate to include all of Dr. Press' statement in the record as though he were here to present that testimony.

[The prepared statement of Dr. Frank Press follows:]

STATEMENT OF DR. FRANK PRESS,
DIRECTOR-DESIGNATE, OFFICE OF SCIENCE AND TECHNOLOGY POLICY,
EXECUTIVE OFFICE OF THE PRESIDENT
ON S. 126, H.R. 35 AND OTHER BILLS

SUBCOMMITTEE ON SCIENCE AND SPACE
SENATE COMMITTEE ON COMMERCE, SCIENCE AND TRANSPORTATION
APRIL 19, 1977

SUBCOMMITTEE ON SCIENCE RESEARCH AND TECHNOLOGY
HOUSE COMMITTEE ON SCIENCE AND TECHNOLOGY
APRIL 20, 1977

MR. CHAIRMAN AND MEMBERS OF THE SUBCOMMITTEE:

It is a great privilege for me to appear before you today to discuss earthquake research, prediction, hazard assessment and earthquake disaster mitigation. I will try to provide a brief overview of a number of developments since the hearings were held in the last session of Congress, discuss some of the Administration plans, and also the legislation under consideration by the Subcommittee. Dr. McKelvey and Dr. Eggers, who are also testifying, will in their statements expand on some of my comments, illustrating among other things why we believe the legislative suggestions I will make are the most appropriate actions for the Congress to take at this time.

During 1976 and so far in 1977, there have been numerous important events in the field of earthquake studies -- both the occurrence of earthquake disasters and progress in earthquake research. I would like to cite just a few of the more salient developments as I see them.

The year 1976 ranks as the second worst year in recorded history for earthquake-caused deaths. According to our best estimates, over 700,000 people lost their lives last year, compared with the worst death toll of over 800,000 which occurred in 1556 when a deadly tremor struck the Sian region of central China. The count of earthquake losses rose through 1976 with alarming regularity: 23,000 in Guatemala, 1,000 in Italy, several thousand in New Guinea, 500 in Indonesia, an estimated 655,000 in China and 5,000 in the Philippines. And now in 1977, the disasters continue with death tolls of 1,500 in Rumania and about 1,000 in Iran in two separate earthquakes.

The U.S. has escaped the list of devastated countries, but it must be realized that this is just good fortune. As cited in the legislation before this Committee, much of the U.S. is vulnerable to earthquakes and that vulnerability mounts with increasing population and development.

The number of large earthquakes that occurred in 1976 was not exceptionally high. In fact, it was almost exactly the long-term average which is 18 earthquakes of magnitude 7 or larger each year. The high casualty figures resulted from the proximity of some of these shocks to major population centers. As the world population increases and is increasingly concentrated in urban areas, the earthquake losses may be expected to increase as well.

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Scientists and engineers can learn much from studying earthquake damage wherever in the world it might occur. There has been a long tradition among earthquake experts of exchanging information and facilitating studies of foreign earthquake disasters. This tradition was demonstrated in March of this year when an American team was invited to Rumania to observe the damage caused there. The characteristics of the tectonic setting of the Rumanian earthquake and the nature of the ground shaking provide useful insight for seismic risk assessment and design practices in the U.S. Planning for the Pacific Northwest and southern Alaska especially can benefit from the Rumanian experience.

Scientific cooperation has continued to develop between the U.S. and the People's Republic of China. As I described in my testimony in June 1976 on the earthquake legislation, the Chinese successfully predicted the occurrence of a magnitude 7.3 earthquake that struck northeast China on February 4, 1975. The Chinese invited a delegation of American scientists to visit the People's Republic of China to learn of their prediction, and in June of 1976 this visit was carried out. The delegation obtained detailed information on the basis of the Chinese prediction and learned much about the experience of the Chinese in issuing warnings to the people. I had the privilege of visiting China in October of 1974 and I can say with assurance that the People's Republic of China has mounted an impressive effort to predict earthquakes.

The long road ahead in achieving a reliable prediction capability, though, was demonstrated by the Chinese failure to predict the earthquake near Tangshan that reportedly killed the 655,000 people, as I mentioned earlier. It would be in the best interest of the U.S. to maintain close contact with the Chinese to learn from their experiences. I would say, Mr. Chairman, that in my discussions with the President he has expressed strong interest in fostering scientific and technical communication with the People's Republic of China.

Our own efforts in the past year have been concentrated on two thrusts: establishing a monitoring program in the region of the land uplift in southern California and designing the accelerated research program which led to the Administration's budget proposals now before the Congress.

The monitoring program in California, in the region of the Palmdale uplift, was mounted with the joint support of the National Science Foundation and the U.S. Geological Survey. The USGS is responsible for the studies, but about 60% of the work is being carried out by universities and private groups. Dr. McKelvey will provide additional information on the California monitoring activities. I would like to note that the partnership in research exemplified by the USGS and NSF cooperation on the governmental level and the cooperation of government, university and private scientists at another level illustrates my belief that basic research is extremely relevant to national problems and can be focused on problems of national importance.

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Through such mission-oriented research all parties can benefit -- those primarily interested in the phenomena of earthquakes and those faced with a pressing national problem. To emphasize this point, I believe that the conduct of good basic research, which attracts the best scientific minds, is compatible with solving problems of national importance.

The Administration has proposed, as a part of the 1978 budget, that earthquake research, monitoring, hazards assessment and mitigation be increased significantly, with a doubling of the effort. The total support for the two principal research and research support agencies would increase from $20.7 million in Fiscal Year 1977 to about $53.6 million in Fiscal Year 1978. We believe that this research program is well-conceived and fully merits the support of the Congress.

The accelerated program that has been proposed follows an extremely successful planning exercise which was carried out through mid-1976. Science Adviser Stever formed an Advisory Group on Earthquake Prediction and Hazard Mitigation which was comprised of experts from the full spectrum of earthquake activities: seismologists, geologists, engineers, sociologists, State and local officials, planners, and building inspectors. The resulting plan, which was submitted to Dr. Stever on September 15, 1976, spelled out three funding options, of which the intermediate one subsequently became the basis for the FY 78 budget request. I should also

note that the Option B level is commensurate with the authorization in H.R. 35 and S. 126. It appears, therefore, that the Congress and the Administration are of a common view with regard to the appropriate level of support for an expanded program. I believe that the important steps that have been taken to strengthen the research program meet the desires of the Members of Congress who have correctly spoken to this need over several years. And, I think that the action taken fulfills in part one of the original objectives sought by the Congress through its hearings and proposed legislation.

We are all aware that success in planning and conducting a scientific research program does not assure that the public will benefit from the results. Implementation of scientific results is often difficult and invariably leads to social, economic and legal problems that can only be resolved through the political process. Therefore, substantial research on such issues is provided for in the Administration's FY 78 budget proposal and it will be a continuing part of the overall research plan.

It is very important, therefore, to tie together the research community and the user community, which is comprised of the Federal, State and local agencies, and the private groups and individuals that have to make the day-to-day decisions with regard to earthquake hazards: To build a dam or reactor or not? To allow development in a fault zone or not? To tear down old buildings or not? These are but a few of the questions faced by decision-makers.

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The wedding of the research and user communities is not an easy task in any field, and certainly is not a task that is solved by the creation of yet another governmental agency. It is a complex problem that requires careful analysis. In the end, it may well be that a new coordinating agency is the solution, but it would be imprudent to jump to that conclusion.

Our experience in developing a plan for research through such a process gives us confidence that it probably would be successful in developing a plan for implementation as well. Therefore, it is our intent to begin a second phase of detailed planning, one that focuses on the user communities. We plan to build on our experience with the Newmark Committee, drawing together experts, including many from the State, local and private sectors and from all areas -- banking, zoning, city planning, engineering, and so forth.

All of the Federal agencies -- both the research and also the disaster preparedness agencies -- and the National Bureau of Standards and others will participate in the planning. This activity will certainly take at least six months and possibly as much as a year. It is a formidable and challenging task. The result will be a detailed implementation plan that will address the following:

- Development of plans for preparedness, prediction evaluation, warning, and total response to future earthquakes;

- Development of ways for State, local and other governmental units to use existing and developing knowledge about the regional and local variation of seismic risk in making their plans for land use.

- Development and promulgation of specifications, building standards, design criteria, and construction practices for achieving appropriate earthquake resistance for new and existing structures.

- Examination of alternative provisions and requirements for earthquake hazards reduction in Federal and federally financed construction, loans, loan guarantees and licenses.

- Determination of the appropriate role for insurance, loan programs, and public and private relief efforts in moderating the impact of earthquakes.

- Timely dissemination to the public of data and information necessary for making knowledgeable decisions.

In addition, it is our expectation that this planning will enable us to make studied recommendations as to any changes in organizational alignment that should take place in the Executive Branch and any additional legislative authority which should be sought from the Congress.

Let me turn now to the legislation that is before the Congress. The Administration would propose amending the legislation to bring it in alignment with the developments that have taken place over the last year and which are planned in the near future. Accordingly, we would suggest a new Section that would revise H.R. 35 and S. 126. The new Section, "Earthquake Hazards Reduction Program" would authorize a continuing program of research and call upon the President to develop an implementation plan for transmittal to the Congress within one year of the date of enactment of legislation. On April 15, I forwarded a drafting suggestion concerning H.R. 35 and S. 126 to the leadership of the committees in both the House and the Senate. I should like, with your permission, to have that letter and the draft section covering these points made a part of the hearing record.

The Administration believes that the specific features of H.R. 35 and S. 126 which would establish a National Advisory Committee of Earthquake Hazards Reduction and an Office of Earthquake Hazards Reduction go too far at this time. The Administration would develop the comprehensive implementation plan that I have outlined before coming down on a proposed organizational arrangement in legislation. There is one further point that I should make. An approach such as the one proposed would be consistent with the President's overall plan for the review of the organization of the Executive Branch which is being carried out under the reorganization authority recently passed by the Congress.

The Adminstration is prepared to work with the committees in achieving mutually agreeable legislation which would incorporate provisions of H.R. 35 and S. 126, together with the drafting suggestion that we have submitted.

In concluding, I would like to emphasize that I think substantial progress has been made over the last year. This progress, coupled with the effort that I have outlined to develop a detailed implementation plan, will begin to put us in the position that we should be in as a nation to meet the disruptive problems caused by major earthquakes. I am impressed with the foresight that has been exhibited by the Congress in this area and want to reaffirm to the Administration's view that the Congress deserves much credit for its attention to this important national problem.

Mr. SMITH. We believe that there have been a number of significant developments internationally and domestically since the hearings held before the committee last summer. As the testimony addresses, there have been a number of major earthquake problems around the world, a very large disaster in China, probably the second largest disaster on record, a number of other tremors including the recent one in Romania in which about 1,000 people lost their lives.

International cooperation has continued to be good. We have had scientists continuing to exchange information with the scientists working in other nations. So there has been the opportunity to learn from the earthquakes that have taken place.

Now as you know, domestically over the last summer, we had a committee of experts organized and called together by Dr. Stever to work on an earthquake research program, an accelerated plan. That program plan became a part of the President's budget.

In the 1978 budget as you know there is a request for about $54 million which doubles the effort in earthquake research, hazard assessment, prediction and so on. We think that this is a good program and an integrated program that includes research on all elements that need to go forward including the questions of the social consequences of earthquake hazards.

We have in the testimony urged the congressional support for this appropriation request. Now at this time—at the time the earthquake research committee was working, all realized—the scientists involved, those of us in the administration and I think also it was recognized here by both this committee and the committee in the Senate—that an accelerated research program was only part of the program.

We also needed to work to develop a much better connecting up of research capability with the State and local government units that make the decisions about handling earthquake problems and connections with the private sector.

Accordingly, we feel that the next appropriate step and the step that we would recommend be handled by the drafting suggestion that we have sent forward by letter at the beginning of last week, would be to spend some months working through this relationship between a growing Federal capability for earthquake prediction and hazard assessment and the State and local and private sector relationships.

Another drafting suggestion that we have submitted calls in effect for the President to undertake a comprehensive review of the implementation plan and to within 1 year submit this plan to the Congress for its approval, to take such steps as he needs to take to improve the organizational lines of authority within the executive branch and to seek legislation from the Congress for any additional coordinating mechanisms that he needs to set up.

Mr. THORNTON. Without objection that letter and the enclosed draft language will be made a part of the record at this point.

[The above mentioned material follows:]

EXECUTIVE OFFICE OF THE PRESIDENT
OFFICE OF SCIENCE AND TECHNOLOGY POLICY
WASHINGTON, D.C. 20500

April 15, 1977

Honorable John W. Wydler
Committee on Science and Technology
House of Representatives
Washington, D.C. 20515

Dear Mr. Wydler:

In recent weeks the Administration has been considering the earthquake legislation developed by Senator Cranston, Mr. Brown and others and introduced in both the House of Representatives and the Senate. In preparing for the hearings that will be held next week by committees of both the House and Senate, we have examined these bills, prior Congressional hearings, and the initiatives that already have been taken to strengthen Federal research efforts.

As you know, about a year ago H. Guyford Stever, my predecessor as Science and Technology Adviser, convened an Advisory Panel on Earthquake Prediction and Hazard Mitigation. This panel, chaired by Professor Nathan M. Newmark of the University of Illinois, prepared a report entitled "Earthquake Prediction and Hazard Mitigation -- Options for USGS and NSF programs". The report provided the basis for recommending substantial increases for earthquake research programs in the Budget for Fiscal Year 1978, presently before the Congress. The total support for the two principal agencies, the National Science Foundation and the Geological Survey, would increase from $20.7 million in Fiscal Year 1977 to about $53.6 million in Fiscal Year 1978. We believe that this research program is well-conceived, well-coordinated and fully merits the support of Congress.

All of us who have been concerned with this matter in the Administration, the Congress, and the community recognize that a research program by itself, however, is not sufficient. An effective program implementing the results of this research, and our expanding understanding of earthquake-related phenomena, must be developed and put into place. Identification of implementation actions that could be taken and their cost and consequences, is difficult, however, because it involves a wide range of interests and many organizational units,

including Federal agencies, State and local governments, and the private sector. As one who has personally been concerned with earthquake prediction and hazards reduction over many years, it is my firm belief that we must devote a substantial effort to determining the appropriate means of implementing the improving Federal capability in earthquake prediction. Along with others in the Administration I am prepared to direct this effort over the months ahead.

It would be most helpful from the Administration's perspective if the legislation that the Congress is considering could reflect the need to have a comprehensive review of an implementation plan before there are created, by legislation, specific advisory or organizational mechanisms for effecting coordination. Enclosed is a drafting suggestion that would provide for this, and, also take into account the accelerated research program as reflected in the Newmark plan and the 1978 budget.

Under the draft section, the President would assure the establishment and development of a comprehensive program for mitigating loss of life and property, and economic and social disruption, from earthquakes. Within 1 year, he would take appropriate actions under existing authority and recommend to Congress any specific legislation required to improve organization and coordination. Further, a comprehensive plan would be developed establishing year-by-year targets for implementation actions, including recommendations about the appropriate roles for Federal, State, and local governmental and private activities.

Consistent with the Administration's commitment to involve the public, the draft section also calls for participation of State and local governments, and the private sector in the formulation and conduct of the program. In making plans for such participation, we will consult with the Members of Congress.

We believe that the enclosed suggestions would greatly strengthen the bills now before the Congress and are prepared to work with you in achieving mutually agreeable legislation in this important matter.

I look forward to testifying next week.

Sincerely,

Frank Press

Frank Press
Director-Designate

Enclosure: Drafting Suggestions
for H.R. 35 and S. 126

SEC. Earthquake Hazards Reduction Program.

(a) The President shall take such action as may be necessary to assure the development and implementation of a coordinated and comprehensive program directed to mitigating loss of life and property, and economic and social disruption from earthquakes. Such program shall be presented in connection with the annual recommendations on the Federal budget.

(1) Research. The research portion of this program shall include but not be limited to the following activities:

(A) Fundamental Earthquake Studies - Research into the basic causes and mechanisms of earthquakes.

(B) Prediction - Development of methods to predict the time, place and magnitude of future earthquakes.

(C) Induced Seismicity - Development of an understanding of the circumstances in which earthquakes might be artificially induced by the injection of fluids in deep wells, by the impoundment of reservoirs or by other means.

(D) Hazard Assessment - Development of techniques for the delineation and evaluation of the potential effects of earthquakes and their application on a regional basis.

(E) Engineering - Development of methods for planning, design, construction, rehabilitation and utilization of man-made works so as to effectively resist the hazards imposed by earthquakes.

(F) Research for Utilization - Exploration of possible options for social and economic adjustments to reduce earthquake vulnerability and to exploit effectly existing and developing mitigation techniques.

(2) Implementation. In addition to the research activities in subsection (a)(1), the President shall have prepared and shall transmit an implementation plan to the Congress within one year from the date of enactment of this Act. Such plan

shall set year-by-year targets through at least 1980, and shall include recommendations as to the appropriate roles for Federal, State and local units of government, and individuals and organizations in the private sector. The plan shall address, but not be limited to, the following:

(A) Development of plans for preparedness, prediction evaluation, warning, and total response to future earthquakes;

(B) Development of ways for State, local and other governmental units to use existing and developing knowledge about the regional and local variation of seismic risk in making their plans for land use.

(C) Development and promulgation of specifications, building standards, design critieria, and construction practices for achieving appropriate earthquake resistance for new and existing structures.

(D) Examination of alternative provisions and requirements for earthquake hazards reduction in Federal and federally-financed construction, loans, loan guarantees and licenses.

(E) Determination of the appropriate role for insurance, loan programs, and public and private relief efforts in moderating the impact of earthquakes.

(F) Timely dissemination to the public of data and information necessary for making knowledgeable decisions.

(b) Within one year of the date of enactment of this Act, the President shall inform the Congress of action taken under existing authorities, and transmit to Congress his recommendations as to any new legislative authority required to conduct and implement effectively an earthquake hazards reduction program. Such actions and recommendations shall address, but not be limited to:

(1) improving coordination of earthquake hazard reduction activities, including research, practices, preparedness planning, and disaster relief;

(2) improving organization within the Executive Branch.

(3) setting program priorities for allocation of Federal spending in earthquake hazards reduction activities.

(c) In carrying out this section, the President shall provide opportunity for participation of States and local governments, and the public and private sectors (including business and industry, the design professions and the research community) in the formulation and conduct of program.

Mr. SMITH. We think that this would be the appropriate way to go. Our testimony outlines the major elements of the implementation plan that we think must be developed. We comment briefly on a couple of provisions that are found in either the House bill or the companion bill from the Senate and suggest that prior to establishing specific organizational arrangements, the implementation review should go forward.

I think that that covers the high points of the testimony. We certainly all feel that the interest that the Congress had had, your committee and the committee in the Senate and the leadership both Mr. Brown and Senator Cranston have given in this area has been very important.

We are most anxious to work with the Congress to achieve mutually agreeable legislation and to meet the timetable that you are working toward in relation to your mid-May point.

Thank you.

Mr. THORNTON. Thank you very much for your testimony. I think it is appropriate to highlight the fact that earthquakes occur very frequently throughout the world. I believe the long-term average is referred to as being 18 earthquakes having a magnitude of seven or more.

As the world's population grows, the chances of this striking a populated area increase. I think this is one of the reasons that we feel it is important to move forward with this legislation even though we have been fortunate in this country in recent years not to experience such a catastrophe.

Do you have any comment with regard to that?

Mr. SMITH. I would agree with you completely. Dr. Press pointed out yesterday when we were at the Senate that we must move forward but that there are many things we still do not understand. It will take time to work out a more reliable prediction system. One point in particular that came up that I think you will be interested in, Mr. Thornton, has to do with the greater difficulty of making predictions about earthquakes that occur in the center of or away from the margins of plates.

Mr. THORNTON. I was hoping you would mention that. That was in my section of the country.

Mr. SMITH. Our most devastating earthquake occurred at a time when the population in the Mississippi River Valley was comparatively small. It would be a much different thing today. Dr. Press did point out that the ability to predict earthquakes in the centers of plates is a more elusive kind of thing than the ones around the edges, such as on the west coast.

There are many things that must be pursued before we can say we have the competence to handle some of these earthquakes problems.

Mr. THORNTON. It is quite a challenge as I understand it with regard to the plate structure in an area like the one you mentioned where you don't have two continental plates rubbing against each other but maybe a lens type structure or a thin structure at some depth which gives totally different characteristics and maybe requires different prediction techniques.

Mr. Dornan, do you have any questions at this time?

Mr. DORNAN. I don't. I was curious about the date of that Mississippi earthquake.

Mr. THORNTON. It was in 1812.

Mr. SMITH. December 16, 1811.

Mr. DORNAN. Has there ever been a projection given today's population density what the projected loss of life and property damage might be?

Mr. SMITH. I don't know precisely but this was a major quake. Tremors were felt over the greater part of the central part of the country and over a larger area.

So when you consider the population centers, Memphis, St. Louis, right on up the river toward Chicago, there would indeed be the possibility of quite severe residential and public building damage and property damage.

In general our problems of loss of life may be less here than in some countries because of the generally better construction techniques that we use in the United States than in some of the underdeveloped nations.

The very severe damage in Guatemala, for example, was largely caused by the inadequate construction of houses. But an earthquake of that magnitude anywhere in the United States, west coast, central, Mississippi Valley, would in any major population center cause a good deal of damage.

Mr. DORNAN. Can reinforced construction hold down loss of life? But isn't it true that these structures would be so damaged that the property damage would still be incredible?

Mr. SMITH. I think not. There are a great many of the large buildings that have fairly good structural integrity. There would be a great deal of rehabilitation, however.

A lot of the construction techniques that use these slab skins on the buildings, that sort of thing would probably be heavily damaged. But I think our feeling is that there is quite a bit of our building technique that is capable of withstanding reasonably heavy earthquakes.

You might want to talk to Dr. Thiel about that when he testifies. He is perhaps the expert amongst us this morning on earthquake engineering specifically.

Mr. THORNTON. The Mississippi quake was the most severe earthquake in recorded history in North America. The tremors were felt as far east as Washington and Philadelphia. It really shook the entire country. The Mississippi River was put out of its banks. In fact, some eyewitnesses said it flowed backward for a time.

It was an amazingly severe earthquake. Because of the plate structure, it is not anticipated that an earthquake of that magnitude is likely to occur again for a period measured in hundreds of years.

But no one knows for sure. I apologize in a sense for adding that to the record, but I am familiar with some of the details of that particular quake.

Mr. Brown?

Mr. BROWN. Mr. Smith, I want to thank you for being here. On the point which Mr. Dornan has raised, I note that Dr. Press' statement indicates that 1976 was the year in which there were unusual losses from earthquakes but that the number of severe earthquakes was

exactly average and this excessive loss situation stemmed from the increasing population and construction and other things which have occurred.

That of course will continue.

Mr. SMITH. That is correct, sir. That, of course, is from our perspective in the United States very much a major reason for getting on with a better predicting and research capability and an implementation program that takes into account hazard assessment, zoning, preparations for earthquakes and such techniques even as retrofitting existing structures where possible to better prepare them to withstand shocks.

We do have major population centers and clusters of people in very earthquake prone regions as you well know.

Mr. BROWN. I want to express my personal gratification at the support which the administration has given.

In fact it developed during the previous year under the former administration and has been continued by the present administration. I don't think there is any substantial difference between the Congress and the executive branch on this, on the importance of having a program.

I think the problems if any, and I hope they will be minimal, exist with regard to the degree of specificity in establishing a legal framework or legislative framework for the program. In that regard, I am sure that the Congress desires to be as flexible and as cooperative as it possibly can.

I would suspect that the Congress takes the view that on a major and important long-range program of this sort it would be helpful if the Congress were to express a legislative intent with a minimum amount of restrictions in order to facilitate public awareness if nothing else of the significance of the program and public support for the expenditure of tax funds in connection with it.

In that regard I would like to explore your thinking and Dr. Press' thinking with regard to the kind of an organizational structure or central coordination that might be best in a legislative framework.

We are, of course, prepared to recognize the fact that it may take some time to develop a plan. The legislation possibly should provide for a period.

Would you like to comment on that a little further?

Mr. SMITH. Yes, sir. We—I would say this. I think that with regard to the research program itself and the relationships between the agencies conducting the research and the review process both by the administration and by the Congress, that we have a fairly systematic way of approaching this coordination.

We have good coopération between the two principal agencies, the National Science Foundation and the U.S. Geological Survey. We have a program plan and a systematic method of reviewing it by way of the budget process, the authorization and appropriations process.

So for the elements of the problem that are within the Federal capability and Federal control, so to speak, undertaking the research, the organizational problems seem to be more clearly worked out.

Now, as the program goes on, there is no question about the fact that there will be some shifts in responsibilities. As you know, the National Science Foundation legislation itself has certain strictures

with regard to the conduct of applied research and demonstration activities.

Some aspects of the earthquake engineering work that now is going on at the National Science Foundation perhaps in time might shift to the Geological Survey. We think that this would be a kind of thing that would be systematically reviewed in our annual program review. Of course, our office, the Office of Science and Technology Policy and the Office of Management and Budget, the domestic policy group, would participate in this kind of a review and possibly change in assignment.

Now, with regard to the implementation, that is the place where I think we ourselves in the administration feel that we really do need to do quite a bit more thinking about how we take our Federal capability, our growing Federal capability for prediction and implementation to the State and local government decisionmaking people who must have the ultimate responsibility.

What do you do, for example? Now we are faced with major water problems in the West. If there were a prediction of a moderate earthquake, it would be a hard decision for a mayor to say that he was going to drain his reservoirs on the basis of a prediction because water is needed very badly.

So we feel that a period of time would be a very beneficial thing to get a group of people together—government agency people, experts from State and local government, private sector people, people who are concerned with insurance, with zoning, with setting of standards, the National Bureau of Standards, the Standards Association and so forth—and really try to think through this and then come back to the Congress with a plan.

I think that this plan would have a proposed organizational structure with some clear assignment of responsibility. I might say one other thing, Mr. Brown. As you know, the Congress has granted the President a general reorganizational authority and that process is now beginning by way of a review of the White House and the Executive Offices.

In connection with that, I might say there are very few activities that have been talked about in terms of putting more things into the White House-Executive Office structure but one thing that has been discussed and is under review is the general question of the preparedness problem, both the preparedness and the disaster assistance.

I think there is a feeling on the part of everyone here in the Congress and in the executive that the splintering up of the activities that took place several years ago might not have been the best approach. So while the general reorganization is going forward and a functional review of these kinds of questions takes place, we would propose a solid piece of work on the earthquake problem and then reporting back with recommendations.

We are in complete agreement with you that there need to be specific assignments, clear lines of reporting authority in particular so that the people who have the decision process ultimately to fulfill, the State and local people, know where to go in Washington and they are not faced with a maze of sometimes even conflicting kinds of authorities.

So that was the thrust of our drafting suggestion. We would hope within a year to come back with this plan. It would have organizational

recommendations in it and some specific step-by-step milestones of how we are going to proceed over the next several years in the same manner as we have laid out for the research program.

Mr. BROWN. I am pleased with that. I note it does not differ substantially from recommendations made by the General Accounting Office several years ago. This administration is approaching this problem in that way and I am glad about that.

Obviously a situation which involved the possibility of major disasters requires some form of centralized leadership. If we are going to say on the basis of developing this particular capability that an earthquake threatens a city of a million, it is going to be pretty hard to persuade that city to evacuate its population or take any other drastic action unless it seems that the leadership of this country is behind that particular prediction or recommendation because it is expensive and it is going to involve upsetting the lives of a lot of people.

It is not some obscure bureau some place that can get away with doing that. This psychological fact alone is conducive to having some central authority that can speak.

I appreciate your proceeding in the fashion you have outlined. I have no further questions.

Mr. THORNTON. Thank you, Mr. Brown. I would like to ask whether you would agree to respond to such questions in writing as may be addressed to you by the subcommittee?

Mr. SMITH. Certainly.

Mr. THORNTON. And particularly I am a little concerned about the area of discussion which has just occurred. The framework of both the House and the Senate bills has included the formation of an agency to act as a central coordinating agency based on the rationale that it is necessary to have a focus for this kind of effort.

The administration recommendation does not establish clearly such a function. I would like for you to address that question either now or in writing.

Mr. SMITH. I think, Mr. Thornton, if we felt we knew what to recommend we would have made a recommendation as to which agency ought to have that responsibility. But I think we would say candidly that we do not now know the answer to that question as to what agency ought to be the central coordinating agency for earthquake prediction and preparedness.

That is one of the things we want to think through and report back to you on. We want to provide you with our best recommendation.

While the language we have set forth is somewhat silent on the subject of external advice, drawing in outsiders, the State and local people, although there is a specific mention of drawing State and local people in our suggestion, certainly it is our intention in this review to bring in many, many people from the outside.

And that is part of the problem. You cannot work this problem out amongst a group of people from Federal agencies gathered together here at this end of the problem. You have got to get the people from the other end—from the State and local level. We will in the process of doing this consult widely and we will look into some of these questions that I know that you have discussed before, the problem of having an external evaluation of an earthquake prediction capability

so that an agency or a group is not in effect with its own resources alone evaluating its own predictions and so forth.

But I think we would say that we ourselves do not know now what we think would be the most effective thing to recommend in the way of a central focal point for prediction and coordination.

Mr. THORNTON. Well, the point I am trying to make is that while I understand how difficult it is to clearly delineate responsibilities for the various agencies and the precise structural formation when we are engaged in reorganization, still I think it may also be important for Congress to install in its legislation that such cooperation is necessary to an effective program of the kind included in this legislation.

If there are no further questions I would like to ask if Dr. Vincent McKelvey is here. Dr. McKelvey, I believe you are accompanied by Mr. James Devine. We are very pleased to have you here before this subcommittee.

We apologize for the hour in which we are asking for your testimony to be presented. I hope that you are not a person who is accustomed to eating precisely at 12 o'clock. I would like to ask you to proceed.

[A biographical sketch of Dr. Vincent McKelvey follows:]

Vincent Ellis McKelvey, Biographical Data

Born: Huntington, Pennsylvania, April 6, 1916.
Married: Genevieve Patricia Bowman, 1937. One son, Gregory Ellis, 1943.
Residence: 6601 Broxburn Drive, Bethesda, Maryland 20034.

Education:
B.A. with Honors in Geology, Syracuse University, 1937.
M.A., University of Wisconsin, 1939.
Ph.D., University of Wisconsin, 1947.

Employment:
Junior Geologist, part-time, Soil Conservation Service, 1938-40.
Asst. Geologist, Wisconsin Geological and Natural History Survey, summers 1939-1940.
Visiting Lecturer, Stanford University, 1956.
Geologist, U. S. Geological Survey, 1941-present;
Chief Radioactive Minerals Investigations, 1950-53;
Asst. Chief Geologist for Interagency Programs, 1960-62;
Asst. Chief Geologist for Economic and Foreign Geology, 1962-65;
Senior Research Geologist, 1969-71;
Chief Geologist, 1971;
Director, December 1971- .

Special Assignments:
Consultant, Chief of Engineers, Manila, 1945.
Minerals specialist, USICA-Government of Jordan, 1958.
Minerals and Fuels Subcommittees, Federal Council for Science and Technology, 1961-63.
Department of Interior Energy Policy Staff, 1961-71.
U. S. representative and advisor to Energy Committee, Organization for Economic Cooperation and Development, 1965-67.
U. S. representative to Government Advisory Committees on Energy and Minerals, United Nations Resource and Transport Division, 1967.
Advisor on phosphate exploration, Government of Saudi Arabia, 1967.
Leader, Department of the Interior Study Group, Outer Continental Shelf Oil, Gas, and Sulfur Leasing Policy, 1968.
U. S. representative to Economic and Technical Subcommittee of United Nations Committee on Peaceful Uses of Seabed and Ocean Floor Beyond the Limits of National Jurisdiction, 1968- .
Chairman, Project Independence Blueprint Interagency Oil Task Force, 1974.

Scientific Publications:

Geological Survey and scientific journal articles dealing with the geology of manganese, phosphate, uranium, mineral and fuel resources, marine resources, methods of estimating reserves, prospecting methods, stratigraphy, sedimentation, mineral economics.

Scientific Societies:
American Association for Advancement of Science (Fellow).
American Geological Institute (Member of Board of Directors 1968-71).
Geological Society of America (Fellow, Member of Council 1968-72).
Society of Economic Geologists (Member of Council 1967-70.
American Geophysical Union (Fellow).
Economic Geology Publishing Co. (Member of Board of Directors).
Geochemical Society.
Sigma Xi.
Cosmos Club (Member of Board of Management).
American Institute of Mining Engineers.
American Association of Petroleum Geologists.
Marine Technology Society.

Honors:
Department of the Interior Distinguished Service Award, 1963.
AIME Henry Krumb Lecturer, 1968.
Seventh McKinstry Memorial Lecturer, Harvard University, 1971.
National Civil Service League 1972 Career Service Award for Sustained Excellence.
Rockefeller Public Service Award, 1973.
D.Sc. (Hon.), Syracuse University, 1975.
D.Sc. (Hon.), South Dakota School of Mines and Technology, 1976.
Donnel Foster Hewett Lecturer, Lehigh University, Bethlehem, Pennsylvania, 1976.
Syracuse University Alexander Winchell Distinguished Alumnus Award, 1976.

STATEMENT OF DR. VINCENT McKELVEY, DIRECTOR, U.S. GEOLOGICAL SURVEY, ACCOMPANIED BY JAMES DEVINE, ASSISTANT DIRECTOR, USGS

Dr. McKELVEY. We are pleased to be here, Mr. Chairman. If my entire statement can be included in the record, I will simply try to touch on some of the highlights.

Mr. THORNTON. Your statement as prepared will be made a part of the record at this point.

Please proceed as you wish.

[The prepared statement of Dr. Vincent McKelvey follows:]

Statement of
V. E. McKelvey
U.S. Geological Survey

Hearing before the Subcommittee on Science, Research and Technology
of the
Committee on Science and Technology

U.S. House of Representatives
April 20, 1977
H.R.35 Earthquake Hazards Reduction Act of 1977

Mr. Chairman, I thank the Committee for the opportunity to discuss once again the role of the Department of the Interior and the U.S. Geological Survey in earthquake hazards reduction. As you know, we have been developing a strong research program, and I am pleased to say that the President and the Secretary of the Interior are lending their full support to the continuation of this program and its further expansion. Evidence of their support comes both in the form of the expanded FY '78 Budget request and their general support of the proposed legislation.

In regard to the legislation before this Committee today, I would like to begin by saying that we are in substantial agreement with the objectives of H.R.35, the "Earthquake Hazards Reduction Act of 1977." We believe, too, that a successful earthquake hazards reduction program must have not only a strong base of research, but a clear delineation of the roles of the various entities involved, and of the cost and consequences of alternative hazards reduction actions.

We believe that H.R.35, if amended along the lines suggested by Dr. Press, would provide an effective and logical vehicle for dealing with these common concerns, and for developing and maintaining in the coming years a comprehensive program. The program developed in the manner suggested would provide a means for the monitoring by Congress of developments in this area. The proposed amendment addresses, realistically we believe, the relative status of the technological bases for hazards reduction and the currently available means to implement them.

With regard to research, we believe that the expanded program, upon which this amendment would build, is consonant with the spirit of, and similar in scope to, the research programs outlined in H.R.35. With regard to implementation, the amendment offered in the letter from Dr. Press would allow the President a flexibility in administering this program that is consistent with the reorganization process now getting underway.

Further in this connection, we do not believe that the optimum Federal strategy for earthquake hazards reduction is yet available, consequently the precise specification of roles or the establishment of new coordinating mechanisms seems premature. We feel that it would be appropriate for the Administration to study these issues carefully and fully, before further structuring the Federal establishment through legislation.

The principle of involving a wide range of interests outside the Federal Government to advise on the direction of the program, contained in H.R.35 is vital. We in the Department of the Interior and Geological Survey are fully committed to this principle, as evidenced by the existence of our Earthquake Studies Advisory panel. The amendments offered in the letter from Dr. Press would require this kind of advice, but would allow desirable flexibility in the manner in which it is obtained.

Turning now to our plans for Fiscal 1978 and beyond, I will say that we are pleased about the expanded program in earthquake hazards reduction contained in the President's Budget that is now before Congress and the prospects it offers for improvement in all approaches to the problem. As you are probably aware the Executive Branch undertook last year a review and analysis of the earthquake hazards reduction programs within the National Science Foundation and the Geological Survey. This process, carried out by an Advisory Group on Earthquake Prediction and Hazard Mitigation chaired by Professor Nathan Newmark, of the University of Illinois, was directed by the Science Adviser to the President. The resulting report "Earthquake Prediction and Hazard Mitigation--Options for USGS and NSF Programs" was used in the budget process for Fiscal Year 1978. Contained in the budget are requests to increase the earthquake program within the Geological Survey from the current level of $11.2 to $28.0 million for FY 1978. Increases of a similar magnitude are proposed for the National Science Foundation. The program will be broadly based. We will share with the Foundation responsibility for fundamental studies of earthquakes but will take the lead in prediction, hazards assessment and the investigation of induced seismicity. The Foundation will take the lead in engineering and research for utilization, a term that includes studies of the social and economic aspects of the problem. Extensive plans are currently being laid to begin this expanded program at the start of the fiscal year, if the requested funds are appropriated by the Congress. We anticipate that a very large part of

the expanded program will be carried out outside the Federal establishment--in universities, private industry and by State and local governments. We are currently involving these groups in the planning of the program.

We are keenly aware that the research and development of scientific capabilities for earthquake hazard reduction are worthless without appropriate means for implementing them. Within our own agency within the last two years, we have established the Office of Land Information and Analysis, in an effort to provide geologic information to decision makers in a format that is useful to them. Preceding this effort we undertook a large demonstration study of the San Francisco Bay Region--joined in part by the Department of Housing and Urban Development. In this effort, geologic data were developed and made available to local governments, firms, and any interested parties. Many of the most popular products--in the view of the users--involved descriptions of earthquake hazards.

But we recognize that these efforts represent only a beginning and that substantial additional effort will be required. It must be remembered in dealing with this problem that most of the significant actions that can be taken to actually reduce the hazard must be taken by entities outside the research and prediction agencies and, indeed, outside, the Federal Government. Actions must be taken by States, local governments, corporations, professional groups, families, and individuals, to name a few of the entities that must be involved. From a Federal perspective the problems we face are, on the one hand, how to develop the research bases for the means of hazards reduction and, on the other hand, how to provide mechanisms and, if justified, incentives for these means to be

utilized. Implementation is a difficult problem that needs much more attention than it has received thus far.

Last year, in testimony before this Committee, I discussed the evolution of our program and the nature of the earthquake threat to the United States. I would like to report now on some of the developments since the last hearings that may be of interest to the Committee.

First, I am pleased to note that last week, we published in the Federal Register a description of "U.S. Geological Survey capabilities and proposed procedures for assisting in warning and preparedness for geologic-related hazards." The purpose of that statement is to describe the Geological Survey's capabilities for advance recognition of various kinds of geologic-related hazards and the procedures proposed to carry out the responsibilities delegated to me under the Disaster Relief Act of 1974. Briefly, we intend to issue technical information in three categories which can be taken as the basis for the issuance of recommendations or orders to take defensive action by State and local governments, where the police and public safety authority rests in our governmental system. These categories are:

- o Notice of Potential Hazard
- o Hazard Watch
- o Hazard Warning

Let me explain these categories as they relate to earthquake hazards. The "Notice of Potential Hazard" would be, for example, the communication of information about the location and characteristics of an identified fault, which, because of geologic evidence for its youthfulness, must be considered as the possible source of a future significant earthquake. A

"Hazard Watch," would be the communication of information, as it develops, about phenomena that could be precursors to a potentially catastrophic earthquake in the area or region, for which no period or time of occurrence can be specified. This would correspond in a general way to the situation we have in southern California at the present time resulting from the discovery last year of a significant land uplift, about which I will say more later. The third category "Hazard Warning," is one for which we now have only a limited capability, but which we are working hard to improve. It would be the communication of information (a prediction if you will) as to the time (possibly within days and hours), location, and magnitude of a potentially disastrous earthquake. We have invited comment on these procedures and will modify them later as appropriate.

With regard to the land uplift in southern California, last year the U.S. Geological Survey and the National Science Foundation reprogrammed $2.1 million of funds to launch an intensive program of study into the earthquake potential associated with the uplift. Those studies are currently underway and we do not yet have any final answers. We do know that the total region covered by the uplift is much larger than we originally thought (some 90,000 square kilometers as compared to the 12,000 square kilometer area first recognized), that the region involved in the uplift grew with time toward the southeast, and that within the last two years a portion of the region began to subside again, reducing the accumulated uplift in that area to about half the maximum value it

had attained in 1974. We do not know at the present time whether the partial subsidence of the uplift increases or decreases the prospects for a large earthquake in this region in the near future, but we believe that the activity justifies continued concern.

Last summer Dr. Barry Raleigh of the Geological Survey led a team of American specialists to the People's Republic of China to learn more about the successful prediction of the magnitude 7.3 earthquake that occurred on February 4, 1975, in Liaoning Province. The group returned satisfied that the Chinese had indeed predicted the earthquake in advance and had taken extensive defensive measures. They learned many details of the observations leading up to the prediction and of how the prediction was used by the Chinese. Of particular interest was that the group included a sociologist specializing in the socio-economic aspects of natural hazards and their prediction. The report of this delegation is scheduled for publication in the next month or so. In addition, one of our geologists, Dr. Edward Chao, visited China this winter, where he learned some of the first results of the Chinese studies of the unpredicted and tremendously damaging Tangshan earthquake of July 28, last year. We intend to utilize the experience gained in China and elsewhere around the world to the fullest extent possible in designing and implementing our program.

In conclusion, I would like to thank you again for the opportunity to discuss this legislation with you. We are in substantial agreement with its objectives. We believe that if the legislation were amended as suggested by Dr. Press, it would provide an effective and logical vehicle for developing and maintaining a comprehensive program. I would particularly like to emphasize that we are pleased to be ready to work with you in developing a legislative basis for a strong national earthquake hazards reduction program.

Dr. McKelvey. Thank you, sir.

I thank the committee for the opportunity to discuss the role of the Department of Interior and the Geological Survey in earthquake hazards reduction. As you know, we have been developing a strong research program and I am pleased to say that the President and the Secretary of the Interior are lending their full support to the continuation of this program and its further expansion.

Evidence of their support comes both in the form of the expanded fiscal year 1978 budget request and their general support of the proposed legislation.

With respect to the legislation under consideration, I wish to say that we are in substantial agreement with the objectives of H.R. 35, the earthquake hazards reduction Act of 1977.

We believe, too, that a successful earthquake hazards reduction program must not only have a strong basis of research, but a clear delineation of the roles of the various entities involved and the cost of and consequences of alternating hazard reduction actions.

We believe that H.R. 35 if amended along the lines suggested by Dr. Press would provide an effective vehicle for dealing with these common concerns and for developing and maintaining in the coming years a comprehensive program.

The proposed amendment addresses realistically, we believe, the relative status of the technological basis and the current available means to achieve them. We are keenly aware that the research and development of scientific capabilities for earthquake hazards reduction are worthless without appropriate means for implementing them.

Within our own agency within the last 2 years we have established the Office of Land Analysis in an effort to provide information. Preceding this effort we undertook a large demonstration study of the San Francisco Bay Region joined there by the Department of Housing and Urban Development. Geologic data were made available and presented to government, private firms, and interested parties. One of the most popular products involved descriptions of earthquake hazards.

We recognize these efforts represent only a beginning and that substantial additional effort will be required. Implementation is a difficult problem. It needs much more attention than it has received thus far.

Last year, Mr. Chairman, in testimony here, I discussed the evolution of our program and the nature of the earthquake threat to the United States. I would like now to report briefly on some of the developments since the last hearings that may be of interest to the committee.

I am pleased to note that on April 12, we published in the Federal Register a description of the U.S. Geological Survey capabilities and procedures for assisting in warning and preparedness for geologic related hazards.

The purpose was to describe the Geologic Survey's capabilities for advance recognition of various kinds of geological related hazards and the procedures proposed to carry out the responsibilities delegated to me under the Disaster Relief Act of 1974.

We intend to issue technical information in three categories which can then be taken as the basis for the issuance of recommendations or orders to take defensive action by State and local governments. These

categories are a notice of potential hazards, a hazard watch, and a hazard warning.

Let me explain these categories as they relate to earthquake hazards. The notice of potential hazard would be, for example, the communication of information about the location and characteristics of an identified fault which because of geologic evidence must be considered as the possible source of a future significant earthquake.

A hazard watch would be the communication of information as it develops about phenomena that could be precursors to a potentially catastrophic earthquake but for which no period of time of occurrence can be specified. This would correspond in a general way to the situation we have in southern California at the present time, resulting from the discovery last year of a significant land uplift about which I will say more in a moment.

The third category, hazard warning, is one for which we now have only a limited capability but which we are working hard to improve. It would be the communication of information, a prediction, if you will, as to the time, possibly within days or hours, the location and the magnitude of a potentially disastrous earthquake.

We have invited comment on these procedures and will modify them later as appropriate.

With regard to the land uplift in southern California, last year the U.S. Geological Survey and the National Science Foundation reprogramed $2.1 million to launch an intensive program of study into the earthquake potential associated with the uplift.

Those studies are currently underway and we do not yet have any final answers. We do know that the total region affected by the uplift is much larger than we originally thought, some 90,000 square kilometers as compared to the 12,000 square kilometer area originally thought involved.

We know that within the last 2 years a portion of the region began to subside again, reducing the uplift in that area to about half the maximum value it had attained in 1974. We do not know at the present time whether the partial subsidence of the uplift increases or decreases the prospects for a large earthquake in this region in the near future.

But we believe the activity justifies continued concern. To conclude, Mr. Chairman, I wish to thank you again for the opportunity to discuss this legislation with you. We are in substantial agreement with its objectives.

We believe that if legislation were amended as suggested by Dr. Press, it would provide an effective and logical vehicle for developing and maintaining a comprehensive program. In particular I wish to emphasize that we will be pleased to work with you in developing a legislative basis for a strong national earthquake hazards program.

Thank you, sir.

Mr. BROWN. We are very appreciative of your testimony, Dr. McKelvey. I think it does indicate that you have come a long way in developing an effective program. I understand that your Geological Survey has a procedure for evaluating earthquake predictions, that you are monitoring earthquake predictions.

Do you feel that there is anything in this legislation that would either contribute or subtract from that present exercise which is not a predicting capability but an evaluating capability?

Perhaps you could explain that.

Dr. McKELVEY. You are correct, Mr. Chairman. We do have a mechanism for evaluating and authenticating earthquake predictions. We established about a year ago, I believe it was, an earthquake prediction council for the purpose of reviewing, evaluating, and authenticating—if that proved to be the case—predictions made by our scientists or by scientists elsewhere who submitted their predictions for this mechanism.

Now H.R. 35 provides for an earthquake prediction board that would serve a similar purpose. I would say that very likely it would add to that evaluation procedure because I think in any case we would want to have a peer review and evaluation within the Geological Survey before any prediction we developed would be released.

Mr. BROWN. This operates on a worldwide basis, I presume? If this group becomes aware of a prediction say in China or Europe, they would monitor the validity?

Dr. McKELVEY. It is conceivable that it could. Of course, our work focuses in the United States and I would expect that the bulk of our activity would be domestic rather than foreign. But it is quite conceivable that such an event might take place where in some way we were able to make a prediction as to an earthquake that might take place elsewhere in the world.

Mr. BROWN. Mr. Dornan?

Mr. DORNAN. No questions.

Mr. BROWN. Dr. McKelvey, to what degree have you attempted to or contemplated the incorporation in the earthquake prediction scheme the use of the kinds of resources that seem to be used in China?

By that I mean the volunteer observers, the observation of the animal behavior and things of that sort?

Dr. McKELVEY. I will take the last part of the first, Mr. Brown. As a part of our ongoing research program attention is being devoted to the study of animal behavior as it would relate to earthquake prediction. We intend to pursue that further.

We had a conference last fall, the results of which have just been published in a 400 page volume summarizing the papers and the proceedings at that conference. While I can say with a good deal of confidence at this time that no one has a clear idea as to just what kind of phenomena animals may react to, there is much evidence to indicate that a variety of animals do react to precursor signals of some kind.

Certainly the topic deserves further research. A lot of it possibly—and this I think is part of the issue—in the past, a lot of it maybe can be classed as folklore and perhaps has been too much so regarded in the past. But certainly the topic does deserve much additional study and we intend to pursue it.

With respect to the first part of your question, the utilization of the general public in collecting precursor information and so on as the Chinese are doing on a very extensive scale, I don't think that we

have thought that that kind of public involvement would be appropriate or even possible in this country.

But we are considering and have begun to pursue the possibility of using high school science classes, possibly, enlisting student participation in the use of rather simple instruments, some of which might be designed just for this purpose.

We think, too, that use of the effort of a larger segment of the public than has been utilized in the past for this purpose is an idea also worth pursuing.

Mr. BROWN. Have your observations in the southern California area included efforts at measuring variations in the height of well water, for example, wells or the radioactive content of the water?

Dr. MCKELVEY. There has been some effort on that aspect, Mr. Chairman, but I am not able to give you any detail on it.

Mr. BROWN. I know that with the Chinese that was an element.

Dr. MCKELVEY. This is one of the precursor phenomena that the Chinese have been using and that has been observed elsewhere, a change in the level of ground water in wells either up or down. It has been recorded in some instances.

Mr. BROWN. Well again, I want to thank you, Mr. McKelvey. I would ask, merely because of the time factor if we need to solicit additional information, if we could get your cooperation in answering written questions?

Dr. MCKELVEY. We will be happy to respond, Mr. Chairman.

Mr. BROWN. Thank you very much and thank you Mr. Devine for also being before us today.

Our next witnesses are Dr. Alfred Eggers, Assistant Director for Research Applications, National Science Foundation, accompanied by Dr. Charles Thiel, Director, Division of Advanced Environmental Research and Technology. We are happy to have both of you gentlemen with us today.

[Biographical sketches of Dr. Alfred J. Eggers and Dr. Charles C. Thiel, Jr., follow:]

NATIONAL SCIENCE FOUNDATION

WASHINGTON, D.C. 20550

DR. ALFRED J. EGGERS, JR.
Assistant Director for Research Applications

Dr. Alfred J. Eggers, Jr. was appointed Assistant Director for Research Applications in the National Science Foundation in March, 1971. In this capacity, he directs the Foundation's program of Research Applied to National Needs (RANN) which focuses scientific and technical research on selected problems of national importance with the objective of contributing to their solution.

Emphasis in RANN has been placed on problems of productivity, environment, and energy and resources. The role of universities, industry, and government has received special attention in mounting effective research to address these problems. Strengthening the capability of State and local Governments to use science and technology more effectively in their decisionmaking processes has been of particular importance in these undertakings.

Before coming to NSF, Dr. Eggers was Assistant Administrator for Policy at the National Aeronautics and Space Administration (NASA). In that capacity he was responsible for managing agency-wide policy research and development with special emphasis on aerospace applications.

From May 1964 until he assumed that position, Dr. Eggers was Deputy Associate Administrator for Advanced Research and Technology at NASA. During that period he also served as Special Assistant to the Administrator of NASA.

Before coming to Washington in 1964, Dr. Eggers was Assistant Director of the Ames Research Center, Moffett Field, California, where he specialized in supersonic and hypersonic aerodynamics with special attention to flight efficiency and atmosphere entry problems.

He was awarded a B.A. degree in 1944 at the University of Omaha, a B.S. degree in 1949 at Stanford University and a Ph.D. degree in engineering mechanics at Stanford in 1956.

Dr. Eggers is a Fellow and Founder-Director of the American Institute of Aeronautics and Astronautics and was Chairman of the AIAA President's Forum Committee on the Interactions of Aerospace Technology and Society. He is also a Fellow of the American Astronautical Society and a member of Sigma Xi, the honorary scientific research fraternity; Tau Beta Phi; the American Ordnance Association; the American Academy of Political and Social Sciences; and the American Association for the Advancement of Science.

In 1956, Dr. Eggers received the Arthur S. Flemming Award as one of 10 outstanding young men in government. In 1957, he was named one of the Ten Outstanding Young Men in the Nation by the U.S. Junior Chamber of Commerce. He received the 1962 Sylvanus Albert Reed Award for outstanding contributions to theory and experiment on supersonic and hypersonic flows. In 1958 he was presented the Outstanding Alumni Award of the University of Omaha.

He received the H. Julian Allen Award for 1969 for the outstanding research report from NASA/Ames Research Center up to 1969 and the Exceptional Service Medal of NASA in 1971. In 1972, Dr. Eggers was elected a member of the National Academy of Engineering and he is a member of the Aerospace Engineering Panel. During 1969-71, he served as the Hunsaker Professor at the Massachusetts Institute of Technology and he delivered the 1970 Minta Martin Lecture on the Interactions of Technology and Society. In 1974, Dr. Eggers was appointed by the President to be Chairman of the Geothermal Energy Coordination and Management Project, and in 1975 he received the Distinguished Service Award of the National Science Foundation.

Dr. Eggers has been active in civic affairs ranging from School Community Development in Los Altos, California to the Boy Scouts and Red Cross in Arlington, Virginia. During World War II, Dr. Eggers served with the U.S. Navy as a Lieutenant, J.G. He resides with his wife, Elizabeth, and their two sons, Jock and Philip, in Arlington, Virginia.

Charles C. Thiel, Jr.

Dr. Charles C. Thiel is Acting Director and Deputy Director, Division of Advanced Environmental Research and Technology, Directorate for Research Applications, National Science Foundation. He was born in 1940 in Chicago, Illinois, and received his education at a number of schools throughout the country, prior to receiving a Ph.D., in Engineering Sciences from Purdue University. Prior to joining the Foundation's staff, he was a research engineer for the General Technology Corporation and a member of the Purdue University faculty. Within the National Science Foundation, Dr. Thiel was program manager for Earthquake Engineering prior to assuming management responsibilities within the division. Dr. Thiel organized and chairs the Interagency Discussion Group on Disaster Mitigation. Internationally, he is a member of the Joint Committee of the US/USSR Agreement on Housing and Other Construction and serves as Chairman of the Construction in Seismic areas group. He also is Task Group Chairman for Engineering Seismology of the US/USSR Agreement on Cooperation in the Field of Environmental Protection. Dr. Thiel serves on several professional committees, is a member of several professional societies, has served on organizing committees for national meetings, and has published in his areas of specialty.

STATEMENT OF DR. ALFRED EGGERS, ASSISTANT DIRECTOR FOR RESEARCH APPLICATIONS, NATIONAL SCIENCE FOUNDATION, ACCOMPANIED BY DR. CHARLES THIEL, DIRECTOR, DIVISION OF ADVANCED ENVIRONMENTAL RESEARCH AND TECHNOLOGY, NATIONAL SCIENCE FOUNDATION

Dr. EGGERS. It is always a pleasure to appear before you and the subcommittee. I have a very short statement.

Mr. BROWN. Without objection your very short statement will be included in the record.

[The prepared statements of Dr. Alfred Eggers and Dr. Charles Thiel follow:]

Statement of Dr. Alfred J. Eggers

Assistant Director, Research Applications Directorate

National Science Foundation

Before

Subcommittee on Science Research & Technology

House Committee on Science & Technology

April 20, 1977

Mr. Chairman, Members of the Committee, I am pleased to appear before you today to discuss the programs of the Foundation in Earthquake Prediction and Hazard Mitigation. As noted in our previous testimony before this Committee and reiterated by Dr. Press today, earthquakes pose a serious threat to the people of the United States. We share with Senator Cranston, Mr. Brown and their colleagues the conviction that there is need for a comprehensive, well coordinated Federal effort in research and implementation. We feel that the Newmark report establishes a sound basis for the conduct of the research program, and have used it as a base in the preparation of the Foundation's portion of the President's Budget for FY1978.

We share Dr. Press' concern that while we feel that a sound basis for pursuing the research program is in hand, we are not in a similar state of readiness to implement the results of such an accelerated plan. As Dr. Thiel shall discuss in some detail we feel that those prescriptive requirements of the legislation that establish particular organizational forms and units for implementation are premature and may indeed not be the most efficient and effective means for decreasing the public's earthquake vulnerability.

In summary, the Foundation endorses the objectives of the Cranston Bill and suggests that it be modified to assure the achievement of its purpose by incorporation of the drafting suggestion forwarded to the Committee by Dr. Press. Dr. Thiel, Director of our Environmental Division, has had responsibility for the development of our Earthquake Engineering program. He will now describe our program in more detail and discuss the nature of some of our research findings that suggest the course of action we endorse.

Statement of Dr. Charles C. Thiel

Director

Division of Advanced Environmental Research & Technology

National Science Foundation

Before

Subcommittee on Science Research & Technology

House Committee on Science & Technology

April 20, 1977

Thank you, Dr. Eggers.

As noted already in this Hearing, Earthquakes are one of nature's severest geophysical hazards. And they threaten virtually the entire Nation with portions of 39 States subject to major or moderate risk.

While we are all aware of the horror of an earthquake occurrence, it must also be kept in mind that we are investing funds everyday in construction to meet earthquake resistant building codes and we are paying annual insurance premiums to protect us from future financial loss in the event that an earthquake occurs. Indeed these current costs on an annual basis are probably as great as the damage that can be expected from future earthquakes, on an annual basis. Affecting a reduction in these multi-faceted impacts of earthquakes in an equitable, efficient, economic way will obviously depend on the careful development of implementation strategies consistent with the constraints and values of the public as it goes about its every day activities.

NSF Research Program

The Newmark report discussed by Dr. Press, presents options for future development of the NSF and USGS research programs, and its Option B is the basis for the strengthening of our program as presented in the President's budget now before the Congress. In the joint Federal program in Earthquake Prediction and Hazard Mitigation. The NSF has responsibility for fundamental earthquake studies, earthquake engineering and research for utilization.

The Earth Sciences Division, in the Geophysics Program, supports the Nation's principal efforts in basic earthquake research, almost entirely conducted by universities. The level of support has risen rather steadily from $1.5M in FY1968, to $3.0M in FY1977 and to a request of $5.3M for FY1978. There is little doubt, at our present state of knowledge, that any national program to predict earthquakes and identify hazards should be based on a program such as this of in-depth studies and measurements of a fundamental nature directed at the development of a thorough understanding of the natural phenomena involved.

The RANN program in Earthquake Engineering has developed in the past five years from a $2M per year effort in FY1971 to an $8.4M effort in FY1977 and a proposed effort in FY1978 of $20M, consistent with the Newmark report. The program is organized into three major categories: Siting, Design and Policy. Each of these elements has vigorous utilization efforts to achieve ready access and timely availability of publications, information and data.

The attachment describes these program activities in more detail. These programs are closely coordinated with other agency activities through formal and informal mechanisms.

ILLUSTRATIVE ACCOMPLISHMENTS

At testimony delivered before this committee, and other committees of the Congress, the NSF has presented a substantial body of accomplishments from our Earthquake Engineering and Geophysics programs that have illustrated the scientific quality, utility, and application of the programs'. activities. Among these have been:

- o Measurement of global stress patterns utilizing a newly established network of ultra-long period seismographs;
- o Successful prediction of small intraplate earthquakes in South Carolina and New York;
- o Collection, analysis and distribution of engineering data recorded during damaging earthquakes;
- o Establishment of the National Information Service for Earthquake Engineering;
- o Improvements in municipal and State building codes, standards and criteria, and model codes to provide more appropriate earthquake safety;

- Improved practices by engineers, designers, and private firms in providing safe structures; and,
- Applications to the design and licensing of nuclear reactors.

Indeed, we feel that the Foundation's Earthquake program is one of our most successful programs in supporting excellent basic and applied research and in the case of the Earthquake Engineering program, implementing the RANN objective of hastening the application of results.

Implementation

Legislation before the Congress at this time proposes first that a vigorous research program be placed and, second that various advisory committees, a prediction evaluation board, organizational assignments and a new organizational unit be formed. These latter points vary between the bills, but their intent seems clear, namely, to provide for the swift incorporation of the results of the program into disaster mitigation practices in the public and private sectors.

Changes in building codes and land-use regulations, and the issuance of earthquake predictions and warnings can have serious ramifications for the social, economic, legal and political aspects of American life. Whether a research product has a positive or negative total effect in mitigating earthquake hazards, or is ignored altogether, could depend very much on the method of communication and utilization of the product.

We council that great care be exercised prior to the establishment of new organizations or committees, the realignment of functions or the specification of roles and responsibilities. We strongly urge that the Congress adopt a sequential strategy regarding implementation of the results of the research program: First, a careful, concentrated effort to determine appropriate rolesrelationships, and activities of Federal, state, and local governmental units and the private sector; and second, the alignment of responsibilities and allocation of authorities to achieve the purpose of improved public safety; third, the proposing of legislation as needed that aids achieving this purpose consistent with the appropriate Federal role; and fourth, vigorously pursuing a

combined research and implementation program for the public's benefit. We are of the opinion that the incorporation of the drafting suggestion of Dr. Press into the bills under consideration will achieve these purposes.

We have reached these conclusions based upon both our experience in managing research applications programs and through an examination of the results of several RANN supported research studies now underway or recently completed.

The Foundation's Research Applied to National Needs (RANN) program has developed considerable expertise in managing programs that intend to both support research and foster its application. RANN also supports, through its Intergovernmental Program, major efforts to increase the capacity and capability of state and local government to use science and technology, especially newly developed, in their operations and policy setting. Our experience in both of these areas indicates that for research to rapidly and effectively be incorporated into public practice, the intended beneficiary (in both the public and private sectors) must be involved in the:

- establishment of objectives
- formulation of the research program
- determination of the implementation strategy
- oversight and conduct of the program
- prototypical application

The Newmark report presents a soundly reasoned base to achieve the research objectives of the Cranston bill, and indeed the user communities were involved in the setting of its objectives and in the formulation of the research program. It is extremely important that the care taken in designing the research program be duplicated in designing the implementation strategy. The proposal of Dr. Press to pursue a "Newmark" type panel study involving state and local officials and elements of the private sector to develop an implementation strategy in our view is required prior to the creation of institutional arrangements and functions such as proposed in current legislation before the Congress.

An essential question is, do we know enough at this point to begin structuring major institutional measures for mitigating the direct and indirect consequences of earthquakes? The answer to this question would seem to be no. Until more knowledge has been accumulated on how populations perceive, respond to, and recover from earthquakes, we need to move in a deliberate rather than a precipitous fashion. The narrow knowledge base that we are working with would seem to require such caution.

Take for example the case of earthquake prediction. The Haas-Mileti research on the "Socioeconomic and Political Consequences of Earthquake Prediction" suggests that with the lead times earthquake predictions probably will provide in the future, it will be possible to initiate a range of social, economic and technological adaptations to mitigate the impact of the predicted events.

Such adaptations might include initiation of warning and public information programs, revisions in building codes and their increased enforcement, and special earthquake insurance programs. Their tentative conclusions are that the prediction may induce economic impacts as large or larger than the earthquake itself. The possible responses to a prediction are so interrelated that even those which at first glance might seem to have no bearing on risks of death and injury do in fact affect such risks.

Following a credible earthquake prediction, families, businesses, and governmental agencies will try to act in a manner favorable to their own interests. Investors will generally put their money outside of the "target" area, or invest very selectively within the area, on the assumption that this will lower their risk. Development planning and construction in the private sector will first be drastically reduced, and then entirely stopped. Local governments will likewise stop or sharply reduce capital construction projects. Influenced by the construction industry, buisness in general will slow its activity, unemployment will rise sharply, especially in the building trades, and local government will suffer severe declines in sales and property tax revenues. In the face of revenue loss, there will be an increase in demand for public services.

This study while tentative, indicates that a number of questions from an implementation standpoint will have to be squarely faced. Among these are:

- How does the liability of a private employer change, if at all, in the face of the "yet to be proven" science of earthquake prediction? Are the liability considerations different for the government as employer? How may these issues be clarified prior to an earthquake prediction?

- Should buildings with anticipated low earthquake-resistance be ordered evacuated? Should public and private buildings be treated alike in this regard? Should different criteria be applied to buildings with different uses--should hospitals, stores, and apartment houses be treated alike?

- Should government--local, state, and/or federal--act to offer property-owners in the threatened area access to earthquake insurance or its equivalent? If so, who will bear the cost?

- Should regulations governing the operation of financial institutions and insurance carriers be altered for firms involved in the target community?

- Should the number of weeks during which unemployment compensation is available be lengthened?

- Should disclosure of earthquake damage risk be required in all real estate transactions?

- If there must be a reduction in public services to cope with the financial squeeze, which services should receive the lowest priority?

These points are indicative of the uncertainties that are placed before us in planning for the response to an earthquake prediction. Similar problems exist in the areas of building codes, land use procedures, financial management, insurance and legal considerations of adopting any of a variety of earthquake hazard mitigation procedures, whether they are tied to an earthquake prediction or not.

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The National Academy of Sciences' Panel on Earthquake Prediction noted in its report that Governments should be prepared to deal with a range of issues related to earthquake prediction and warning including those of equity, responsibility, and legal implications. The panel indicated that unless these issues were adequately and systematically addressed before institutional and organizational arrangement were adopted, the effectiveness of such arrangements might be jeopardized. Otherwise, such arrangements themselves may create more problems than they solve.

There are, of course, many disaster mitigation organizations and institutions at many levels of Government already in place throughout the country. Yet, like other institutions in the society, they frequently experience organizational and operational problems. Relatively few studies have focused on how effective these organizations are in preparing for, responding to, and recovering from earthquakes. It would seem wise, then, to conduct more such efforts before Governments develop new earthquake mitigation arrangements or alter existing ones.

One of the most serious problems Government officials with disaster-mitigation responsibilities may have is communicating with a threatened population. This has been suggested, for example, by such studies as the one conducted by Haas and Mileti and the NAS Panel on the Public Policy Implications of Earthquake Prediction. Threatened populations may not understand or indeed choose to ignore the advice offered by responsible Government authorities. One way that this communication barrier may be reduced is by involving larger numbers of individual citizens and civic groups in disaster-mitigation planning along with Government officials. Such an approach has not been tried

frequently, yet it promises greater understanding on the part of citizens and increased commitment to disaster-mitigation. The Government might be advised to attempt such an approach before moving ahead with developing new mechanisms in parts of the country subjected to earthquake risk. A RANN project with the Council of State Governments, "State Government Policy Options for the Utilization of Earthquake Prediction Technology " provides one vehicle to achieve this public participation. It involves a variety of Government and other persons throughout the country in a consideration of ways to enhance the potential social benefits of the developing earthquake prediction capability. Its results will provide good policy guidance on how best to structure Federal-state earthquake prediction institutions and procedures.

We believe that these studies support Dr. Press' suggestions for modification of the proposed legislation. With this modification, we are supportive of the proposed legislation and look forward to working with the Congress in formulating and implementing an effective program in Earthquake Prediction and Hazard Mitigation.

Attachment

The National Science Foundation Programs in Earthquake Prediction and Hazard Reduction

Under the aegis of the President's Science Advisor, a report on Earthquake Prediction and Hazard Mitigation was submitted to the President in September 1976. It presents options for future development of the NSF and USGS research programs, and its Option B is the basis for the strengthening of our program. The goal of the joint NSF-USGS earthquake prediction and hazard mitigation activities is to reduce casualties, damage, and social and economic disruption from earthquakes. The social, economic, and political actions that can be taken to attain this goal are based on technological capabilities that require development through research. The primary objectives of this research are:

- Earthquake Prediction - Develop the capability to predict the time, place, magnitude and effects of earthquakes so that more effective preparedness actions can be undertaken;
- Earthquake Modification and Control - Develop techniques that allow the control or alteration of seismic phenomena;
- Land Use - Develop procedures for assessing seismic risk and evaluating earthquake hazards so that appropriate construction and land use plans can be implemented;
- Design Improvement - Develop improved, economically feasible design and construction methods for building earthquake resistant structures of all types and for upgrading existing structures; and,

- Social and Behavioral Response - Develop an understanding of the factors that influence public utilization of earthquake mitigation methods.

Responsibility for fundamental earthquake studies to help meet the goal of this program are with the Geophysics program subelement of NSF and the USGS. Earthquake prediction, induced seismicity and hazards assessment are the responsibility of USGS, and earthquake engineering and research for utilization are the responsibility of NSF/RANN. These agency programs are closely coordinated through formal and informal mechanisms to achieve the objectives set forth in the report to the President.

The RANN program in Earthquake Engineering has developed in the past five years from a $2M per year effort in FY1971 to an $8.4M effort in FY1977 and a proposed effort in FY1978 of $20M, consistent with the Newmark report. The program is organized into three major categories: Siting, Design and Policy. Each of these elements has vigorous utilization efforts to achieve ready access and timely availability of publications, information and data.

SITING (FY1978 Proposed Budget: $6,000,000)

Earthquake damage results from the energy released by the earthquake being transmitted through rock and soil to the site where a facility is located. In some cases an earthquake may trigger secondary geophysical hazards, such as tsunamis, land slides, or flood waves from ruptured dams, that can have devastating impacts. The siting research area seeks to determine the nature of the potentially damaging earthquake hazard at particular sites so that structures may be adequately designed and social and economic policies may be appropriately developed. The specific objectives of this research area are to:

- o Improve methods to characterize the nature of the input motions and corresponding response of simple structural systems for use in engineering analysis, planning and design;
- o Obtain a comprehensive data base on the nature of earthquake motions at typical sites and in representative structures;
- o Devise in-situ and laboratory methods to determine the dynamic properties of soils and analytic procedures, including the potential for failure of slopes, embankments and foundations; and,
- o Identify procedures for integrating information on geophysical hazards into land use planning and siting procedures.

DESIGN (FY1978 Proposed Budget: $9,000,000)

The processes of design, analysis and construction are central to the achievement of safe structures and systems. In turn, these processes depend on the formulation, testing, validation and presentation of appropriate conceptual and mathematical representations of their characteristics. These models must represent the capacity of the structures and systems at various levels of motion which occur in potentially damaging earthquakes. They must include multidimensional, nonlinear, and inelastic characteristics. At present, design procedures are largely based on linear, elastic, one-dimensional models.

The specific objectives of this research area are to:

- o Improve analytical procedures for characterizing the earthquake response of structures and structural elements based on both analytical and experimental studies;
- o Devise analytical methods to evaluate the earthquake response of special types of structures (dams, critical facilities, bridges and other extended structures) and of interconnected structures and systems (pipelines, transmission lines, etc.);
- o Obtain information for engineering analysis and design from observations of damage (or lack of damage) following earthquakes that support the development of improved U.S. engineering practices and construction techniques;

- Identify economically feasible design and construction methods for building earthquake resistant structures and facilities; and,
- Develop methods to evaluate the hazard potential of existing structures and investigate innovative methods for improving their performance.

The majority of existing buildings have little earthquake resistance, including many buildings in high risk areas of the West. This occurs because earthquakes were not considered in their construction; the structural resistance provided against other dynamic loads, e.g., wind, is insufficient, or the earthquake risk was underestimated. Previous initiatives to upgrade hazardous structures have been limited by high cost. Costs reduced by several factors still seem too high to warrant widespread upgrading when one considers the average risk and realistic economic discount factors. However, the emerging potential for earthquake prediction could substantially alter this economic environment to one in which decisions to upgrade hazardous structures may be made by stimulating the investment of substantially larger amounts to obtain improved seismic performance in selected areas. For this reason, research on upgrading and reinforcing existing hazardous structures will be greatly expanded in the coming years. Particular attention will be given to western masonry structures and to other potentially hazardous building types prevalent in the eastern midwestern United States.

POLICY (FY1978 Proposed Budget: $5,000,000)

This research area is directed at facilitating the utilization of research findings developed in the NSF and USGS research programs on earthquake hazards by private citizens and organizations, local communities, and State and Federal agencies. It focuses research on such social adjustments to earthquakes as preparedness, relief and rehabilitation, as well as on identifying factors related to the actual adoption of known social and technological solutions to disaster-generated problems.

The specific objectives of this research area are to:

- o Increase the base of knowledge on alternative social adjustments to earthquakes;
- o Identify the social, economic, political, legal and related factors which facilitate or hinder the adoption of both social and technological solutions to earthquake hazards;
- o Facilitate the beneficial utilization of earthquake hazard mitigation measures by devising effective techniques for disseminating information to the public and decisionmakers at local, State and national levels; and,
- o Investigate measures which will reduce possible negative social, economic, and political consequences of earthquake predictions and warnings.

Dissemination of research results is vital in any effort to increase the capability of both public and private officials to implement

earthquake and other hazard mitigation measures. There is a need for knowledge on the most effective ways to disseminate information to relevant groups and organizations before, during, and following earthquakes and other disasters. More effective means must be found to increase the interaction between the research and user communities so that important findings on building construction, emergency preparedness, relief and rehabilitation, insurance, and emergency communications become known to individuals, and to public and private agencies with hazard mitigation capabilities and responsibilities. Major efforts are being initiated in these vital areas of technology transfer and public policy.

FUNDAMENTAL STUDIES (FY1978 Proposed Budget: $5,300,000)

The Earth Sciences Division, in the Geophysics Program, supports the Nation's principal efforts in basic earthquake research, almost entirely conducted by universities. The level of support has risen rather steadily from $1.5M in FY1968, to $3.0M in FY1977 and to a request of $5.3M for FY1978.

There is little doubt, at our present state of knowledge, that any national program to predict earthquakes and identify hazards should be based on a program of in-depth studies and measurements of a fundamental nature directed at the development of a thorough understanding of the natural phenomena involved.

Dr. EGGERS. Thank you, sir. Let me just say the following: Dr. Thiel certainly will be the principal witness, but I did want to join with him in appearing before you because our earthquake research program in the Foundation is important to me.

As you know, the Foundation has been the lead agency for earthquake engineering research since the inception of the RANN program. Earthquake research has been in the Foundation for a total of about 10 years now. The total expenditure of funds, I believe, is now on the order of about $35 million.

As you also know, Mr. Chairman, from the many times I have testified before you in the past, we have from the outset of this activity placed very great emphasis on the coupling of the research with the user community.

Our most recent evaluations of the utilization of the results of that effort indicate many billions, indeed tens of billions of dollars of construction in the United States have utilized the results of that earthquake engineering effort.

One thing we have learned over the past several years to be of very great importance in this type of activity is what we tend to refer to as systematic and in-depth post-disaster audits.

Speaking now of the San Fernando earthquake, I might say that one of the most profitable efforts on our part to learn better how to design buildings came as a result of the extensive study of the damages resulting from that earthquake.

We invested some $2½ million in study and dissemination of that information. As you know, among other things, the design codes for all earthen dams in California have been changed as a result of the findings, including especially the findings of soil liquefaction, and there have been studies and reviews of all earthen dams in California since then.

Mr. BROWN. Can't you make those studies in some other State and avoid having to wait for an earthquake in California? [Laughter.]

Dr. EGGERS. Well, we will entertain any recommendations you have on that. [Laughter.]

We do study the disasters in foreign countries, but I think I should quit talking now, Mr. Chairman. With your permission I will turn the testimony over to our principal witness, Dr. Thiel, who has had many years of experience in this area.

Mr. BROWN. Without objection, your statement will be included in full in the record also.

Dr. THIEL. Thank you. While we are all aware of the horror of an earthquake occurrence, it must also be kept in mind that we are investing funds every day in construction to meet earthquake-resistant building codes and we are paying annual insurance premiums to protect us from future financial loss in the event that an earthquake occurs.

Indeed, these current costs on an annual basis are probably as great as the damage that can be expected from future earthquakes, on an annual basis. Affecting a reduction in these multifaceted impacts of earthquakes in an equitable, efficient, economic way will obviously depend on the careful development of implementation strategies consistent with the constraints and values of the public as it goes about its everyday activities.

The Newmark report discussed by Dr. Press presents options for program development, and its option B is the basis for the strengthening of our program as presented in the President's budget now before the Congress. In the joint Federal program in earthquake prediction and hazard mitigation, the NSF has responsibility for fundamental earthquake studies, earthquake engineering and the research for utilization.

The Earth Sciences Division in the geophysics program supports the Nation's principal efforts in basic earthquake research, almost entirely conducted by universities. The level of support has risen rather steadily from $1.5 million in fiscal year 1968 to $3 million in fiscal year 1977 and to a request of $5.3 million for fiscal year 1978.

The RANN program in earthquake engineering has developed in the past 5 years from a $2 million per year effort in fiscal year 1971 to an $8.8 million effort in fiscal year 1977 and a proposed effort in fiscal year 1978 of $20 million. The program is organized into three major categories: Siting, design, and policy.

The attachment describes these programs in more detail.

In testimony delivered before this committee and other committees of the Congress, the NSF has presented a substantial body of accomplishments from our earthquake engineering and geophysics programs that have illustrated the scientific quality, utility, and application of the programs' activities. Among these have been:

Successful prediction of small intraplate earthquakes in South Carolina and New York;

Establishment of the National Information Service for Earthquake Engineering;

Improvements in municipal and State building codes, standards and criteria, and model codes to provide more appropriate earthquake safety; and

Improved practices by engineers, designers, and private firms in providing safe structures.

Indeed, we feel that the Foundation's earthquake program is one of our most successful programs in supporting excellent basic and applied research and—in the case of the earthquake engineering program—implementing the RANN objective of hastening the application of results.

Legislation now before the Congress proposes first that a vigorous research program be placed and, second, that various advisory committees, a prediction evaluation board, organizational assignments and a new organizational unit be formed.

These latter points vary among the bills but their intent seems clear; namely, to provide for the swift incorporation of the results of the program into disaster mitigation practices in the public and private sectors.

Changes in building codes and land use regulations and the issuance of earthquake predictions and warnings can have serious ramifications for the social, economic, legal, and political aspects of American life. Whether a research product has a positive or negative total effect in mitigating earthquake hazards, or is ignored altogether, could depend very much on the method of communication and utilization of the product.

We counsel that great care be exercised prior to the establishment of new organizations or committees, the realinement of functions or the specifications of roles and responsibilities. We strongly urge that the Congress adopt a sequential strategy regarding implementation of the results of the research program. First, a careful concentrated effort to determine appropriate roles, relationships, and activities of Federal, State, and local governmental units, and the private sector; second, the alinement of responsibilities and allocation of authorities to achieve the purpose of improved public safety; third, the proposing of legislation as needed that aids achieving this purpose consistent with the appropriate Federal role; and fourth, vigorously pursuing a combined research and implementation program for the public's benefit.

We are of the opinion that the incorporation of the drafting suggestion of Dr. Press into the bills under consideration will achieve these purposes.

We have reached these conclusions based both upon our experience in managing research applications programs and through an examination of the results of several RANN-supported research studies now underway or recently completed.

The Foundation's research applied to national needs program has developed considerable expertise in managing programs that intend to both support research and foster its application. RANN also supports, through its intergovernmental program, major efforts to increase the capacity and capability of State and local government to use science and technology, especially newly developed, in their operations and policy setting. Our experience in both of these areas indicates that for research to be incorporated rapidly and effectively into public practice, the intended beneficiary at both the public and private levels must be involved in the:

Establishment of objectives; formulation of the research programs; determination of the implementation strategy; oversight and conduct of the program; and finally, through prototypical application.

The Newmark report presents a soundly reasoned base to achieve the research objectives of the Cranston bill (S. 126), and indeed, the user communities were involved in the setting of its objectives and in the formulation of the research program.

It is extremely important that the care taken in designing the research program be duplicated in designing the implementation strategy.

The proposal of Dr. Press to pursue a "Newmark" type panel study involving State and local officials and elements of the private sector to develop an implementation strategy in our view is required prior to the creation of institutional arrangements and functions such as those proposed in current legislation before the Congress.

An esential question is: Do we know enough at this point to begin structuring major institutional measures for mitigating the direct and indirect consequences of earthquakes? The answer to this question would seem to be, "No." Until more knowledge has been accumulated on how population perceives, responds to, and recovers from earthquakes, we need to move in a deliberate rather than a precipitous fashion. The narrow knowledge base that we are working with would seem to require such caution.

Take, for example, the case of earthquake prediction. The Haas-Mileti research on the "Socioeconomic and Political Consequences of Earthquake Prediction" suggests that with the leadtimes earthquake predictions will probably provide in the future, it will be possible to initiate a range of social, economic, and technological adaptations to mitigate the impact of the predicted events.

After a credible earthquake prediction, families, business, and governmental agencies will try to act in a manner favorable to their own interests.

Investors will generally put their money outside of the target area, or invest very selectively within the area, on the assumption that this will lower their risk. Development planning and construction in the private sector will be first drastically reduced, and then almost entirely curtailed.

Local governments will likewise stop or sharply reduce capital construction projects. Influenced by the construction industry, business in general will slow its activity, unemployment will rise sharply, especially in the building trades, and local government will suffer severe declines in sales and property tax revenues. In the face of revenue loss, there will undoubtedly be an increase in demand for public services. This study, while tentative, indicates that a number of questions from an implementation standpoint will have to be squarely faced. Among these are:

How does the liability of a private employer change, if at all, in the face of the yet to be proven science of earthquake prediction? Are the liability considerations different for the Government as employer?

Should regulations governing the operation of financial institutions and insurance carriers be altered for firms involved in the target community?

Should the number of weeks during which unemployment compensation is available be lengthened?

These points are indicative of the uncertainties that are placed before us in planning for the response to an earthquake prediction. Similar problems exist in the areas of building codes, land use procedures, financial management, insurance, and legal considerations of adopting any of a variety of earthquake hazard mitigation procedures, whether they are tied to an earthquake prediction or not.

One of the most serious problems Government officials with disaster mitigation responsibilities may have is communicating with a threatened population. Threatened populations may not understand or indeed choose to ignore the advice offered by responsible Government authorities. One way that this communication barrier may be reduced is by involving larger numbers of individual citizens and civic groups in disaster mitigation planning along with Government officials. Such an approach has not been tried frequently, yet it promises greater understanding on the part of citizens and increased commitment to disaster mitigation.

The Government might be advised to attempt such an approach before moving ahead with developing new mechanisms in parts of the country subjected to earthquake risk. A RANN project with the Council of State Governments, "State Government Policy Options for the Utilization of Earthquake Prediction Technology," which will be

completed this coming spring, provides one vehicle to achieve this public participation. It involves a variety of Government and other persons throughout the country in a consideration of ways to enhance the potential social benefits of the developing earthquake prediction capability.

Its results will provide good policy guidance on how best to structure Federal/State earthquake prediction institutions and procedures.

We believe that these studies support Dr. Press' suggestions for modification of the proposed legislation. With these modifications, we are supportive of the proposed legislation and look forward to working with the Congress in formulating and implementing an effective program in earthquake prediction and hazard mitigation.

That concludes my testimony, Mr. Chairman.

Mr. BROWN. I would assume from the laudatory comments made about Dr. Press' proposal, that they probably had some role in writing it?

Dr. THIEL. That would be a safe assumption.

Mr. BROWN. I applaud you for developing a uniform approach to this. I might comment that I think your statement is a very thoughtful and rational explanation of some of the problems involved as we move ahead in this area.

I am struck by the parallel between the problems that face us here and the problems that face us in other areas where there are potential disasters that might face us.

We don't react rationally sometimes. There is danger from flood, from war, from environmental catastrophe of all kinds, including the ozone depletion problem. These are in a sense similar problems, in many cases with a common base of either scientific knowledge or lack of scientific knowledge.

It strikes me that we would be well advised in connection with developing a national policy in this area to treat it as the scientists might rather than a politician, as an exercise in how we go about rationally developing a capability that does not—that expands our knowledge, that does not overreact and that involves the concerned public at whatever level in the most practical way that we can get operable results.

Some of the things that you warn of here we experience today. For example, a fear of nuclear powerplant siting. Again it is connected in large part to seismic fears, although there are other fears also involved. But we might in developing this legislation set an example of how we move into areas where we are not quite sure of what we ought to do but we are fairly sure that we ought to be doing something.

If we could adopt that type of an attitude we might come out with better legislation.

Dr. THIEL. I am in total agreement.

I might point out that the earthquake engineering program is contained within the RANN program on disasters and natural hazards which is looking at other hazard forms. There is an important point that you have brought out and that is that earthquakes are but one of a litany of environmental insults that the body politic is subject to. There is great similarity in the social response of the public to different types of threats.

We will be pursuing a policy of relating earthquake activities in the RANN program with an eye toward what the impacts are on other types of hazards.

Mr. BROWN. Within the Foundation which is oriented basically toward the RANN program which is pointed toward the engineering aspects of the problem, you have commented on the importance of policy and social and psychological aspects of this problem.

Is there central coordination for both types of research within the RANN program and/or within the Foundation? In other words, you don't try to separate out from the program research on what the public reaction will be, for example, to an erroneous prediction from the general policy problems involving developing this research?

Dr. THIEL. The areas of research we are discussing here are administratively all within the division which I head, the Advanced Environmental Research and Technology Division. In many cases the research support associated with earthquakes is managed by the same individual who manages other activities with respect to other hazards. So we have not separated them managerially from one another. We have made a very strong effort to keep them together.

Dr. EGGERS. If I could amplify a little bit on Dr. Thiel's response to the question, Mr. Chairman, it has been our management philosophy from the outset in the RANN program that the hardware and software issues of a problem have to be dealt with together. So you will find, for example, in Dr. Thiel's division that he has engineers, sociologists, and economists. They pool their capabilities and go forward with an effective management on an interdisciplinary basis. They bring to bear the total expertise required to deal with the problem.

Mr. BROWN. That is the problem I am getting at, the difficulties in managing a large-scale interdisciplinary program. That in itself is almost an area for research in some situations.

Mr. Dornan?

Mr. DORNAN. No questions, thank you.

Dr. THIEL. You raised the question concerning the New Madrid earthquake. There have been several studies that have attempted to identify the nature of the potential damage that could be caused by a recurrence of the 1811–12 shocks. Those estimates, at least in terms of those which I give credibility to, look at the $5 to $10 billion property damage loss levels. So it poses a very serious threat in that part of the country.

Mr. BROWN. If I understand correctly, the present geological theory is that this particular zone has a resonance to it which tends to amplify the original shock, to spread it rather widely over a large area, that the plate structure there is not broken up but rather continuous.

In this way, at least, I have heard some geologists express this to me. Is that a proper understanding?

Dr. THIEL. If you look at the size of the damage area for equivalent size earthquakes between the Los Angeles versus the midcontinent, the same energy release will cause damage over an area approximately 100 times larger in the Midwest.

Mr. BROWN. Thank you.

Mr. THORNTON. Thank you.

Mr. BROWN. Well, gentlemen, I want to thank both of you and just reiterate our apologies for the time inconvenience this morning. I hope we can continue to call on you for help. Thank you very much.

I would now like to invite Congressman Glenn Anderson, our distinguished colleague from Los Angeles. He is accompanied by Councilman David Cunningham who will also give us the benefit of his experience.

Gentlemen, we apologize for any inconvenience for changes in our schedule.

Congressman Anderson, you may proceed.

[A biographical sketch of Mr. David Cunningham follows:]

BIOGRAPHY

Councilman David Cunningham was first elected to the Los Angeles City Council from the 10th District on September 18, 1973, in a special election held to fill the seat vacated by Mayor Tom Bradley. He was re-elected on April 1, 1974, by an overwhelming majority of the vote, to a full four year term.

He currently serves as Chairman of the Building and Safety Committee, and is a member of the Public Health, Welfare and Environment and Governmental Efficiency Committees. In addition he is a member of the Special Committee on Equal Opportunities.

Councilman Cunningham has been actively and deeply involved in the problems of the Central Los Angeles 10th District since he settled in the District immediately after his graduation from college.

Councilman Cunningham has initiated many forward-thinking programs in the Tenth District Council District as part of his overall plan to upgrade the economic and social status of the community. He opened the first field office in the District's history to make government more accessible to the residents. The Field Office assists hundreds of constituents every month with various problems involving all levels of government.

Cunningham sponsors the Tenth Council District Women's Steering Committee, a group he founded to encourage women to participate in their local community. The Steering Committee holds an annual Women's Leadership Conference where workshops are offered to discuss and encourage community activities and various projects the committee has worked on during the year.

Cunningham has also been instrumental in founding the Mid-City Chamber of Commerce, the first organization of this type for businesses in the Tenth District.

Councilman Cunningham has recently opened a Community Services Office to give community organizations assistance and guidance in attempting to achieve their specific goals.

Governor Edmund G. Brown, Jr., appointed Cunningham to the California Council on Criminal Justice, the state board charged with earmarking federal funds for crime prevention programs in California.

Born 40 years ago on the Southside of Chicago. David Cunningham and his sisters traveled extensively with their father and brother, who are both ministers, until finally settling in St. Louis, Missouri. There, Dave attended Charles Sumner High School graduating near the top of his class. He then went to the Harriet Beecher Stowe Teachers College and completed two years of study.

At the age of nineteen, Dave joined the U.S. Air Force where he rose to the rank of sergeant. At the conclusion of his service, he was honorably discharged at March Air Force Base in Riverside.

Upon his graduation with a B.A. in political science and economics, Dave had the honor of being selected as an intern by the prestigious CORO Foundation, which trains selected students for roles in government and politics. While with CORO he had the opportunity to study and work in such diverse agencies as the L.A. County Public Health Department, the United Auto Workers, and as Administrative Assistant to Assemblyman Charles Warren.

In 1965, Dave accepted a position with the Dukane Corp., a firm which manufactures medical and educational training aids. As a regional manager, he was afforded an opportunity to develop his business skills while traveling through West Africa on behalf of the firm.

In 1967, he was asked to head the Hughes Aircraft Community Relations Program. Shortly, thereafter, he became co-founder of Cunningham, Short, Berryman & Associates, Inc., which specializes in solving governmental and economic problems.

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In 1970, Dave received his Master of Arts degree in Urban Studies from Occidental College; after which he was asked to serve as Special Consultant to the U.S. Department of Health, Education and Welfare.

Through the years, Dave has been involved as a volunteer in a broad range of community organizations, including the California Minority Employment Council, past vice-president of the CORO Alumni Association; Chairman of the Executive Committee and a member of the Board of the Interracial Council for Business Opportunity; member of the World Affairs Council; member of the National Urban League; and 1971–72 Chairman of the Los Angeles Brotherhood Crusade.

STATEMENT OF HON. GLENN ANDERSON, A REPRESENTATIVE IN CONGRESS FROM THE STATE OF CALIFORNIA, ACCOMPANIED BY COUNCILMAN DAVID CUNNINGHAM, CITY OF LOS ANGELES

Mr. ANDERSON. Thank you, Mr. Chairman and members of this distinguished committee. I want to thank you very much for the opportunity to testify today on legislation drafted to reduce the hazards of an earthquake in our country.

I am pleased to be accompanied by the Honorable David Cunningham, city councilman of the city of Los Angeles. In our country, the States of California and Alaska are considered to be extremely vulnerable to earthquakes. This is not a west coast problem, however, since some 70 million Americans live in the 39 States that are wholly or partly in earthquake areas, this legislation should be of vital interest to them.

During our 200-year history major earthquakes have struck as follows:

Cape Ann, Mass., 1755.
New Madrid, Mo., 1811–12.
Charleston, S.C., 1886.
San Francisco, Calif., 1906.
Long Beach, Calif., 1933.
Seattle, Wash., 1949.
Hebgen Lake, Mont., 1959.
The Good Friday earthquake near Anchorage, Alaska, 1964.
San Fernando Valley, Calif., 1971.

This has resulted in the loss of approximately 1,600 lives and property damage totaling $1.8 billion.

The potential for another disaster is self-evident. Last year in the wake of the worst earthquake to strike Guatemala in 20 years, estimates of 22,000 dead, 74,000 injured and damages in excess of $600 million were put forth. Worldwide some 74 million people have died as a result of earthquakes. The second quarter of the 20th century saw 350,000 people lose their lives in earthquakes and related disasters.

On September 20, 1975, the House voted down a bill that would have established an earthquake hazard reduction program. It was ironic to me that the House earlier approved $25 million in relief to an earthquake stricken Guatemala, but refused to take action forestalling a similar disaster in our own country.

After the tragedy legislation calling for emergency relief, rehabilitation, and humanitarian assistance is fine for Guatemala, but I hope this committee and the Congress will pass preventive legislation for the United States.

Lately it is believed that strain in the zone known as the San Andreas fault in California is building up, causing the Palmdale bulge uplift. The San Andreas fault extends from the Imperial Valley at the Mexican border north to San Bernardino, Calif., where it curves west into the San Fernando Valley. North of Los Angeles the fault resumes a northerly course and runs into the Pacific just west of San Francisco. The uplift is a signal to the experts that a major earthquake will occur in the future. As a result California's Seismic Safety Commission has passed a resolution calling the Palmdale bulge a possible threat to public safety.

The challenge here is to establish a well-funded, coordinated, and effective Federal earthquake program. The inevitability of another earthquake in our country is well recognized. It is simply foolish to be other than the best prepared we can be for it.

Thank you very much.

At this time I will present Councilman Cunningham.

Mr. CUNNINGHAM. Thank you very much, Mr. Chairman and members of this distinguished committee. I am David Cunningham for the 10th district of the city of Los Angeles and also chairman of the Los Angeles City Council building and safety committee which has had to wrestle with this problem with reference to structures.

I am testifying today before your committee in favor of H.R. 35 and emphasize the need for legislation providing Federal support for long term, low interest loans to enable owners of unreinforced, masonry bearing wall buildings to meet building code requirements for seismic safety.

While research and development of earthquake prediction technology is important, it seems essential to me to take immediate steps to provide Federal support for a program to protect and conserve structures in existing communities such as Los Angeles which are highly developed. The amount of financial support which will be necessary to accomplish this is far beyond the scope of local resources.

While the potential hazard of earthquakes is a serious matter for communities throughout the country, it is no secret that the city of Los Angeles, along with other west coast communities, has reason to treat this potential hazard with a great sense of urgency.

The State Seismic Safety Commission has found that the bulge in Southern California is a threat to public safety and in subsequent resolutions has requested State and local agencies to take the steps to mitigate the potential disaster, stimulate preparedness, and inform the public.

We are today concerned that we have not done enough to safeguard our citizens against a very large quake either in terms of accurate earthquake forecasting or in terms of structural specifications and design.

As chairman of the city's building and safety committee, I have recently completed a thorough review of our own situation within the city. I would like to take a moment, Mr. Chairman, to tell your committee about the problem as we view it in Los Angeles.

We currently have an estimated 14,000 buildings within the city limits which are extremely vulnerable under our existing seismic code requirements. Many of these are private and public structures of unreinforced masonry built before October 6, 1933.

That is a landmark date because that was subsequent to which the devastating Long Beach earthquake occurred. We are particularly concerned with these structures. My committee has estimated that should a major earthquake hit the Los Angeles area before proper modifications can be made to these buildings, as many as 48,000 casualties and 12,000 fatalities could occur—not to mention the untold amount of property and general economic loss and dislocation.

Now, Mr. Chairman, I would like to go beyond the scope of this bill and possibly beyond the jurisdiction of this committee and propose the type of additional Federal program which I feel is sorely needed. As I have told you today the city of Los Angeles, its council, on which I serve, and its mayor, Tom Bradley, have taken positive action to address the issue.

The city of Los Angeles has established a task force with responsibility to conduct a citywide survey to identify and catalog all pre-1934 unreinforced, masonry bearing wall buildings and to develop a com prehensive earthquake safety ordinance.

After 1933 statewide minimum standards were enacted.

The city's civil defense and disaster corps is holding training exercises to activate appropriate city departments, familiarizing them with the problems they may face in the event of a sizable earthquake and to set up a cooperative organization and communication network with county, State, and Federal and private emergency service organizations.

The mayor has also established an earthquake prediction task force to deal with the problems associated with a reliable earthquake prediction. I also serve as the city council representative on that task force.

It is on the basis of these actions, some of which parallel the programs sponsored and proposed in H.R. 35, that I feel there is sufficient reason to come before the Congress and request some form of economic relief assistance. Mr. Chairman, while we applaud your approach as contained in the subject legislation, we feel that there are areas in the country where the need for action extends beyond the present scope of the bill.

In those communities, where it can be demonstrated that there is a real and present danger of a major earthquake, and where the local government has taken positive steps to control location and structural strength of new and existing buildings then there should be made available the type of Federal assistance which would permit the community to meet these goals without imposing undue economic hardship. The Federal assistance could take several forms, possibly including outright grants. However, I would like to recommend here today that legislation providing long-term, low-interest Federal loans be considered.

We are confident that the private and business interests in our city will not dodge their responsibility in providing then for the safety of their employees and customers. Additionally, given the nature of the problem and the involvement of the Government, they have a right to the very limited type of assistance which I am calling for today on behalf of the city of Los Angeles.

I might add we also plan to ask other appropriate congressional committees to consider some method of providing this assistance. We are not satisfied that we need to wait until the disaster occurs as some

have told us. We feel that in those cases where the local government has taken positive steps to insure compliance to specific seismic standards, Federal and State assistance is justified now.

Mr. Chairman, I commend your committee for the concern it has demonstrated for the problem of earthquake hazards. Clearly it warrants immediate congressional attention at the national level. We all know how the Nation would rally to help a community devastated by a severe earthquake. Who then would not find it a good investment for the Nation to take measures today which will reduce the potential loss in terms of life and property?

Thank you very much.

Mr. BROWN. Thank you, Mr. Cunningham. I commend you on your statement and on what you have been doing in Los Angeles. We are pleased to see that as usual you are ahead of other jurisdictions in approaching problems of this sort.

Mr. Dornan, do you have any questions?

Mr. DORNAN. I just wondered about this Long Beach earthquake. Was that tied in with the San Andreas fault and have there been any tremors in that area with its high population density?

Mr. ANDERSON. Long Beach is not part of the San Andreas fault. It is considerably west of it. Mr. Chairman, these two gentlemen are from my own area so we are talking local things. Other districts are adjoining. There is another fault called the West Basin that divides our district so if you drill for water on one side you get it—and on the other side you don't get it. I think that West Basin is more related to the Long Beach earthquake than anything else you can really identify.

But almost everyone you talk to says well, no, that is a different one because it is a highly technical subject.

Mr. DORNAN. Even though we talk a great deal about the San Andreas fault, there are all sorts of minor faults that given a violent earthquake could cause as much damage as something that would come from the San Andreas.

Mr. ANDERSON. I am not expert in this at all but I would assume that if the Palmdale bulge is as drastic as some of the experts think it is, and if it does have a real jar, it could set something off in some other part of California, for instance in the West Basin.

Mr. DORNAN. Mr. Cunningham, on the building restrictions in the Los Angeles area, will there be continued hearings this year in depth from some of the business interests that are dragging their feet but possibly with some justification because of the economic implications?

Mr. CUNNINGHAM. Sometime ago we attempted to write an ordinance. As a matter of fact we did write it. We went to the council with it. One of the penalties it carried was that we would post our buildings that were pre-1934 construction that were of this masonry wall bearing type with these hazard signs clear to the public that should you enter this building and should an earthquake occur more than likely you would find there was a high risk and you might in some way be injured.

We held a series of extensive hearings and at first we could not find too many people who were concerned about the fact that we would go forward with this piece of legislation. We took it to the council and

there was a big brouhaha by the public brought forth at that time. Since then we have returned it to my committee.

We have formed this task force made up of the public, made up of business interests, made up of structural engineers, mechanical engineers, and several others to put together based on this survey that we are doing of the 14,000 buildings a task force that can develop this ordinance.

We realize that there is one imperfection that we are faced with once we do that. We will have the ordinance that says you must bring your building up to these standards, that you must modify your building, reinforce it. We understand from the experts that there are several modifications which can be made.

But the problem is that the expense involved is prohibitive. What has been said to us by many of the managers and owners of these buildings since something like 70 percent of them are residential structures—some of the statistics we have looked at indicate that residential structures contain about 72,000 people, housing for 72,000 people.

We don't want to see all of that housing stock demolished, destroyed, walked away and abandoned by these owners. We feel the only way we will be able to get a well-thought-out program and get compliance with the ordinance is to have the kind of low-interest dollars, low-interest loans available to these owners to repair the buildings.

I might also add that our council is on record—we have gone on record supporting the seeking of legislation to do what we are trying to accomplish today. The businessmen in our community have not been dragging their feet. They have now become part of this action.

They are prepared to move forward to support whatever we do as long as they see that the necessary dollars are there. I might add also in reference to the question that you asked, Congressman, and as you know, the city has in its general plan what is called a seismic safety element of our plan.

We have located and done some mapping of all of the facts that occur within the city limits and the city jurisdiction of the city of Los Angeles. We sit on a highly vulnerable area of a number of faults, San Andreas, the one most talked about is only one.

We are in a highly earthquake-prone area. It is almost like playing Russian roulette. We know that we have to take some action but we need assistance in order to accomplish what we think we can do.

Mr. DORNAN. I have no further questions.

Mr. BROWN. Mr. Thornton?

Mr. THORNTON. Mr. Cunningham, I want to congratulate you on your very fine testimony, particularly on the thought which you are giving to possible procedures to be followed following the Earth detection and earthquake research which this bill is directed to. In that regard Dr. Press has suggested as you heard this morning through his prepared statement in addition to deal with ways to deal with the aftermath.

Mr. CUNNINGHAM. We wholeheartedly support that. One of our thoughts is that that should be made one of the prerequisites for having this kind of Federal assistance available to you. Any local jurisdiction or local entity that has taken the necessary preventive steps to try to develop a well-thought-out program for construction safety elements as well as the ability to include its entire population

and its entire interests, centers of interest involved in it, should be one of the requirements for the availability of such Federal assistance.

Mr. THORNTON. I would also like to welcome our colleague, Glenn Anderson, and recognize his significant contribution to this area of concern. I think it is particularly appropriate that the leading edge of this is being taken by people who are most intimately concerned about the possibility of recurring earthquakes in the California area but that it is also important to recognize that there is a broad national purpose and that earthquakes are not limited to any one section of the country.

We appreciate the leadership which you have provided, Mr. Anderson. I want to thank you for that.

Mr. DORNAN. Just one further observation where we might prevent the killing of two birds with one stone. There are some naturalists who will be worried about earthquakes but who don't see any danger from possible nuclear confrontation and the reverse is sometimes true. People now interested in national defense could care very little about natural disaster.

Is there some way to approach this with a civil defense program that would take both natural and manmade disasters into account and get the people's attention this way? I know that a great warning label on a building, this building may be hazardous to your health, is something people are going to disregard when they could not seem to care less about lung cancer.

I am somewhat of an amateur archeologist. When I deal with history and long-range periods, some of the greatest buildings ever created by mankind are eventually caught up with, whether it is the great earthquake of the 11th century or the 16th. Is there any way civil defense can be used?

Mr. CUNNINGHAM. We found through our task force, not my building and safety task force, but a task force made up by the mayor concerned with earthquake predictability. One of the things they have run recently was a simulated earthquake recurrence. It was published in the paper to make it clear that it was a simulation. The amount and degree of the disaster fatality account, as well as the economic loss occurred, as well as some of the devices and measures that were used indeed to provide relief or to make certain that our citizens were cared for.

It is the intent of this mayor's task force to go through these simulated disaster problems as a result of earthquakes located in various areas. This is to begin to sensitize our public to what measures and to what steps can be taken.

Part of what our program is now as we go through this thing is to begin to publish the pamphlet kind of information that will make it clear to our citizens some of the things that they did do best to protect themselves against it. We also happen to think that one of the first things that mitigates against the potential loss is to begin with the proper kinds of structures and to make certain that these structures are indeed constructed in the proper location with proper zoning protection and with the proper kind of construction protection.

I have found—I don't know to what degree I have become an expert—but I have found from a series of hearings that we had that involved geologists and those who deal in seismic safety managements

and mechanical and structural engineers that there are things that will mitigate against this release of energy through the building materials.

We found one of the elements is the sale and the ability of the construction that you put on that soil and its ability to oscillate or to ride with that soil and have the kind of resilience that allows for the force to be dissipated, that you can have that kind of building that is safe to that degree.

But these are elements that we have to know. We have to evaluate them and then we have to make certain that the construction materials are available and the construction techniques are available, as well as to inform our citizens what they can do in case of an impending earthquake or in case they find themselves in an earthquake.

What is the safest part of the building? Our building and safety department can't tell you what is the safest part of a building and where you should go should an earthquake occur.

Mr. DORNAN. These 55-story buildings—the one put up by Atlantic Richfield, all of these people came to you and availed themselves of all the latest science and technology?

Mr. CUNNINGHAM. They are built under rigid seismic safety codes for our city. I might indicate to you that the Union Bank Building which is there which is a 33-story structure had been built prior to the 1971 earthquake.

I might indicate to you that there was a great deal of oscillation in the building. I happen to have a friend that worked for Jeffrey Bank Note which is at the top of that building who got a very good ride in his office chair from side to side. But the building had no damage to it, no structural damage to it and it is still standing and it is built under our existing codes for new structures.

As you know, we have just—just this past Saturday there was a rededication over the spot where we lost Mount Olive Hospital. A new hospital has been put on that site with the stringent building code requirements that we have adopted for new construction.

We have no problem in terms of our new construction codes. Our problem lies with these 14,000 buildings that we must recycle. We know that they are potentially a hazard to their—it is a hazard for them to continue to be inhabited. We need help to do something about that.

Mr. DORNAN. Could I ask you to elaborate on your decade here in the Congress on this civil defense issue, having come from an area where there was a major earthquake in 1933. Is Long Beach prepared with stores and supplies to survive any kind of a civil disaster, natural or man created?

Mr. ANDERSON. Long Beach has built a number of new buildings since the earthquake of 1933 and all of these have met at different stages the requirements at that time.

Of course our most recent buildings, almost all of them have gone through the same procedures that the city of Los Angeles has. They have areas of protection and so on, and directions of what to do and so on. Your other comment earlier, I see a relationship between the civil defense and the earthquake tragedy, not running two separate organizations, but I think there would be great value in combining them.

I assume you would use in many cases the same kind of leadership from each community, people who are going to be concerned about warning their neighbors under one circumstance would be equally concerned on the other.

They would probably be the ones who would learn what to do and what to advise a person to do in case of a civil defense problem. They would also advise the neighbors what to do in case of earthquake. I think it would be foolish to have two separate approaches.

I think that brings strength to both of them.

Mr. DORNAN. After the February 9 earthquake I remember how difficult it was for some of the police agencies to get people in the San Fernando Valley to evacuate their homes.

Two weeks ago on television there was a program based upon a very smooth burglary operation that actually went around in full fire department gear warning people to evacuate their houses and as soon as they left their houses with the doors unlocked they went in and inventoried the house and cleared it out, emptying everything of value into vans. I hope it was not a case of another one of these ideas of a screen writer having an original idea that the criminal people pick up later.

But this would cause people not to leave their homes in an emergency. I think we have to have Government agencies that have the respect and confidence of the people to handle these emergencies.

Mr. ANDERSON. People that they know if their own neighbors——

Mr. DORNAN. Right, people that will be able to evacuate people with speed and safety. If you have all the great devices in the world to warn about earthquake and a nuclear attack, and people don't pay attention, it has all been in vain.

Thank you very much.

Mr. BROWN. Thank you gentlemen, both of you. Mr. Cunningham, may I express the hope that the next earthquake that hits your area, that your city will be spared?

Mr. CUNNINGHAM. We have escaped a number of them but we felt the tremors. By the time we find out what relief is available for the problem, the inner city is always late getting the relief. I recall that in 1971. I lost a house as a result of that and never was able to get repairs done to it.

We appreciate your concern. Thank you very much.

Mr. ANDERSON. I did not ignore you. [Laughter.]

Mr. BROWN. Our next witness is Dr. James Skehan, director of the Weston Observatory, Weston, Mass., representing the Association of Professional Geological Scientists. He is accompanied by Dr. Edward F. Chiburis. We welcome both of you gentlemen. We extend our usual apologies for the time problem.

[A biographical sketch of Professor James W. Skehan, S.J. follows.]

SUMMARY BIOGRAPHICAL RESUME

OF

REVEREND PROFESSOR JAMES W. SKEHAN, S. J.

James W. Skehan, S.J. was born in Houlton, Maine the eldest son of James W., formerly of Fitchburg, Mass. and Mary Effie Coffey-Skehan, formerly of North Richmond, New Brunswick, Canada. He received his pre-college education in St. Mary's School from the Sisters of Mercy and in the public Houlton High School. He received his Bachelor's Degree from Boston College majoring in Philosophy, two in Theology and two in Geology, his highest being a Doctorate from Harvard University in 1953. He was ordained a priest of the Jesuit Order in 1954.

Professor Skehan has authored and edited many scientific papers and books especially those concerned with the geology of New England or younger volcanic areas such as Iceland and the Pacific Northwest States. He is an active member of several learned and professional organizations in this country and abroad and is an officer in several of them. He is especially active in the Geological Society of America (GSA), the Natioanl Association of Geology Teachers (NAGT), in the American Institute of Professional Geologists (AIPG) and in the Association of Engineering Geologists (AEG).

Father Skehan's professional and personal accomplishments have been recognized by having been included in a number of books of biography such as American Men of Science, Marquis' Who's Who in America, Dictionary of International Biography, Outstanding Educators of America, Men of Achievement, American Biographical Institute (Bicentennial), National Register of Prominent Americans and Notables as well as in the World Who's Who in Science.

Father Skehan founded the Department of Geology at Boston College and served as its first Chairman. In 1968, he served as the first Chairman of the newly combined Department of Geology and Geophysics. In 1970, he was active in the founding of the Boston College Environmental Center (BCEC) and served as its first Director; he became Acting Dean of the College of Arts and Sciences, 1972-73; Acting Director and Director of Weston Observatory in 1973-74 and 1974- respectively.

May 1975

STATEMENT OF DR. JAMES W. SKEHAN AND DR. EDWARD F. CHIBURIS, WESTON OBSERVATORY-BOSTON COLLEGE, ON BEHALF OF THE ASSOCIATION OF PROFESSIONAL GEOLOGICAL SCIENTISTS

Dr. SKEHAN. Mr. Chairman and members of the subcommittee, for necessary background, I am representing the Association of Professional Geological Scientists on behalf of whom this testimony is given. It is an organization of over 3,000 geologists whose professional activity encompasses many fields of geology and geophysics. I personally am director of Boston College's Weston Observatory, a research institute in geophysics and geology.

With me is professor Edward Chiburis who heads up our seismology program at Weston Observatory. I think it is relevant to the present topic to indicate that Weston Observatory has the longest record of monitoring earthquake activity of any currently active institution in Northeastern United States.

We have recognized the importance of monitoring earthquakes, the Jesuit order in particular, our observing order dating back to 1930, funded entirely until the 1950's by the Jesuit order. Additionally I served last year on the earthquake hazards committee of the Association of Engineering Geologists.

The bill appears to be adequate in its overall emphasis and scope. That there is a critical and timely need for such legislation is clear as evidenced, among others, the increased construction activity in areas of high and moderate seismic risk, the siting of nuclear powerplants throughout the United States and unusually high and devastating seismicity during the past several years in various parts of the world.

The potential for catastrophe exists in many metropolitan areas in the United States should an earthquake of the size of the San Fernando event of 1971 occur in any of them. In this regard although the Eastern United States is commonly, and erroneously believed to be an earthquake free—I refer to data in the data bulletin published by the Northeastern United States Seismic Network.

[The above-mentioned material follows:]

UCONN-NUREG-0208-009

NORTHEASTERN U. S. SEISMIC NETWORK

BULLETIN NO. 4

OF

SEISMICITY OF THE NORTHEASTERN UNITED STATES

July 1, 1976 - September 30, 1976

Compiled and Edited by

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January 1977

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Pennsylvania State University
Delaware Geological Survey

Nuclear Regulatory Commission
United States Geological Survey
National Science Foundation
New York State Energy and Resources Development Authority
New York State Science Service

1.

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The Nuclear Regulatory Commission - Office of Reactor Safety Research,
The United States 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 the Seismic Network operated by the Consolidated Edison Company of New York were provided to NEUSSN and the receipt of these data is gratefully acknowledged.

In addition to the above operational support, equipment was also provided by the Office of Environmental Geology of the U.S. Geological Survey to members of NEUSSN.

The Advanced Research Projects Agency of the Department of Defense provided a number of geophones and amplifiers to all members of NEUSSN.

ABSTRACT

This report is the fourth quarterly bulletin of seismicity in the northeastern United States and covers the period July - September 1976. Included are geographic maps of the seismic station locations, the epicenters for the quarter, and the cumulative epicenters for the four quarters. Also included are table of the station locations and of arrival times, amplitudes, and periods for the fourth quarterly epicenters.

INTRODUCTION

This report is the fourth quarterly bulletin of seismicity in the northeastern United States for the period July - September, 1976. The organizations supplying data for this bulletin are Weston Observatory of Boston College, Lamont-Doherty Geological Observatory of Columbia University, the Massachusetts Institute of Technology, the Pennsylvania State University, the Delaware Geological Survey, and the University of Connecticut. Additional data for earthquakes in southeastern New York and northern New Jersey were supplied by the Consolidated Edison Indian Point network. Arrival time data for events in Canada near the United States were supplied by the Earth Physics Branch, Department of Energy, Mines and Resources, Canada.

Eight seismic stations operating during this reporting period were not listed in the previous bulletin. The eight new stations are TRM-ME, GPD-NJ, ALX-NY, HNY-NY, IPS-NY, WND-NY, BRV-VT, and ESJ-VT. Stations BKH-NY, DHN-NY, GFN-NY, and SSL-PA were not operating during this reporting period. Station WFM-MA was previously listed as WMA. The locations for stations OGD-NJ and LAF-RI have been corrected in this listing. Table I is a list by state, of the stations operating during the period July-September 1976. The format of the information included in the table is as follows:

1. Three letter station code, as recognized by the National Earthquake Information Center of the U.S. Geological Survey (except some codes for the Consolidated Edison and Pennsylvania State stations).
2. Station latitude, degrees-minutes-seconds, north.
3. Station longitude, degrees-minutes-seconds, west.
4. Station elevation, meters.
5. Geographic name of station.
6. Network operator responsible for station.

Figure 1 is a geographic map of the Northeastern U.S. Seismic Network (NEUSSN). In New York, there are three regions of coverage having clusters of stations too dense to represent separately: near Attica in the west, near Blue Mountain Lake

in the north, and the stations of the Indian Point nuclear facility in the southeast.

NORTHEASTERN U.S. SEISMICITY

During the period covered by this bulletin, twenty-four earthquakes were detected and located in the northeastern United States; included in this total are eighteen earthquakes of magnitude less than one in the Blue Mountain Lake region of New York. One earthquake occurred near the coast of Maine and is included in the twenty-four. In addition, three earthquakes occurred in Canada having an epicenter within 100 kilometers of the U.S. border. Figure 2 is a geographic map of the epicenters for July - September, 1976. Table II is a chronological list of the epicenters in Figure 2 with the following format:

1. Date and geographic name of the event.
2. The source of epicenter determination
   LDO - Lamont-Doherty Geological Observatory
   UTC - University of Connecticut
   WES - Weston Observatory
   MIT - Massachusetts Institute of Technology
3. Origin time of the event, hours-minutes-seconds, UTC.
4. Event latitude, degrees north.
5. Event longitude, degrees west.
6. Root-mean-square error of the least-squares solution.
7. Event magnitude. Most magnitudes were computed using the relation developed by Nuttli for the "vertical component Lg wave"; although the wave periods of the events in Table II are often less than one second, the computed magnitudes appear to be consistent within the network. Magnitudes computed using Nuttli's relation are labelled MBN.
8. Event depth, kilometers. If the solution was restrained to a particular depth, the letter R is appended.

For events that have epicenters determined by more than one

source, each of the locations is listed.

EARTHQUAKE DATA

The station arrival times and amplitudes used for epicenter and magnitude calculations are listed in Table III, as well as the information already included in Table II. The format for the additional information in Table III is as follows:

1. Station code.
2. Emergent (E) or impulsive (I), followed by phase type: P, PG, P*, PN, S, SG, S*, SN. If the phase is impulsive, direction of first motion is also included if the system polarity is known: compression (C) or dilatation (D).
3. Station arrival time, hour-minute-second, UTC.
4. Epicentral distance, kilometers. For those events having more than one epicenter reported, the first epicenter listed is used for distances.
5. Peak-to-peak ground motion, in millimicrons, of the maximum recorded amplitude of the vertical-component signal (Rayleigh wave). All reported amplitudes have been corrected for system response.
6. Period, in seconds, of the wave from which the amplitude was measured.
7. Nuttli magnitude as computed from the amplitude, period and distance.

SUSPECTED AND POORLY LOCATED EARTHQUAKES

In addition to the earthquakes listed in Table II, seven events were detected which could not be definitely identified as being earthquakes or not enough arrivals were detected to allow an acceptable computer solution. This class of events is listed in Table IV, which has the same format as Table III.

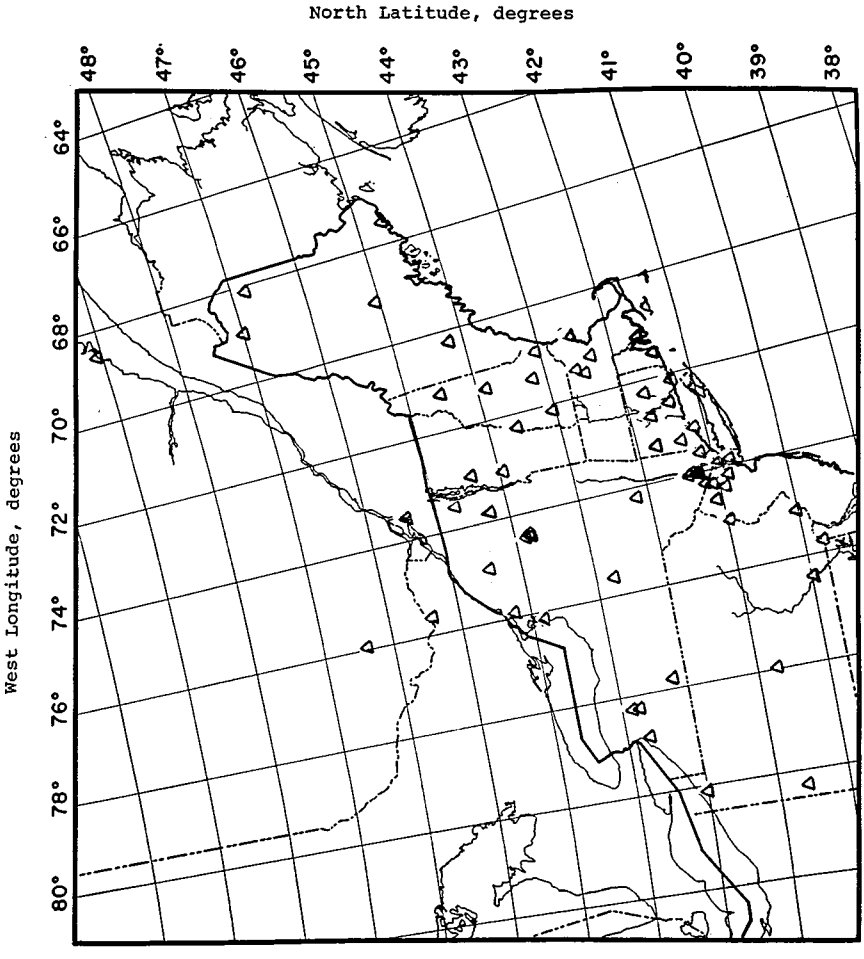

Figure 1. Seismic stations operating during the period July - September 1976.

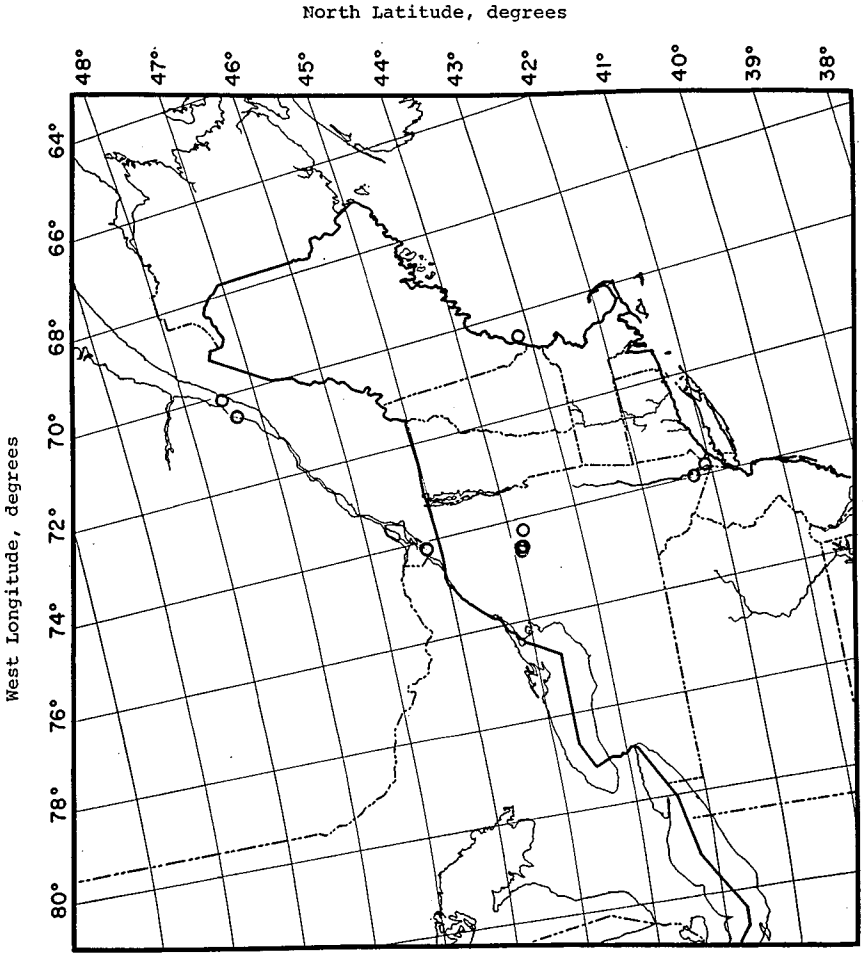

Figure 2. Earthquake epicenters during the period July - September 1976.

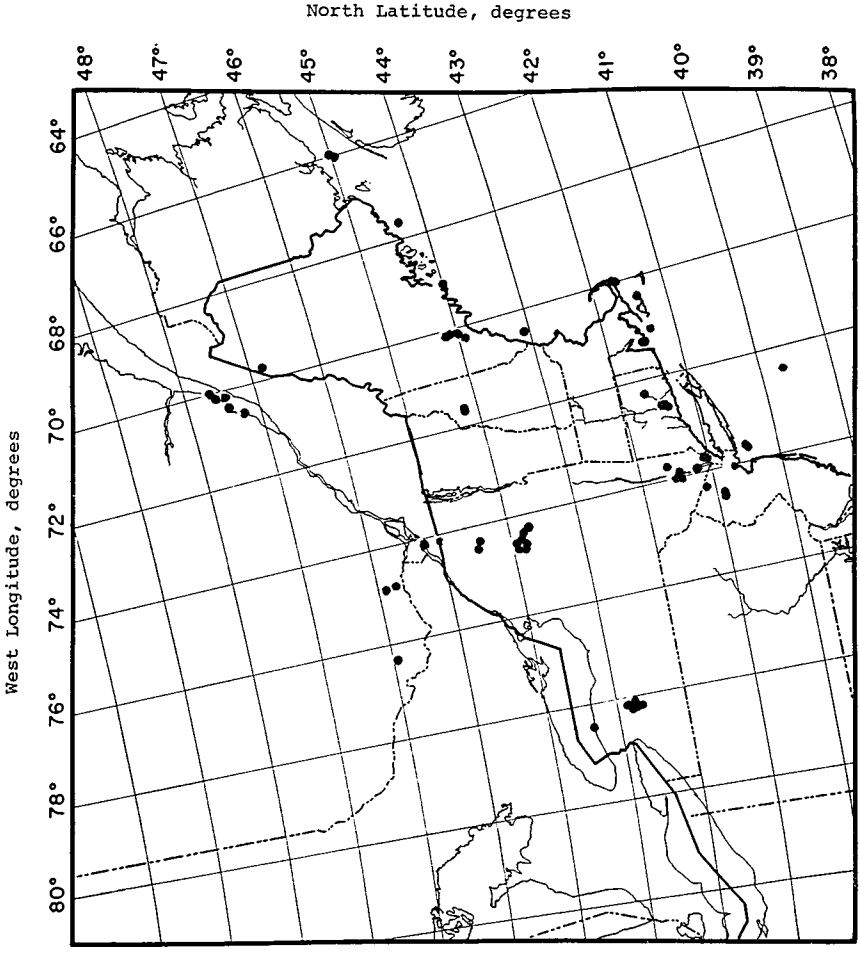

Figure 3. Earthquake epicenters during the period October 1975 - September 1976.

TABLE I
LIST OF OPERATING SEISMIC STATIONS BY STATE
JULY - SEPTEMBER 1976

STA ID	LATITUDE DGMNSEC	LONGITUDE DGMNSEC	ELEVATION METERS		OPERATOR
CANADA, STATIONS USED FOR LOCATIONS IN THIS BULLETIN					
HTV	491124. N	682324. W		HAUTERIVE, QUE.	EPB
MNI	462212. N	755812. W		MANIWAKI, QUE.	EPB
MNQ	503148. N	684612. W		MANICOUAGAN, QUE.	EPB
MNT	453009. N	733723. W	112	MONTREAL, QUE.	EPB
OTT	452338. N	754257. W	83	OTTAWA, ONT.	EPB
CONNECTICUT					
APT	411857.5N	720350.0W	3	AVERY PT., CT.	UCT
BCT	412936. N	732302. W	69	BROOKFIELD CENTER, CT.	UCT
BPT	411319.5N	731432. W	83	BRIDGEPORT, CT.	UCT
ECT	415004.7N	732440.8W	342	ELLSWORTH, CT.	UCT
HDM	412908.8N	723123.6W	24	HADDAM, CT.	UCT
TMT	414841. N	724756. W	290	TALCOTT MT., CT.	UCT
UCT	414954. N	721502. W	149	STORRS, CT.	UCT
DELAWARE					
NED	394215.2N	754229.5W	46	NEWARK, DE	DGS
MAINE					
AGM	470454. N	690124. W	216	ALLAGASH, ME	WES
CBM	465557. N	680715. W	250	CARIBOU, ME	WES
EMM	444421. N	672922. W	20	EAST MACHIAS, ME	WES
MIM	451437. N	690225. W	140	MILO, ME	WES
TRM	441534.9N	701518.3W	113	TURNER, ME	WES
MASSACHUSETTS					
FLR	414300.0N	710717.5W	52	FALL RIVER,MA	WES
GLO	423825. N	704338. W	15	GLOUCESTER,MA	MIT
HRV	423023. N	713330. W	180	HARVARD,MA	MIT
WES	422304.9N	711919.5W	60	WESTON,MA	WES
WFM	423638. N	712926. W	88	WESTFORD,MA	MIT
NEW HAMPSHIRE					
BNH	443526. N	711523. W	472	BERLIN,NH	WES
DNH	430721. N	705341.3W	24	DURHAM,NH	MIT
HNH	434219. N	721708. W	180	HANOVER,NH	MIT
ONH	431645. N	713020. W	280	OAKHILL,CONCORD,NH	MIT
PNH	430539. N	720809. W	659	PITCHER MT.,NH	MIT
WNH	435206. N	712359. W	220	WHITEFACE,NH	MIT

TABLE I. CONT.

NEW JERSEY					
GPD	410103.6N	742739.0W	360	GREENPOND, NJ	LDO
OGD	410515.0N	743545.0W	-363	OGDENSBURG,NJ	LDO
PNJ	405425.5N	740917.4W	31	PATERSON,NJ	
PQN	410026.4N	750509.0W	229	PAHAQUARRY,NJ	LDO
NEW YORK					
ADN	435000.0N	760710.8W	137	ADAMS,NY	LDO
ALF	421331.2N	774749.8W	671	ALFRED,NY	LDO
ALX	441921.0N	755540.8W	122	ALEXANDER BAY,NY	LDO
APH	435028.8N	742949.2W	564	AIRPORT HANGAR,BLUE MTN.,NY	LDO
CLY	435104.8N	742656.4W	579	CRYSTAL LAKE, NY	LDO
CTR	435227.0N	742736.0W	585	CASTLE ROCK,NY	LDO
DNY	425010.8N	781007.8W	381	DERSAM,NY	LDO
EGN	435134.7N	742854.6W	549	EAGLE'S NEST,NY	LDO
ELM	425100.6N	783836.0W	216	ELMA,NY	LDO
FOR	405147.0N	735308.0W	24	FORDHAM,NY	LDO
HNY	424954.6N	753053.4W	500	HAMILTON,NY	LDO
HMB	423916.2N	785109.0W	290	HAMBURG,NY	LDO
MRH	425021.0N	781424.0W	448	MERCHANTS HILL, NY	LDO
OCN	435305.4N	743145.6W	701	OVER CASTLE ROCK,NY	LDO
PAL	410015.0N	735433.0W	91	PALISADES,NY	LDO
PNY	445003.0N	733318.0W	177	PLATTSBURG,NY	LDO
PTN	443421.0N	745858.2W	238	POTSDAM,NY	LDO
TBR	410830.0N	741320.0W	261	TABLEROCK,NY	LDO
WWL	435016.2N	743236.0W	561	UTOWANA LAKE,NY	LDO
WLI	441832.4N	760035.4W	90	WELLESLEY I.,NY	LDO
WND	422015.0N	740909.0W	602	WINDHAM,NY	LDO
WNY	442327.6N	735134.2W	598	WILMINGTON,NY	LDO
WPR	411516.8N	733508.4W	152	WARD POUND RIDGE,NY	LDO
BLM*	411947. N	735718. W	134	BLUM,NY	CON
CHR*	411229. N	741316. W	183	CALLS HOLLOW ROAD,NY	CON
DBM*	411740. N	735830. W	27	DUNDERBURG MTN.,NY	CON
DPL*	411510. N	735439. W	67	DELLI PAOLI, NY	CON
GOB*	411946. N	735519. W	150	GOBBELET,NY	CON
GSC*	411558. N	740014. W	110	GIRL SCOUT CAMP,NY	CON
IPS*	411602. N	735654. W			CON
OSB*	412137. N	735526. W	212	OSBORN,NY	CON
SNP*	411427. N	735816. W	30	STONEY POINT,NY	CON
SPS*	411807. N	735326. W	168	ST. PETERS SCHOOL,NY	CON
SRM*	411342. N	740050. W	165	SCHERMAN,NY	CON
STL*	411119. N	740013. W	125	STILES,NY	CON
WGL*	412132. N	735358. W	152	WEGEL,NY	CON

TABLE I. CONT. PAGE 3 OF 3

* CONSOLIDATED-EDISON, INDIAN POINT SEISMIC NETWORK, POLARITY UNKNOWN
* STATION CODES NOT ALL CLEARED THROUGH NEIC

PENNSYLVANIA

BVR	4042	N	8020	W		BEAVER,PA	PSU
ERI	4208	N	7959	W		ERIE,PA	PSU
MLV	395930.	N	7622	W		MILLERSVILLE,PA	PSU
PHI	4007	N	7508	W		ABINGTON,PA	PSU
SCP	404742.0	N	775154.0	W	352	STATE COLLEGE,PA	PSU

RHODE ISLAND

LAF	413403.	N	713024.	W	40	LAFAYETTE,RI	UCT

VERMONT

ESJ	443112.	N	730154.	W		ESSEX JUNCTION,VT	LDO
MDV	435957.	N	731052.2	W	134	MIDDLEBURY,VT	LDO

OPERATOR CODE

CON -CONSOLIDATED-EDISON, INDIAN POINT,NY
DGS -DELAWARE GEOLOGICAL SURVEY
EPB -EARTH PHYSICS BRANCH,DEPT. OF ENERGY, MINES AND RESOURCES, CANADA
LDO -LAMONT-DOHERTY GEOLOGICAL OBSERVATORY OF COLUMBIA UNIVERSITY
MIT -MASSACHUSETTS INSTITUTE OF TECHNOLOGY
PSU -PENNSYLVANIA STATE UNIVERSITY
UCT -UNIVERSITY OF CONNECTICUT
WES -WESTON OBSERVATORY-BOSTON COLLEGE

TABLE II

EPICENTER LIST
NORTHEASTERN UNITED STATES
AND ADJACENT REGIONS
JULY - SEPTEMBER 1976

SOURCE	H-TIME(UTC) HR MN SEC	LATITUDE DEG	LONGITUDE DEG	RMS	MAGNITUDE	DEPTH KM
01 JUL	BLUE MOUNTAIN LAKE,NEW YORK					
*LDO	07 15	43.86N	74.48W		MBN =1	
01 JUL	BLUE MOUNTAIN LAKE,NEW YORK					
*LDO	09 44	43.86N	74.48W		MBN =1	
04 JUL	BLUE MOUNTAIN LAKE,NEW YORK					
*LDO	09 50	43.86N	74.48W		MBN =1	
05 JUL	BLUE MOUNTAIN LAKE,NEW YORK					
*LDO	10 58	43.86N	74.48W		MBN =1	
11 JUL	ST.LAWRENCE VALLEY,QUEBEC					
*WES	05 15 04.3	47.37N	70.26W	0.47SEC	MBN=2.4UCT OR	
13 JUL	VALLEYFIELD,QUEBEC INT.V					
*LDO	03 51 14.0	45.18N	74.10W	0.17SEC	MBN=2.9	
*WES	03 51 14.0	45.29N	74.06W	0.98SEC	MBN=3.0UCT OR	
15 JUL	BLUE MOUNTAIN LAKE,NEW YORK					
*LDO	08 57	43.86N	74.48W		MBN=1	
19 JUL	BLUE MOUNTAIN LAKE,NEW YORK					
*LDO	07 37	43.86N	74.48W		MBN=1	
20 JUL	BLUE MOUNTAIN LAKE,NEW YORK					
*LDO	05 56	43.86N	74.48W		MBN=1	
21 JUL	BLUE MOUNTAIN LAKE,NEW YORK					
*LDO	20 58	43.86N	74.48W		MBN=1	
23 JUL	BLUE MOUNTAIN LAKE,NEW YORK					
*LDO	09 31	43.86N	74.48W		MBN=1	
25 JUL	BLUE MOUNTAIN LAKE,NEW YORK					
*LDO	03 58	43.86N	74.48W		MBN=1	
28 JUL	OFF COAST SOUTHWESTERN MAINE					
*WES	02 04 34.8	43.16N	70.24W	0.9 SEC	MBN=2.3UCT OR	
*MIT		43.15N	70.32W			OR
01 AUG	BLUE MOUNTAIN LAKE,NEW YORK					
*LDO	03 58	43.86N	74.48W		MBN=1	

TABLE II,CONT. PAGE 2 OF 2

02 AUG	BLUE MOUNTAIN LAKE,NEW YORK						
*LDO	18 45	43.86N	74.48W		MBN < 1		
03 AUG	ST.LAWRENCE VALLEY,QUEBEC						
*WES	02 57 15.5	47.58N	70.06W	0.24SEC			OR
14 AUG	BLUE MOUNTAIN LAKE,NEW YORK						
*LDO	10 44	43.86N	74.48W		MBN < 1		
19 AUG	RAQUETTE LAKE,NEW YORK						
*LDO	15 47 53.6	43.89N	74.64W	0.00SEC			4
20 AUG	MOUNT PLEASANT,NEW YORK						
*LDO	22 08 14.3	41.11N	73.75W	0.15SEC	MBN=2.5		6
21 AUG	RAQUETTE LAKE,NEW YORK						
*LDO	14 00 12.5	43.89N	74.66W	0.3 SEC			1.4
12 SEP	BLUE MOUNTAIN LAKE,NEW YORK						
*LDO	19 15	43.86N	74.48W		MBN < 1		
16 SEP	BLUE MOUNTAIN LAKE,NEW YORK						
*LDO	08 34	43.86N	74.84W		MBN < 1		
16 SEP	BLUE MOUNTAIN LAKE,NEW YORK						
*LDO	13 37	43.86N	74.84W		MBN < 1		
18 SEP	SOUTHEAST OF BLUE MOUNTAIN LAKE,NEW YORK						
*LDO	01 15 23.0	43.82N	74.20W	0.21SEC	MBN=1.6		
20 SEP	BLUE MOUNTAIN LAKE,NEW YORK						
*LDO	10 44	43.86N	74.48W		MBN < 1		
21 SEP	BLUE MOUNTAIN LAKE,NEW YORK						
*LDO	21 29	43.86N	74.48W		MBN < 1		
22 SEP	INDIAN POINT,NEW YORK						
*LDO	09 04 44.9	41.29N	73.95W	0.04SEC	MBN=1.8		8

* SOURCE
DGS - DELAWARE GEOLOGICAL SURVEY
EPB - EARTH PHYSICS BRANCH,DEPT.OF ENERGY,MINES AND RESOURCES
LDO - LAMONT-DOHERTY GEOLOGICAL OBSERVATORY OF COLUMBIA UNIV.
MIT - MASSACHUSETTS INSTITUTE OF TECHNOLOGY
PSU - PENNSYLVANIA STATE UNIVERSITY
UCT - UNIVERSITY OF CONNECTICUT
WES - WESTON OBSERVATORY - BOSTON COLLEGE

TABLE III

EARTHQUAKE DATA LIST
NORTHEASTERN UNITED STATES
AND ADJACENT REGIONS
JULY - SEPTEMBER 1976

SOURCE	H-TIME (UTC) HR MN	SEC	LATITUDE DEG	LONGITUDE DEG	RMS	MAGNITUDE	DEPTH KM
01 JUL	BLUE MOUNTAIN LAKE, NEW YORK						
*LDO	07 15		43.86N	74.48W		MBN < 1	
01 JUL	BLUE MOUNTAIN LAKE, NEW YORK						
*LDO	09 44		43.86N	74.48W		MBN < 1	
04 JUL	BLUE MOUNTAIN LAKE, NEW YORK						
*LDO	09 50		43.86N	74.48W		MBN < 1	
05 JUL	BLUE MOUNTAIN LAKE, NEW YORK						
*LDO	10 58		43.86N	74.48W		MBN < 1	
11 JUL	ST. LAWRENCE VALLEY,QUEBEC						
*WES	05 15	04.3	47.37N	70.26W	0.47SEC	MBN=2.4 UCT OR	
AGM EPG	05 15	20. 0		99KM			
AGM EPN	05 15	22. 0		99KM			
AGM ESG	05 15	32. 3		99KM			
CBM EPN	05 15	31. 2		169KM			
CBM EPG	05 15	33. 1		169KM			
CBM ESN	05 15	50. 1		169KM			
CBM ESG	05 15	52. 4		169KM			
BNH EPN	05 15	49. 5		318KM			
BNH ESN	05 16	22. 4		318KM			
EMM EPN	05 15	54. 1		363KM			
EMM ESN	05 16	32. 2		363KM			
UCT				636KM	5MU 0.4 SEC	MBN=2.33	
TMT				650KM	6MU 0.5 SEC	MBN=2.36	
ECT				664KM	4MU 0.4 SEC	MBN=2.36	
HDM				678KM	5MU 0.4 SEC	MBN=2.37	
BCT				699KM	6MU 0.4 SEC	MBN=2.49	
13 JUL	VALLEYFIELD,QUEBEC INT.V						
*LDO	03	51 14.0	45.18N	74.10W	0.17 SEC	MBN=2.9	
*WES	03	51 14.0	45.29N	74.06W	0.98 SEC	MBN=3.0 UCT OR	
MNT EPGD	03	51 22.3		52KM			
MNT ESG	03	51 28.7		52KM			
PNY EPGC	03	51 23.1		55KM			
PTN EP D	03	51 29.1		97KM			
OTT EP	03	51 34.0		129KM			
OTT ES	03	51 49.4		129KM			
CTR EP D	03	51 36.7		148KM			
OCN EP C	03	51 36.9		148KM			
MDV EP	03	51 37.0		150KM			

TABLE III. CONT. PAGE 2 OF 5

EGN	EP	D	03	51	37.1	150KM			
CLY	EP	D	03	51	37.2	150KM			
APH	EP	D	03	51	37.4	152KM			
UWL	EP	C	03	51	37.7	153KM			
WLI	EP	D	03	51	41.7	180KM			
MNI	EP		03	51	44.5	197KM			
ADN	EP	D	03	51	47.5	220KM			
HNH	EPN		03	51	48.1	226KM			
HNH	EPG		03	51	51.0	226KM			
HNH	ESN		03	52	12.2	226KM			
BNH	EPN		03	51	49.7	235KM			
BNH	EPG		03	51	52.1	235KM			
BNH	ESN		03	52	16.5	235KM			
BNH	ESG		03	52	19.7	235KM			
ECT	EPN		03	52	09.8	388KM			
ECT	EP*		03	52	13.4	388KM			
TMT	EPN		03	52	10.1	400KM	95MU	0.5SEC	MBN=3.23
UCT						401KM	48MU	0.4SEC	MBN=3.03
BCT	EPN		03	52	12.1	426KM			
BCT	EP*		03	52	20.7	426KM			
AGM	EPG		03	52	25.6	437KM			
AGM	ESN		03	52	57.1	437KM			
HDM	EPN		03	52	13.2	441KM			
HDM	EP*		03	52	23.3	441KM			
BPT						445KM	32MU	0.6SEC	MBN=2.72
CBM	EPN		03	52	20.7	494KM			
EMM	EPN		03	52	23.7	522KM			
EMM	ESN		03	53	16.2	522KM			
EMM	ESG		03	53	42.1	522KM			

15 JUL BLUE MOUNTAIN LAKE,NEW YORK
*LDO 08 57 43.86N 74.48W MBN < 1

19 JUL BLUE MOUNTAIN LAKE,NEW YORK
*LDO 07 37 43.86N 74.48W MBN < 1

20 JUL BLUE MOUNTAIN LAKE,NEW YORK
*LDO 05 56 43.86N 74.48W MBN < 1

21 JUL BLUE MOUNTAIN LAKE,NEW YORK
*LDO 20 58 43.86N 74.48W MBN < 1

23 JUL BLUE MOUNTAIN LAKE,NEW YORK
*LDO 09 31 43.86N 74.48W MBN < 1

25 JUL BLUE MOUNTAIN LAKE,NEW YORK
*LDO 03 58 43.86N 74.48W MBN < 1

28 JUL OFF COAST SOUTHWESTERN MAINE

*WES	02	04	34.8	43.16N	70.24W	0.9 SEC	MBN=2.3UCT	OR
*MIT				43.15N	70.32W			OR
DNH	EPG	02	04	42.6	53KM			
DNH	ESG	02	04	49.6	53KM			
GLO	IPG	02	04	44.5	70KM			
GLO	ESG	02	04	53.0	70KM			

TABLE III. CONT. PAGE 3 OF 5

WFM	IP	02	04	52.9	119KM			
WFM	ES	02	05	08.6	119KM			
WNH	EP	02	04	54.3	122KM			
WNH	ES	02	05	08.8	122KM			
WES	EP*	02	04	55.0	124KM			
WES	ES*	02	05	08.9	124KM			
HRV	EP	02	04	55.5	130KM			
HRV	ES	02	05	10.9	130KM			
PNH	IP	02	04	59.1	154KM			
PNH	ES	02	05	17.4	154KM			
FLR	ESN	02	05	22.9	176KM			
HNH	ESN	02	05	22.8	176KM			
BNH	EPN	02	05	01.5	179KM			
BNH	ESN	02	05	23.9	179KM			
BNH	ESG	02	05	25.2	179KM			
UCT	EPN	02	05	08.9	222KM	9MU	0.3SEC	MBN=2.26
UCT	ESN	02	05	33.6	222KM			
UCT	ESG	02	05	37.5	222KM			
TMT					258KM	7MU	0.4SEC	MBN=2.09
HDM	EP*	02	05	16.6	265KM	6MU	0.3SEC	MBN=2.19
HDM	ESG	02	05	48.2	265KM			
EMM	EPN	02	05	16.7	282KM			
EMM	ES*	02	05	51.0	282KM			
ECT	EP*	02	05	22.3	299KM	5MU	0.1SEC	MBN=2.50
ECT	ESN	02	05	48.6	299KM			

01 AUG BLUE MOUNTAIN LAKE,NEW YORK

*LDO	03	58	43.86N	74.48W		MBN = 1

02 AUG BLUE MOUNTAIN LAKE,NEW YORK

*LDO	18	45	43.86N	74.48W		MBN = 1

03 AUG ST.LAWRENCE VALLEY,QUEBEC

*WES	02	57	15.5	47.58N	70.06W	0.24SEC	OR
AGM	EPG	02	57	31.3	96KM		
AGM	ESG	02	57	42.7	96KM		
CBM	EPN	02	57	41.7	163KM		
CBM	ESN	02	58	00.2	163KM		
EMM	EPN	02	58	07.0	373KM		
EMM	ESN	02	58	45.5	373KM		

14 AUG BLUE MOUNTAIN LAKE,NEW YORK

*LDO	10	44	43.86N	74.48W		MBN = 1

19 AUG RAQUETTE LAKE,NEW YORK

*LDO	15	47	53.6	43.89N	74.64W	0.000SEC	4
APH	EPGD	15	47	55.7	13KM		
APH	ESG	15	47	57.4	13KM		
OCN	EPGD	15	47	55.1	9KM		
OCN	ESG	15	47	56.3	9KM		
EGN	EPGD	15	47	55.7	13KM		
EGN	ESG	15	47	57.5	13KM		
CTR	EPG	15	47	56.0	15KM		
CTR	ESG	15	47	57.9	15KM		
CLY	EPGD	15	47	56.2	16KM		
CLY	ESG	15	47	58.3	16KM		

TABLE III.CONT. PAGE 4 OF 5

20 AUG	MOUNT PLEASANT,NEW YORK								
*LDO	22	08	14.3	41.11N	73.75W	0.15SEC	MBN=2.5	6	
PAL	EPGD	22	08	17.6	18KM				
PAL	ESG	22	08	19.8	18KM				
BLM	ESG	22	08	22.7	20KM				
WPR	EPGD	22	08	17.9	21KM				
WPR	ESG	22	08	20.5	21KM				
DPL	EPG	22	08	18.0	21KM				
DPL	ESG	22	08	20.6	21KM				
SNP	EPG	22	08	18.4	24KM				
SNP	ESG	22	08	21.3	24KM				
IPS	EPG	22	08	18.4	24KM				
IPS	ESG	22	08	21.4	24KM				
DBM	EPG	22	08	19.0	26KM				
GOB	EPG	22	08	19.0	28KM				
GSC	EPG	22	08	19.0	32KM				
GSC	ESG	22	08	22.3	32KM				
BCT	IPGD	22	08	22.7	33KM				
BCT	ESG	22	08	28.8	33KM				
BPT	IPGD	22	08	21.7	44KM				
BPT	ESG	22	08	27.0	44KM				
CHR	EPG	22	08	19.1	44KM				
CHR	ESG	22	08	22.5	44KM				
TBR	EPGD	22	08	20.6	47KM				
TBR	ESG	22	08	25.3	47KM				
ECT	IPGC	22	08	27.9	85KM				
ECT	ESG	22	08	37.6	85KM				
TMT	EPG	22	08	32.2	111KM	23MU 0.2 SEC	MBN=2.50		
PQN	EPGC	22	08	32.1	119KM				
PQN	ESG	22	08	45.1	119KM				
HDM	IPGD	22	08	32.0	130KM	41MU 0.2 SEC	MBN=2.83		
HDM	ESG	22	08	44.3	130KM				
UCT	EP	22	08	37.7	149KM	25MU 0.2 SEC	MBN=2.76		
21 AUG	RAQUETTE LAKE, NEW YORK								
*LDO	14	00	12.5	43.89N	74.66W	0.3 SEC		1.4	
OCN	EPGD	14	00	14.2	11KM				
OCN	ESG	14	00	15.4	11KM				
APH	EPGD	14	00	14.8	14KM				
APH	ESG	14	00	16.5	14KM				
EGN	EPGD	14	00	14.8	15KM				
EGN	ESG	14	00	16.6	15KM				
CTR	EPG	14	00	15.1	16KM				
CTR	ESG	14	00	17.0	16KM				
CLY	EPGD	14	00	15.3	18KM				
CLY	ESG	14	00	17.4	18KM				
12 SEP	BLUE MOUNTAIN LAKE,NEW YORK								
*LDO	19	15		43.86N	74.48W		MBN = 1		
16 SEP	BLUE MOUNTAIN LAKE,NEW YORK								
*LDO	08	34		43.86N	74.48W		MBN = 1		

TABLE III.CONT. PAGE 5 OF 5

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16 SEP    BLUE MOUNTAIN LAKE,NEW YORK
*LDO    13 37        43.86N    74.48W                    MBN = 1

18 SEP    SOUTHEAST OF BLUE MOUNTAIN LAKE,NEW YORK
*LDO    01 15 23.0  43.82N    74.20W   0.21SEC  MBN=1.6    0
  CLY EPGD 01 15 26.2       20KM
  CLY ESG  01 15 28.7       20KM
  CTR EPGD 01 15 26.5       22KM
  CTR ESG  01 15 29.1       22KM
  EGN EPGD 01 15 26.7       23KM
  EGN ESG  01 15 29.5       23KM
  WNY ESG  01 15 42.9       69KM
  MDV EPG  01 15 36.7       84KM
  MDV ESG  01 15 46.8       84KM

20 SEP    BLUE MOUNTAIN LAKE,NEW YORK
*LDO    10 44        43.86N    74.48W                    MBN = 1

21 SEP    BLUE MOUNTAIN LAKE,NEW YORK
*LDO    21 29        43.86N    74.48W                    MBN = 1

22 SEP    INDIAN POINT,NEW YORK
*LDO    09 04 44.9  41.29N    73.95W   0.04SEC  MBN=1.8    8
  DBM EPGC 09 04 46.3        2KM
  DBM ESG  09 04 47.3        2KM
  IPS IPGC 09 04 46.3        3KM
  IPS ESG  09 04 47.2        3KM
  BLM IPGC 09 04 46.5        4KM
  BLM ESG  09 04 47.6        4KM
  DPL IPGC 09 04 46.5        5KM
  DPL ESG  09 04 47.6        5KM
  SPS IPGC 09 04 46.5        5KM
  SPS ESG  09 04 47.7        5KM
  GOB IPGC 09 04 46.5        5KM
  GOB ESG  09 04 47.7        5KM
  SNP IPGC 09 04 46.4        6KM
  SNP ESG  09 04 47.6        6KM
  OSB IPGC 09 04 46.9        8KM
  OSB ESG  09 04 48.3        8KM
  WGL EPG  09 04 46.9        9KM
  WGL ESG  09 04 48.4        9KM
  CHR IPGC 09 04 47.3       24KM
  CHR ESG  09 04 49.0       24KM
  TBR IPGD 09 04 49.5       28KM
  WPR IPGD 09 04 50.1       31KM
  WPR ESG  09 04 53.9       31KM
  GPD IPGD 09 04 53.4       52KM

*SOURCE
 DGS - DELAWARE GEOLOGICAL SURVEY
 EPB - EARTH PHYSICS BRANCH, DEPT. OF ENERGY,MINES AND RESOURCES,CANADA
 LDO - LAMONT-DOHERTY GEOLOGICAL OBSERVATORY OF COLUMBIA UNIVERSITY
 MIT - MASSACHUSETTS INSTITUTE OF TECHNOLOGY
 PSU - PENNSYLVANIA STATE UNIVERSITY
 UCT - UNIVERSITY OF CONNECTICUT
 WES - WESTON OBSERVATORY - BOSTON COLLEGE
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TABLE IV

SUSPECTED AND POORLY LOCATED EARTHQUAKES
NORTHEASTERN UNITED STATES
AND ADJACENT REGIONS
JULY - SEPTEMBER 1976

SOURCE	H-TIME(UTC) HR MN SEC	LATITUDE DEG	LONGITUDE DEG	RMS	MAGNITUDE	DEPTH KM
12 JUL	BAY OF FUNDY					
*WES	22 52 43.1	44.89N	66.40W	2.42SEC		OR
EMM EPG	22 53 00.6		88KM			
EMM ESG	22 53 06.3		88KM			
CBM EPN	22 53 18.5		264KM			
CBM ESN	22 53 50.9		264KM			
AGM ESN	22 54 01.6		318KM			
16 JUL	LAKE ONTARIO					
*LDO	18 57 29.9	43.99N	77.86W	0.26SEC		0
ADN EPG	18 57 51.5		141KM			
ADN ESG	18 58 08.3		141KM			
WLI EP	18 57 53.4		152KM			
WLI ES	18 58 11.1		152KM			
02 AUG	NEAR EASTPORT MAINE					
*WES	05 14 47.5	44.85N	66.93W	0.00SEC		OR
EMM EPG	05 14 55.0		46KM			
EMM ESG	05 15 00.5		46KM			
CBM ESN	05 15 50.9		250KM			
03 AUG	NORTHERN NEW BRUNSWICK					
*WES	00 44 39.5	46.87N	66.88W	1.46SEC		OR
CBM EPG	00 44 53.3		95KM			
CBM EP*	00 44 54.6		95KM			
CBM EPN	00 44 55.0		95KM			
CBM ESG	00 45 07.3		95KM			
CBM ESN	00 45 10.6		95KM			
AGM EPN	00 45 04.7		165KM			
AGM EP*	00 45 07.7		165KM			
AGM ESG	00 45 26.8		165KM			
EMM EPN	00 45 17.0		242KM			
EMM EPG	00 45 21.1		242KM			
EMM ESG	00 45 46.5		242KM			
30 AUG	ST.LAWRENCE RIVER VALLEY,QUEBEC					
*WES	00 30 38.8	47.65N	69.77W	0.19SEC		OR
AGM EPG	00 30 52.5		85KM			
AGM ESG	00 31 03.0		85KM			
CBM EPN	00 31 02.9		148KM			
CBM ESN	00 31 20.1		148KM			

TABLE IV,CONT. PAGE 2 OF 2

15 SEP ATTICA,NEW YORK
*LDO 08 32
DHN EPGD 08 32 31.5
DHN ESG 08 32 32.3
DNY EPGD 08 32 31.7
DNY ESG 08 32 32.6

16 SEP EDWARDS,NEW YORK
*LDO 06 51 07.1 44.38N 75.29W 0.33SEC MBN=1.7 6
PTN EPG 06 51 12.4 32KM
PTN ESG 06 51 16.6 32KM
ALX EPG 06 51 15.3 51KM
ALX ESG 06 51 21.8 51KM
CTR EPGD 06 51 20.1 87KM
CTR ESG 06 51 31.7 87KM

* SOURCE
DGS - DELAWARE GEOLOGICAL SURVEY
EPB - EARTH PHYSICS BRANCH, DEPT.OF ENERGY,MINES AND RESOURCES,CANADA
LDO - LAMONT-DOHERTY GEOLOGICAL OBSERVATORY OF COLUMBIA UNIVERSITY
MIT - MASSACHUSETTS INSTITUTE OF TECHNOLOGY
PSU - PENNSYLVANIA STATE UNIVERSITY
UCT - UNIVERSITY OF CONNECTICUT
WES - WESTON OBSERVATORY - BOSTON COLLEGE

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5	Dr. M. Nafi Toksoz, Massachusetts Institute of Technology
5	Dr. Yash P. Aggarwal, Lamont-Doherty Geological Observatory
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5	Dr. Ken Woodruff, Delaware Geological Survey
5	Dr. Peter Basham, Earth Physics Branch, Canada
1	Consolidated Edison of New York
15	Dr. Paul Pomeroy, New York State Geologist and Coordinator NEUSSN.

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I can furnish this for the subcommittee. This is one of the quarterly bulletins published during the last couple of years by the Northeast Seismic Network. The population density in the East, the older types of construction in many cities, the relative number of nuclear powerplants in operation or planned, and the lack of earthquake awareness on the part of the citizenry, all make the Eastern and particularly the Northeastern United States very susceptible to the ill effects of earthquakes.

It is for these reasons that sufficient emphasis and support be given in the administration of the bill to research programs directed toward understanding the seismotectonic processes in that section of the country, as well as to the Western United States where the seismic problem is obvious.

Just as the bill points out that it is not desirable to concentrate in one place the expertise required to address the many facets of earthquake hazard reduction, so too it is not desirable to concentrate in one place the storage and distribution of physical data related to earthquakes. Therefore consideration should be given to the concept of regional data centers, which would encourage the involvement of and stimulate those researchers most familiar with the seismotectonic processes in their own areas, and would provide more immediate access to those data appropriate for the region than has been the case in the past several years up to the present.

Advances in earthquake prediction require a prior knowledge of fault locations and a sufficient amount and accuracy of earthquake locations to determine which faults may be active, if not known from geologic observations.

In California and to a lesser degree in the entire Western United States the larger fault zones have been mapped and there is a large amount of information as to what faults are known or may be active.

This unfortunately is not the case in much of the Eastern United States. May I offer as an illustration of the Boston region, a map prepared by the U.S. Geological Survey? This is the kind of map that will look familiar to the members of the subcommittee from California.

This new map of the Boston region shows it to be at least as much faulted as comparable areas in southern California and is indicative of faulting in the region. We do not know which of these faults or other structures may be responsible for the earthquakes that are recorded in this region. To remedy this lack of fundamental seismotectonic data we recommend that basic mapping of the geology be carried out on a continuing basis.

But vast areas in New England and much of the east coast is lacking this important data base upon which to build an adequate earthquake hazards reduction program. Limitations of funding in recent years and other priorities than earthquake hazard reduction have limited the amount of such basic mapping particularly in the eastern two thirds of the United States.

Fortunately the use of aerial geophysical surveys and the use of satellite images—Landsat—can help speed the process. The development of such maps as the Boston Sheet proceeding along with the acquisition of more precise locations of earthquake from improved permanent and portable seismograph networks will enable the identification of active faults in the region.

The information on regional geology also is necessary for, and is part of, the development of regional tectonic studies. These studies subdivide regions into areas of differing geologic histories and movements. It is this information when fully integrated with the earthquake history of a region and the effects and intensity of the earthquakes that results in seismic zoning or microregionalization.

Regional geologic and tectonic studies are critical to the program in the eastern United States. We suggest that an expanded program similar to that at Weston will assist in assessing needs and means for earthquake hazards reduction in the Northeastern United States. These will include cooperative programs with university, private industry, State, regional and Federal agencies to acquire the necessary information.

Some of our staff, members of APGS, and other groups as well, have played a role in developing building codes in Boston and as input to the national building codes developed by the Association of Engineering Geologists. These are cited for the reason that they are examples of what various private sector and public sector agencies can provide by way of input.

One of the problems of the past and present is that while there are many very excellent geoscientists on the east coast as well as elsewhere in the country, they have been trained and specialized in fields that only indirectly contribute to the types of studies mentioned. There is a shortage of people in Eastern United States with the proper background for the kinds of regional studies that are required. A program such as that envisioned by H.R. 35 can only be successful if it addresses, at least in part, the question of training of geoscientists in field geology and geophysics.

Concerning the level of funding, it appears to be sufficient, provided that higher priority be given, at least initially, to physical studies and to structural studies. In this way, as full an understanding as possible of the various physical processes and their associated effects can be obtained before bringing to full support levels those programs for social, legal and economic research and for implementation.

We believe that the agency or agencies which administer the program should be selected on the basis of proven capability of enlisting the considerable expertise required by the program and available in the several sectors of our society. We suggest that the programs be carried out not only by Federal agencies but that State, regional, and local agencies, universities, and private industry in all parts of the Nation be given an expanded role based on competence.

Thank you very much.

Mr. BROWN. Thank you very much, Dr. Skehan.

Did Dr. Chiburis have anything he wanted to add?

Dr. CHIBURIS. No.

Mr. BROWN. Mr. Dornan?

Mr. DORNAN. On the map of the Boston area, it looks as though there are more faults than any given part of southern California area. How similar or dissimilar are these faults to the ones in California?

Dr. SKEHAN. The ones in the Boston area are, for the most part, faults that we interpret as having been developed deep within the crust

of the Earth prior to erosion of a thickness of some several miles or so of sediment.

We think the type of structure that is exposed here is fairly dissimilar, at least in the characteristics of the rocks that are exposed widely over the surface, to those in California. We believe that the processes that are going on at some miles beneath the surface of California are those that are producing features similar to those which are now exposed at the surface of this eastern Massachusetts area and rather widely over some of the older rock terrain of eastern North America.

Mr. DORNAN. Congressman Anderson in his statement mentioned the Cape Ann, Mass., earthquake of 1755. What type of a seismographic power did that earthquake have?

Dr. SKEHAN. There were no seismographs at that time. There are verbal accounts only with respect to the 1755 earthquake. However, there are studies that have been going on rather extensively in connection with the hearings concerned with Pilgrim 2, the Plymouth nuclear power plant siting question and exhaustive studies have been made of the Cape Ann region and the literature that is extant relating to those.

The general conclusion is that the earthquake has to be interpreted as probably in the range of intensity VIII or magnitude 6, or possibly 5. I might point out also that nearby in the St. Lawrence River region, say 100 miles or so from northern Maine, there have occurred in the 1920's a couple of earthquakes in the range of 7 and 7.2 that are certainly therefore in the range of the 1971 San Fernando quake.

The Grand Banks earthquake of 1929, I believe it was, was in the same range of intensity, producing tidal waves in the Burin Peninsula of Newfoundland and smaller tidal waves in Maine.

Mr. DORNAN. Where is Cape Ann?

Dr. SKEHAN. Just north of Boston. On this particular map it would be located at this particular point [indicating].

Dr. SKEHAN. The best epicenter location that can be devised from all the records we know to date would place that particular earthquake just offshore. If I might, that brings up a point with respect to an interpretation of the cause of earthquakes that may be relevant to the Charleston area and to the New England earthquake scene. There is a growing body of evidence, although certainly not conclusive at this time, to suggest that the cause of earthquakes in these regions may possibly be related to an unlocking of igneous plutons of greater density from the country rock in which they are encased. Stresses built up in the individual plutons may be released in the vicinity of these individual plutons as earthquakes. These plutons are igneous rock bodies that are essentially cylindrical masses of higher density and therefore of contrasting properties to the bedrock in which they are encased, the enclosing bedrock having had its stresses released long ago. This is one possibility that I think it is worthy of a great deal more research to determine whether or not earthquakes can be predicted not only as to location but also in terms of time.

Mr. DORNAN. Not coming from what is generally known as earthquake country, do you have the same stringent building standards as we have in California? I was in Boston some years ago and one of

your largest glass insurance buildings was shedding the outside glass the way that a fall tree should be shedding leaves.

I wondered what would happen under an earthquake situation with a building like that.

Dr. SKEHAN. I am sure there would be a lot more windows lost under such a situation. Certainly oscillations or vibrations of the kind in the Cape Ann quake would cause tremendous damage. The facades of these buildings, the ornaments attached to the buildings in that case would produce significant damage and probably even a large number of deaths.

Mr. DORNAN. Do you have surveys going on now to assess the weaknesses of your older buildings? I recall in New York City a hotel just collapsed like a deck of cards a few years ago. It was older and going through a condemnation process so tragically it was just older, senior citizens involved in the death toll. But certainly a building like that, without an earthquake just collapsing from old age would go down instantly in an earthquake situation.

Dr. SKEHAN. To my knowledge there is no program at all to look at the problem of the integrity of different structures in most parts of the East.

Mr. DORNAN. Again maybe in the context of civil defense preparedness for the horror of a nuclear war, it might turn up a lack of safety standards that could prevent a high death toll in a natural disaster.

Dr. SKEHAN. I might mention that there are areas that selectively feel the effects of some of the local earthquakes in New England. For instance, in the 1920's, there was a earthquake in the Canadian area, the area that I mentioned before. For the most part the eastern part of the United States is built on fairly dense rock providing a sound building foundation.

There are other areas of filled in land which vibrate quite like a bowl of jelly and the filled in portions of Boston felt the vibrations of those larger earthquakes in the twenties rather severely and produced quite a bit of panic on the part of people in those structures.

So there is a need for considering building codes selectively on the type of foundation material which is involved as foundation material. I think it might impose quite a hardship were uniform building codes imposed without reference to the rocks on which the buildings sit.

Mr. BROWN. I want to thank you particularly for your testimony as it relates to indicating that this is a national rather than a regional problem. I think that emphasis needs to be made. And your emphasis of the need for training of additional geoscientists which obviously is implied with the initiation of any major new program in this area is appreciated also.

I would like to ask this: You have commented on the utility of the photographs which came out of the advances in the space photography over the last 15 years. Other developments have occurred over that period of time. I wondered if you could make a comment with regard to the relevance of these scientific advances to the need for this legislation?

In other words, have we reached a period of scientific breakthrough where a stronger program in this area can be justified from these scientific advances?

Dr. SKEHAN. Perhaps Professor Chiburis could respond from his viewpoint. I would say that there has been now almost a decade of experience with some of the theoretical approaches to the geosciences, namely tectonics.

It is one of the major ideas which is a unifying factor in the understanding of the Earth as a whole. So scientifically, I think that we are at a very advantageous place where we have experience with a theory that has a lot of promise as well as acknowledged deficiencies.

I think the data that can and will be brought forth from satellite photography which when integrated with the growing amount of seismic data in this kind of a program will go a long way to understanding the causes and mechanisms of earthquakes in relation to our theoretical models.

Mr. BROWN. I ask this because we have had earthquakes for a long time and the question arises: Why an earthquake program now? I want to really relate this, if it is possible, to the new developments in the scientific field.

Dr. SKEHAN. In the East we have had important earthquakes in the past, but most people are unaware of this completely. We have had a series of earthquakes over the past year that have been felt by several thousand local residents. And yet 2 months later they had forgotten all about it. The general public seems not even aware that individuals had commented and responded to questionnaires as to the degree to which they felt the earthquake. Your question, Congressman Brown, may be answered best, I believe, by saying that the present time in history is the right time for such a program because we now have the basic seismic instruments, a body of data that has been accumulating at an ever accelerated rate, other powerful tools such as LandSat and other imagery, and conceptual models for exploring and explaining the causes of earthquakes. It is therefore an opportune time from so many points of view for this program to yield the hoped-for results.

Perhaps I could add one comment with respect to the LandSat imagery. There is so much information contained in the satellite imagery that is on a scale which brings out features that Earth scientists and others had never noted before. It is a very powerful tool, among others, for looking at the various features of Earth and its structure and increasing our potential for understanding the tectonics of the globe.

Mr. BROWN. Thank you very much. I thank both of you gentlemen for your contributions. It has been very helpful to us. We appreciate your staying with us as long as you have.

We have one more witness and before I invite him to come forward, I would like to note that our reporter has gone through 4 continuous hours. Would you like a break, Ms. Reporter?

The REPORTER. I would love about 5 minutes.

Mr. BROWN. Fine. We will take a 5-minute break.

[Five minute recess.]

Mr. BROWN. The subcommittee will reconvene. We have one remaining witness, Dr. Ralph Turner, who is professor of sociology at UCLA and formerly Chairman of the Panel on Public Policy Implications of Earthquake Predictions of the National Academy of Sciences.

He will contribute some of the social aspects of earthquake predictions which has been referred to by other witnesses but not in the depth that I am sure Dr. Turner will be able to provide us with.

We welcome you, Dr. Turner. We again apologize for keeping you this long. As I explained to you, we hope this will expedite the process of moving this bill along into legislation. You may proceed with your statement. The full text will be included in the record.

[A biographical sketch and the prepared statement of Dr. Ralph Turner follow:]

Ralph H. Turner October, 1973

BRIEF RESUME

Present position:

Professor of Sociology, University of California, Los Angeles

Education:

University of Southern California, B.A., 1941, M.A., 1942;
University of Wisconsin, 1942-43;
University of Chicago, Ph.D., 1948.

Professional experience:

Research Associate, American Council on Race Relations, 1947-48;
Instructor to Professor, University of California, Los Angeles, 1948---;
Chairman, Sociology Department, UCLA, 1963-68;
Visiting Professor, University of Washington, summer, 1960;
Visiting Professor, University of Hawaii, summer, 1962;
Visiting Scholar, Australian National University, Aug.-Nov., 1972.
Visiting Professor, University of Georgia, spring, 1975.

Fellowships:

S. S. R. C. Research Training Fellowship, 1947-48;
S. S. R. C. Faculty Research Fellowship, 1953-56;
Fulbright Research Fellowship, United Kingdom, 1956-57;
Guggenheim Fellowship, 1964-65.

Offices in Professional Organizations:

Pacific Sociological Association -- Secretary-treasurer, Vice president, President (1956-57), Advisory council;
American Sociological Association -- Council, Executive Committee, Chairman of Social Psychology Section (1960-61), President (1968-69), Chairman of the Section on Theoretical Sociology (1973-74);
Society for the Study of Social Problems -- Council (1963-64);
Sociometry -- Editor (1962-64);
Behavioral Science Study Section, N.I.H.,(1961-66), Chairman (1963-64);
Social Science Research Council -- Director-at-Large (1965-66);
Foundations Fund for Research in Psychiatry -- Director (1970-73).
Nat'l Academy of Sciences--Chmn. Panel on Public Policy Implications of earthquake prediction (1964-65).

Books published:

Collective Behavior (with L. Killian), Prentice-Hall, 1957; Second Edition, 1972;
The Social Context of Ambition, Chandler, 1964;
Robert Park: On Social Control and Collective Behavior, University of Chicago Press, 1967;
Family Interaction, John Wiley, 1970.

STATEMENT OF RALPH H. TURNER, PROFESSOR OF SOCIOLOGY, U.C.L.A., AND FORMERLY CHAIRMAN, PANEL ON PUBLIC POLICY IMPLICATIONS OF EARTHQUAKE PREDICTION, NATIONAL ACADEMY OF SCIENCES. APRIL 20, 1977.

My comments will deal with the social, psychological, economic, legal, and political aspects of reducing earthquake hazard, and with research needed for policy development in these same areas. Planning and research concerning the socioeconomic aspects of earthquakes are less advanced than they are for disasters such as floods, tornadoes and hurricanes. In 1975, the National Academy of Sciences Panel on Public Public Policy Implications of Earthquake Prediction published a comprehensive but preliminary examination of problems that may arise in attempting to use earthquake prediction capability for public benefit. These problems were outlined in testimony before the U.S. Senate, Ninety-fourth Congress, in connection with Senate Bill 1174, and reported in the Congressional Record for February 19, 1976. There is no need to repeat that discussion here. In addressing the current proposed legislation I shall draw from this Report, from experience with the N. A. S. Earthquake Study Team to the Peoples Republic of China in 1976, and recent research including a current investigation of community response to earthquake threat in Southern California.

I am especially gratified that provision for physical and engineering studies is adequately balanced in the proposed legislation (H.R. 35) by attention to socioeconomic problems of implementation and relevant social, legal, and economic research.

STATEMENT OF RALPH H. TURNER

The achievements of physical science and engineering are like the raw materials of production. Without them we are condemned to a primitive existence. But unless they are transformed through the miracle of modern production methods and distribution, we remain like the peasant farmer for whom petroleum bubbling up in his land only reduces his agricultural yield. Earthquake prediction may be one of the great scientific achievements of this century for saving human lives. The technical knowledge for building quake-resistant structure and locating them to minimize risk has already served us well. But making constructive use of earthquake prediction and earthquake technology is as difficult and complex as transforming iron ore and other raw materials into modern automobiles.

Two circumstances illustrate the problem. In Southern California about fourteen months ago, an uplift of the San Andreas Fault was publicly identified as probably signalling a forthcoming earthquake of destructive magnitude. But efforts to prepare the community for the coming earthquake are still sporadic, and research indicates that many people still doubt that anything can be done ahead-of-time to minimize loss of life, injury, and property damage. There may be a deep psychological cal resistance to admitting and dealing with risk that must be understood and overcome if we are to reap the benefits of prediction. But certainly we can hardly expect community support for a program of hazard reduction until people see convincing evidence that something <u>can</u> be done and are presented with a credible program. Also in Southern California

STATEMENT OF RALPH H. TURNER

there are ~~estimated to be in excess of 10,000~~ known to be thousands of un reinforced masonry buildings constructed before current regulations were enacted in 1933. These buildings are almost certain to collapse and kill or injure most of their occupants in the event of a severe earthquake in the vicinity. Although earthquake engineers can identify the unsafe structures and design relatively safe new buildings, little headway is made in speeding up the evacuation and demolition of the unsafe structures. For understandable reasons, even a proposal to post warnings outside of unsafe structures to alert potential users has been blocked by aroused public resistance. Similarly, residents living below the Little Rock Dam have taken legal action to prevent the lowering of water levels in the dam when that step was mandated in order to reduce hazard in the case of an earthquake on the nearby San Andreas Fault. So far no plan has been devised in either situation that deals realistically with the legitimate bases for resistance to implementing our technical knowledge to save lives. No plan yet proposes to amortize the costs to property owners, to minimize disruption of business and neighborhood life, or to recognize the racial implications of dispossessing people who are concentrated in minority neighborhoods. Water users have not been systematically consulted in the course of planning for dam safety in case of earthquake.

Legislation such as that proposed should help to promote the more effective planning needed in the many situations such as we have just outlined in which scientific knowledge and technical skills remain

unused for lack of attention to socioeconomic considerations.

While physical and engineering research into earthquakes has been Federally funded, planning for the socioeconomic aspects of earthquake disaster has often been left to the states and local governments. But the Federal initiative proposed in this legislation is essential for several reasons. First, compared with other familiar natural disasters, destructive earthquakes occur quite infrequently in the United States. With intervals from decades to centuries between destructive quakes in various locations, there is little opportunity to accumulate experience on a local basis. Where there are annual tornado or flood seasons, agencies and their personnel can build up a fund of experience that keeps them prepared to respond effectively to the disaster event and to the warning. Locally, earthquake hazard reduction must be the responsibility of agencies that are preoccupied on a day-to-day basis with problems that recur at shorter intervals. Lessons learned from one destructive earthquake can often not be applied or tested in the same locality for decades, when agency personnel have been succeeded by a new and inexperienced generation of workers. Likewise, the folk wisdom that guides public response to many natural disasters and warnings cannot accumulate unless event follows upon event while the memory of each experience remains fresh. Consequently, the need is especially acute in case of earthquakes for assembling and assessing earthquake experience on a national basis, and as far as possible internationally. In this way, a thorough analysis of socioeconomic features

of one destructive earthquake, or of the prediction and warning of such a quake, can be reflected in planning for the next such event wherever it occurs, and the revised plans tested and revised again within a brief span of years.

Second, the multiplicity of jurisdictions affected by an earthquake poses a variety of problems. It is neither practicable nor cost-efficient to duplicate planning efforts in all potentially affected counties and cities. Because of the concentration of earthquake hazard and resources, a single state such as California can provide much of the planning assistance required by its local jurisdictions. But few other states can allocate the resources needed to guide local planning. Nor is there any advantage to duplicating research and planning activities in the thirty-nine states in which earthquake hazard is known to exist.

And third, the prospect of an earthquake prediction capability poses an entirely new set of problems for all the affected states. Local governments in earthquake-prone communities have understandably developed disaster plans on the assumption that earthquakes will come without warning. Civil defense and sheriffs and police departments take the lead in emergency planning and emergency response. Their emergency roles are designed to make good use of their skill and experience in restoring order and responding to crises instantaneously. But hazard reduction in advance of a predicted earthquake is remote from their usual realm of activity. Planning departments and Building and Safety Departments, on the other hand,

are accustomed and equipped to deal principally with ~~and implement~~ hazard control in the long range. Local jurisdictions are not now organized or equipped to make and implement the critical decisions that could substantially reduce the hazard of earthquakes based on a few days, weeks, or months of advance notice. Prototype planning based on a thorough understanding of how local governments work under normal and emergency conditions, what are the relevant legal opportunities and constraints, and what steps promise effective hazard reduction is essential. Planning to deal with earthquake warning will require cooperative efforts among the potentially affected jurisdictions in which the personnel and financial resources of Federal government can be crucial.

In addition, there is evidence to suggest that the fate of communities in which earthquakes have been predicted may be largely determined by decisions made outside of the local and state jurisdictions. Recently completed research by Eugene Haas and Dennis Mileti has shown that business and financial leaders are concerned but uncertain over what course to follow in case of earthquake prediction. Their decisions may follow in domino fashion upon assumptions about what other units in business or government are doing. The result may be to precipitate a disabling recession in the affected communities, or to establish a firm base for mobilizing the community to deal with the earthquake threat. But crucial decisions will likely be made by officials of lending institutions and insurance companies located thousands of miles from the affected area. The immediate costs of short-term hazard reducing programs will almost certainly be beyond the capability of the local community and will

require financing from public and private sources outside of the area. Local jurisdictions can only hope to plan for the advent of earthquake prediction in collaboration with the Federal government. What the local community can realistically do will depend upon what support the Federal Government is prepared to offer on very short notice. At the very least, low interest Federally backed loans to finance the reinforcement of existing structures and the provision of temporary housing for vulnerable populations must be part of the planning. Since time will be of the essence, it is essential that agreement has been reached in advance between Federal and local jurisdictions over the resources available and the conditions under which they will be supplied.

Some of the objectives for legislation deserve special notice. The need for "education of the public, including State and local officials," can be related to observed problems in the wake of the current earthquake threat in Southern California. By December, 1976, Southern Californians had been exposed to serious discussion of the significance of the Mojave uplift, a carefully ~~guarded~~ qualified and hypothetical prediction issued by a seismologist at the California Institute of Technology, and a specific prediction for December 20 issued by an amateur who was unknown to the scientific community. A small pilot survey in early December shwowed that more people were aware of the amateur's prediction than of the two scientific announcements. But the amateur was commonly identified as a "Cal Tech professor." The lessening of this kind of confusion in the future will require informed and coordinated planning between public officials

and the news media, based on understanding of the nature and reasons for the confusion.

Experience in the Chinese People's Republic suggests the advantages of going beyond educating the public to actively involving them in the earthquake preparation and prediction effort. In the successfully predicted Haicheng earthquake of February 1975, public cooperation with evacuation orders was impressive. It seems likely that cooperation was facilitated by the organization of amateur groups as part of the earthquake prediction effort. These groups gave many more people a stake in the effort, and served to advertize the prediction effort concretely to neighbors and friends. The U. S. Weather Bureau has long had a successful program for using amateur tornado spotters. While it is unclear at present whether amateur observations can actually contribute to the prediction of earthquakes, exploratory programs should be encouraged.

Because of limited experience with destructive quakes, communities are not sensitized concerning the exceptional vulnerability of certain population segments to earthquake risks. There is a common impression that death and destruction strike randomly in an earthquake, and everyone is in much the same potential danger before a quake. Public programs seldom take account of the fact that substantial reduction of risk can be achieved by many people for relatively little cost or inconvenience, while for some the costs are insuperable. Because death and injury will be disproprotionately concentrated among the latter, only limited hazard reduction

can be achieved through usual regulation-and-policing methods. Identifying these vulnerable populations and familiarizing the larger community with their problems are essential parts of earthquake planning.

Two critical factors in planning for earthquake hazard reduction are law and insurance. Our legal system generally works to make us go slowly in situations where policies may have unanticipated effects on community and individual welfare. Because of the need to respond quickly to earthquake prediction and earthquake disaster, it is essential to clarify the legal contingencies as far as possible in advance of need. Preliminary exploration of legal aspects reveals a great deal of work to be done before the law becomes more an asset than a liability in earthquake planning.

The role of insurance as a tool of hazard reduction is still unclear. Insurance can be used to spread disaster costs over time and over the population and, through differential rates, to create incentives for bringing structures up to acceptable standards of earthquake safety. In the Haas-Mileti research the availability of uncancellable insurance was often mentioned by business leaders as a critical factor in their decisions in responding to earthquake prediction. On the other hand, even Federally subsidized disaster insurance has attracted little public interest, and the prospect of massive and concentrated losses raises questions concerning the

practicability of this approach. There is much planning yet to be done concerning the role of insurance. Because of the nature of the underwriting problems and the organization of insurance companies, this planning can only be done on a national rather than local basis.

For the most part, earthquake rehabilitation policies have been mere transplantations from the more abundant experience with such disasters as floods and tornadoes. Only a small beginning has been made in studying the social and psychological effects of United States earthquakes on the basis of the San Fernando quake of 1971. Today, there is debate over the need for psychological services -- especially for children -- after a quake. It is still unclear whether the 1971 earthquake experience has made the affected area more receptive to hazard reduction plans or more resistant to facing the prospect of a future quake. We have not yet learned how to apportion post-earthquake assistance to insure that it goes to the needy, and so as to insure that the rebuilt community will be an improved place in which to live and work.

I have already touched on the possibly disruptive economic adjustments that may accompany earthquake predictions. Although we cannot yet say with certainty what these adjustments will be in case of an actual earthquake prediction, it is clear that disruption can be minimized only with collaborative advance planning between government and business, with the active support of the Federal government.

11.

STATEMENT OF RALPH H. TURNER

In concluding my testimony I want to reiterate the main conclusion; that effective earthquake hazard reduction requires careful and sophisticated socioeconomic planning, that can only be executed effectively with full cooperation and initiative from the Federal government.

STATEMENT OF DR. RALPH TURNER, PROFESSOR OF SOCIOLOGY, UCLA, AND FORMER CHAIRMAN, PANEL ON THE PUBLIC POLICY IMPLICATIONS OF EARTHQUAKE PREDICTION, NATIONAL ACADEMY OF SCIENCES

Dr. TURNER. Thank you, Congressman Brown.

My comments will deal with the social, psychological, economic, legal, and political aspects of reducing earthquake hazards and with research needed for policy development in these same areas.

In 1975 the National Academy of Sciences Panel on Public Policy Implications of Earthquake Predictions published a comprehensive but preliminary examination of problems that may arise in attempting to use earthquake prediction capability for public benefit.

These problems were outlined in testimony before the U.S. Senate, 94th Congress, in connection with Senate bill 1174, and reported in the Congressional Record for February 19, 1976. There is no need to repeat that discussion here. In addressing the current proposed legislation I shall draw from this report, from experience with the NAS earthquake study team to the People's Republic of China in 1976, and recent earthquake research including a current investigation of community response to earthquake threat in southern California.

I am especially gratified that provision for physical and engineering studies is adequately balanced in the proposed legislation by attention to socioeconomic problems of implementation and relevant social, legal, and economic research.

The achievements of physical science and engineering are like the raw materials of production. Without them we are condemned to a primitive existence. But unless they are transformed through the miracle of modern production methods and distribution, we remain like the peasant farmer for whom petroleum bubbling up in his land only reduces his agricultural yield. Earthquake prediction may be one of the great scientific achievements of this century for saving human lives. The technical knowledge for building earthquake resistant structures and locating them to minimize risks has already served us well.

But making constructive use of earthquake prediction and earthquake technology is as difficult and complex as transforming iron ore and other raw materials into modern automobiles.

Two circumstances illustrate the problem. In southern California about 14 months ago, an uplift of the San Andreas Fault was publicly identified as probably signaling a forthcoming earthquake of a destructive magnitude. But efforts to prepare the community for the coming earthquake are still sporadic, and research indicates that many people still doubt that anything can be done ahead of time to minimize loss of life, injury, and property damage. There may be a psychological resistance to admitting and dealing with risk that must be understood and overcome if we are to reap the benefits of prediction. But certainly we can hardly expect community support for a program of hazard reduction until people see convincing evidence that something can be done and are presented with a credible program. Also in southern California there are known to be thousands of unreinforced masonry buildings constructed before current regulations were enacted

in 1933. These buildings are almost certain to collapse and kill or injure most of their occupants in the event of a severe earthquake in the vicinity. Although earthquake engineers can identify the unsafe structures and design relatively safe new buildings, little headway is made in speeding up the evacuation and demolition of the unsafe structures. For understandable reasons even a proposal to post warnings outside of unsafe structures to alert potential users has been blocked by aroused public resistance.

While physical and engineering research into earthquakes has been federally funded, planning for the socioeconomic aspects of earthquake disaster has often been left to the States and local governments. But the Federal initiative proposed in this legislation is essential for several reasons. First, compared with other familiar natural disasters, destructive earthquakes occur quite infrequently in the United States. With intervals from decades to centuries between destructive earthquakes in various locations there is little opportunity to accumulate experience on a local basis. Locally earthquake hazard reduction must be the responsibility of agencies that are preoccupied on a day-to-day basis with problems that recur at shorter intervals. Lessons learned from one destructive earthquake can often not be applied or tested in the same locality for decades, when agency personnel have been succeeded by a new and inexperienced generation of workers. Likewise, the folk wisdom that guides public response to many natural disasters and warnings cannot accumulate unless event follows upon event while the memory of each experience remains fresh.

Consequently the need is especially acute in case of earthquakes for assembling and assessing earthquake experience on a national basis, and as far as possible internationally. In this way a thorough analysis of socioeconomic features of one destructive earthquake, or of the prediction and warning of such a quake, can be reflected in planning for the next such event whenever it occurs, and the revised plans tested and revised again within a brief span of years.

Consequently the need is especially acute in case of earthquakes for poses a variety of problems. It is neither practicable nor cost efficient to duplicate planning efforts in all potentially affected counties and cities, or even in the 39 States in which earthquake hazard is known to exist.

And third, the prospect of an earthquake prediction capability poses an entirely new set of problems for all the affected States. Local governments in earthquake prone communities have understandably developed disaster plans on the assumption that earthquakes will come without warning. Civil defense and sheriffs and police departments take the lead in emergency planning and emergency response. Their emergency roles are designed to make good use of their skill and experience in restoring order and responding to crises instantaneously. But hazard reduction in advance of a predicted earthquake is remote from their usual realm of activity. Planning departments and building and safety departments, on the other hand, are accustomed and equipped to deal principally with hazard control in the long range.

Prototype planning based on a thorough understanding of how local government works under normal and emergency conditions, what are the relevant legal opportunities and constraints, and what steps promise effective hazard reduction is essential. Planning to deal with earth-

quake warning will require cooperative efforts among the potentially affected jurisdictions. The personnel and financial resources of Federal Government can be crucial in this planning.

In addition, there is evidence to suggest that the fate of communities in which earthquakes have been predicted may be largely determined by decisions made outside of the local and State jurisdictions. Recently completed research by Eugene Haas and Denis Mileti has shown that business and financial leaders are concerned but uncertain over what course to follow in case of earthquake prediction. Their decisions may follow in domino fashion upon assumptions about what other units in business or Government are doing. The result may be to precipitate a disabling recession in the affected communities or to establish a firm base for mobilizing the community to deal with the earthquake threat. But crucial decisions will likely be made by officials of lending institutions and insurance companies located thousands of miles from the affected area. The immediate costs of short-term hazard reducing programs will almost certainly be beyond the capability of the local community and will require financing from public and private sources outside of the area.

In this connection I concur heartily with Councilman Cunningham's recommendation for low-interest loans. Since time will be of the essence it is essential that agreement has been reached in advance between Federal and local jurisdictions over the resources available and the conditions under which they will be supplied.

Some of the objectives for legislation deserve special notice. The need for education of the public, including State and local officials, can be related to observed problems in the wake of the current earthquake threat in southern California.

A small pilot survey in early December showed that more people were aware of the amateur's prediction than of the two scientific announcements. But the amateur was commonly identified as a Cal Tech professor. The lessening of this kind of confusion in the future will require informed and coordinated planning between public officials and the news media, based on understanding of the nature and reasons for the confusion.

Because of the limited experience with destructive quakes, communities are not sensitized concerning the exceptional vulnerability of certain population segments to earthquake risks. I am very gratified that there is a paragraph dealing with this in the legislation because it is so frequently overlooked. I personally wrote and insisted on the inclusion of such a chapter in our National Academy of Sciences report. There is a common impression that death and destruction strike randomly in an earthquake, and everyone is in much the same potential danger before a quake. Public programs seldom take account of the fact that substantial reduction of risk can be achieved by many people for relatively little cost or inconvenience, while for some the costs are insuperable. Because death and injury will be disproportionately concentrated among the latter, only limited hazard reduction can be achieved through usual regulation and policing methods. Identifying these vulnerable populations and familiarizing the larger community with their problems are essential parts of earthquake planning.

Two critical factors in planning for earthquake hazard reduction are law and insurance. Our legal system generally works to make us go slowly in situations where policies may have unanticipated effects on community and individual welfare. Because of the need to respond quickly to earthquake prediction and earthquake disaster, it is essential to clarify the legal contingencies as far as possible in advance of need.

The role of insurance as a tool of hazard reduction is still unclear. Insurance can be used to spread disaster costs over time and over the population and through differential rates to create incentives for bringing structures up to acceptable standards of earthquake safety. In the Haas-Mileti research the availability of uncancelable insurance was often mentioned by business leaders as a critical factor in their decisions to respond to earthquake predictions. On the other hand, even federally subsidized disaster insurance has attracted little public interest, and the prospect of massive and concentrated losses raises questions concerning the practicality of this approach.

I have already touched on the possibly disruptive economic adjustments that may accompany earthquake predictions. Although we cannot yet say with certainty that these adjustments will be in case of an actual earthquake prediction, it is clear that disruption can be minimized only with collaborative advance planning between government and business, with the active support of the Federal Government.

In concluding my testimony I want to reiterate the main conclusion: that effective earthquake hazard reduction requires careful and sophisticated socioeconomic planning, that can only be executed effectively with full cooperation and initiative from the Federal Government.

Thank you.

Mr. BROWN. Thank you very much, Dr. Turner, for your testimony. I think you have helped fill out the record in an extremely valuable way. You have emphasized some of the kinds of policy considerations which we don't always get sufficient attention about.

I assure you that will be very helpful to us.

Dr. Turner, I have no questions with your testimony and recognizing the time that we have imposed on you in remaining here this morning, I think it would be desirable if we did not take up any more of your time. We may want to ask you some questions in writing, if we may. I hope that you will be able to help us out.

Dr. TURNER. I would be very happy to help in any way we can.

Mr. BROWN. I thank you for being here and making this contribution to the committee record.

With that the subcommittee will be adjourned until the call of the Chair.

[Whereupon, at 2:30 p.m., the subcommittee adjourned subject to call of the Chair.]

APPENDIX

DEPARTMENT OF CIVIL ENGINEERING
N. M. NEWMARK

UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN
URBANA, ILLINOIS 61801

1211 Civil Engineering Building
15 April 1977

Mr. Thomas R. Kramer
Science Consultant
Committee on Science and Technology
U. S. House of Representatives
Suite 2321 Rayburn House Office Building
Washington, D. C. 20515

Dear Mr. Kramer:

Thank you for your letter of 4 April containing the copy of H.R. 35. I am sending you my comments herewith.

The best statement of my views is contained in a paper entitled "The Future of Earthquake Engineering," dated 17 September 1976, and presented at the Inaugural Symposium of the John A. Blume Earthquake Engineering Center at Stanford University. A copy of this paper is enclosed. You may find pages 4 to 18 of most importance to the issues addressed by the bill.

With regard to specific comments on H.R. 35, I think it expresses quite well the report of the committee of which I chaired, appointed by H. Guyford Stever last year, to advise on the funding for earthquake prediction and earthquake hazard mitigation. I would suggest some minor changes, however.

On page 2, line 7, I believe that "design" should be referred to as well as "construction," so as to make that line read as follows: improved design and construction methods and practices, prediction.....

At the bottom of page 2 and the top of page 3, I believe that within ten years we may not be able to predict as accurately as implied in the bill the "time, place, magnitude, and physical effects of earthquakes....." The statement that I made in my report indicated that "We shall be able to make reasonably accurate predictions of the place and probable magnitude and somewhat less accurate predictions of the time of occurrence, of earthquake motions within the next ten to twenty-five years."

As far as general comments are concerned, I believe that somewhere there ought to be included in the bill the matter of "engineering judgment and experience." It would be wrong to give the

impression that all of the functions of earthquake engineers in design of structures can be supplanted by computer analyses based on research. There are economical considerations of major importance. Complete safety of all structures against all possibilities of earthquakes is definitely not warranted economically, and should not be promised.

I trust that these comments will be helpful to you.

Sincerely yours,

N. M. Newmark

N. M. Newmark,
Professor of Civil Engineering
& in Center for Advanced Study, Emeritus

dp

enclosure

17 September 1976

THE FUTURE OF EARTHQUAKE ENGINEERING

by

Nathan M. Newmark
Professor of Civil Engineering, Emeritus
University of Illinois at Urbana-Champaign

OPENING REMARKS

It is a pleasure to speak to you on the occasion of the Inaugural Symposium of the John A. Blume Earthquake Engineering Center. These fine facilities and the people associated with its operation will make an important contribution to one of the most difficult problems of our planet, the calamities caused by natural, or in some cases man-made, earth motions and the phenomena resulting from these motions.

This is an area to which the generous donor of these facilities, John Blume, has devoted much of his life and his abundant energies. It has been my pleasure to be associated with John for at least twenty years, both professionally and socially, and from time to time I have worked closely with him - never without argument but seldom with violence.

The eminent speakers that you have heard today have discussed a number of the aspects of earthquake engineering, and some have taken you for a brief look at the future developments of their particular topic. I have the task of enlarging upon the theme of this symposium, the future of earthquake engineering, and I have set certain ground rules that I should like to discuss briefly.

First, I have considered that there are two points in time that we shall consider as the "future": (1) the short range, or what we

might expect in the next decade; and (2) the longer range, or what we might expect in the next quarter century. I have not considered it possible to take any real long range view into the future; the crystal ball rapidly becomes too cloudy.

The second ground rule is my definition of earthquake engineering. I have considered this as a very broad topic involving not only the design and proportioning of structures, but also the definition of ground motions, the possibility of earthquake prediction, the possible reduction of future hazards from seismic events, and even the utilization of the results of research efforts.

Fortunately I have unique qualifications for this task. Not of my own volition, I have had the honor for the past several months of being the chairman of the "Advisory Group on Earthquake Prediction and Hazard Mitigation" to Dr. H. Guyford Stever, the Science Advisor to President Gerald Ford. This Advisory Group is made up of twenty-two of the outstanding seismologists, geophysicists, geologists, earthquake engineers, architects, building code officials, sociologists, and the like, working closely with and assisted ably by outstanding scientists and engineers in the National Science Foundation and the United States Geological Survey. I have drawn freely on my experiences with that Advisory Group, and I have taken the liberty of using with some modifications parts of our report which is now in its final stages of preparation.

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THROUGH A GLASS - DARKLY

The problems and pitfalls of prophecy are many and difficult; how does one infer what the future holds? An obvious answer would seem to be: "by extrapolating from the experience of the past and the practices of the present." This involves the implicit assumption that science or engineering travels in a predictable path much as a straight line is determined by two points or a smooth curve by several points through which the curve may pass and then is extended beyond the end point. However, this is not the way that things go, particularly not in scientific matters, nor in areas that are sharply dependent on interpretation of observations, especially during the course of acquisition of data. Research, and particularly fundamental research, is based on the development of hypotheses that may differ radically from preconceived notions or previous concepts and ideas. When these hypotheses agree substantially better than previous concepts with observations and facts, or when newly discovered facts or augmented observations enable a better hypothesis to be built, a step-function change occurs, and the straight line or curve takes an abrupt departure from its previous trend. Hence one should not expect that the next ten years or the next twenty-five years will be built on the firm foundation of the past and the present; these well may be unstable bases on which to build the future.

With this warning clearly in mind, let us light our lanterns and step bravely forth.

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WHAT IS EARTHQUAKE ENGINEERING?

The aim of the broad concept of earthquake engineering that I described earlier is to save lives, reduce injuries, reduce damage, and mitigate social and economic disruption in the event of earthquakes and earthquake induced phenomena, and to find means of doing so at a cost reasonable enough that society can afford the necessary actions.

To accomplish this objective we need interactions among the various components of the technical and political community. The problems are not all technical but there are major technical problems, to be sure. For example, ground shaking is influenced by many factors, and no generally acceptable procedure has been developed for evaluating and estimating the relevant parameters. In consequence, land use zoning cannot be rationally based yet on seismic risk, except in a very limited way.

Similarly, precursors to earthquake motions have been widely observed, but their characteristics are not sufficiently well known, their correlation with subsequent earthquakes have not yet been adequately established, and instruments are not yet deployed in sufficient numbers to permit reliable earthquake predictions.

Again, structural engineering and structural design are old and established fields of learning. Yet, buildings designed in accordance with recent building codes have suffered damage and in some cases even collapse in earthquakes, and we cannot yet say that we can design to resist

earthquakes without paying the severe economic penalty of the extreme conservatism that we find necessary in the case of special structures such as nuclear power plants.

Regardless of our limited understanding of earthquake mitigation methods, investments are being made, structures are being built, land is being developed, earthquake motion precursors are being observed, and interpretations based on our current inadequate understanding are being made.

However, because of the fact that the public in general, and responsible public officials, are rapidly becoming aware of the problems of earthquake hazard and the necessity for hazard mitigation, I feel confident that within the next ten years there will be substantially increased funds available for those areas of research and study that need to be developed in order to attain the goal of the earthquake engineer and his brother scientists in the areas of geotechnology. These involve studies in five areas, all supported by a broadly based program of fundamental studies in earthquake motions and earthquake related phenomena. These five areas include the following:

(1) Earthquake prediction - involving the development of the capability to predict the time, place, magnitude, and effects of earthquakes.

(2) Earthquake modification and control - involving the development of techniques to allow the control or alteration of seismic phenomena, whether natural or man-made.

(3) Hazard assessment - involving the development of assessing seismic risk and evaluating the possibilities of earthquake motions so that appropriate construction and land use plans can be implemented.

(4) Design improvement - involving the development of improved, economically feasible, design and construction methods for building earthquake resistant structures, dams, nuclear reactors, pipelines, communication facilities, etc.; and for upgrading existing structures.

(5) Utilization - involving an understanding of the factors that influence use of earthquake mitigation methods, and including social and behavioral response.

Before we take a more direct look at each of these topics, it may be worthwhile considering a general overall view as to what we might expect in each of these areas. The limited goals that we might reach in the short or longer range future are described on the basis that there will be substantially increased funding for research in all of these aspects of earthquake engineering and geotechnical studies, including the fundamental studies that are necessary to support all of them.

It seems likely that we shall be able to make reasonably accurate predictions of the place and probable magnitude, and somewhat less accurate predictions of the time of occurrence, of earthquake motions within the next ten to twenty-five years. On the other hand, it does not seem likely that, even within the next twenty-five years, we will have made substantial developments in earthquake modification and control unless

a major scientific breakthrough occurs. Nevertheless, we can probably count on developing a better knowledge of hazard assessment within the next ten to twenty-five years, that may not be completely reliable but will be sufficiently valid so that useful and effective decisions can be made regarding land use plans, at least in some specific areas of the country and the world.

Regarding improvement in design, it is my belief that we have available now much of the basic information that is needed to have assurance of design capabilities of specific structures to resist earthquake motions. However, our procedures must perforce be overly expensive unless further research effort is spent in reducing the uncertainties and in developing less costly methods of assured accuracy and effectiveness. In other words, if one is willing to pay an excessive cost, I am confident that we can now design for almost any contingency. We cannot afford to do so except for a few limited cases of extremely important structures. We must continue to be over conservative until we have developed more rational and appropriate methods, and until those methods have been reduced in complexity to the extent that engineers and architects in general can apply them properly. If the proper emphasis is put on this topic, great progress can be made within the next ten years. Without such emphasis, it may take a quarter of a century.

I should like it clearly understood, however, that these methods may not necessarily involve what purports to be more accurate computer programs. A computer program is no more accurate than the assumptions on which it is based, and our difficulties lie not with the mathematical

techniques or the numerical analyses, but with the validity of the assumptions on which the analyses are based.

In the area of utilization of earthquake mitigation methods, the problem is more difficult because it involves education of the public and the body politic, especially at the local level, to insure the proper response to warnings, proper appreciation of the necessity of improved building codes, and proper restrictions on land use planning.

FUNDAMENTAL STUDIES

To establish a scientific basis rather than to depend on a wholly empirical approach to the understanding of destructive earthquake ground motion requires a greatly increased knowledge of the physical processes leading to and constituting an earthquake, under conditions that exist in the upper crust, lower crust and upper mantle of the earth. Theoretical models of the earthquake process must be developed. Both pre-earthquake phenomena and the ground motion caused by the earthquake are tightly linked with the faulting process itself. We do not yet know what physical properties are the most critical, or the nature of the instability that causes an earthquake. The failure criteria and the role of stick-slip and pre-seismic, or co-seismic creep must be understood in order to calculate fault propagation and stress or motion propagation. The surficial and sub-surface properties and the tectonic setting affect the amount of energy released and the characteristics of the generated motion.

The new plate tectonic theory envisions the earth's surface as comprised of a discrete number of large plates moving in relationship to each other. This concept has allowed us to explain the distribution of the bulk of the world's earthquakes and their seismic radiation patterns. We need a more detailed knowledge of how stress is accumulated, distributed and released along the boundaries of these moving plates. To date, basic studies of worldwide earthquakes have been the primary tool in outlining the plates, in determining their relative motions, in outlining the downgoing slabs, and in defining seismic gaps. Such studies are broad, interdisciplinary and conducted on a worldwide basis, on land and at sea. They provide essential basic data.

But current knowledge of plate motions does not adequately explain the occurrence of large and destructive intraplate earthquakes (i.e. New Madrid, Boston, and Charleston). These earthquakes may have quite different causes than those along the San Andreas fault system and may well prove to be the most difficult to forecast. Measurements of intraplate stresses and measurement of intraplate strains, on a plate-wide and world-wide basis are required, together with more local studies on the relationship of seismicity to geologic structure in known seismic regions. Studies of plate motions, their causes and consequences, are at the heart of understanding earthquake origins.

Seismic and other geophysical observatories and networks provide the essential data for all studies in seismology, including earthquake hazard reduction. The systematic location and cataloging of earthquakes on a global basis is central to these studies.

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EARTHQUAKE PREDICTION

In February 1975 a major earthquake (magnitude 7.3) destroyed the town of Haicheng in the Peoples Republic of China and caused extensive damage to industrial plants. Chinese earthquake specialists actually predicted this earthquake. The population was removed from hazardous buildings and only a few were killed even though a million people live in the area. It is reported that the Chinese successfully predicted earthquakes in May 1976 (Yunnan Province) and August 1976 (Szechwan Province), and endangered people were warned to evacuate hazardous structures. However, the Chinese did not predict accurately what may be one of the worst earthquakes in this century, in the Tangshan-Tientsin region of north China, on July 27, 1976. In 1976 other disastrous earthquakes struck Guatemala, Italy, Western New Guinea, Bali and Mindanao in the Philippine Islands. This will be recorded as one of the worst years in this century for deaths due to earthquakes.

In the Los Angeles area, Geological Survey scientists reported an uplift of the earth's crust along a section of the San Andreas Fault that has been relatively quiet since the great earthquake of 1857. This uplift is not necessarily an earthquake precursor, but it is cause for concern.

The growing prospects for earthquake prediction, based in part on the still tentative experience of the Chinese, Japanese, and the Soviets suggest that in coming decades we may have a capability to predict earthquakes in the United States. The achievement of prediction will depend largely on the capability and capacity of our scientists and engineers

to observe and interpret precursory effects. It should be noted, however, that local communities and State governments need to make changes in their land use and building codes to reduce earthquake vulnerability if the goal of a significant capability to predict the location, time and magnitude of earthquakes is to result in reduction in property damage and life loss.

EARTHQUAKE MODIFICATION AND CONTROL

There are over 20 cases around the world where the filling of large reservoirs appears to have triggered or induced earthquakes. The triggered earthquakes range from microearthquakes recorded only instrumentally to earthquakes as large as magnitude 6.5. The largest earthquake thought to be so induced, near the Koyna Dam in India, December 10, 1967, resulted in 177 killed, 2,300 injured and extensive damage. While few large reservoirs are known to have triggered earthquakes, there is currently no accepted procedure to determine in advance of construction whether filling a reservoir will trigger an earthquake. Nor is there a procedure defined to allow operation of a reservoir (raising and lowering the head of water behind the dam) without danger of triggering earthquakes.

Experience with inadvertently triggered earthquakes associated with the deep waste disposal well near Denver, Colorado, and in a recently completed earthquake-control experiment in an oilfield near Rangely, Colorado, shows that, under certain conditions, man can influence the occurrence of earthquakes. It was shown by Terzaghi many years ago that

an increase in the pore pressure of fluids results in a decrease in shear strength in the rock or soil, which could in turn allow the release of tectonic strain at a fault zone. This release can cause an earthquake even when it is not intentional. The experiences at Denver and Rangely confirm this concept. It is reasonable to expect that techniques can be developed that can greatly reduce, if not eliminate, the problem of the inadvertent triggering of earthquakes. Further, it is possible that this hypothesis might lead in certain areas to a technique for modifying natural earthquakes. To do so successfully may well be a very long range possibility.

HAZARD ASSESSMENT

Earthquake hazard assessment involves the delineation and description of potential effects from seismically induced processes at or near the ground surface. Estimates of how strongly and how often the ground will shake are basic to building codes and engineering design. Knowledge of areas susceptible to strong shaking, ground failure, surface faulting, or inundation by tsunamis or dam failure is necessary for land-use planning in earthquake susceptible regions. Appraisals of probable damage patterns can guide both pre- and post-disaster planning. The accurate assessment of earthquake hazards also is a key element in effective action to take advantage of an earthquake prediction capability.

Some techniques for mapping and evaluating earthquake geologic hazards are relatively well developed. Within certain constraints, faults

capable of rupturing the ground surface can be recognized and mapped. Techniques also exist for identifying slopes susceptible to landsliding. The processes of soil liquefaction and differential settlement are understood in general terms, if not in detail. Rough techniques for predicting tectonic surface distortions and level changes, critical for the prediction of the post-earthquake operability of canals and pipelines, also exist.

The most pervasive and important hazard--ground shaking--can now be estimated only within broad limits. The strength and character of ground shaking at a site depend on the geologic conditions there, as well as on the distance and characteristics of the source. Not all of the mechanisms and details of this dependence are clear.

Most of these techniques for hazard assessment require additional development, but most may be applied region by region at present to varying degrees. They require substantial field investigation and the gathering of significant regional geologic data. To predict areas susceptible to liquefaction, for example, requires substantial information about subsurface soil and ground water conditions. Efforts to obtain the required data and apply these techniques have begun only at a low level.

Methodology for estimating earthquake damage and loss, including methods for estimating damage patterns, is developing. Adequate progress in this area will take at least twenty years, but a good start is possible within the decade.

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DESIGN IMPROVEMENT

Earthquake resistant design encompasses various disciplines, including especially geotechnical, structural, mechanical and electrical engineering, and architecture. It is concerned with the design and development of physical systems to withstand earthquakes.

An earthquake may cause damage to a structure by ground shaking, fault slip, subsidence, or landslides. Fundamental to the understanding of these phenomena is accurate knowledge of the ground movement. There are two approaches to this information: first, placing instruments to measure how the ground responds to earthquakes; and second, developing analytic models that consider source mechanism, propagation path properties, and soil or rock conditions. Such models may delineate site spectra; or maximum acceleration, velocity, displacement, and duration; or time histories of motion.

A structure can be damaged either by the failure of the soil or rock that supports it or by the shaking transmitted to it by the surrounding soil. When soils are strongly shaken they may amplify the displacement imparted to the supported structure or may fail through a variety of mechanisms, including settlement of cohesionless soils, bearing capacity failure, embankment failure, and soil liquefaction.

Structural integrity depends upon the complementary activities of design and construction. The basic problem in design is to synthesize the structural configuration (size, shape, materials and interrelation of load bearing and nonload bearing elements) with methods of fabrication so that the structure is able safely and economically to withstand earthquake induced motions.

Analysis, which forms part of the basis for design, involves modelling of the hypothetical structure, and calculation of limits for the stresses and displacements produced by the motions. Accuracy in the analytical process may be illusory; accuracy in the physical properties and assumptions is essential for efficient and economical design, and reliability in the design factor of safety. Design and analysis processes are complicated because: (1) even simple structures are exceedingly complex dynamic systems; (2) the nature of earthquake occurrences and input motions is probabilistic; and (3) the construction process leads to a structure that cannot be precisely described or modelled. Design and analysis must be carried out for all parts of the structure, structural and non-structural, and must consider action of the structure well beyond the linear elastic range, up to the point of collapse. Of special importance are assessing and improving the earthquake resistance of structures already built, but having possible inadequate resistance.

Research is required to define the relative motion of nearby points on the ground surface and at varying depths. Such relative motions may influence the design of extended structures such as dams, multi-span bridges, or long buildings and underground facilities as well as inter-connected systems such as pipelines, aqueducts, and transmission lines.

Research is required to determine the potential merit or hazard involved in selecting foundation designs, elevations, and embedments for various site conditions. Closely related to the study of ground motion and structural response is the study of the interaction of supporting soils with the structure.

Basic principles of planning dictate that systems should not be located where soil failure (liquefaction or landsliding) is likely to occur. Many times, however, systems such as wharfs, bridge approaches, and highways must be located at sites where the potential for soil failure is severe. Methods for controlling soil failure or alleviating the consequences must be developed.

Building codes, which provide the most effective check against building damage or collapse in an earthquake, vary greatly in their incorporation of seismic safety provisions and in practice. However, many aspects of earthquake-resistant design cannot be covered effectively in building codes. These aspects must include the responsibility of the architect and engineer. A code is of value only as long as it is followed, enforced, and maintained. Construction practices also play a critical role. The success of the Field Act in California in reducing damage to schools during earthquakes demonstrates the efficacy of a comprehensive program of building regulation, design review, construction inspection, and maintenance.

UTILIZATION OF RESEARCH

Up to this point I have concentrated on the development of science and engineering capabilities to mitigate the effects of earthquakes. Now I want to discuss briefly the social, economic, legal, and political factors which sometimes act as a deterrent to the adoption of technological findings.

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Possible mitigation measures that could reduce earthquake effects are advance preparation, land use, building codes and standards, insurance and relief incentives, and information and education. While each of these is being pursued in varying degrees and with widely divergent effectiveness, there is little research that has been performed or is currently underway to develop more effective and efficient adoption and implementation of mitigation measures.

Changes in building codes and land-use regulations, and the issuance of earthquake predictions and warnings can have serious ramifications for the social, economic, legal and political aspects of American life. Whether a research finding has a positive or negative effect in mitigating earthquake hazards, or is ignored altogether, could depend very much on the method for communication and utilization of the results of the research. The use of any research product is highly unlikely unless it is made adaptable to fulfill a recognizable need in an appropriate form.

Public reaction to the issuance of an earthquake prediction is very difficult to anticipate. It is clear that public information programs, preparedness planning, and governmental coordination must go hand in hand with prediction. The potential positive benefits of predictions are clear in the saving of lives and reduction of damage. But potential negative effects of predictions are also present.

The operation of a community during and after an earthquake depends upon how well the utility and public service facilities function

as a system with elements located at many sites. The failure of an element can cause the total system to malfunction or be inoperative. Thus the design of system elements must consider the seismic performance characteristics required of the total system, not just the individual elements. Both physically connected (e.g. water distribution), and nonconnected (e.g. hospitals, clinics and laboratories) systems must be considered. The design of systems with appropriate seismic resistive characteristics is intimately related to local and regional planning. Such planning must consider both the direct impact of ground displacement and ground shaking as well as the indirect impacts.

Those of us who have a hand in the development of technological improvement in earthquake engineering have also a responsibility to assist in the education of the public to make appropriate use of the findings in order that our efforts will not have been in vain.

COMPTROLLER GENERAL OF THE UNITED STATES
WASHINGTON, D.C. 20548

CED7-417
B-126965

APR 14 1977

The Honorable Olin E. Teague, Chairman
Committee on Science and Technology
House of Representatives

Dear Mr. Chairman:

Pursuant to your request of March 9, 1977, for our views and recommendations on H.R. 1457 and H.R. 2392, 95th Congress, cited as the Earthquake Hazards Reduction Act, and H.R. 4190, 95th Congress, cited as the Earthquake Hazards Reduction Act of 1977, we are providing the following information.

Congressman Ray Thornton, Chairman of your Subcommittee on Science, Research, and Technology, advised us by letter dated March 17, 1977, that the Subcommittee planned to hold hearings in mid-April on H.R. 35, cited as the Earthquake Hazards Reduction Act of 1977, and also asked that we provide him with any pertinent information developed during our current work on earthquake hazards which may be helpful to the Subcommittee during its hearings. Therefore, a copy of this letter is also being sent to Chairman Thornton.

The above-mentioned bills, including H.R. 35, would institute, through public and private efforts, a coordinated and comprehensive national program of earthquake hazards reduction. The bills provide for development of earthquake prediction techniques, early warning systems, and coordinated emergency preparedness plans. They also provide for developing earthquake resistant design and construction methods, finding ways of controlling or altering earthquakes, coordinating information about earthquake hazards with land use decisions, and educating the public about earthquake risks.

Generally, pertinent provisions of the bills cover matters which were discussed in our September 11, 1972, report to the Congress entitled "Need for a National Earthquake Research Program" (copy enclosed). Our prior findings

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and information on corrective actions taken by Federal agencies are summarized below. Also, we have identified provisions of the bills which we believe warrant the attention of your Committee and/or the Subcommittee on Science, Research, and Technology.

PRIOR GAO FINDINGS

Our September 11, 1972, report discussed the need for a national program in earthquake research to achieve maximum benefit from Federal funds for earthquake research. The report pointed out that under a national program goals and priorities should be established, agency responsibilities should be clearly defined, and coordination among the agencies conducting earthquake research should be improved. The report noted that fragmentation of Federal responsibility and the lack of national goals made it extremely difficult for the Federal agencies supporting earthquake research to launch a coordinated attack on the Nation's earthquake problem. Further, the complexities of earthquake research required continuous comprehensive planning and an assessment of research activities at the Federal level.

The Office of Management and Budget (OMB) is responsible for insuring that agency programs are coordinated and that the funds appropriated by the Congress are spent in the most economical manner with the least duplication and overlapping. We therefore recommended that OMB

--establish goals and priorities for a national earthquake research program;

--establish criteria by which to judge the effectiveness of the program;

--define and reassign, if appropriate, the responsibilities of Federal agencies involved in earthquake research;

--establish a permanent coordinating group, independent of the agencies involved, to provide guidance and assistance in conducting the national earthquake research program; and

--monitor agency earthquake research activities to insure the coordination of these activities and the most effective use of available resources.

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OMB, in response, generally agreed with our recommendations and stated that the President's 1973 budget provided for a substantially expanded earthquake research program. OMB said that several actions were being considered for developing a detailed plan for an expanded research program, establishing criteria for evaluating the effectiveness of programs in achieving their objective, defining agency responsibilities for carrying out earthquake research programs, and monitoring earthquake research activities to help insure the most effective use of resources. OMB stated, however, that it was not feasible or desirable to have a group independent of the agencies involved to direct the Federal program. OMB said it might be more desirable to establish a group independent of the agencies involved to evaluate the effectiveness of agencies' efforts to provide advice to the Executive Office of the President on national goals, improvements in coordination efforts, or improvements in agency program management.

In December 1972, OMB advised the Department of Commerce of its concern over the need to clarify earthquake research objectives, establish clear responsibilities for achieving those objectives, and eliminate undesirable duplication of effort. In this regard, OMB requested that the Department of Commerce jointly prepare reports with the Department of the Interior and the National Science Foundation concerning their roles in earthquake research. Such joint reports, however, were not prepared because the Department of Commerce, in January 1973, decided because of budget reduction for fiscal year 1973 to terminate its strong-motion instrumentation program and its earthquake prediction research.

In March 1977, OMB officials told us that a complete turnover of staff since 1972 and a lack of adequate documentation prevented them from determining what specific actions, if any, OMB had taken to implement our recommendations. They added, however, that OMB had not issued any formal directives or OMB Circulars to the Federal agencies on Federal earthquake hazard reduction efforts in general.

We discussed these matters with officials of several Federal agencies involved in earthquake-related activities. These officials said they had not received from OMB any specific directives or guidance pursuant to the recommendations made in our 1972 report.

OBSERVATIONS ON PENDING LEGISLATION

The Geological Survey, the National Science Foundation, and the scientific community have expressed increasing concern

over the earthquake hazards in the United States. They pointed to the need for a concerted effort by the Federal Government to help insure that earthquake risk areas of the country are prepared to effectively respond to such disasters. In this respect, H.R. 35, H.R. 1457, H.R. 2392, and H.R. 4190 provide for the establishment of a needed, coordinated earthquake hazard reduction program to help reduce the loss of life, property destruction, and economic and social disruption from future earthquakes. The bills generally provide for (1) establishing the Federal Government's role in an effective earthquake hazards reduction program, (2) defining and assigning agency responsibilities, and (3) establishing a lead agency to coordinate the program. Because OMB has not acted on similar recommendations included in our September 1972 report aimed at a coordinated research program, we concur that these provisions should be included in legislation by the Congress.

Sections 5(c) of H.R. 1457 and H.R. 2392 list nine Federal agencies which should be involved in the earthquake hazard reduction program. Sections 5(b)(4) of H.R. 35 and H.R. 4190 list 12 agencies which should be included in the program. None of the bills include all agencies involved in earthquake-related activities, however (for example, the Department of Transportation). We believe that the appropriate sections of these bills should be revised to include language that would insure that the pertinent activities of all Federal agencies are included in developing the program.

Section 5 of each bill provides for the establishment of the earthquake hazard reduction program, but does not require that (1) goals, priorities, time frames, and target dates be established for implementing the program and (2) criteria be established for judging the effectiveness of Federal agency efforts. To help insure that Federal efforts are effective in accomplishing the objectives of the proposed legislation, these requirements should be included in the bills.

Sections 6(d) of H.R. 1457 and H.R. 2392, and sections 5(b)(3) of H.R. 35 and H.R. 4190 contain no provision for payment of salaries or per diem for members of the National Advisory Committee on Earthquake Hazard Reduction, even though some members would not be Federal employees. We suggest that the following or similar language be included in the bills:

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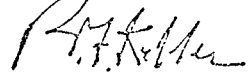
"Each member of the Committee who is not a Federal employee shall be reimbursed for necessary travel expenses (or in the alternative, mileage for use of his privately owned vehicle and a per diem in lieu of subsistence not to exceed the rates prescribed in 5 U.S.C. 5702, 5704), and other necessary expenses incurred by him in the performance of duties vested in the Committee, without regard to the provisions of subchapter 1, chapter 57 of title 5 of the United States Code, the Standardized Government Travel Regulations, or 5 U.S.C. 5731."

Sincerely yours,



Deputy Comptroller General
of the United States

Enclosure

WRITTEN REMARKS FOR CONGRESSIONAL RECORD-HOUSE CONCERNING THE "EARTHQUAKE DISASTER MITIGATION ACT OF 1977"-HR 35

by

Carl L. Monismith
Chairman, Department of Civil Engineering
University of California, Berkeley

The purpose of these remarks is to strongly support House Bill 35 and urge its expeditious passage. Specifically my comments are directed to support of the engineering research and education aspects of the Bill.

Urgent need for recognition and reduction of earthquake hazards to the works of may has been graphically demonstrated by the continuing sequence of earthquake-produced disasters in many parts of the world. The recent tragic event in Rumania is only the latest in the current sequence which includes Guatemala, Haicheng, China in 1974, Managua, Nicaragua in 1972 and San Fernando, California in 1971.

Research has now advanced sufficiently far to demonstrate clearly that earthquake hazards can be reduced in the United States. The possibility that earthquake prediction can lead to significant reductions in loss of life was demonstrated by the Chinese with the 1974 Haicheng earthquake, and there is no doubt that intensive efforts should be made in this country to develop prediction capabilities. However, even if and when such techniques are perfected, the need for improved earthquake engineering practices will remain. Prediction capabilities cannot alter the fact that earthquakes will occur in our populated regions; the destruction or severe damage to dams, power plants, hospitals, office and apartment buildings, transport systems, etc., could deal a severe blow to our economy even if it were possible to minimize loss of life by evacuating people in advance of the earthquake. Thus these remarks are intended to complement those already presented by emphasizing the importance of achieving a significant mitigation of the earthquake hazard by means of earthquake engineering research.

Improved understanding of the behavior of structures during earthquakes which has resulted from engineering research in recent years has led to significant advances in design of earthquake resistant structures. Each recent earthquake, including the Guatemala disaster, has provided numerous examples of the generally superior performance of structures designed with the aid of recently developed knowledge. Failures have been observed, however, in new structures designed by current code procedures, such as the Olive View Hospital in San Fernando and the Four Seasons Apartment Building in Anchorage, Alaska; these clearly demonstrate that additional research must be accomplished before reliable as well as economical solutions to the seismic hazard problem can be achieved.

Although many government agencies participate in earthquake engineering research, and although many professional engineers are concerned with the need for improved design procedures, a significant part of the research effort must be accomplished by academic institutions. Meaningful contributions from these institutions have been and will continue to be associated with two areas namely:

(1) developing better understanding of earthquake ground motions which are the essential source of the problem;

(2) developing improved understanding of the behavior of structures of all types which are subjected to the earthquake motions.

The first need in the study of earthquake ground motions is an expanded network of strong motion seismograph stations which will provide data on the nature of the earthquake input in a variety of soil and geologic conditions. Installation and maintenance of this network should be the responsibility of a government agency. However, it is important to emphasize that the acquisition of these records alone does not provide the solution to the problem of designing structures providing an adequate degree of seismic safety. The records must be analyzed, the factors influencing the characteristics of the ground motions must be determined, and finally methods must be developed for utilizing the characteristics of past records to predict the nature of ground motions from earthquakes which may occur in the future, in different tectonic regions, for different source mechanisms, with different magnitudes, for different site conditions, and at different distances from the source of the earthquake. In addition, relationships must be developed between the probability of damage to various kinds of structures and the intensity of ground shaking. This involves detailed damage surveys, studies of the observed performance of structures of all kinds (buildings, earth dams, port facilities, etc.) in relation to the intensity of shaking to which they were subjected, the development of the analytical procedures required to anticipate the stresses and deformations likely to be produced in these structures by various types of earthquake motions, and thus the ultimate development of a reliable capability to predict potential damage patterns in advance of any anticipated earthquake occurrence. By this means critical structures can be designed to remain functional, hazardous structures can be recognized and appropriate precautions taken for the safety of their occupants, and all structures can be checked to ensure an adequate level of seismic safety.

Attention must also be given to damages resulting from ground failure and settlement, sometimes leading to serious settling and tilting of buildings and land areas, inundation of low-lying areas, to the loss of support for otherwise well-designed structures leading to failure or collapse, or the complete covering of developed areas with landslide debris - all phenomena observed in earthquakes during the past 12 years.

Understanding the behavior of structures when subjected to any specified earthquake motions is an essential step in the design of safe and economical structures for seismic regions. Significant advances in the mathematical procedures for calculating the response of structures to earthquake motions have been made during the past 20 years, since it became possible to use digital computers in the analysis. The application of these mathematical procedures is necessarily seriously limited, however, unless they are supplemented by extensive experimental studies which determine the behavior of typical structural materials and structural systems when subjected to severe dynamic loads. Such experimental data are an essential part of the information which must be provided to the computers in order that the refined methods of analysis may be applied.

A large program of experimental research directed toward study of the behavior of structures subjected to severe earthquakes has been funded by the National Science Foundation at the Earthquake Engineering Research Center of the University of California during the past 10 years, and this work has contributed significantly to current earthquake resistant structural design capabilities. The 20-ft square earthquake simulator funded by NSF and operated by the EERC is the world's most advanced facility for study of the earthquake behavior of structures. Studies of this type must continue.

While we tend to think primarily of building damage during earthquakes it is imperative that research also be directed to problems associated with "life line" systems, i.e., transportation and water and energy transmission systems. Seismic effects on and seismic design of structures such as highways and railway bridges, port and harbor facilities, airport control towers, dams, electricity transmission systems, buried and above-ground pipelines for the transmission of petroleum and natural gas, and fuel storage facilities must be considered. It is not difficult to imagine the disastrous consequences of disruption of services brought about by a destructive earthquake. For example, in the San Fernando earthquake of 1971 a number of major bridge structures were completely destroyed. Similarly in a study of 120 bridges after the Anchorage earthquake, 30 structures (25 percent) either collapsed or were determined to be unserviceable. Such disruption could preclude the transmission of needed emergency supplies, the prevention of fire fighting equipment from access to fires, etc. In the Niigata earthquake of 1964 complete destruction of a refinery by fire resulted because of failure of bridges on the roadway system leading to the refinery.

Of special importance in the earthquake engineering field is the need to ensure the seismic safety of such critical structures as nuclear power plants, dams, and high rise buildings, the failure of which could lead to the loss of many hundreds and possibly thousands of lives. It was only by good fortune, for

example, that the earthquake of February 9, 1971 in San Fernando, California did not lead to the greatest natural disaster in the history of the United States. The major slide in the upstream slope of the Lower San Fernando Dam resulting from this earthquake left only a five foot wedge of soil separating the water in the reservoir from thousands of homes and people located downstream from the dam. If the earthquake had occurred at some other time when the reservoir level was five or ten feet higher (as it was, for example, on February 9, 1970) the reservoir water would have overtopped the remaining part of the dam and erosion might easily have led to a total loss of water from the reservoir. The recent failure of Teton Dam in Idaho serves as a dramatic reminder of the hazards associated with the failure of dams to fulfill their function of safely impounding water. The possibility of dam failures adjacent to urban areas constitutes one of the greatest hazards resulting from earthquakes and requires the development of both reliable and economical design procedures to ensure that such incidents cannot and do not occur.

It should be emphasized that the earthquake engineering side of earthquake disaster mitigation is not limited to the development of improved procedures for the design of new structures. By far the greater hazard is represented by the vast number of older structures, e.g., buildings which were designed according to less restrictive codes or to no code at all. Intensive research efforts will be required to develop techniques for assessing the adequacy of existing construction, and to provide economical systems for strengthening structures which are not up to standard.

The conduct of fundamental research studies to provide a deeper understanding of all these phenomena would be a major contributing factor to the development of engineering design procedures for evaluating the safety of existing structures and designing new structures to safely withstand the effects of earthquakes with a reasonable balance between safety and economy. Academic institutions play a strong role in the development of such studies. Translation of the results of this research into engineering design practice is a critical part of this effort. Without this, the most sophisticated studies are of little social or public value and potentially invaluable results lie dormant and unused. To insure this research implementation, well-trained practitioners are required; here also academic institutions have an important role.

In general, to achieve the desired objectives of mitigating the destructive effects of earthquakes, an adequate supply of highly trained design engineers and researchers must be forthcoming on a continuing basis since requirements for solutions are extensive. Universities play a significant role in these educational research efforts. Reference has

already been made to the Earthquake Engineering Research Center at the University of California. Faculty and student research in this center has contributed to the knowledge required to improve our design capabilities while the educational activities of the Department of Civil Engineering coupled with the research program of the Center have provided some of the required engineers and researchers. Similarly other universities such as the California Institute of Technology, Stanford University, the University of Illinois, Massachusetts Institute of Technology and others have also been developing needed research and necessary people to work in the field. These efforts have received substantial support from the National Science Foundation. Passage of this Bill will assure continued support of these engineering programs through NSF which will in turn continue to provide needed basic engineering research and trained design and research engineers. Thus I urge that this Bill be expeditiously passed by the Congress.

CALIFORNIA BUSINESS PROPERTIES ASSOCIATION / 2311 WEST EL SEGUNDO BOULEVARD/HAWTHORNE, CALIFORNIA 90250/OFFICE (213) 757-9151

APR 25 197?

April 21, 1977

The Honorable Ray Thornton

To: Members, Senate Commerce, Science & Transportation Committee

Members, House, Science & Technology Committee

Re: S-126 & H.R. 35, Earthquake Prediction & Hazards Reduction

In addition to the innate worthiness of Earthquake Prediction and Hazards Reduction legislation now being considered by Congress, (S-126 and H.R. 35) we urge a particularly intense research leading to amelioration through legislative recommendation concerning the socio-economic impacts that will occur between prediction and quake.

In view of the scientifically provocative nature of the topic, prediction is likely to occur within the research community regardless of the status of federally-supported research; albeit congressionally-funded endorsement will increase the dedication and scope of prediction research.

Prediction tends to substitute for hazard reduction programs and focuses interest on specificity of prediction at the expense of attention to prediction effects.

Preliminary information indicates that economic and social reactions triggered by prediction could be a great deal more costly in terms of income, employment, economic decisions, dislocation and social instability than the actual quake. This preliminary information is rudimentary, but already it indicates these issues could become the altering force, for better or worse, of earthquake prediction.

Consequently, we urge that Congress specify additional and concurrent research on the following topics leading to reports in one year's time as the basis of legislation to mitigate the socio-economic effects of earthquake prediction.

- Government assumption of insurance guarantees, at least commensurate with the level of pre-prediction insurance carried by the property owner.

- Tax incentives and tax reductions
  - For precautionary alteration and construction on existing buildings, and
  - for offsetting economic and business decline.
- Offsetting of tax revenue declines for local, state and regional governments through federal aid.
- Government aid to communities for the continuation of public services after, and as, tax revenues decline.
- Unemployment compensation to counter prediction-stimulated economic dislocation and decline.
- Assurances of continuation of public and private projects planned or underway in predicted areas through government aid.
- Amelioration of financial consequences for development projects already in a period of "front end" financing,and/or long-term financing concurrent with earthquake prediction announcement.
- Research on economically practical up-grading of precode buildings.
- Economic inducements for up-grading precode buildings.
- Methods of forestalling adverse, domino-effect, economic decisions by small and satellite businesses based on perceptions of major industrial, financial institution, and public agency actions.
- Economic effects and prevalence of opportunism generated by prediction.
- Necessity for alteration of financial institution regulations as a consequence of prediction.

- Stability aids for residential, owner-occupied real estate values.
- Mortgage availability and consequences of prediction.
- Precataclysmic assistance for disaster effects arising from prediction.
- Legal, economic and credibility consequences of false alarms and inaccurate predictions.
- Local, state and regional government announcement policies, procedures and preferred strategies.

If the foregoing precautionary observations are made an integral research requirement for earthquake prediction legislation now being considered, we believe that Congress will be better equipped to respond with appropriate legislative safeguards at the time prediction systems become a reality.

Sincerely,

James A. Cook
Executive Vice President

JAC:dh